Marion Hersh *Editor*

Ethical Engineering for International Development and Environmental Sustainability

Springer

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Editor
Marion Hersh
School of Engineering
University of Glasgow
Glasgow, Scotland

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To my mother. We do not always agree, but she showed me the importance of standing up for what you believe in.

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A Hitman's Approach to Ethics: Temptations and Challenges and Book Overview

Marion Hersh, Alan Cottey, David Elliott, Wiebina Heesterman, Anita Kealy, Jozef Bohdan Lewoc, William D. Tucker, and Dave Webb

1 A Hitman's Approach to Ethics

Editing a contributed book is often not an easy process, and chapters are often delayed. One of the authors sent me a couple of emails with the subject heading 'almost hitman time' and told me that if he did not make the promised deadline, I had his permission to hire an assassin. I replied that unfortunately institutional budget cuts meant that there were no longer funds available for hiring assassins and that this might also be counter to institutional ethics policies.

M. Hersh (✉)
School of Engineering, Biomedical Engineering, University of Glasgow,
Rankine Building, Glasgow, Scotland
e-mail: marion.hersh@glasgow.ac.uk

A. Cottey
School of Chemistry, University of East Anglia, Norwich, England

D. Elliott
Faculty of Maths, Computing and Technology, Open University, Milton Keynes, England

W. Heesterman
School of Law, University of Warwick, Coventry, England

A. Kealy
Centre for Information Systems and Technoculture, Waterford Institute of Technology,
Waterford, Republic of Ireland

J.B. Lewoc
BPBIT Leader LLC, Newark, DE, USA

W.D. Tucker
Department of Computer Science, University of the Western Cape,
Cape Town, South Africa

D. Webb
Peace and Conflict Studies, Leeds Beckett University, England

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We then had a slightly flippant discussion about the ethics of hitmen (it is probably not an equal opportunities profession) and the ethics of using them to threaten or inflict retribution on authors who do not deliver chapters. This started me thinking about the ethics of hired killers.

I will admit to having no first-hand knowledge of hitmen. While I rarely talk about subjects of which I have little or no knowledge, the purpose of this discussion will be made clear later. I presume successful hitmen, like other successful 'professionals', must have a code of professional ethics. It might cover issues such as charging a fair price, confidentiality, refusing bribes, meeting deadlines, rejecting commissions which cannot be fulfilled and behaving discretely and professionally. Looking at this list, it would seem equally appropriate for an engineer (in private practice).

However, there is still the issue of whether it is in any sense meaningful for a hitman to behave in accordance with professional ethics. For instance, not accepting bribes may mean killing (murdering) a person or group of people according to contract rather than accepting money not to do so. Meeting deadlines means killing one or more people to an agreed deadline rather than at some later unspecified time. Rejecting commissions which cannot be fulfilled means not taking money to kill one or more people and then not killing them (and disappearing with the money). The problem is that killing people in return for an agreed sum is not ethical. Not overcharging, not accepting bribes and meeting deadlines do not make it so.

So what relevance does this discussion have for engineers? There has been a tendency for discussion of engineering ethics to focus on the ethics of professional practice. This is clearly very important. However, it is not sufficient. As the discussion of the professional ethics of contract killers illustrates, it is also essential for engineers to consider the ethics of what they are doing. For instance, are they involved in activities that benefit humanity and the environment, or are they the engineering equivalent of hitmen?

It should also be noted that hired killers who use state-of-the-art weapons to carry out their professional activities (murdering people for pay) are using technology designed by engineers. Engineers who are involved in weapons' design and development cannot be sure that these weapons will not end up being used by contract killers. Highly professional and highly paid hitmen will want the best modern technology in order to carry out their profession as effectively and professionally as possible. Naturally, the best modern weapons technology is designed and developed by engineers.

At the first international academic conference I attended there was what was supposed to be a light humorous talk in the afternoon. All I remember of it was the presenter talking about producing sub-standard cement and selling it to majority world (developing) countries. The buildings built with this substandard cement fell down after a short period, providing more opportunities to sell cement. I made a protest against this, dressed up in slightly technical terms, as it was an academic conference. Now I would probably be blunter, but I was a research student attending my first conference. Unfortunately no-one else said anything.

Producing substandard cement is not quite the same as being a professional killer. However, if buildings collapse as a result, this could lead to death and injury, possibly even on a much wider level than caused by the hitman. This approach also shows a total lack of respect for other human beings, particularly those in the majority world countries. In addition, the hitman at least has his professional ethics and possibly respect for himself as a highly trained professional (killer).

2 The Ethical Engineer

This raises the issue of the essential nature and characteristics of an ethical engineer. There is no unique answer. This book explores some of the issues and hopefully will put readers in a better position to behave ethically in both their professional and personal lives.

Being an engineer is both an enormous privilege and a very great responsibility. This gives rise to the question of an engineer's responsibilities. At the simplest level, this should require using their skills to make a positive difference to people, animals and/or the environment, as well as drawing attention to abuses, preferably with colleagues to avoid victimisation (Hersh 2002).

Unlike being a hitman, engineering should be an equal opportunities profession, but currently tends not to be (Hackett et al. 1992; Hersh 2000; Wynarczyk and Renner 2006). In addition to issues of justice, there is also the case of benefitting from the different perspectives of a wider section of the population. People may also design better for those who are similar to themselves. Therefore, involving a wider section of the community as engineers and designers may lead to products which more closely approach the ideal of design for all (Connell et al. 1997). In addition, it is only people in a particular community who fully understand the requirements and preferences of that community, giving rise to the need for end-user involvement in project design and the incorporation of material in engineering courses on working with diverse groups of end users.

Both the professional hitman and the substandard cement producer illustrate the temptations faced by engineers which must be resisted in order to remain ethical and to be true to themselves. One important temptation is to be interested purely in solving problems and involvement with an interesting state-of-the-art technology while not paying attention to the nature of the application and its ethical and other implications, as well as potential misuses. Another important temptation is to cut corners in order to make a quick profit. I like symbols, though I recognise that not everyone does, and therefore, I find the symbols of the hitman and the substandard cement producer useful in reminding me of what sort of engineer not to be. The hitman and substandard cement producer are complementary or probably, better said, an unholy duo. One lacks professional ethics and the other pays no attention to unethical outcomes.

It may be a truism to state that engineering and technology are at the basis of modern society. To give an example, many technological developments have dramatically increased the impact of modern war, including its geographical extent, environmental damage and large-scale casualties amongst civilians. Modern information and communications technologies could be considered to have had an almost revolutionary impact, which has produced great changes on most aspects of life. On the one hand, information and communication technology (ICT) has made it possible to communicate with friends and family all over the world, presented opportunities for overcoming some of the barriers experienced by disabled people and enabled the detection of global climate change at an earlier stage than would have been possible otherwise. On the other, ICT has changed the nature of work for many people and often speeded it up, has made possible very intrusive surveillance including in the workplace, had an important role in the development of military technologies and had played a significant role in increasing consumption.

This means that engineers have the potential to both have a significant positive influence on society and cause very serious and possibly lasting damage. Thus, being an engineer could be considered to be both a great privilege and a real responsibility. However, few engineering undergraduate, postgraduate, higher national diploma (HND) or vocational programmes have a significant component on engineering ethics, and even fewer, if any, try to integrate engineering ethics into all aspects of the curriculum.

3 Overview of the Book

Ethical engineering is a very wide subject. Therefore, I have chosen to focus on ethical engineering in the context of two very important global problems: sustainable development and international stability. Even with this restriction, it would be difficult within a reasonable length to cover everything, and the focus has been more on physical engineering than, for instance, biotechnologies. However, most of the ethical issues covered and solutions proposed are relevant across all of engineering.

In addition to the introduction and conclusion parts, the book is divided into three main parts, which examine the following important topics:

- Ethical impacts of advanced applications of technology.
- Engineering ethics and sustainable development.
- Engineering ethics and international stability.

Particular features of the book include the following:

- The application of ethical engineering to the two vitally important issues of environmental and international stability.
- The international perspective and authors, their expertise and experience and very different backgrounds.

- The origin of the book in the International Federation of Automatic Control (IFAC) Supplemental Ways of Improving International Stability (SWIIS) Technical Committee, now Technology, Culture and International Stability (TECIS 9.5), which has facilitated the discussion of the issues and refinement of the arguments presented in the book over a number of years.
- The parallel discussions taking place in Science for Global Responsibility (SGR), with most of the authors actively involved in either SGR or TECIS 9.5 and some, like Marion and Alan, involved in both.
- The detailed reference list at the end of each chapter and the bibliography of additional reading at the end of the book.

The main benefits of reading the book are the following:

- An increased understanding of what is meant by ethical engineering and its practical implications.
- The consequences of ethical and unethical behaviour for sustainable development and international stability.
- Increased understanding of some of the wider implications of the decisions made by engineers in their working lives and the types of ethics-related questions to ask before making these decisions.

4 Part I: Introduction

This part contains two chapters. Chapter 1 is this overview chapter, and Chap. 2 is 'Ethical Engineering: Definitions, Theories and Techniques' by Marion Hersh, Scotland. This chapter on engineering ethics provides the background and supporting framework to the book through presenting a number of definitions, theories of ethics and techniques and approaches for applying them in practice. After the introduction, the chapter is divided into three main sections. Section 2 considers different theories of ethics, including rule-based approaches such as the professional codes of engineering societies. These theories are organised according to a classification based on the two categories: (1) monist/pluralist and (2) process based, outcome based and process and outcome based. This section also includes a table of a number of theories of ethics, their properties and some references.

Section 3 presents a number of methods, approaches and techniques for applying ethical principles in practice. These include the ethical grid (Seedhouse 1988), which was originally developed to support ethical reasoning and decision making by health workers, an approach called perspectives, principles and paradigms (Anon undated) and the formation of a complete picture through the consideration of different ethical theories (Hersh 2003). Approaches to understanding individual values based on the Johari window (Brockbank and McGill 1999) and to achieving a change of ethos in organisations using multi-loop action learning (Hersh 2006; Nielson 1996) are also presented.

Section 4 considers ethical issues associated with processes and outcomes and uses the example of assistive technology to present some of these issues. It also considers research ethics with regard to both the outcomes, including those related to research aims, and the process or the ethical conduct of research, including working with human participants. Ethical issues relating to safety, good design, gatekeeping and suppressing dissenting opinions and minority group researchers and whistleblowing are also discussed.

5 Part II: Ethical Impacts of Advanced Applications of Technology

Part II consists of two chapters on roboethics and ethical uses of outer space. Chapter 3 on ‘Roboethics’ by Peter Kopacek, Austria, and Marion Hersh, Scotland, considers the opportunities, threats and ethical issues in the fast-developing field of robotics. The chapter starts with definitions and statistics and a brief overview of some of the main technological developments and current and probable future applications of robots. This includes industrial and service robots, mobile robots, cloud and ubiquitous robots and bioinspired robots. The ethical issues raised by some of these types of robots are also discussed briefly.

The concept of roboethics is then introduced, and the limitations of early approaches focused on Asimov’s (undated) laws of robotics are noted. However, the more general definition (Veruggio and Operto 2008) is able to cover the wider social implications of the introduction of robots and could be extended to cover the impact on the environment and other species. The ethical issues of current and future applications of robots are illustrated by a number of examples covering a wide range of applications, including health care, military robots and toy and companion robots. Some of the ethical theories presented in Chap. 2 are then applied to the evaluation of some of the applications of robots, and the reduction of their environmental impacts is also considered.

Chapter 4 on ‘The Ethical Use of Outer Space’ by Dave Webb, England, notes the rapid increase in the commercial and military uses of the space environment and that, whether we realise it or not, our lives are becoming increasingly influenced by and dependent on the use of space technology. The thousand or more operational satellites that currently orbit the Earth collect and broadcast enormous amounts of information worldwide, making important contributions to mapping and communications, environmental monitoring, agriculture, weather forecasting and an ever-growing range of human activities.

However, competition for valuable geostationary orbits and the positioning of military spy and other satellites has led to a situation where, rather than being viewed as a global resource, space is subject to commercial exploitation by whoever gets there first and open to military exploitation by whoever can develop the appropriate technology to dominate it. We have learned an astonishing amount about the Universe through international scientific collaboration, and it is now essential that we learn to cooperate further and develop global agreements on the way we make use of the space environment. This chapter explores the reasons why this is becoming increasingly necessary and important, why it is difficult to achieve and the progress that has been and is being made.

Section 2 discusses what we mean by outer space by tackling the question – where does outer space begin? This is followed by a description of the various forms of human activity in the region (exploration, commercial and military) along with estimates of their cost in Sect. 3. The various problems arising from the military use of space and the current projects that threaten space security are outlined. Section 4 emphasises the need to be aware of and care for the space environment, and this leads into a discussion of the problems of an unregulated use of space in terms of a tragedy of the commons in Sect. 5. Section 6 then looks at the ethical situation regarding a just and beneficial use of the space environment, and the existing international treaties and agreements are outlined along with the adopted procedural mechanisms. Finally, Sect. 7 concludes with some suggestions for future progress.

6 Part III: Ethical Engineering and Sustainable Development

Part III comprises three chapters on green jobs and energy, climate change and environmentally friendly bathing. Chapter 5 on 'Green Jobs and the Ethics of Energy' by David Elliott, England, affirms the irrefutable environmental case for switching to nonfossil energy, buttressed by the clearly unsustainable nature of our existing energy system, with climate change being the most obvious and pressing issue. This chapter looks at the social case for the transition and, in particular, at the claim that this switch could lead to more and better employment – good jobs in a green society. To set the scene, it first examines the record of the existing range of energy technologies in terms of their social and environmental impacts and their limited available resources, and then at the emergence of new renewable energy technological options that avoid or limit these impacts and constraints. The employment implications of these new options are then explored, as are trade union responses to the opportunities they offer and the challenges of a switch over to sustainable energy.

There will be jobs lost by the move away from reliance on the existing energy sources and a need for retraining. While there may be a net increase in employment, it is argued that what is perhaps more relevant is the type and duration of the new jobs. The chapter explores the emerging trade union view that what is needed is a 'just transition' to properly paid, sustainable employment with good conditions. It is argued that, although there is a need to change the way energy is produced and used and this change will create new jobs, we do not want jobs at any cost.

Chapter 6 on 'Disparagement of Climate Change Research: A Double Wrong' by Wiebina Heesterman, England, stresses the critical role of the engineering profession in the fight against climate change. This goes much further than risk management and the repair of structures damaged by extreme weather events such as persistent flooding. A crucial task is the development of a robust infrastructure capable of withstanding further weather onslaughts. New ways of working will be necessary to create resilient structures and services aimed at a low-carbon economy and the adaptation and mitigation of climate change. This also needs to be reflected in the professional education of future engineers. An understanding of the activities of the forces committed to dismissal and misrepresentation of the scientific evidence of climate change is essential.

The chapter focuses first of all on the scientific evidence for the reality of climate change. It then describes the ways in which vested interests have been able to harness the fears and feelings of those too scared to admit the possibility of it being true. This is followed by a discussion of the techniques and methods employed by individuals and organised groups intent on refuting and rejecting scientific arguments. Often, this process involves maligning the scientists and their integrity in order to create doubt regarding the science itself. Financial rewards from the fossil fuel industries which stand to sustain heavy losses from disinvestment certainly play an important role, although it is nearly impossible to discover which particular companies and/or individuals are involved. This is illustrated by specific examples, including a case study of an incident widely regarded as having transformed public consciousness to the extent that at least for a period the issue of climate change largely dropped out of sight. This is followed by the textual analysis of two books by authors not generally regarded as climate sceptics. However, much of their reputation has by and large been gained by making light of the issue and/or suggesting that climate change activists may well employ questionable techniques to reinforce their message.

Chapter 7 on ‘Environmental and Social Aspects of Domestic Bathing’, by Alan Cottey, sets domestic bathing in the broad context of the large and increasing overload of the planet’s ecology by human activity. The domestic bathing practices of prosperous, westernised people are extravagant and involve the use of large amounts of water and energy. The section ‘Technical Aspects of Bathing’ contains a quantitative discussion of water and energy use and of greenhouse gas emissions, under various conditions, including different means of heating the water. These general conditions are followed by a comparison of different methods of bathing, principally shower, bath and basin.

Ways in which bathing can remain pleasurable and hygienic, yet use an order of magnitude less water and energy, are discussed. Such a reduction cannot be achieved through technical efficiency alone, because capitalism *requires* net economic growth of the historic kind. Hitherto, growth (roughly a few percent per annum) has exceeded efficiency gains (roughly one percent per annum). Thus, the fundamental questions are political. In particular, humanity must change from an ethos of domination and exploitation to an ethos of sharing our earthly home. The chapter shows that, with a radical change of economic ideas (household management that is simultaneously grand and modest) and with some simple (appropriate technology) developments of equipment, effective and pleasurable bathing is possible using resources at a level far below the current norm for prosperous people.

The discussion of bathing provides an example and draws out ideas which can be applied to other cases of human profligacy. The role of engineers, both as ordinary members of society and individuals with special talents and trained skills which can be applied to the invention and development of useful arts, is apparent throughout the chapter. In this Anthropocene epoch (This overload is indeed so marked that the term Anthropocene is widely used for a new geological epoch in which human influence is a major factor), the *creativity* of engineers, amongst others, is called for to work *with* the rest of nature towards a sustainable and beautiful twenty-first century.

7 Part IV: Ethical Engineering and International Security

This part consists of four chapters. The first three chapters examine ethical issues related to development in three different contexts: the automation and information and communications technology (ICT) industries in Poland, a telemedicine centre in Kosovo and technology development for Deaf people in South Africa. The fourth chapter considers ethical issues associated with military work.

Chapter 8 on 'Engineering Ethics Problems in a Developing Country' by Józef B. Lewoc, Poland, and colleagues draws on case studies of the experiences of successful leading designers in the areas of hardware, software, applications and research to discuss ethical issues related to working in the ICT and automation industry in Poland. The situation both pre and post the political and economic changes in 1989 is considered, with developments in the subsequent period based almost exclusively on technology transfer. A number of ethical theories are applied to analyse the actions of leading designers, large corporations post-1989 and the authorities in the state-owned firm Elwro pre-1989. Similarities and differences in the experiences of leading designers in the two periods are noted, and various suggestions for surviving while behaving ethically are made.

Chapter 9 on 'Rebuilding Hope in Post-conflict Regions: Telemedicine in Kosovo' by Anita Kealy and Larry Stapleton, Ireland, defines post-conflict regions as territories where there has been a severe, recent violent conflict which has fundamentally destabilised a society. Because of this, post-conflict regions frequently have a particular set of features which differentiate them from other developing or more stable regions. Studies from both developed and developing regions show that developing and implementing medical informatics or e-health are becoming a crucial part of effective health care. Developing and implementing large-scale, technologically enabled infrastructures such as health services are notoriously difficult, even in stable regions.

Post-conflict regions are extreme situations with many additional complicating features for large-scale technology projects. This chapter aims to set out the factors leading to a successful implementation of a telemedicine ICT system in Kosovo. Ciborra (2002) argues that ICT is more than a combination of hardware and software. ICT creates a backdrop for human actors that work with it and can both reflect and impact on the organisation it has become part of. Ciborra (2002) puts forward five features of the 'host', who is receiving the technology as a 'guest'. These features are evident in the findings from the successful implementation of the telemedicine centre. This research found that the impact on the organisation of hosting the technology emerges as one of the main factors which influenced the success of the centre. These findings suggest that when investigating the outcomes of large-scale technology projects in post-conflict developing regions, this aspect of the technology warrants further exploration.

Chapter 10 on 'Beyond Traditional Ethics when Developing Assistive Technology for and with Deaf People in Developing Regions' by Bill Tucker, South Africa, highlights the limitations of traditional ethical approaches and procedures when engaged in assistive technology (AT) research for Deaf people in a developing region. Nontraditional issues arise as a consequence of employing action research, including how informed consent is construed and obtained, empowerment of participants to become involved in co-design, awareness of the unfamiliar cultural issues of participants (as opposed to subjects) and accommodating community-centred, as opposed to person-centred, nuances. Action research is a useful paradigm for ICT for development and requires that researchers intervene in a community to transform social practices based on mutually defined research goals. The author's approach to action research is called community-based co-design where technological innovation emerges together with a technology-empowered community.

This chapter describes work with the Deaf Community of Cape Town (DCCT), a disabled people's organisation that works on behalf of a marginalised community of undereducated, underemployed and semi-literate Deaf people across metropolitan Cape Town. Here, the capital 'D' calls attention to a cultural identity due to either the physical deafness or a preference for using signed language to communicate, in this case South African Sign Language (SASL).

This chapter shows how community-based co-design can direct academic research to bridging communication gaps while simultaneously providing ICT solutions to empower marginalised Deaf people towards independent communication. There is a conflict/tension between these two goals, with ethical issues nuanced by sensitivity to Deaf culture and their preference for SASL communication, power relations and technical and socio-economic disparity. There is also tension between the requirements of the Deaf community, and the evolving and changing roles and expectations of the research and traditional ethics processes, including those of university institutional review boards. The chapter discusses related work to identify the central shortcomings of traditional computer science and engineering approaches to ethics and illustrates the associated challenges with examples from work with the Deaf Community of Cape Town. The author reflects on how these ethical issues affect AT design, based on long-term engagement, and how this has affected the research team's practices and offers suggestions to others working on AT in developing regions.

Chapter 11 on 'Ethics, Scientists, Engineers and the Military' by Marion Hersh, Scotland, discusses the ethical issues arising from military work by scientists and engineers. The chapter is introduced by an overview of global military expenditure and its consequences. A number of statistics are presented on the trends in military expenditure and its consequences, as well as the resulting deaths and social costs in terms of inadequate development, poverty and lack of education. A three-part model of the causes of conflict is presented and discussed and used to highlight the importance of resolving the underlying issues that lead to conflict and changing the context that may encourage war rather than peaceful resolution. This leads into the discussion of military technology as part of this unfortunate context. An overview of different types of military technology is presented from nuclear weapons to small arms, and the various arms control agreements are discussed. This is followed by a discussion of the arms trade. Despite cuts in military expenditure due to austerity measures, this still remains very significant and includes sales to countries with severe human rights violations. Corruption in the arms trade is considered, and features of the arms trade which encourage corruption are noted.

A case study of military research in the UK is presented and makes depressing reading. It is noted that most of the research relates to offensive rather than defensive weapons and that UK weapons are often exported to countries with very poor human rights records, which reduces rather than increases security. The penultimate section considers the impacts of military expenditure on the economy and discusses the research which shows that other types of expenditure generally lead to creation of more jobs than military expenditure. The final section summarises the chapter and presents further discussion. It notes that developments in military technology have transformed the nature of conflict and heightened insecurity. It is pointed out that the data shows that for many countries military spending relates to power, prestige and status rather than 'defence' and that engineers and scientists have had a major role in developing military technologies which have made conflict more lethal and to take place over a much wider area, involving more civilians. The importance of security policies based on peace building and resolving problems rather than fear and high-tech weapons is again highlighted.

8 Part V: Looking to the Future

This short part rounds off the book and contains one chapter, Chap. 12 on 'Conclusions and Looking to the Future' as well as resource materials, a list of additional reading, and contact for organisations of engineers and scientists working for change.

References

Anon (undated) Perspectives, principles, paradigms – ethical guidance from the ASTRID project. http://www.ict-ageing.eu/?page_id=1271. Accessed 5 Feb 2015

Asimov I (undated) I, Robot, p. 27. i, robot.pdf. Accessed 14 May 2014

Brockbank A, McGill I (1999) Facilitating reflective learning in higher education. Society for Research into Higher Education & Open University Press, Buckingham

Ciborra C (2002) Labyrinths of information: challenging the wisdom of systems. Oxford University Press, Oxford

Connell BR, Jones M, Mace R, Mueller J, Mullick A, Ostroff E, Sanford J, Steinfeld E, Story M, Vanderheiden G. (1997) The principles of universal design version 2.0. http://www.design.ncsu.edu/cud/about_ud/udprinciplestext.htm. Accessed 11 Aug 2010

Hackett G, Betz NE, Casas JM, Rocha-Singh IA (1992) Gender, ethnicity, and social cognitive factors predicting the academic achievement of students in engineering. J Couns Psychol 39(4):527

Hersh M (2000) The changing position of women in engineering worldwide. IEEE Trans Eng Manag 47(3):345–359

Hersh MA (2002) Whistleblowers – heroes or traitors?: individual and collective responsibility for ethical behaviour. Annu Rev Control 26:243–262

Hersh MA (2003) Ethical analysis of the information society. In: IFAC 8th symposium on automated systems based on human skill and knowledge, Göteborg

Hersh MA (2006) Mathematical modelling for sustainable development. Springer, Berlin/New York. ISBN 3-540-24216-3

Nielson RP (1996) The politics of ethics. Methods for acting, learning, and sometimes fighting with others in addressing ethics problems in organizational life. Oxford University Press, New York

Seedhouse D (1988) Ethics: the heart of health care. Wiley, Chichester

Veruggio G, Operto F (2008) Roboethics: social and ethical implications of robotics. In: Siciliano B, Khatib O (eds) Handbook of robots. Springer, Heidelberg, pp 1499–1522

Wynarczyk P, Renner C (2006) The “gender gap” in the scientific labour market: the case of science, engineering and technology-based SMEs in the UK. Equal Oppor Int 25(8):660–673

Chapter 2
Ethical Engineering: Definitions, Theories and Techniques

Marion Hersh

Overview
This chapter on engineering ethics provides the background and supporting framework to the book through presenting a number of definitions, theories of ethics and techniques and approaches for applying them in practice. After the introduction, the chapter is divided into three main sections. Section 2 considers different theories of ethics, including rule-based approaches such as the professional codes of engineering societies. Section 3 presents a number of methods, approaches and techniques for applying ethical principles in practice. Section 4 considers ethical issues associated with processes and outcomes and uses the example of assistive technology to present some of these issues. It also considers research ethics with regard to both the outcomes and in particular the research aims and the process or the ethical conduct of research, including working with human participants.

1 Introduction

Ethics relates to questions about right and wrong conduct and techniques and approaches that can be used to try and obtain satisfactory answers. Often the questions do not have one clearly defined answer. There may be a number of possible solutions, all of which have disadvantages or problems, or there could be a number of obviously wrong answers, but it may be less obvious what the right answer is.

In some cases, ethical issues and the choices of right and wrong are very clear. For instance, murdering a colleague for personal advantage, for instance, to increase your chances of promotion or leading a particular project, is clearly unethical.

M. Hersh (✉)
School of Engineering, Biomedical Engineering,
University of Glasgow, Rankine Building, Glasgow, Scotland
e-mail: marion.hersh@glasgow.ac.uk

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However, it is not always (immediately) clear what is and is not ethical. There are often trade-offs between different interests and the benefits and disadvantages to different groups of people, as well as conflicts of loyalties.

There is also the well-known means and ends argument. Is it justifiable or ethical to do something (slightly) wrong/unethical in order to achieve a greater good? Is it possible to achieve ethical aims by unethical means? How can ethical decisions be made when you do not know what their consequences will be? Or is ethics only about good/right actions rather than consequences? Is a particular decision or action always right in all circumstances? Or do the circumstances make a difference?

This chapter will discuss these issues and present some of the theories and techniques that can be used to support ethical decision making. Many of the examples are based on assistive technology. In addition to raising ethical issues, it is an example of the application of engineering to benefit end-user groups who are frequently marginalised. It therefore raises ethical issues which are important to international stability.

Ethical questions are sometimes phrased in terms of ‘should’, ‘ought’, ‘right’ and ‘wrong’. They include the following:

- What should I do if I realise that the firm I am working for is carrying out activities that are damaging to the environment or proposing to distribute a product before carrying out sufficient tests of its safety?
- Should I accept money from a tobacco company/the military to develop a new assistive device? Does this depend on the type of device? Other available sources of funding? The benefits to the tobacco company/military? Whether there will be any restrictions on publishing freely?
- What should I do if I suspect my line manager is bullying and harassing colleagues? How much evidence do I need before taking action? What should I do if I refer this issue to the head of the company, but they do not take any action?
- I am working on an engineering project in a majority world (developing) country with a collective approach to ethics. My home organisation requires me to obtain signed informed consent forms from individuals, but the people I am working with consider this insulting. What should I do?
- Devices have been developed which can be used to lock the front door and prevent elderly people with dementia going out at night. Is this ethical? Who should make this sort of decision? What about conflicts between the wishes of the person with dementia and their friends and relatives. What if it is not possible to determine the views of the person with dementia?
- I am working on a project with a very limited budget. Is it more ethical to travel to project meetings and conferences by train or plane? Travelling by plane is more damaging to the environment, but train travel is more expensive and uses up too much of my small budget.

The ethical answers to many of the above questions are not immediately obvious. Some people will find the issues controversial and they could lead to heated debate. The answers given by different individuals will depend on a number of different factors, including the information available to them; their own ideological, political, religious and ethical values and points of view; and the ethos and cultural context of their environments.

Engineers in particular are frequently required to make decisions with serious consequences. Many of these decisions have an ethical component. As indicated above, ethical decision making is not simple, but awareness of this complexity should not act as a barrier or delaying factor. Doing nothing is also a form of 'action' which can have its own problems.

1.1 Some Definitions

The terms *ethics* and *morals* are often used interchangeably. However, it can be useful to make the distinction that (Gluck 1986):

- Morality is concerned with right and wrong conduct and motives.
- Ethics is the philosophical study of morality.

Thus, ethics can be seen as a framework in which to study moral problems (Bennet 1996) and how to solve them (Vesilund 1988). However, despite this distinction, the term ethics is generally used to describe both right and wrong conduct and motives in a professional context and moral issues and decisions.

Engineers have a number of ethical duties and responsibilities, including the following:

1. To the people who are or will be using the technologies they are researching, developing, supplying or otherwise working with.
2. To society as a whole, including anyone who will be affected, whether positively or negatively, by any technologies they are researching, developing, supplying or otherwise working with.
3. Private duties and ethical responsibilities as professionals.
4. To the planet.
5. To other species.

I recognise that point 5 and to a lesser extent point 4 are controversial. However, particularly in the context of environmental stability, we need to recognise ethical duties to the planet and also to other species.

The approaches to the study of morality can be divided into *nonnormative* approaches, which do not involve taking moral positions and *normative* ethics which do. Nonnormative approaches can be divided further into (1) descriptive ethics, which gives a factual description and explanation of moral beliefs and behaviour, and (2) meta-ethics which involves analysis of the meanings of terms, such as right, obligation, good, virtue, responsibility and morality.

Normative approaches can be classified as (1) general normative ethics, which is a philosophical attempt to formulate and defend basic moral principles and standards of virtue, and (2) practical normative ethics, which is based on the application of moral principles and standards of virtue.

Many ethical approaches are based on rules and/or principles. Both principles and rules are ‘general action guides specifying that some type of action is prohibited, required or permitted in certain circumstances’ (Solomon 1978). The term norms is sometime used to cover both principles and rules. It has been suggested that principles are more general norms, whereas rules are more specific norms. Therefore, principles often motivate more specific rules which give a more concrete specification of the particular prohibited, required or permitted action(s) (Childress 1998).

2 Theories of Ethics

2.1 Introduction

There are a number of different ethical theories of appropriate professional and personal conduct. There are also a number of different perspectives on the role of such theories. Some people consider that they should be used purely to provide guidance and highlight issues in ethical decision making, whereas others consider that they can be applied to obtain the correct decision.

One of the main distinctions is between (Ersdal and Aven 2008):

- Deontological approaches, which are based on independent moral rules and duties, which should be defined ‘objectively’ rather than subjectively.
- Consequentialist approaches, which are concerned with the consequences of actions and with the balance between benefits and harms.

The difference between deontological and consequentialist ethics relates to the means and ends argument. Is it justified to do (slightly) wrong in order to achieve (a greater) good? Do only results matter or is how you achieve them equally or even more important?

I would suggest that being really ethical requires both means and ends, i.e. actions and consequences, to be ethical. This means that both end products, including technologies and devices, and the processes used to obtain these end products should meet the highest ethical standards. As an extreme example in ethical terms, it is clearly nonsensical to:

- Produce cost-effective gas chambers (for eliminating political opponents and other ‘undesirables’) which meet the strictest health and safety standards, have low emissions and energy consumption and are powered by solar panels.
- Produce safe, educational, fully accessible and fun toys in slave labour conditions in a factory that tips radioactive waste into the local river.

These examples have been deliberately chosen to be extreme and therefore to highlight the ethical issues. Most situations are not so extreme and the ethical issues are not always as clear. It is these unclear areas that make ethical issues both difficult and interesting. It has been suggested (Seedhouse 1988) that many writers about technical ethics unfortunately consider them a form of intellectual game and do not actually behave in accordance with their own ethical theories. However, it seems to me that there is little value in ethical theories that are not applied in practice.

Ethical principles can also be classified either as universalist or absolutist and situation based. *Absolutist* approaches assume that a particular set of ethical principles is always valid, regardless of the surrounding circumstances. Both deontological and consequentialist approaches can be absolutist. In the deontological case, there are absolute obligations or duties which are generally binding, though they can be challenged by competing moral obligations. In the consequentialist case, consideration of consequences or utility is an absolute rule with no exceptions. *Situation-based* ethics modifies ethical principles or prioritises them differently, to take account of the particular situation. Although situation-based approaches are often more realistic, care has to be taken to ensure that situation-based ethics is not used as an excuse to avoid the hard ethical issues.

The following subsections discuss a number of different theories and philosophies of ethics. *Monist* approaches only apply one theory, whereas *pluralist* approaches apply several theories. There has been some criticism of pluralist approaches in that they generally do not indicate how the different theories, approaches and philosophies should be weighted against each other or decisions made when the different theories are in conflict. However, if, like me, you consider that the aim of the different theories is to structure situations, highlight problems and issues and support ethical thinking and decision making rather than tell you what to do in particular situations, then this is not a problem. The different theories can then be considered to be complementary rather than mutually exclusive alternatives. Since different theories will sometimes lead to very different conclusions as to what is and is not ethical, a pluralist approach based on a combination of several different theories is likely to give a much clearer picture of the ethical issues involved than any monist approach on its own. This is particularly relevant to both consequentialism and deontology, which should be considered complementary approaches.

Thus, it is possible to categorise ethical theories and principles in a number of different ways, including (1) monist or pluralist, (2) motivations/processes or consequences/outcomes (means and ends), (3) absolutist or situation based and (4) technology centred, human centred and/or environment centred. A useful categorisation of the different theories and principles can be obtained using the first three of these categories and is presented in Table 2.1. Absolutist or situational and monist or pluralist are pairs of opposites, whereas motivations/processes and consequences/outcomes are not mutually exclusive, giving three options, in this case, process oriented, outcomes oriented and process and outcomes oriented.

The theories in Table 2.1 are presented in slightly more detail in this section, with a brief overview given for each theory. The table is also used to order the material in the chapter. It should be noted that, in addition to the materials referenced specifically in the text, the descriptions of the ethical theories are taken from the books Babcock (1991), Beauchamp (2001), Beauchamp and Leroy (1978), Kuhse and Singer (1998), Madu (1996) and Martin and Schinzinger (1996, 2004) and the web page http://atheism.about.com/library/FAQs/phil/blphil_eth_index.htm. A further table (Table 2.2) at the end of the section summarises the details of each theory and gives some further useful references.

Table 2.1 Classification of different theories of ethics

Theory	Monist	Pluralist	Absolutist	Situational	Process oriented	Outcomes oriented	Process and outcomes
Care, ethics of		√		√		√	
Case approach		√	√		√		
Deontological	√		√		√		
Eco-centred		√		√			√
Existential ethics	√		√			√	
Experimentation, ethics of	√		√		√		
Hippocratic or engineering oath	√		√				√
Human-centred	√		√		√		
Narrative ethics		√		√			√
Negative utilitarian ethics	√			√		√	
Normative ethics		√	√		√		
Positive utilitarian	√			√		√	
Rights ethics		√	√		√		
Rule based		√	√		√		
Virtue ethics	√		√		√		

2.2 Monist Ethical Theories and Approaches

2.2.1 Process-Oriented Ethical Theories and Approaches

2.2.1.1 Deontological Ethics

Deontology is derived from the Greek word deon, duty, and logos, science. It is based on the requirement to carry out duties, generally regardless of consequences. Therefore, deontological ethics requires determination of your obligations and duties, as well as weighing up obligations under different duties. However, there is not a total agreement on what these duties are. Rule deontology is a particular case in which the moral duties to be followed are based on a set of rules rather than personal or social judgements.

Kant's (1792, 1818) categorical imperative is a particular and well-known example of deontological ethics. It is 'categorical' because it is independent of desires. The basic principle is that everyone is entitled to equal respect. The main features of Kant's ethical theory can be expressed in terms of the following three principles, which state his basic requirements for acting morally:

1. Act in every circumstance as though your every action were to become law for everyone, yourself included, in the future.
2. Always treat other human beings as 'ends in themselves' and never merely as 'means'. This requires a recognition that other people exist in their own right with their own feelings, ambitions and aims and are not tools to be exploited.

Table 2.2 Summary of theories and approaches to understanding ethics

Theory	Properties	Concepts	References
Care, ethics of	Monist, situational, outcomes oriented	A context-based approach to preserving relationships	Gilligan (1982), Held (2006), Morris (2001), and Sevenhuisjen, (1998)
Case approach	Pluralist, absolutist, process oriented	Rule-based analysis of particular cases to obtain general rules to analyse complicated cases	Chadwick (1992). Cooper (2012), Harris et al. (1996), and Newberry (2004)
Deontological	Monist, absolutist, process oriented	Intention and innate virtue of a course of action	Collins and Miller (1992), Ersdal and Aven (2008), and Kant (1792, 1818)
Eco-centred	Pluralist, situational, process and outcomes oriented	Connections and interactions, a holistic perspective including long-term and indirect consequences for the environment	Callicott (1992), Hersh (2000, 2013, 2014),. Mosquin and Rowe (2004), Nash (1989), and Taylor (2011)
Existential ethics	Monist, absolutist, outcomes oriented	Morality from individual's concern for continuing and enhanced existence	Kaufman (1956), Macquarrie (1955), Sartre (1985, 1992), and Warnock (1970)
Experimentation, ethics of	Monist, absolutist, process oriented	This stresses informed consent	Hersh (2012a, b), Hersh and Tucker (2005), and Martin and Schinzinger (1996, 2004, 2010)
Hippocratic or engineering oath	Monist, absolutist, process, and outcomes oriented	Public personal ethical commitment. Avoid harm, share knowledge, admit ignorance	Bitay et al. (2005), Laplante (2004), and Singleton (1991)
Human-centred	Monist, absolutist, process oriented	Focus on people and relationships rather than technology, power structures or organisations	Hersh (2013, 2014), and Stapleton and Hersh (2004)
Narrative	Pluralist, situational, both process and outcomes oriented	Use of stories, literary criticism, and narrative theory to understand underlying issues	Hersh et al. (2005), Frey and O'Neill-Carillo (2008), McCarthy (2003), and Walker (1993)

(continued)

Table 2.2 (continued)

Theory	Properties	Concepts	References
Negative utilitarian	Monist, situational,outcomes oriented	Mainly concerned with offsetting or mitigating present or future harms	Hersh (2003, 2012b), Inglehart et al. (1987), and Rothbart and Edwards (2003)
Normative	Pluralist, absolutist, process oriented	The defence of principles, such as beneficence, justice and autonomy	Cooper (1987), Hersh (2012b), and Kagan (1998)
Positive utilitarian	Monist, situational, outcomes oriented	Assesses benefits against risks and costs	Hersh (2003, 2012b), and Mill (1871)
Rights	Pluralist, absolutist, process oriented	Considers actions to be wrong if they violate fundamental moral rights	Basart and Serra (2013), Gardiner et al. (2010), Hersh (2012b), and Nino (1993)
Rule based	Monist, absolutist, process oriented	Application of rules, e.g. institutional codes of ethics or professional conduct	Engineering Council (2010), Oldenquist and Slowter (1979), Parker (1968), and VDI (2002)
Virtue	Monist, absolutist, process oriented	Supports actions which build good character	Beauchamp (2001), Doris (1998), Havard (2007), Hursthouse (1999), and Swanton (2003)

3. Always act as a member of a community where all the other members of that community are ends, just as you are.

Kant defines the moral value of an action in terms of three principles or propositions:

1. The moral worth of an action is due solely to it being commanded by rules of obligation and not due to its consequences.
2. An action's moral value is due to the motivating rule of obligation, not its success in accomplishing particular goals.
3. Obligation to perform an action derives from respect for the law.

The first two principles can be considered to be statements of what deontological ethics is. The third principle assumes that there is a strong correspondence between ethics and law, i.e. all the laws (of a given society) are fully ethical and all ethical principles are enshrined in law. This is very rarely the case. The main problem with Kant's approach is the inflexibility of the first statement. Although it has the advantage of making you consider how the world would be if everyone acted on the same principles, it takes no account of particular circumstances.

Criticisms of deontological ethics include difficulties in 'objectively' determining the moral duties and problems in deciding which moral duty to follow when they are in conflict. In addition deontological approaches to ethics have the disadvantage of ignoring consequences, just as consequentialist approaches have the disadvantage of ignoring motivation and obligations. It is therefore generally appropriate to consider deontological and consequentialist approaches together.

2.2.1.2 The Ethics of Experimentation

It has been suggested by Martin and Schinzinger (1996) that engineering should be treated as social experimentation. This has the advantage of making explicit the importance of informed consent. This requires 'subjects' to have sufficient and appropriate information to make properly informed decisions and participate voluntarily without any kind of coercion or deception.

Such experiments may involve complex technologies. Therefore, in the longer term, informed consent would require improvement in the general level of technical education to make the arguments and issues more accessible, as well as better communication skills for engineers and scientists so they can clearly explain the issues to the general public.

Informed consent also requires genuine understanding of the level of risk for particular benefits. In some cases, the general public has a very different attitude to risks from experts or regulatory bodies. Individuals are generally more willing to accept the risks from new technologies if they see obvious benefits. For instance, mobile phones are very widely used due to the perceived benefits, despite the fact that there may be health risks, but there is little definite information.

This raises the question of how acceptable levels of risk for different activities should be determined. It also implies that present approaches by experts and regulatory bodies may be inadequate in ethical terms. The high degree of uncertainty in evaluating the risk associated with many new technologies also raises ethical questions. Particular examples include nuclear energy and genetically modified foods. Both these examples can be considered social experiments with unknown outcomes and possibly unforeseeable long-term consequences, making the use of the precautionary principle appropriate.

Another important issue is that of dissenting minorities. Responsible experimentation would require informed consent by all participants. This raises ethical problems in the case of, for instance, particular energy technologies, where it may not be possible for dissenting or concerned individuals to opt out.

The implications of the ethics of experimentation for assistive technology research include the following:

1. The importance of involving disabled people in the development of new assistive technology products, as part of the ethical responsibility for ensuring that the resulting devices do meet the needs of the group of disabled people they have been designed for and are likely to enhance their lifestyles.
2. Recognition that new assistive technologies can have unexpected and unforeseen consequences on the lives and social relationships of disabled people and their families and friends and personal assistants. There is an ethical responsibility to take these unexpected consequences into consideration.
3. The importance of not pressurising groups of disabled people to participate in questions or user studies on new assistive devices.

2.2.1.3 Human-Centred Ethics

Human-centred ethics focuses on people first with the organisation and technology in the second and third places and on the needs of individuals and groups rather than those of vested interests and power structures. Human-centred ethics is related to human-centred systems which are based on the social structures that surround the work and information being used by the individual (Hersh et al. 2005) and are designed to complement the skills of the user (Kling and Star 1998). Introducing new technologies can have a profound effect on an organisation or even a whole society (Hersh et al. 2005). This requires human-centred approaches in which decisions about both whether the technology is introduced and, if this is agreed, the process by which it is introduced are based on human requirements, and it is possible to refuse it rather than feeling compelled by technological determinism (Ellul 1954; Winner 1977) or power structures and vested interests (Stapleton and Hersh 2003).

The following two principles of Kant's (1792, 1818) categorical imperative are very relevant to human-centred ethics: (1) treating other people as 'ends in themselves' rather than 'means', i.e. recognising that they have their own needs and are not tools to be exploited, and (2) acting as a member of a community where all the other members are also 'ends'.

2.2.1.4 Virtue Ethics

Virtue ethics, which dates back to Aristotle (Koehn 1995), supports actions which build good character. It differs from both deontological and consequentialist ethics in that the focus is the effects of the action on the person carrying it out (and the relationship between action and character) rather than on the results of the action or particular obligations and rules. However, despite these different emphases, obligation and virtue-based ethics are generally not in conflict. Schemes showing that each moral obligation has a corresponding virtue have been drawn up and also criticised (Beauchamp 2001). Although there is some correspondence between groups of different types of obligations and virtues, there is not a one-to-one correspondence, and many virtues do not seem to have associated principles or obligations.

Virtue ethics is based on the premise that a person with moral virtues is more likely to behave ethically than someone who purely follows rules. This is possibly an elaboration of the fact that people are generally more motivated and more successful working on a project they believe in than one they have been assigned to without consulting their interests. Behaviour often has an impact on character. Therefore, in addition to virtue ethics being defined in terms of the expected behaviour of a person with particular virtues, virtue ethics can also be seen as the type of behaviour which will promote the development of particular virtues. A number of different suggestions for appropriate virtues have been made. However, it may be difficult to determine the appropriate list of virtues without considering their relationship to the principles of ethical action, responsibilities or duties and the consequences of the action. In addition, different ethnic and other groups with different values are likely to have different lists of desired virtues.

Different writers on philosophy tend to have differing opinions as to whether obligations or virtues should be the primary category in ethical theory. Criticisms of virtue ethics include the fact that the rules that can be derived from virtue ethics are often too vague to act as a guide to conduct and the possibility of unethical conduct through the inappropriate application of virtues. However, unethical conduct can result from following rules without thinking about the probable consequences of applying them. It has also been suggested that absolute prohibitions are required. However, most systems of rules allow for exceptions in the case of apparent absolutes such as killing. In theory, the promotion of virtue seems highly desirable. However, in practice, the outcomes will depend on what types of virtues are being promoted. For instance, a number of societies and groups within societies both historically and in the present have made 'virtues' of a lack of tolerance and the conviction of the overwhelming superiority of their culture and beliefs and the inferiority of other cultures and the wrongness of other beliefs. This has led to discrimination or actual violence against people with different beliefs and been used to make imperialist and colonialist occupations desired for economic reasons seem a moral imperative.

These criticisms of virtue ethics indicate the problems with monist theories of ethics and the need to combine virtue ethics with deontological and consequentialist approaches. The strength of virtue ethics is its recognition that conduct has an effect on the person. This gives a feedback system, as illustrated in Fig. 2.1, in which ethical

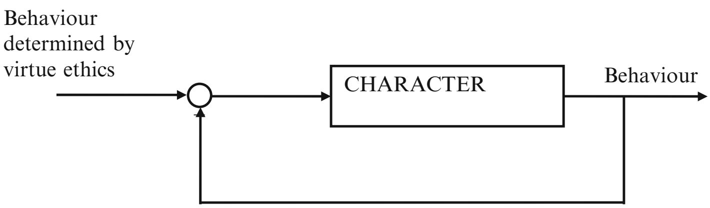

Fig. 2.1 Feedback from ethical behaviour to virtuous character

conduct has an effect on character and the development of virtues and these virtues lead to further ethical behaviour. Virtue ethics is also consistent with spiritually motivated approaches to ethics, since it could be considered to encourage personal and spiritual development through ethical behaviour. However, it is unrealistic to define ethics in terms of the behaviour of a virtuous person, since even 'virtuous' people sometimes make mistakes or do things they subsequently regret, and there is no generally accepted understanding of a 'virtuous' person.

2.2.2 Outcomes-Oriented Theories and Approaches

2.2.2.1 Consequentialist Ethics

Consequentialism is based solely on consideration of the consequences of actions. It requires trying to assess the likely consequences of actions and only carrying them out if the expected benefits exceed the expected disadvantages. This immediately raises the issue of how uncertainties in the likely consequences should be taken into account. In many cases, the precautionary principle is required. It attempts to remove the need to prove a causal link between specific emissions and observed environmental damage before action is taken to reduce the environmental damage caused by substances with a known 'hazard potential' (Hersh 2006). Although generally stated in terms of environmental harm, it can also be applied to other types of harms.

Utilitarianism is a particular type of consequentialism, based on the maximisation of utility. This was originally expressed in terms of happiness or pleasure, but the theory has now expanded to include other measures of utility. There is a whole economic and mathematical theory of utility (Fishburn 1970), which will not be discussed here. In general terms, it is based on the idea that a 'rational man' will maximise utility through consumption. Although more recent developments allow for an increase of utility resulting from positive altruistic emotions and experiences, it tends to encourage egotism, materialism and consumption.

However, utilitarianism is not egotistical and is based on maximising overall good, whether defined as the total of individual measures of utility, pleasure or happiness, generally without taking account of how it is distributed. It generally requires the ethical decision maker to give no greater value to their own good or happiness than to that of anyone else. One problem is that it does not take into account the distribution of benefits and therefore tends to support the status quo. Thus, a scheme which further enriched the richest 10% of the population but had no effect on poverty could be considered ethical in terms of utilitarian ethics if it enriched the rich sufficiently.

Utilitarianism can further be categorised as:

1. General utilitarianism, which is based on considering the consequences 'if everyone did that'.
2. Act utilitarianism, which is based on assessing which of the actions open to you are likely to produce the greatest balance of 'good' (however defined) over 'evil'. However, this could require you to carry out an act which is wrong in itself, such as paying bribes in order to obtain a contract which will bring jobs to your area, if the action is expected to have an overall positive effect.
3. Rule utilitarianism, which is based on acting in accordance with rules to achieve the greatest good. However, unlike rule deontological ethics, the rules to be followed are derived from their expected consequences rather than their value in themselves. In addition determination of these rules is generally based on their expected effects in general rather than in a specific case.

Another division of utilitarianism (Lappé and Bailey 1999) is into:

1. Positive utilitarianism, which assesses new technologies in terms of their benefits against the risks and costs and generally favours new technologies and pays little attention to the risks of, for instance, the destruction of ecosystems.
2. Negative utilitarianism, which is mainly concerned with offsetting or mitigating present or future harms and is more obviously compatible with the precautionary principle (Harremoës et al. 2002).

Thus, both positive and negative utilitarianism compare costs and benefits, but positive utilitarianism does so in a way that stresses the benefits, whereas negative utilitarianism is more concerned with the costs.

There has been considerable criticism, as well as spirited defence of utilitarianism (Scheffler 1994). A particular problem is the lack of consideration of equity and distribution of benefits. There is also a lack of clarity about exactly what utilitarianism maximises. In the literature, the concept of agent-centred restrictions, i.e. allowing 'good' not to be maximised in circumstances where it would require unethical actions to be carried out, is controversial. However, the discussion is often in the context of extreme examples, such as being forced to choose to kill one person in order to save others (Scarre 1996), though such choices are rarely put into a historical context in which they would be relevant. This indicates a lack of flexibility in the theory and the need to combine utilitarian with deontological and other approaches to ethics.

2.2.2.2 Existentialist Ethics

While there is not a generally agreed definition of existentialism, the term is applied to the philosophy of a number of the nineteenth- and twentieth-century thinkers who (despite serious differences) based their thought on the acting, feeling and living individual (Anon 2014). Existentialism is about examining the world and ourselves, the nature of our experience and the meaning of being in the world (Cunliffe 2009). Although he did not use the term existential and existentialist ethics has also been associated with Aristotle (Stack 1974), Søren Kierkegaard is generally credited with being the first existentialist. He considered that individuals rather than society or religion were responsible for giving meaning to life. The first prominent philosopher to use the term was Jean-Paul Sartre. He considered that existence or being an independently acting, responsible person was more important than essence, or the details of the labels, roles and categories the individual identified with. Sartre suggested that human nature is not fixed and people change by imagining who they want to be. The nature of a person depends on both what they are and what they are not, as it is also defined by what they could be. Individuals are considered to be responsible for their actions, the consequences of these actions and the values they hold. They therefore need to consider their values rather than just accepting the values of their society. Existentialism considers authenticity to be important, i.e. accepting responsibility and being true to oneself rather than behaving in accordance to expectations based on particular characteristics or labels (Anon 2014; Cunliffe 2009).

2.2.3 Process- and Outcomes-Oriented Theories and Approaches

2.2.3.1 Hippocratic or Engineering Oath

The idea of an oath for engineers is based on the well-known Hippocratic oath for doctors. This serves as a way of encapsulating their main ethical responsibilities and making a personal and generally public commitment to fulfil these responsibilities. Particular features (Bitay et al. 2005; Laplante 2004) include avoiding harm, sharing knowledge and experience and admitting when you do not know something. A hypocratic oath for engineers was written by Susskind (1973), but does not seem to have been used to any extent. Its text includes the following 'I solemnly pledge myself to consecrate my life to the service of humanity. ... I will exercise my profession solely for the benefit of humanity ... I will speak out against evil and unjust practice wheresoever I encounter it; ... I will endeavour to avoid waste and the consumption of non-renewable resources.' The closest to a Hippocratic oath for engineers in current use are the Canadian ritual of the Calling of an Engineer and the Obligation of an Engineer oath of the US Order of the Engineer (Goodyer 2012). The Canadian ritual dates to a 1922 meeting of seven former presidents of the Canada Institute of Engineers at which the idea of an oath to guide the development of young graduates was proposed. However, the ritual is private and its content has not been officially publicised. The US oath involves the virtues of integrity, respect, honesty and tolerance. Both ceremonies involve the engineer being given a ring to remind them of their vows and responsibility to the general public.

The question of an engineering oath was presented in a recent issue of the Engineering and Technology magazine (Goodyer 2012). An oath for software engineers has been proposed (Laplante 2004), involving not doing harm, not using tools or practices they do not understand, expanding skills and understanding, maintaining confidentiality, aiding stakeholders, devoting themselves to their projects and maintaining and raising the standard of the profession. A Hippocratic oath was also discussed by Bitay et al. (2005). Although they do not propose a specific text, they do quote the text of a poem found on the wall of a site engineer's hut in 1995 during a visit of the president of the Institution of Civil Engineers and suggest that this is a form of engineering oath. It is quoted in part below, partly on account of its poetic form despite the gender-specific language. Unfortunately the author(s) are not known.

> I take the magic which comes from dreams
> and apply the magic of science and mathematics
> adding the heritage of my profession
> and my knowledge of Nature's materials
> to create a design.
> I am an Engineer.
> I serve mankind
> By making dreams come true.

2.3 *Pluralist Theories and Approaches*

2.3.1 Process-Oriented Theories and Approaches

2.3.1.1 The Case Approach

The case approach is the art of analysing particular cases, using abstract principles, maxims or rules, in order to derive more general principles or rules which can then be applied to other more complicated cases or general cases of the particular type. It generally involves:

1. Describing the case in appropriate detail.
2. Giving the case a label or name.
3. Fitting the case into a taxonomy or structured set of responses to paradigm cases.
4. Determining where the new case fits in the continuum from cases with ethically acceptable responses to cases with unacceptable responses.

The advantages of the case approach include its immediate practical applications and not requiring a knowledge of theory. In addition, the comparison with real examples may help to clarify the issues and problems in a way that is easy to get to grips with for people with little knowledge of or interest in ethical theories.

It has been criticised as being insufficiently critical. In addition the results of reasoning by analogy are considered indeterminate, particularly in cultures with several different value systems. This is only a problem if the approaches used are expected to give a unique solution rather than to highlight issues and help in structuring the problem. There is probably also a role for the case approach in testing solutions reached by other more analytical approaches.

2.3.1.2 Rights Ethics

Rights ethics considers actions to be wrong if they violate fundamental moral rights. There are a number of different types of rights including the following:

1. Moral rights, which includes all rights that are held to exist prior to or independently of legal or institutional rules.
2. Legal and institutional rights, due to national (or international) legislation and institutional regulations.
3. Human rights: The Universal Declaration of Human Rights was adopted by the United Nations General Assembly in 1948.

Moral rights include:

1. Conventional rights due to established customs and expectations.
2. Ideal rights, i.e. rights that should be legal, institutional or conventional rights.
3. Conscientious rights.
4. Exercise rights, i.e. moral justifications for the exercise of another type of rights.

The Universal Declaration of Human Rights has 30 articles covering a wide range of rights, including the following: (not the full list and the numbers do not correspond to the article numbers) (1) life, liberty, to be equal in dignity and rights; (2) freedom from slavery, torture and arbitrary arrest; (3) recognition as a person in law, equality before the law and equal protection from the law; (4) the right to a nationality, to marry and find a family and to work with free choice of employment; and (5) the right to join a trade union and freedom of thought, conscience, religion, opinion and expression. These rights are independent of 'race, colour, sex, language, religion, political or other opinion, national or social origin, property, birth or other status'. Due to the early date, disability, gender identity and sexual orientation are not listed explicitly, though they could possibly be considered to be included under 'other status', and the language used is male centric. Groups such as Amnesty International and War Resisters International have asked for the right not to kill to be included. Some steps have been taken, but this is currently only stated in less important United Nations documents. An amended version was adopted by the Council of Europe in 1971. It has since then been further amended and the most recent version (http://conventions.coe.int/treaty/EN/Treaties/html/005.htm) entered into force in November 1998. It has also become part of national legislation, for instance, as the Human Rights Act 1998 in the UK.

Rights have also been classified as absolute or non-absolute. Absolute rights do not have limitations or exceptions, i.e. they hold in all circumstances regardless, whereas non-absolute rights do have limitations and exceptions. Human rights are often considered to be absolute. However, in practice, different rights may be in conflict with each other. For instance, the rights to be equal in dignity and the right to free speech could be in conflict, if the right to free speech is considered to include the right for instance to make insulting statements about disabled or ethnic minority people.

2.3.1.3 Rule-Based Ethics: Codes of Ethics and Legislation

Rule-based ethics is based on the application of rules. Rule-based deontological and consequentialist ethics have already been discussed. One important source of rules is the codes of ethics or professional conduct of professional societies and institutions, such as those in the different branches of science and engineering. Many professions and professional societies have codes to guide the actions of their members. Codes can provide general guidelines about appropriate and ethical behaviour. However, codes should not be considered a substitute for taking individual and collective responsibility. For instance, the situation you are dealing with may not be covered by the code. It should also be recognised that, although codes of conduct may have an ethical role, they are not identical to codes of ethics. However, both can have similar roles, and professionalism should be an additional motive for ethical behaviour.

Codes can fulfil a number of useful functions, including providing support for engineers and other professionals with concerns about the way a project is carried out or its long-term consequences and giving engineers some group backing in taking stands on ethical issues. They could also provide legal support to engineers criticised for following professional obligations.

An analysis of several different codes shows that their provisions (Oldenquist and Slowter 1979) can be divided into three main categories: (1) the public interest, (2) desirable qualities and (3) professional performance. Although this analysis is not recent, it still holds for many current codes. However, such codes rarely indicate how decisions should be made in the case of conflicting obligations, although it is such conflicting obligations that frequently give rise to ethical problems.

While there is a difference between professional codes and codes of ethics, many of the ethical codes seem closer to codes of professional practice. Engineering codes generally consider that engineers have primary duties to the public, the profession and the employer or client. Unfortunately these different duties may be in conflict. Although codes are important for encouraging ethical practices, existing codes have some limitations. In the past, they have tended to restrict ethical behaviour by individual engineers to protecting the profession's public image. There can be tensions between obligations to employers and the profession and wider obligations to society. Conflicts of interest arise when it is difficult or impossible to meet all obligations simultaneously, but codes rarely provide guidance on the priorities in meeting conflicting obligations. As in other areas, there are trade-offs between different factors, such as simplicity and specificity. In addition ‘political’ factors and the interests of protecting the profession probably still influence the codes. This may be the reason why codes do not require engineers (and other professionals) to always prioritise the public interest. Most codes of ethics recognise the responsibilities of engineers to protect public health and safety. However, this responsibility may be in conflict with duties to the employer or client, including to protect confidential information.

A Statement of Ethical Principles drawn up by the Royal Academy of Engineering and Engineering Council (undated) and several professional engineering institutions in the UK states that ‘Professional Engineers work to enhance the welfare, health and safety of all whilst paying due regard to the environment and the sustainability of resources. They have made personal and professional commitments to enhance the wellbeing of society through the exploitation of knowledge and the management of creative teams’. However, the four subsequent principles are based largely on professional practice. The Engineering Council (2010) has also issued a six-point code on the role of professional engineers in sustainability which updates the previous 1993 nine-point code of practice Engineers and the Environment (Engineering Council 1993). The Code requires engineers to ‘Use resources efficiently and wisely’ and ‘Contribute to building a sustainable society and future’. It also recognises that ‘A purely environmental approach is insufficient, and increasingly engineers are required to take a wider perspective including goals such as poverty alleviation, social justice and local and global connections’. However, the Environment Code was one of the few that explicitly mentioned ethical, in this case environmental, reasons for not carrying out a particular project, whereas this is not in the Sustainability Code.

The Union of German Engineers (VDI 2002) has a 10-point code of ethics, which stresses continuing education, including on the basics of ethics and work, environmental and technology rights and the need to discuss conflicting subject and cultural values. The Institute of Electrical and Electronics Engineers (IEEE) code of ethics (IEEE 2014) is a 10-point professional code, which includes avoidance of ‘discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity or gender expression’ and disclosing ‘promptly factors that might endanger the public or the environment’, but does not include the required action in this case. It has also produced guidelines for ‘engineers dissenting on ethical grounds’ (IEEE 1996).

Legislation and Ethics

Legislation can be considered another type of rule to follow in rule-based decision making, though for some people following legislation may be a principle in itself. However, it cannot be assumed that all legislation is ethical or that all the requirements of ethics are covered by legislation. Legislation has two categories, legal and illegal, though in practice there is often a third category of neither legal nor illegal. Morality has three categories: moral, immoral (not moral) and amoral (neither moral nor immoral). This gives nine possible categorisations, as shown in Fig. 2.2.

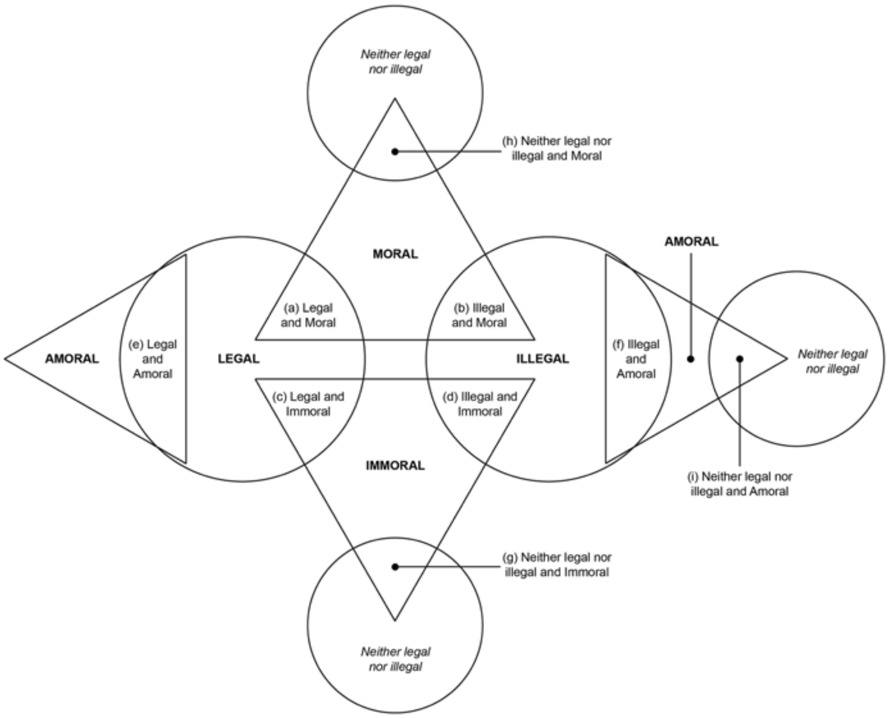

Fig. 2.2 Law and morality (From Seedhouse 1988)

However, the term amoral tends to be used to refer to people with little understanding of morality rather than to actions.

Examples of activities which are illegal and moral include:

- Blocking the road by chaining wheelchairs across it in order to protest against nuclear weapons or improve the rights of disabled people.
- Breaking import and other regulations in order to supply HIV-positive people with cost-free treatment.

Examples of activities which are legal and immoral include the following:

- Cutting the budget for higher education or assistive technology, thereby depriving people of education or technology that could make them more independent and give them access to education and employment.
- Making asylum seekers who have been tortured but have failed the bureaucratic process destitute and evicting them from their accommodation.

Ethical behaviour requires you to obey the law except where it is immoral and may require you to go beyond the law. You also have some degree of ethical responsibility to raise awareness of unethical aspects of legislation and to work together with other people for changes in this legislation. In some extreme cases, you could even have the responsibility to break unethical laws.

2.3.2 Outcomes-Oriented Theories and Approaches

2.3.2.1 Ethics of Care

The ethics of care is a context-based approach to preserving relationships. There are five central ideas:

1. Moral attention, which is attention to the situation in all its complexity.
2. Sympathetic understanding, which involves sympathising and even identifying with other people in the situation, trying to work out what they would want you to do and how they would like their wishes and interests to be carried out. It requires a particular sensitivity to the wishes and interests of others.
3. Relationship awareness, where you recognise the other person is in a relationship to you. As well as awareness of the specific relationship, including role relationships, there is awareness of the network of relationships that connect people and care about preserving and nurturing these relationships.
4. Accommodation to the needs of everyone, including yourself, particularly when the course of action is not clear.
5. Response, where you respond to need and show caring.

The ethics of care originated with Gilligan (1982). Her applications of Kohlberg's (1981) theory on how people reason and develop morally to female subjects of all ages led her to theorise that an ethics of care was more appropriate for women.

Lyons (1983) identified two different types of self-understanding:

1. The separate/objective self: people who fit this model describe themselves in terms of personal characteristics and consider moral dilemmas to be a conflict between their principles and someone else's needs, desires or demands. Therefore, though they may also value interaction and relationships (as a means of individual satisfaction), interactions are likely to be in terms of ground rules and procedures, often called the voice of justice.
2. The connected self: people who fit this model describe themselves in terms of connections to other people, such as friend of, and identify moral dilemmas as involving the breakdown of relationships. Relationships are seen as central to self-identity and the issue is to protect the ties of connection and affection. This leads to the voice of care which is concerned with moral dilemmas about preserving these ties of care when they are threatened.

It is useful to consider which of these categories you fit into or whether you have elements of both of them.

2.3.2.2 Normative Ethics

(Practical) normative ethics is generally based on the basic principles of beneficence (and non-maleficence), justice and autonomy. This is the type of ethics that has most frequently been discussed in the context of assistive technology, most frequently for people with learning difficulties (Raskind and Higgins 1995) or dementia (Marshall 1999; Anon undated).

Beneficence involves the active promotion of acts that benefit others, helping people to further their legitimate interests and removing or preventing possible harm. It has been suggested (Seedhouse 1988) that the principle of beneficence goes some way to unifying deontology and consequentialism, as the desire to maximise good over evil is not motivated simply by the desire for better consequences, but is also a result of the duty to do good and prevent harm. It has been summed up as (Frankena 1963) the obligations not to inflict evil or harm, to prevent evil or harm, to remove evil and to do or promote good. This still leaves the problem of determining what should be considered 'good' and what 'evil'.

There are a number of different definitions of the term autonomy. A number of the definitions are based on a libertarian philosophy of the defence of individual rights against the state, but there is no particular reason for this narrow definition to be accepted. Wider definitions include the autonomy of social groups as well as individuals. In this context, it is useful to consider the discussions of using technology and other approaches to increase the independence of disabled people. Independence has been interpreted to indicate 'someone who has taken control of their life and is choosing how that life is led … The most important factor … is the amount of control they have over their everyday routine' (Brisenden 1986, p. 178). These factors of control over your own life, choosing how it is led and control over everyday activities are also important components of autonomy.

Justice involves behaving fairly and in accordance with what is owed or due. However, this does not take into account existing inequalities and the differing needs of different social groups. Distributive justice requires the just distribution of social benefits and burdens and everyone to be treated equally. However, different (unequal) treatment can sometimes be required to alleviate structural or other inequalities and in this context should be considered just (Barbour 1995). For instance, there is the context of positive discrimination to overcome the disadvantage experienced by women and various ethnic minority groups, and, for instance, UK legislation allows more positive treatment of disabled people if required to overcome the disadvantage they would otherwise experience.

The concept of justice as fairness has been defined in accordance with people receiving their deserts, their rights or their needs. All three of these concepts are open to interpretation. With regard to rights, everyone should have a wide and equal range of rights, for instance, under the UN Charter of Human Rights. The idea of deserts raises a number of issues. It could be argued that everyone has equal deserts on the basis of being human. However, it is often argued that people who have contributed 'more' (however this is measured) 'deserve' more. This interpretation generally tends to strengthen existing inequalities, and the evaluation of a greater contribution may involve value judgements based on the status quo. For instance, the 'deserts' of the entrepreneur who contributes the finance to set up a new firm are frequently given a higher value than those of the workers who actually carry out the work. The concept of needs is also not unambiguous. Autonomy should allow people to define and determine their own needs, but this often does not happen in practice. On the one hand, meeting appropriately defined needs can be used to correct structural and other inequalities. On the other hand, using the concept of rights to correct inequalities can be more empowering and therefore more in accordance with the principle of autonomy.

Rawls (1971) has a theory of justice with an egalitarian basis, which he presents in terms of the following two principles:

1. Everyone is entitled to the most extensive basic liberty which is compatible with similar liberty for everyone else.
2. Social and economic inequalities should be arranged so that (a) they are expected to be of the greatest benefit to the least-advantaged members of the society, consistent with the just savings principle (*the difference principle*). (b) Offices and positions are open to everyone under conditions of fair equality of opportunity.

The aim of the second principle, which Rawls calls the difference principle, is to ensure that social inequalities are distributed in ways that reduce disadvantage, rather than that there are no inequalities, and that no-one should be advantaged or disadvantaged on the basis of factors such as sex, race, religion or the presence or absence of particular skills. He also suggests that everyone would adopt this principle if they were situated behind a ‘veil of ignorance’ in which they did not know their situation. However, it has been suggested that some people would prefer a more risky and unequal system. There are also many people, including the author, who would prefer the total abolition of disadvantage and inequality with improved rights and opportunities for everyone. In terms of justice, it could also be argued that social and economic inequalities are unjust; however they are distributed and should be eliminated. It also seems probable that, while there are inequalities, they will have most affect on the people who are currently disadvantaged. The just savings principle relates to intergenerational equality. It could be argued that removing inequality would lead to advantages for future generations, though this would need to be done in ways that do not significantly affect the availability of resources.

Discussions of justice in the literature and the theories and principles posed by particular authors depend largely on their particular political philosophies. Therefore, authors with libertarian political philosophies or who support (free) market economics and politics will be critical even of not particularly radical egalitarian philosophies such as Rawl’s and be more concerned with theories of justice that defend individuals against the state rather than considering society as a whole. They will also be opposed to any elements of planning or patterning of society. From my particular socialist perspective, both the rights of individuals and society are important, and the just distribution of resources and opportunities to everyone, regardless of factors such as sex, race or disability, is required. This illustrates how it is often very difficult to separate consideration of ethics from political and other values. Feminist writers such as Okin (1989) have criticised both the more egalitarian and libertarian approaches to theories of justice for ignoring justice issues associated with gender relations and implicitly assuming that women will continue to do most of the domestic work, without which society cannot function. It could therefore be useful to situate discussion of justice within the ‘norm’ of a disabled, Black, lesbian who is a single parent mother and living in one of the African countries. This could give a very different understanding of justice from the current norm of a White middle-class heterosexual nominally Christian, youngish non-disabled male living in Europe or the USA, which fits less than 5% of the world's population.

2.3.3 Process- and Outcomes-Oriented Theories and Approaches

2.3.3.1 Eco-centred Ethics

The field of environmental ethics developed in the 1970s in response to increased awareness of social and environmental issues. Most environmental ethicists consider that the application of traditional Western moral philosophy to environmental issues will make the situation worse, as it is based on human action in relation to other people and considers nature to be a means, not an end. Eco-centred environmental ethics focuses on connections and interactions and a holistic perspective based on ecological systems and therefore increases the likelihood of awareness of long-term and indirect consequences. However, it has holistic as well as, rather than instead of, individualistic concerns and does not replace socially generated duties and relationships, though the focus is on the holistic rather than individuals. It can therefore be considered to add new ethical responsibilities to existing ones (Callicott 1992). A manifesto for earth (Mosquin and Rowe 2004) has four core and seven action principles. The core principles include 'the ecosphere is the centre of value for humanity', 'the creativity and productivity of earth's ecosystems depend on their integrity', 'an ecocentric worldview values diversity of ecosystems and cultures' and 'ecocentric ethics supports social justice'. The action principles include the reduction of human consumption and population and promoting governance that does encourage over-exploitation and destruction of ecosystems. It should be noted that population reduction may itself raise ethical issues, depending on how it is carried out.

2.3.3.2 Narrative Ethics

Ethics and ethical decision making are often treated as being about discrete actions and decisions rather than processes which are embedded in systemic structures. Narrative ethics is one of the approaches which stresses the importance of systems and processes. It uses narratives or stories told by individuals to explore ethical issues. In this way, it can also give a voice to individuals whose experiences might otherwise be marginalised or ignored.

Other than a few exceptions, e.g. (Hersh et al. 2005; Frey and O'Neill-Carillo 2008), there has been little work on the consideration of the ethics of engineering and information systems in terms of narrative ethics. One of the areas in which there is a body of work, for instance (Lindsay and Graham 2000; Marck 2000; Sørlie et al. 2004; Widdershoven and Smits 1996), on narrative ethics, is nursing. There is increasing recognition of the importance of human-centred design and that the satisfactory performance of technological systems may even require the subordination of technological specifications to the needs of the people involved. In addition, all the engineering institutions are now trying, often not very successfully, to attract more women to a historically male profession (in most countries). It is interesting to apply some of the lessons from the use of narrative ethics in nursing to engineering due to the pre-eminence of the human relationships between nurses and their patients and the predominance of women in nursing.

One of the interesting points in the literature on narrative ethics and nursing is that nurses tend to use narrative approaches to ethics, whereas doctors prefer the application of rules and principles (Widdershoven and Smits 1996), generally autonomy, beneficence and/or non-maleficence. There are a number of possible explanations, including the fact that nurses are generally more closely involved with their patients as people, whereas doctors may tend to focus on particular conditions or diseases. If this is the case, then there is an implication that narrative ethics may be particularly appropriate for human-centred approaches to engineering.

However, narrative and rule-based approaches to ethics should not be considered to be in opposition, but rather to complement each other. In addition there can be benefits in applying multi-loop action learning to encourage the development of further layers of the narrative. Narratives are often about the relations between individuals, but these relations take place within and are often conditioned by the ethos of an organisation and/or the wider social context. For example, a discussion of the use of narrative ethics to obtain insurance funding for rehabilitative exercise treatment (Lindsay and Graham 2000) does not consider the wider ethical question of why individuals in the US have responsibility for obtaining funding for their own treatment rather than this being considered a societal responsibility and provided by national, state or local government through taxation. However, there is no reason why narratives cannot be considered in their wider context and include factors such as power structures and socio-economic inequalities.

3 Methods, Approaches and Techniques for Applying Ethical Principles in Practice

3.1 Values and the Johari Window

3.1.1 Values

In some cases, the requirements for ethical action in a particular situation are very clear. However, in others applying different ethical theories, philosophies or approaches will clarify the issues, but value judgements will still be required to support decision making. There are a number of different sources of values, including religion, politics, humanist or other non-religious philosophies, education, family and friends, culture and the surrounding society. There are also considerable differences between the ethical values of different societies and a wide range of different codes of values. However, this does not mean that all possible codes of values should be considered ethical.

Unfortunately specifications to be met by ethical codes of values or tests to determine which sets of values are ethical have not yet been devised. However, common elements have been noted in the values systems of very different societies and groups. For instance, it has been suggested (Kluckholm 1955) that every culture has a concept of murder and distinguishes murder from other types of killing which are not considered murder and that every culture has some regulations about permitted and forbidden sexual behaviour. However, the significance may be in the details, where there are often very great differences rather than in the superficial commonality. Even within one society, there are often significant differences in values, as evidenced by intense debates about abortion, euthanasia and capital punishment.

3.1.2 Bad Faith

The notion of bad faith in ethical decision making is due to Jean-Paul Sartre. It involves people not being honest with themselves, often but not always, by burying themselves in professional or other roles. This can lead to a total identification with the role and a focus of the role requirements and result in individuals no longer thinking for themselves and abdicating moral responsibility. This is in particular very much counter to existentialist ethics, which requires people to take responsibility for their thoughts and actions and not to automatically take on the beliefs of their society or the beliefs and behaviour expected of someone in their particular role.

An associated problem is letting other people, such as doctors, lawyers, politicians and 'experts', make decisions for you. This is another type of abdication of moral responsibility. For some people, it can be very tempting. It means they do not have to make decisions or be responsible and there is someone else to blame when things go wrong. It is often easier to complain or blame someone else than try to change things.

3.1.3 Values: The Johari Window

The Johari window was originally developed as a diagrammatical device by which people may be made more open to one another and is widely used in reflective learning (Brockbank and McGill 1999). Figure 2.3 illustrates the typical Johari window. It can be used to help people work out their own value systems (Stapleton and Hersh 2003).

The quadrants of the window represent one person in relation to others, with each quadrant revealing awareness of behaviour, emotions and subjective space. Some awareness is shared (intersubjective) and some is not. Material is allocated to a quadrant on the basis of who knows about it.

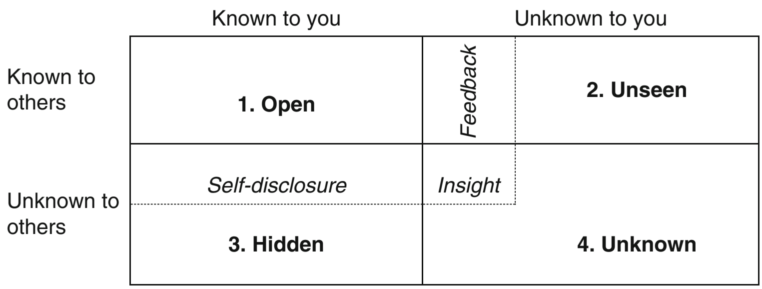

Fig. 2.3 The Johari window

Quadrant 1: The open quadrant: behaviour and issues are known to the self and others. This is the quadrant that each of us opens to the world and is the basis of most interactions that we willingly display.

Quadrant 2: The unseen quadrant: issues and behaviours which others see but which I do not. Actions here will be seen in the public gaze – I will be aware of some actions (in quadrant 1) and unaware that I am displaying other things (quadrant 2). For example, an engineer may not realise that they have inadvertently used a racist or disablist expression to another colleague. How the colleague points this out and how the engineer reacts will influence how the engineer learns about that part of their behaviour of which they were previously unaware.

Quadrant 3: The 'hidden' quadrant: things I know about myself but which I am unwilling to convey to others. If I disclose issues in this quadrant, then they move from here to quadrant 1, reducing the quadrant's 'size'.

Quadrant 4: The unknown quadrant is something we may get insights into through dreams, psychological counselling and in other ways. This window does contribute to our behaviour, but no-one, including ourselves, is aware of the deep issues involved.

The Johari window can be used in a work group to raise important ethical issues, maintaining them within their local, intersubjective, context.

3.1.4 Johari Window in Localised Ethical Discourse

A group of engineers and/or other professionals who wish to explore their own ethical positions can participate in a workshop with an experienced facilitator and use the Johari window to gain potentially deep insights into their own and others' viewpoints. The workshop will be most effective when major stakeholders and/or a variety of perspectives are brought into the discourse.

As far as possible, a 'safe space' should be created for all participants to enable them to talk about personal viewpoints and experiences. Practical barriers to doing this, including the power imbalances between participants, should be recognised. A number of organisations have what are often called safer spaces policies (Whitzman 2002). A policy or document detailing basic principles of a safe or safer space should be made available.

The facilitator typically 'breaks the ice' by disclosing something about themselves, thus encouraging others to do the same. It is important that the facilitator ensures that disclosures are appropriate (Egan 1973) in order to ensure that the ethics, interpersonal psychology and authenticity of the process are protected. The statements that are made need to be authentic in terms of the following criteria:

1. Breadth: how much do you want to tell?
2. Depth: level of intimacy.
3. Duration: amount of time devoted to the process (experience indicates this frequently overruns!).
4. Target: to whom is information to be disclosed?
5. Relationships: is it a friend, acquaintance, colleague etc.?
6. The situation in which the workshop takes place: for example, private or public place.

Guidelines for using this technique (Brockbank and McGill 1999; Cozby 1973) include encouraging participants to use statements which begin with 'I' rather than 'you', talk about feelings rather than 'facts' and avoid the abstract and remain relevant and interesting.

Self-disclosure can be difficult in western cultural settings where it is discouraged amongst, for example, students. Reflecting back is also very powerful in this context. It is important to recognise potential power dynamics between different members of the group, due to identity factors, such as gender, class or race, different experiences and minority positions. This is in addition to power dynamics resulting from differences in position, status and security of tenure in the organisation and the possibility of discussions that should be confidential to the group being reported back to management. The workshop can be accompanied by a semi-structured questionnaire exploring primary dimensions of the gestalt which the group wishes to address.

The essence of the approach is to expand quadrant 1 in terms of personal ethics through an increased awareness of the engineer's (or other participant's) personal values as well as an impression of others' personal positions and ways in which your personal ethics impinge upon others.

3.2 The Ethical Grid

The Ethical Grid (Seedhouse 1988) was developed as a tool to support ethical reasoning and decision making by health workers. However, it can also be applied in other areas, including engineering projects. It is presented here as an example of a pluralist methodology, which combines basic principles and deontological and consequentialist ethics. It thus has a number of advantages. However, all methodologies also have their drawbacks. The Ethical Grid consists of four different layers, as shown in Fig. 2.4:

1. The first layer consists of basic ethical statements. It provides the core issues of creating and respecting autonomy, respecting persons equally and serving needs before wants. These issues are considered to present a rich and fruitful theory

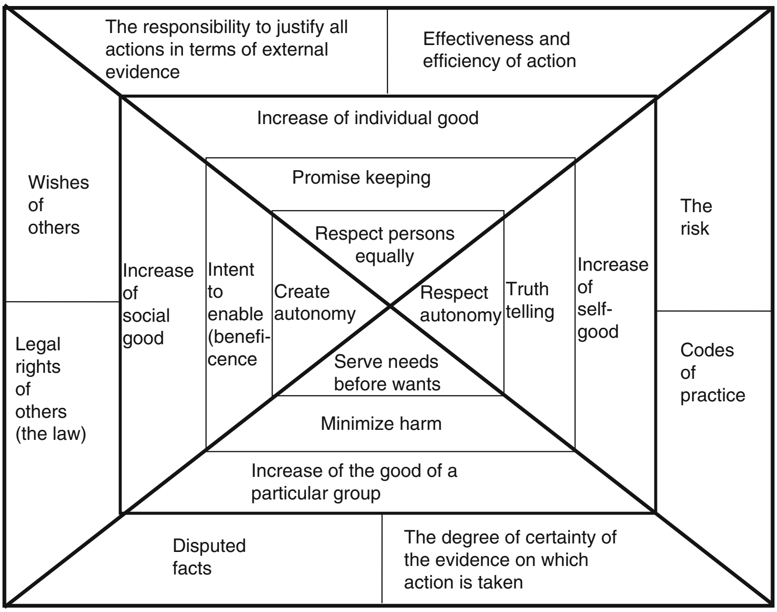

Fig. 2.4 The Ethical Grid (Seedhouse 1988)

of health. The principles of autonomy and respecting people are also highly appropriate to assistive technology, but that of serving needs first may need to be modified or replaced.

2. The second layer is based on deontological theories. It focuses on duties and motives, including promise-keeping, truth-telling, minimising harm and beneficence. It is intended to encourage the consideration of principles in moral deliberations. However, there may be occasions when it is justifiable to weaken or omit one or more of these principles, but the ethical justification for doing this should be clear.
3. The third layer is based on consequentialist theories. It considers the consequences of proposed actions, both the long-term and indirect ones and the immediate ones. The consequences are expressed in terms of increasing the following goods: individual, social, of a particular group and of yourself. It should be noted that this is equivalent to reducing the associated negative impacts. Additional consequences could be added, for instance, increasing environmental goods or distributive equality, though that is possibly implied by increasing the goods of a particular group and the social good.
4. The fourth layer involves external considerations, including the wishes and legal rights of others; the responsibility to justify action with external evidence; risks, effectiveness and efficiency of action; codes of practice; and the degree of certainty of the evidence on which action is taken. It could also be useful to include cultural and other specific factors of the environment in this layer.

The grid can provide a structure for ethical reasoning, but its successful use depends very much on users being honest with themselves and being willing to put in the necessary effort.

3.3 Perspectives, Principles and Paradigms

This approach (Anon undated) is based on the three components of perspectives, principles and paradigms. *Perspectives* involve the consideration of the views of all the people involved in the proposed action and the consequences of not taking the actions.

The four *principles* considered are (1) respect for autonomy, (2) beneficence (doing one's best for the person), (3) non-maleficence (not harming the person) and (4) justice.

Paradigms provide reference situations in which the ethical issues are clear and use these reference situations as a comparison for evaluating the ethics of a particular solution. This is analogous to the case approach.

3.4 The Application of Different Ethical Theories

In this approach (Hersh 2003), the following ethical theories are used to structure the problem and highlight the relevant issues:

1. Process and consequences
   - Deontological ethics: considers duties and obligations.
   - Positive utilitarianism: assesses benefits against risks and costs.
   - Negative utilitarianism: is mainly concerned with offsetting or mitigating present or future harms.
2. Character, rights and principles
   - Virtue ethics: supports actions which build good character.
   - Rights ethics: considers actions to be wrong if they violate fundamental moral rights.
   - Normative ethics: the defence of principles, such as beneficence, justice and autonomy.
3. Consent, relationships and consequences
   - The ethics of social experimentation: this stresses informed consent.
   - The ethics of care: a context-based approach to preserving relationships.
   - Eco-centred ethics: connections and interactions, including long-term and indirect consequences.

In general the different ethical theories will raise different ethical concerns and may lead to different conclusions. In practice it is generally not necessary to apply

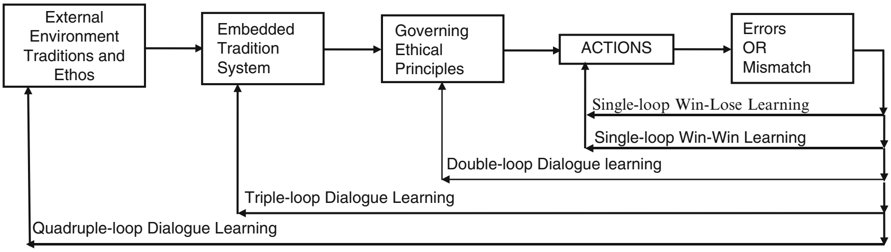

Fig. 2.5 Multi-loop learning

all the theories to each problem, as they are not necessarily always all relevant. Decision making then requires consideration of values and the reliability of the available information.

3.5 Single-, Double- and Triple-Loop Action Learning

3.5.1 Introduction

The previous sections have discussed theories, philosophies and methods to be used to support decision making to help determine what is ethical in a particular context. However, once decisions have been made on what is ethical in the particular context, it will be necessary to implement them. In some cases, this will be relatively easy, whereas in others action will require the involvement of other people and/or organisations and there may be institutional and other barriers. In the latter case, there is a need for methods for overcoming barriers to ethical action and persuading individuals and organisations of the value of such action. Some of the available methods have been categorised (Nielson 1996) as single-, double- and triple-loop action learning, and it is also useful to add quadruple-loop action learning. This is illustrated in Fig. 2.5.

The following distinctions can be made (Hersh 2006; Nielson 1996):

1. Single-loop action learning is about changing behaviour rather than learning about ethics and changing values.
2. Double-loop action learning involves changes in values (generally of individuals) as well as behaviour.
3. Triple-loop action learning involves changes in the underlying tradition or ethos of the organisation, as well as changes in values and behaviour.
4. Quadruple-loop action learning additionally involves changes in the ethos or tradition of the surrounding society. Alternatively it involves changes in the underlying tradition with reference to the nature of the organisation in addition to its practice.

This will be illustrated by the example of changing the position of disabled people, including increasing the percentage of disabled people in senior positions:

1. Single-loop action learning could lead to measures to increase the proportion of disabled people recruited to senior positions, for instance, due to fear of legal action on the grounds of disability discrimination, without any increase in awareness of the ethical responsibility to recruit more disabled people or the need for a change in values.
2. Double-loop action could lead to a change in ethical values on the part of some individuals in the organisation with a recognition of the ethical responsibility not to discriminate against disabled people, in addition to practical measures. This ethical commitment is likely to make the practical measures more effective than they would be otherwise.
3. Triple-loop action could lead to a change in the ethos of the organisation with a recognition of the value to the organisation and the ethical responsibility to employ more disabled people at a senior level. This could be accompanied by measures to overcome structural barriers and make the organisation attractive as a place of employment for disabled people.
4. Quadruple-loop action could lead to a change in the ethos of the wider society with an ethical commitment to the value of diversity in society and ensuring equality and lack of discrimination for the diverse population. Disabled people would be considered one of many of the diverse groups which enrich society. Furthermore measures would be taken to remove structural barriers and make all environments attractive and accessible to the whole population, of which disabled people are a part.

The descriptions of the methods in subsections 3.5.2–3.5.4 are obtained from Nielson (1996), to which readers are referred for further details and examples.

3.5.2 Single-Loop Action Learning

Single-loop action learning methods have been divided into win-win and win-lose. In win-win methods, there are net benefits to everyone. This is not the case in win-lose methods, and therefore pressure of some type is required to implement them.

Win-lose methods include the following:

1. Bottom-up forcing methods, such as whistleblowing (see Sect. 4.5), refusal to cover-up unethical behaviour and avoiding the implementation of unethical policies and orders.
2. Top-down forcing methods, such as the boss producing and imposing ethical policies without consultation. However, this is ethically questionable, for instance, in terms of normative ethics and the maintenance of autonomy.
3. Win-lose negotiations, such as leverage building, good guy-bad guy and making extreme demands in order to then achieve a 'compromise'. However, these methods may themselves be unethical, depending on how they are applied. For instance, leverage building could have some similarities to blackmail.

Win-win methods include the following:

1. Mutual gain negotiation in which there are sufficient benefits on both/all sides to agree a deal. Ethical issues can be included, if they are part of the agenda of one party, without being mentioned explicitly.
2. Persuasion in which you use language and/or illustrations to convince the other parties to do something. People can be persuaded not to behave unethically by the fear of getting caught, the benefits of the ethical conduct or the disadvantages of the unethical behaviour, in addition to consideration of the value of ethics.
3. Minimal peaceful coexistence negotiation in which you negotiate an improvement of a bad situation rather than mutual gains.

Both win-win and win-lose methods can be effective in encouraging ethical behaviour, but without leading to any learning, changes in values or greater understanding of ethics. They are likely to lead to results more quickly than double- and triple-loop methods. Win-win behaviour may result in better relationships and lead to productive cooperation and could therefore give more scope for learning and changes in values through the subsequent application of double-loop dialogue methods. However, win-win approaches can result in learning for people who learn through doing. Bottom-up forcing is appropriate when you are aware of unethical behaviour and find it unlikely that any other way of doing something about it will be effective. I consider the other win-lose methods to be ethically questionable and that it is preferable not to use them.

3.5.3 Double-Loop Action Learning

Double-loop methods are generally based on dialogue. They can be used to develop or maintain an ethical organisational culture and can sometimes lead to the adoption of ethical values. They can sometimes have win-win outcomes, though this is not the (main) aim. They are appropriate when there is misunderstanding or lack of knowledge about what is ethical in addition to unethical behaviour, but should not be applied when the problem is purely unethical behaviour. They are also unlikely to work in environments which discourage dialogue and/or where there is pervasive low-level pressure to behave unethically. Double-loop dialogue methods include (1) Socratic iterative dialogue, (2) action-science dialogue and (3) action-inquiry dialogue.

Socratic iterative dialogue consists of the following four parts which are carried out sequentially:

1. An initial respectful and friendly approach.
2. The facilitator asks the other participants for a potential solution and helps them consider its advantages.

3. The facilitator helps the other participants consider the drawbacks of the potential solution and iteratively suggests other solutions to retain the advantages and reduce the drawbacks of previous solutions.
4. Continuing the process iteratively until the solution cannot be improved further.

Action-science dialogue has the following seven implementation rules (Argyris et al. 1985), which are not necessarily sequential:

1. Combine advocacy with inquiry.
2. Illustrate your inferences with fairly directly observable data.
3. Make your reasoning explicit and publicly test for agreement at each inferential step.
4. Actively seek contrary data and alternative explanations.
5. Recognise that mistakes occur and you can learn from them.
6. Actively investigate your impact on the learning context.
7. Design ongoing experiments to test competing views.

Action-inquiry dialogue has the following four components (Torbert 1987):

1. Framing: determining the frame or purpose of everyone's not just the speaker's participation.
2. Advocating: what the speaker proposes in the frame.
3. Illustrating: using a concrete example to clarify what the speaker means.
4. Inquiring: how the others respond to the speaker's perspective and initiative.

All three dialogue methods can be used to change both values and behaviour, but require a certain degree of consensus from the dialogue participants for success. The iterative Socratic method is explicitly friendly and respectful and may be the most appropriate with less powerful people, people from cultures where there is little experience of advocacy and directness, and/or subordinates fearful of being misunderstood if they present different perspectives. Action-science is the most thorough as it explicitly uses new experimental and experiential data and multiple alternatives. It is therefore likely to take the longest. Action-inquiry is the most focused on the required action and therefore likely to be the fastest and most direct. It is also possible to combine elements of the different methods, for instance, to add explicit friendliness to the action-science method or experimentation to action-inquiry.

3.5.4 Triple-Loop Action Learning

Triple-loop methods include (1) Woolman's friendly disentangling, (2) friendly upbuilding, (3) friendly reconstruction, (4) (adversarial) deconstruction and (5) experimental neopragmatism.

Woolman's (1774) friendly disentangling method has four main components:

1. Framing a 'we' fellowship relationship with others and seeking the cause of current problematic behaviour in biases of the embedded tradition.
2. Approaching others in a friendly way.

3. Asking for help in disentangling problematic behaviour from potential biases in 'our' embedded tradition system.
4. Working with those willing to experiment with alternative behaviours and values that are not based on the problematical biases of the tradition system.

The social tradition is both criticised and treated as a partner in the dialogue. The method can enable peaceful change, reform organisation tradition biases, facilitate change of ideas and sometimes leads to win-win solutions. The 'we' fellowship relationship is a central element of the approach. It is therefore unlikely to work in organisations or situations where the people involved do not see or value a 'we' relationship or 'us versus them' behaviour is more important. It will also not work when the people in power present ethical issues in terms of their self-interest and ignore alternative perspectives. It is inappropriate when there is no significant negative bias in the system and the cause of unethical behaviour lies largely in individuals.

The concept of upbuilding is derived from Kierkegaard's work (1944; 1967). Friendly upbuilding is based on protecting and extending an existing ethical tradition in a destructive external environment and using it to solve problems. It combines the following three processes:

1. Explicit building from within an ethical environment as a way of framing and solving problems in a problematical environment.
2. Generation of ethical decisions informed by the tradition.
3. Leaving the tradition open to criticism, modification and further development.

Upbuilding can help organisations resist negative environmental pressures and simultaneously develop their own traditions. It can facilitate peaceful change through friendly peaceful efforts and enable ethical learning by individuals. Since it is based on an existing ethical tradition, it will not work when the tradition is insufficiently ethical or there is insufficient consensus about its ethical components. It may also be too conservative.

Friendly reconstruction (Gadamer 1989), (adversarial) deconstruction (Derrida 1981; Foucault 1972) and experimental neopragmatism (Rorty 1982, 1991) are postmodernist approaches. Postmodernism is a particular period or perspective of western thought. It differs from earlier philosophies in not recognising a centre or single ideal purpose in life. Instead there is recognition of the value of the similarities and differences of both one's own and other traditions. Friendly reconstruction tries to bridge differences, whereas (adversarial) deconstruction exposes negative biases and experimental neopragmatism aims at peaceful coexistence and small improvements through experimentation.

In (adversarial) deconstruction, criticism of negative biases and oppressions is used to achieve and maintain difference and diversity. This is often accompanied by adversarial criticism of individuals representing the mainstream. Positive reconstruction builds on tradition-based positive biases and commonalities. It combines this with friendly criticism and dialogue about positive and negative biases in cultures and systems. Experimental neopragmatism experiments with win-win solutions in the absence of objective standards or principles. Rather than examining positive and negative biases, it is accepted that people from different traditions may have different needs and experiments are used to explore temporary win-win solutions which satisfy these different needs.

Each of the postmodernist approaches has advantages and disadvantages and the three methods can be combined. Reconstruction can bridge cross-cultural differences to solve problems, whereas deconstruction can enable people to act constructively by removing individual blame, and neopragmatism can facilitate low-risk incremental improvements. However, reconstruction will not work when the divisive effects of negative biases are stronger than the unifying effects of positive ones and deconstruction can expose the critics of a powerful system to victimisation. There may be no win-win experimental outcomes for neopragmatism or the process may break down.

4 Ethical Issues Associated with Processes and Outcomes

4.1 Introduction

As discussed previously, both processes and outcomes can raise ethical issues. For instance, the arms trade by its nature raises a number of ethical issues about outcomes, whereas projects involving research on animals or discharging pollutants into the local river raise process-related ethical issues. In some cases, there are ethical problems associated with both processes and outcomes. Much of the engineering literature has focused on processes or how activities are carried out and ignored outcomes, e.g. examined the ethical conduct of a project or ethical behaviour of an engineering firm, but not whether the project aim or core business of the engineering firm was ethical. For instance, one of the case studies produced by a US National Science Foundation-funded project on introducing ethics into engineering teaching considers the case of three civilian chemical engineers convicted for illegally storing, handling and disposing of hazardous waste while developing a new chemical weapon. This case study considers a range of ethical issues associated with hazardous chemicals, but not the ethics of developing or using chemical weapons. Some of these process-related issues are discussed by Magnusson and Hanson (2003) and Seymour and Ingleton (1999).

In the area of assistive technology, outcomes-related ethical issues include the following:

1. End users being pressurised into using inappropriate assistive devices which have not been designed to meet their needs.
2. Negative changes to the social and other relationships between disabled end users and their family, friends and personal assistants resulting from device use.
3. Mismatches between the requirements for devices of disabled end users and those of their family, personal assistants, social workers or other professionals working with them.

Process-related ethical issues include the following:

1. Disabled people being pressurised to participate in a study because they know the researcher, have benefitted from a device the research group has previously developed or think they will be higher up the queue to obtain this or other devices.
2. Unethical practices related to working with disabled end users, including not treating them with respect, pressurising them to take part in studies or not setting up fully accessible environments in which disabled end users can participate fully and properly express their views.
3. Possible role conflicts, for instance, if some of the tests take place in a hospital and the researcher(s) have medical or nursing training.
4. Setting of appropriate boundaries, including with regard to expectations of contact outside the project and the development of friendships between researchers and disabled participants.

4.2 Research Ethics

Research raises a number of very specific ethical issues. These can be divided into three main categories: (1) the research aims and applications, (2) the conduct of the research and presentation of results and (3) treatment of minority and dissenting views and individuals.

Much of the discussion of research ethics has focused on issues relating to the conduct of research, but the other two categories are equally important. The first category can be further divided into (1) ethical aims and (2) trying to ensure that the results of the research are only used in ethical ways.

4.2.1 The Ethics of Research Aims

Issues that should be taken into account in considering the ethics of research aims include the following:

1. The motivation for carrying out the research.
2. The nature of the expected results, including whether they are likely to contribute to solving real social, developmental and environmental problems and/or increasing knowledge.
3. Whether the research involves an effective use of (scarce) resources.
4. Who the research is sponsored by, whether the sponsoring organisation(s) have ethical policies, the nature of the funders' core activities and any ethically questionable practices or activities by the funders.
5. Likely applications of the research, including by the funders.
6. The ways in which different groups are likely to be affected by the research.

If the aims of the research are ethical and it is carried out in an ethical manner, then it is likely that its direct applications will also be ethical. However, assistive technologies and other products with ethical aims may have possibly unforeseen military or other applications, which raise ethical questions. There is a consequent ethical responsibility to give some thought to the full range of potential applications. When the main applications of a technology are ethical, but it is very likely that there will also be some unethical applications, it can be useful to use consequentialist approaches to balance the probable advantages of the development of the assistive device or other ethical application against the likely disadvantages of the unethical applications.

4.2.2 The Ethical Conduct of Research

Guidelines for the ethical conduct of research include the following:

1. Scientific standards:
   (a) Research procedures that meet the highest scientific standards and lead to repeatable results.
   (b) Not falsifying data.
   (c) Not making false claims or inflating the significance of your results. It should be noted that publication of your best rather than their average results is ethically questionable, as it can make the work seem more significant than it is.
   (d) Being very careful to avoid or at least reduce any bias in your choice of samples and evaluating the likely bias in responses, for instance, when it is necessary to choose convenience samples or there is a low response rate.
2. Respecting and crediting others for their work:
   (a) Acknowledging and referencing all your sources. This should include when the results of another researcher are being repeated, for instance, to test a new methodology.
   (b) Giving full credit to the people who have actually done the work, including when they are junior to you, and not claiming someone else's work as your own.
   (c) Only putting your name on research papers and reports you have actually made a significant contribution to.
   (d) Not plagiarising, i.e. not passing other people's work off as one's own. As well as not copying (large) chunks of text from the Internet, this includes not giving full attribution. Vigilance is required to avoid unintentional plagiarism.
3. Maintaining independence:
   (a) Not accepting sponsorship that will restrict the independence of your work.
   (b) Not holding on to pet theories after they have been demonstrated to be flawed.
   (c) Flexibility and openness and willingness to listen to opposing views and new paradigms.

(d) Being aware of and avoiding potential conflicts of interest. These arise in different ways. For instance, there is a conflict of interest if you are reviewing a paper or grant proposal and have an interest in the paper or proposal being accepted. If you are in doubt, it is advisable to inform the organisers/person in charge and let them make the decision.

4. Safety:

    (a) Evaluating safety, risk and ethical issues and obtaining permission from relevant ethics committees before starting the research. The research aims and methodology may have to be modified to take account of ethical, safety and risk issues.
    (b) In the worst case, being prepared not to do the research if it is not possible to do it ethically.

Bias is an error which is consistently in one direction. A biased sample in a survey or questionnaire is one which is unrepresentative due to systematic errors. In general only a (relatively small) proportion of respondents will reply to most types of survey. This gives two possible types of bias, which there is an ethical responsibility to try to reduce as far as possible. These are (1) bias due to the choice of an unrepresentative sample and (2) bias due to certain groups being more likely to respond than others.

4.3 Working with Human Participants

The British Psychological Society has drawn up Ethical Principles for Conducting Research with Human Participants. These principles (BPS 1990) are summarised below and are widely used, not just in the UK:

1. *Voluntary informed consent*. Investigators will inform all participants of the objectives of the investigation. They must agree voluntarily to participate in the research.
2. *Right to withdraw*. Investigators will explain in clear terms to participants their right to withdraw from the research at any time, irrespective of whether or not payment or any other inducement has been offered.
3. *Deception.* Withholding of information or misleading of participants is unacceptable.
4. *Confidentiality.* Information obtained about a participant during the investigation is confidential unless otherwise agreed in advance.
5. *Protection of participants*. Investigators have a primary responsibility to protect participants from physical and mental harm during the investigation.

Voluntary informed consent requires that subjects are given information on the following:

1. The main aims of the research or other activity.
2. The specific details of their desired involvement, i.e. exactly what they are required to do and how long this is likely to take.

3. The availability of payment or expenses for participation. There are differing views on the ethics of paying research participants. Payment of research subjects has frequently been opposed, including by many ethics committees, and is often considered likely to distort the results. However, as discussed by Wilkinson and Moore (1999), it is not clear why this should be the case, and payment could be considered as a recognition of the importance and indeed indispensability of the research subjects. This can be particularly important for disabled and unemployed subjects, who are more likely than other subjects to have had experiences of being devalued and taken for granted. However, it is important that payment is not used as a way of recruiting subjects for risky experiments. Any payments should also be made in a way that does not have negative financial implications for participants, for instance, by affecting their entitlement to welfare benefits.
4. What training, if any, will be provided.
5. Expected outcomes and how likely they are to occur, e.g. whether they are fairly definite or only probable. Information on outcomes should include likely benefits and whether these are general, e.g. advancement of knowledge, or more specific, e.g. for development of a new device for blind people. There should also be an indication of the time span over which benefits are likely to occur and whether they are likely to occur in time to affect the specific individual or group of people participating in the research.
6. Any risk, which should be minimised. Issues relating to risk are discussed below.
7. The treatment of data and, in particular, whether it will be confidential and/or anonymous.

However, investigators may not be aware of the implications of the research for all participants, particularly when they have different socio-economic and demographic characteristics. In general this will give rise to an ethical obligation for consultation with a member of the same population group as the participant, as they will be in the best position to describe the implications for the participant. However, it should also be recognised that minority groups are not totally homogenous and that something which does not seem distressing or offensive to one member of a minority group could cause distress and/or offence to another member of the group.

Consent should include:

1. Specific mention of any photos or video recordings, including their intended use, for instance for analysis or publication, since photos and recordings are more difficult to anonymise than other types of data.
2. Details of any observation of subjects, for instance, using a particular assistive device. The devices used by people with sensory impairments in general will not raise particular issues. However, some areas, such as devices used in toileting, require sensitive treatment. It should not be assumed that, for instance, participants will be willing to be observed just because they are accustomed to obtaining support. The number of researchers observing sensitive activities should be minimised, though there can be benefits in observation by more than one researcher.

Information supplied to researchers can be (1) confidential, (2) anonymous, (3) confidential and anonymous or (4) non-confidential and non-anonymous.

Confidentiality means that information cannot be passed on, other than to a named group of people, without the permission of the owner of the information. In the case of a totally confidential interview, the researcher agrees not to pass on the information collected to anyone else. Information is more commonly confidential to a particular group, e.g. a research team, which means that it can be discussed within the research team, but not more widely.

Anonymity means that information is collected and recorded without a name or other identifying mark. This information may additionally be confidential or non-confidential.

Ethical research requires that respondents, e.g. to a questionnaire or interview, are informed of the status of the information and how it will be used, e.g. whether or not it is confidential and/or anonymous. Subjects need to know who the information is confidential to, particularly as many people are not aware that confidentiality can be to a group instead of to an individual. As generally interpreted, confidentiality and anonymity of information do not prevent the resulting statistical data or quotes being openly published, as long as informants are informed of this when the data is collected and any quotes are presented in a way that does not allow them to be identified. However, although standard good practice involves data being recorded anonymously, some research participants may prefer not to be anonymous and this should always be their choice.

Ethical considerations about risk imply that:

1. One group of individuals should not be exposed to risk and another group to which they do not belong receive the benefits.
2. Individuals or groups of people should not be exposed to risk without their informed consent. This informed consent must involve a full understanding of the situation, the extent of the risk and the likely benefits to themselves and/or others.
3. There should be some correlation between the nature and extent of risks and benefits, e.g. people should not be exposed to serious risks for minimal benefits.
4. Alternative approaches which avoid risks should be used wherever possible. Saving money by using less expensive techniques is not a valid reason for exposing people to risk.
5. In general experiments which expose subjects to greater risk than involved in their normal day-to-day activities should be avoided and very significant (potential) benefits with a high likelihood would be required to justify any such risks.

Studies should involve a variety of segmentation variables, such as gender, age and socio-economic status. In the past, there has tended to be a male norm for research subjects. However, an assistive device developed for young white men may be of little use to elderly Asian women.

If the principles of the British Psychological Society and the other conditions discussed here cannot be met, there are serious ethical issues about the particular research or development programme going ahead. In general the ethical response will be to modify the research programme to resolve the ethical problems and, if this is not possible, to cancel it. However, this is a fairly extreme scenario, and in general it should be possible to carry out research or develop products and devices in assistive technology without exposing anyone to risk or behaving unethically. As indicated earlier, it is not just the process of carrying out the research that needs to be ethical but also the outcomes. There are therefore projects which should not be carried out, regardless of whether or not the actual research process is ethical.

4.4 Gatekeeping and Suppressing Dissenting Opinions and Minorities

Another issue in research process and practice that has associated ethical concerns is gatekeeping. However, less attention has been given to it than, for instance, to plagiarism. It is not often recognised that gatekeeping raises ethical problems. This involves, for instance, (1) women and ethnic and other minorities having less access to grants and publications in prestigious journals and (2) barriers being set up to the publication of theories that challenge accepted orthodoxies.

Suppressing minority or dissenting opinions or excluding women and minorities clearly raises serious ethical issues. It is also likely to have undesirable practical consequences on the progress of research, as the suppression of certain types of opinion or making things difficult for particular researchers is not conducive to the development of research. It is also possible that it is the minority opinions or minority group researchers that would lead to the really significant research advances. Therefore, exclusion of these researchers or suppression of their views will prevent or delay these significant research advances. In addition, this type of suppression is counter to the principles of academic freedom and respect for persons and autonomy.

4.5 Whistleblowing

Much of the literature on ethics focuses on individual responsibility and ignores collective and social responsibility. However, everyone is part of society and many engineers work as part of an organisation. Collective responsibility should be considered a way of sharing responsibilities and supporting and encouraging ethical behaviour rather than as a way of getting out of individual responsibilities. Collective responsibility also includes some responsibility for the ethical behaviour of the profession as a whole and a responsibility for providing support to colleagues to behave ethically. These aspects of collective responsibility can best be exercised by joining trade unions and organisations of concerned professionals. Support for ethical behaviour from such organisations can be very helpful.

As already indicted, collective responsibility includes a degree of responsibility for encouraging ethical behaviour and preventing unethical behaviour in your own organisation. Obviously mistakes and misunderstandings occur in all organisations, and some problems can be resolved through discussion. However, raising the issues with the relevant people may not lead to a resolution or there may be problems or concerns about doing this.

This raises the issue of whistleblowing (Hersh 2002). *Whistleblowing* involves the reporting of activities of questionable morality and/or wrongdoing which is not confined to illegality. There is some discussion as to whether this term should only be used when disclosures are unauthorised, take place outside the organisation and the whistleblowers belong to the organisation they are criticising.

Although focusing solely on considerations of self-interest is unlikely to lead to ethical behaviour, individuals are entitled to consider the likely costs of ethical actions to themselves and their families and friends. In some cases, the potential risk to, for instance, health, safety and the environment will be so great that there is no question about the ethics of public disclosure, particularly if disclosure within the organisation has had no effect. However, whistleblowing generally involves conflicts of loyalties. Whistleblowing can be a risky business and whistleblowers may experience retaliation and harassment, lose their jobs and become seriously ill due to stress. Factors to be taken into consideration include the nature and severity of the problem, the probable effectiveness of disclosure in resulting in measures to resolve the problem and the likely consequences to yourself, fellow workers, family and friends. This still raises the issue of your ethical responsibilities in the case of a severe problem, where you think that disclosure is unlikely to be effective, but could have severe consequences for you.

Discussion of whistleblowing in the literature has focused solely on individuals and not considered group responsibilities. However, group action clearly has a number of advantages. It is likely to be more effective and reduce the jeopardy to the individual whistleblowers.

The case of unethical behaviour by a colleague can raise particular difficulties and conflicts of loyalties, particularly if they do not seem to respond appropriately when you raise the issue with them. Reporting a colleague could have serious consequences on their career, even if they are exonerated of misconduct (Lubalin et al. 1995) and the available evidence may be inconclusive or have several possible interpretations.

A number of countries now have legislation to protect whistleblowers. For instance, in the UK, whistleblowers are protected in certain circumstances by the Public Interest Disclosure Act 1998 (http://www.legislation.gov.uk/ukpga/1998/23/contents). There are six specific categories of what are called qualifying disclosures. Qualifying disclosures are those which tend to show that one or more of the following has occurred, is occurring or is likely to occur in the future:

1. A criminal offence.
2. Failure to comply with legal obligations.
3. A miscarriage of justice.
4. Danger to health and safety of any individual.
5. Environmental damage.
6. Deliberate concealment of information relating to the five previous categories.

The legislation includes protection against victimisation. Dismissal for making a protected disclosure is automatically considered unfair dismissal. The degree of protection depends on who the disclosure is made to. Workers are also entitled to compensation if victimisation occurs. However, there is no protection against any third party other than the employer. It remains to be seen how effective this legislation will be, particularly in encouraging people to report serious violations which pose a real threat and in effectively protecting whistleblowers from retaliation.

4.6 Safety Considerations

Safety raises legal, practical and ethical issues. The catastrophic accident at the Union Carbide plant at Bhopal, as a result of which 3,800 people were killed and more than 200,000 others injured (*New York Times*, Sept 12, 1990), shows the consequences of ignoring safety. It also illustrates the ethical dimension of safety, since, for instance, safety precautions, including the use of computerised instruments to control safety systems and detect leaks, were not transferred from the West Virginia plant to Bhopal, where the workers were required to detect leaks by seeing or smelling them (Martin and Schinzinger 2004).

Organisations therefore need to have a safety culture, including at a minimum the following:

1. Safety rules and procedures which meet appropriate national and international standards and are regularly updated.
2. Regular training of all personnel in these procedures.
3. Clearly displayed information about hazards and the most important safety procedures.
4. All safety information notices and materials to be made accessible with regard to both language and format. This may require them to be provided in several different languages and different formats, including large print and sign language videos.
5. All safety-related materials, including fire extinguishers, first-aid equipment and protective clothing to be supplied and maintained by the organisation not individuals.
6. Regular health and safety audits.
7. Effective evacuation procedures in the case of fire or other emergency and which include individual procedures for disabled or other people who require support.

Protecting research subjects and participants from mental harm can be more difficult than protecting their physical safety and generally receives less attention in the design of research and development projects or from ethics committees. It can probably be assumed that a well-run project is unlikely to cause severe damage to the physical health of research subjects. However, it may be more difficult to identify and avoid possible sources of mental distress, as this may require extensive knowledge of the research subjects. Ethical responsibilities in this area include, but are not restricted to, the following:

1. Trying to identify possible causes of mental distress and eliminating them where possible.
2. Where this is not possible, evaluating the ethics of continuing with the research, taking into account the likelihood and probable severity of any possible mental distress and the probable benefits of the research, amongst other factors.
3. Providing appropriate support for participants.
4. Being alert to possible sources of stress and anxiety and trying to reduce them.
5. Being alert to subjects' feelings and reactions and providing breaks or terminating sessions if necessary.

4.7 The Role of Good Design

Good design practice can have an important role in reducing the negative environmental and social impacts of technology and promoting social inclusion. However, it should not be considered a universal panacea and needs to take place in a political and social context which is committed to reducing consumption, equality of opportunities, equal access to resources and social inclusion.

Engineering design involves the development of a system, component or process to meet particular criteria. Decisions made at the design stage will largely determine product performance, including its environmental and social impacts, throughout the lifecycle and which social groups, including disabled people, are able to use the product. Up to 85% of costs are committed by the end of the preliminary design stages (Fabrycky 1987). Design choices, such as the choice of materials for a given product, how they are processed and whether coatings and labels are applied to plastics, will also have significant effects later in the product life on, for instance, waste production in the manufacturing process and the viability of recycling at end of life.

Changes introduced after the design stage will generally give rise to additional costs, be more technically complicated and may not result in satisfactory performance. For instance, many of the underground stations in Glasgow, Scotland, are not accessible to wheelchair users. If wheelchair accessibility had been considered at the original design stage, it could have easily been incorporated. However, making the existing stations accessible to wheelchair users is going to be technically more complicated and probably have high costs.

Both sustainable design and design for all are of vital importance in designing products and services which meet real rather than artificially created needs and are accessible to as many people as possible while having minimal environmental and social impacts. It is therefore fortunate that both sustainable design and design for all can also have economic benefits. For instance, environmentally friendly design generally results in reduced material and energy consumption and a reduction in waste, leading to cost savings for materials and waste disposal, including any associated permits. There may also be improvements in employee morale and the avoidance of environmental fines, as well as new business opportunities. Design for all can also lead to new business opportunities, as products and processes become available to a wider section of the population. The need to combine these two paradigms has given rise to ecodesign for all (Hersh 2001). This is both in accordance with holistic systems-based philosophies and should be considered a part of standard good design practice rather than an optional extra.

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References

Anon (2014) Existentialism. https://en.wikipedia.org/wiki/Existentialism. Accessed 8 May 2014
Anon (undated) Perspectives, principles, paradigms – ethical guidance from the ASTRID project. http://www.ict-ageing.eu/?page_id=1271. Accessed 5 Feb 2015
Argyris C, Putnam R, Smith DM (1985) Action science. Jossey-Bass, San Francisco
Babcock DL (1991) Managing engineering and technology. Prentice-Hall, Englewood Cliffs
Barbour IG (1995) Ethics in an age of technology: the Gifford lectures, 2. Harper, San Francisco
Basart JM, Serra M (2013) Engineering ethics beyond engineers' ethics. Science and Engineering Ethics 19(1):179–187
Beauchamp TL (2001) Philosophical ethics: an introduction to moral philosophy. McGraw Hill Higher Education, New York
Beauchamp TL, LeRoy W (eds) (1978) Contemporary issues in bioethics, chapters 1 and 2. Dickenson Publishing, Encino
Bennet FL (1996) The management of engineering human, quality, organizational, legal, and ethical aspects of professional practice. Wiley, Chichester; New York
Bitay B, Brandt D, Savelsberg E (2005) Global validity of ethics: applying ethics to engineering and technology development. In: Proceedings of the International Federation of Automation and Control (IFAC) World Congress, Prague
BPS (1990) Ethical principles for conducting research with human participants BPS guidelines. The Psychologist 3:270–272
Brisenden S (1986) Independent living and the medical model of disability. Disabil Handicap Soc 1:173–178
Brockbank A, McGill I (1999) Facilitating reflective learning in higher education. Society for Research into Higher Education & Open University Press, Buckingham
Callicott JB (1992) Environmental ethics. In: Becker LC (ed) Encyclopedia of ethics 1. Garland, New York, pp 311–314
Chadwick RF (1992) Ethics and nursing practice: a case study approach. Palgrave, Basingstoke
Childress JF (1998) A principle-based approach. In: Singer P, Kuhse H (eds) A companion to bioethics. Blackwell, Oxford, pp 61–71
Collins WR, Miller KW (1992) Paramedic ethics for computer professionals. J Syst Softw 17(1):23–38
Cooper TL (1987) Hierarchy, virtue, and the practice of public administration: a perspective for normative ethics. Public Adm Rev 47(4):320–328
Cooper TL (2012) The responsible administrator: an approach to ethics for the administrative role. Wiley, Chichester
Cozby P (1973) Self-disclosure: a literature review. Psychol Bull 79:73–91
Cunliffe AL (2009) The philosopher leader: on relationalism, ethics and reflexivity – a critical perspective to teaching leadership. Manage Learn 40(1):87–101
Derrida J (1981) Limited INC. Northwestern University Press, Evanston
Doris JM (1998) Persons, situations, and virtue ethics. Nous 32(4):504–530

Egan G (1973) Face to face: the small group experience and interpersonal growth. Brookes/Cole, Monterey
Ellul J (1954) La Technique ou l'Enjeu du Siècle. Librairie Armand Colin, Paris
Engineering Council (1993) Engineers and the environment. Engineering Council, London
Engineering Council (2010) Guidelines on sustainability. Engineering Council, London. http://www.engc.org.uk/about-us/sustainability. Accessed 8 May 2014
Ersdal G, Aven T (2008) Risk informed decision-making and its ethical basis. Reliab Eng Syst Saf 93(2):197–205
Fabrycky W (1987) Designing for the life cycle. Mech Eng 109(1):72–74
Fishburn PC (1970) Utility for decision making, Publications in operations research, no 18. Wiley, New York
Foucault M (1972) Power/knowledge (Gordon, C, ed). Pantheon, New York
Frankena WK (1963) Ethics. Prentice-Hall, Englewood Cliffs
Frey WJ, O'Neill-Carrillo E (2008) Engineering ethics in Puerto Rico: issues and narratives. Sci Eng Ethics 14(3):417–431
Gadamer H-G (1989) Truth and method. Crossroad, New York
Gardiner SM, Caney S, Jamieson D, Shue H (2010) Climate ethics: essential readings. Oxford University Press, Oxford
Gilligan C (1982) In a different voice. Harvard University Press, Cambridge, MA
Gluck SE (1986) Ethical engineering. In: Ullmann JE (ed) Handbook of engineering management. Wiley, New York, p 176
Goodyer J (2012) Would you swear an engineering oath. Eng Technol Mag 7(2). http://eandt.theiet.org/magazine/2012/02/would-you-sign-up-to-this.cfm. Accessed 8 May 2014
Harremoës P et al (2002) The precautionary principle in the 20th century late lessons from early warnings. Earthscan, London
Harris CE, Davis M, Pritchard MS, Rabins MJ (1996) Engineering ethics: what? why? how? and when? J Eng Educ 85(2):93–96
Havard A (2007) Virtuous leadership: an agenda for personal excellence. Scepter, New York
Held V (2006) The ethics of care: personal, political, and global. Oxford University Press, Oxford
Hersh MA (2000) Environmental ethics for engineers. Eng Sci Educ J 9(1):13–19
Hersh MA (2001) Ecodesign for all. WACRA, Vienna
Hersh MA (2002) Whistleblowers – heroes or traitors?: individual and collective responsibility for ethical behaviour. Annu Rev Control 26:243–262
Hersh MA (2003) Ethical analysis of the information society. In: IFAC 8th symposium on automated systems based on human skill and knowledge, Göteborg
Hersh MA (2006) Mathematical modelling for sustainable development. Springer, Berlin/New York. ISBN 3-540-24216-3
Hersh MA (2012a) Military research, ethics, values and academic freedom. In: Vinthagen S, Kentrick J, Mason K (eds) Tackling trident, academics in action through academic conference blockades. Irene Publishing, Scandinavia, pp 225–242
Hersh MA (2012b) Ethical analysis of trident: the application of different ethical theories. In: Vinthagen S, Kentrick J, Mason K (eds) Tackling trident, academics in action through academic conference blockades. Irene Publishing, Scandinavia, Beauchamp, pp 103–118
Hersh MA (2013) Barriers to ethical behaviour and stability: stereotyping and scapegoating as pretexts for avoiding responsibility. Annu Rev Control 37:365–381
Hersh MA (2014) Science, technology and values: promoting ethics and social responsibility. AI Soc 29(2):167–183
Hersh MA, Tucker WD (2005) Ethics and mono-disciplinarity: positivism, informed consent and informed participation. In: 16th IFAC Congress, Prague, Czech Republic
Hersh MA, Stapleton L, Duffy D (2005) Applications of narrative ethics to engineering. In: 16th IFAC Congress, Prague, Czech Republic
Hursthouse R (1999) On virtue ethics. Oxford University Press, Oxford
IEEE (1996) Guidelines for engineers dissenting on ethical grounds. Available at end of IEEE Students Ethics Competition Guidelines and Requirements. www.ieee.org/documents/SEC_v2.pdf. Accessed 8 May 2014

IEEE (2014) IEEE code of ethics. www.ieee.org/about/corporate/governance/p7-8.html. Accessed 8 May 2014
Inglehart R, Rabier JR, Reif K (1987) The evolution of public attitudes toward European integration: 1970–1986. J Eur Integr 10(2–3):135–155
Kagan S (1998) Normative ethics. Perseus Books Group, Boulder
Kant I (1792) Grundlegung zur Metaphysik der Sitten (Foundations of the metaphysics of morals). Dritte Auflage, Riga
Kant I (1818) Critik der Practischen Vernunft (The critique of practical reason). Johann Friedrich Hartknoch, Leipzig
Kaufmann WA (1956) Existentialism from Dostoevsky to Sartre. Meridian Books, New York
Kierkegaard S (1944) [1843] Either/or (trans: Swenson DF, Swenson L, Lowrie W). Princeton University Press, Princeton
Kierkegaard S (1967) [1845] Stages on life's way (trans: Lowrie W). Shocken Press, New York
Kling R, Star L (1998) Human centred systems in the perspective of organisational and social informatics. Comput Soc 28(1):22–29
Kluckholm C (1955) Ethical relativity: sic et non. J Philos 55:663–667
Koehn D (1995) A role of virtue ethics in the analysis of business practice. Bus Ethics Q 5(3)
Kohlberg L (1981) The philosophy of moral development. Harper and Row, New York
Kuhse H, Singer P (eds) (1998) A companion to bioethics (chapters 1–12, 40 and 41). Blackwell, Oxford
Laplante PA (2004) First, do no harm: a Hippocratic oath for software developers? Queue 2(4):14
Lappé M, Bailey B (1999) Against the grain. Earthscan, London
Lindsay R, Graham H (2000) Relational narratives: solving an ethical dilemma concerning an individual's insurance policy. Nurs Ethics 7(2):149–157
Lubalin JS, Ardina M, Matheson J (1995) Consequences of whistleblowing. Research Triangle, Washington, DC
Lyons N (1983) Two perspectives on self relationship and morality. Harv Educ Rev 53:125–145
Macquarrie J (1955) An existentialist theology. SCM, London
McCarthy J (2003) Principlism or narrative ethics: must we choose between them? Med Humanit 29(2):65–71
Madu CN (1996) Managing green technologies for global competitiveness. Quorum Books, Westport
Magnusson L, Hanson EJ (2003) Ethical issues arising from a research, technology and development project to support frail older people and their family carers at home. Health Soc Care Commun 11(5):431–439
Marck PB (2000) Recovering ethics after 'technics': developing critical text on technology. Nurs Ethics 7(1):5–14
Marshall M (1999) Technology to help people with dementia remain in their own homes. Generations 23(3):85–87
Martin MW, Schinzinger R (1996) Ethics in engineering, 3rd edn. McGraw-Hill, New York
Martin MW, Schinzinger R (2004) Ethics in engineering, 4th edn. McGraw-Hill, New York
Martin MW, Schinzinger R (2010) Introduction to engineering ethics. McGraw-Hill Higher Education, Boston
Mill JS (1871) Utilitarianism, 4th edn. Longmans, Green, Reader, and Dyer, London
Morris J (2001) Impairment and disability: constructing an ethics of care that promotes human rights. Hypatia 16(4):1–16
Mosquin T, Rowe S (2004) A manifesto for earth. Biodiversity 5(1):3–9
Nash RF (1989) The rights of nature: a history of environmental ethics. University of Wisconsin Press, Madison
Newberry B (2004) The dilemma of ethics in engineering education. Sci Eng Ethics 10(2):343–351
Nielson RP (1996) The politics of ethics. Oxford University Press, Oxford
Nino CS (1993) The ethics of human rights. Clarendon, Oxford
Okin SM (1989) Justice, gender and the family. Basic Books, New York

Oldenquist G, Slowter EE (1979) Proposed: a single code of ethics for all engineers. Prof Eng 49(5):8–11

Parker DB (1968) Rules of ethics in information processing. Commun ACM 11(3):198–201

Raskind MH, Higgins EL (1995) Reflections on ethics, technology and learning disabilities: avoiding the consequences of ill-considered action. J Learn Disabil 28(7):425–428

Rawls J (1971) A theory of justice. Belknap Press of Harvard University Press, Cambridge, MA

Rorty R (1982) Consequences of pragmatism. University of Minnesota Press, Minneapolis

Rorty R (1991) Essays on Heideger and others, vol 2, Philosophical papers. Cambridge University Press, Cambridge

Rothbard NP, Edwards JR (2003) Investment in work and family roles: a test of identity and utilitarian motives. Pers Psychol 56(3):699–729

Royal Academy of Engineering & Engineering Council (undated) Statement of ethical principles. http://www.raeng.org.uk/societygov/engineeringethics/principles.htm. Accessed 8 May 2014

Sartre JP (1985) Existentialism and human emotions. Citadel, Secaucus

Sartre JP (1992) Notebooks for an ethics. University of Chicago Press, Chicago

Scarre G (1996) Utilitarianism. Routledge, New York

Scheffler S (1994) The rejection of consequentialism. Clarendon Press, Oxford

Seedhouse D (1988) Ethics the heart of health care. Wiley, Chichester

Sevenhuijsen S (1998) Citizenship and the ethics of care: feminist considerations on justice, morality and politics. Routledge, London/New York

Seymour JE, Ingleton C (1999) Ethical issues in qualitative research at the end of life. Int J Palliat Nurs 5:65–73

Singleton M (1991). The need for engineering ethics education. In: Frontiers in education conference, 1991. Twenty-first annual conference. 'Engineering education in a new world order' proceedings, September. IEEE, New York, pp 145–150

Solomon WD (1978) Rules and principles. In: Reich WT (ed) Encyclopedia of ethics, vol 1. Free Press, New York, pp 407–413

Sørlie V, Larsson Kihlgren A, Kihlgren M (2004) Meeting ethical challenges in acute care work. Nurs Ethics 11(2):179–188

Stack GJ (1974) Aristotle and Kierkegaard's existential ethics. J Hist Philos 12(1):1–19

Stapleton S, Hersh M (2003) Exploring the deep structure of ethics in engineering technology: design and deployment methodology. In: IFAC workshop on "Technology and international stability", SWIIS'03, Waterford, Ireland

Stapleton S, Hersh MA (2004) Blowing the whistle on social order in engineering. In: International Federation of Automatic Control Multitrack conference on advanced control strategies for social and economic systems, Vienna, Austria

Swanton C (2003) Virtue ethics: a pluralistic view. Clarendon, Oxford

Taylor PW (2011) Respect for nature: a theory of environmental ethics. Princeton University Press, Princeton

Torbert WR (1987) Managing the corporate dream: restructuring for long-term success. Dow-Jones, Irwin, Homewood

VDI (2002) Ethische Grundsätze des Ingenieurberufs. www.vdi.de/fileadmin/media/content/hg/16.pdf. Accessed 10 Mar 2014

Vesilund PA (1988) Rules, ethics and morals in engineering education. Eng Educ 78:289–92

Walker MU (1993) Keeping moral space open: new images of ethics consulting. Hastings Center Rep 23(2):33–40

Warnock M (1970) Existentialism. Oxford University Press, Oxford

Whitzman C (2002) Feminist activism for safer social space in High Park, Toronto: how women got lost in the woods. Can J Urban Res 11(2)

Widdershoven GAM, Smits M-J (1996) Ethics and narratives. In: Josellson R (ed) Ethics and process in the narrative study of lives. Sage, Thousand Oaks, pp 275–287

Wilkinson M, Moore A (1999) Inducements revisited. Bioethics 13(2):114–130

Winner L (1977) Autonomous technology: technics-out-of-control as a theme in political thought. MIT Press, Cambridge, MA

Woolman J (1774) [1818] The works of John Woolman in two Parts, 5th edn. Benjamin and Thomas Kile, Philadelphia

Part II
Ethical Impacts of Advanced Applications of Technology

Chapter 3
Roboethics

Peter Kopacek and Marion Hersh

Overview
Robotics is a very fast-growing field and presents us with both a number of exciting possibilities and the threat of significant changes to society, possibly in unforeseeable and undesirable directions. The chapter discusses the associated ethical issues. It is introduced by definitions and statistics on different types of robots and continues to a brief overview of some of the main technological developments and current and probable future applications of robots. The concept of roboethics is then introduced and the limitations of early approaches based on Asimov's (undated) laws of robotics are noted. However, the more general definition (Veruggio and Operto 2008) is able to cover the wider social implications of the introduction of robots and could be extended to include the impacts on the environment and other species. The ethical issues of current and future applications of robots are illustrated by a number of examples covering a wide range of applications, including health care, military robots and toy and companion robots. A number of the ethical theories presented in Chap. 2 are then applied to the evaluation of several of the applications of robots.

1 Introduction

Robotics is still a relatively new field. Many different types of robots have been developed and significant numbers are in use, both in industry and in service applications. However, robots and domestic service robots in particular still have science

P. Kopacek (✉)
Vienna University of Technology, IHRT, Wien, Austria
e-mail: kopacek@ihrt.tuwien.ac.at

M. Hersh
School of Engineering, Biomedical Engineering, University of Glasgow, Rankine Building, Glasgow, Scotland
e-mail: marion.hersh@elec.gla.ac.uk

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fiction associations (Forlizzi and diSalvo 2006). This may make it more difficult to evaluate their probable advantages and disadvantages. However, as illustrated by science fiction accounts, robots have the potential to have a very significant impact on the shape of society in the future, though not necessarily the type of impacts depicted in these stories. Some of these influences will be beneficial, whereas others will be harmful.

The development of new technologies is often determined by 'design drivers', such as costs, timing and technical factors. These design drivers can determine the goals to be achieved, such as the desired functionality and/or constraints, such as limits on costs. Ethics is an equally important design driver which is often omitted from discussion of technology development and other engineering projects. Consideration of ethical factors as constraints may lead to decisions not to participate in or to cancel certain projects because they do not meet appropriate ethical standards. Equally ethics can act as a goal to be achieved, with regard to, for instance, the highest health and safety standards, lowest impacts on the environment and applications which are valuable to humanity and the environment.

Robots have the potential to carry out a range of tasks previously carried out by people, act autonomously at least to some extent and have a possibly high degree of intelligence. This raises a number of important ethical issues related to the wider impacts of robots on society, including with regard to employment, deskilling, need for reskilling, human relationships and human-robot relationships. In addition, if it does prove possible (which is as yet still questionable) to develop robots with a high degree of intelligence and even some self-awareness, there may also be issues of the responsibilities of humanity to them. For instance, is it ethical to treat an intelligent and possibly self-aware robot as an object and does it have rights? Increasingly intelligent and autonomous robots are likely to have an increasing influence on society, raising further ethical issues.

The development of robotics and, in particular, advanced applications is still at an early stage. It is therefore a good time to consider the wider implications of robots and their effects on society and the environment in order to make decisions as to the ways in which we want to use robots and the types of developments that we do and do not want in order to shape the society of the future. Otherwise, we give in to technological determinism (Ellul 1954; Winner 1977) according to which technology is all powerful and, in the strongest versions, totally determines the future of society in ways which are not possible to resist. The engineering community needs to take responsibility for future developments in robotics and their impacts on society, rather than giving in to technological determinism and the assumption that all possible technological developments should be implemented. There are also highly complex power relations and dynamics that affect choices about the development and use of technology and whose interests they serve (Stapleton and Hersh 2003), often leading to advantage to some groups and disadvantage to others and frequently also to the environment. Understanding of both the ethical issues and the power dynamics related to technology development will better enable the robotics community to resist them and ensure that the development of robots benefits human society, particularly its poorest and most disadvantaged members, and the environment.

There has been some discussion of the social aspects of robotics for the last few decades and this discussion has increasingly involved ethical issues (Kopacek 2012). The term ‘roboethics’ was introduced by Veruggio (2002) and officially proposed during the First International Symposium on Roboethics in 2004. However, much of the discussion of roboethics has focussed on ethical issues related to the actions (autonomous or otherwise) of individual robots rather than the wider impacts of the use of robots on society and the environment. An understanding of what types of robotics developments are feasible is important for the discussion of the associated ethical issues. This chapter aims to provide an overview of roboethics firmly grounded in an understanding of the underlying technological robotics issues.

2 Robots

2.1 Definitions and Statistics

There are a number of different definitions of robots, as well as many different applications. One of the main categorisations of robots is into industrial and service robots, with a further classification of service robots into personal and professional service robots (Shibata 2004). The most authoritative definitions are those in the International Organization for Standardization Standard ISO 8373:2012 which specifies the terminology to be used in discussing robots and robotic devices:

- A *robot* is an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks. Autonomy in this context means the ability to perform intended tasks based on current state and sensing, without human intervention.
- An *industrial robot* is an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications with the terms defined as follows (1) *reprogrammable*: whose programmed motions or auxiliary functions may be changed without physical alterations, (2) *multipurpose*: capable of being adapted to a different application with physical alterations, (3) *physical alterations*: alteration of the mechanical structure or control system except for changes of programming cassettes, ROMs, etc., and (4) *axis*: direction used to specify the robot motion in a linear or rotary mode.
- A *service robot* is a robot that performs useful tasks for humans or equipment excluding industrial automation application. Note: The classification of a robot into industrial robot or service robot is done according to its intended application.
- A *personal service robot or a service robot for personal use* is a service robot used for a non-commercial task, usually by lay persons. Examples include domestic servant robot, automated wheelchair, personal mobility assistive robot and pet exercising robot.

- A *professional service robot or a service robot for professional use* is a service robot used for a commercial task, usually operated by a properly trained operator. Examples are cleaning robot for public places, delivery robot in offices or hospitals, firefighting robot, rehabilitation robot and surgery robot in hospitals. In this context an operator is a person designated to start, monitor and stop the intended operation of a robot or a robot system.

According to these definitions, service robots require a 'degree of autonomy', but not full autonomy or fully automatic operation, unlike industrial robots. This may range from fully autonomous systems without active human interaction through some degree of human-robot interaction to full teleoperation. Human-robot interaction involves information and action exchanges between the user and robot via a user interface in order to achieve a task, which may involve the robot assisting the user. Whether a robot should be considered a service or industrial robot depends on the application it is being used in, not the structure of the particular robot. Service robots are often, though not necessarily, mobile and may have several arms attached to a mobile platform and controlled analogously to the arms of an industrial robot.

Statistics produced by the International Federation of Robotics on industrial (http://www.ifr.org/industrial-robots/statistics/) and service (http://www.ifr.org/service-robots/statistics/) robots show that personal service robots are the category with the largest number of robots sold each year. However, the value of each robot is much lower than for industrial and professional service robots, as they are produced for a mass market. The data can be summarised as follows:

1. Personal service robots: (1) about 3 million sold in 2012, worth US$1.2 billion; (2) an increase of 20% over 2011; (3) projected sales for 2013–2016 of about 22 million units worth US$5.6.
2. Professional service robots: (1) 16.067 units sold in 2012, worth US$3.42 billion; (2) number of units sold increased 2% from 2011, but their value dropped by 1%; (3) projected sales for 2013–2016 of about 94,8000 units worth US$17.1 billion; (4) more than 126,000 robots have been included in these statistics since 1998, but varying life spans make it impossible to estimate how many are still in operation.
3. Industrial service robots: (1) 159,346 units sold in 2012, (2) decrease by 4% from 2011; (3) sales for 2013 projected to increase by 2% to 162,000 units; (4) robot installations are estimated to increase by 6% on average per year from 2014 to 2016; (5) the total global stock of operational industrial robots at the end of 2012 was between 1.235 and 1.5 million units.

By far the greatest uses of industrial robots are in the automotive (40%) and electronics and electrical (21%) industries, followed by the chemical, rubber and plastics industries. A few per cent are used in each of the metal products, communication, food and industrial machinery industries (http://www.ifr.org/industrial-robots/statistics/). About 40% of professional service robots were used by the military aka 'defence' applications in 2012; 8% in medicine, including robotic surgery and therapy; and 9% in logistic systems. Medical robots are the most expensive in this category, with an average price of US$1.5 million.

About 1.96 million domestic (household) robots, including vacuum and floor cleaners and lawnmowers were sold in 2012. The other main applications were entertainment and leisure robots, including toys, hobby systems, education and research. Personal transportation and human security and surveillance robots are expected to become increasingly important in the future. Despite the potential, only 159 assistive robots for disabled and elderly people were sold in 2012 (http://www.ifr.org/service-robots/statistics/). It is probable that this is a significant underestimate, as a number of the systems in use are non-commercially available prototypes which do not appear in the statistics. It is projected that about 6,400 robots for elderly and disabled people will be sold in 2013–2016 and that there will be substantial expansion within the next 20 years.

2.2 Developments in Robotics

Some of the main developments in robotics are illustrated in Fig. 3.1 and a categorisation of different types of robots is presented in Fig. 3.2. The earliest robots were 'unintelligent', stationary industrial robots. They were used mainly in production systems equipped with numerically controlled or computer numerically controlled (CNC) machines as well as in computer integrated and intelligent manufacturing systems. The ethical issues raised are similar to those related to the use of other types of machines in the industry, including safety issues, environmental impacts over the life span and impacts on employment and skill levels.

Subsequently three main developments have taken place, namely, (1) mobility, (2) 'intelligence' and (3) cooperation. The foundation for 'intelligent' behaviour is information about the environment, which the robot can process and respond to.

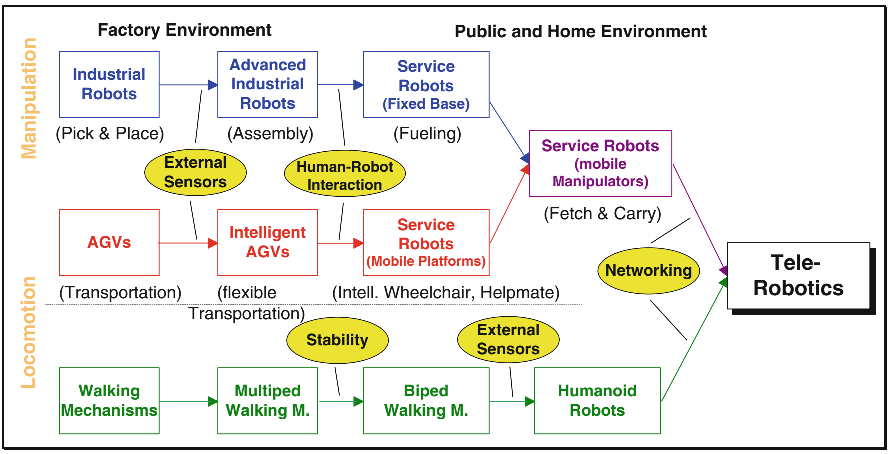

Fig. 3.1 From industrial to service robots (Kopacek 2005)

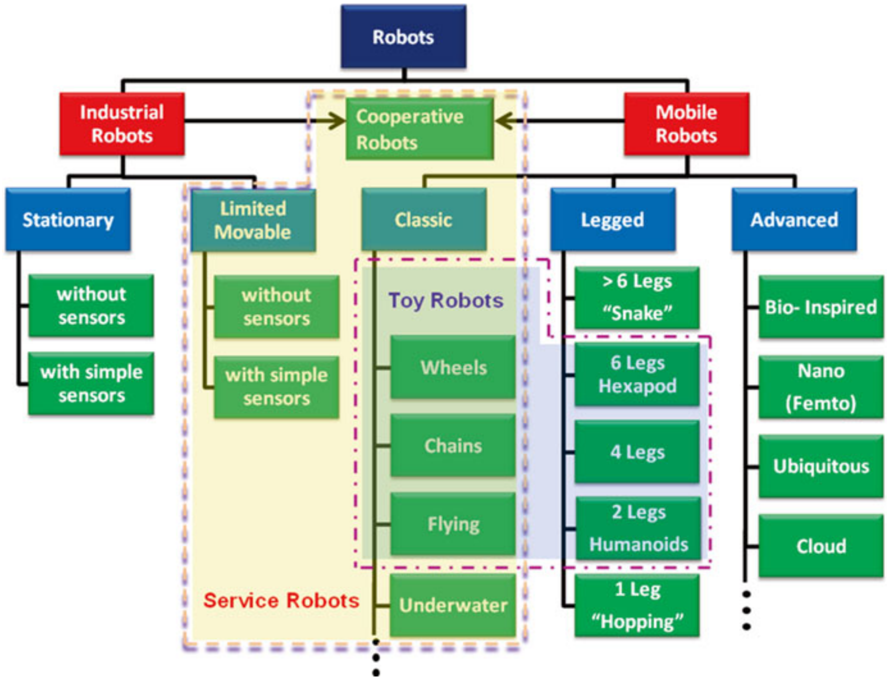

Fig. 3.2 Robots (Kopacek 2013)

This requires the robot to have sensors. They should be inexpensive to reduce overall costs and have high accuracy and reliability to ensure high-quality information which is always available. There are three main starting points for the development of intelligent robots: (1) conventional, stationary industrial robots; (2) mobile, unintelligent robot platforms; and (3) legged robots or walking mechanisms (see Fig. 3.1). For instance, many stationary industrial robots have been equipped with simple external sensors for 'intelligent' operations such as assembly and disassembly and fuelling cars, making them 'intelligent', as shown in the left two columns of Fig. 3.2.

One of the current trends in robotics is cooperation. This involves the connection and synchronisation of (industrial) robots by their controllers or the control of a number of robots by one controller. There is potential for intelligent robots, particularly intelligent mobile platforms and humanoid robots, to work together on a common task or tasks in a cooperative way. The goal is so-called multi-agent systems in which several agents interact in an attempt to jointly solve tasks or maximise utility (Panait and Luke 2005). A robotic multi-agent system consists of several different robots (agents), equipped with various devices, such as arms and grippers to carry out activities and a host computer to coordinate them (Kim et al. 1997). The host computer divides the task into a number of subtasks of appropriate size to be carried out by one agent. Other developments involve modular metamorphic or reconfigurable robots of which there are several different types (Pamecha et al. 1997; Yim et al. 2002). They comprise large numbers of connected robots of the same type and physical properties or a small number of different types. These robots are able to diagnose and replace faulty modules, increasing robustness, and are very useful in tasks that need versatility. Applications include obstacle avoidance in highly constrained and unstructured environments and ‘growing’ bridges, buttresses and other structures in emergencies (Pamecha et al. 1997). However, the need for a very large number of modules could make the total cost very high even if the unit cost is very low (Yim et al. 2002).

2.3 Mobile Robots

While all robots raise some ethical issues, these are particularly important for mobile, autonomous and intelligent robots. Mobile robots generally have the following features or characteristics which are required for effective and unobtrusive operation:

1. Physical structure, including expressive ability: What the robot looks like and its ability to express ‘emotions’ and respond to the user will affect potential users’ responses and the effectiveness of the interaction with the robot.
2. Mobility system: The robot has a means of moving itself which is appropriate to the intended activities and the environment. The most common means are wheels followed by legs. Other options include suction cups and adhesive pads. The mobility system also includes one or more motors and drivers.
3. Autonomy: Some degree of ‘independent’ decision-making and control. In some cases, such as the case of many intelligent/robotic wheel chairs and other service robots, there is shared control between the user and the robot (Goodrich et al. 2001; Yu et al. 2003).
4. Human-machine interface (HMI): An interface with the human operator or user is required to enable the user to provide instructions and receive information and feedback. The interface should be designed to be easy and intuitive to use. The type of interface will depend on the type of users and the circumstances. For instance, a speech interface has advantages for many users but is not suitable in noisy environments or for deaf users.
5. System of sensors: This should include both proprioceptive sensors to obtain information about the robot’s state and exteroceptive sensors to obtain information about the environment. Sensors may include cameras, infrared sensors, sonars and laser range finders.
6. Processors: This may involve one or more microprocessors, laptops or other devices. The processors can be onboard or external. The processors are programmed to carry out the functions situated in many of the other modules.
7. Multilayer architecture for intelligent robot control system: This allows different types of behaviours and interactions between the robot and the user at different levels.

8. Artificial intelligence: The ability to respond appropriately to information from the sensors and use it to determine behaviour, including in unfamiliar environments with limited information, time variation and uncertainty. An intelligent robot should be able to compensate for all these effects at least to some extent.

There are a number of different ways of classifying mobile robots, and classifications include the following: (1) the type of application, i.e. industrial robots or service robots, and (2) the type of mobile structure, e.g. mobile platforms on wheels and legged robots. Some of the applications of industrial and service robots were discussed briefly in Sect. 2.1, so mobile platforms and legged robots will be considered now.

2.3.1 Mobile Platforms

Mobile platforms with external sensors have been available for a number of years and can be used in a wide range of applications. The main components of the robot are situated on the platform and include an onboard PC, drives, a power supply, a human-machine interface and devices, such as wheels, to support movement. Various additional devices can be attached to the platform, including arms, grippers and transportation equipment. Communication between the onboard and supervisory PCs is carried out by radio-based networks, WLAN (wireless local area networking). Recorded or synthetic speech messages can be used for communication with users. Only about 10% of industrial robots are mobile (http://www.ifr.org/service-robots/statistics/).

Applications could involve the teleoperation or semi-autonomous operation of robot platforms, with some of the possibilities including the following:

- *Factory automation*: Mobile robots transport components between machining and (dis)assembly sites.
- *Operation in hazardous environments*: This could include the use of mobile robots in the clearance of mines and cluster bombs and in mine excavation.
- *Planetary and space exploration*: This could involve the use of autonomous rovers and probes and the employment of tele-robotic systems in construction in space. However, it should be noted that space exploration raises ethical issues, including issues relating to resource use and environmental impacts, and is probably not ethically justified, particularly at the current time.
- *Deep-sea surveying* and prospecting: This could again involve the use of autonomous robots and probes and allow information to be obtained at reduced risk to people and reduced costs.

2.3.2 Legged Robots

Most mobile robots are wheeled. This gives them advantages over legged robots with regard to stability. However, wheeled robots have disadvantages in terms of the inability to go up and down the stairs, move on rough terrain without restrictions and move sideways or turn quickly. Therefore, legged robots can work in environments which are unsuitable for wheeled robots. However, wheeled robots which use Mecanum wheels can also, in principle, move in any direction using rollers at an angle around the periphery or sometimes centrally mounted on an axle that can be pivoted (Diegel et al. 2002).

The design of legged robots is a more complex problem than the design of wheeled robots, since a generally smooth pace is required and the robot needs to remain stable. Where interaction with the user is involved, the robot will need to move at walking pace, adjust its speed to the user's desired pace, not overbalance the user, and have motion which looks natural. Legged robots can be classified by their number of legs, i.e. (1) one leg (hopping), (2) two legs (biped), (3) four legs (multiped), (4) six legs (hexapod) and (5) more than six legs (snake).

From the control engineering perspective, walking on two legs is a complex stability problem. Bipedal robots have high-order highly coupled nonlinear dynamics and discrete changes in dynamics. While walking, the robot alternates between a statically stable phase with both feet on the ground and a statically unstable phase with only one foot in contact (Katić and Vukobratović 2003). The two main approaches to achieving stable and reliable bipedal walk are walking pattern generators and robot controllers (Zhou and Low 2001; Zhou et al. 2000; Zielinska and Heng 2002). Mechanisms to prevent overbalance include control of the foot landing position and the desired zero momentum point (Hirai et al. 1998).

Humanoid robots have 'human characteristics'. Bipedal walking machines equipped with external sensors are the basis for humanoid robots, and a number of prototypes are currently available (Kopacek 2013). They have a torso, two arms and two legs and a head with a 'face', 'eyes' and a 'mouth'. However, there is a great difference between a bipedal walking machine and something which looks and thinks like a person and is, for instance, able to display emotion appropriately, engage in conversation with people and learn from experience and by observing its surroundings. A number of robots, including some museum guide robots (Burgard et al. 1999; Thrun et al. 2000) and humanoid robots (Barakova and Lourens 2010), have simple displays of emotion and are able to engage in simple interactions with people. The voice quality in synthetic speech output is improving and becoming more natural. However, the development of 'intelligence' able to produce appropriate output in response to complex input is still technically challenging. The associated ethical issues will be discussed in Sect. 3.

Research on the desirability or otherwise of the resemblance of robots to a person is still inconclusive. For instance, Mori (1970) developed a function relating robot acceptance to its similarity to a person and found an 'uncanny valley' in which robots are too similar to people and the differences cause disquiet. Several studies (e.g. Arras and Cerqui 2005, Hersh and Johnson 2010, Oestreicher 2007 and Wu et al. 2012) have found that potential users preferred a robot looking like a machine to one with a humanoid appearance. On the other hand, other studies indicate that people prefer software agents with human faces (Kiesler and Sproull 1997; Koda and Maes 1996; Takeuchi and Naito 1995), robots with a more human appearance (Hinds et al. 2004) and robots to communicate in a humanlike way (Dautenhahn et al. 2005).

Humanoid walking robots have been categorised both by their walking mechanisms and the development context. Categorisation by walking mechanism gives the following three categories:

1. Static walkers with very slow motion and stability dependent on the projection of the centre of gravity.
2. Dynamic walkers with feet and actuated ankles and stability dependent on joint velocities and acceleration and the possibility of static motion if the feet are large enough and the motion if slow.
3. Purely dynamic walkers without feet and the projected centre of mass allowed outside the area of the base of the legs.

Categorisation by development context gives the following four categories:

1. *'Professional' humanoid robots* developed by large companies with very large research capacities. Examples include the Honda robots (P1, P2, P3, ASIMO) intended to assist humans in the workplace and the SONY robots (SDRX – 3,4,5,6 and QRIO) intended to be used in entertainment, leisure and hobbies and in the future as personal robots.
2. *'Research' humanoid robots:* Currently more than 1,000 university institutes and research centres worldwide are active in this field, giving a large number of mainly prototypes developed by computer scientists to implement and test methods for artificial intelligence, image processing, walking mechanisms, control strategies and human-machine interfaces to support efficient communication between humans and humanoid robots.
3. *Humanoid 'toy' robots*: A fairly large number of humanoid toy robots, mostly developed by small- or medium-sized companies, are now available for purchase. They generally have very limited capabilities with very basic programming software and no need for advanced programming knowledge. They can walk, run, flip, cartwheel and dance. They are generally available either as a kit or preassembled.
4. *Cost-oriented humanoid robots* (Kopacek 2011) are intended to overcome the limitations of the other three categories, particularly the limited market and the high price of professional humanoid robots, the fact that research humanoid robots rarely get beyond prototypes and the limited capabilities of humanoid toy robots. These robots are intended to support humans in everyday life, e.g. in the workplace, at home in the household and in leisure and entertainment, and should be available at a reasonable price. This will require the standardisation of the hardware and software platforms, using the latest technologies and applying modern control concepts.

3 Robots of the Future

One of the most ambitious aims of robotics is to design an autonomous robot that could reach and even surpass human intelligence and performance in partially unknown, changing and unpredictable environments. This raises the issue of what differentiates human intelligence from machine intelligence. We already have computers with computing power many times greater than that of a human, but they are clearly not intelligent. Relevant factors include creativity, flexibility, independent thinking and probably also unpredictability. If meaningful technological representations of these qualities are feasible, which is still an answered question, their combination with high computing power could lead to a very formidable and possibly highly dangerous intellect. Artificial intelligence approaches used to investigate this problem include the following: (1) perception and analysis of the environment, (2) natural language processing, (3) human interaction, (4) cognitive systems, (5) machine learning and behaviour and (6) neural networks.

An important feature of intelligent robots is their ability to learn, for instance, the characteristics of the surrounding physical environment and the animals and people that inhabit it. In addition to learning about their environment, robots should be able to learn about their own behaviour, through a self-reflective process. This will include learning from experience, replicating the natural processes of the evolution of intelligence in humans and animals, including synthesis procedures, trial and error and learning from experience. Intelligent robots would require the ability to learn about ethical issues and the consequences of their decisions and actions.

Figure 3.3 shows one possible development path for robotics. This involves changes from unintelligent industrial robots via intelligent industrial robots to intelligent mobile, including humanoid, robots to the third generation of advanced intelligent robots which are able to interact and work together with people.

This raises ethical issues related to both the robot's actions and the desirability of such developments and their impacts on human societies. It is these latter impacts which are the most important and the most worrying, as well as very difficult to foresee. While it is likely that there will be threats and disadvantages, current predictions may be incorrect and it is also difficult to imagine what the real benefits,

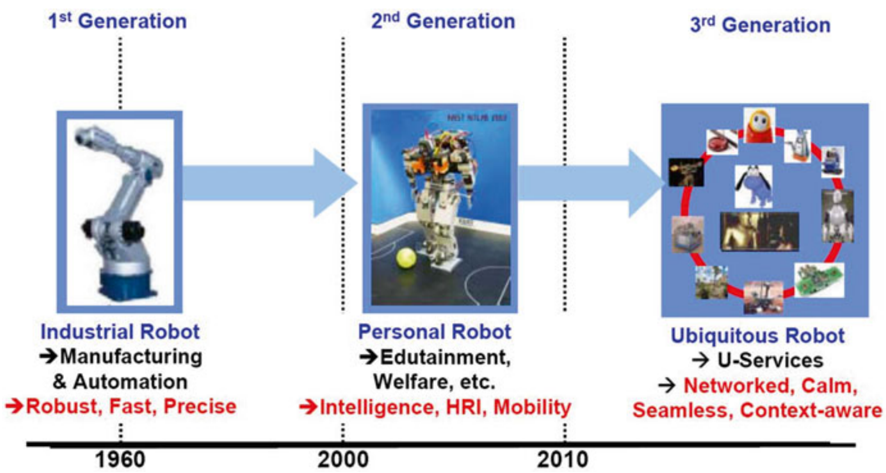

Fig. 3.3 Development trends in robotics (Kopacek 2005)

if any, will be to set against these threats. The approach taken to developments in robotics to date seems to have largely been based on technological determinism (Ellul 1954; Winner 1977) with developments taking place because they are possible without regard to their wider impacts and desirability.

Possibly the most important issues relate to the effects on human society and the way in which the presence of an intelligent robot population would change it. A number of different ethical theories discussed in Chap. 2, including deontological ethics, utilitarian ethics, the ethics of care and virtue ethics, can usefully be applied to these questions. The precautionary principle is also relevant. It attempts to encourage anticipatory environmental protection by identifying the potential for environmental harm in advance and to remove the need to prove a causal link between specific emissions of substances with a known hazard potential and observed environmental damage before action is taken to reduce the environmental damage (Dethlefsen et al. 1993). The approach can be extended to anticipatory reduction of other types of harm, for instance, to social relations and the structure of society.

While it seems unlikely that a truly intelligent and aware robot will be developed at any time in the foreseeable future, the possibility raises the ethical issues of the rights and responsibilities of such a robot. For instance, should an intelligent robot have the same rights and responsibilities as a person and be treated in the same way? Do we need to change our attitudes to robots to prevent exploitation of them? It would be desirable and probably necessary for an intelligent robot to be a moral agent. Programming 'ethical' behaviour into robots, as suggested by Asimov's stories, is one possible solution. However, this would remove their 'free will' and, as illustrated by these stories, is an inflexible approach which frequently leads to difficulties in real situations.

The role of the robots of the future could be extended by embedding them into emerging IT environments characterised by a growing spread of ubiquitous and cloud computing, communications and ad hoc networks of sensors forming what has been termed 'ambient intelligence'. However, this raises important ethical issues related to privacy and security, including of personal data. A number of potential uses of robots, including in travel aids for blind people, will involve the use of sensor system to obtain and disclose location-based and context-sensitive personal information, raising privacy threats. Changing contexts introduce new privacy threats and make it difficult to continuously satisfy privacy requirements. It will therefore probably be necessary to use adaptive approaches to manage changing privacy concerns. Privacy threats need to be taken seriously by all users, as illustrated by the increasing prevalence of digital identity theft (Lynch 2005) and cyberstalking (Spitzberg and Hoobler 2002). However, the privacy threats associated with the use of sensor systems have been underresearched.

It is probably fortunate that currently available robots are far away from this vision or possibly nightmare of being able to understand their environments, their goals and their own capabilities or to learn from their experiences. We are probably even further away from exploring and understanding the underlying ethical issues.

The time required to resolve the technical problems will make time available for us to consider these ethical issues and make decisions as to what types of robots we want in the future and probably even more important what types of developments we do not want and should not initiate. However, it is still open to question whether we will have the sense to do this rather than proceeding indiscriminately with all possible developments.

3.1 Industrial Robots

Current development trends in Europe include robots for small and medium enterprises (SMEs), some of which could make use of simple, flexible and cheap automation solutions based on robots. However, cost is an important issue for all SMEs and particularly for the smaller firms. Reliability and ease of maintenance will also be important, since SMEs are unlikely to have teams of technical people able to repair malfunctioning robots. Safety is another very important issue, since the robots may be in closer proximity to workers than is common in industrial practice and their users may include ‘white collar’ workers unused to working with equipment. There will probably be a need for very flexible and multifunctional robots as well as cooperative robots. Fulfilling all these specifications at low cost will be a considerable challenge. Approaches based on modular metamorphic robots (see Sect. 2.2) could be interesting, but the cost would need to be very significantly reduced to make them affordable.

3.2 Mobile Robots

Technological advances and the maturing of several technologies will facilitate the development of cheaper, faster mobile robots which are able to follow trajectories more accurately. These development include the following:

1. Developments in cognitive architectures and contextualisation which have enabled the development of context-based systems and customisation.
2. Major advances in processing technology and miniaturisation, allowing significant processing power to be included on pocket-size devices.
3. The development of smartphones with Bluetooth, Wifi and GPS.
4. The development of high-precision sensors.
5. Simultaneous localisation and mapping (SLAM) algorithms.
6. The development and improvement in accuracy of GPS-based navigation and the development of systems of multifunctional environmental information beacons.
7. The development of smart and lighter-weight materials and miniaturisation of components, facilitating the development of smaller, lighter and more attractive robots.

Some of the unresolved problems associated with mobile robots involve the following:

1. The development of effective location, mapping and navigation or SLAM-equivalent algorithms which can be used outside, particularly in unstructured and unknown environments, which have not been tagged, for instance, by radio-frequency identification (RFID) tags.
2. Improved stability and smoothness of gait.
3. Improved methods for each degree of freedom of motion of legged robots using artificial 'muscles' which are closer to human and animal muscles. Currently each degree of freedom is realised by an electric motor, a gear without backlash and a high reduction ratio and a controller.
4. Significant reductions in power consumption as well as the development of improved low-cost miniature power supplies.

Improvements in the design and functionality of mobile robots will lead to new applications, such as their use as 'agents' in the automation of production. There are also many potential applications in the area of service robots. A very brief overview of existing applications was presented in Sect. 2.1. One of the areas with considerable potential, as well as a number of challenging ethical issues, is robots for elderly and disabled people, sometimes called assistive service robots.

3.3 Service Robots

The use of personal and, to a lesser extent, professional service robots raises particular safety issues. In particular the users are untrained members of the general population rather than engineers or workers trained and experienced in working with robots. The nature of many applications means that the robot is much closer to the user than in most industrial applications. In addition, service robots are used to carry out activities which are part of the user's normal lifestyle, making the wearing of protection intrusive and socially unacceptable. In some applications, such as those involving disabled and elderly people, users may have slow reaction times or not be able to move away (quickly) in the case of incidents. For all these reasons, service robots should be considered safety critical systems and great attention paid to safety features in the design.

3.3.1 Assistive Service Robots

Combining the definition of robot and service robot in Sect. 2.1 with a definition of assistive technology (Hersh and Johnson 2008), assistive service robots can be defined as *an actuated mechanism programmable in two or more axes with a degree of autonomy which performs useful tasks for disabled and/or elderly people* to overcome *social, infrastructural and other barriers to independence, full participation in society and carrying out activities safely and easily.* Work on assistive robots started in the early 1960s and has intensified over the past 15 years or so, partly due to advances in technology. While a number of useful assistive robots have been developed, many projects did not go beyond the prototype stage and others did not even produce prototypes.

The main classification of assistive robots is into socially assistive robots, which, for instance, act as companions and toys, and physically assistive robots, such as robotic wheelchairs, smart homes and manipulators (Brose et al. 2010). A potential third category includes robotic limbs and organs (Burgar et al. 2000) and a fourth category design-for-all personal service robots. Design-for-all personal service robots are personal service robots, including the increasingly popular domestic vacuum cleaners and lawnmowers, which have been designed in accordance with design-for-all (universal design) principles (Connell et al. 1997). The aim of the design is to make these robots accessible and usable by as wide a range of the population as possible, regardless of factors such as age, gender, disability and size. In the case of disabled and elderly people, this will include designing appropriate interfaces to enable them to operate the robots and receive feedback from them.

To be attractive to disabled and elderly people, these robots will need to be very competitively priced, easy and intuitive to use, robust and reliable. They will also need improved navigation and obstacle avoidance functions to ensure that they do not bump into and damage furniture or, even worse, the user if they do not go out while the robot is working. A number of these robots are already able to return to their docking stations themselves. Useful future developments would include automatic emptying of the containers of vacuum cleaners. Robotic domestic appliances may be easier to use for many disabled and elderly people than existing appliances. However, it is important that the availability of such appliances is not used to justify a reduction in the funding of personal assistance.

Physically assistive robots include the following:

1. Robotic wheelchairs.
2. Robotic manipulators for reaching and lifting, personal care, eating and drinking.
3. Shopping aids, particularly for blind people, to guide them around shops and stores, locate and provide information about products and locate and fetch them.
4. Smart homes with a range of facilities.

Socially assistive robots include the following:

1. Social assistants, particularly for autistic people, including to facilitate social contact and practice social interaction.
2. Robotic guides for blind people.
3. Toy robots for children, including to facilitate social interaction.

Robots with both physically and socially assistive roles include the following:

1. Personal assistants and/or companions.
2. Travel support robots, including when overseas.
3. Guides and physical support in public buildings, including museums, shopping centres and hospitals.

Robotic guides in public buildings may also be of interest to younger and non-disabled people. For instance, robotic shopping guides have been trialled in home improvement stores in Germany (Gross et al. 2009). A design-for-all approach could ensure that they had suitable functionality and interfaces to be of use to disabled and elderly people.

3.4 Ubiquitous and Cloud Robots

The term ubiquitous robotics is derived from ubiquitous computing. Basic concepts of ubiquitous robots include networking of every robot, seamless and intuitive operation of user interfaces, robot accessibility at any time and any place and the provision of context-based services, i.e. services which are determined by the particular context.

Cloud robots use a cloud computing infrastructure for fast processing of data, particularly data-intensive tasks such as image processing and voice recognition. This has the advantages of reducing the memory and processing requirements of the onboard processor or other computing devices, since the robot uses the processing power of the cloud computing infrastructure. For conventional robots, every task, such as moving a foot, grasping an object or recognising a face, requires a significant amount of processing and preprogrammed information. Consequently, sophisticated systems such as humanoid robots need powerful computers and large batteries on board to power them. Using the cloud has the advantages of both reducing the need for a powerful computer and large battery on board and improving the robot's capabilities in areas such as speech recognition, language translation, path planning and 3D mapping.

However, the use of a cloud raises ethical issues relating to privacy and data security with the possibility of unauthorised users having access to data and data processing which does not take account of users' privacy requirements. In addition, users frequently lack knowledge of the issues and are therefore not in a position to make appropriate trade-offs between privacy and other issues. Designers of cloud robots therefore have an ethical requirement to both make users aware of the privacy threats and to design adaptive privacy management systems into the cloud robot to counter them. In addition, cloud options can sometimes be very slow or even unavailable. A back-up option could ensure robot functionality when the cloud is not available but would negate the advantages of using a cloud. Therefore, there is a need for research to improve cloud reliability and speed, as well as on adaptive privacy management.

Current research topics in this field include the following:

1. Development of a very large database where robots can store and retrieve information about objects, environments and different tasks.
2. Development of a cloud computing infrastructure for generating 3D maps of the robot environment, as this is much faster than using an onboard computer.
3. A software platform for the control of robots by smartphones or repositories for frequently manipulated objects by robots to simplify gripping tasks.

3.5 Bioinspired Robots

In the past, the behaviour of technical systems has often been considered to be very different from that of organic systems. However, there is now increasing interest in looking to bioinspired approaches or using solutions in nature to find responses to technological problems. Classical examples include cyborg insects developed as part of the Hybrid Insect Micro Electromechanical Systems (HI-MEMS) programme (http://spectrum.ieee.org/podcast/biomedical/bionics/cyborg-cockroaches-to-the-rescue), which is aiming to develop methods for controlling insect locomotion, and the six-legged spider walking robot Lauron (http://www.fzi.de/forschung/projekt-details/lauron/). There are also a number of animal robots, which are attractive as toys and companions. One of the oldest and best known is the Sony AIBO dog robot (Fujita 2001; Golubovic and Hu 2002). Others include the NeCoRo cat robot (Libin and Libin 2004) and the Paro baby harp seal robot (Wada and Shibata 2007; Wada et al. 2004).

4 Roboethics

4.1 Introductory Ideas

Current approaches to roboethics are mainly based on considering how to make intelligent robots behave morally, largely through the provision of moral rules to govern their actions rather than considering the wider issues associated with the (widespread) introduction of (intelligent) robots. The basis of roboethics is Isaac Asimov's '3 (4) laws of robotics' (undated, p. 27).

First Law: A robot may not injure a human being or, through inaction, allow a human being to come to harm.

Second Law: A robot must obey orders given to it by human beings, except where such orders would conflict with the First Law.

Third Law: A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Fourth Law (Law Zero) (added later): No robot may harm humanity or, through inaction, allow humanity to come to harm.

While these laws are very simple, conflicts and contradictions will occur in practice, as Asimov (undated) illustrates in his short stories. As discussed in Chap. 2, there have been attempts to encapsulate human ethics in a single principle, but in practice a combination of ethical principles is required to give a full approach to ethics. In addition, many of these ethical principles are more complex than Asimov's laws of robotics, and they frequently require interpretation. One of the problems with this approach to morality for robots is that it is purely rule based and does not allow for intelligent decision-making or any actual agency, therefore making robots tools rather than moral agents. This is very much distinct from approaches to morality and ethics for humans which assume that they are moral agents capable of making decisions. This is particularly relevant to the case of decision-making in the presence of uncertainty, where the inflexible application of rule-based approaches can lead to serious or even fatal errors. There are many situations in which only limited information is available, but people generally try to use their intelligence to compensate for this lack of information and avoid many of the problems that would otherwise occur.

In Asimov's stories, the laws are designed into the robots, so (at least in theory) they are unable to cause harm or disobey humans. In practice their lack of flexibility and inability to respond to the unexpected sometimes leads to situations where quick and creative reaction is required by humans in order to avoid harm. The idea of designing the inability to cause harm into technologies is an interesting one, but as the stories indicate (even leaving aside the fact that we have not quite reached this point of technological development yet), this is not simple. The term 'harm' is not very precisely defined and is capable of different interpretations. There is also a probabilistic element in determining what will cause harm, particularly with regard to mental harm, where it is more difficult to define precisely what will cause harm than in the case of physical harm.

Despite the contradictions between the laws in many situations, it would be interesting to consider the application of these laws (extended to include other species and the environment) to all technologies. They would definitely prohibit the development of offensive weapons and support alternative approaches to security (as discussed in Chap. 11). However, the laws do not give clear answers in the case of self-defence. Application of the laws would also lead to much stricter regulation of technologies with possible negative impacts on health and safety and the environment. This would result in, for instance, much stricter limits on discharges and emissions.

Asimov's laws would prohibit the use of robots by the military. As discussed in Chap. 11 and Sect. 5.2 of this chapter, the use of military robots is likely to reduce the barriers to military conflict and war, increase the percentage of civilian casualties and increase the number and probably also the seriousness of human rights violations. While the laws make robots pacifists, they lead to conflict in the case of the appropriate response to an attack. The first clause of the first law requires robots to take a very strict pacifist position which does not allow self-defence using force in response to an attack, as this might result in harm to a human. However, the second clause of this law requires them to take a less strict pacifist position and to use limited force to defend humans against an attack which would otherwise cause them harm. There is therefore clearly a contradiction. A further ambiguity results from the fact that it may not be clear when it is possible to defend humans against an attack without the use of force which will lead to harm to other humans.

The following parody of Asimov's laws has been designed for military robots and illustrates the ethical problems associated with their use:

1. A robot may not injure an authorised representative of the government or giant corporation but has to terminate all intruders.

2. A robot must take orders from authorised representatives of the government or giant corporations, except when their results would be in conflict with the third law.
3. A robot must protect its own existence at any price, because a robot is terribly expensive.

Application of Asimov's laws would considerably improve the functioning of many police forces across the world which resort to the use of force unnecessarily and carry out various abuses, particularly against members of minority groups. However, it would lead to uncertainty and an inability to act in the limited number of cases in which it is necessary to restrain someone in order to prevent them from causing harm to themselves or others.

4.2 Wider Approaches to Roboethics

Developments in robotics to date have been based on mathematics, science and engineering. However, discussion of roboethics in both its narrower and wider senses requires a contribution from the humanities, including ethics, philosophy and theology, as well as the biological sciences, including physiology and neuroscience. Roboethics could thus be considered to span a range of different fields and requires expertise in both science and engineering and the humanities.

The main issues in roboethics are the much wider issues relating to decisions on what types of applications of robots can be implemented ethically, as well as the process of implementation to ensure that they are ethical in practice. The following commonly used definition of roboethics by Veruggio (2002) does allow for this wider understanding, particularly as modified by the authors to include the impacts on other species and the environment: *'Roboethics is an applied ethics whose objective is to develop scientific/cultural/technical tools that can be shared by different social and technological groups. These tools aim to promote and encourage the development [including the latest developments] of robotics for the advancement of human society and individuals [and protection of other species and the environment and to help preventing its misuse against humankind [other species and the environment].'*

5 Illustration of Ethical Issues

The current and future applications of robots present both numerous opportunities and many threats. Unfortunately, a number of applications raise ethical issues and in some cases the appropriate solution should be not to proceed. In this section some of the ethical issues associated with robots are illustrated through discussion of particular applications. An overview of some of the benefits and problems, as well as possible ethical solutions or recommendations, is presented in Table 3.1, following which the ethical issues in some of these applications are discussed in detail.

Table 3.1 Selected examples of the use of robots, some of which are adapted from Veruggio (2010)

Robots	Benefits	Problems	Ethical recommendations
Industrial	Possible increase in productivity and speed. The ability to carry out tasks which are dangerous or unpleasant for humans	Possible deskilling and loss of jobs and workplaces. Possible loss of respect for manual work	Evaluation of appropriate roles for robots and where it is better to use people. Limited use of robots or decisions not to use them in some applications. Programmes to create new skills. Political and other measures to increase job availability and security
Mobile robots	Wide range of applications including personal assistants and travel support	Safety, (data) security, privacy	Information to make users aware of privacy and security issues. Improve design to increase safety and include adaptive privacy management. Update safety, security and privacy standards
Humanoid robots	Increased efficiency in performing complex tasks, possibility of carrying out dangerous and unpleasant tasks	Possible deskilling; unpredictable long-term social impacts and unpredictable behaviour of robots	Programmes to create new skills. Political and other measures to increase job availability and security. Controlled introduction of humanoid robots and ongoing study of their impacts on society with the possibility of curtailing or restricting further introduction of robots if necessary. Systems for the control of robot autonomy
Domestic robots	Potentially give people more time for social interaction and leisure by liberating them from household tasks	Possible safety issues, particularly when the household includes children or animals. Possible loss of respect for manual work and housework	Design to very high standards and extensive testing, paying particular attention to possible presence of children and animals
Cloud robots	Reduced requirements for onboard processing and increased efficiency in performing complex tasks	Possibility of reduced speed of operation, reliability problems and breakdowns, (data) security and privacy issues	Update international fault tolerance standards to take into account cross-effect complexity. Update safety, security and privacy standards. Make users aware of privacy and security issues. Improve design to improve reliability and robustness and increase safety and include adaptive privacy management

Exploration and demining robots	Use of robots in dangerous situations; reduction of risk to humans	Unpredictable impacts on the environment	Investigation of the impacts of robot use on the environment
Health care	Minimally invasive surgery; reduction in patient recovery time	Breakdown of surgical robot systems can cause potentially fatal problems; possible deskilling of medical personnel. The risk of unauthorised people accessing data from the robots	Very strict standards, including for safety issues. Regular updating of standards and reviews of use context. Very cautious introduction of robots to health care with constant monitoring and research on impacts and the possibility of limiting or halting this introduction. The development of privacy management systems for health care (robots)
Military robots	Attractive to military, but no real benefits to people	Reduced resistance to violent conflict and war. Increasing percentage of civilian casualties	Cease development of military robots and decommission those already in use. Programmes of conflict prevention, environmental protection, poverty alleviation and peace building
Toy and companion robots	Fun to play with. Can facilitate social interaction of some autistic children and young people. Potential for teaching all children and young people more cooperative approaches to social interactions	Impacts on social relationships and longer-term impacts on society are unpredictable. Risk of focussing on behaviourist approaches with autistic children rather than developing strengths	Research on impacts of toy and companion robots for autistic, and other disabled and non-disabled children and adults. Cautious and carefully targeted introduction with monitoring of the impacts
Socially assistive companion robot for adults	Can interest, motivate and engage people and encourage them to participate in activities and do exercises and calm them when depressed	Risk of reduced human (or animal) companionship for which robots are not a substitute. Deception may be used, e.g. with people with dementia to make them think the robots are real. Risk of ignoring problems that are causing agitation. Risk of use as a control mechanism, including of behaviour. Privacy risks if user data is collected	Good resourcing of support for elderly and disabled people. Disability and elderly equality training for all professionals working with disabled and elderly people. Improved training in communication strategies and the provision of information, e.g. to people with dementia. Research on privacy management. Full information to potential users about privacy issues so they can make informed choices

5.1 Robotic Systems for Health Care

Medical robots (Li and Xu 2007; Mavroidis et al. 1997) are being used in health care, including in operating theatres (Mettler et al. 1998; Ruurda et al. 2002). This includes very small-scale systems down to subatomic particle size, and systems an order of magnitude smaller are being developed. Applications can be divided into the following three groups: (1) robotics for medical procedures, (2) systems to support training and (3) robotic body part replacement or strengthening. They include the following:

1. Robotics for medical procedures.
   (a) Robotic telesurgical workstations.
   (b) Robotic devices for endoluminal surgery.
   (c) Robotic diagnosis systems, including computerised axial tomography (CAT) scan, nuclear magnetic resonance (NMR) and positron emission tomography (PET).
   (d) Robots for therapy, including laser eye treatment, targeted nuclear therapy and ultrasonic surgery.
2. Robotic systems to support training.
   (a) Virtual environments for surgical training.
   (b) Haptic (tactile) interfaces for surgery and physiotherapy training.
3. Robotic body part replacement or strengthening.
   (a) Artificial limbs (legs, arms).
   (b) Artificial hearts, kidneys and other organs.
   (c) Artificial sensory organs (or parts of sensory organs), including the eyes and ears.
   (d) Exoskeleton to strengthen limbs and/or the spine.

Medical robotics raises a number of challenging ethical, social and technical questions. From the technical perspective, many medical applications and, in particular, surgery have very low tolerance of error. In addition, robotic surgery generally involves a small workspace and reduced sensory input. Issues of safety, reliability and control are of fundamental importance and back-up systems may be required. Size, costs and functionality are also important. The use of robotic surgery may require surgeons to develop additional skills while maintaining existing skills. There are also ethical issues relating to the role of the robot. In the case of robotic surgery involving very small-scale robots, e.g. nano- and femtorobots, on the scale of or able to manipulate items of size from 10^{-9} to 10^{-15} m, it is probably natural to consider the robot a tool, even if it has some degree of intelligence. There may also be issues of the degree of autonomy which it is appropriate to grant this robot. This raises the question of the overall ethical responsibility of the surgeon, particularly in the case of very-high-performance and high-reliability robots which can carry out tasks more safely and effectively than the surgeon. However, there will still be a need to intervene in case of problems. The role of the medical robot and whether it should be considered a tool or an aid to doctors and other medical personnel are probably more ambiguous in other circumstances. However, the final responsibility should always be that of the human surgeon (Veruggio 2002).

Nano- and femto-(subatomic particle size) robots may revolutionise medicine and enable a wide range of conditions, such as heart disease and cancer, including currently untreatable serious and life-threatening illnesses to be cured. However, considerable further research will be required before this is possible (Kostarelos 2010). Therefore, the first ethical issue is great care in the dissemination of information about such treatments to avoid raising unjustified expectations and hopes. From the ethical perspective, nano- and femto-scale robots have a number of disadvantages. In particular, their short- and long-term impacts on humans and the environment are unknown due to lack of experience of their use. Therefore, the associated risks are also highly uncertain. However, potential impacts could occur at the molecular level, making nano- and femto-scale robots qualitatively different from existing medical technologies. This argues for considerable caution and the need for extensive testing before they are used. It may also be difficult to develop appropriate ethical testing procedures which do not put people, animals or the environment at risk.

Although the technology is not yet available, it is not unlikely that at some point in the not too distant future, semi-autonomous nanorobots will be developed that can be implanted in the body to detect and repair at least some problems. Such robots would raise a number of additional ethical issues, including issues related to informed consent and understanding of the long-term implications, particularly since the robots would remain permanently in the person's body. There would probably also be associated (data) security and privacy issues, since the robots will probably obtain and may store or transmit medical data about the person. It is therefore essential both that individuals know and fully understand what type of information is being produced and stored about them and that appropriate privacy management systems are implemented to ensure they have control over this data and its uses.

5.2 Military Robots

This is unfortunately one of the areas in which there is considerable interest and for which significant research funding and other resources are available. As discussed in Chap. 11, robotic aircraft or armed drones flown by ground-based pilots and guided by space satellite technology from computer terminals are being used in a range of applications, including spying and surveillance. Other possibilities include autonomous tanks or armoured vehicles carrying weapons and/or tactical payloads, intelligent bombs and missiles, autonomous underwater vehicles and submarines and intelligent torpedoes. Particular problems with the use of drones and other autonomous and robotic systems include the impossibility of distinguishing between civilians and combatants and the distancing of both governments and the military from the consequences of the use of military force and feelings of responsibility. Thus, the use of robotic aircraft, underwater vehicles or missiles is likely to increase both the incidents of violent conflict and war and the number of civilian deaths in them. As discussed in Chap. 11, armed drones have already been used to kill 'militants' in Pakistan by operators based in the USA. Thus, their use has the potential to extend the scope of the battlefield, for instance, from the USA to the rest of the world. This is very worrying and has serious ethical implications.

The use of advanced military technologies, such as robotics, is likely to be the most 'effective' and make the greatest difference in conflicts where there is a great disparity between the resources available to the two sides. Their use therefore has the potential to increase the likelihood of massacres and other human rights violations. In the case where the sides are more nearly balanced in resources, the use of robots is unlikely to give a significant advantage or be particularly effective. In conflicts between two highly industrialised nations, it would be possible to imagine two robot armies fighting each other with little involvement of humans. This would reduce the loss of life of combatants but not necessarily of civilians and would also lead to some or even significant destruction of infrastructure. However, in this case, if it is really not possible for the two (or more) sides to get together to discuss the issues, it would be a lot more sensible to use a game of Robotsoccer to decide the outcome. The development of expensive military technology, such as military robots, also has very high opportunity costs, as it diverts scarce resources from other areas which benefit people and/or the environment. For instance, several studies have shown (e.g. Anderson et al. 1991; Knight et al. 1996; Melman 1988) that military spending reduces economic growth and productive investment and creates fewer jobs and lower total income than spending on education, public transport, health care and construction for home weatherproofing.

In addition to the impact on specific conflicts, robotic weapons can effect international stability more generally. New weapons are likely to be a source of increased instability. This is particularly relevant to robotic weapons with some degree of autonomous firing, since this can reduce barriers to indiscriminate killing, violent conflict and war and increase the proportion of civilian casualties. Therefore, the development of military robots is likely to reduce international stability and should be avoided.

5.3 Armed Robotic Security Forces

'Robosoldiers' were developed by Thai scientists. A particular example is Roboguard which is intended to provide a cheap alternative to soldiers, policemen and security forces. It is armed with a pistol or gun and equipped with a small video camera and infrared sensors. The user can control the Roboguard remotely over the Internet and only needs to enter the password and give the command to shoot a suspected intruder. The ability to shoot from a distance and without having to actually see the person being shot is likely to lower barriers to shooting. It also both removes any check that the ‘intruder’ actually intends harm to the people in the building and de facto removes the rights of the ‘intruder’, as well as increasing the likelihood of possibly fatal accidents to, for instance, members of the household returning unexpectedly, children playing pranks and even cats who have managed to sneak in. In addition, the presence of armed police can increase tension and the likelihood of violence. Robot technology has not yet developed to the point where robots can be used for more sophisticated police roles that do not involve shooting. The use of armed robots in the home also raises questions about the type of society we want to live in. There are ethical ways of reducing the incidence of burglary through social, political and economic changes, as well as improved security measures that do not lead to people living in (armed) fortresses.

5.4 Companion and Toy Robots

The lifestyles of young people are changing and some sort of virtual or online component is becoming increasingly important. Robots have a role as toys and companions for children and (young) people. They have a particular role in providing support for autistic children and young adults and have been shown to be able have a role in mediating interaction, including with other children (Dautenhahn 2007; Robins et al. 2005). Robots can also be fun to play with, and simpler robots in particular can be built from a kit, allowing children and (young) people to learn about technology design and construction, as well as learning to work cooperatively, for instance, on the construction of the robot. Robots can also have a number of other educational roles. However, the widespread use of robots as toys and companions may have significant impacts on society. Therefore, there is a need to research and try to evaluate the potential impacts of different types of social use of robots and to use the results to introduce them in ways that have desirable rather than negative impacts.

Humanoid robots include Emiew (Hosoda et al. 2006) developed by Hitachi, which balances on two wheels, moves at a good walking pace (6 km/h) is 130 cm high, has a vocabulary of 100 words and is able to avoid obstacles and shake hands. It has been cynically suggested that the ability to say 100 words and shake hands would allow Emiew to become a politician.

Archie (Baltes et al. 2009) (Fig. 3.4) is being developed at the Vienna University of Technology as an ethical, cost-oriented humanoid robot able to support individuals in everyday life. Archie is humanoid, has the size of a teenager and has a head, a torso and a pair of arms, legs and hands. Archie should be able to walk in unknown environments, carry out a number of tasks and express ‘emotions’ appropriately depending on the context. As well as other applications, Archie can be used to support the development and evaluation of different walking algorithms, such as the zero-moment point method (Vukobratović and Borovac 2004).

A number of robots have been used with autistic children, including the humanoid robots Robota (Billard et al. 2007), Kaspar (Robins et al. 2010), Keepon (Kozima

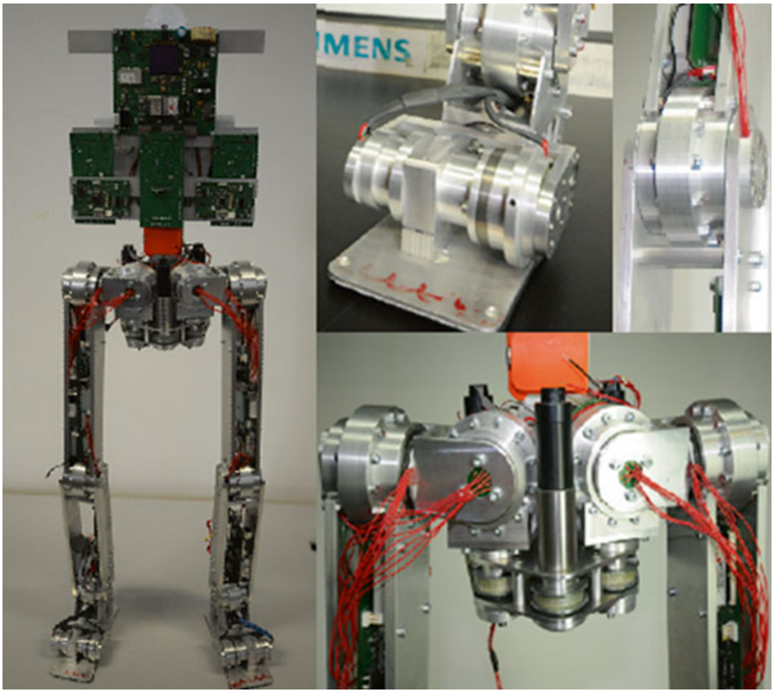

Fig. 3.4 Archie

et al. 2005) and NAO (Barakova and Lourens 2010; Gillesen et al. 2011; Shamsuddin et al. 2012) and non-humanoid robots, including a mobile flat-topped robotic platform (Werry and Dautenhahn 1999). The NAO robot from Aldebaran Robotics is a commercially available 50 cm-high walking humanoid robot with 25 degrees of freedom, digital cameras, speakers, microphones, touch sensors and wireless communication capabilities. Movement, speech, touch and LEDs in the face and body provide interactive behaviour, including simulated facial expressions. NAO is able to communicate using simple expressions in eight languages and is able to recognise and remember faces, voices and body shapes. (Gillesen et al. 2011). Small-scale studies have shown that autistic children enjoy playing with these robots and that their use can have positive impacts on social interaction and behaviours (Dautenhahn 2007; Robins et al. 2005). However, the use of robots in this way has frequently been based on assumptions about appropriate types of social interaction. On the one hand this can have advantages in supporting social development and social interaction and moves towards increased independence. On the other, if not carefully managed, the use of robots in this way could lead to robotic-type behavioural imitation without understanding and force development in ways that are not natural for the particular autistic child and hinder the development of their strengths and natural ways of interacting.

5.5 Robotsoccer

Robotsoccer is played in teams by small mobile robots (see Fig. 3.5). It was first introduced about two decades ago to develop intelligent cooperative multi-robot (agent) systems (MAS) and as an easy means of the young generation learning about difficult scientific and engineering subjects through games. From the scientific viewpoint the soccer robot is an intelligent autonomous agent which carries out tasks with other agents in a cooperative, coordinated and communicative way. Robotsoccer has generally proven to be a good test bed for the development of MAS tools. In addition, a number of people find it enjoyable and this makes it a useful educational tool (Kopacek 2009). Soccer robots should be programmed to play ethically, i.e. a hard but fair game, and not try to cheat or commit fouls. It is also important to examine the potentially negative impacts of Robotsoccer. It seems unlikely that playing Robotsoccer will replace actual involvement in sports but could substitute for watching soccer and other games. The latter effect, if it occurs, could have a negative impact on soccer and other teams.

5.6 Networked Robots

Robots with an Internet connection are a precursor stage for cloud robots. This will permit access to Internet-based resources as well as both human-robot interaction, including for operation at a distance, and robot-robot interaction, including for data

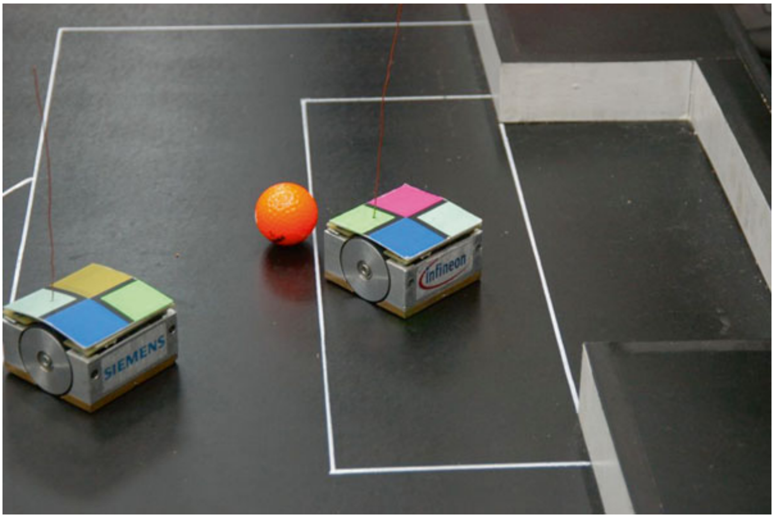

Fig. 3.5 Robotsoccer

sharing and cooperative working and learning. On the other hand there are risks. In particular, these include data security and privacy issues resulting from the notable insecurity of the Internet (Cohen 2001), including the ability to track all operations of the robot. As in the case of the Internet, once they are readily available, it is likely that many individuals and organisations will become dependent on networked robots. This would lead to serious problems in the event of server or robot malfunction. In the case of the provision of primary services, it is important that non-robot options are available both as a back-up in the case of robot malfunction and to avoid the exclusion of people who do not want to use robots. The social and psychological impacts are still unpredictable and require further research, including the possibilities of technology addiction, changes in behaviour or psychological problems from constant interaction with robots.

5.7 Search and Rescue Robots

Robots can be used for exploration, search and rescue, particularly in difficult and dangerous terrain or after a fire, structural collapse or other accidents or disasters both within and outside (large) buildings. They could also be used to support human rescuers through the use of swarms of small flying robots, which are able to monitor the area, maintain contact with a controller and warn human searchers of potential dangers in time for them to depart safely or to take other effective action. If small amphibious, swimming or underwater robots with similar capabilities are developed, then they could carry out similar monitoring or rescue operations in and underwater, for instance, on a capsized ship. Robots built from sufficiently fireproof materials could be used to support fire fighters and to rescue people trapped in burning buildings which fire fighters are only able to enter at great risk to themselves.

The use of robots in this way would have significant advantages in terms of improving safety and reducing the risks to human search and rescue personnel and firefighters, as well as reducing the time required to locate and rescue trapped individuals. This could lead to an in increase in the percentage of trapped individuals located and rescued and reduce the time to rescue. This would improve survival rates by reducing both the time individuals are trapped in difficult conditions and the time until they receive medical care. This type of application in which robots are used to support humans or enter areas which are too dangerous for them raises few ethical issues. However, care will be required in the use of the sensor data from such rescue operations to avoid security and privacy violations. At the current state of the art, such search and rescue support robots require human supervision (Beer et al. 2012). However, in the future such robots could become more autonomous and possibly start to replace people, giving rise to the possibility of job losses and deskilling, as well as putting trapped individuals at risk in the case of robot breakdown.

5.8 Socially Assistive Robots for Older People

Socially assistive robots, including animal robots such as the cat NeCoRo (Libin and Libin 2004), baby harp seal Paro (Wada and Shibata 2007; Wada et al. 2004) and dog AIBO (Fujita 2001), provide assistance to people through social interaction (Scassellati et al. 2012). It is possible that the human tendency to attribute human intentions and goals to even very simple mobile devices may increase the effectiveness of companion and social robots, compared to, for instance, a program on a computer or mobile phone (Feil-Seifer and Mataric 2005).

A review of the studies of the use of socially assistive robots with people with dementia (Mordoch et al. 2013) found that the animal robots NeCoRo, Paro and AIBO led to increased social interaction and reduced stress (as measured by physiological symptoms) and reduced staff burnout when used in a day care centre. This is clearly positive. However, there is the risk that the fact that robots are calming people by their presence is a case of treating symptoms rather than their causes and therefore results in the underlying problems which are causing this stress being ignored. In one study (Marti et al. 2006), Paro, which has a ubiquitous tactile sensor between the hard inner skeleton and the white fur, making it soft and pleasant to stroke, was found to calm an elderly man with dementia. However, part of the calming effect seemed to relate to his belief, supported by the therapist, that Paro was alive and the resulting feelings of responsibility for it. On the one hand, he benefitted in the short and possibly also the long term from increased feelings of calmness. On the other, deception was used and may have encouraged or strengthened his feelings of confusion between real people and objects, such as robots. The use of deception could also be considered to indicate a lack of respect towards him.

Studies have found that older people in an institutional setting were excited about the presence of a robot and that it led to increased activity (Pineau et al. 2003). On the one hand this is positive. On the other, it raises the issue of whether this group of people were frequently bored and felt abandoned. In this case the solution would be to make available more activities, including activities outside the institution, and options for contact with other people, as well as with animals. This supposition is supported by evidence from three focus groups (Wu et al. 2012) with older people (65–89 years old), some with cognitive impairments. While they reacted positively to several of the robots they were shown, they were concerned and even afraid of contact with robots being substituted for contact with people and robotic projects being funded rather than human assistants for older people. Although they considered the seal robot Paro charming, they considered interaction and communication with it ‘not a genuine interaction’ and ‘communicat[ion] with nothing’.

6 Ethical Evaluation Using Theories of Ethics

The ethical issues associated with both the increasing use of robots in general and some specific applications will now be discussed using some of the theories of ethics presented in Chap. 2. Many of the long- and even medium-term impacts of the widespread introduction of robots are difficult to predict. They are also likely to affect a large proportion of the population, including many people who do not use robots. This situation is covered by the ethics of experimentation in which the introduction of technology is treated as social experimentation and requires 'subjects', i.e. everyone affected, to have full information to make informed decisions and voluntary participation without coercion or deception. This would require information about the potential impacts of different types of robots to be prepared in jargon-free form for people without a technical background and widely distributed and all services provided with the assistance of robots to be available in other ways. In a society in which robots become all pervasive, it would be very difficult for individuals or even groups to opt out, indicating that the pervasive use of robots is not totally in accordance with the ethics of experimentation.

The ethics of experimentation is also relevant to specific applications such as medical robotics. While informed consent is part of standard medical practice, the choice may be between accepting a particular treatment and no treatment. If the use of medical robotics becomes pervasive, for certain conditions the only treatments on offer may be based on the use of robots. Where other options are not available or difficult to access, the idea of informed consent loses some of its meaning. This is particularly problematical, since very limited information is currently available about the short- and long-term impacts of the use of different types of robots, including nano- and femto-scale robots. Therefore, the ethics of experimentation would imply that the provision of medical and other services through robotics should be one of a number of options rather than replacing existing treatments.

The ethics of care involves a context-based approach to preserving relationships. Here the issue is the impact of the use of robots on relationships between people and, to a lesser extent, between people and robots. Particular applications of relevance include industrial robots and companion and toy robots. In the case of industrial robots, any applications which lead to a reduction in either available employment or working conditions will lead to a deterioration of relationships and are likely to be counter to the ethics of care. However, it should be noted that the use of robots may have a complex impact on the workplace and change the nature of the jobs carried out by human workers rather than reducing the total number of jobs available. It could both lead to deskilling and change the skills required. The impacts of the use of companion and toy robots on the relationships between people, including children, will depend on the way in which they are introduced and the extent to which they complement or replace human companionship. Trials indicate that robot use can increase the interaction and communication competencies of autistic children and that they are using the robot as a 'mediator' to support interaction with the experimenter and other children (Dautenhahn 2007; Robins et al. 2005). There may therefore be a wider role for social robots in training and preparing children and young people for positive interactions with others based on cooperation rather than competition. However, it is important that, particularly in the case of autistic children and young people, social robotics are used to support them and encourage development of their strengths and not in an attempt to 'normalise' them or force them to interact in particular ways.

In terms of deontological ethics, the aims of the development and introduction of robots are generally positive and based on the application of technology to benefit humanity, though the approach sometimes ignores the environment and other species and/or may be driven by the possibilities of developing the technology rather than the benefits to be derived from it. With regard to utilitarianism, many of the consequences are not foreseeable in advance. Positive utilitarianism requires careful consideration to be given to risks and costs as well as benefits and negative utilitarianism to offsetting and mitigating present and future harms. Thus, a careful approach is required to developments in robotics where the short- and long-term impacts are unknown and/or it is difficult to determine and evaluate the risk.

7 Reducing Environmental Impacts

Since the first industrial revolution, humanity, particularly in the minority world ('developed') countries, has consumed increasing amounts of natural resources and emitted increasing volumes of pollutants into the environment. Technological improvements have resulted in significant energy and resource efficiencies but not sufficient to counter the effects of continuing growth.

The use of robots affects the environment in two different ways: (1) the impacts of robot production and use over the life cycle, which should be minimised, and (2) changes in resource and energy requirements and emissions and waste in processes in which robots are used.

Minimising the environmental impacts of robot production and use should include the following:

1. Minimisation of material and energy requirements including through appropriate design choices and efficiency gains.
2. Minimising transportation of components and finished robots, e.g. by manufacturing robots near where they will be used with locally produced components and, as far as possible, using local materials.
3. Minimising waste and emissions, for instance, through appropriate design and efficiency gains.
4. Maximising life span, for instance, through design for easy upgrading. It seems probable that in the more demanding applications, robot hardware and software will become dated over a period of 2–3 years, analogously to computers. In these applications, upgrading rather than replacement will only occur if this is both relatively easy to do and cost effective. In other applications, the robustness of

the robot and its resistance to temperature, humidity and other environmental conditions will determine its life span.

5. Design to minimise energy use, including various power management options.
6. End-of-life management (Kopacek and Kopacek 2013) based on reuse, refurbishment or upgrading and recycling, supplemented by energy recovery, with the preference for reuse or refurbishment. Robots should therefore be designed to facilitate upgrading and recycling, for instance, through a modular design and design for easy dismantling.

While the use of robots to replace human workers will generally have energy consumption costs related to robot use, their use may lead to reductions in energy and resource use, emissions and/or waste which can be set against this. More generally, the use of advanced technologies such as robots can have positive environmental impacts over the whole life cycle, but this will require appropriate design and implementation (Hersh 1998).

8 Conclusions

The chapter has discussed various ethical issues related to the (widespread) use of robots from an informed technological perspective. A brief overview of some of the main developments in robotics and some of the main applications of robots was provided as a background for the informed discussion of ethical issues. A number of potential future applications of robots were introduced and some of the associated ethical issues discussed. Introductory ideas in roboethics based on Asimov's (undated) laws of robotics were presented and their limitations as an approach to roboethics considered, including the limitations of focussing largely on ethical issues associated with robot behaviour. This was followed by the presentation of a wider definition of roboethics by Veruggio (2002) with modifications by the authors to move to a wider than purely human-centric perspective and explicitly mention the environment. This definition covers the wider ethical implications of robots and, in particular, the ethical issues associated with particular types of applications, including whether certain types of application should not be implemented on ethical grounds. A number of the theories of ethics presented in Chap. 2 of the book were applied to highlight some of the ethical issues associated with robotics.

A table of the benefits, potential problems and possible ethical solutions for a number of different types of robots was presented, and some of the underlying ethical issues were illustrated by discussion of examples of a number of applications, not all of which were considered to be ethical. In particular, the problems with military robotics were noted and it was suggested that research and implementation in this area should cease. This was further highlighted in the subsection on military uses of robotics. The impacts of robots on the environment were also discussed and suggestions made for reducing their environmental footprint over the life cycle.

Robotics is a fast developing area. Both advances in technology and new applications will give rise to new ethical questions, which will need to be investigated. Currently technological determinism, leading to developments because they are feasible rather than because they are desirable, and powerful vested interests, such as the military, have had too much influence in determining the nature of developments in robotics. This needs to change and more attention be given to what is desirable and beneficial for both humanity as a whole, including its poorest members, and the environment rather than technology development and introduction being driven purely by what is technologically possible.

There are a number of questions which require further investigation. In particular, there are many uncertainties with regard to both the short- and long-term impacts and potential and likely benefits and harms of particular uses of robotics, especially those associated with nano- and femto-scale robots. This complicates evaluation of the ethical issues and may lead to a focus on issues of low relevance while ignoring other more important ones. The potential impacts of nano- and femto-scale robots at the molecular scale make them different in kind from other types of technologies and may complicate the development of ethical procedures for evaluating their impacts. Particular investigation is also required of the short- and long-term human and environmental impacts of the use of nano- and femto-scale robots. Another important area is the impacts on social relationships of the increasing use of companion and toy robots and how such robots could be used to encourage positive and more cooperative rather than competitive social behaviours.

Currently robots are machines and therefore raise many of the same ethical issues as other types of machines. While they are treated as machines, then issues of responsibility in the case of problems are similar to those for other machines. Developers should be considered to have a particular responsibility for design which is easy to use, is reliable and makes it easy to avoid errors. This should include incorporation of both usability (McLaughlin and Skinner 2000; Nielsen 1993; Quesenbery et al. 2001) and design-for-all principles (Connell et al. 1997; CEN 2003). In the case of usability, checkability, low error rates or error tolerance and design to prevent errors caused by interaction with the user and to help the user recover from errors, including by checks to ensure that the correct information is entering and leaving the system, are particularly important. Design-for-all principles should include design for simple and intuitive use with the design easy to understand, regardless of the user's experience, knowledge, language skills or current level of concentration. Organisations in which robots are used have an ethical responsibility to avoid the systemic factors which lead to technology failure and are subsequently generally inappropriately blamed on operators rather than systemic organisational problems being investigated and corrected (Hersh 2006).

As indicated by the discussion of early approaches to roboethics, there is considerable interest in the potential for robots to become autonomous agents, moral or otherwise. As indicated by the discussion of military robots, some robots are already able to act with autonomy in limited circumstances. However, there seems to be particular interest in robots as independent decision makers, implying a considerable degree of intelligence. Some independent decision-making would be possible with an intelligence based on a very sophisticated rule-based system, though more complex decisions would require the ability to go beyond rules and use the type of creativity typical of people. This raises the questions of the extent to which robots will ever be capable of this type of creative thought and their rights and moral responsibilities if this happens. While interesting from a research perspective, this issue is not of immediate practical relevance. There are also associated ethical and other issues of whether there is any need and role for robots with human behaviour and reasoning ability. This is particularly relevant in the context of a large and still increasing human population. It seems likely that such robots would be used to replace people and drive down wages in a variety of applications. While such robots have the potential to be used to teach positive social relationships and interactions based on collaboration rather than competition, the potential to turn (humanoid) robots off and leave them in a corner when not required or when they ask awkward questions (if the technology develops to the point of enabling them to do this) could encourage a lack of respect within relationships.

In summary, robots are a technology with considerable potential, but a number of as yet answered technical, ethical and other questions. This argues for both further research and caution in the introduction of technologically advanced, particularly intelligent, robots to give sufficient time to research, monitor and evaluate the impacts, which are likely to result.

References

Anderson M, Bischiak G, Oden M (1991) Converting the American economic: the economic effects of an alternative security policy. Employment Research Associates, Lansing

Arras KO, Cerqui D (2005) Do we want to share our lives and bodies with robots? A 2000 people survey, Technical report nr 0605-001. Autonomous Systems Lab, Swiss Federal Institute of Technology, Lausanne

Asimov I (undated) I, Robot i,robot.pdf. Accessed 14 May 2014

Baltes J, Byagowi A, Anderson J, Kopacek P (2009) Teen sized humanoid robot: Archie. In: Moreno-Díaz R, Pichler F, Quesada-Arencibia, A (eds) Progress in robotics. Springer, Berlin/Heidelberg, pp 34–41

Barakova EI, Lourens T (2010) Expressing and interpreting emotional movements in social games with robots. Pers Ubiquit Comput 14(5):457–467

Beer M, Alboul L, Norling E, Wallis P (2012): Using agents in virtual environments to assist controllers to manage multiple assets. In: Proceedings of the workshop on "Cognitive Agents for Virtual Environments, AAMAS 2012", Valencia

Billard A, Robins B, Nadel J, Dautenhahn K (2007) Building Robota, a mini-humanoid robot for the rehabilitation of children with autism. Assist Technol 19(1):37–49

Brose SW, Weber DJ, Salatin BA, Grindle GG, Wang H, Vazquez JJ, Cooper RA (2010) The role of assistive robotics in the lives of persons with disability. Am J Phys Med Rehabil 89(6):509–521

Burgar CG, Lum PS, Shor PC, Van der Loos HF (2000) Development of robots for rehabilitation therapy: the Palo Alto VA/Stanford experience. J Rehabil Res Dev 37(6):663–674

Burgard W et al (1999) Experiences with an interactive museum tour-guide robot. Artif Intell 114:1–53

CEN (2003) CEN/CENELEC Guide 6: guidelines for standards developers to address the needs of older persons and persons with disabilities. ftp://ftp.cen.eu/BOSS/Reference_Documents/Guides/CEN_CLC/CEN_CLC_6.pdf. Accessed 3 May 2010

Cohen A (2001) Internet insecurity. Time 15726:44–51

Connell BR, Jones M, Mace R, Mueller J, Mullick A, Ostroff E, Sanford J, Steinfeld E, Story M, Vanderheiden G (1997) The principles of universal design version 2.0. http://www.design.ncsu.edu/cud/about_ud/udprinciplestext.htm. Accessed 11 August 2011

Dautenhahn K (2007) Socially intelligent robots: dimensions of human–robot interaction. Philos Trans R Soc Lond B Biol Sci 362(1480):679–704

Dautenhahn K, Woods S, Kaouri C, Walters ML, Koay KL, Werry I (2005) What is a robot companion-friend, assistant or butler? In: IEEE/RSJ international conference on intelligent robots and systems. Institute of Electrical and Electronics Engineers (IEEE) Piscataway, pp 1192–1197

Dethlefsen VT, Jackson T, Taylor P (1993) The precautionary principle. In: Jackson T (ed) Clean production strategies, developing preventive environmental management in the industrial economy. Environment Institute, Stockholm, pp 41–62

Diegel O, Badve A, Bright G, Potgieter J, Tlale S (2002). Improved mecanum wheel design for omni-directional robots. In: Proceedings of the 2002 conference on robotics and automation, Auckland, pp 112–121

Ellul J (1954) La Technique ou l'Enjeu du Siècle. Librairie Armand Colin, Paris

Feil-Seifer D, Mataric MJ (2005) Defining socially assistive robotics. In: Proceedings of "9th international conference on rehabilitation robotics". Institute of Electrical and Electronics Engineers (IEEE), Piscataway, pp 465–468

Feil-Seifer D, Matarić MJ (2011) Ethical principles for socially assistive robotics. IEEE Robot Automation Magazine 18(1):24–31. Institute of Electrical and Electronics Engineers (IEEE), Piscataway

Forlizzi J, DiSalvo C (2006) Service robots in the domestic environment: a study of the roomba vacuum in the home. In: Proceedings of the 1st ACM SIGCHI/SIGART conference on Human-robot interaction, Salt Lake City. ACM (Association for Computing Machinery), pp 258–265

Fujita M (2001) AIBO: toward the era of digital creatures. Int J Robot Res 20(10):781–794

Gillesen JCC, Barakova EI, Huskens BEBM, Feijs LMG (2011) From training to robot behavior: towards custom scenarios for robotics in training programs for ASD. In: IEEE international conference on rehabilitation robotics (ICORR), Piscataway, pp 1–7

Golubovic D, Hu H (2002) A hybrid evolutionary algorithm for gait generation of Sony legged robots. In: 28th annual conference of the IEEE industrial electronics society, Sevilla, Spain

Goodrich MA, Olsen DR, Crandall JW, Palmer TJ (2001) Experiments in adjustable autonomy. In: Proceedings of IJCAI workshop on autonomy, delegation and control: interacting with intelligent agents, Sage Publications, pp 1624–1629

Gross HM, Boehme H, Schröter C, Mueller S, Koenig A, Einhorn E, Bley A (2009) TOOMAS: interactive shopping guide robots in everyday use-final implementation and experiences from long-term field trials. In: IEEE/RSJ international conference on intelligent robots and systems, Piscataway, pp 2005–2012

Hersh MA (1998) A survey of systems approaches to green design with illustrations from the computer industry. IEEE Trans Syst Man Cybern 28(4):528–540

Hersh MA (2006) Mathematical modelling for sustainable development. Springer, Berlin/Heidelberg/New York. ISBN 3-540-24216-3

Hersh MA, Johnson MA (2008) On modelling assistive technology systems part I: modelling framework. Technol Disabil 20(3):193–215

Hersh MA, Johnson MA (2010) A robotic guide for blind people part 1: a multi-national survey of the attitudes, requirements and preferences of potential end-users. Appl Bionics Biomech 7(4):277–288

Hinds PJ, Roberts TL, Jones H (2004) Whose job is it anyway? A study of human-robot interaction in a collaborative task. Human Comput Interact 19:151–181

Hirai K, Hirose M, Haikawa Y, Takenaka T (1998) The development of Honda humanoid robot. In: Proceedings 1998 IEEE international conference on robotics and automation. Leuven, Belgium, pp 1321–1325

Hosoda Y, Egawa S, Tamamoto J, Yamamoto K, Nakamura R, Togami M (2006) Basic design of human-symbiotic robot EMIEW. In: IEEE/RSJ international conference on intelligent robots and systems, IEEE, Piscataway, pp 5079–5084

Katić D, Vukobratović M (2003) Intelligent control of robotic systems. Kluwer Academic Publishers, Dordrecht

Kiesler S, Sproull L (1997) "Social" human-computer interaction. In: Friedman B (ed) Human values and the design of computer technology. CSLI Publications Center for the Study of Language and Information Leland Standord Junion University/Press Syndicate of the University of Cambridge, Cambridge/Melbourne, pp 191–199

Kim JH, Shim HS, Kim HS, Jung MJ, Choi IH, Kim JO (1997) A cooperative multi-agent system and its real time application to robot soccer. In: Proceedings, 1997 IEEE international conference on robotics and automation, Piscataway, vol 1, pp 638–643

Knight M, Loayza N, Villaneuva D (1996) The peace dividend: military spending cuts and economic growth. IMF Staff Pap 43(1):1–37

Koda T, Maes P (1996) Agents with faces: the effect of personification. In: 5th IEEE international workshop on robot and human communication, Piscataway, pp 189–194

Kopacek P (2005) Advances in robotics. In: Proceedings of the 10th international conference on computer aided systems theory – EUROCAST 2005, Las Palmas de Gran Canaria, Spain, Springer, pp 549–558

Kopacek P (2009) Automation in sports and entertainment. In: Nof S (ed) Springer handbook of automation. Springer, Berlin/Heidelberg, pp 1313–1331

Kopacek P (2011) Cost oriented humanoid-robots. In: Proceedings of the IFAC world congress 2011, vol. 18, Part 1, pp 12680–12685. doi:10.3182/20110828-6-IT-1002.01056

Kopacek P (2012) Roboethics. In: Proceedings of the IFAC workshop on supplemental ways for improving international stability – SWIIS 2012, pp 67–72, Elsevier, 2013, published on line under. doi:10.3182/20120611-3-IE-4029.00015

Kopacek P (2013) Development trends in robotics. Elektrotechnik Informationstechnik 130(2):42–47. Published on line under doi 10.1007/s00502-013-0129-1, Springer Verlag, Wien, 2013

Kopacek B, Kopacek P (2013) End of life management of industrial robots. Elektrotechnik Informationstechnik 130(2):67–71. Published on line under doi 10.1007/s00502-013-0131-7, Springer Verlag, Wien, 2013

Kostarelos K (2010) Nanorobots for medicine: how close are we? Nanomedicine 5(3):341–342

Kozima H, Nakagawa C, Yasuda Y (2005) Interactive robots for communication-care: a case-study in autism therapy. In: IEEE international workshop on robot and human interactive communication, 2005. ROMAN, Piscataway, pp 341–346

Li Y, Xu Q (2007) Design and development of a medical parallel robot for cardiopulmonary resuscitation. IEEE/ASME Trans Mechatron 12(3):265–273

Libin AV, Libin EV (2004) Person-robot interactions from the robopsychologists' point of view: the robotic psychology and robotherapy approach. Proc IEEE 92(11):1789–1803

Lynch J (2005) Identity theft in cyberspace: crime control methods and their effectiveness in combating phishing attacks. Berkeley Technol Law J 20:259

Marti P, Bacigalupo M, Giusti L, Mennecozzi C, Shibata T (2006) Socially assistive robotics in the treatment of behavioural and psychological symptoms of dementia. In: The first IEEE/RAS-EMBS international conference on biomedical robotics and biomechatronics, pp 483–488

Mavroidis C, Dubowsky S, Drouet P, Hintersteiner J, Flanz J (1997) A systematic error analysis of robotic manipulators: application to a high performance medical robot. In: Proceedings, 1997 IEEE international conference on robotics and automation, vol 2, pp 980–985

McLaughlin J, Skinner D (2000) Developing usability and utility: a comparative study of the users of new IT. Technol Anal Strateg Manag 12(3):413–423

Melman S (1988) The demilitarized society: disarmament and conversion. Harvest House, Montreal

Mettler L, Ibrahim M, Jonat W (1998) One year of experience working with the aid of a robotic assistant (the voice-controlled optic holder AESOP) in gynaecological endoscopic surgery. Hum Reprod 13(10):2748–2750

Mordoch E, Osterreicher A, Guse L, Roger K, Thompson G (2013) Use of social commitment robots in the care of elderly people with dementia: a literature review. Maturitas 74(1):14–20

Mori M (1970) The uncanny valley. Energy 7(4):33–35

Nielsen J (1993) Usability engineering. Academic Press Ltd., New York

Oestreicher L (2007) Cognitive, social, sociable or just socially acceptable robots? In: Proceedings of the 16th IEEE international symposium on robot and human interactive communication RO-MAN, JejuIsland, Korea, pp 558–563

Pamecha A, Ebert-Uphoff I, Chirikjian GS (1997) Useful metrics for modular robot motion planning. IEEE Trans Robot Autom 13(4):531–545

Panait L, Luke S (2005) Cooperative multi-agent learning: the state of the art. Auton Agent Multi-Agent Syst 11(3):387–434

Pineau J, Montemerlo M, Pollack M, Roy N, Thrun S (2003) Towards robotic assistants in nursing homes: challenges and results. Robot Auton Syst 42(3):271–281

Quesenbery C, Jarrett J, Ramsey J, Redish G (2001) What does usability mean? In: Siciliano B, Khatib O (eds) (2008) Handbook of robots. Springer, Berlin/Heidelberg

Robins B, Dautenhahn K, Te Boekhorst R, Billard A (2005) Robotic assistants in therapy and education of children with autism: can a small humanoid robot help encourage social interaction skills? Univ Access Inf Soc 4(2):105–120

Robins B, Ferrari E, Dautenhahn K, Kronrief G, Prazak B, Gerderblom G-J, Caprino F, Laudanna E (2010) Human-centred design methods: developing scenarios for robot assisted play informed by user panels and field trials. Int J Hum-Comput Stud IJHCS 68(12):873–898

Ruurda JP, van Vroonhoven TJ, Broeders IAMJ (2002) Robot-assisted surgical systems: a new era in laparoscopic surgery. Ann R Coll Surg Engl 84(4):223

Scassellati B, Admoni H, Mataric M (2012) Robots for use in autism research. Annu Rev Biomed Eng 14:275–294

Shamsuddin S, Yussof H, Ismail L, Hanapiah FA, Mohamed S, Piah HA, Ismarrubie Zahari N (2012) Initial response of autistic children in human-robot interaction therapy with humanoid robot NAO. In: IEEE 8th international colloquium on signal processing and its applications (CSPA), pp 188–193

Shibata T (2004) An overview of human interactive robots for psychological enrichment. Proc IEEE 92(11):1749–1758

Spitzberg BH, Hoobler G (2002) Cyberstalking and the technologies of interpersonal terrorism. New Media Soc 4(1):71–92

Stapleton L, Hersh M (2003) Exploring the deep structure of ethics in engineering technology: design and deployment methodology. In: IFAC workshop on technology and international stability, SWIIS '03, Waterford, Ireland

Takeuchi A, Naito T (1995) Situated facial displays: towards social interaction. In: Proceedings of the SIGCHI conference on human factors in computing systems, ACM Press/Addison-Wesley Publishing Co., New York, pp 450–455

Thrun S et al (2000) Probabilistic algorithms and the interactive museum tour-guide robot Minerva. Int J Robot Res 19(11):972–999

Veruggio G (2002) Views and visions in robotics. Hearing at the Italian Senate's 7th Permanent Commission, Rome

Veruggio G (2010) Roboethics. Robot Autom Mag IEEE 17(2):105–109

Veruggio G, Operto F (2008) Roboethics: social and ethical implications of robotics. In: Siciliano B, Khatib O (eds) Handbook of robots. Springer, Berlin/Heidelberg, pp 1499–1522

Voss T (1992) Converting the defence industry: have we the political will. Oxford Research Group no. 9, London

Vukobratović M, Borovac B (2004) Zero-moment point – thirty five years of its life. Int J Humanoid Robot 1(1):157–173

Wada K, Shibata T (2007) Living with seal robots – its sociopsychological and physiological influences on the elderly at a care house. IEEE Trans Robot 23(5):972–980

Wada K, Shibata T, Saito T, Tanie K (2004) Effects of robot-assisted activity for elderly people and nurses at a day service center. Proc IEEE 92(11):1780–1788

Werry I, Dautenhahn K (1999) Applying mobile robot technology to the rehabilitation of autistic children. In: Proceedings of the SIRS99, 7th symposium on intelligent robotic systems. Conference took place in Coimbra, Portugal

Winner L (1977) Autonomous technology, technics-out-of-control as a theme in political thought. MIT, Cambridge, MA

Wu YH, Fassert C, Rigaud AS (2012) Designing robots for the elderly: appearance issue and beyond. Arch Gerontol Geriatr 54(1):121–126

Yim M, Zhang Y, Duff D (2002) Modular robots. IEEE Spectr 39(2):30–34

Yu H, Spenko M, Dubowsky S (2003) An adaptive shared control system for an intelligent mobility aid for the elderly. Auton Robot 15(1):53–66

Zhou C, Low KH (2001) Combined use of ground learning model and active compliance to the motion control of walking robotic legs. In: Proceedings 2001 of the IEEE international conference robotics and automation, Seoul Korea, pp 3159–3164

Zhou D, Low KH, Zielinska T (2000) An efficient foot-force distribution algorithm for quadruped walking robots. Robotica J 18:403–413. Cambridge University Press

Zielinska T, Heng J (2002) Development of walking machine: mechanical design and control problems. Mechatronics 12:737–754

Chapter 4
The Ethical Use of Outer Space

Dave Webb

Acronyms

AFSPC	(US) Air Force Space Command
AP-MCSTA	Asia-Pacific Multilateral Cooperation in Space Technology and Applications
APRSAF	Asia-Pacific Regional Space Agency Forum
APSCO	Asia-Pacific Space Cooperation Organization
ASAT	Antisatellite technology
BDS	BeiDou Navigation Satellite System
BRIC	Brazil, Russia, India and China
CD	Conference on Disarmament
CEA	Conferencia Espacial de las Americas – Space Conference of the Americas
C4ISR	Command, Control, Communications, Computer, Intelligence, Surveillance and Reconnaissance
COMEST	Commission on the Ethics of Scientific Knowledge and Technology
COPUOS	Committee on the Peaceful Uses of Outer Space
DARPA	Defense Advanced Research Projects Agency
DMC	Disaster Monitoring Constellation
EPA	Environmental Protection Agency
ESA	European Space Agency
EU	European Union
FAI	Fédération Aéronautique Internationale
GGE	Group of Governmental Experts
GLONASS	(Russian) Global National Satellite System
GMES	Global Monitoring for Environment and Security

D. Webb (✉)
Peace and Conflict Studies, Leeds Beckett University, England
e-mail: d.webb@space4peace.org

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GPS	Global Positioning Satellite/System
IADC	Inter-Agency Space Debris Coordination Committee
ICBM	Intercontinental Ballistic Missile
ICRAC	International Committee for Robot Arms Control
INES	International Network of Engineers and Scientists
INESAP	International Network of Engineers and Scientists Against Proliferation
ISS	International Space Station
ITU	International Telecommunications Union
KSAT	Kongsberg Satellite Service
LEO	Low Earth orbit
MDG	Millennium Development Goals
NASA	National Aeronautics and Space Administration
NGO	Non-governmental organisation
ODA	Official Development Assistance
OECD	Organisation for Economic Cooperation and Development
OST	Outer Space Treaty
PAROS	Prevention of an Arms Race in Outer Space
PNAC	Project for the New American Century
PSG	Perchlorate Study Group
SGR	Scientists for Global Responsibility
SSN	Space Surveillance Network
TCBM	Transparency and Confidence-Building Measures
UCS	Union of Concerned Scientists
UAV	Unmanned Aerial Vehicle
UNCOPUOS	UN Committee on the Peaceful Uses of Outer Space
UNGA	United Nations General Assembly
UNOOSA	UN Office for Outer Space Affairs
UN-SPIDER	UN Platform for Space-based Information for Disaster Management and Emergency Response
USAF	United States Air Force
USAFWC	United States Air Force Warfare Center
USSPACECOM	United States Space Command
USSTRATCOM	United States Strategic Command
WILPF	Women's International League for Peace and Freedom

Overview

There is an ever-increasing use of space for all manner of activities, and we have already become quite dependent on the use of space technology in our everyday lives. For example, we are increasingly using satellite navigation for vehicle and pedestrian journeys, to track goods and estimate bus arrival times. We are also employing satellite systems for communication and entertainment (TV, interactive games), international financial transactions and air-traffic management.

What this means however is that space has become a marketplace and a competitive arena for commercial and military interests. Space has become the subject of commercial exploitation and is open to military exploitation. During the rapid development of space technology, a number of agreements and legally binding treaties were drawn up, but the technology and use of the region is continually outstripping their usefulness. Can we learn to share this crucial and delicately balanced region or will it go the way of the oceans, rain forests and other precious environments that have been spoiled by uncontrolled and unethical exploitation?

In this chapter I explore the reasons why it is becoming increasingly necessary and important to monitor and control, in particular, the growing military use of and interests in outer space. I examine the ethics of a just and beneficial use of the space environment and the existing international treaties and agreements and conclude with some suggestions for future progress.

1 Introduction

The night sky in all its glory is undoubtedly an inspiring sight, and the origins of much of our scientific and philosophical thought lie in our ancestors' experiences of observing and questioning heavenly displays. Unfortunately, urban light pollution is making it increasingly difficult for city dwellers to wonder at the splendour of a starry night, and it is even possible that access to outer space will soon be denied. The commercial and military uses of the space environment are increasing rapidly and, whether we realise it or not, our lives are becoming increasingly influenced by, and dependent on, the use of space technology. The thousand or more operational satellites that currently orbit the Earth collect and broadcast enormous amounts of information worldwide, making important contributions to mapping and communications, environmental monitoring, agriculture, weather forecasting and an ever-growing range of human activities.

However, competition for valuable geostationary orbits and the positioning of military spy and other satellites has led to a situation where, rather than being viewed as a global resource, space is subject to commercial exploitation by whoever gets there first and open to military exploitation by whoever can develop the appropriate technology to dominate.

We have learnt an astonishing amount about the universe through international scientific collaboration, and we must now learn to cooperate further and develop global agreements on the way we make use of the space environment. In this chapter we explore the reasons why this is becoming increasingly necessary and important, why it is difficult to achieve and the progress that has been and is being made.

In Sect. 4.2 we identify what we mean by outer space by tackling the question – where does outer space begin? This is followed by a description of the various forms of human activity in the region (exploration, commercial and military) and will then be presented along with estimates of their cost in Sect. 4.3. The various problems arising from the military use of space and the current projects that threaten space security will be outlined. Section 4.4 emphasises the need to be aware of, and care for, the space environment, and this also leads to a discussion of the problems of an unregulated use of space in terms of a tragedy of the commons in Sect. 4.5. Section 4.6 then looks at the ethical situation regarding the just and beneficial use of the space environment, and the existing international treaties and agreements are outlined along with the adopted procedural mechanisms. Finally, Sect. 4.7 concludes with some suggestions for future progress.

2 Just What Is Outer Space?

So, where does the Earth's atmosphere end and outer space begin? The atmosphere is a relatively thin layer of gases surrounding the Earth, held there by the planet's gravity. Among other things, it contains the oxygen we need to survive and the weather patterns that have helped determine our development, and it protects us from the harmful ultraviolet radiation emitted by the Sun. Travelling upwards from the Earth's surface takes you through various layers as shown in Table 4.1.

Officially, outer space begins at the Karman line – at an altitude of 100 km above sea level. At least this is the definition accepted by the Fédération Aéronautique Internationale (FAI), the international standard setting organisation for aeronautics and astronautics. Theodore von Kármán calculated that at this altitude, the atmosphere becomes so thin that, in order to gain enough aerodynamic lift, aeroplanes would need to travel at orbital speed.

This definition is the one used in the formulation of treaties and the construction of space law and helps determine how outer space is perceived by nations and how they believe it should be used and cared for.

Table 4.1 The Earth's atmosphere

Region		Height above sea level (km)	Height above sea level (miles)
Exosphere	Where the atmosphere merges with outer space	>700	>440
Thermosphere	Almost a vacuum and heated by solar radiation – temperatures may reach 2,000 °C	80–700	50–440
Mesosphere	Temperature decreases with increasing height – temperatures may fall to −143 °C. Region where most meteors burn up	50–80	31–50
Stratosphere	Contains the ozone layer which absorbs harmful ultraviolet radiation from the Sun	12–50	7–31
Troposphere	Contains most of the weather. Mostly heated by energy emitted from the surface	0–12	0–7

3 The Uses of Outer Space

In just a few decades, outer space has become of the utmost importance for global commercial, political and military interests. Now, a wide range of satellites systems are involved in communication, navigation, entertainment, business and humanitarian disaster relief. People around the world will be aware of, and possibly use, a Global Positioning Satellite/System. The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the US Department of Defense. GPS was originally intended for military applications, but in the 1980s, the US government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 h a day and with no subscription fees or setup charges. By providing computer networks with an almost instantaneous global coverage, satellites now play important roles in our daily lives. Their use for monitoring, communication and control systems has led to a dramatic growth in the use of space. As with most applications of large-scale technology, there are a number of ethical issues that arise. The increased use of satellite and high-tech systems has not only added to our scientific understanding of our environment and the means to see and experience conditions from outside the protective atmosphere of our home planet, it has also resulted in new possibilities for commercial and political exploitation. Satellites and sophisticated computer systems have provided the ability to collect, store and analyse huge amounts of information on personal, company and state business and operations, enabling mass surveillance and personal profiling by governments and/or by corporations either on behalf of governments or for their own use. The operations involved may or may not be legal and may or may not require official authorisation. Although it is claimed that these processes are carried out for the benefit of consumers or for national security, they are also subject to criticism as they also offer new challenges to civil and political rights and freedoms. New advances in space technology are happening so fast that a full consideration of how to control any possible misuse can lag far behind the possibilities opened up by new developments.

There has also been an enormous increase in the number of Earth satellites, and thousands have been blasted into space since the first was launched by the Soviet Union in 1957. Some have crashed back into the atmosphere; others have escaped Earth's gravity and are flying off into deep space. The US Space Surveillance Network[1] has tracked over 24,500 objects larger than about 10 cm in space and is watching about 8,000 of them currently in orbit. Most of these objects are useless space junk (which is itself a huge global problem), but the US Union of Concerned Scientists has compiled a Satellite Database which lists over 1,000 operational satellites currently in orbit. Of these, almost half, close to 450, are operated by the United States and over 100 have a military use. Russia appears to have less than 100

[1] Established to detect, track, catalogue and identify artificial objects orbiting Earth is the responsibility of the Joint Functional Component Command for Space, part of the United States Strategic Command (USSTRATCOM) – see them on Facebook at https://www.facebook.com/pages/United-States-Space-Surveillance-Network/133008113403721

Table 4.2 Estimated space budgets for 2010 (OECD 2011)

Country/group	$US million
G7	53,239.6
United States	43,600.1
BRIC	10,537.1
China[a]	6,502.0
EU[b]	6,294.6
Japan	3,551.0
Russian Federation	2,665.4
France	2,615.3
Germany	1,668.8
India	1,193.7
Italy	933.7
United Kingdom	482.5
Canada	338.1
Korea	273.8
Brazil	176.0
Argentina	55.2
Indonesia	42.1
Turkey	33.1
Australia	11.8
World total	**65,300.0**

[a]Unofficial data
[b]For the EU, only 17 countries with national space budgets are included: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden and Switzerland

satellites in total and China just over 50. Not only has the number of satellites increased but so have the number of nations and government consortia operating in space – there are currently around 60 – and nine states and the European Space Agency have demonstrated an independent orbital launch capability. A number of other state actors are developing the capability and there are non-state actors (e.g. Sea Launch and International Launch Services) who provide commercial orbital launch services using others' rockets. In addition, there are a further 18 states that have suborbital launch capability, and two more appear to be developing long-range missile programmes that could help them develop an orbital launch capability.

From Table 4.2 we see that, in 2010, the total space budget for the 35 top-spending countries was estimated to be $65.3 billion, with most coming from the G7 and BRIC countries.

The scientific exploration of space has often advanced international cooperation and technical achievement but the recent commercial exploitation of space has resulted in competition for business and particular orbital placements. In addition, state funding and policy priorities have indicated a growing political rivalry in space. In 2003 China became the third country to launch a human into space; soon

Table 4.3 State expenditure on space exploration[a]

Country/group	$US million
United States	17,700
Russia	5,600
ESA[b]	5,380
France	2,822
Japan	2,460
Germany	2,000
India	1,320
China	1,300
Italy	1,000
Iran	500
Canada	489
United Kingdom	414
World total	**40,600**

[a]As compiled by Wikipedia – http://en.wikipedia.org/wiki/List_of_government_space_agencies

[b]The national budgets shown for European contributors to ESA are separate from their contributions to ESA

after India proposed its own human spaceflight programme and the United States, Russia, Japan, India, China and the European Space Agency (ESA[2]) all have plans for future lunar expeditions.

3.1 Space Exploration

National activities related to space exploration are organised through governmental space agencies. The official 2011 annual budgets for national space agencies around the world are shown in Table 4.3.

The national space agency budgets shown in Table 4.3 are used differently by different nations. For example, the US Global Positioning System is maintained from its defence budget, while ESA's money is used for developing the European Galileo positioning system.

Cooperation and rivalry in space usually mirror the geopolitical patterns on Earth, and partnerships develop out of political and commercial interests. For example, the United States is working on a number of space projects[3] and space

[2]The member states of the ESA are Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom.

[3]See, for example, '*A Remarkable Expansion of US-India Cooperation on Science & Technology*' a media note from the US State Department – available at http://www.state.gov/r/pa/prs/ps/2013/06/211028.htm

defence[4] technology sharing programmes with India, despite some international concerns, while China is working with key allies such as Pakistan, Nigeria and Venezuela.

With regard to international collaboration, perhaps the best known project is the International Space Station (ISS).[5] This is a joint project by five participating space agencies from the United States, Russia, Japan, Europe and Canada to develop a habitable artificial satellite in low Earth orbit. The first component was launched in 1998 and the station has been continuously occupied since November 2000 and has 19 research facilities. It is serviced by a variety of spacecraft from the United States, Russia and Japan and has been visited by astronauts and cosmonauts from 15 different nations. The ownership and use of the space station is established by intergovernmental agreements and, at an estimated cost of $160 billion and rising, it is generally understood to be the most expensive object ever built.

Other international collaborations include:

- The Disaster Monitoring Constellation (DMC) – a partnership between Algeria, Nigeria, China, Turkey, the United Kingdom and Spain. Each of the six countries owns and operates a low-cost satellite[6] and together they provide daily imaging capability to the partner nations. Images are also sold commercially but distributed freely in times of natural disasters.
- The Asia-Pacific Regional Space Agency Forum (APRSAF) was created in 1993 by 27 states (Australia, Bangladesh, Brunei, Bhutan, Canada, Cambodia, China, France, Germany, India, Indonesia, Japan, Korea, Laos, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Philippines, the Russian Federation, Singapore, Sri Lanka, Thailand, the United States and Viet Nam) to enhance space activities in the Asia-Pacific region. In addition, the Asia-Pacific Space Cooperation Organization (APSCO), created in 2005, focuses on education and training. It involves Bangladesh, China, Indonesia, Iran, Mongolia, Pakistan, Peru, Thailand and Turkey and builds on the Asia-Pacific Multilateral Cooperation in Space Technology and Applications (AP-MCSTA) convention signed by China, Pakistan and Thailand in 1992.
- The Space Conference of the Americas (Conferencia Espacial de las Americas – CEA) started in 1989 as a forum to discuss progress in space matters and to strengthen educational programmes and training in space science and technology among countries that encourage the use of space applications for the benefit of the developing countries in Latin America.

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[4] Despite concerns in India about becoming too close to the United States and in the United States about the possible implications for nuclear weapons proliferation and Indo-Pak nuclear stability, the United States and India are developing a growing cooperation with projects such as missile defence – for example, see http://cogitasia.com/toward-u-s-india-missile-defense-cooperation/

[5] For more information see, for example, http://www.nasa.gov/mission_pages/station/main/index.html#.Uu0kELSPuyM

[6] The satellites are built by Surrey Satellite Technology Ltd – for more details, see http://www.sstl.co.uk/Divisions/Earth-Observation-Science/EO-Constellations

A very recent international collaboration was announced early in 2014 following a UN mandate to establish a high-level group to help coordinate expertise and capabilities for missions aimed at monitoring threats from near-Earth encounters of asteroids (Yu 2013). The need for such action was perhaps prompted in February of 2013, when a large meteor exploded high above Chelyabinsk, Russia, with 20–30 times more energy than the atomic bomb that destroyed Hiroshima.

3.2 Commercial Space Use

Space is now recognised as big business. The Space Foundation (2013) reports that in 2012 the global space economy rose to $304.31 billion – an increase of 6.7% from 2011. The majority of this increase was attributed to commercial growth, which constitutes over 70% of the space economy. GPS devices and chipsets and direct-to-home television are identified as particularly important growth areas.

Commercial space companies are also offering space transport facilities (such as Space Exploration Technologies Corporation – or *SpaceX*) to private sector companies for launch services into low Earth or geostationary orbits. Interest in space tourism (personal spaceflight for recreational, leisure or business purposes) also appears to be growing. Companies such as *Virgin Galactic* are hoping to create an industry offering orbital opportunities to the growing number that can afford the $250,000 ticket (quite cheap compared with the $20–40 million or more fare charged by Russia through *Space Adventures* for trips during the period 2001–2009).

Collaborations in space ventures have some obvious advantages. It costs around $20,000 to launch 1 kg of something into orbit so collaborative projects in civil space programmes can help emerging space actors access and use space.

3.3 The Military Use of Space

Space systems now play a vital role in issues of peace and war. The power of space technology provides new ways of managing security concerns – it allows global access, achieves a global presence and can deliver nearly ubiquitous capabilities. The Free Dictionary defines space power as 'the total strength of a nation's capabilities to conduct and influence activities to, in, through, and from space to achieve its objectives'[7] but Marquart (2011) uses the more aggressive definition 'military assets located at or above the Karman line used for dominance over land-based enemies'. Space power provides opportunities to secure the peace and/or to fight wars. It can also help provide transparency through global surveillance – thereby removing uncertainties and security concerns – or it can provide opportunities for states to locate, monitor, track and target any groups or individuals they may take an interest in.

[7] Free dictionary – http://www.thefreedictionary.com

Cooperative ventures in space can lead to better international relationships and confidence building, but Dinerman (2013) warns of the asymmetric proliferation of space power, where the military of wealthier nations use satellites for reconnaissance, targeting and managing theatres of war, and weaker nations consider defending themselves by developing antisatellite systems.

Military space budgets are difficult to establish and are usually estimated from unclassified official sources and selected non-official sources or based upon overall national space spending or overall military budget trends. A clear distinction between military space and civil space spending is also often blurred by dual-use programmes and applications. The 2014 Pentagon spending request included $8 billion for unclassified military space programmes which is about the same as was received in 2013 and which was a cut of 22% from 2012 budget. The United States undoubtedly spends the most on military space activities, and it is likely that they spend as much as the rest of the world put together and so the total global military space spending is possibly around $20 billion.

The initial development of modern day space technologies was through a military route – starting in 1930s Germany with the work of Nazi rocket pioneers led by Wernher von Braun. Their V2 missiles were constructed at Mittelwerk in tunnels under Kohnstein Mountain near Nordhausen by slave labour from the Dora, Harzungen and Ellrich concentration camps. In the 20 months of construction work that took place at Mittelwerk, around one half of the 60,000 prisoners used to build the rockets died of starvation and abuse (mass executions were commonplace) (Béon 1997). More people were killed in the construction of the rockets than the rockets killed at their targets.

At the end of the war, von Braun and his team were gathered together by the US Army and were assimilated into the United States. At that time, anyone who had been a member of the Nazi party or an active supporter of Nazism or German militarism was not allowed to work in the United States, so a programme known as 'Operation Paperclip' (Lasby 1975; Thieme 2003) was used to obscure the histories of the German scientists and engineers. This operation, which lasted well into the 1950s, allowed the law and presidential directive to be bypassed to enable von Braun's group to continue building rockets in the United States. They produced the first ICBMs and the Saturn V which was used by the United States to transport the first humans to the Moon in 1969.

The Soviets also took their share of German scientists from von Braun's team and the V2 technology was copied for their first missile, the R-1, a later version of which (the R-7) was used to launch the world's first artificial satellite in 1957. Sputnik 1 was a small 58-cm (23-in.)-diameter polished metal sphere, launched into a low elliptical Earth (Asif Siddiqi 2006). It caused general panic in the United States because it meant that the Soviets had the capability to reach (and possibly target) anywhere on the planet from their own territory. Therefore, this event launched not only a space race but also a new type of potential arms race. From these less than auspicious beginnings, space technology developed in the United States and the USSR through the political and military competitiveness of the Cold War.

At the end of the Cold War, US and USSR military space systems were providing key functions for command, control, communications, computer, intelligence, surveillance and reconnaissance (C4ISR) in addition to important early warning, navigation and weapon guidance applications.

3.3.1 US Military Space Development

'Operation Desert Storm' in Iraq in 1991 is considered to be the first time that there was a significant use of space technology for warfighting. The United States employed so-called 'smart' weapons whose guidance and targeting systems employed the use of satellites (Webre 2003). This experience was extended in Yugoslavia in 1999, when the aerial bombardment of Serbia was described by Chalmers Johnson as the first 'space-enabled' war (Johnson 2004), and the War in Afghanistan in 2001 through to 'Operation Iraqi Freedom' in 2003, and space technology was used to integrate land-, sea- and air-based military networks together into a combined command and control system. This use of space technology and the networking of the control and management of military activities have become known as 'netcentric warfare' (Halpin et al. 2006).

Development of satellite technology for C4ISR has reached a level where a military response is expected to be achieved in minutes rather than hours or days. To US space commanders, space has become 'the ultimate military high ground' through the deployment of, and dependence on, a range of space systems that handle and integrate communications, weather forecasting, eavesdropping, surveillance and early-warning functions. In addition the US Global Positioning System (GPS) has become part of a space-based weapon system and is being used to direct troops, support vehicles and guide the so-called 'smart' weapons. However, the dependence on space-based technologies has created a difficulty for the military. Donald Rumsfeld's 2001 *Space Commission Report* highlighted the vulnerability of satellite systems and concluded that it was necessary for the United States to completely dominate all aspects of space in order to ensure an adequate defence of their space assets and to protect against a possible 'Space Pearl Harbour'.

This centred the prevailing US military thinking around concepts such as 'full-spectrum dominance' in which it was important to 'pursue superiority in space through robust … defensive and offensive capabilities', maintain a fully integrated 'land, sea, air and space war-fighting system' (US Space Command 1997) and integrate civil and commercial space operations with military ones (Garamone 2000). To achieve this, the US Air Force adopted a doctrine of 'Counterspace Operations' – 'the ways and means by which the Air Force achieves and maintains space superiority' – the 'freedom to attack as well as the freedom from attack' (Air Force Doctrine Center 2004). Although the forceful and confrontational language may have changed somewhat since George W. Bush's Administrations, the intent seems to remain. Despite cuts in spending during the recent financial crisis, the United States continues to spend billions of dollars on the development of a number of military space programmes (Werner 2013; Rawnsley 2011) and the deployment of missile defence systems – which have already been demonstrated as effective antisatellite weapons (Webb 2009).

Space power has therefore been developed to the extent that it has now become part of daily military operations and provides technologies for intelligence sharing and communications across continents, enabling (in theory) all branches of the military to operate together with precision. In the early years, the three major branches of the US armed services (army, navy and air force) all developed their own space projects, but in 1985 the Department of Defense created the US Space Command (USSPACECOM) at Peterson Air Force Base in Colorado Springs. It was merged with US Strategic Command (USSTRATCOM) at Offutt Air Force Base in 2002. Military space operations now come under Air Force Space Command (AFSPC), and the US Air Force Warfare Center (USAFWC) facilitates the development and integration of operational and tactical warfighting capabilities for all Air and Space Component Commanders. The USAFWC also includes the 50th Space Wing, which has the responsibility of tracking and maintaining the command and control, warning, navigational and communications satellites for AFSPC and also manages the Global Positioning System and has the motto 'Master of Space'.[8]

The US military is regularly realigning to keep in touch with global and technological developments and to maintain its dominance in space.

3.3.2 Other Military Space Developments

Russia has a number of military satellite programmes for early warning, imaging, intelligence, communications and navigation. A dual-use (i.e. commercial and military) Global National Satellite System (GLONASS) which is similar to GPS was completed in 1995. According to Poroskov and Novostey (2003), Russian armed forces were due to be outfitted with GLONASS receivers by 2005, but the system fell into disrepair following the collapse of the Russian economy. During the 2000s, President Putin made the restoration of the system a top government priority and funding was substantially increased. In 2010 it was allocated 3.7 billion roubles, consuming a third of the budget of the Russian Federal Space Agency, and achieved 100% coverage of Russia's territory. The full orbital constellation of 24 satellites was restored in 2012, enabling full global coverage (Hill 2013).

China has also launched a number of satellites for military communications and navigation. It also maintains three satellites for tactical reconnaissance and surveillance and is developing its own GPS system of satellites – the BeiDou Navigation Satellite System (BDS – also known as COMPASS). According to the Chinese National Space Administration, the system should have a full coverage of China by 2012 and will cover neighbouring regions by 2020.

The European Union has developed a range of military space systems. France, Germany, Italy, Spain, Belgium and Greece jointly use the Helios-1 military optical observation satellite system, and France, Germany and Spain have developed a

[8] As shown here: http://www.schriever.af.mil/library/factsheets/factsheet.asp?fsID=3909

range of radar reconnaissance and communications capabilities. France is also developing a missile early-warning system, while the United Kingdom maintains three military communications satellites in geosynchronous orbit. The European Space Agency (ESA), set up to be an entirely independent organisation focussing on commercial and scientific programmes, is slowly becoming politicised (with increasing control from the European Commission as described by Hagen 2004) and militarised through the Galileo satellite navigation (Hasik and Rip 2003) and other systems. Initiated in 1999, Galileo was originally intended to be for civil and commercial use but will now have a joint dual-use capability.

In 2005 a European Commission report by a panel of EU experts concluded that ‘Europe must establish a new balance between civil and military uses of space’, and in 2007 29 European countries adopted a resolution on the European Space Policy that added a new dimension to European space activities, namely, that strategic objectives of space for Europe should ‘meet Europe’s security and defence needs’ (ESA Briefing 2011). It is argued that ‘peaceful purposes’ can be interpreted in the light of international space law as nonaggressive and that the ESA Convention does not prevent it from being active in the security and defence fields. However, to many this represents a significant change in attitude which attempts to exploit the fact that some tasks performed by satellites can be used by for military and civil purposes (e.g. imaging, communications, positioning systems, etc.) – so why not share costs? The problem being that the intended use of the end product is not specified in detail. While some military applications might be considered to be ethical (e.g. global environment/weather monitoring, imaging for treaty verification, etc.), the same information could also be used to plan attack scenarios. In addition some civil applications might be considered as unethical (e.g. signal interception for the purposes of commercial espionage), although the same techniques might be used to help track down criminals or terrorists. As the different functions of space activity are increasingly becoming the domain of specialist companies, the systems that deal with the collection and distribution of satellite data are not aware (or even interested) in its ultimate use – see Sect. 4.3.4 for further discussion.

Israel has military satellites and is planning new communications, imaging and radar satellites. It is also considering a system that would allow launch on demand of small satellites from fighter aircraft (Rome 2003). Other countries such as Brazil, Pakistan and Ukraine have military space capability or potential, and Australia has a dual-use military-commercial communications satellite (Spacedaily 2003). Japan operates satellites for military communications and has four ‘information gathering’ remote sensing satellites – two optical and two radar.

As more countries develop their own military space capabilities, the United States becomes increasingly concerned that its technological advantage in space is diminishing. New commercial technologies that could be put to military use (such as high-resolution commercial imagery and satellite navigation/positioning equipment) are becoming more readily available in the open marketplace, and an increasing number of space programmes have a dual (commercial and military) purpose. Therefore, the rapid expansion in space use and the difficulty of determining the true intent of some satellite systems are leading many analysts to the conclusion that the next steps in the militarisation of space will be the development, deployment and eventual use of space weapons.[9]

3.3.3 The Weaponisation of Space

> The 'militarisation' of space is a phrase used to describe the development and deployment of space assets that enable the military to maximize their effectiveness. It should not be confused with the 'weaponisation' of space, which would involve the placing of weapons in orbit around the Earth. At present, although there are no actual weapons stationed in space, it can be argued that there are components of weapons and many other military related systems positioned there. (Webb 2010)

Although the Outer Space Treaty (discussed below) prevents the positioning of weapons of mass destruction in space, it does not prevent them passing through (as intercontinental ballistic missiles) nor does it prevent other types of weapon or weapon components from being stationed there. Although the development or siting of weapon systems in space is not against the letter of the law, it would undoubtedly contravene the spirit of the Outer Space Treaty which seeks to prevent 'a new form of colonial competition' and declares outer space to be 'the province of all mankind'.

However, the difficulty of determining the true intent of some space systems and the lack of a definition of a space weapon (military satellites could already be interpreted as being components of a distributed weapon system) are leading many analysts to the conclusion that the next steps in the militarisation of space will be the development, deployment and eventual use of space weapons.[10]

A major problem with satellite systems used for warfighting is that they are extremely vulnerable, and the major space power states (Russia, the United States and China) have or have had antisatellite (ASAT) programmes (Grego 2012) and have demonstrated to each other that they have the capability to deploy them:

- The Soviet Union declared its co-orbital ASAT weapon operational in 1971 following a number of explosive encounters with their own target satellites (Grahn 1996).
- In January 2007, China tested an antisatellite weapon against one of its own ageing weather satellites[11].

[9] For more information on this, see the discussions and publications by the Stimson Centre (http://www.stimson.org/space/programhome.cfm), the Acronym Institute (http://www.acronym.org.uk/space/index.htm), the Centre for Defense Information (http://www.cdi.org/), etc.

[10] See, for example, the results of a high-level workshop on the threats arising from the weaponisation of space, by the World Academy of Arts and Science in collaboration with the Global Security Institute at the GSI's offices in New York City available at http://worldacademy.org/content/weaponization-outer-space

[11] More details of the Chinese antisatellite programme can be obtained from GlobalSecurity.org at http://www.globalsecurity.org/space/world/china/asat.htm

- In February 2008, the United States shot down one of its own failed satellites with a Standard Missile-3, used as an interceptor for the US Navy's missile defence system.

In fact many states will have the technological ability to blind or interfere with satellite system even if they can't destroy them. At the start of the Iraq War in 2003, the United States destroyed several satellite jamming installations the Iraqis were using to try and jam GPS signals (Schultz and Goler 2003).

As more states obtain or develop missile technologies that could also have ASAT capabilities, weaker space power actors may decide to employ space weapons in an attempt to counter the advantage space confers powerful states. However, a very dangerous situation would occur if two powerful space power states go to war – and at the 2010 UN General Assembly, the international community agreed to launch in 2012 a Group of Governmental Experts (GGE) to explore transparency- and confidence-building measures that could be undertaken to enhance space security.

Growing regional military tensions on Earth, coupled with the increasing military reliance on space and the growing capabilities of space and missile technology, mean that there is a grave risk of force being deployed in space at some stage.

3.3.4 New Military Developments

Current and future projects seem set to take warfighting more directly into space. In 1976 NASA unveiled the Shuttle as the world's first reusable manned spacecraft, and the first actual flight took place 5 years later when *Columbia* was launched into orbit from Cape Canaveral by its three main engines and two powerful rocket boosters and glided back to Earth, touching down on a runway 54 h later. The Shuttle programme operated for 30 years and secret military operations accounted for part or all of its many missions. Shuttles were equipped with a large cargo bay and a robotic manipulator arm which was used for placing satellites (some of which were for military communications) into orbit or retrieving them. The first defence-related payload was carried by *Columbia* on its fourth orbital flight in June 1982, and the first all-military Shuttle mission was made by *Discovery* in January 1985. Another 6 all-military classified flights were to follow and other missions included some military activity, with an unclassified series of military-related experiments being carried out on *Discovery* in April 1991 (Cleary 1994).

No wonder then that the US Space Shuttle programme was always viewed with suspicion by the Russians; as the shuttles were frequently used to fly military missions, there was some concern that they might even carry bombs and become military space planes. Indeed, one of the Shuttle's successors now being tested by the United States is a reusable remotely piloted space plane. The X-37B began as a NASA project in 1999 and was transferred to the Department of Defense in 2004. It has flown three test missions to date, the second of which in 2011–2012 involved a 16-month stay in space. In addition, the US Army is running field tests of a new hypersonic flight weapon 'designed to fly within the earth's atmosphere at hypersonic speed and long range … as well as seeing how well it manoeuvres and how precisely it could strike a target' (Miles 2012). The Defense Advanced Research Projects Agency (DARPA) – the US military's advanced technology and innovation arm – is also developing a Hypersonic Technology Vehicle 2 (HTV-2) as part of the advanced Conventional Prompt Global Strike weapons programme (Space.com 2012), and the USAF is testing another DARPA hypersonic aircraft – the Waverider, or X-51A – although tests so far have not been very successful (Slosson 2012).

More recently, satellites are being used to enable Unmanned Aerial Vehicles (UAVs, or drones) flown by the United States in places such as Afghanistan and Pakistan, to be remotely piloted from thousands of miles away in control centres in the United States. The majority of drones are used for surveillance, but some are armed with missiles targeted and fired from the United States. The growing use of this form of remote warfare has caused an international outcry (Medea and Ehrenreich 2012). Pilots operate drones and fire their missiles from thousands of miles away at no risk to themselves, and there is concern that this leads more readily to decisions to deploy them to remove 'ringleaders' in the short-term rather than develop long-term diplomatic processes aimed at identifying the root causes of the conflict. In addition, the 'PlayStation mentality' of some pilots used to playing realistic video games may lower the threshold for the use of lethal force as seeing targets on a video screen is quite different from seeing them in the flesh.

Drones are being deployed by an increasing number of countries and there is a growing interest in the development of autonomous military robotic systems such as Unmanned Combat Aerial Vehicles (UCAVs, systems that will not need a human 'in the loop' to make decisions in combat situations). There are serious ethical questions arising over whether armed robots should be able to make life or death decisions. The International Committee for Robot Arms Control (ICRAC) and the Campaign to Stop Killer Robots believe this would be:

> inherently wrong, morally and ethically. Fully autonomous weapons are likely to run afoul of international humanitarian law, and there are serious technical, proliferation, societal, and other concerns that make a preemptive ban necessary.

This issue is also now being addressed by the UN Convention on Conventional Weapons whose purpose is to ban or restrict the use of weapons considered to cause unnecessary or unjustifiable suffering to combatants or to affect civilians indiscriminately.

3.4 Dual-Use Space Systems

International agreements ensure that all states have the right to develop space technologies but also attempt to ensure that outer space remains free for all to use and does not become a battleground. There are problems with identifying the purpose behind many of the satellites launched as many of their capabilities can be useful for civil or military purposes. For example, the military can and do purchase images and bandwidth from commercial organisations operating communications and reconnaissance satellites. Space planes and small (or micro) satellites have greater manoeuvrability than other systems and could provide useful inspection and maintenance capabilities. However, microsatellites can be released into orbit and approach other satellites discreetly, they are difficult to detect and, as with space planes, they could support more aggressive activities such as interception and interference in space.

Dual-use systems are blurring the boundaries between military and commercial space projects – making overall intentions more difficult to determine. Civilians have become dependent on systems developed by the military (such as GPS) and dual use is resulting in the militarisation of previously non-military institutions – e.g. NASA and the European Space Agency (ESA). The Guardian of 11 October 2006 reported that America's civilian and military space programmes are converging and that NASA has already become an integral part of US Space Command. Former NASA director, Sean O'Keefe, is quoted as saying that NASA was looking forward to providing agency resources for the 'war on terror' and that from now on all space missions had to be considered 'dual purpose', i.e. military and civilian.

As for the ESA, Article II of its Convention (ESA 2005) states that the purpose of the Agency is 'to provide for and to promote, for exclusively peaceful purposes, co-operation among European States in space research and technology and their space applications'. However, a Commission of the European Communities Green Paper on the ESA presented on the 21st of January 2003 declares that '… there are many common features of civil and military space technologies, so that it is appropriate to combine resources in the most effective manner…' and a growing number of ESA projects are dual use. The Copernicus Global Monitoring for Environment and Security (GMES), a joint initiative of the European Commission and ESA, aims at achieving a European capacity for Earth observation and assumes a fairly broad definition of security. A number of military services are key elements for European security, such as optical imaging, infrared and radar systems (observation and reconnaissance) and information, command and control systems (satellite communication). There is also the Galileo military/civilian satellite navigation system being built by the European Union (EU) and the European Space Agency (ESA), at a cost of some €5 billion. The project aims to provide an independent, high-precision positioning system for Europe. After 9–11, the United States opposed the Galileo project and argued that it would end the ability of the Pentagon to shut down satellite navigation when it thought necessary. However, in June 2004, an agreement was signed between the United States and the EU whereby it was agreed that Galileo would operate in a way that would allow it to coexist with GPS and the EU agreed to address the 'mutual concerns related to the protection of allied and U.S. national security capabilities'.

An example of how dual use can cause international conflict is illustrated by *SvalSat*, a satellite downlink station in Svalbard (a remote Norwegian archipelago in the Arctic). *SvalSat* is one of the ground stations run by the Kongsberg Satellite Service (KSAT), a commercial Norwegian company, 50% owned by the state. The Svalbard Treaty of 1920 between Russia and Norway strictly forbids military operations of any kind from here, but Norwegian journalist Bård Wormdal (2013) has discovered that *SvalSat* downloads images of the Earth that are used for intelligence and military activities. During the Libyan war, *Landsat* images were sold by the Italian company *e-GEOS* to the Italian Armed Forces; satellite images were sold to the US Armed Forces during the War in Afghanistan, and images of North Korean installations have been sold to the United States. These were downloaded from different satellites, all using *SvalSat* as a ground station.

The problem this highlights is that the satellites are controlled by one group (civilian or military), while another is responsible for running the downlink operations and yet another runs the equipment that receives and distributes the data. The last two are often civilian groups whose services act as conduits for the images and data transmitted from satellites. They may have no idea what the data is that they are transferring and the end user can be (and often is) the military. A similar case exists at the rocket launch and testing facility *Esrange* in Sweden used by the scientific community to launch upper atmosphere probes but it also acts as a downlink facility for satellite data that is often for military use – although the personnel involved may not be aware of this because it is not them but their customers, who deal with the data, who know who the final users will be.

The military uses of space are no longer restricted to the superpowers, and earthly rivalries are being played out in space via military or dual-use space systems – Taiwan and China, Japan and North Korea, Pakistan and India and Israel and Iran have mutual concerns about each other's space activities (West 2007).

4 Environmental Effects of Space Use

Firing rockets into space will affect not only the atmosphere but also the ground and outer space environments and, as the use of space is increasing dramatically, any problems caused could become serious. The major detrimental effects identified so far are pollution from the rocket propellant; damage to the upper atmosphere as rockets pass through and space debris from various space activities. It is worth looking at these effects a little more closely.

4.1 Rocket Fuel Pollution

Rockets can use solid or liquid fuels or a hybrid mixture. Up until the last century, all rockets used a solid or powdered propellant, but then liquid and hybrid fuels were developed that offered more efficient and controllable alternatives.

Solid-fuel rockets can be kept for long periods with minimum maintenance and launched at short notice and are therefore frequently used in missiles. Liquid rockets may use one, two or even three types of propellant, often held in liquid form at very low temperatures, which are pumped into a combustion chamber for ignition. Sometimes an inert gas is used instead and this is forced under pressure into the chamber; these are often used in satellites to enable small changes of orbit.

Solid-fuelled rockets generally have a lower performance than liquid-fuelled ones and so are not often used to launch medium-to-large payloads such as commercial satellites or major space probes. However, they are frequently used as strap-on boosters to increase payload capacity or as spin-stabilised add-on upper stages when higher-than-normal velocities are required. Solid rockets are used as light launch vehicles for low Earth orbit (LEO) payloads under 2 t or escape payloads up to 1,100 pounds.

Perchlorate is a major oxidiser in solid rocket fuel and can interfere with iodide uptake into the thyroid gland (which helps to regulate the body's metabolism). It is also highly soluble and has been found to be a pollutant in drinking water and food sources in more than 20 states in the United States. In 1992 the US Environmental Protection Agency (EPA) proposed a safe reference dose (SRD) level of four parts per billion (ppb) for perchlorates in drinking water. A group of manufacturers and users of rocket fuel (including Aerojet, American Pacific Corporation, Kerr-McGee Chemical and Lockheed Martin) joined together to form the *Perchlorate Study Group* (PSG) and provided the EPA with evidence they had gathered on the health effects of perchlorate. Subsequently, in 2005 the EPA raised the SRD to 24.5 ppb. However, Madsen and Jahagirdar (2006) claim that rather than supplying the EPA with good scientific evidence, the PSG 'paid millions of dollars to fund misleading research and millions more to influence the scientific and public debate'. In addition, a 2005 report released by the US *National Academy of Sciences* that was supposed to evaluate the potential health threats posed by perchlorate was strongly criticised by the US *National Resources Defense Council* who state in a press release that:

> Documents obtained from a series of Freedom of Information Act requests and lawsuits against the White House, Department of Defense and the Environmental Protection Agency indicate that the panel was subjected to massive pressure to downplay the hazards of the chemical. (NRDC 2005)

The issue remains controversial and the risks to health and the extent of pollution from rocket fuel remain unclear. A proper independent study is still required to test these areas of concern, and several US states have initiated regulatory reviews to prepare a drinking water standard for perchlorate. In the mean time, California and Massachusetts have set 'public health goals' for contaminant levels of 6 ppb and 1 ppb, respectively.[12]

This situation is probably familiar to many campaign groups who find that so-called scientific evidence is far from scientific but has in fact been commissioned and monitored by corporations with a vested interest in the results. The problem is

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[12] See more at http://www.drinktap.org/home/water-information/water-quality/perchlorate.aspx#sthash.doA52MRF.dpuf

that companies sponsoring the research can often then determine the conditions of release of results and therefore block the publication of findings that might harm their business. As universities become more and more commercialised, research scientists seeking funds to keep going will need to be increasingly careful about the ethical implications of the contracts they sign or that are signed on their behalf.

4.2 The Ozone Layer

Given the importance of the ozone layer in protecting living organisms from harmful ultraviolet radiation, it is important to understand how rockets passing through might affect it. For example, although it is not known how liquid-fuel rockets affect the upper atmosphere, it is known that solid-fuel rockets release chlorine gas directly into the stratosphere, where the chlorine can react with oxygen to form ozone-destroying chlorine oxides. Ross et al. (2009) have estimated the extent of the damage as a function of payload launch rate and a mix of solid and liquid rocket emissions. They found that global rocket launches deplete the ozone layer by only about 0.03%, which is an insignificant fraction of the depletion caused by other ozone depletion substances. However, they point out that as the space industry (including military activity and new ventures such as space tourism) grows and CFC substances fade from the stratosphere, depletion from rockets could become more significant, perhaps even requiring some level of regulation. They suggest it may even become necessary to limit launches to as little as several tens of kilotons per year. However, they also emphasise that new studies are needed to help guide any possible future restrictions on commercial and state rocket launches. Nevertheless, it is also clear that it should be the responsibility of those involved in space technology to ensure that we are not removing one danger to the protective ozone layer, only to replace it with another.

4.3 Space Situational Awareness

Space Situational Awareness refers to the knowledge of location and function of natural and artificial space objects and the space environment. The increasing utilisation of space is presenting us with a growing problem – space debris. As activities in space increase, so does the amount of junk – burnt out rocket stages, defunct satellites and wreckage from collisions, explosions, antisatellite tests, etc. All these have contributed to the tens of thousands of fragments that have formed a cloud about the Earth.

Travelling at orbital speeds of around 8 km/s, a collision with the smallest piece of space junk could breach the walls of a satellite or spacecraft and damage it. Initial thoughts about the Columbia disaster in February 2003 were that it had been struck by debris. Two of the worst debris-creating events in history occurred in the first 6 weeks of 2007. On 11 January 2007, the Chinese conducted an antisatellite test, destroying one of their own satellites with an interceptor, and on 19 February, a Russian rocket body exploded. As a result of these two incidents, the amount of large space debris (greater than 10 cm in diameter) in heavily used orbits increased by over 20%.

Space debris is recognised as a growing problem, affecting military, commercial and scientific space systems. In a worst case military scenario, a debris collision with a militarily sensitive satellite could be interpreted as an attack. If this were to occur at a time of international tension, with little time for careful consideration, it could lead to a devastating retaliation. Currently radars can give warnings of possible collisions with objects larger than 10 cm (the International Space Station has had to be repositioned a number of times for fear of a possible collision), but there are at least 100,000 objects in the 1–10 cm range and the amount of debris in space is increasing at a rate of around 4% per year. Plotting a way through is becoming a major problem for spacecraft aiming to leave the near-Earth environment, and according to Prof Heiner Klinkrad, the head of the European Space Agency's (ESA) Space Debris Office:

> There is a consensus among debris researchers that the present orbit debris-environment is at the rim of becoming unstable within a few decades, a phenomenon that is commonly known as the Kessler Syndrome,[13] and that only active removal of five to 10 large objects per year can reverse the debris growth,[14]

The results of research presented at the conference where this statement was made demonstrated the need for much stronger international agreements on the use of space.

5 A Tragedy of the Commons

The global and outer space environments may both be considered as commons.[15] As such they are valued resources that lie outside the jurisdiction and sovereignty of any individual state. The commons of the global environment include the climate (and any changes in it), the ozone layer, the oceans, etc. The commons of space

[13] The Kessler syndrome was proposed by the NASA scientist Donald J. Kessler in 1978; it occurs when the density of objects in low Earth orbit is high enough that collisions cause a cascade of debris to the extent where the distribution of debris in orbit could render space exploration, and even the use of satellites, unfeasible for the future. (See 'Collision Frequency of Artificial Satellites: The Creation of a Debris Belt' by Donald J. Kessler and Burton G. Cour-Palais, *Journal of Geophysical Research* 83: 2637–2646, 1978.)

[14] At the 6th European Conference on Space Debris in Darmstadt, Germany, held in April 2013 – see the report '"Urgent need" to remove space debris' published on 25th April 2013 by BBC science correspondent Jonathan Amos at http://www.bbc.co.uk/news/science-environment-22299403

[15] Commons are traditionally defined as elements of the environment that are shared, used and enjoyed by all.

include orbital paths, access to outer space, the planets and other celestial bodies, etc. These environmental resources are nationally non-appropriable and so free access to, free use of and freedom of action within them are required. As outer space is essentially deregulated, it is subject to a 'tragedy of the commons'.

This is a dilemma arising from a number of individuals, acting independently and rationally in their own self-interest, ultimately depleting a shared limited resource – even when it is clear that it is not in anyone's long-term interest for this to happen.[16]

In his original article on tragedy of the commons, Garret Hardin pointed out that an article by Wiesner and York (1964) on the future of nuclear war concluded the following:

> Both sides in the arms race are …confronted by the dilemma of steadily increasing military power and steadily decreasing national security. *It is our considered professional judgment that this dilemma has no technical solution*. If the great powers continue to look for solutions in the area of science and technology only, the result will be to worsen the situation.

This is also the situation with the use of outer space – although individual states cannot own outer space, in order to avoid a tragedy, they will collectively need to agree to cooperate in its use. A generally acceptable ethical code must therefore be developed that can be reliably followed and which will benefit all without polluting the near-Earth environment, restricting access to deep space or employing space as a means of domination.

6 The Ethical Use of Outer Space

Sections 4.3, 4.4 and 4.5 have detailed a number of problems arising from the increased use of space for scientific, civil or military purposes. The increasing military activity in space (perhaps leading to the stationing of weapons there), the vulnerability of key military components and the likelihood of international incidents through natural accidents or technical failures are of some concern. In addition, the increasing dangers due to space debris and the lack of regulation are strong indications that there is a need for some internationally agreed constraints to ensure the sustainable use of outer space. As the number of space-faring nations increases, the stakes get higher and it becomes more difficult to manage political and military tensions.

In addition, the enormous costs involved with space activities raise questions regarding the setting of priorities – there is an urgent need for funds to save lives down here on Earth, should we continue to spend limited resources on space operations when there is so much human suffering that could be eased with the same

[16]This dilemma was first described in an influential article titled 'The Tragedy of the Commons', written by Garrett Hardin and first published in the journal *Science,* Vol. 162, No. 3859, Dec. 13, 1968, pp. 1243–1248. Available at http://www.sciencemag.org/content/162/3859/1243.full

amount of money and international cooperation? For example, a 2012 OECD[17] study estimates that the cost of achieving the first six Millennium Development Goals would cost a little over $120 billion of new resources beyond the current flows of investment, ODA and public spending in the developing world (Stijns et al. 2012) – about 2 years worth of world spending on space. We are often told of the spin-offs associated with space research and development, but these are mostly of a technological nature and unlikely to help with achieving MDGs. It seems more likely that focussed research and development on specific problems would yield more useful outcomes and more quickly.

Some space activities can be very beneficial. For example, governments are relying on data from Earth observation satellites to forecast and respond to weather events; to help with mapping and with geological prospecting; to monitor crops, fisheries and forests; to provide warnings of solar outbursts that could disrupt power lines; and to monitor potential human rights violations in war-torn areas. Space has also become critical for disaster relief. Cospas-Sarsat is an international satellite system for search and rescue that provides alert and location data to national search-and-rescue authorities worldwide, without discrimination, independent of country participation in the management of the programme. Similarly, in 2006 the UN General Assembly agreed to establish the UN Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER).

What is required therefore is the understanding and agreement by all states to develop their space activities for the benefit of all. A state's attitude to developing a policy on outer space is likely to be closely related to, and associated with, its foreign policy. Generally, we might think (or hope) that respectable democratic processes (if they exist at all) should encourage the pursuit of ethical foreign policies (at least, it is difficult to imagine that they would develop an unethical one), but it is often argued that a foreign policy (and therefore a space policy) should only be formulated in a way that allows the pursuit of national self-interests, and therefore we can only really expect policies 'with an ethical dimension'. The assumption in this argument is that ethical issues are somehow counter to a 'national interest' and that this is best served by ensuring the well-being of a controlling elite, who will then spread their wealth down to others through various paths of business and patronage. However, a more ethical view would be that what is best for the state must be what is best for the majority of the population.

Robin Cook famously spoke of formulating 'a foreign policy with an ethical dimension' in the first weeks of the New Labour government in 1997, and in 2004 Nicholas Wheeler and Tim Dunne examined how far this had been achieved. In doing so, they argued that an ethical foreign policy could be pragmatic and wouldn't necessarily involve the sacrifice of national interests. They concluded that 'despite the criticism heaped upon it for proclaiming an ethical foreign policy, the government was right to do so' and that 'to protect itself from unreasonable criticism, the government could do more in terms of setting out the principles underpinning the

[17] The OECD (Organisation for Economic Cooperation and Development) is an international economic organisation of 34 countries founded in 1961 to stimulate economic progress and world trade.

policy and acknowledging a) these are not always mutually compatible and b) what priority ought to be accorded to the various moral values'.

So, what of the 'ethical use' of space – what are the moral values? A moral approach to something generally means a consideration of what ought to be, rather than what actually is. After all, we might not need to consider what we ought to do if we always did it as a matter of course. In order to define an ethical approach, we will need to adopt some normative moral principles in order to assess or justify particular courses of action and/or behaviour. What we are actually discussing then is the development of a set of generally agreed principles that will ensure that outer space is used in the best possible way for the benefit of the global community.

In 1998 UNESCO set up a World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) and established a Joint Working Group on 'the Ethics of Outer Space'; a joint report with ESA was issued in 2000.[18] The report examined the ethical problems posed by the utilisation of outer space and discussed topics such as manned space flight, the search for life in space, the return of samples from other celestial bodies, space debris, Earth monitoring and the public image of space exploration. According to Antonio Rodotà at ESA:

> Ethics is a fundamental aspect of human society. For those who are involved in space activities, ignoring this debate is not an option… At the European Space Agency we are committed to ensuring that the ethics of space science and technology will be considered in our decisions and in our programmes.[19]

The report hardly mentioned the militarisation of space and was concerned mainly with how the non-military sector should organise to ensure the ethical use of space, but it does point out that 'space activities need a precise juridical framework, underpinned by an ethic defined and then clearly accepted by all participants'. It envisaged space on several different levels:

- As an area which raises ethical questions.
- As part of the shared heritage of humankind.
- As a need to limit the pollution created by space activities.
- As a perception to manage risks and develop a space culture based on mediation.

As 'globalisation' progresses, we need to move to a greater awareness of our collective responsibilities and be clear about the consequences of our actions in an ethical way. The criteria used for making decisions cannot be just economic but should be extended to embrace fundamental commitments to human rights and freedoms and to the cultural identity of each nation. This is particularly the case for space technology, because of the considerable imbalances its use can generate in relations between countries, as well as between the private sector and the public at large. Access to space programmes requires substantial resources – costs put them

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[18] The report of the Working Group was presented in July 2000 by Professor Alain Pompidou, former member of the European Parliament, and Antonio Rodotà, ESA's director general, can be downloaded from http://unesdoc.unesco.org/images/0012/001220/122048e.pdf

[19] As quoted in the ESA press release: http://www.esa.int/For_Media/Press_Releases/The_ethics_of_outer_space

out of reach of many countries – especially the majority world countries (see the discussion on costs in Sect. 4.6). Therefore, the exploration of space should be pursued in an international context – outer space having been acknowledged as the common heritage of (hu)mankind.

Space policies should keep in mind the vulnerability of human beings and respond to public anxieties through an objective, independent and transparent approach – interaction between scientists and experts in different disciplines, elected representatives, political decision-makers and the media. Motivations need to be questioned – the inalienability of space as a scientific territory should guarantee free access and protection against pollution from space debris – there is a need for the management of risks in space, especially those associated with debris and the use of nuclear reactors. What has become very clear recently is that operators with access to space are able to penetrate the private sphere of citizens through satellite surveillance, communications and positioning – so protections of individual liberties, cultural identities, etc., are needed.

In fact a number of international agreements and understandings on the use of outer space have been made, many with ethical as well as practical concerns. It is worth looking at what the international community has been able to achieve so far.

In September 2000, the Project for the New American Century (an influential think tank established in 1997 'to promote American global leadership'[20]) published a report entitled *Rebuilding America's Defenses; Strategy, Forces and Resources For a New Century*; it showed how the future space policy of the United States would be developed by Donald Rumsfeld and George W. Bush et al.:

> Much as control of the high seas – and the protection of international commerce – defined global powers in the past, so will control of the new 'international commons' be a key to world power in the future. An America incapable of protecting its interests or that of its allies in space or the 'infosphere' will find it difficult to exert global political leadership. (Jessop 2008)

However, PNAC was shut down in 2006, and although it perhaps did exert some influence in its heyday, its ideas did not really dominate (Reynolds 2006). The parallel between space and the 'freedom of the high seas' can be seen as an exploitative colonial paradigm that is not applicable to space. International law has changed over the last 500 years, and events such as de-colonisation and the formation of the United Nations have introduced a certain element of cooperation and brought about a structural change in international law. Many believe therefore that there is a need for a 'Treaty on the Cooperative Use of Outer Space' that goes beyond the mere prohibition of weapons in space and would lay the foundation for Common Security in Outer Space.

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[20] PNAC was founded in 1997 by William Kristol and Robert Kagan; it was a strong proponent of military strength, promoting the view that 'American leadership is both good for America and good for the world'. It had members in key positions in the administration of President George W. Bush, affecting the development of US military and foreign policies at the time of the Iraq War. The project was officially ended in 2006 – more details at the website http://www.newamericancentury.org/

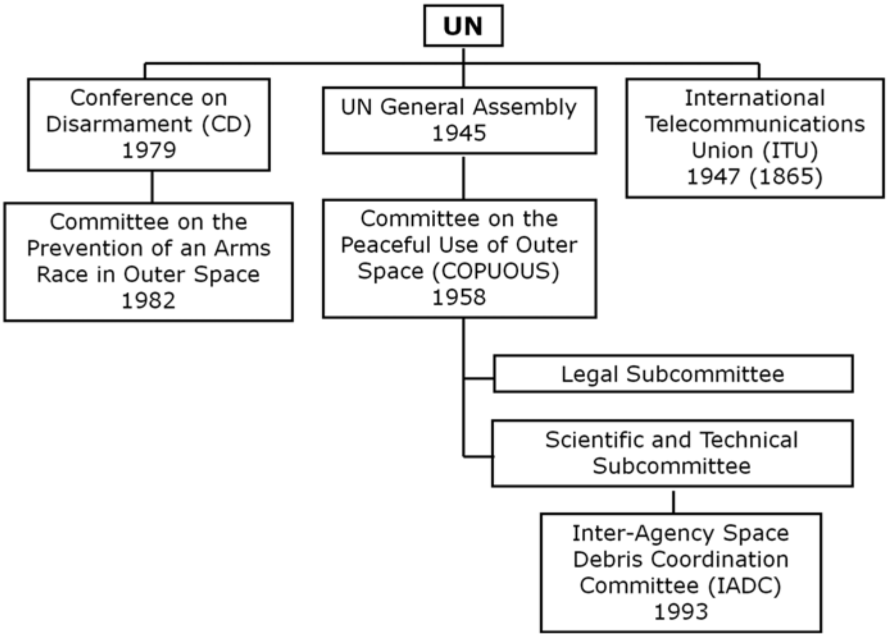

Fig. 4.1 International space security negotiations at the United Nations

6.1 Space Law

Perhaps the best place for discussing international treaties is the United Nations, and Fig. 4.1 shows the structure of departments within the United Nations that deal with issues concerning outer space. Commercial and civil space issues are considered and regularly addressed by the UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS), while military issues and challenges are discussed at the Conference on Disarmament (CD) and the UN General Assembly (UNGA) where issues such as the Prevention of an Arms Race in Outer Space (PAROS) are pursued. Other international agreements on space activities have been developed by the International Telecommunication Union (ITU) and the Inter-Agency Space Debris Coordination Committee (IADC) who address problems regarding the radio-frequency spectrum, orbital slots and space debris.

The current space law has been largely determined by UNCOPUOS which was established in 1959 by the UN General Assembly to review international cooperation and devise UN programmes related to the peaceful use of outer space, encourage research and dissemination of information on outer space and consider legal issues arising from the exploration of outer space. As of 2012, UNCOPUOS has 74 member states; it meets annually in Vienna. Its decisions are implemented by the UN Office for Outer Space Affairs (UNOOSA), which was initially created as a small expert unit to service the ad hoc COPUOS. UNOOSA became a unit within the Department of Political and Security Council Affairs in 1962, when COPUOS

Table 4.4 The five major global space treaties

Treaty	Date	Ratifications	Signatures
Outer Space Treaty	1967	98	26
Astronaut Rescue Agreement	1968	92	26
Liability Convention	1972	89	25
Registration Convention	1975	60	6
Moon Agreement	1979	15	4

met for the first time, and was transformed into the Outer Space Affairs Division of that department in 1968. In 1992 the division was transformed into UNOOSA within the Department for Political Affairs. In 1993 the office was relocated to the UN Office in Vienna, supporting the Scientific and Technical Subcommittee and the Legal Subcommittee. Questions relating to the militarisation of outer space are dealt by the Conference on Disarmament, based in Geneva.

The need to create legal norms acceptable to all interested states, led the Committee to adopt consensus as a major procedural principle governing space rule-making negotiations. Consensus is an important factor in space lawmaking and is considered to be a major achievement of UNCOPUOS and through it the Committee has developed five sets of legal principles governing space-related activities – shown in Table 4.4.

The framework for international space law was ratified in the United Nations, at the height of the Cold War in 1967, and laid down in the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies* – commonly known as the *Outer Space Treaty* (or OST). The OST was considered by the Legal Subcommittee in 1966 and agreement was reached in the General Assembly in the same year as Resolution 2222 (XXI) (United Nations Office for Outer Space Affairs 1966). The treaty was opened for signature by the three depository governments (the Russian Federation, the United Kingdom and the United States) in January 1967 and entered into force in October 1967.

The treaty enshrines the principle that space is a global commons to be used for peaceful purposes for the benefit of all humankind, and its concepts and some of its provisions were modelled on the *Antarctic Treaty* of 1961. Both treaties were attempts to prevent 'a new form of colonial competition' and the possible damage that self-seeking exploitation might cause – but these ideals are not without practical difficulties (e.g. the 'tragedy of the commons'). The OST provides the basic framework for international space law, including in particular, the following principles:

- The exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind (Article I).
- Outer space shall be free for exploration and use by all states (Article I).
- Outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation or by any other means (Article II).
- International law and the UN Charter extend to the exploration and use of outer space (Article III).

- States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner (Article IV.1).
- The Moon and other celestial bodies shall be used exclusively for peaceful purposes (Article IV.2).
- Astronauts shall be regarded as the envoys of mankind (Article V).
- States shall be responsible for national space activities whether carried out by governmental or non-governmental entities (Article VI).
- States shall be liable for damage caused by their space objects (Article VII).
- States shall avoid harmful contamination of space and celestial bodies (Article VIII).

The other major agreements shown in Table 4.1 expand on relevant sections of the OST. The UNOOSA 1968 *Agreement on the Rescue of Astronauts* provides that states shall take all possible steps to rescue and assist astronauts in distress and promptly return them to the launching state and that states shall, upon request, provide assistance to launching states in recovering space objects that return to Earth outside the territory of the launching state. The UNOOSA 1972 *Convention on International Liability for Damage Caused by Space Objects* provides a detailed regime for the liability of states for damage caused by space objects on the surface of the Earth, to aircraft in flight and in outer space. The UNOOSA 1975 *Convention on the Registration of Objects Launched into Outer Space* specifies the requirement for the registration of space objects – a registry of launches has been maintained by the secretariat since 1962, in accordance with *General Assembly Resolution 1721 (XVI)* (United Nations Office for Outer Space Affairs 1961). The 1979 *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies* (also known as the Moon Treaty) reaffirms a number of OST principles but also declares the Moon to be the 'common heritage of mankind' and calls for the creation of an international regime to govern the exploitation of the natural resources of the Moon.

In addition to these multilateral treaties dealing specifically with space and space activities, the international community has agreed a number of other conventions relevant to space activities (see Table 4.5). In particular, the 1963 *Partial Nuclear Test Ban Treaty* bans nuclear explosions in outer space; the 1977 *Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques* bans the use of certain environmental modification techniques aimed at changing the dynamics, composition or structure of outer space. Further, the 1932 *International Telecommunications Convention* contains provisions relating to space communications. In particular Article 45 of the Convention aims to prevent harmful interference with the services or communications of its members, while Article 33, note 20, provides that all countries should have equal access to radio frequencies and the geostationary satellite orbit, 'taking into account the special needs of the developing countries'.

As well as discussing and developing treaties and agreements, every year UNCOPUOS invites member states to submit reports on national research on space debris, the safety of space objects with nuclear power sources on board and any

Table 4.5 Other global space conventions and treaties

Treaty	Date	Ratifications	Signatures
Partial Nuclear Test Ban Treaty[a]	October 1963	126	10
Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques	December 1976	76	48
The International Telecommunications Convention	The current Constitution and Convention was adopted in 1992 in Geneva. Subsequent conferences have only adopted amendments		193 (members)

[a]The Treaty banning nuclear weapon tests in the atmosphere, in outer space and under water (1963) can be viewed at: http://www.un.org/disarmament/WMD/Nuclear/pdf/Partial_Ban_Treaty.pdf

problems of their collisions with space debris. The information received is then disseminated by the United Nations.[21] In June 2007, UNCOPUOS also adopted *Space Debris Mitigation Guidelines* – which member states pledged to implement 'to the greatest extent feasible' (United Nations Office for Outer Space Affairs 2010). The 2007 session of UNCOPUOS also agreed on a draft resolution on the practice of states and international organisations in registering space objects to be submitted to the General Assembly and approved a work plan for the *UN Platform for Space-based Information for Disaster Management and Emergency Response* (UN-SPIDER).

Every year the UN General Assembly discusses resolutions relating to activities in outer space.[22] Table 4.6 shows some additional principles on the use of space which have been adopted. Every year they adopt a resolution calling for 'International Cooperation in the Peaceful Uses of Outer Space' usually without a vote. There are also regular discussions on the *Prevention of an Arms Race in Outer Space* (PAROS)[23] and on *Transparency and Confidence-Building Measures* (TCBMs) in Outer Space. Both resolutions are adopted by an overwhelming majority of UN member states with every country votes in favour of the resolution – except for the United States who usually vote against and Israel, who abstain. The United States argues that the existing multilateral arms control regime is sufficient and that there is no need to address a nonexistent threat, but other countries view this suspiciously and are frustrated that progress cannot be made on this subject until the most powerful country in space agrees.

[21] The reports from 2004 to 2010 are available from http://www.unoosa.org/oosa/en/natact/sdnps/index.html

[22] An index of resolutions can be found here – http://www.oosa.unvienna.org/oosa/SpaceLaw/gares/gavotes.html

[23] For much more information and coverage of UN discussions on PAROS, see the 'Reaching Critical Will' website – http://www.reachingcriticalwill.org/resources/fact-sheets/critical-issues/5448-outer-space

Table 4.6 Principles on space adopted by the UN General Assembly

Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space (1963)	Space exploration should be carried out for the benefit of all countries. Outer space and celestial bodies are free for exploration and use by all states and are not subject to national appropriation by claim of sovereignty. States are liable for damage caused by spacecraft and bear international responsibility for national and non-governmental activities in outer space
Principles on Direct Broadcasting by Satellite (1982)	All states have the right to carry out direct television broadcasting and to access its technology, but states must take responsibility for the signals broadcasted by them or actors under their jurisdiction
Principles on Remote Sensing (1986)	Remote sensing should be carried out for the benefit of all states, and remote sensing data should not be used against the legitimate rights and interests of the sensed state
Principles on Nuclear Power Sources (1992)	Nuclear power may be necessary for certain space missions, but safety and liability guidelines apply to its use
Declaration on Outer Space Benefits (1996)	International cooperation in space should be carried out for the benefit and in the interest of all states, with particular attention to the needs of developing states

The PAROS resolution calls for states to refrain from actions contrary to the objective of PAROS and to ‘contribute actively’ to that objective. A PAROS treaty would also prevent any nation from gaining a military advantage in space and reduce the military use of space. In 2007, the UN Secretary General released a report on ‘Transparency and confidence-building measures in outer space’, on behalf of the European Union which proposed the development of a comprehensive code of conduct in space and suggested guidelines for the general principles, scope and participation for such a code. A first draft of a ‘Code of Conduct’ was published by the EU in 2008 and a revised draft released September 2010, with the latest version being presented in June 2012 (European Union 2012). It calls on countries to refrain from actions that would damage or destroy other satellites or interfere with their communications and to minimise the risk of collisions and limit the creation of orbital debris. Its preamble states:

> [T]he formation of a set of best practices aimed at ensuring security in outer space could become a useful complement to international space law.

As a PAROS treaty has proved difficult, the CD has focused instead on a treaty to prevent the placement of weapons in outer space. This circumvents the US argument against PAROS but doesn’t solve the questions of where outer space begins, what type of weapons should be prohibited or if the treaty would be verifiable. On 12 February 2008, Russia and China formally introduced to the CD a draft *Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects* (PPWT). The draft treaty is designed ‘to eliminate existing lacunas in international space law, create conditions for further exploration and use of space, preserve costly space property, and strengthen general security and arms control’.

7 Conclusion

The international community has successfully established a broad, basic legal framework for the uses of outer space. However, the growing diversity of space activities; the environmental, political, military and technological challenges; and the lack of meaningful progress in important areas mean there is an urgent need to develop new legal rules and structures to regulate new activities in space. To address the challenges and rapidly changing security context in outer space will require a significant international dialogue which is absent at this time. Gennady M. Danilenko (1989) has described the growing problems of consensus decision-making in relation to agreements on the use of outer space. He points to the increasing number of states being involved which has resulted in discussions on space issues becoming more confrontational as the different groups of states have radically different positions. This makes the possibility of reaching a consensus more unlikely and outcomes tend towards the lowest common denominator, so as to ensure reasonable conditions for the states involved. Danilenko comments that ‘such a consensus often serves only as a disguise for continued disagreement’ but suggests that it does mean that more equitable international relations are gradually coming to the fore. As an example, he points to how the demands of the developing countries led to the 1986 Principles Relating to Remote Sensing creating preferential rights for them. In addition, the issue of equitable access to geostationary orbit is also increasingly being discussed in terms of the economic benefits and rights of the less developed nations.

In all the international discussions and debates on the use of space so far, necessity and self-interest (whether it be political, military or industrial) have usually been at the forefront. Hardly ever does an ethical argument enter into discussions. Although the OST could be said to be basically ethical, it was an agreement made before most of the world had any stake in outer space. Treaties of an ethical nature that followed, such as protecting the Moon and planets against ownership and exploitation, have become far less popular – especially as ideas for mining the Moon, the asteroids and even Mars appear to be considered seriously (Lewis 1996; Spacedaily 2012; Chang 2012). Other problems, such as access to orbits that are popular for global communication or surveillance purposes, are growing and an arms race in outer space looks increasingly likely – if it hasn’t begun already. The real problem at the moment is that any legal framework requires the cooperation and consent of those most likely to benefit from its absence – and in particular the United States. This is a problem faced in other areas of concern such as climate change, nuclear disarmament and autonomous military robots.

It is a very good time therefore to consider improvements, and in so doing states must realise that, in order to be effective, space lawmaking should increasingly be based on legislative techniques that will reflect the realities of international relations. The future of the space legislative process depends primarily on the ability of the international community to achieve a genuine understanding and a consensus reflecting both the legitimate common interests of all states in space and the special interests and responsibilities of the space powers in the exploration and use of outer space for the benefit of all humankind. This would seem to be as close to an ethical approach as we could hope for at the moment. However, most of the world is probably not even aware that there are problems with the use of outer space.

There are active NGO groups such as the Global Network Against Weapons and Nuclear Power in Space, Pugwash, the International Network of Engineers and Scientists for Global Responsibility (INES) and the Women's International League for Peace and Freedom (WILPF) who are actively campaigning to draw attention to the problems and prevent the further militarisation and weaponisation of space. Each year in October, the global space community celebrates a UN-Declared World Space Week; events are held around the world to promote space and inspire students. At the same time, peace activists and campaigners call for a 'Keep Space for Peace Week' and use the same week to highlight the need to demilitarise the thinking about outer space. Conferences, public meetings and protest actions at military bases or manufacturers associated with the militarisation of space are organised as awareness-raising activities.

I believe that it is extremely important that NGOs, grass roots organisations and campaigning groups take up this issue. It will only be through worldwide pressure, being energised from a global protest, that the US stranglehold on further meaningful progress can be made. Often governments only take notice after a major avoidable calamity has taken place (such as Chernobyl or Fukushima), but those campaigning to keep space for peace for nuclear disarmament or robotic arms control are doing so in order to prevent such disasters. At one particular 1999 NGO event, the ethical use of space was the topic of a conference entitled *Space Use and Ethics. Criteria for the Assessment of Future Space*, held at the *Darmstadt University of Technology* (TUD) in Germany (INESAP 1999). The conference declared that, in the twenty-first century, space technology should contribute to solving conflicts and problems on Earth in a sustainable way. In order to assess the use of space technology and to ensure its societal acceptance, costs and resources, goals and benefits and also undesired consequences and risks, Jürgen Scheffran from *INESAP* (the International Network of Engineers and Scientists Against Proliferation, a subgroup of INES established to study the problems associated with technical aspects of nuclear and military proliferation issues) suggested eight concrete criteria for the assessment of future space projects which can also be applied to other fields of technology:

- Exclude the possibility of a severe catastrophe that could result in wide spread death and/or destruction.
- Minimise adverse effects on health and environment.
- Assure scientific-technical quality, functionality and reliability.
- Solve problems and satisfy needs in a sustainable and timely manner.
- Seek alternatives with best cost-benefit effectiveness.
- Guarantee social compatibility and strengthen cooperation.
- Justify projects in a public debate involving those concerned.

These seem very reasonable, even necessary, conditions for an ethical space policy, but it seems that little progress can be made until international relations on Earth improve. Some will undoubtedly argue that a democratically elected government with a mandate to work for the best financial and political interests of the electorate might not be ready to pursue an ethical space policy at the expense of other domestic security, prosperity or employment and interests. However, there will always be those who will respond that ethical (or moral) values should govern all relationships and that morality cannot be turned on and off at national convenience. As usual, NGOs and campaigners are acting as the conscience of the world, but it will require much more international cooperation and some courageous and inspirational world leaders to ensure that the wonder and awe with which we hold space does not become the shock and awe of just another battleground for the military.

References

Air Force Doctrine Center (2004) Counterspace operations – Air Force doctrine document 2-2.1. https://www.fas.org/irp/doddir/usaf/afdd2_2-1.pdf

Air Force Space Command (2003) Strategic master plan FY06 and beyond. http://www.wslfweb.org/docs/Final%2006%20SM--igned!v1.pdf

Anon (2008)Treaty on the prevention of the placement of weapons in outer space, the threat or use of force against outer space objects (PPWT) – from the permanent mission of the Russian Federation to the UN Office in Geneva. Detailed at http://www.cfr.org/space/treaty-prevention-placement-weapons-outer-space-threat-use-force-against-outer-space-objects-ppwt/p26678

Asif Siddiqi A (2006) Challenge to Apollo: the Soviet Union and the space race, 1945–1974. NASA, archived from the original. NASA History Division, Washington

BeiDou Navigation Satellite System. http://en.beidou.gov.cn/

Béon Y (1997) Planet Dora: a memoir of the Holocaust and the birth of the space age (translated from the French "*La planète Dora*" by Béon Y, Fague RL). Westview Press, Division of Harper Collins

Chang K (2012) Mining asteroids in our future? The Olympian. Available from http://www.space-4peace.org/articles/mining_asteroids_for_our_future.htm

Cleary MC (1994) The Cape: military space operations 1971–1992. Chapter 2, Section 9. Available from www.globalsecurity.org/space/library/report/1994/cape/index.html

Commission of the European Communities (2003) Green paper on European space policy. Available from Obtainable from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2003:0017:FIN:EN:PDF

Danilenko GM (1989) Outer space and the multilateral treaty-making process. Sp Policy 5:321–329. An extended version is available from http://www.law.berkeley.edu/journals/btlj/articles/vol4/Danilenko/HTML/text.html#B1

Dinerman T (2013) Proliferating space power in 2013 and beyond. Space Rev. http://www.thespacereview.com/article/2236/1

European Commission (2005) Report of the panel of experts on space and security. Project number 200446. http://europa.eu.int/comm/space/news/article_2262.pdf

European Union (2012) Working document (revised draft). International code of conduct for outer space activities. Detailed at http://eeas.europa.eu/non-proliferation-and-disarmament/pdf/12_06_05_coc_space_eu_revised_draft_working__document.pdf

European Space Agency (ESA). www.esa.int

European Space Agency (2011) An evolving commitment: ESA and the domain of security and defence. A briefing, 16 Feb 2011. ESA Communications, The Netherlands

European Space Agency Convention (2005) http://www.esa.int/About_Us/Welcome_to_ESA/ESA_SP-1317_EN_i_The_ESA_Convention_i

Fédération Aéronautique Internationale (FAI). http://www.fai.org
Garamone J (2000) Joint vision 2020 emphasizes full-spectrum dominance. American Forces Press Service, US Department of Defense. http://www.defenselink.mil/news/Jun2000/n06022000_20006025.html.
Global network against weapons and nuclear power in space. www.space4peace.org
Grahn S(1996) Simulated war in space – Soviet ASAT tests, Space history notes. http://www.svengrahn.pp.se/histind/ASAT/ASAT.htm
Grego L (2012) A history of anti-satellite programs. UCS Global Security Program. http://www.ucsusa.org/assets/documents/nwgs/a-history-of-ASAT-programs_lo-res.pdf
Hagen R (2004) Europe – the leading space power? INESAP Bulletin #23. Available from http://www.inesap.org/bulletin23/art04.htm
Halpin E, Trevorrow P, Webb D, Wright S (eds) (2006) Cyberwar, netwar, and the revolution in military affairs. Palgrave Macmillan, Basingstoke
Hasik J, Rip M (2003) An evaluation of the military benefits of the Galileo System. GPS World. http://www.gpsworld.com/gpsworld/article/articleDetail.jsp?id=53279
Hill J (2013) Russia's Glonass constellation back to full strength. Satellite Today. Available at http://www.satellitetoday.com/publications/st/feature/2013/03/05/russias-glonass-constellation-back-to-full-strength/
INESAP (1999) INESAP Bulletin, 17, Space use and ethics. Available from http://www.inesap.org/sites/default/files/inesap_old/bulletin17/bulletin17.htm
International Committee for Robot Arms Control (ICRAC). www.icrac.net
International League for Peace and Freedom (WILPF). http://www.wilpfinternational.org/
International Network of Engineers and Scientists for Global Responsibility (INES). www.ines-global.com
International Telecommunications Union (1932) International telecommunications convention. Detailed at http://www.itu.int/en/history/Pages/ConstitutionAndConvention.aspx
Jessop B (2008) Pentagon: the internet needs to be dealt with as if it were an enemy 'weapons system'. Global Research. Available from http://www.globalresearch.ca/pentagon-the-internet-needs-to-be-dealt-with-as-if-it-were-an-enemy-weapons-system/7980
Johnson C (2004) The sorrows of empire: militarism, secrecy and the end of the Republic. Metropolitan Book, New York, p 79
Lasby C (1975) Operation paperclip. Scribner, New York
Lewis JS (1996) Mining the sky: untold riches from the asteroids, comets, and planets. Helix Books/Addison Wesley, Reading
Madsden T, Jahagirdar S (2006) The politics of rocket fuel pollution: the Perchlorate Study Group and its industry backers. Environment California Research & Policy Center, Los Angeles
Marquart S (2011) Space power: a unique military asset. Int Aff Rev XX(2):47–54
Medea B, Ehrenreich B (2012) Drone warfare: killing by remote control. OR Books, London/New York
Miles C (2012) X-37B space plane: Air Force super weapon is just one of many wild new US military toys. PolicyMic. Available from http://www.policymic.com/articles/20537/x-37b-space-plane-air-force-super-weapon-is-just-one-of-many-wild-new-us-military-toys
Natural Resources Defense Council (2005)White House and Pentagon Bias National Academy Perchlorate report. Press Backgrounder. Available at http://www.nrdc.org/media/pressreleases/050110.asp
Organisation for Economic Co-operation and Development (OECD) (2011) The space economy at a glance 2011. OECD Publishing, Paris
Poroskov N, Novostey V (2003) Platoon with a satellite. In: Russian general staff approves plan to equip troops with GLONASS navigation receivers. Quoted in http://cns.miis.edu/research/space/russia/mil.htm
Pugwash Conferences on Science and World Affairs. www.pugwash.org

Rawnsley A (2011) Shoot the moon: missile defense costs as much as Apollo Program. Wired. Available from http://www.wired.com/dangerroom/2011/08/shoot-the-moon-missile-defense-costs-as-much-as-apollo-program/
Reynolds P (2006) End of the neo-con dream: the neo-conservative dream faded in 2006. BBC News, 21 Dec 2006
Rome BO (2003) Israel makes plans for broad space capabilities. Space News, 25 August 2003
Ross M, Toohey D, Peinemann M, Ross P (2009) Limits on the space launch market related to stratospheric ozone depletion. Astropolitics 7(1):50–82
Rumsfeld D (2001) Report of the commission to assess United States National Security Space Management and Organization. Available from http://www.dod.gov/pubs/space20010111.pdf
Schultz T, Goler W (2003) Military wipes out Iraqi GPS Jammers. Fox News. Available from http://www.foxnews.com/story/2003/03/25/military-wipes-out-iraqi-gps-jammers/
Slosson M (2012) U.S. military hypersonic aircraft trial set for 2013. Reuters. Available from http://www.aviationweek.com/Article.aspx?id=/article-xml/awx_10_25_2012_p0-510571.xml
Space Adventures. http://www.spaceadventures.com/
Space Surveillance Network (SSN) Facebook. https://www.facebook.com/pages/United-States-Space-Surveillance-Network/133008113403721
Space.com (2012) US military to launch hypersonic rocket plane by 2016. Available from http://www.space.com/16524-darpa-hypersonic-rocket-plane-2016.html
Spacedaily (2003) France launches Australian MilSat half owned by Singtel. http://www.spacedaily.com/news/milspace-comms-03t.html
Spacedaily (2012) Mining the asteroids – a new industry. http://www.spacedaily.com/reports/Mining_Asteroids_A_New_Industry_999.html
Spacex. http://www.spacex.com/
Stijns J-P, Garroway C, Atisophon V, Bueren J, De Paepe G, Sanchez C (2012) Can we still achieve the millennium development goals?. OECD Development Centre. Available at http://www.oecd-ilibrary.org/content/book/9789264173248-en
The Free Dictionary. http://www.thefreedictionary.com/
The Space Foundation (2013) 2013 space report. Available from http://www.spacefoundation.org/programs/research-and-analysis/space-report
The Union of Concerned Scientists. Satellite Data Base. http://www.ucsusa.org/nuclear_weapons_and_global_security/space_weapons/technical_issues/ucs-satellite-database.html
Thieme R (2003) Operation paperclip revisited. Counterpunch, http://www.counterpunch.org/2003/08/21/operation-paperclip-revisited/
United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). http://www.oosa.unvienna.org/oosa/COPUOS/copuos.html
United Nations Documents (1977) Convention on the prohibition of military or any other hostile use of environmental modification techniques. Detailed at http://www.un-documents.net/enmod.htm
United Nations Office for Outer Space Affairs (UNOOSA). http://www.oosa.unvienna.org/oosa/SpaceLaw/treaties.html
United Nations Office for Outer Space Affairs (1961) Resolution 1721 (XVI) adopted by the general assembly: international co-operation in the peaceful uses of outer space. Detailed at http://www.oosa.unvienna.org/oosa/SpaceLaw/gares/html/gares_16_1721.html
United Nations Office for Outer Space Affairs (1966) Resolution 2222 (XXI): treaty on principles governing the activities of States in the exploration and use of outer space, including the moon and other celestial bodies. Detailed at http://www.unoosa.org/oosa/SpaceLaw/gares/html/gares_21_2222.html
United Nations Office for Outer Space Affairs (1967) Treaty on principles governing the activities of States in the exploration and use of outer space, including the moon and other celestial bodies, (The Outer Space Treaty). Detailed at http://www.unoosa.org/oosa/SpaceLaw/outerspt.html

United Nations Office for Outer Space Affairs (1968) Agreement on the rescue of astronauts. Detailed at http://www.oosa.unvienna.org/oosa/SpaceLaw/rescue.html

United Nations Office for Outer Space Affairs (1972) Convention on international liability for damage caused by space objects. Detailed at http://www.oosa.unvienna.org/oosa/SpaceLaw/liability.html

United Nations Office for Outer Space Affairs (1975) Convention on the registration of objects launched into outer space. Detailed at http://www.oosa.unvienna.org/oosa/SORegister/regist.html

United Nations Office for Outer Space Affairs (1979) Agreement governing the activities of States on the moon and other celestial bodies (The Moon Treaty). Detailed at http://www.oosa.unvienna.org/oosa/SpaceLaw/moon.html

United Nations Office for Outer Space Affairs (2006) UN-SPIDER. http://www.unoosa.org/oosa/en/unspider/index.html

United Nations Office for Outer Space Affairs (2010) Space debris mitigation guidelines of the committee on the peaceful uses of outer space. Detailed at http://www.unoosa.org/pdf/publications/st_space_49E.pdf

United States Space Command (1997) Vision for 2020. Available from http://www.fas.org/spp/military/docops/usspac/visbook.pdf

United States Strategic Command (STRATCOM). www.stratcom.mil

Virgin Galactic. http://www.virgingalactic.com/

Webb D (2009) Space weapons: dream, nightmare or reality? In: Bormann N, Sheehan M (eds) Securing outer space. Routledge, London/New York

Webb D (2010) Weaponisation of space. In: Young N (ed) The Oxford international encyclopedia of peace. Oxford University Press, Oxford/New York

Webre AL (2003) 'Star Wars' weapons against Iraq. Global Outlook. Available from http://globalresearch.ca/articles/WEB303A.html

Werner D (2013) US military space spending set at $8 billion for 2014. Space News. Available from http://www.space.com/20702-united-states-military-space-budget-2014.html

West J (2007) Back to the future: the Outer Space Treaty turns 40. The Space Review, 15 October 2007

Wheeler N, Dunn T (2004) Moral Britannia? Evaluating the ethical dimension in labour's foreign policy. Available from http://fpc.org.uk/fsblob/233.pdf

Wiesner JB, York HF (1964) National Security and the Nuclear-Test Ban. Sci Am 211(4):27

Wormdal B (2013) Satellite war. Available from http://www.amazon.co.uk/The-Satellite-War-ebook/dp/B009J1D1N4

Yu A (2013) Space agencies of the world, unite: the U.N.'s Asteroid Defense Plan. http://www.npr.org/2013/11/03/242353389/space-agencies-of-the-world-unite-the-u-n-s-asteroid-defense-plan

Part III
Ethical Engineering and Sustainable Development

Chapter 5
Green Jobs and the Ethics of Energy

David Elliott

Overview
This chapter looks first at the social and environmental case for the transition to an energy supply system based on renewable energy sources and then, in more detail, at the employment implications of that change. There may be a net increase in employment, over and above the jobs lost as employment related to fossil and nuclear energy sources is phased out, but it is argued that, in ethical terms, it is also important to consider the quality of the new green jobs, as well as their quantity. Trade union views over the so-called just transition are explored, as are some longer-term issues concerning sustainable employment patterns in a stable state economy.

1 Introduction

At present, globally, around 80% of the energy that we use comes from burning fossil fuel – coal, oil and gas. The environmental case for switching to nonfossil energy seems irrefutable, buttressed by the clearly unsustainable nature of our existing energy system, with climate change being the most obvious and pressing issue. In this chapter, I look at the social case for the transition and in particular at the claim that this switch could lead to more and better employment – good jobs in a green society.

To set the scene, I first look at the record of the existing range of energy supply technologies in terms of their social and environmental impacts and their resource limits and at the emergence of new technological options that avoid or limit these impacts and constraints. The most obvious limit is that coal, oil and gas are all finite planetary resources: so too is uranium. The more we use, the less there is

D. Elliott (✉)
Faculty of Maths, Computing and Technology, The Open University, Milton Keynes, England
e-mail: d.a.elliott@open.ac.uk

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available for future use, with the rate of finding new resources reaching a peak and then falling. However, there is also a wide range of continually renewed energy sources, mostly based on incoming solar energy, which can be used without depleting reserves. A range of technologies has emerged to capture these renewable energy flows, and a transition to a sustainable energy future based on their use, coupled with energy efficiency measures to reduce demand, seems both feasible and likely. I look at the economics of some of the technologies and then at some of the wider strategic choices ahead in terms of their deployment, with employment issues being one factor.

The relationship between investment and employment creation is a complex one, as I try to show by a review of some existing studies of impacts on the energy sector. There are debates about the total numbers and net of jobs lost by the transition away from reliance on the existing energy sources. However, what is perhaps more relevant, from an ethical perspective, is the type and duration of the new jobs. I explore the emerging trade union view that what is needed is a 'just transition' to properly paid, sustainable employment with good conditions. We do need to change the way we produce and use energy, and the change will create new jobs, but we surely do not want jobs at any cost.

2 The Changing Energy Context

Energy is vital for heating, transport, food production and many other key services. Initially human beings focussed on heating, using wood, but subsequently discovered fossil fuels in the ground and learnt how to use them for heating, to power vehicles and for electricity production. However, there are risks with extracting and using energy resources. Ever since human beings discovered how to make fire by burning wood, there have been injuries and deaths. As other fuels (coal, then oil and natural gas) came into use, along with more sophisticated techniques for converting them into useful energy, the risks have grown, culminating in perhaps the most risky option, electricity generation using nuclear technology.

In the first instance, it is those who collect the fuels who are most at risk – coal miners, uranium miners, oil and gas rig workers and so on. But those who work in power stations are also at risk, from everyday incidents as well as major accidents. Occupational health and safety issues have been addressed over the years, with varying degrees of rigour, and we have also tried to reduce the health impacts on the wider community of fossil and nuclear fuel use but with limited success.

An OECD review reported that between 1969 and 2000 there were 1,870 accidents causing five or more 'prompt' deaths in energy industries in OECD member countries, resulting in 81,258 deaths (OECD 2010). The vast majority of these occupational deaths will have been due to fossil fuel-related operations, but the total included 31 workers who died as a result of the Chernobyl nuclear plant disaster. However, given the long-lasting health concerns in areas affected by Chernobyl, the OECD quote a figure of 9,000–33,000 eventual deaths in the wider community, including workers brought in for clean-up operations, from effects of Chernobyl over the next 70 years. Others have put the figure at up to 60,000 (Fairlie and Sumners 2006).

Nuclear and fossil fuels are not alone is presenting big risks from accidents. The OECD also noted that the Banqiao/Simantan dam failure in China (then outside the OECD) in 1975 claimed 30,000 lives. And there have been many other large hydro plant failures in China and elsewhere. However, to put that in perspective, it is estimated that 300,000–700,000 people a year die from outdoor air pollution in China, much of it from coal-burning power plants (World Bank 2007).

Certainly in terms of health damage in the wider community, the use of fossil fuel, and coal especially, has major impacts, even in countries with significant air pollution controls. Here we are not talking about accidents, but routine emissions. For example, in the USA, studies have suggested that about 13,000 people die each year in the USA from air pollution from coal-burning power plants (CATF 2010; ALA 2011). Worldwide, the World Health Organization estimates that about 1.2 million people die each year from outdoor air pollution, much of this being from coal burning and vehicles (WHO 2010). For example, premature deaths caused by particulates from fossil fuel generation are thought to be around 288,000 per year worldwide, based on OECD data.

Focusing on deaths is obviously important, but some of the impacts of coal burning are more diffuse and delayed, leading to respiratory illnesses later on, only some of them fatal. With nuclear it is even harder to assess long-term impacts, in that radiation can lead to a range of diseases and conditions, some which can kill later on, and perhaps not be directly attributed to earlier radiation exposure, e.g. immune system damage. Moreover, radiation exposure may not just be from power plant accidents and leaks but also from the release of radioactive dust from uranium mining, milling and processing operations, as well as, potentially, from waste storage, long-term active waste disposal being as yet an unresolved problem (Alley and Alley 2013).

Scientists and engineers do what they can to reduce these risks, but the nature of the basic energy sources, the associated energy conversion processes and the dangerous by-products and wastes most generate, in many cases, makes it hard to eliminate risk. For example, our success at generating energy on a vast scale has been based on systems that rely on transporting and using potentially dangerous materials and the use of very high temperature and pressure processes, most of which need very careful control. We do not always succeed. Accidents happen, in mines, in fuel transport, in power stations and in waste dumps and tragically also include large hydro-dam failures. In addition to deaths, most involve major pollution episodes with ecological consequences. The names of episodes with large-scale impacts often become familiar due to media coverage – the Torrey Canyon oil tanker disaster, the Pipa Bravo gas blow out, the BP Deepwater Horizon oil spill and the Chernobyl and Fukushima nuclear disasters. The list goes on and includes many that do not get global media coverage (Madrigal 2011).

And yet there seemed to be no alternative. The risks associated with large-scale energy production were often portrayed as the price of progress, even though the costs and the benefits were often being distributed unequally across society and even though it became clear that the leaks, emissions and spills were also having major impacts on the natural environment as well as on humans. Technologists do what they can to minimise that but mostly nevertheless have continued to use fundamentally dangerous, dirty and high impact technologies.

However, the situation has now changed. Firstly it has become clear that the fossil energy reserves will run out: the debate is just about when, not if. Have we already reached 'peak oil', or will that point (when extraction rates reach their maximum and then begin to fall) be in a decade or so? Will peak gas follow soon after, even given shale gas finds? Peak coal, perhaps a bit later (Patzek and Croft 2010). There are disputes and debates about the timing, but everyone agrees that these are all finite resources. Sooner or later, we have to move to other sources. But then comes our second new point: we may not be able to burn off all the remaining fossil fuel resources without seriously damaging the climate system; we may have to leave them in the ground.

Climate change is the big fossil fuel show-stopper. It stops us taking the apparently easy way out of switching back to coal when oil and gas run out. Burning coal is much dirtier in emission terms than burning gas, and converting coal into vehicle fuel or gas also has major issues. Whatever mix of fossil fuels we used, the scale of the potential environmental and social impacts could dwarf anything we have experienced so far (IPCC 2014).

Some look to nuclear energy as the solution. But that too relies on finite resources, and several studies have shown that reserves of uranium are already limited and unsustainable (EWG 2006; Dittmar 2013). The use of fast neutron breeders or perhaps thorium, or even, one day, fusion, might extend the life of the nuclear option, with unknown costs and risks, but not indefinitely (Abbott 2012). We need longer-lived energy sources, and we are unlikely to find them in the ground, at least not on this planet.

Fortunately, as noted earlier, there are a range of alternative energy sources which are not based on finite reserves, but on natural energy flows in the environment, which should continue more or less unabated as long as the planet does – they are naturally renewed and low or zero carbon (Boyle 2012). Large-scale hydro may be an exception, but the renewable sources are mostly environmentally benign, based on intercepting and redistributing a fraction of the natural flows and not releasing trapped energy from fossil or nuclear sources. There may be some small local impacts and disturbance (e.g. visual intrusion from wind farms), but nothing on the global scale associated with burning fossil fuels.

Large hydro apart, the technologies themselves are also in the main individually smaller scale than conventional power plants, and less aggressive in the way they convert energy flows into useful energy, since in most cases the energy fluxes and power densities are much lower. Using diffuse and variable energy flows, not intense-stored energy sources, is of course a problem in terms of high-yield energy production, with implications for land use and meeting energy demand with variable renewables like wind (Elliott 2013). However, these are not unsurmountable problems. For example, offshore wind uses no land, and there are many ways to ensure that grid systems balance out variable energy supply and meet demand. Moreover, even though they may require new approaches to energy use, using these sources should reduce safety risks and environmental impacts.

That is not to say it eliminates them. People fall off roofs putting up solar cells or fall while installing wind turbine blades up towers. But the numbers are relatively small (e.g. one survey reported 146 wind turbine-related fatalities in total, globally, up to 2013) and are mostly limited to the construction phase. Catastrophic disasters are unlikely in relation to solar and wind, although are possible with large hydro projects. Indeed, as already noted, dam failure is one area where major disasters do occur. The point is that no technology is entirely benign, but some are worse than others. We need to select the ones we want, and for many environmentalists, while small hydro and run of the river systems may be viable, large hydro is not on the list. In addition to social dislocation resulting from inundating large areas when the reservoirs for large hydro projects are filled, in some climates the biomass can collect up behind hydro dams, rot and produce methane, a powerful greenhouse gas (International Rivers 2014).

Given their potential impact on the local and regional ecosystem, large tidal barrage projects are also seen as likely to be unviable environmentally, as well as hard to integrate into grid systems, given that they produce large bursts of energy on a lunar cycle, ill-matched to daily consumer demand cycles (Elliott 2010a).

This is not the place for a detailed breakdown of the pros and cons of each renewable source (Elliott 2013). Biomass aside, they are, in operation, carbon-free, apart from the energy used in construction of the energy conversion plant, and as Table 5.1 illustrates, they mostly have significant advantages over the only other nonfossil fuel option, nuclear power. The fossil options of course would score very poorly in nearly all categories.

The overall message is that although some projects and some scales of technology may not be viable, there is a wide range and type of very different technologies using very different energy sources at a range of scales. We have to choose amongst them.

3 Technological Choice

Environmental impact and health and safety issues will be amongst those influencing the choice of option, along of course with costs. We cannot escape economic reality! Fortunately most of the new renewables are getting cheaper rapidly. Indeed wind power is now competitive with conventional sources in some locations and PV solar is expected to be soon. See Table 5.2 for some cost comparisons. Some even argue that renewables will replace conventional sources simply as a result of market forces. But that may take time, and if we are to meet the climate change challenge, we may need to move faster. Otherwise climate impacts could impose massive costs on society, much more than the cost of limiting it through mitigation measures (Stern 2006).

Table 5.1 Comparison of nuclear and renewables

	Nuclear	Renewables
Resource lifetime	Uranium reserves ~100 years *at current use rates* ~1,000 years with fast breeders?	Effectively infinite resource lifetime
Resource scale (REN21 2014)	Currently ~3% of world energy, ~11% of electricity	Currently ~19% of world energy (with hydro) ~22% of electricity
	Projection: maybe up to 50% of world *electricity*. But lifetime of the resource would then be limited	Projection: at least 50% of world *energy* by 2050, perhaps near 100% but with possibly some local access limits
Eco impacts	Infrastructure impacts, cooling water impacts, risks from very long-term wastes ~10,000 years. Emissions from fuel production and routine use	Local visual intrusion and land-use conflicts, some local eco-impacts (especially with biomass large hydro, large tidal barrages)
Safety	Major accidents ~10,000 deaths, occasional/routine emissions of radioactive material ~100s of deaths	Generally low risk, except large hydro ~10,000 deaths
Costs	High and could rise as uranium resource dwindles, but new technology could emerge	Some high, but most are moderate, and all are falling as technology develops
Output	Electricity, but could be used for direct heat or hydrogen production	Diverse sources: electricity, heat, fuels
Reliability	Occasional shutdowns	Some rely on variable sources, so need grid balancing/backup
Supply security	Uranium/thorium deposits limited to a few locations	Widely diffused energy sources though some only localised
Security risks	Significant terrorist targets, plutonium proliferation threat	No significant problems except with large hydro

The renewables, along with energy-saving measures, can help to reduce this impact. There are now many scenarios suggesting that the EU, and indeed the world as whole, could aim to get 100% of its electricity and perhaps also near 100% of total energy, from renewables by around 2050 (MNG 2013). Even the relatively conservative Global Energy Assessment, produced by an international team led by the International Institute for Applied Systems Analysis, concluded that 'The share of renewable energy in global primary energy could increase from the current 17% to between 30% to 75%, and in some regions exceed 90%, by 2050' (GEA 2012).

Expansion on that scale may be technically credible and even economically possible, but is it politically likely? The ethical arguments in favour of making a transition to green energy include the basic one that we should not bequeath to our descendants a ruined planet, in terms of climate change and resource depletion, and the parallel view that it is also inequitable to leave them with radioactive waste to deal with.

The ethical case for a radical change in approach to energy has been explored widely, for example, by Sovacool in 'Energy and Ethics' (Sovacool 2013). Certainly, as he and many others indicate, the rapid development of renewables, coupled with

Table 5.2 Generation cost estimates per MWh delivered, in the UK based on Mott MacDonald data, levelised costs in £/MWh (MacDonald 2011)

Electricity option	Current cost	Cost in 2040
Onshore wind	83–90	52–55
Offshore wind	169	69–82
Tidal barrage	518	271–312
Tidal stream	293	100–140
Wave (fixed-floating)	368–600	115–300
Hydro (small/run of river)	69	52–58
Solar photovoltaics (PV)	343–378	60–90
Biomass (wastes/short rotation coppice)	100–171	100–150
Biogas (anaerobic digestion/wastes)	51–73	45–70
Geothermal	159	80
Nuclear (water-cooled reactors)	96–98	51–66
Gas with carbon capture and storage	100–105	100–105
Coal with carbon capture and storage	145–158	130

The data above is not definitive: critics have suggested that the estimates for nuclear are optimistic (being for as yet un-built plants of new types) and those for renewables pessimistic, given current price reduction trends for actual projects. Certainly Mott Macdonald say they were 'bullish' on nuclear costs, and critics have argued that in fact nuclear costs are likely to go up (Harris et al. 2012)

energy efficiency to reduce energy wastage, seems to be the answer to these challenges, with few downsides: the environmental costs in the costs of conventional sources make the alternative options more attractive, and these costs will grow.

There are also wider ethical, social and political arguments for this change, in that, for example, it is claimed that it will enable a shift to a more decentralised caring society – and away from large-scale centralised technology, dominated by powerful corporate elites (Miller and Hopkins 2013). That is an attractive vision, but can perhaps be too technologically determinist: there once was a society based on using natural energy flows, feudalism, and that was not exactly utopia! The point is that technology does not automatically define society. Technology may make new social forms possible, but there is no guarantee that it will lead to a socially equitable state of affairs. Though it is hard to see how a society based on renewables could be quite the same as one based on say nuclear power (e.g. given that smaller-scale renewables are well suited to local co-operative ownership), there will still be political battles to fight, as of course is recognised by the grass-roots activists striving for green futures.

Within that broad context, one specific argument that has been used to spur on the transition to green energy is the claim that it would create a lot of employment and better employment and job security – sustainable green jobs. If true, that claim offers powerful political ammunition at a time when employment is threatened by recession and by new patterns of global economic competition. In what follows, I ask if this claim is valid. It sounds like a very desirable option – clean, safe, green jobs replacing dirty, dangerous, non-sustainable jobs. But is that really what is on offer?

4 Technology and Employment

A common starting point in the analysis of the relationship between energy and employment, and indeed technology and employment generally, is the distinction between capital-intensive and labour-intensive projects. In the former, the hardware dominates, in the extreme in a completely automated plant; in the latter, workers dominate, in the extreme performing traditional farming or other purely manual tasks.

On this view, everything else is strung out between these extremes, and as a society we are in the process of moving from manual to high tech, with capital constantly replacing labour. The main driver for this process is said to be the increased productivity obtained when machines replace (or at least augment) people. The result is increased profitability, on the assumption that the cost of investing in major new expensive capital plant will be paid back by an increase in output, and the reduction in the need to pay large numbers of workers. Industrial history has been shaped by this process, which has often displaced unskilled labour in some sectors but also replaced skilled labour in others, as craft work and small batch production have been replaced by mass production in factories using unskilled labour. But, in turn, mass production has then given way to automated process production, with a few highly skilled staff (Elliott 1975).

In reality the process is more complex and uneven. While labour is replaced in some sectors, it expands in others, e.g. in services and retail, until some of them are also automated. The debate over the impacts of automation in the 1970s assumed that this process would continue. Optimists looked to a future of leisure with reduced work hours and a cornucopia of automated production while pessimists to a future of mass unemployment and deskilling, driven by a triumphant capitalism, benefiting only an elite (Elliott and Elliott 1976).

In the event, capitalism has triumphed, but so far has arguably managed to spread affluence to some degree by accelerating growth in both production and consumption, using advanced technology. We have seen the creation of mass consumerism and global markets, often based on new advanced products, with new groups of workers in newly developing countries taking over from the earlier unskilled workforce and the rise of technically skilled workforce alongside a vast new service and retail sector. With new patterns and types of work emerging (Rifkin 1995) and major changes in the global economy, there have been growing concerns about the long term.

Certainly whether this process can or should continue indefinitely has long been the subject of debate. With the exploitation of natural resources and the planet deepening, it has been argued that there may be internal economic contradictions in the process (O'Connor 1991). Karl Marx saw this in terms of the falling rate of profit as rival chunks of capital tried to expand, forcing capitalist to reduce wages. The vast increase in productivity through technology has mostly avoided that outcome for the moment: some of the benefits have spread. However, there is of course a vast underclass of sweated labour, who barely enjoy any benefits, and the potential still for a major confrontation and certainly continued struggle (WFTU 2011; Lanchester 2012).

The Marxist and radical view has also been updated into an analysis of the limits of technological advance. For example, in his seminal 1976 book 'The Poverty of Power', Barry Commoner argued that the cost of new more advanced capital plant was rising faster than the increases in productivity it would yield, so there would be a shortage of capital for continued expansion (Commoner 1976). He focussed on energy technology and illustrated his analysis by showing how nuclear power plants were far more capital intensive than those they replaced, but did not yield sufficient extra profits to sustain further investment. On this view, the capitalist system was running out of productivity gains. It has replaced most labour, so there were few savings available from further replacement or exploitation (with lower wages), and there was no way for its raw capital base in the energy sector to improve and expand.

In the event, new energy technology emerged that, for the moment, has avoided or limited this problem, most notably gas-fired combined-cycle turbines. From the 1990s onward in the UK and then elsewhere, there was a 'dash for gas', coinciding with privatisation and the liberalisation of electricity markets, with cheap simple gas turbines using the cheap natural gas that had been found in the North Sea and elsewhere (Roberts et al. 1991). This was cheaper than nuclear and even coal in the UK. It was a significant transition (Winskel 2002). Moreover, although not the initial aim, using gas in more efficient plants also to some extend reduced the emerging problem of carbon emissions. However, this was no long-term solution. North Sea gas reserves have declined, and despite the recent discovery of shale gas reserves, the overall resource is limited and gas is still a fossil fuel. So although emissions per unit of energy produced are around half that from coal, expanding the use of gas would still lead to climate problems and in any case cannot be continued indefinitely. Like the other fossil fuels, gas is a finite resource (Maggio and Cacciola 2012).

If the capital expansion process was to continue, then given environmental and resource limits, a new technology would be needed. The initial default focus was back to nuclear: surely this could be made cheaper with new technology? That was the view that seemed to inform the compilers of Table 5.2. So far however the reality has proved different. Nuclear has become increasingly expensive, in part due to the need to ensure its safety after a series of major accidents (Elliott 2010b, 2012).

It is one of the few technologies with a negative learning curve, with its cost going up not down as the technology develops (Gruber 2010).

As high-grade uranium reserves are depleted, the situation will get worse, since it will cost more to produce the fuel (Harvey 2010). Enthusiast still point to new technologies that they claim will be better (e.g. fast breeders using thorium), but they are long off, with many unknowns (Ashley et al. 2012), and it is clear that the renewables are already doing much better, with costs falling dramatically (IRENA 2012a; IEA 2013; WEC 2013).

The battle over technology choice still continues, but the case for renewables has become much stronger. For example, when in 2012 German utility E.ON withdrew from the UK Horizon nuclear project, it said 'We have come to the conclusion that investments in renewable energies, decentralised generation and energy efficiency are more attractive- both for us and for our British customers' (Teyssen 2012).

The rise of renewables should be aided by the rise in cost of conventional energy, due to diminishing fuel reserves and rising environmental costs, and that will also provide an incentive to avoid energy waste. That in turn will make it easier for renewables to meet the reduced energy demand. Energy-saving technologies, and new patterns of energy use, are a vital part of moving towards a sustainable future.

Although energy saving and renewables complement each other, in this chapter, I have focussed on the new energy supply options rather than on energy efficiency and energy saving, partly for reasons of space: it is a very broad topic, covering a wide range of potential technical upgrades and reconfigurations in many sectors of the economy, as well as possibly the adoption of new patterns of (lowered) consumption. That deserves a chapter on its own, looking at the potential economic and employment gains. Suffice it to say that the potential gains in energy terms are very large, with, for example, Germany aiming to cut its overall energy demand by 50% by 2050 and for the UK, a DECC report in 2012 identifying a potential for cutting electricity demand in some key industrial and building-related sectors by 40% by 2030 (DECC 2012a).

However, there are longer-term limits to how much energy waste can be reduced. For example, once the easy, quick and cheap energy-saving options have been exploited, as they should be, the cost of saving more is likely to rise, and there can be implementation issues related to behavioural change and consumer take-up (Elliott 2013). The implication is that even with a major energy-saving programme, if climate change impacts are to be contained, there will still also be a need for new cleaner sources of energy supply. That said, there is much that can and should be done in terms of changing how energy is used, as part of the process of moving to a more efficient and sustainable energy system.

So having now completed our brief detour around the broad technology change issues and associated choices, we can go back to our main focus and look in detail at what the employment implications might be for the new set of green energy supply technologies.

5 Energy and Employment

On the basis of the simple 'capital versus labour-intensive' distinction outlined above, it is sometimes argued that relatively simple, often small-scale, technologies like solar cells and wind turbines are bound to be less capital intense than large, very complex nuclear power plants, and so their development should lead to more employment. Superficially at least, it certainly seems likely that a lot of people will be needed to build sufficient solar and wind devices to equal the output of a nuclear plant.

Some economists use economic multipliers to indicate the difference in terms of job creation between capital- and labour-intensive pathways, and in early studies of job creation, it was often suggested that developing technologies like renewables would create 2–3 times more jobs/unit of energy output than the development of nuclear plants (Elliott 1976).

The econometric multiplier approach, using sectorial input and output tables, allows for assessment of indirect jobs, created by the supply of materials and services (the supply chain) as well as induced jobs, created in the economy by direct and indirect workers spending their wages on (unrelated) goods and services. But it can be an imprecise science, relying on uncertain assumptions and data, e.g. for the productivity in each sector, which may change over time and by location (IRENA 2012b).

Some economists argue that the best way to understand employment creation is by simply following the money. In this view, the money initially injected for a specific project will trickle down through wages spent in various parts of the economy. In the final analysis, although some money may be banked/saved temporarily, all the injected money will eventually go through wages at some point, whether for indirect, indirect or induced jobs, including any money that goes into profits. On this view then, the only thing that matters in comparing projects is how much money is initially injected. If a project is expensive, it will ultimately create more jobs. On that basis, if it is accepted that they are more expensive, building nuclear power plants should create more jobs per megawatt (MW) of capacity than say building wind projects.

In reality there are some complexities that undermine this simple argument. Firstly, jobs are not just created in construction but also in plant operation, spread over the lifetime of the plant and paid from earnings from sale of its output. However, that means, all other things being equal, that the number of operational jobs will depend ultimately on the MWhs produced, which in turn will depend on the MW capacity, modified by the load factor the plant can achieve, i.e. how much of its installed capacity can actually be used over the year. But in reality, all other things are not equal. For example, some technologies require different levels of skill in both construction and operation, and these will have different wage and salary levels.

So our second complicating issue is that the total number of jobs will depend on the pattern of pay levels, as the money injected for construction, or paid for operation, is deployed. To take an extreme, investing a fixed amount in insulating buildings will create many low paid relatively unskilled direct jobs. Similarly, investing in biomass production will create a lot of unskilled agricultural work on plantations. By contrast, investing the same amount of money in high-tech nuclear project work, using well-paid specialists, will create far fewer direct jobs, but possibly more indirect and induced jobs. So the types and numbers of jobs will vary in each pathway. So will their location: some may be abroad, especially indirect and induced jobs.

A third factor then emerges – the timing/duration of the jobs will vary. A major programme of investment in building insulation (a vital step in any green future) would create a lot of low paid low skill jobs quickly. The money would be spent fast, although only for perhaps a short period, episodically, unless the programme is continued. By contrast, major capital projects take much longer to get going, and may take a long time to complete. Economists use 'job-year' figures to reflect this duration issue, and, certainly, in terms of job security, longer-term employment is desirable. But the quantity versus quality issue is harder to deal with. The differences in job type/pay/quality opens up wide social issues – what type of jobs do we want?

To summarise, on this essentially 'monetarist' view, it can be argued that the number of jobs (direct, indirect and induced) ultimately created in the economy will depend basically on the cost of the project (i.e. the capital injected and the operational costs), but the timing, location, duration and type of the direct jobs, including pay levels, will vary depending on the technology. That will also have a knock-on effect on the indirect and induced jobs. However, it can also be argued that, as Maynard Keynes famously put it, in the end, we are all dead! It may be that some of the injected or operational money will go through the economy creating more or less well-paid or larger numbers of jobs, but as the money passes through into indirect and induced jobs, the net quantitative jobs effect may end up being the same or similar. It is not for nothing that some call economics the dismal science! Certainly, given the complexity of economic interactions, seeking to identify job impacts from investment in green energy programmes, so as to guide energy and employment policies, is hard. Indeed a recent critical study of Low Carbon Jobs concluded that 'the proper domain for the debate about the long-term role of renewable energy and energy efficiency is the wider framework of energy and environmental policy, not a narrow analysis of green job impacts'. (UKERC 2014)

6 Employment Estimates

Despite the methodological difficulties, economists do produce estimates of employment creation for various investments. For example, an EU-wide study 'EmployRES – The impact of renewable energy policy on economic growth and employment in the European Union' was conducted on behalf of the European Commission's Directorate-General Energy and Transport in 2009 (EmployRES 2009). It claimed that policies that support renewable energy sources (RES) could give a significant boost to the economy and the number of jobs in the EU.

The study was based on an input–output model (MULTIREG) that was used to assess the effect of developments in the RES sector on other economic sectors. With regard to future developments, the analysis employed a RES sector bottom-up model (GREEN-X) that was designed to simulate the effect of RES support policies to 2030.

It noted that in 2005 the RES sector employed 1.4 million people and generated Euro 58 billion value added. The total gross value added generated by the RES industry reached Euro 58 billion in 2005, equal to 0.58% of EU gross domestic product (GDP). About 55% of value added and employment occurred directly in the RES sector and 45% in other sectors due to the purchase of goods and services.

For the future, the EmployRES study assessed the economic effects of supporting RES, looking not only at jobs in the RES sector itself but also taking into account its impact on all sectors of the economy. A key point is that, in a transition to renewables, jobs would be lost in traditional energy sectors. So there is a need for a net job estimate – the final sum of positive and negative effects – as well as a comparison with what would have happened anyway under a business as usual (BAU) approach. The study compared a business as usual approach with an approach with stronger RES support policies scenario, which would lead to a share of RES in final energy consumption of 20% by 2020 and 30% by 2030.

It found that improving current policies, so that the target of 20% RES in final energy consumption in 2020 could be achieved, would provide a net effect of up to 417,000 additional jobs, over and above those lost, rising to 545,000 by 2030. This compared to 201,000 by 2020 and 300,000 by 2030 in the BAU case. Under the BAU scenario, there was €99bn in added value by 2020 (0.8% of total GNP), under the RES scenario €129,000bn (1.1% of total GNP), which it was claimed could be raised to €197bn by 2030 under an accelerated renewables scenario with more optimistic assumptions about exports. The extra added value in the renewables scenarios is in part due to the fact that less fossil fuel had to be used.

This type of wider economic analysis has continued to gain attention in recent years, given that fossil fuel prices have risen and look likely to continue to rise. In addition nuclear costs have also risen. For example, in Germany, there has been much attention paid to what is sometimes called the 'merit-order effect', i.e. the tendency, given the feed-in tariff system, for the output from renewables like wind to displace output from fossil sources, thus reducing costs to consumers. It is claimed that the overall savings are greater than the feed-in tariff subsidy they pay for wind (Sensfuß et al. 2007). The basic argument is that, if an investment portfolio approach is adopted, renewables like wind, with zero fuel costs, may win out (Awerbuch and Berger 2003).

A more recent comparative study by financial group Ernst and Young (E&Y) seems to confirm this. By factoring in returns to GDP, like jobs and local taxes, E&Y's analysis challenged the power sector's standard 'levelised cost of energy' (LCOE) approach. E&Y claimed that the *net* cost of European wind power was up to 50% lower than that of its main conventional power rival, combined-cycle gas-fired plants.

They noted that in Spain, producing 1 MWh will generate €56 of gross added value from wind, as opposed to €16 from CCGT. Across the six EU focus countries (Spain, UK, France, Germany, Portugal and Poland), wind's net cost was competitive and, extrapolated across the EU as whole, actually cheaper (Ernst and Young 2012).

Following a similar *net cost* approach, a major renewables company, Mainstream Renewables, has pushed for recognition of the wider strategic benefits of offshore wind, for example, in terms of security of supply and employment creation. They noted that a 2012 UK study of the 'Value of Offshore Wind' had looked at the benefits of investment in offshore wind. The study had found that, by 2015, it could increase UK GDP by 0.2%.

It would also create over 45,000 full-time jobs. By 2020, it could increase GDP by 0.4% and the number of people employed to over 97,000, and by 2030, it could add 0.6% to GDP growth, create 173,000 jobs and deliver an increase in net exports of £18.8 billion, covering nearly 75% of the UK's current balance of trade deficit (Mainstream 2012).

The studies looked at above have focused on the UK and the EU, but similar studies have also been carried out in the USA, with a 2010 meta-study drawing together the results. It concluded that, in net job terms, 'all renewable energy and low carbon sources generate more jobs than the fossil fuel sector per unit of energy delivered, while the type of employment differs between technologies' (Wei et al. 2010).

7 Better Jobs?

As we have seen, it seems credible that investment in renewable energy supply will create a net gain in employment in the EU, with the number depending on the scale of the programme. No doubt this pattern would apply to other areas. Certainly there is a boom in renewables around the world and that is creating many jobs. A 2008 UNEP review gave the following data for renewable energy jobs: China 943,000 (2007), USA 446,000 (2006), Germany 259,000 (2006), Spain 89,000 (2007) and globally 2.3 million (see Table 5.3). It suggested that the total could be over 8 million by 2020 and that may well prove to be a major underestimate (UNEP 2008). A more recent IRENA study (IRENA 2014) put the global total for 2013 at 6.5 million, led by China at 2.6 million, followed by the EU at 1.2 million, Brazil at 0.9 million and the USA at 0.6 million. Clearly expansion is well underway around the world. See Box 5.1 for UK data.

Crucially, however, the type of work can vary. For example, PV solar cell production has boomed in Germany, but much of this has occurred in the poor east of the country where wage levels are often low and trade union rights sometimes absent. More recently there has been a boom in PV cells manufacture and export in China, where wages are likely to be even lower and working conditions possibly worse, although improving (ILO 2012). There has also been a boom in biofuel production for vehicles, with major plantations in developing countries like Malaysia, where working conditions may be very poor and environmental impacts significant, opening up a 'food versus fuel' and development policy debate (Oxfam 2007).

Even in the industrialised countries, there are issues related to safety and working conditions. Most renewables-related work is relatively risk free, and mostly compares well with that in other areas of energy supply (IRENA 2012b). However, care has to be taken working at heights and with the toxic materials sometimes used in making PV cells. Some of the new work will be in factories, but much of it will involve on-site installation and maintenance, often in harsh environments, including offshore. On the smaller scale, there will be jobs fitting systems to houses and offices, with regular maintenance: the classic small company with a white van. Some of this work may be outsourced to individual operators, and much of it may be nonunion, a common trend for casual/contract work of this type in many industrial countries.

Table 5.3 *UNEP estimates* by technology/location. 'Green jobs' UNEP (2008)

Renewable Energy jobs
Wind 300,000
Germany 82,100
United States 36,800
Spain 35,000
China 22,200
Denmark 21,000
India 10,000
Solar PV 170,000
China 55,000
Germany 35,000
Spain 26,449
United States 15,700
Solar thermal 624,000-plus
China 600,000
Germany 13,300
Spain 9,142
United States 1,900
Biomass 1,174,000
Brazil 500,000
United States 312,200
China 266,000
Germany 95,400
Spain 10,349
Hydropower 39,000-plus
Europe 20,000
United States 19,000
Geothermal 25,000
United States 21,000
Germany 4,200
Renewables, combined 2,332,000

Trade unions in the UK and elsewhere have been relatively quick to recognise the importance of this new pattern of employment. However, while they have welcomed the growth of green jobs, they also worry about pay and conditions and the possible trend to nonunionised work. The UK's Trades Union Congress (TUC) has been campaigning for what are sometimes called 'just jobs' – green jobs which are sustainable and safe as well as properly paid – as part of a 'just transition'. The positive side of this reflects the workers' plans for socially useful work that emerged in the UK in the 1970s (Wainwright and Elliott 1982).

There is also a wider dimension to the transition concept. It is sometimes argued that, in order to deal with climate change and other environmental constraints, there will have to be a reduction in the level of economic growth. More immediately, the transition to renewables will mean the loss of jobs in conventional energy industries,

Box 5.1: Some UK Job Estimates
Overall UK employment in energy industries was around 600,000 in 2012, with about 10% in the nuclear sector (DECC 2013). The Renewable Energy Association (REA) in *Renewable Energy: Made in Britain* estimated that the UK renewable energy sector employed 99,000 people in 2010–2011 and 110,000 people in 2012 and that by 2020 this could rise to 400,000 (REA 2012). The Department of Energy and Climate Change's *Renewable Energy Roadmap 2012 Update* suggests that in addition to the REA's estimate of 110,000 direct jobs in 2012, there were an estimated extra 160,000 jobs along the supply chain and that in 2020, in addition to the 400,000 jobs estimated by the REA, there would likewise be 'many more further along supply chains' (DECC 2012b). For comparison in Germany, in 2013, employment in green energy neared 400,000.

Looking further ahead, the Centre for Alternative Technology, in its Zero Carbon Britain study, suggested that in their ambitious scenario, aiming to get to near 100% renewables by 2030 would create over 1.3 million new jobs in energy supply and with energy efficiency and new farming jobs added, over 1.5 million in all (CAT 2013).

where unions are often well established. These issues can lead to conflicts between environmentalists and workers, and sometimes quite bitter confrontations. While it may be true that longer term there will be more jobs, in the short term, there could be painful disruptions, especially for older people who cannot easily retrain or adapt.

The unions have sometimes fallen back on a more defensive line. For example, the TUC report 'A Green and Fair Future', says that union support for environmental policies is 'conditional on a fair distribution of the costs and benefits of those policies across the economy, and on the creation of opportunities for active engagement by those affected in determining the future wellbeing of themselves and their families'.

However, there are also more radical strands in union thinking, sometimes building on common interests. For example, the American Wind Energy Association and the United Steelworkers have created a 'Partnership for Progress' to accelerate wind-power development and deployment in the USA. The European Union body ETUC has called for a binding EU target to cut greenhouse gas emissions by 75% by 2050 and has called for a tripartite dialogue to address negative social effects of restructurings (ETUC 2013). In general, although some unions remain committed to nuclear power, most are very pro-renewables, given their job creation potential, and are keen to build links with environmental groups and campaigns. For example, Guy Ryder, General Secretary of the International Trade Union Confederation (ITUC), has backed a radical energy transition proposal by Greenpeace. He commented 'While many additional 'Just Transition' policies will be needed to ensure workers will reap the benefits of a new low-carbon economy- skills, social protection, quality of jobs; the Energy Revolution report introduces interesting ideas which will scale up investments in renewable energies, something crucial if we want to fight future unemployment in the energy sector and avoid the poorest of the planet, whose jobs depend on natural resources, paying the costs of business-as-usual'.

Moreover, pushing ahead to positive targets, a report from the UK Campaign against Climate Change Trade Union group called for 'One Million Climate Change jobs now', outlining how cutting emissions by 80% by 2030 would create jobs in energy and related sectors (CaCC 2012). Overall then there are some hopeful signs around the world (Räthzel and Uzzell 2013).

8 Jobs and Growth

The trade union concern about the impacts on jobs of any major reduction in economic growth opens up the fundamental issue of what type of society and economy we might aim for. The radical environmental view that we should move to a stable state economy is quite convincing but not widely shared. Tim Jackson has outlined some possible ways ahead in terms of moving towards sustainable consumption, but consumerism is deeply entrenched (Jackson 2009). Most people still see renewables as a technical fix, allowing this to continue, at least in some form, and in particular to provide jobs. Otherwise 'hard line' deep greens may nevertheless welcome the fact that, even in the recession, green energy was one of the few areas where there was growth.

That opens up the issue of whether an expansion of renewables could, would and should support continued growth. The resource potential is certainly there, and a full transition away from fossil and nuclear would result in a major increase in green energy employment, its scale depending on how quickly the transition was carried out. So growth in this sector would happen regardless of whether wider growth was deemed necessary. However, after the new energy system was established, with its burst of job creation, the demand for new projects and jobs would fall off, unless the global economy was to continue to expand. Some might be happy with a more or less stable state maintenance level for the energy system, with employment also stabilising or even reducing. But for most, continued wider growth would be the aim, especially for those who have not as yet begun to enjoy the benefits of affluence.

Renewables as such do not remove the need for decisions about the nature of the society we want. Their adoption may reduce most of the environmental impacts caused by the use of fossil and nuclear energy, but there would still be a range of constraints on further growth, some of them relating to conflicts between renewables and the environment (e.g. land-use conflicts) but most relating to other resources, such as fresh water. We can't expand indefinitely, in terms of consumption and population, on a finite planet. Indeed some worry that there will not be enough energy and material resources to build the sustainable energy system (Chefurka 2007). To some extent, that depends on how rapidly we want to make the transition. Given time, some scare materials can be recycled from earlier uses, and the amount of energy needed to build new renewable systems is falling rapidly as the technology improves.

For example, energy returned on energy invested (EROEI) ratios are rising for all of them: wind is now up to 80:1, concentrating solar thermal electric power (CSP) up to 40:1 and PV solar (the most energy-intensive one) up to 25:1. For comparison the EROEI for nuclear is around 16:1 and will fall further to maybe 5:1 or less, as high-grade uranium ores become scarcer: it takes more energy to mine and process the ore into reactor fuel, to the point when it is not worth doing, even if nonfossil fuels (including nuclear) can be used for the fuel production process to avoid generating emissions (Harvey 2010). Meanwhile, fossil EROEIs are falling. Indeed some estimates put them in single figures (Harvey 2010).

That is worrying for a range of economic and environmental reasons and strengthens the case for moving away from fossil fuels. We will have to use some fossil sources for a while, but it can be argued that rather than wasting our fossil fuel inherence just supplying general needs, until it is all gone, increasingly we should reduce energy use as much as possible and use as much of this remaining energy as possible to build the sustainable replacement system (Heinberg 2009). Exactly what the interim and long-term synergies would mean for employment is unclear – it will depend on the scale and pace of the changeover. However, it seems clear that new types of job will emerge. In my final section, I want to look at what the implication of that might be.

9 A Just Transition to Decent Green Jobs

The case for a rapid transition can be made on environmental grounds and also on broadly social and ethical grounds. In his book ‘Energy and Ethics’, Sovacool outlines basic principles for the selection of new energy technologies, focusing on social concerns such as wider democratic involvement and accountability and intragenerational equity. The analysis above has indentified some specific strategic issues related to how the global energy system should or could develop, some of which link to the nature of jobs in the new system. The availability of what the International Labour Organisation calls ‘decent work’ (congenial, safe, properly remunerated and sustainable employment) could be seen as an ethical requirement, a basic right. It seems possible this can be achieved as part of the process of converting to green energy, but it is not automatic. It will need political struggle. As one trade unionists has put it, bluntly, ‘A green boss is still a boss’.

However, in general, the trade union movement backs change via a just transition. In its policy document ‘Equity, justice and solidarity in the fight against climate change’, the International Trade Union Confederation says ‘Just transition is a tool the trade union movement shares with the international community, aimed at smoothing the shift towards a more sustainable society and providing hope for the capacity of a "green economy" to sustain decent jobs and livelihoods for all'. (ITUC 2009).

The ITUC position emphasises the production process as well as products, as part of a transition to a 'fairer, environmentally responsible society that respects human and labour rights' and it is campaigning on that (ITUC 2010). It is a big project. Radicals hope that it will be pursued by grass-roots initiatives, which can lay the basis for the new society. As Kolya Abramsky puts it, 'the most important single factor determining the outcome of this change will be the intensity, sophistication, and creativity of grass-roots social mobilization'(Abramsky 2010). But he also recognises that there could be problems. For example, he says 'The quest for renewable energy could result in a new and perhaps unprecedented land-grab by companies and investors, which would create the potential for even more extreme patterns of displacement and appropriation of land than other forms of energy have done'. He also points to disputes over pay, conditions and job security within the renewables industry.

In the transition to a green economy and green jobs, there is clearly a need for some ethical and political principles and to resolve some strategic issues. What type of employment counts as green? It is not just work on renewable energy projects. They will need conventional industry to supply materials like steel and aluminium, so those are green jobs too. The transport system will have to change, another area for green employment, farming as well as the building industry.

More generally is working on all renewables equally valid? Surely we do not want to have sweated 'zero hours' labour for low pay in bad conditions. It is not a matter of jobs at all costs. These issues will become urgent as employment in the renewables sector expands. A review by the International Renewable Energy Agency estimated that gross global renewable energy employment increased from 1.3 to more than 3.5 million jobs worldwide between 2004 and 2010, with the biofuels sector accounting for about half (1.5 million in 2010). It notes that one study suggested gross employment effects of up to 20 million jobs globally by 2030, with the highest job creation in the biofuel sector (up to 12 million) followed by solar (6.3 million) and wind (2.1 million) (IRENA 2012b).

Not everyone will welcome the expansion of biofuels work, depending on the employment conditions (which can in some regions be very poor) and eco/land-use implications (the 'food versus fuel' debate), with at the very least tight regulation being needed (FAO 2010; IEA 2010). However, although the issue of biomass imports remains, within the EU, the emphasis is more on wind and solar, with the EU passing the 1 million green energy jobs mark in 2012. And interestingly, in IRENA's 2014 review of renewable jobs globally, PV, at 2.27 million, led by China, had overtaken biofuels, at 1.45 million, with, as noted earlier, the grand total for all renewables in 2013 being put at 6.5 million globally (IRENA 2014).

The definition of green jobs can of course be widened beyond just green energy-related jobs. For example, Federal Environment Agency data show that there were 1.93 million people working in the environment protection sector in Germany in 2008, and the building trade is increasingly involved with environmentally sound construction and energy-efficient housing, but even just staying with jobs in renewable energy supply, this is clearly a growth area, opening up many issues concerning, for example, regulation and training needs (Duell and Vetter 2013).

Interestingly, Germany, along with Denmark, has also pioneered new decentralised forms of ownership of the new energy technologies. For example, in Germany only about 13% of the country's 70,000 MW of renewable energy generation capacity is now owned by big energy companies. The rest is owned by households, communities, local co-ops, development trusts and farmers. Over 900 energy co-ops have emerged, some of them quite large, town sized. The old political issue of ownership and control is back on the agenda in a new form (WFC 2012; DGRV 2013; Debor 2014).

10 Conclusions

The complexities of global economies and policies mean that the pace of change is uncertain, but a transition to using renewable energy on a wide scale seems inevitable, given the limits of and constraints on conventional energy sources. Although the EU, and to a lesser extent the USA, have made much of the running in terms of green energy so far, in the years ahead China seem likely to dominate, as it tries to grapple with the impacts of its rapid growth, pollution, and the need for nonfossil fuel. That, and the wider uptake of green energy around the world, will create many new jobs and may give the ethical, political and strategic issues touched on above a new dimension and urgency.

In terms of immediate practical issues and strategies, what emerges from the analysis above is a need to develop ways for easing the transition – on the assumption that this will go ahead anyway. Campaigning to make sure that it happens at the national policy level is an obvious necessity, and environmental groups, along increasingly with trade unions, are engaged in that. But at the same time, there are specific areas that need attention, for example, plans for retraining workers displaced from conventional energy industries and support for the creation of new local green energy enterprises and energy co-ops.

There is also a need for wider debate on what type of society we want to create. Will it be based on economic growth or on more sustainable approaches at the local level? Is a degree of economic protectionism necessary to limit the power of global markets, as in the 'local content' rules adopted by some countries seeking to limit imports of green energy system from overseas and protect local jobs? Would that inhibit or stimulate innovation? Can the transition to green energy and efficient energy use really be achieved area by area, nation by nation, or do we need a more coherent international plan?

The transition will in part be brought about by individuals and groups working in their own communities and in their workplaces. We are seeing local transition plans emerging around the UK, and elsewhere in the EU, there are some dramatic examples of local co-operative efforts. We might see green plans emerging again from groups of workers faced with plant closures and job losses as happened in the 1970s. There are certainly plenty of technical options for diversification which could ensure continued employment. And for scientists and engineers, there are some fascinating challenges in developing the necessary technologies, reducing costs and improving efficiency as well as opening up new lines of innovation. For example, new types of carbon-based solar cell are emerging that avoid the use of toxic materials, and a wide range of marine energy systems is being developed (Elliott 2013).

However, for all those involved in the transition, it is important that ethical, environmental and political concerns shape the selection of options and the way they are then used. It is not just about the switch to new technology. For energy, as in all spheres, the issue is the same: we must control technology, not let it be directed in ways which undermine life, including working conditions, or the environment (Elliott and Elliott 1976). A range of ethical and environmental codes and principles have been suggested for technology choice and 'sustainable engineering', with the type of work involved being one element (Elliott 2003). They need to be acted on to ensure that what emerge are jobs that are not only green in environmental terms but also socially acceptable – good jobs in a good society.

References

Abbott D (2012) Limits to growth: can nuclear power supply the world's needs? Bull Atomic Sci 68(5):23–32. http://www.eleceng.adelaide.edu.au/personal/dabbott/publications/BAS_abbott2012.pdf

Abramsky K (ed) (2010) Sparking a world-wide energy revolution. AK Press, Oakland. http://www.akpress.org

ALA (2011) Toxic air. American Lung Association, New York/Washington, DC. http://www.lungusa.org/assets/documents/healthy-air/toxic-air-report.pdf

Alley W, Alley R (2013) Too hot to touch: the problem of high-level nuclear waste. Cambridge University Press, Cambridge

Ashley S, Parks G, Nuttall W, Boxall C, Grimes R (2012) Nuclear energy: thorium fuel has risks. Nature 492:31–33, 6 December. http://www.nature.com/nature/journal/v492/n7427/full/492031a.html

Awerbuch S, Berger M (2003) Applying portfolio theory to EU electricity planning and policy making. OECD/IEA, Paris. http://www.awerbuch.com/shimonpages/shimondocs/iea-portfolio.pdf

Boyle G (ed) (2012) Renewable energy. Oxford University Press/OUP, Oxford

CaCC (2012) One million jobs-now. Campaign against Climate Change Trade Union Group Campaign and Booklet. http://www.campaigncc.org/greenjobs

CAT (2013) Zero carbon Britain, 3rd edn. Centre for Alternative Technology, Machynlleth. http://www.zerocarbonbritain.org

CATF (2010) The toll from coal. US Clean Air Task Force, Boston. http://www.catf.us/resources/publications/files/The_Toll_from_Coal.pdf

Chefurka P (2007) World energy and population, web paper. http://www.paulchefurka.ca/WEAP/WEAP.html

Commoner B (1976) The poverty of power. Knoph, New York

Debor S (2014) The socio-economic power of renewable energy production cooperatives in Germany: results of an empirical assessment. Wuppertal Institute, Wuppertal. http://epub.wupperinst.org/frontdoor/index/index/docId/5364

DECC (2012a) Capturing the full electricity efficiency potential of the UK. Department of Energy and Climate Change, London. http://webarchive.nationalarchives.gov.uk/20121217150421/http://www.decc.gov.uk/en/content/cms/emissions/edr/edr.aspx
DECC (2012b) Renewable energy roadmap 2012 update. Department of Energy and Climate Change, London
DECC (2013) UK energy sector indicators 2012. Department of Energy and Climate Change, London
DGRV (2013) Energy co-operatives. DGRV-Deutscher Genossenschafts und Raiffeisenverband e.V., Berlin. http://xa.yimg.com/kq/groups/20593576/937211628/name/Energy_Cooperatives%20DGRV%202012%20how%20to%20Establish1%2Epdf
Dittmar M (2013) The end of cheap uranium. Sci Total Environ 461–462:792–798, 1 September 2013. http://www.sciencedirect.com/science/article/pii/S0048969713004579
Duell N, Vetter T (2013) EEO review: promoting green jobs throughout the crisis. European Employment Observatory, German Study. http://www.eu-employment-observatory.net/
Elliott D (1975) 'The Future of Work' man made futures course file, T262/7. The Open University, Milton Keynes
Elliott D (1976) Energy options and employment. Centre for Alternative Industrial and Technological Systems, North East London Polytechnic, London
Elliott D (2003) Energy society and environment. Routledge, London
Elliott D (2010a) Sea power- how we can tap wave and tidal power. In: Elliott D (ed) Sustainable energy. Palgrave Macmillan, Basingstoke
Elliott D (2010b) Nuclear or not? Palgrave Macmillan, Basingstoke
Elliott D (2012) Fukushima: impacts and implications. Palgrave Macmillan, Basingstoke
Elliott D (2013) Renewables: a review of sustainable energy supply options. Institute of Physics Publications, Bristol. http://iopscience.iop.org/book/978-0-750-31040-6
Elliott D, Elliott R (1976) The control of technology. Taylor and Francis, London
Employ RES (2009) The impact of renewable energy policy on economic growth and employment in the European Union, Report for the European Commission's Directorate-General Energy and Transport, by Fraunhofer ISI, Ecofys, Energy Economics Group, and others. http://ec.europa.eu/energy/renewables/studies/doc/renewables/2009_employ_res_report.pdf
Ernst & Young (2012) Analysis of the value creation potential of wind energy policies: a comparative study of the macro-economic benefits of wind and CCGT power generation. Ernst and Young consultants report for ACCIONA—EDP, Spain, May, Link from http://www.eurotrib.com/story/2012/11/1/65817/6658
ETUC (2013) ETUC position on the fight against climate change in Europe and the World' European Trade Union Confederation, Brussels. http://www.etuc.org/a/11400
EWG (2006) Uranium resources and nuclear energy. Energy Watch Group, Berlin EWG-Paper No 1/06. http://www.energywatchgroup.org/Uran.60+M5d637b1e38d.0.html
Fairlie I, Sumners D (2006) TORCH: the other report on chernobyl, produced for the Greens/EFA in the European Parliament. http://www.chernobylreport.org
FAO (2010) Making integrated food-energy systems work for people and climate. UN Food and Agriculture Organisation. http://www.fao.org/docrep/013/i2044e/i2044e.pdf
GEA (2012) Global energy assessment. International Institute for Applied Systems Analysis, Austria. http://www.iiasa.ac.at/web/home/research/researchPrograms/Energy/Home-GEA.en.html
Gruber A (2010) The costs of the French nuclear scale-up: a case of negative learning by doing. Energy Policy 38:5174–5188. http://www.sciencedirect.com/science/article/pii/S0301421510003526
Harris G, Heptonstall P, Gross R, Handley D (2012) Cost estimates for nuclear power in the UK. ICEPT working paper WP/2012/014, August. Imperial College, London
Harvey D (2010) Carbon free energy supply. Earthscan, London
Heinberg R (2009) Searching for a Miracle. Post Carbon Institute/International Forum on Globalization. http://richardheinberg.com/searching-for-a-miracle

IEA (2010) Bioenergy, land use change and climate change mitigation. IEA Bioenergy, International Energy Agency, Paris. http://www.ieabioenergy.com/LibItem.aspx?id=6770
IEA (2013) Re-cost, Prysma report on behalf of IEA-RETD. International Energy Agency. http://iea-retd.org/archives/publications/re-cost
ILO (2012) Study on green employment in China. International Labor Organisation, Geneva. http://www.ilo.org/
International Rivers (2014) Reservoir emissions. International Rivers, webpage: http://www.internationalrivers.org/campaigns/reservoir-emissions
IRENA (2012a) Renewable power generation costs in 2012. International Renewable Energy Agency, Abu Dhabi
IRENA (2012b) Renewable energy jobs: status, prospects & policies. International Renewable Energy Agency, Abu Dhabi. http://www.irena.org/REjobs
IRENA (2014) Renewable energy and jobs. International Renewable Energy Agency, Abu Dhabi. http://www.irena.org/REjobs
ITUC (2009) What is just transition? International Trade Union Confederation, Brussels, http://www.ituc-csi.org/what-s-just-transition
ITUC (2010) Resolution on combating climate change through sustainable development and just transition. International Trade Union Confederation, Brussels. http://www.ituc-csi.org/resolution-on-combating-climate
Jackson T (2009) Prosperity without growth. Sustainable Development Commission report, London. http://www.sd-commission.org.uk/publications/downloads/pwg_summary_eng.pdf
Lanchester J (2012) Marx at 193. Lond Rev Book 34(7):7–10, 5 April, http://www.lrb.co.uk/v34/n07/john-lanchester/marx-at-193
MacDonald M (2011) Costs of low-carbon technologies. Report for the Committee on Climate Change, May
Madrigal A (2011) 25 other energy disasters from the last year. The Atlantic. http://www.theatlantic.com/technology/archive/2011/03/25-other-energy-disasters-from-the-last-year/72814/
Maggio G, Cacciola G (2012) When will oil, natural gas, and coal peak?. Fuel 98:111–123, August. http://www.sciencedirect.com/science/article/pii/S001623611200230X
Mainstream (2012) Capturing the value of offshore wind. Mainstream Renewables. http://www.mainstreamrp.com/content/reports/capturing-the-value-of-offshore-wind.pdf
Miller A, Hopkins R (2013) Climate after growth: why environmentalists must embrace post-growth economics & community resilience. Post Carbon Institute, Santa Rosa. http://www.postcarbon.org/report/1882095-climate-after-growth
MNG (2013) List of 60 or more reports on decarbonising the UK, Europe and the world. MNG NGO Network, UK. http://www.mng.org.uk/gh/scenarios.htm
O'Connor J (1991) Capitalism, nature, socialism. In: Conference paper CES/CNS Pamphlet 1, Centre for Ecological Socialism, Santa Cruz
OECD (2010) Comparing nuclear accident risks with those from other energy sources. OECD/Nuclear Energy Agency. http://www.nea.fr/ndd/reports/2010/nea6862-comparing-risks.pdf
Oxfam (2007) Bio-fuelling poverty: why the EU renewable-fuel target may be disastrous for poor people. Oxfam, Oxford. http://policy-practice.oxfam.org.uk/publications/biofuelling-poverty-why-the-eu-renewable-fuel-target-may-bedisastrous-for-poor-114092
Patzek T, Croft G (2010) A global coal production forecast with multi-Hubbert cycle analysis. Energy 35(8):3109–3122, August. http://www.sciencedirect.com/science/article/pii/S0360544210000617
PCC (2014) Climate change 2014: impacts, adaptation and vulnerability. In: Fifth assessment report of the Intergovernmental Panel on Climate Change, Working group II report, Geneva. http://www.ipcc.ch/
Räthzel N, Uzzell D (eds) (2013) Trade unions in the green economy, working for the environment. Earthscan, London
REA (2012) Renewable energy: made in Britain. Renewable Energy Association, London

REN21 (2014) Renewables 2014 Global Status Report, Renewable Energy Policy Network for the 21st century, Paris. http://www.ren21.net/REN21Activities/GlobalStatusReport.aspx. Accessed 25 Feb 2015
Rifkin J (1995) The end of work. Tarcher/Putnam, New York
Roberts J, Elliott D, Houghton T (1991) Privatising electricity. Belhaven, London
Sensfuß F, Ragwitz M, Genoese M (2007) Sustainability and innovation. Fraunhofer Institute working paper S7/2007
Sovacool B (2013) Energy and ethics. Palgrave Macmillan, Basingstoke
Stern N (2006) Stern review on the economics of climate change. HM Treasury, London. http://www.webcitation.org/5nCeyEYJr
Teyssen J (2012) E.on confirms strategy focused on renewables. Windpower Monthly, quoting E. ON executive Teyssen's comments to German business daily Handelsblatt, 30 March, http://www.windpowermonthly.com/go/windalert/article/1124937/?DCMP=EMC-CONWindpowerWeekly
UKERC (2014) Low Carbon Jobs. UK Energy Research Centre, London, http://www.ukerc.ac.uk/support/Low+Carbon+Jobs<http://www.ukerc.ac.uk/support/Low+Carbon+Jobs>
UNEP (2008) Green jobs. United Nations Environment Programme. http://www.unep.org/publications/search/pub_details_s.asp?ID=4002
Wainwright H, Elliott D (1982) The Lucas plan. Allison and Busby, London. Update at http://www.redpepper.org.uk/a-real-green-deal/
WEC (2013) World energy scenarios: composing energy futures to 2050. World Energy Council, London. www.worldenergy.org/publications/2013/world-energy-scenarios-composing-energy-futures-to-2050
Wei M, Patadia S, Kammen D (2010) Putting renewables and energy efficiency to work: how many jobs can the clean energy industry generate in the US? Energy Policy 38:919–931
WFC (2012) From vision to action: a workshop report on 100% renewable energies in European regions. World Future Council, Workshop presentations: www.power-to-the-people.net/100-renewable-energy-european-regions. Final report www.worldfuturecouncil.org
WFTU (2011) World federation of trade unions. In: Conference declaration on global environmental problems, Athens. http://www.wftucentral.org/wp-content/wftu_congress-documents_for-the-global-environmental-problems_2011_en_esp_fr.pdf
WHO (2010) Exposure to air pollution. World Health Organisation, Geneva. http://www.who.int/ipcs/features/air_pollution.pdf
Winskel M (2002) When systems are overthrown: the 'Dash for Gas' in the British Electricity Supply Industry. Soc Stud Sci 32(4):563–598, August. http://sss.sagepub.com/content/32/4/563.abstract#aff-1
World Bank (2007) Cost of air pollution in China. World Bank. Appen A.1, p. 100. http://siteresources.worldbank.org/INTEAPREGTOPENVIRONMENT/Resources/China_Cost_of_Pollution.pdf

Chapter 6
Disparagement of Climate Change Research: A Double Wrong

Wiebina Heesterman

Acronyms

AAAS	American Association for the Advancement of Science
AR4 Syn	Synthesis of the 4th Assessment Report
AR5	Fifth Assessment Report
BP	British Petroleum
CH_4	Methane
CFC	Chlorofluorocarbon
CO_2	Carbon dioxide
CRU	Climate Research Unit
ENSO	El Niño – Southern Oscillation
GHG	Greenhouse gas
GWPF	Global Warming Policy Foundation
IEA	Institute of Economic Affairs
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
N_2O	Nitrous oxide
NOAA	National Oceanic and Atmospheric Administration
OHC	Ocean Heat Content
ppm	parts per million
SF	Science fiction
SO_2	Sulphur dioxide
SPM	Summary for Policymakers
SRX	Managing the Risks of Extreme Events and Disasters
U.C.S.	Union of Concerned Scientists
UEA	University of East Anglia

W. Heesterman (retired) (✉)
School of Law, University of Warwick, Coventry, England
e-mail: W.Heesterman@btinternet.com; http://www.RediscoveringSustainability.org.uk

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UNEP	United Nations Environment Programme
WGI	Working Group I
WGIAR4	Working Group I of the 4th Assessment Report
WGII	Working Group II
WMO	World Meteorological Organization

Overview

The engineering profession has a critical role to play in the fight against climate change. It goes much further than risk management and the repair of structures damaged by extreme weather events such as persistent flooding. A crucial task is the development of a robust infrastructure capable of withstanding further weather onslaughts. New ways of working will be necessary to create resilient structures and services aimed at a low-carbon economy and the adaptation and mitigation of climate change. Section C-2 of the March 2014 instalment of the fifth IPCC Report, *IPCC WGII AR5 SPM* (IPCC 2014a), emphasises the importance of the development of adaptive learning in order to develop effective adaptation and mitigation measures to create climate-resilient infrastructures. This also needs to be reflected in the professional education of future engineers. The latest IPCC Report, *IPCC WGIII AR5 SPM* (IPCC 2014b), stresses the global risk of climate change and the need to take steps to build resilience and sustainability, in urban areas in particular. Undoubtedly, this implies the involvement of the engineering profession. An understanding of the activities of forces committed to dismissal and misrepresentation of the scientific evidence of climate change is essential (see The Association of Professional Engineers and Geoscientists of British Columbia 2014; Lucena et al. 2011; Parkinson 2003; The Royal Academy of Engineering 2011).

This chapter illustrates the way in which vested interests enable global warming scepticism to push concern over climate change to the background, damaging the reputation of climate science and climate scientists in the process. The first, introductory section explains the processes involved in climate change and the way in which it impacts adversely on human beings as well as the natural world. It also describes the role of the Intergovernmental Panel on Climate Change (IPCC), the body accepted as defining the consensus view of the phenomenon. This is followed by a description of the preferred modes of those seeking to discredit the science in order to continue ‘business as usual’ and of the concerted efforts of organisations dedicated to this goal and of their sources of funding. The chapter then discusses two authors whose work subtly undermines the authority of climate science and concludes with the reaffirmation that doing one’s utmost to counteract the obfuscation is an inescapable ethical imperative.

1 Introduction: The Science and What the World Stands to Lose

Cases of scientific dishonesty are not unusual: academic reputations have been won on the strength of questionable scholarship. Scientists have taken shortcuts in order to reach particular results or drawn conclusions on the basis of selective records, on occasion fabricating evidence in order to support controversial theories. Misrepresentation and obfuscation have also been brought into play to undermine the importance of research results and damage the reputation of respected scholars.

Climate change research is a salient example. Distortion of research results is a serious misdemeanour; denial of the reality of climate science is unethical on two counts: without clear contrary evidence, it debases the reputation of scientific research, while it is prejudicial to the future of the natural world.

Climate change threatens to be much more than an inconvenience. There is a moral imperative in limiting the rising amounts of atmospheric gas which trap an increasing amount of heat in the lower part of the atmosphere, the troposphere. On the other hand, the upper atmosphere (the stratosphere), which is regarded as ending at approximately 50 km above the earth's surface, has cooled due to a reduced heat flow through the tropopause (the boundary between the two, where the air ceases to cool with height). If the heat of the sun was the cause of global warming, the temperature would rise throughout the entire atmosphere. The IPCC confirms that the warming of the troposphere alone is a clear indication that the activities of humankind are giving rise to climate change.

The 2013 *Summary for Policymakers* of the report of Working Group I, the Physical Science Basis (IPCC 2013), published on 30 September 2013 in anticipation of the full fifth series of Assessment Reports expected in 2014 expresses it as follows:

> It is virtually certain that globally the troposphere has warmed since the mid-20th century … It is very likely that anthropogenic influence, particularly greenhouse gases and stratospheric ozone depletion, has led to a detectable observed pattern of tropospheric warming and a corresponding cooling in the lower stratosphere since 1961 (IPCC 2007a). (IPCC WGIAR5 SMP: B2, D3 2013)

and in the Fourth Assessment Report (WGIAR4):

> Radiosonde-based[1] observations (with near global coverage since 1958) and satellite-based temperature measurements (beginning in late 1978) show warming trends in the troposphere and cooling trends in the stratosphere. (IPCC, Working Group I, 2007c: 9.4.4)

The 'standard' view of climate change has come to be defined by these Assessment Reports. The IPCC is the leading international body for the assessment of climate change, established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). Thousands of climate scientists and researchers contribute to the findings. As the IPCC reports are intended to inform policymakers in the first place, experts from non-environmental disciplines also participate, addressing the economic and political implications. For instance, the *Synthesis Report* of the forthcoming Fifth Assessment is expected to contain chapters on the 'Economics of Adaptation' and on 'Cross-cutting Investment and Finance Issues'.

[1] Radiosonde: small, expendable instrument package, suspended 25 m (about 80 ft) below a large balloon inflated with hydrogen or helium gas.

1.1 The Science

Light emitted by the sun, a body with a surface temperature of some 5,700 °C, consists of electromagnetic radiation of different wavelengths, infrared and visible light as well as some ultraviolet radiation. On average, each square metre of the earth's surface receives about 288 watts of radiation (Houghton 2004: 15). Were it not for the presence of tiny amounts of certain naturally occurring substances, the amounts of solar energy reaching the earth in the daytime and being emitted at night as infrared radiation would be in balance at a much lower temperature. In consequence, the world would be an icy place at perhaps −6 °C, too cold to be liveable. Without 'this aqueous vapour', 'the sun would rise upon an island held fast in the iron grip of frost' (Tyndall 1863: 417–418). It is a happy circumstance that the action of matter such as volcanic gas and water vapour causes the lower atmosphere to absorb a portion of the outgoing infrared radiation and raises the temperature to an average of about 15 °C (Houghton 2004: 15).

Once humankind started to make use of fossil fuels, the energy balance came to be disturbed, first only slightly, but the difference has become significantly larger, with the process going into overdrive since the mid-twentieth century. This is due to the increased level of gases such as carbon dioxide and methane, emitted into the atmosphere because of activities like agriculture, industry and transportation. Because heat is trapped by these and other gases, they are often called greenhouse gases, comparing the effect to that of the heat preserving panes of a greenhouse. This means that there is an imbalance between the incoming radiation from the sun and the outgoing infrared radiation into space. The difference leads to a gradual warming of the earth's surface and the oceans in particular.

The fact that CO_2, the main gas generated by the burning of fossil fuels, absorbs infrared radiation has long ago been demonstrated in the laboratory by John Tyndall (1861: 25–28). We know from the study of carbon isotopes in CO_2 trapped in air bubbles of ice core layers dating from different periods that the ratio of heavier to lighter atmospheric carbon dioxide has decreased by 1.4 per mil since fossil fuels began to be used (Quai et al. 1992: 75). This is the case because the leaf pores of plants take up more of the lighter than the heavier form during photosynthesis, as the former moves more quickly. Accordingly, fossil fuels have a higher 12C/13C ratio than the pre-industrial atmosphere.

In addition, fossil fuels do not contain $^{14}CO_2$; as this, the only radioactive isotope present in plant material – but only in extremely small quantities – has decayed during the many millennia, it has been lying deep underground. Yet atmospheric $^{14}CO_2$ content is important, even though less than 0.0001% of the total CO_2, as it can be used to establish the age of air samples (Shoemaker 2010).

The changed composition is once again a clear indication that climate change is due to human activity. Other greenhouse gases, such as methane, nitrous oxide and water vapour, block other wavelengths and so trap infrared radiation with a different position in the spectrum (Houghton 2004: Chapter 3). The fact that the average surface temperature has remained at 0.8 °C above the 1960s average since about

2005 does not imply that climate change has come to a standstill. According to a recent study, the heat increase is significantly higher than the figure of a mere 0.04 °C per decade since 1998, as calculated by the UK Met Office's Hadley Centre. The fact is that satellite measurements indicate that temperatures in the Arctic have risen far faster than elsewhere – 'a very rapid temperature change over recent years' (Cowtan and Way 2013). Unfortunately, there are few weather stations or ocean temperature gauging floats close to the North Pole. However, if surface temperatures calculated by extrapolating satellite figures are used to model the heat increase in combination with the few available polar surface data, the pause is no longer so pronounced.

In addition, the oceans, which cover about 70% of the earth's surface, play a crucial role. They absorb much of the solar radiation warming the earth, amounting to some 93% of excess heat energy, during the last 50 years (Chambers 2013). However, large bodies of water, such as the oceans, take a long time to heat up, while in recent years, more heat energy appears to have penetrated deeper into the oceans – below 700 m (Balmaseda et al. 2013: 1755, Table 1: OHC (Ocean Heat Content, linear Trends)).

Also conditions related to heat anomalies caused by the 'El Niño–Southern Oscillation (ENSO)' are characterised by conditions such as the ones dominant in 1997–1998. 'A strong El Niño or La Niña event is capable of bumping global temperatures upwards or downwards for a year or two' (Ibid.: 1756). El Niño, that is 'The Boy' or Christ Child, because the phenomenon tends to manifest itself around Christmas, is defined as 'a disruption of the ocean–atmosphere system in the Tropical Pacific'. Normally, cold water transported by the Peru Current, the eastern part of the Pacific Gyre, flowing towards the Equator along the Latin American coast, gives rise to an upwelling of nutrient-rich cold water from the ocean depths. This occurs at about 5° south, where the current curves westwards deflected away from Peru. This westward flow is caused by the fact that the Southern Hemisphere trade winds whip the top ocean layer in a westerly direction, although minor subsurface countercurrents tend to appear in late December. These normally last only a few weeks. However, in an El Niño year, the trade winds abate, while the undercurrents, flowing eastwards towards Peru, turn into oxygen-deficient streams of some 30 °C. This can last for months, if not years (Madl 2000). In consequence, the productive fishing grounds off the Latin American coast are subjected to a nutrition-poor, hot bath, rushing in from the seas around Indonesia. The heat energy from the ocean rises up into the atmosphere through cooling evaporation – the top ocean layer cools, while the air heats up. In 'La Niña' years, the cold westward current is unusually strong. The expression 'La Niña' (or: 'The Girl') for cool years succeeding the warm ones arose by analogy. Due to the absence of major El Niños in the last 15 years, the earth's surface has warmed up less than in the late twentieth century (Kosaka and Xie 2013).

In addition, the cooling effect of sulphur dioxide (SO_2) aerosols from volcanic activity has been approximately twice as strong in the years 2008–2011 than between 1999 and 2002, as there have been more, relatively modest volcanic eruptions (WGIAR5 SPM. C). In addition, the SO_2 content of urban air pollution from

Southern Asia and China also leads to some further cooling (Ramanathan and Feng 2008: 14248).

Even so, the last decade has been the warmest decade on record since modern meteorological measurements began around the year 1850 (WMO 2013a: 3). In fact each of the last three decades has been successively warmer at the earth's surface than any preceding decade since 1850 (WGIAR5 SPM: B1). This confirms that it is 'extremely likely that human influence has been the dominant cause of the observed temperature change since the mid-20th century' (Ibid.: B, D.3). The expression 'extremely likely' is used to describe the confidence level of a conclusion being correct as lying between 95 and 100% (Ibid, footnote 1; WGIAR4: 23).

> Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased (see Figures SPM.1, SPM.2, SPM.3 and SPM.4 in WGIAR5 SPM). Human activities result in emissions of four long-lived GHGs: CO2, methane (CH4), nitrous oxide (N2O) and halocarbons (a group of gases containing fluorine, chlorine or bromine). Atmospheric concentrations of GHGs increase when emissions are larger than removal processes. … The atmospheric concentrations of CO2 and CH4 in 2005 exceed by far the natural range over the last 650,000 years. (IPCC Climate Change 2007c: *Synthesis Report* 2.2)

The 2013 IPCC report concludes that this has resulted in higher sea levels as well as more extreme weather events and will continue to do so (Ibid: D.3; E.6; Figure SPM.9, Table SPM.1; IPCC: 2012: 5; AR4 Syn: 3.2.3, 5.2, 6.2, 2007c, see also WMO 2013a).

The first measurements of the levels of atmospheric CO_2 were taken in1952 on Mount Kilauea on Hawaii. We know that the pre-industrial 'carbon' count amounted to 280 parts per million (ppm), while it surpassed the 400 ppm marker on 9 May 2013. Now, it is quite true that in the distant past, the heat balance has changed due to natural causes. Then, the temperature rose first, followed by an increase in CO_2. According to the 2007a IPCC Assessment Report, the mid-Pliocene, 3.3 to 3.0 Million years ago, was the most recent time in the earth's history with a carbon count of the current magnitude (Working Group 1, the Physical Science Basis, WGIAR4: 6.3.2). At the time, the mean global temperatures remained substantially warmer for a sustained period – estimated by GCMs (general circulation models) at 2–3 °C higher than pre-industrial temperatures. During this period, the area around the North Pole was much warmer than at present (Brigham-Grette et al. 2013). Now, Arctic temperatures are rising faster than the mid-latitudes and tropics as well.

While the term 'climate change' is to be preferred, changes caused by increasing CO_2 levels in the atmosphere used to be called 'global warming'. However, this suggests equal distribution of heat around the globe. Nothing could be more misleading: certain regions warm much more than others, notably, the North Pole, and somewhat less evident, the South Pole – 'the Arctic region will warm more rapidly than the global mean' (WGIAR5 SPM: Figures SPM.7 and SPM.8, and Table SPM.2). The extreme Arctic warming enhances the risk of the escape of the large reservoir of methane presently preserved in the permafrost of the polar region

(AR4 Syn: 1.1 (IPCC 2007c); IPCC, Working Group II: 15.3, (IPPC 2007b)). Certain regions are increasingly subject to severe drought, while others suffer torrential rain leading to catastrophic flooding. Equally, sea levels are not rising at the same rate worldwide. What is inescapable is the observable fact that the number of extreme weather events is on the increase (IPCC 2012, 'Managing the Risks of Extreme Events and Disasters' (SREX): 8, 13).

Climate modelling works with a range of assumptions and outcomes, rather than the certainty requested by policymakers. The latter tend to favour outcomes in the lower ranges, while climate scientists, concerned that the reality may well be much higher, are routinely accused of scare mongering. The change has been a powerful tool wielded by those wedded to 'business as usual', to oppose strong measures to combat climate change – or any measures whatsoever. The need for adaptation and mitigation is unavoidable. Even so, several climate change specialists hold that the conclusions of the IPCC reports do not go far enough in alerting the public to potentially disastrous consequences. For instance, Hansen et al. warned as early as 2008 that a figure in excess of 350 ppm of CO_2 in the atmosphere, such as the 385 ppm measured at the time, was already too high. It should be reversed if humanity wanted to maintain the planet in a state conducive to life. More recent papers by Anderson and Bows (2011) and Hansen et al. (2013) convey even starker warnings: '… 2 °C (3.6 °F) above the pre-industrial level is too high and would subject young people, future generations and nature to irreparable harm' (Hansen et al. 2013: 1). The research team included several experts from other disciplines, such as economics in addition to climate scientists.

1.2 What Is at Stake

Not only is a liveable world a question of intergenerational justice – of not depriving our descendants of what we value ourselves, such as a reasonable standard of living, clean air and attractive surroundings; there is far more at stake.

First of all, there are those who have never been able to enjoy what tends to be taken for granted in the west, not only access to food, health services and energy but also an unpolluted environment. Are they not entitled to a decent life, both now and in the future? Climate change already affects lives in some majority world countries adversely (United Nations Development Report (UNDP) 2013: 6). By all accounts, the most vulnerable, such as the very young and the very old, are those suffering most from extreme weather events. While the north–south dimension of the threat is discussed extensively by Edenhofer et al. (2012), one should not forget the human rights of those within affluent societies, who will find it difficult to protect themselves from erratic weather because of poverty and rising food prices. There are also dimensions other than directly observable human well-being. The world is not only threatened by the effects of climate change but also by other forces, several of which interact with climate change, for instance, a phenomenon called *acidification* of the oceans: the natural pH factor has decreased from 8.2 to 8.1 (WGIAR5 SPM: B2).

As this is a logarithmic measure of alkalinity rather than acidity, it amounts to some 26 percent increase of acidity on a linear scale.

1.2.1 The Precautionary Principle

Any detraction of climate science implies denial of the validity of the precautionary principle underlying the Rio Declaration of 1992.

> The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. (Article 3 of the *United Nations Framework Convention on Climate Change*)

The principle comprises basic concepts such as:

- Preventative anticipation: a willingness to take action in advance of scientific proof of evidence.
- Duty of care or onus of proof on those who propose change.
- Promotion of the cause of intrinsic natural rights as well as payments for past ecological debt (Kriebel et al. 2001).

The response of those unconvinced of the urgency of taking measures to counteract climate change is to call attention to the fact that structures are in place to assess any potential risks. As decision makers have a tendency to request certainty before measures can be approved, it may be argued that the defining feature of the precautionary principle is that it 'places a governmental entity in a role as a risk gatekeeper' (Sachs 2011: 1298).

1.2.2 The Planetary Boundaries Declaration

The October 2011 *Planetary Boundaries Declaration*, drawn up at Exeter University along the lines proposed by the Stockholm Resilience Centre (Rockström et al. 2009), identifies the limits of nine earth system processes, intended to guarantee 'a safe operating place for humanity'. These were not to be exceeded, if life was to continue with avoidance of mass extinctions. The processes in question are (1) the stratospheric ozone layer, (2) biodiversity, (3) the dispersion of chemicals, (4) climate change, (5) ocean acidification, (6) freshwater consumption and the global hydrological cycle, (7) land system change, (8) nitrogen and phosphorus inputs to the biosphere and oceans and (9) atmospheric aerosol loading. Nos. 2, 4 and 8 have already been surpassed; see Stockholm Resilience Centre's website for a symbolic representation of these separate though interconnected threats (2012).

The Declaration proposes the creation of a global governance framework capable of protecting the well-being of present and future generations and of the natural world. The draft states among other things: 'we are all responsible for safeguarding those processes from the threats of serious or irreversible damage as a result of human activities.' This clause draws attention to the fact that human beings are not the only ones harmed by damage to the environment. We need to take into account that the human race shares the planet with millions of other creatures who also have to suffer the consequences of thoughtless actions. Climate change and acidification of the oceans with carbonic acid threaten biodiversity in their turn (Royal Society 2005: 35; Chivian and Bernstein 2008: 57, 69–70). Both loss of biodiversity and changes in ocean chemistry augment the consequences of climate change. For instance, warming of sea water results in the reduced capacity to absorb CO_2 and so heightens the effects of climate change. In addition, the increased acidity of the water due to the emitted anthropogenic carbon dioxide already has absorbed about 30% of the greenhouse gas and affects marine organisms (WGIAR5 SPM: Figure SPM.4). This in its turn impacts on the food chain. Again, it is the poor whose nutritional intake suffers.

Increasing temperature affects both tropical forests and the ice cover of the Arctic and Antarctic regions. Open water being much darker than ice reflects less of the sun's heat back into space. In reality, although helpful in understanding the magnitude of the problem, separating the onslaught by humanity on the ecosystem into different areas is artificial: the various strands interact in a complicated web.

2 Climate Scepticism: From Arguments for 'Business as Usual' to Outright Denial

2.1 The False High Expense Argument

How has it been possible that the urgency of taking action to minimise the risk from climate change has been relegated to the background? The reasons for the breakdown are twofold: first, a general objection to recommendations to decarbonise the economy stems from the mistaken perception of the huge expense of taking action. Economists make use of a method called cost–benefit analysis, developed from the investment evaluation technique used to assess whether investment projects would be sufficiently profitable. It also tends to be applied in the case of public infrastructure projects in order to establish which of two or more projects should be undertaken. To illustrate, the assumption is that the construction of additional hospitals makes future populations more prosperous and that this is fairly reflected by the financial return on investment. Projects of this kind are evaluated according to expected results expressed in terms of financial gain. In consequence, the value of the treatment of future patients is rated lower than if the same amount is spent on patient care in the present. Calculating which is more valuable tends to take the form of *discounting* – future revenues (and by implication, costs) are evaluated at five or six percent per year less than if these were made now. Many economists also use this calculation method in connection with issues of long-term environmental degradation such as climate change or loss of biodiversity. In this case, it is employed to establish whether it is worthwhile in financial terms to carry out certain projects. This implies that the further in the future any damage to the natural world is to be expected, the lower the financial evaluation of its mitigation. It has been questioned whether it is valid to assess the benefits of an unspoilt environment by extending this type of analysis to the environmental field. For instance, '… the process of reducing life, health, and the natural world to monetary values is inherently flawed' (Heinzerling and Ackerman 2002: 1) and '… an abdication of our moral responsibility for future generations' (Heesterman and Heesterman 2013: 214). The spurious cost argument has been eagerly exploited by individuals and groups which stand to profit from the status quo and in consequence continue to make sustained efforts to confuse the issue. In addition, the price tag of any future damage due to climate change tends to be vastly underestimated. Wagner and Weitzman warn about 'The high cost of doing nothing' (2012).

Any economists who do not subscribe to the practice of using this method are met with scorn and derision. The criticisms of the *Stern Review of the Economics of Climate Change* commissioned in 2005 by Gordon Brown, the then Chancellor of the Exchequer, are an example. The *Review* is a study on the economic impacts of climate change conducted by a team of economists, led by Sir Nicholas Stern, expert in economics and development. It contains a stark warning: 'The evidence shows that ignoring climate change will eventually damage economic growth,' adding that 'the earlier effective action is taken, the less costly it will be' (Stern 2007: ii). Attempts to discredit this landmark publication have been made by several (mainly) economist professionals.

2.2 *Scientific Argument Versus Anecdotal Assertion*

As explained earlier, climate research is based on the fundamental laws of physics. In the Anglo-Saxon world researchers who work by making use of numerical models to project climatic conditions of the past into the future tend to be called 'climate scientists.' They typically verify results with statistical methods and comparison with observations, while it is often necessary to use a proxy relation. Researchers who mainly rely on statistical and/or conceptual methods are called climatologists (Climate Science Program, Iowa State University 2012). This distinction is not made elsewhere. The confusion between the two designations allows those intent on deprecating the results of the modelling exercises to present themselves as experts on climate issues, styling themselves 'climatologists'. There is at least one climate change sceptic, Timothy Ball, who claimed to have been Canada's first PhD in climatology as well as professor in the subject. As he did not receive his PhD until 1983 – and it happened to be in geography – this is somewhat devious (Powell 2011: 72). Ball is still described as such on the Heartland Institute's website, despite having abandoned his 2006 lawsuit against Professor of Environmental Science D. Johnson and the *Calgary Herald* (action No. 0601-10387). Ball objected to the following statement in Johnson's article in the *Herald* of June 2006 which contained the following statement: 'The Plaintiff (Dr. Ball) is viewed as a paid promoter of the agenda of the oil and gas industry rather than as a practicing scientist.'

Conversely, genuine scientists tend to rely on their findings and make every effort to engage in serious debate. An example is the correspondence between Paul Nurse (President of the Royal Society) and Lord Lawson (former Chancellor of the Exchequer under Mrs. Thatcher's Government), February 25–March 13, 2013, in which the latter is openly aggressive: '… there should be a difference between the behaviour appropriate to a President of the Royal Society and acting as a shop steward for some kind of scientists' closed shop' (20130311094819649.pdf, received from a member of Scientists for Global Responsibility).

In a sense, individuals and groups advocating 'business as usual' address a willing audience: the thought that the earth and its denizens are under attack from a creeping self-inflicted harm, likely to damage our familiar world irreparably, is just too frightening. Anything that might offer a way out of the dilemma is understandably welcome – no wonder that individuals and organisations which offer reassurance – '[warming] will not pose a devastating problem for our future' (Lomborg 2001: 4) – easily collect large numbers of devoted followers.

2.3 The Attitude of 'Business-as-Usual' Devotees

2.3.1 Common Objections

Cost is a recurring argument with those embracing a 'business-as-usual' approach. They argue that the economy is at all times on a path to ever continuing growth, which should make the next generations richer. This will enable them to deal with any future problem, including environmental degradation.

In the words of Lord Lawson: '… since there are so many future generations involved, we ought to make a big sacrifice now in order to confer on each distant (and incidentally better off) generation a trivial benefit [. .] That is the ethics of the Stern Review' (2009: 86). Lawson then piles insult upon injury claiming in his 'Afterword' chapter: 'Most reputable economists regard the Stern methodology as deeply flawed'. This is misleading but the slur is repeated by Lomborg in *Cool It* (Lomborg 2008), mounting an attack by proxy on page 136: 'Yet a raft of academic papers have now come out all strongly criticizing Stern, characterizing his report as a "political document", using terms such as "sub-standard", "preposterous", "incompetent", "deeply flawed", and "neither balanced nor credible".' To begin with, the economist Nordhaus (2006/2007) commented that 'the review should be read primarily as a document that is political in nature and has advocacy as its purpose' (2006). As Stern was charged with leading a major review of the economics of climate change …, what else would it be? Lomborg's expression, 'a political document', creates a rather different impression from 'a document that is political in nature'. Nordhaus's criticism centres upon the low discount rate Stern used instead of the customary five or six, as does a review by other economists such as Tol and Yohe (2006: 234), using the expression 'substandard' in *World Economics*, a business journal. The epithet 'preposterous' is due to Tol, commenting on the sentence: 'climate change will cause economic disruption now and forever' (2006: 977). Then, there is the importance Stern paid to agriculture: 'Most of the world's economic activity today takes place indoors: generally speaking, the outputs of both manufacturing and services are unaffected by outdoor conditions': … and 'the share of these vulnerable sectors can be expected to decline to a relatively low level' (Byatt et al. 2006: 39). One wonders what these 'indoor' workers are going to eat, as the authors do not appear to rate future 'food security' as of any significance. Despite the many attacks, the Stern Review remains 'the prominent report' regarding 'the cost of solving and not solving climate change' (Berners-Lee and Clark 2013: 113).

Another common objection is that people are not convinced that 'the science is settled' (Oreskes and Conway 2010: 169), for example, David Davies (MP): 'It is not proven' (*Hansard*, 10 Sep 2013: Column 237WH). The sceptics then add that warnings such as a sentence in the *Stern Review* – '… major, irreversible changes to the Earth system … [which] may take us past irreversible tipping points' (Stern 2007: 331) – are unduly alarmist (Lawson 2009: 47).

A third claim is that 'there is no consensus among scientists' (Lindzen 2009). Several contrarians – the preferred term in the USA – subscribe to the 'Leave it to the Market' mantra, a standpoint also endorsed by several UK economists and politicians (Lack 2013: 23, 35, 50).

2.3.2 Leaving the Door Open to Criticism

Unfortunately, the fact that few climate scientists are consummate communicators has made it possible for the silver tongue of those favouring laissez faire and self-interest to dominate the discussion. On occasion, unfortunate and careless use of language has been less than helpful. An example is the use of the term 'global warming', which suggests a pleasantly balmy climate affecting different regions equally instead of tending towards extremes with temperature anomalies on the increase.

This lack of precision in terminology allows detractors from the science to ignore the damage to the ecosystem caused by all the associated processes. For instance, Lord Lawson consistently chooses to adhere to the term 'global warming' instead of 'climate change', hammering the point home as it were by repetition: "I deliberately use the term 'global warming, rather than the attractively alliterative weasel words, 'climate change', throughout" (Lawson 2009: 2), "the latest scare – global warming" (Ibid: 3), followed by the repeated use of 'gentle', 'modest' or 'slight' warming (Ibid: 27, 28, 51). The recurring phrase leaves the reader in no doubt that he thinks climate change is nothing to worry about. He also uses the expression: 'a modest degree of recorded global warming during the twentieth century', subsequently disavowed with the words 'there has been no further recorded global warming at all for the past 15 years ….'

2.3.3 Attitudes and Methods Employed by Climate Sceptics

There is a whole range of attitudes among the detractors from climate change science. These extend from denial that any change in the earth's temperature is occurring at all, or they claim that it is entirely natural if it occurs. They argue that there have been warmer periods in the past – which cannot possibly be attributed to human activity. Therefore, it must be caused by the activity of the sun or by cosmic rays. However, the fact that the lower atmosphere is warming rather than the stratosphere (the next layer up, as explained on the second page of this chapter) makes clear that it is not related to solar activity.

Others concede that, yes, perhaps there is a slight change in temperature, possibly amplified by human activity, but it is nothing serious and we cannot do much about it anyway. If there is a problem, the ingenuity of mankind will surely find a solution. Not to worry, there are more serious problems to be solved first. The next technology will certainly come to the rescue.

Again, some contrarians are openly offensive, for instance, Seitz flatly accused climate scientists of dishonesty in the foreword to a book by a fellow sceptic, who claims that any warming is entirely natural (Singer 1995: 2). This is the first sentence of the book: 'For scientists wanting fame and fortune, it has become far easier to pander to irrational fears of environmental calamity than to challenge them' (Ibid.: Foreword by Seitz). But why would a scientist want to challenge a fellow scientist for writing about scientific facts, unless for political purposes? Other titles are even more outspoken such as *The Greatest Hoax: How the Global Warming Conspiracy Threatens Your Future* by Senator James Inhofe, who also claimed divine knowledge declaring 'God says that climate change is a hoax' (Radio interview with Voice of Christian Youth America, 1 March 2012).[2]

Another familiar tactic used time and time again works by attacking the science through vilification of the scientists and their reputation. The ordeals of some of these eminent scientists, James E. Hansen, Benjamin D. Santer and Michael E. Mann, are described by Oreskes and Conway (2010: 128, 264, 3–5, 208–211). Other individuals, campaigning on the issue of climate change, such as Al Gore (2006) and Bill McKibben, have also been subjected to attacks.

2.4 Case Study: Climategate

A mere mention of the attack on Mann and a team of climate scientists at the University of East Anglia, popularly known as 'Climategate', does not do justice to the impact of the incident. It has been highly influential and is by all accounts one of the reasons why the 2009 Copenhagen Summit on Climate Change failed to reach a satisfactory agreement. It began with the hacking of a server at the Climatic

[2] Inhofe did not mention in the interview that he received $1,352,523 in campaign contributions from the oil and gas industry, including $90,950 from Koch Industries.

Research Unit of the University of East Anglia (CRU) in November 2009, just a few weeks before the Copenhagen Conference. 1,073 email exchanges, spanning 13 years of correspondence, between scientists at the CRU and Professor Mann of the Pennsylvania State University and other US scientists were copied onto the Internet. Certain phrases from them were then quoted out of context as ‘proof’ of duplicity of the climate scientists concerned. Much of the stolen material had been written by climate experts whose papers had been extensively cited in reports by the IPCC. A few examples of the way the expressions were distorted will suffice: an email from the head of the Unit, Professor Phil Jones, reads: ‘I’ve just completed Mike’s Nature trick of adding in the real temps to each series for the last 20 years (from 1981 onwards) and from 1961 for Keith’s to hide the decline’. The word ‘trick’ is a jargon term for clever ‘method’ of data handling used by scientists, referring in this case to the linkage of different types of data, while the ‘decline’ concerns proxy temperatures derived from tree ring analyses.

Another example is an email from Kevin Trenberth, head of the Climate Analysis Section at the National Center for Atmospheric Research in Boulder, Colorado:

> We are not close to balancing the energy budget. … The fact is that we can’t account for the lack of warming at the moment and it is a travesty that we can’t.

Even long before the email theft, the researchers at the CRU had been harassed by multiple freedom of information requests, which led to resentment on their part, as they regarded the need to respond as a waste of their time. Professor Jones acted less than diplomatically vis-a-vis the main requestor:

> Many of us in the paleo field get requests from skeptics (mainly a guy called Steve McIntyre in Canada) asking us for series. Mike and I are not sending anything … mostly because he’ll distort and misuse them (7/5/2004).

And ‘Can you delete any emails you may have had with Keith re AR4?’ (29/5/2008)

On 24 November, the University of East Anglia issued a statement on the contents of the emails:

> There is nothing in the stolen material which indicates that peer-reviewed publications by CRU, and others, on the nature of global warming and related climate change are not of the highest quality of scientific investigation and interpretation.

In total, eight panels on both sides of the Atlantic exonerated both the scientists of the CRU and their correspondents in the USA, although

> [t]he [Muir Russell] Review found an ethos of minimal compliance (and at times non-compliance) by the CRU with both the letter and the spirit of the FoIA and EIR. We believe that this must change”. The Review also made it clear that CRU did not receive enough support from UEA management, and made recommendations to the university on how it should handle future information requests. (Report, July 2010)
>
> (Data from Powell 2011: Chapter 14 and Wight 2010; Cook, SkepticalScience 2014)

2.5 Climate Sceptic Foundations and Their Websites

Many of the detractors from climate science are supported by organisations with dedicated websites, such as those of the Global Warming Policy Foundation, the Marshall Institute and the Heartland Institute. It is revealing to look at the language used on these sites as well as in publications by their protagonists. A high moral tone is not unusual, although this typically comes in the form of utilitarian arguments.

2.5.1 Favoured Modes and Techniques

In many cases, authors and speakers make use of a strategy of ridicule and innuendo instead of engaging in logical debate when attempting to convince their readership. This applies, in particular, to those intent on attacking reports of environmental degradation. It is difficult for a victim of ridicule to defend herself. The audience or readership is drawn as it were into a conspiracy. The speaker or author acts as though sharing a joke with the audience. A listener tends to feel embarrassed and puts herself in the wrong by reluctance to intervene, afraid of being thought a spoilsport. A leading exponent of the technique is Lord Lawson whom I personally heard talking scathingly about the notion that carbon dioxide emissions might be called 'pollution'. The strategy is also used by authors on other environmental issues who regard continuing economic growth as a prerequisite to a brighter future, for instance, Huber (2000: 5) in *Hard Green*, reacting to a report on overpopulation with 'Thomas Malthus back to life, torrents of gloomy electrons in the solid-state brain of a machine'. Authors like Huber tend to emphasise the inventiveness of mankind, arguing that technology will surely save humanity from any tight spot. Unfortunately, these kinds of mocking stock phrases are quite insidious, because they tend to be so eminently memorable.

Others opposed to a relaxation of 'growth as usual' use the techniques of rhetoric, for instance, by linking two or more disparate concepts. This is possible by a process of association aimed at creating the impression that climate scientists and environmental activists unnecessarily exaggerate the serious character of climate change. One example is the story woven around the worldwide 'lights out campaign' in Lomborg's foreword to *Cool It*, written by himself (2008: xii–xiii).

According to the 'lights out' website, the rationale for the campaign is to inspire and motivate participants to change their lifestyle, thereby saving energy with the implication that it might well lead to greater satisfaction in life. Instead, Lomborg paints a ludicrous picture of families sitting comfortably around a candle – or rather a forest of candles – enjoying the warm and cosy atmosphere. He then emphasises that it is a futile exercise, which defeats the avowed purpose of saving energy and instead generates a great deal of pollution, with candles lit all over the world instead of keeping the lights on as usual. Here, he makes two assumptions, first, that the annual lights out hour is solely intended to save energy rather than to act as inspiration to do so all the year round and, second, that people are unable to spend even 1 h in the dark without their creature comforts. He ends by linking the word 'dark' with the notion that the environmental movement can be said to constitute a 'literal dark force'. Readers are likely to be amused by the association. But the suggestion sticks.

Then, there is the use of biased language casting doubt on a scientist's scholarship by drawing conclusions from expressions taken out of context by quoting part of a sentence. For instance, in a 1989 paper by Colinvaud in *Scientific American*: 'As human beings lay waste to massive tracts of vegetation, an incalculable and unprecedented number of species are rapidly becoming extinct'. According to Lomborg, 'Colinvaud *admits* in *Scientific American* that the rate is incalculable' (Lomborg 2001: 254).[3] The use of the word 'admits' creates the impression that Colinvaud was unsure of his data, while 'incalculable' here clearly stands for 'untold' or 'countless' rather than that the author harboured any reservations about the validity of the claim.

Associations with biblical imagery (Lomborg 2008: 60): 'Another of the most doom-laden impacts from global warming is the rising sea levels. Many commentators powerfully exploit this biblical fear of flooding, as when Bill McKibben said of our responsibility for global warming that "We are engaging in a reckless drive-by drowning of much of the rest of the planet and much of the rest of creation"' (2004).

Sceptics have also been able to make great mileage from a partial misinterpretation by the environmental movement (see the Heartland Institute's website). The fact is that the failure of the Kilimanjaro glaciers may well be due to causes other than climate change, such as reduced precipitation – at least at the initial stage (Kaser et al. 2004: 334). It was known to be in retreat well before the 1880s, earlier than any significant greenhouse gas warming could have taken effect. What the sceptics omit to tell is the fact that the temperature subsequently begins to rise because the heat of the sun shining on exposed rock is not reflected back into space as effectively as from a white snow-covered surface (the albedo effect). This leads to further melting. Examples of other glacier systems, such as the ones in the Andes, which are retreating at a superfast rate, would have been more effective (Kaser and Osmaston 2002). A 2005 summary of the state of tropical glaciers by Pierrehumbert can be found on the RealClimate website.

Another commonly voiced argument is that 'increased atmospheric carbon dioxide levels are beneficial because they fertilize plant growth', used, for example, by physicist Will Happer in a testimony before a committee of the US House of Representatives in 2010.[4] He happens to be Chairman of the Board of the Marshall Institute, another sceptic organisation. Scientists associated with the Institute (all with expertise in other fields) also declared on occasion that (1) the twentieth century is not unusually warm and (2) global warming came to a halt in 2005.

[3] Cursive '*admits*' in the original text.

[4] In reality, according to the 1830s 'Liebig's Law of the Minimum', plant growth is controlled, not by the total resources available but by the scarcest resource (limiting factor). This may refer to conditions, such as humidity, nitrogen or temperature.

2.5.2 Details of Selected Sceptic Organisations and Their Sources of Funding

The largest number of advocacy organisations seeking to confuse the public on global warming issues is to be found in the USA and tends to appeal mainly to US interests. However, since the advent of the Internet, sceptical think tanks increasingly direct their efforts to an international fellowship by digital means rather than printed material.

The details of several contrarian organisations are presented below: first, those of three US think tanks. Note that certain individuals belong to several. The details of two of the seven UK organisations, mentioned by Lack (2013: 20), are described in the next paragraph, and three more internationally oriented organisations follow. Note that the same names keep appearing on different websites. Several are registered as educational charities and are therefore exempt from the obligation to publish any funding sources and from paying tax. Most of the UK think tanks are dedicated to free trade and therefore hostile to measures aimed at curtailing the fossil fuel economy.

1. *The Heartland Institute* (www.heartland.org), founded in 1984. Its mission is 'To discover, develop and promote freemarket solutions to social and economic problems'. Some of the members are Timothy Ball (see Powell 2011: 72), David Bellamy (Botanist, the Conservation Foundation), Myron Ebell (Director, Energy and Global Warming Policy of the Competitive Enterprise Institute) and Michael G. Hintze (Wisconsin State Coordinator) and also the Tea Party Patriots: Richard Lindzen (Professor of Meteorology, Massachusetts Institute of Technology), Patrick Michaels (Senior Fellow, Cato Institute), Lord Christopher Monckton (Chief Policy Advisor, Science and Public Policy Institute), S. Fred Singer (Director, the 'Science and Environmental Policy Project') and Anthony Watts (founder of the *WattsUpWithThat blog*). The funding received from ExxonMobil amounted to $676,500 between1998 and 2006. The think tank published two printed pamphlets: *The Skeptics Handbook* (2009) and *Climate Change Reconsidered* (2009).
2. *The Competitive Enterprise Institute*, founded in 1984 (www.cei.org/). Its mission is stated as promoting free markets and limited government. Some associate individuals are Myron Ebell (Director of the Center for Energy and Environment), Fred Singer and Patrick Michaels (see above). The organisation received $2 million from ExxonMobil between 1998 and 2006.
3. *George C. Marshall Institute*, founded in 1984 (www.marshall.org/). Some associates are Frederick Seitz (now deceased), Richard Lindzen and Patrick J. Michaels. According to the Marshall website, its mission is 'To promote Science for better Public Policy'. The think tank received $630,000 from ExxonMobil between 1998 and 2005 as well as funding from the American Petroleum Institute.

Two sceptic organisations, aimed specifically at the UK public:

4. *Global Warming Policy Foundation* (www.thegwpf.org), a lobbying group, launched on 24 November 2009, just a week after the theft of emails from the Climate Research Unit of the University of East Anglia (www.thegwpf.com). The website states: 'an all-party and non-party thinktank and a registered educational charity which, while open-minded on the contested science of global warming, is deeply concerned about the costs and other implications of many of the policies currently being advocated and we encourage media to become more balanced in its coverage of climate change.' Two individuals associated with the organisation are Lord Lawson and Benny Peiser, social anthropologist, who launched the GWPF in 2009 at a session in Parliament. According to Readfearn et al. (2012), Michael Hintze, who runs the £5bn hedge fund CQS Rig Finance, was a donor to the GWPF as well as to the Institute of Economic Affairs.
5. *The Institute of Economic Affairs* (www.iea.org.uk), founded in 1955. The IEA is the UK's original free-market think tank. 'Our mission is to improve understanding of the fundamental institutions of a free society by analysing and expounding the role of markets in solving economic and social problems.' Individuals associated with the IEA are Mark Littlewood (Director), Richard Wellings (Deputy Editorial Director) and Michael Hintze (Trustee).

Several other newcomers which seek their readership worldwide, largely through the Internet:

6. *WattsUpWithThat* (WUWT, a blog at http://wattsupwiththat.com/), established in 2006 by Anthony Watts, a meteorologist, which reports on anthropogenic global warming-related issues from a sceptical point of view. The WUWT was one of the first three blogs to post links to the cache of material, purloined from the web server of the Climate Research Unit at the University of East Anglia, to several anonymous servers on Tuesday 17 November 2009.
7. *The Copenhagen Consensus Center* (www.copenhagenconsensus.com/), associated with Björn Lomborg, describes its missions as to prioritise issues of global concern. It describes itself as a think tank that publicises the best ways for governments and philanthropists to spend aid and development money. We commission and conduct new research and analysis into competing spending priorities. Climate change only rated a priority of tenth. Between 2006 and 2011, the Centre received funding from the Danish state.
8. *The New Zealand Climate Science Coalition* (www.climatescience.org.nz), which holds that 'climate science is not settled and that the world is not on the brink of a man-made global warming catastrophe'.

In general, sources of funding are difficult to find, as many are registered as educational charities, which are not obliged to publish bequests. However, we know that a network of 33 sceptic organisations in the USA, listed by the Union of Concerned Scientists (UCS 2007), received funding from ExxonMobil to a total of nearly $16 million (UCS; Powell 2011: Chapters 9 &10). Although contributions from ExxonMobil and the Koch brothers appear to have ceased, it is impossible to verify whether this really is the case, as a secret conduit for anonymous donations has come into being. A paper by a sociologist at Drexel University, published online on 21 December 2013 in *Climatic Change*, provides some insight into more recent sources of funding of what he calls the 'climate change counter movement'. He found that 140 foundations had made 5,299 grants worth $558 million to the 91 out of 118 prominent climate denial organisations between 2003 and 2010.

However, about three quarters of the hundreds of millions of dollars donated were from unidentifiable sources. Two organisations called Donors' Trust and Donors' Capital Fund provided 25% of all traceable funding. But organisations or individuals which in turn funded the Donors' Trust were untraceable. They are both 'donor-directed' foundations, which make grants based on the priorities of the contributing individuals or groups. The identity of the original donor remains out of sight, so that large sums can be ploughed anonymously into climate change denial operations. Therefore '… we need to focus on the institutionalised efforts that have built and maintain this organised campaign' (Brulle 2013).

2.5.3 Utilising Misgivings About Regulation and State Intervention

These climate sceptic groups have to be seen as part of a general campaign by vested interests against state intervention, first set in motion by the fear of regulation of tobacco products back in the 1960s in response to the US 1964 landmark report, *Smoking and Health*. Oreskes and Conway describe how a sustained campaign by vested interests originated in the USA. Executives of the tobacco industry enlisted the help of the Marketing Company R.J. Reynolds, which began by developing a strategy of doubt regarding the validity of, to begin with, the results of medical research, in order to ward off a likely attack on profitability (2010: Chapter 1). R.J. Reynolds then established a fund for the Biomedical Sciences and Clinical Research at the Rockefeller Institute, amounting to a cool annual $500,000 for a 5-year period (Ibid.: 25–26). The programme proved a powerful tool in the fight against regulation in general, not least because it was seemingly unrelated to controversies regarding vested interests such as the tobacco industry (Ibid.: 10-35). The scientists involved, already hostile to regulation of any kind, showed themselves more than prepared to submit critical reviews of research papers which might be harmful to their benefactor. 'If the public could be convinced that science in general was unreliable, then there was no need to argue the merits of any particular case.…' (Ibid.: 217). Hostility against regulation of any kind, including the causes of acid rain, CFCs, greenhouse gases and second hand smoke, is seen as an attack on liberty, a dangerous step on the path to communism: 'environmentalists were like a watermelon, green on the outside, red within.' Many groups were (and still are) fervently opposed to any conclusion they conceive as being hostile to American ideals. The early eighties saw major changes in the economic climate, allowing a libertarian thought pattern to become dominant worldwide. Free-market principles replaced the belief that the state has a duty to regulate potentially harmful activities in order to protect both the environment and human health (Ibid., 2010: 248–250).

This realisation soon brought other vested interests to take advantage of the arrangement and make use of the R.J. Reynolds connection. The Company proceeded by encouraging the creation of organisations, likely to attract anyone hostile to the idea of seeing any part of their lives regulated by the state. An example is the GGOOB (get government off our backs) coalition of strongly ideological groups, many of which received considerable amounts of funding from the tobacco industry (Apollonio and Bero 2007: 419–427). Subsequently, spreading doubt concerning research results unwelcome to vested interests grew into a widely used tactic.

A ten-page table of payments made by Philip Morris Inc. in 1997 can be found in the Legacy Tobacco Documents Library. The main beneficiaries were business-oriented organisations, many of which would in time become the most vocal detractors from climate change science. For instance, $200,000 was donated to TASSC (The Advancement of Sound Science Coalition), $175,000 to the Cato Institute and smaller amounts to the Heartland Institute ($50,000) and Defenders of Property Rights $45,000 (full 1997 list at BN 2078848138). To illustrate, a 1997 document in the collection, a memo, 'BP and Climate Change' (BN: 2085126534/6536), provides some insight into an important coalition of companies with an interest in the disparagement of climate science:

> [Note: This is a personal view of the situation. It is based on B-M's experience of working closely with BP on these issues and is not intended for circulation],. … In 1996, all the major oil companies were under increasing attack from the NGOs (in Europe and the USA) for their refusal to acknowledge the reality of climate change. [.….].

Continued:

> [Lord] Browne spoke at Stanford University in May 1997. … This was the first time that an oil industry leader had accepted the evidence on climate change. Browne had broken ranks with the industry and his peers were quick to condemn him for doing so.

Yet soon after, several other fossil fuel companies followed suit and left the Global Climate Coalition, a grouping opposed to the reduction of greenhouse gases.

3 Two Influential Detractors from the Mainstream Science

I want to draw the reader's attention to the work of two individuals – neither of which has been involved in climate change research – who have been instrumental in bringing the science into discredit. The first is Michael Crichton, anthropologist and successful SF writer of the late twentieth century, who worked reservations concerning climate change science into a techno-thriller, *State of Fear* (2004). The book features attacks by a group of environmental activists, who stage 'quasi-natural disasters' in order to convince the unconvinced of the reality of climate change. The environmentalist baddies are unconcerned about any victims. Although a work of fiction, it is amply provided with charts and tables which give the book a seeming authenticity. Several scientists whose research had been cited in the novel complained about its distortion. 'Our results have been misused as "evidence" against global warming' (Doran 2006). 'We have seen from encounters with the public how the political use of *State of Fear* has changed public perception of scientists, especially researchers in global warming, toward suspicion and hostility' (American Geophysical Union 2006: 364). It has been pointed out that Crichton's texts work 'by blurring the borders between false documents and hard data' (Genty 2009: 6). In addition, the Union of Concerned Scientists published a list of the novelist's mistakes, underlining the existence of a real consensus among climate change experts and challenging Crichton's biased selection and presentation of scientific data (Union of Concerned Scientists 2005). Yet Crichton has been taken for a climate change expert. He appeared on many television talk shows, while Senator Inhofe, of 'greatest hoax' fame, made *State of Fear* the 'required reading' for the Senate Committee on Environment and Public Works which he chaired from 2003 to 2007 and to which he called Crichton to testify in 2005. Crichton's deprecation of science is revealing: 'Scientists know that continued funding depends on delivering the results the funders desire. As a result, environmental studies are every bit as suspect as industry studies' (Afterword of *State of Fear*).

The other is an author of several books on the environment, two of which I have examined personally. He is a superb communicator, who uses his considerable talents to cast doubt on the validity of the science and the integrity of scientists. This is Lomborg who declares on a website created to attract requests for speakers: 'In 2008 he was named "one of the 50 people who could save the planet by the UK Guardian".' Although employed as adjunct professor in economics and statistics at Copenhagen's Business School with a doctorate in social and political studies, he styles himself a 'leading expert on global sustainability' on the site in question. This is at variance with his earlier statement in the preface of the book that made his name, The *Skeptical Environmentalist*, '…but I am not myself an expert as regards environmental problems' (2001: xx).

At first sight, many of Lomborg's statements appear to be highly credible. He draws readers into sympathising with his views by addressing them at a level non-academics can understand. His language appears deliberately populist, suited to attract many readers who might well be scornful of serious scientific debate when writing: 'Not surprisingly, a headline like "Climate Change Death Toll Put at 150,000" sells a lot of newspapers.' Or 'Let us take a peek under the hood of this number'. (Lomborg 2008: 93). His prose might be deliberately calculated to give the impression of being 'antiscience', when writing: '…This chapter accepts the reality of global warming but questions the way in which future scenarios have been arrived at and finds that forecasts of climate change of 6 degrees by the end of the century are not plausible' (Lomborg 2001: 258). As a reviewer commented: '…it is ironic that in a popular book by a statistician one can't find a clear discussion of the distinction among different types of probabilities … He uses the word "plausible" often, but curiously for a statistician, he never attaches any probability to what is "plausible"' (Schneider 2002: 61).

Any confidence one might have in his expertise begins to fade, when it becomes clear that his authority is based on countless mistakes. He was either very careless or relied on the belief that readers would not take the trouble to verify the facts used to support his presumptions. For instance, *The Skeptical Environmentalist: Measuring the Real State of the World* supports his premise that the environment is not under threat and that environmentalists exaggerate by means of 2,930 endnotes. It might be calculated to convince readers that someone with so many facts at his finger tips must be very knowledgeable. However, Friel (2010: 46–65) undertaking the laborious task of checking their validity found that many were either irrelevant or did nothing to substantiate Lomborg's thesis. In the *Cool It* book (Lomborg 2008), which deals explicitly with climate change, this is even more difficult: the system might well have been designed to confuse the reader. To give an example of the endnote organisation, nine notes refer to the statement: 'Several coalitions of states have set up regional climate-change initiatives, and …' . The endnote page in question repeats the phrase 'several coalitions of states have set up', followed by two source references in brackets (AP 2006a; Pew Research Center 2006) without any further clarification. Due to the profusion of notes, the system used obscures the fact that certain assertions are unsupported.

The claim that 'Statements about the strong, ominous, and immediate consequences of global warming are often wildly exaggerated, …' on page 8 of *Cool It*, comes unsupported. It is no more than an unsubstantiated assertion. Earlier, he drew attention to the fact that authors such as Al Gore as well as those of 'a raft of book titles' are sincerely worried but, as he assures the reader, unnecessarily so (2008: 4). The next paragraph adds that 'pundits [are] aiming to surpass each other in suggesting that "we face societal collapse in just forty years" unless we "make massive and draconian changes to the way we live"'. Notice that the sequence of these rather emotive expressions, 'pundits', 'surpass', 'societal collapse' and culminating with 'draconian measures', builds up to the impression of an assault on people's daily lives. He then followed this with the comment that *Time* did a special report on global warming in 2006 with the 'scare story' on the front cover. These two words serve to deflate the menace implied by the accounts, creating the impression that the threat of climate change is not real, no more than an exaggeration which can legitimately be dismissed.

An instance where Lomborg sought to discredit Al Gore's comments regarding the warming of Antarctica (2008: 65), concerns a reference to Pudsey et al. (2006):

> Studies show that in the middle of our present interglacial age the Larsen area saw "widespread ice shelf breakup".

This quote is disingenuous, as Pudsey et al. wrote 'northern shelf area'. Originally, the Larsen ice shelf consisted of a series of shelves which occupied three distinct embayments along the coast. Larsen A, the smallest and most northern one, broke up in 1995; then about a 100 km further south, the Larsen B ice shelf, which collapsed most spectacularly in 2002; and another hundred and ten or so km further south, the Larsen C and D, which are still intact. Now, the Larsen A shelf had been ice-free some 4,000 years ago, but the Larsen B had been stable for the last 12,000 years. 'Collapse of the Larsen B ice shelf is unprecedented during the

Holocene' (Domack et al. 2005). This kind of cherry-picking is conspicuous throughout (Friel 2010: 142).

4 Conclusions

The fact that climate change has been demoted to the background may well be due to the activities of climate change sceptics, with the 'Climategate' affair just a few weeks before the 2009 Copenhagen Summit on Climate Change. Groups like the Global Climate Coalition have been so successful at shifting the debate that the Bush administration credited them with playing a key role in America's rejection of the Kyoto protocol (Berners-Lee and Clark 2013: 126). Apart from Senator Inhofe, there are many influential public figures who uncritically repeat the unscientific statements favoured by the contrarians (for a full list, see Skeptical Science). The Australian Prime Minister, Tony Abbott, who in 2009 remarked that the science behind climate change was 'crap' (Rintoul 2009), seems intent on repealing the climate policies of the previous government. While the attitude in the UK to the subject is mostly one of indifference, several politicians and journalists appear to accept the stories fabricated by those hostile to the scientific findings on climate change uncritically, for instance, Peter Lilley MP, who once declared 'I am a global lukewarmist',[5] and 'I just think its effects tend to be exaggerated', as well as Owen Paterson MP, Secretary of State for Environment, Food and Rural Affairs, seemingly downplaying the message of the 2013 IPCC Report: '…I am relieved it is not as catastrophic in its forecast as we had been led to believe early on…' and 'The climate is always changing … and I think in the Holocene the Arctic melted completely …' (June 7th edition of *Any Questions*, Radio BBC 4).

Also, Ann Widdecombe, former MP, asked the rhetorical question 'What do Peter Lilley, Andrew Tyrie, Philip Davies, Christopher Chope and I have in common?' in an article in the *Daily Express*. She then answered herself with some apparent satisfaction: 'We were the only MPs to vote against the 2008 Climate Change Bill.' The article in question was tellingly entitled: 'Even scientists are now cooling on climate change' (13 March 2013). Then, there is John Redwood, whose vote was, as he said 'a mixture of for and against', justifying his doubts by referring to Channel 4's *The Great Global Warming Swindle* documentary. There are also journalists, such as Martin Durke, director of the aforesaid documentary, and Melanie Phillips – 'global warming is a scam' (Phillips BBC 2009), and Climate scepticism flourishes outside the Anglo-Saxon countries as well: a book *Die Kalte Sonne* (English: *The Neglected Sun* – Vahrenholt and Lüning 2012), with contributions from the Dane Henrik Svensmark, the Israeli Nir Shaviv, the American Nicola Scafetta and the German Werner Weber, with as central thesis 'that the Earth has not warmed since 1998, that the Hockey Stick graph was a hoax, that only the sun is to blame for global warming'.

[5] http://www.theguardian.com/environment/2012/oct/25/peter-lilley-climate-change-quotes

Routinely, there are calls for balance in TV programmes and newspaper articles. But how can 'balance be achieved' by giving a voice to those who challenge refereed and published scientific findings without proper references?

Despite the setbacks, there is pressure from different quarters to take strong measures to limit greenhouse gas emissions, as the costs due to erratic weather patterns are rising steeply. One industry which is directly involved is insurance, with annual revenues of $3 trillion. It has clearly seen the writing on the wall on climate change. As the Insurance Group Munich Re put it: '… Climate change is a subject that concerns us all. It is one of the greatest risks facing mankind'.

As to any ethical reasons, the message of the Human Development Report 2007/2008 United Nations 2008, the 21st Century Climate Challenge, was clear enough:

> Future generations will see our response to climate change as a measure of our ethical values. That response will provide a testimony on how political leaders today acted on their pledges to combat poverty and build a more inclusive world. Leaving large sections of humanity even more marginalized would signify a disregard for social justice and equity between countries. (United Nations 2008, 22)

In fact, a great deal of damage has already taken place, and a decent existence is as far off as ever for many poverty-stricken people, especially in majority world countries. Situations have worsened due to climate extremes (IPCC 2012 – or SREX -: 231). As mentioned earlier, the Human Development Report 2013 concludes that climate change has made life much more difficult in the majority world countries. Research by the UK Met Office confirms that man-made greenhouse gas emissions appear to have contributed to the recent East African drought (Met Office 2013). The findings were published in *Geophysical Research Letters*: 'Human influence was found to increase the probability of 'long rains' as dry as, or drier than, 2011' (Lott et al. 2013: para 18). In Peru, glacier retreat due to warming is threatening water supplies (World Bank 2013), while Bangladesh is considered to be one of the countries most vulnerable to the sea-level rise and storm surges associated with climate change because of its low-lying, deeply serrated coast (Mondal et al. 2013: 62). Then, in November 2013, the storm surge caused by Typhoon Haiyan appears to have been more extreme because of climate change-related aspects: added moisture in the atmosphere and higher sea levels, resulting in a wall of water of some 7 metres high being pushed inland (WMO 2013b). Also, the direction of the track typhoons which has been following since 1977 is reported to be changing towards the Northwest (Park et al. 2014: 1). The 2013–2014 flooding of the Somerset Levels and along the Thames in the UK may also be partly attributed to climate change. According to the Met Office's chief scientist, "all the evidence pointed to climate change as the cause, although there was not yet 'definitive proof'," [6] dismissed by Lord Lawson with: 'It is just this Julia Slingo woman…'.[7]

It has to be said that there are many prominent personalities who back urgent action. For instance, Jim Hansen and Bill McKibben campaign actively on

[6] BBC News Politics, 12 February 2014.

[7] Mason, *The Guardian*, 13 February, page 6.

environmental issues as well as write on the danger of climate change, motivated by concern for future generations and the natural world. Both have been arrested several times. However, it is Stern, the economist, who, defending himself from the 'low discount rate' accusation referred to earlier, puts it most clearly: '… there is no getting away from the fact that making policy towards climate change unavoidably requires one to take a stand on ethical questions' (Stern 2009: 77).

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References[8]

American Geophysical Union (2006) Forum: award to Novelist Crichton is inappropriate. Eos Trans Am Geophys Union 87(36):364, 5 September 2006

Anderson KL, Bows A (2011) Beyond dangerous climate change: emission scenarios for a new world. Philos Trans R Soc A Math Phys Eng Sci 369:20–44

Apollonio DE, Bero LA (2007) The creation of Industry Front Groups: the tobacco industry and 'Get Government Off Our Backs'. Am J Public Health 97(3):419–427

Balmaseda MA, Trenberth KE, Källén E (2013) Distinctive climate signals in reanalysis of global ocean heat content. Geophys Res Lett 40:1754–1759. doi:10.1002/grl.50382

BBC News Politics (2014) Met office: evidence 'suggests climate change link to storms.' 9 February 2014, Last updated at 13:16

Berners-Lee M, Clark D (2013) The burning question: we cannot burn half the world's gas, coal and oil, so how do we quit? Profile Books, London

Brigham-Grette J, Melles M, Minyuk P, Andreev A, Tarasov P, DeConto R, Koenig S, Nowaczyk N, Wennrich V, Rosén P, Haltia E, Cook T, Gebhardt C, Meyer-Jacob C, Snyder J, Herzschuh U (2013) Pliocene warmth, polar amplification, and stepped Pleistocene cooling recorded in NE Arctic Russia. Science 340:1421–1427, Abstract consulted

Browne J (1997) Full text of the speech at Stanford University. http://www.bp.com/en/global/corporate/press/speeches/john-brownes-speech-at-the-2007-agm.html. Accessed 1 Jan 2014

Brulle RJ (2013) Institutionalizing delay: foundation funding and the creation of U.S. climate change counter-movement organizations. Clim Change, published online 21-12-13, prior to the printed version at http://www.drexel.edu/~/media/Files/now/pdfs/Institutionalizing%20Delay%20-%20Climatic%20Change.ashx, doi:10.1007/s10584-013-1018-7. Accessed 1 Jan 2014

Byatt I, Castles I, Goklany IM, Henderson D, Lawson N, McKitrick R, Morris J, Peacock A, Robinson C, Skidelsky R (2006) The Stern review, a dual critique: part II: economic aspects. World Econ 7(4):135–198, November/December 2006

Chambers D (2013) Ocean observations of climate change: overview of the IPCC 5th assessment report, Ocean surface topography science team meeting, 8–11 October 2013. http://www.joss.ucar.edu/sites/default/files/meetings/2013/documents/OSTST13_abstracts_book_0.pdf

Chivian E, Bernstein A (2008) How is biodiversity threatened by human activity. In: Chivian E, Bernstein A (eds) Sustaining life: how human health depends on biodiversity. Harvard, Center for Health and the Global Environment: Harvard Medical School/Oxford University Press, Oxford/New York, pp 29–73

Climate Science Program, Iowa State University (2012) http://climate.engineering.iastate.edu/whatisclimatesciences.html. Accessed 1 Jan 2014

[8] (All websites accessed the 31st of January 2014 or later)

Cook J (2014a) Full list of climate myths and what the science says, SkepticalScience. http://www.skepticalscience.com/argument.php. Accessed 1 Jan 2014
Cook J (2014b) What do the 'Climategate' hacked CRU emails tell us? http://www.skepticalscience.com/Climategate-CRU-emails-hacked.htm and http://www.skepticalscience.com/Freedom-of-Information-FOI-requests-climate-scientists.htm. Accessed 1 Jan 2014
Cowtan K, Way RG (2013) Coverage bias in the HadCRUT4 temperature series and its impact on recent temperature trends. Q J R Meteorol Soc. doi:10.1002/qj.2297, accepted, doi:10.1002/qj.2297, see also http://www-users.york.ac.uk/~kdc3/papers/coverage2013/background.html. Accessed 1 Jan 2014
Crichton M (2004) State of fear. Avon Books, New York
Domack E, Duran D, Leventer A, Ishman S, Doane S, McCallum S, Amblas D, Ring J, Gilbert R, Prentice M (2005) Stability of the Larsen B ice shelf on the Antarctic Peninsula during the Holocene epoch. Nature 436(7051):681–685
Doran P (2006) Cold, hard facts (Opinion). The New York Times, 27 July, http://www.nytimes.com/2006/07/27/opinion/27doran.html?_r=0_2006. Accessed 1 Jan 2014
Edenhofer O, Wallacher J, Lotze-Campen H, Reder M, Knopf B, Müller J (eds) (2012) Climate change, justice and sustainability: linking climate and development policy. Springer, Dordrecht
Friel H (2010) The Lomborg deception: setting the record straight about global warming. Yale University Press, New Haven/London
Genty S (2009) Apparent truth and false reality: Michael Crichton and the distancing of scientific discourse. GERAS, pp 95–106, http://asp.revues.org/290. Accessed 1 Jan 2014
Gore A (2006) An inconvenient truth: the planetary emergency of global warming and what we can do about it. Rodale Press, Emmaus
Hansen JE, Sato M, Kharecha P, Beerling D, Berner R, Masson-Delmotte V (2008) Target atmospheric CO_2: where should humanity aim? Open Atmos Sci J 2:217–231
Hansen J, Kharecha P, Sato M, Masson-Delmotte V, Ackerman F, Beerling DJ, Smith PJP, Steffen K, Van Susteren L, von Schuckmann K, Hearty OH-G, Shi-Ling Hsu SL, Parmesan C, Rockstrom J, Rohling EJ, Sachs J, Zachos JC (2013) Assessing "dangerous climate change": required reduction of carbon emissions to protect young people, future generations and nature. PLoS One 12:e81648. doi:10.1371/journal.pone.0081648. Accessed 1 Jan 2014
Heesterman ARG, Heesterman WH (2013) Rediscovering sustainability: economics of the finite earth. Gower Publishing Ltd, Farnham/Burlington
Heinzerling L, Ackerman F (2002) Pricing the priceless, cost-benefit analysis of environmental protection. Georgetown Environmental Law and Policy Institute, Georgetown University Law Center. http://www.ase.tufts.edu/gdae/publications/C-B%20pamphlet%20final.pdf. Accessed 1 Jan 2014
Houghton J (2004) Global warming: the complete briefing, 3rd edn. Cambridge University Press, Cambridge
Huber P (2000) Hard green: saving the environment from the environmentalists: a conservative Manifesto. Basic Books, London
Inhofe J (2012) The greatest hoax: how the global warming conspiracy threatens your future. WMD Books, Washington (Kindle ed)
Intergovernmental Panel on Climate Change (IPCC) (2007a) Contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change (WGIAR4). Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL (eds). Cambridge University Press, Cambridge/New York. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm. Accessed 1 Jan 2014
Intergovernmental Panel on Climate Change (IPCC) (2007b) Summary for policy makers in climate change 2007, the physical science basis, contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change, I (WGIAR4 SPM). Cambridge University Press, Cambridge
Intergovernmental Panel on Climate Change (IPCC) (2007c) Climate Change 2007: synthesis report, Contribution of Working Groups I, II and III to the fourth assessment report of the

Intergovernmental Panel of Climate Change 2007, Core Writing Team: Pachauri RK, Reisiger A (eds). Cambridge University Press, Cambridge

Intergovernmental Panel on Climate Change (IPCC) (2012) Managing the risks of extreme events and disasters to advance climate change adaptation (SREX). A special report of working groups I and II of the Intergovernmental Panel on Climate Change (WGIIAR4). In: Field CB, Barros V, Stocker TF, Qin D, Dokken DJ, Ebi KL, Mastrandrea MD, Mach KJ, Plattner G-K, Allen SK, Tignor M, Midgley PM. Cambridge University Press, Cambridge/New York. http://ipcc-wg2.gov/SREX/

Intergovernmental Panel on Climate Change (IPCC) (2013) Climate change, fifth assessment report, working group I, the physical science basis, summary for policymakers. http://www.ipcc.ch/report/ar5/index.shtml. Accessed 1 Jan 2014

Intergovernmental Panel on Climate Change (IPCC) (2014a) Climate change, fifth assessment report, working group II, impacts, adaptation and vulnerability, summary for policymakers. http://www.ipcc.ch/report/ar5/index.shtml. Accessed 1 Jan 2014

Intergovernmental Panel on Climate Change (IPCC) (2014b) Climate change, fifth assessment report, Working Group III, mitigation of climate change, summary for policymakers. http://www.ipcc.ch/report/ar5/index.shtml. Accessed 1 Jan 2014

Kaser G, Osmaston HAO (2002) Tropical glaciers. Cambridge University Press, Cambridge

Kaser G, Hardy DR, Mölg T, Bradley RS, Hyera TM (2004) Modern glacier retreat on Kilimanjaro as evidence of climate change: observations and facts. Int J Climatol 24:329–339

Kosaka Y, Xie S-P (2013) Recent global-warming hiatus tied to equatorial Pacific surface cooling. Nature 501(7467):403–407

Kriebel D, Tickner J, Epstein P, Lemons J, Levis R, Leochner EL, Quinn M, Rudel R, Schettler T, Stoto M (2001) The precautionary principle in environmental science. Environ Health Perspect 109(9):871–876

Lack M (2013) The denial of science: analysing climate change scepticism in the UK. Authorhouse, Bloomington

Lawson N (2008/2009) An appeal to reason: a cool look at global warming, with a new Afterword. Duckworth Overlook, London

Library of Tobacco Documents (1997) Containing more than 14 million documents related to their advertising, marketing, manufacturing and scientific activities. Available at http://legacy.library.ucsf.edu/

Lindzen RS (2009) The climate science isn't settled; confident predictions of catastrophe are unwarranted. Wall Str J, Opinion, 30 November 2009. http://online.wsj.com/article/SB10001424052748703939404574567423917025400.html#articleTabs_comments. Accessed 1 Jan 2014

Lomborg B (2001) The skeptical environmentalist: measuring the real state of the world. Cambridge University Press, Cambridge

Lomborg B (2008) Cool it: the skeptical environmentalist's guide to global warming. Vintage Books, New York

Lomborg B. Author and leading expert on global sustainability. A-Speakers, International Speakers Bureau, Odense. http://www.a-speakers.com/speakers/bjorn-lomborg/ (online Speakers database only). Accessed 1 Jan 2014

Lott FC, Cristidis N, Stott PA (2013) Can the 2011 East African drought be attributed to human-induced climate change? Geophys Res Lett 40(6):1177–1181, 28 March 2013

Lucena J, Delborne J, Johnson K, Leydens JA, Munakata-Marr J, Schneider J (2011) Integration of climate change in the analysis and design of engineered systems: barriers and opportunities for engineering education. In: Proceedings of the ASME 2011 international mechanical engineering congress & exposition. 11–17 November 2011, Denver, CO. In New York: ASME, Proceedings of ASME. 54914, vol 5, Engineering education and professional development, pp 199–206

Madl P (2000) The El-Niño (ENSO) phenomenon. Environmental Physics/Lettner, VO 437-503. http://biophysics.sbg.ac.at/atmo/elnino.htm. Accessed 1 Jan 2014

McKibben B (2004) The submerging world. Orion. http://www.orionmagazine.org/index.php/articles/article/146/. Accessed 1 Jan 2014

Met Office (2013) http://www.metoffice.gov.uk/news/releases/archive/2013/east-africa-drought. Accessed 1 Jan 2014
Mondal M, Jalal M, Khan M, Kumar U, Rahman R, Huq H (2013) Hydro-meteorological trends in southwest coastal Bangladesh: perspectives of climate change and human interventions. Am J Clim Change 2(1):62–70
Munich Re Insurance Group. http://www.munichre.com/en/group/focus/climate_change/default.aspx. Accessed 1 Jan 2014
Nordhaus WD (2007) A review of the stern review on the economics of climate change. J Econ Lit 45(3). http://www.aeaweb.org/articles.php?doi=10.1257/jel.45.3.686. Accessed 1 Jan 2014
Oreskes N, Conway EM (2010) Merchants of doubt: how a handful of scientists obscures the truth on issues from tobacco smoke to global warming. Bloomsbury, London
Park D-SR, Ho C-H, Kim J-H (2014) Growing threat of intense tropical cyclones to East Asia over the period 1977–2010. Environ Res Lett 9:014008–014015
Parkinson S (2003) Tackling climate change – the role of the engineer. In: Women's Engineering Society annual conference, 'Proper practice: professionalism and ethics in engineering and science', SGR. http://www.sgr.org.uk/resources/tackling-climate-change-role-engineer. Accessed 1 Jan 2014
Phillips M (2009) Global warming is a con-trick. Daily Mail, Nov 27, news.bbc.co.uk/2/hi/programmes/question_time/8382037.stm. Accessed 1 Feb 1015
Pierrehumbert RT (2005) Tropical glacier retreat. http://www.realclimate.org/index.php/archives/2005/05/tropical-glacier-retreat/. Accessed 1 Jan 2014
Powell JL (2011) The inquisition of climate science. Columbia University Press, New York
Pudsey CJ, Murray JW, Appleby P, Evans J (2006) Ice shelf history from petrographic and foraminiferal evidence, Northeast Antarctic Peninsula. Quat Sci Rev 25(17–18):2357–2379. (abstract consulted)
Quai PD, Tilbrook B, Wong CS (1992) Oceanic uptake of fossil fuel CO2: carbon-13 evidence. Science 256(5053):74–79
Ramanathan V, Feng Y (2008) On avoiding dangerous anthropogenic interference with the climate system: Formidable challenges ahead. Proc Natl Acad Sci U S A 105:14245–14250
Readfearn G, Hickman L, Neate R (2012) Michael Hintze revealed as funder of Lord Lawson's climate thinktank. The Guardian, 27 March 2012. http://www.theguardian.com/environment/2012/mar/27/tory-donor-climate-sceptic-thinktank. Accessed 1 Jan 2014
Rintoul S (2009) Town of Beaufort changed Tony Abbott's view on climate change. The Australian. http://www.theaustralian.com.au/archive/politics/the-town-that-turned-up-the-temperature/story-e6frgczf-1225809567009. Accessed 1 Jan 2014
Rockström J, Steffen W, Noone K, Persson Å, Chapin FS III, Lambin E, Lenton TM, Scheffer M, Folke C, Schellnhuber H, Nykvist B, De Wit CA, Hughes T, van der Leeuw S, Rodhe H, Sörlin S, Snyder PK, Costanza R, Svedin U, Falkenmark M, Karlberg L, Corell RW, Fabry VJ, Hansen J, Walker B, Liverman D, Richardson K, Crutzen P, Foley J (2009) Planetary boundaries: exploring the safe operating space for humanity'. Nature 461:472–475. Also Ecology and Society 14(2): 32. http://www.ecologyandsociety.org/vol14/iss2/art32/. Accessed 1 Jan 2014
Royal Society (2005) Ocean acidification due to increasing atmospheric carbon dioxide. The Royal Society. Available at: http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2005/9634.pdf. Accessed 1 Jan 2014
Sachs NM (2011) Rescuing the strong precautionary principle from its critics. Univ Ill Law Rev 2011:1285–1338
Schneider S (2002) Global warming: neglecting complexities. In: Rennie J (ed) Misleading maths about the earth, Sci Am :61–63
Shoemaker LG (2010) Fingerprints of emissions and the carbon cycle: stable and radiocarbon isotopes of carbon dioxide. NOAA/ESRL. http://www.esrl.noaa.gov/gmd/outreach/isotopes/. Accessed 1 Jan 2014
Singer SF (1995) Hot talk, cold science: global warming's unfinished debate. The Independent Institute, Oakland, with foreword by F. Seitz
Stern N (2007) The economics of climate change: the Stern review. Cambridge University Press, Cambridge

Stern N (2009) Blueprint for a safer planet: how to manage climate change and create a new era of progress and prosperity. Chapter 5: ethics, discounting and the case for action. Bodley Head, London

Stockholm Resilience Centre (2012). http://www.stockholmresilience.org/21/research/research-news/7-2-2012-planetary-boundaries-are-valuable-for-policy.html. Accessed 1 Jan 2014

The Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) (2014). http://www.apegm.mb.ca/pdf/PD_Papers/cc-eng.pdf. Accessed 1 Jan 2014

The Royal Academy of Engineering (2011) Infrastructure, engineering and climate change adaptation – ensuring services in an uncertain future. http://www.theiet.org/policy/collaboration/etf/infrastructure.cfm. Accessed 1 Jan 2014

Tol RSJ (2006) The stern review of the economics of climate change: a comment. Reprint from Energy Environ 17(6):977–981

Tol RSJ, Yohe GW (2006) A review of the Stern review. World Econ 7(4), 233ff

Tyndall J (1861) The Bakerian lecture: on the absorption and radiation of heat by gases and vapours, and on the physical connexion of radiation, absorption, and conduction. Philos Trans R Soc Lond 151. http://www.jstor.org/stable/108724?origin=JSTOR-pdf

Tyndall J (1863) Heat considered as a mode of motion. Longmans, Green and Co, London

Union of Concerned Scientists (2005) Crichton's thriller state of fear: separating fact from fiction. http://www.ucsusa.org/global_warming/science_and_impacts/global_warming_contrarians/crichton-thriller-state-of.html. Accessed 1 Jan 2014

Union of Concerned Scientists (2007) ExxonMobil report: smoke, mirrors & hot air. http://www.ucsusa.org/global_warming/science_and_impacts/global_warming_contrarians/exxonmobil-report-smoke.html. Accessed 1 Jan 2014

Union of Concerned Scientists http://www.ucsusa.org/global_warming/science_and_impacts/global_warming_contrarians/global-warming-skeptic.html

United Nations (2008) United Nations Human Development Report (UNDP) 2007/2008, the 21st century climate challenge programme, United Nations Human Development Report, 2007/2008. http://hdr.undp.org/sites/default/files/reports/268/hdr_20072008_en_complete.pdf. Accessed 1 Jan 2014

United Nations (2013) United Nations Human Development Report (UNDP) 2013. The rise of the south: human progress in a diverse world. http://hdr.undp.org/en. Accessed 1 Jan 2014

United Nations Human Development Report (UNDP) (2007/2008) Fighting Climate Change: Human Solidarity in a divided world Palgrave Macmillan, New York/Basingstoke. http://hdr.undp.org/sites/default/files/reports/268/hdr_20072008_en_complete.pdf. Accessed 1 Jan 2014

United Nations Development Report (UNDP) (2013) The rise of the South: human progress in a diverse world. United Nations Human Development Report 2013, United Nations, New York/London, Also at: http://hdr.undp.org/en. Accessed 1 Jan 2014

Vahrenholt F, Lüning S (2012) Die kalte Sonne: Warum die Klimakatastrophe nicht stattfindet. Hoffmann und Campe, Hamburg

Wagner G, Weitzman ML (2012) Playing God. Foreign Policy. http://www.foreignpolicy.com/articles/2012/10/22/playing_god?page=0,2&wp_login_redirect=0 (Registration required to read the article). Accessed 1 Jan 2014

Widdecombe A (2013) Even scientists are cooling on climate change. www.express.co.uk/2013/comment/columnists/ann-widdecombe/385446/Even-scientists-are-cooling-on-climate-change. Accessed 1 Jan 2014

Wight J (2010) The fake scandal of *climate*gate. http://www.skepticalscience.com/fake-scandal-Climategate.html

World Bank (2013) http://www.worldbank.org/en/news/feature/2013/03/25/peru-prepares-to-face-the-retreat-of-andean-glaciers. Accessed 1 Jan 2014

World Meteorological Organisation (2013a) The global climate 2001–2010: a decade of climate extremes, Summary report, WMO-No 1119. Geneva

World Meteorological Organisation (2013b) Typhoon Haiyan more extreme due to climate change, says WMO. http://www.rtcc.org/2013/11/13/typhoon-haiyan-more-extreme-due-to-climate-change-says-wmo/. Accessed 1 Jan 2014

Chapter 7
Environmental and Social Aspects of Domestic Bathing

Alan Cottey

Overview
This chapter sets domestic bathing in a broad context – the large and increasing overload of the planet's ecology by human activity. (This overload is indeed so marked that the term Anthropocene is widely used for a new geological epoch in which human influence is a major factor.) The domestic bathing practices of prosperous, westernised people are extravagant, mainly through the use of large amounts of water and energy. Ways in which bathing can remain pleasurable and hygienic yet use an order of magnitude less water and energy are discussed. Such a reduction cannot be achieved through technical efficiency alone, because capitalism *requires* net economic growth of the historic kind. The fundamental questions are political. In particular, humanity must change from an ethos of domination and exploitation to an ethos of sharing our earthly home. The discussion of bathing is an example, drawing out ideas applicable to other cases of human profligacy. The role of engineers, as normal members of society who also bring their talents and trained skills to the invention and development of useful arts, is apparent throughout the chapter.

1 Domestic Bathing

In this chapter, domestic bathing, which I will usually call simply 'bathing', means bodily washing for reasons of hygiene, pleasure or both. It includes taking a bath or shower, washing oneself at a washbasin or washing one's feet in a lightweight bowl. Hygiene or pleasure arrangements of a few other kinds come into the category, such as the bidet and any of the numerous kinds of domestic spa pool, waterjet pool and sauna, but an exhaustive treatment of all such types is not attempted.

A. Cottey (✉)
School of Chemistry, University of East Anglia, Norwich, England
e-mail: a.cottey@uea.ac.uk

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This chapter is organised by establishing the importance of bathing; by discussing the social and personal aspects of bathing, which are fundamental; and then by turning to technical aspects, which are responses to the fundamental needs and values. To that point the discussion is general. The ground is then prepared for discussing the various methods of bathing and comparing them. Finally, we step back and take a second look at the whole subject in its cultural context.

2 Context

> It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us …. (Dickens 1859, p 1)

A book which deals with international stability, environmental stability, engineering ethics and sustainable development must surely engage at many points with the contradictions so eloquently indicated in this quotation, even if our take on our own times inevitably differs from Dickens' view of an earlier time. Excessive consumption by those prosperous enough to do so is one of the principal contradictions of our times. Bathing is here treated as an exemplar of these contradictions. On the one hand, thoughtless, consumerist bathing contributes significantly to resource use and pollution; on the other hand, mindful bathing can be economical and pleasurable.

International Stability This phrase has a special connection with the Cold War and needs some unpicking in order that we may deal with today's conditions. In those times the principal actors on the world stage were *thought* to be nation states, especially the two superpowers, the USA and the Soviet Union. Today, this is seen not to be the case, and one may indeed question whether it was ever that simple. There is now more interest in additional actors, notably banks, other large multinational corporations, powerful plutocratic individuals and religious groups. As for stability, the concern then, understandably enough, was to save ourselves from an apocalyptic instability in the form of a release, in whatever manner and for whatever reason, of the gigantic nuclear arsenals which were deployed with hair-trigger readiness (Craig and Jungerman 1986). In this article I will assume that the stability we now seek is of a more general kind, global and cultural. Such a stability cannot however mean stasis. We may hope and work for no more (!) than improving justice, marginalising war and reversing the overload of the earth's long-developed ecology.

Environmental Stability In the course of history (i.e. the period in which written records exist), many sophisticated and large empires have flourished – and died. Yet human civilisation did not die out, because others, dismissed by the imperialists as barbarians, turned out not to be so very different and established a new empire. In many cases those imperial collapses were due to exhaustion of natural resources (Diamond 2011; Ponting 2007) and could possibly have been avoided if the nature of the impending crisis had been understood or wise counsels had prevailed. Now we are faced with the prospect of a similar collapse of civilisation (Beddington 2009; Chamberlin 2008; de la Rue du Can and Price 2008), but this time it is different from others in the historical period, though possibly not in archaeological or geological periods. Now the danger is of a global collapse, of culture, of economy and of biodiversity. We cannot plead ignorance of the signs – see, for example, World Meteorological Organization (2013). We have to admit to lack of wisdom (Maxwell 2007). We have lacked the ability – so far – to turn away from the ideology of exploitation (Locke 1690; and see Macpherson 1962 for a critique) which has set us on course for 'our headlong collision with nature', an apt phrase used as a subtitle in Edwards et al. (2006).

Sustainable Development This collision may be traced to the uncritical pursuit of economic growth throughout the recent centuries of capitalism, punctuated by frequent crashes. Each such crash comes as a surprise and seems at the time to be terrible, but so far the crashes have been short lived. An analysis of this kind presumably is maintained, though not expressed openly, by those who favour economic growth. The belief in continued business-as-usual economic growth, bizarre as it may seem to those who understand the true ecological situation, dominates popular discourse, economic discourse and political discourse. This may be observed by critical attention to the language and selectiveness of the mass media (Media Lens undated).

Engineering Ethics A principal response from the advocates of growth, when challenged with the proposition that growth cannot continue indefinitely, is to call up the efficiency argument. Great weight is placed upon the drive for improved efficiency of private and public institutions and of technical processes. This is where engineers and technologists come in. The very words are related to ingenuity and techne (art, skill), and it is widely supposed that we will be able to solve present problems by applying technical skills. Through the earlier part of the last century, the age of leisure was foreseen, with machines and computers doing most of the heavy and repetitive work. Since the 1950s the paperless office was confidently predicted. Since the same period, cheap abundant energy was promised, first through nuclear fission and, when that was seen to be problematic, nuclear fusion. For decades now, climate change has been known to be a potential danger and more recently known to be an actual danger. Solution? Fusion energy or, failing that, geoengineering; they will come up with something.

Unfortunately, the histories of the age of leisure and of the paperless office do not bolster faith in the prospects of fusion energy or geoengineering for actually *solving* problems. They may come to pass, as did digital representation and storage of data, as did the use of heavy machinery and clever robots and as did fission energy. Yet we use paper with extreme profligacy, in the home as well as the office and especially in advertising. We use energy profligately, so that net use increases, despite the undoubted (and hard-won) gains in thermodynamic and transmission efficiency provided by engineers. Information technology, which could have greatly reduced the physical energy needed for processing and transmitting information, has not fulfilled its potential in this respect. Instead surprisingly large amounts of energy are consumed, worldwide, by electronic equipment. According to Raghavan and Ma (2011), the Internet (including the embodied energy of associated hardware) uses between 1 and 2% of the world's energy consumption. In summary, growth (roughly a few percent per annum) always caps efficiency gains (roughly one percent per annum). This conclusion applies to the increase of water and energy use for bathing, as we will see in detail, in much the same way as to the increased use of paper, of fossil fuels and indeed of almost everything. This situation should not, however, deter engineers from doing what they can in an ethical way. An inspiring example may be found in the ideas and work of Meredith Thring (Fitzgerald 2006; Thring 1980).

Why are we in this dysfunctional situation? In my analysis, the problem is deeper than the growth demanded by capitalism (which I define to be the system in which economic activity is driven to a large extent by the prospect of high interest returns on capital). Even if there were no capitalist systems, our problems would still exist, although emerging more slowly, as long as human culture maintains an attitude of domination and exploitation, that is, an attitude of domination and exploitation by power elites of other human beings, of all other life forms and of the nonliving 'resources' of the planet. This attitude is revealed by the current widespread use of the word resource, notably in the euphemistic abbreviation HR (human resources). What is needed, instead, is a radical change of attitude, so that humans *cohabit* this planet respectfully. In such a culture, the contributions of the engineer and technologist, their ingenuity and their art, would permit the realisation of many of the dreams that have been seen and are, contrary to popular assumptions, entirely feasible (Neville-Sington and Sington 1993; Shostak 2003). This is what I see as the important part of engineering ethics for our time.

The UK and the World As the above remarks should make clear, the canvas is wide, in space and time. Most of the data and calculations in later sections are based on the current UK scene. Nevertheless, I have tried in the general remarks to maintain an overall awareness of and applicability to the bigger picture, in particular to a putative just and sustainable culture, even if this may be by most people's standards in the far future.

In summary, these large questions relate to bathing via the excessive consumption by a privileged minority. They contribute to environmental instability (Chew 2001) and to the tensions leading to international instability (Beddington 2009). They undermine progress towards genuine sustainable development (Trainer 1995). The ethical engineer will use his or her technical skills and moral resources to help society transcend this dysfunctional conduct (Thring 1980).

3 Importance of Bathing

> He steps under the shower … When this civilisation falls … this will be one of the first luxuries to go. The old folk crouching by their peat fires will tell their disbelieving grandchildren of standing naked mid-winter under jet streams of hot clean water …. (McEwan 2005, p 149)

Henry Perowne's musings here are drawn to a dystopian vision. Yet, if we all give up hope, that is the likely outcome. Holding on, instead, to strategic optimism, we can note that profound changes of human values have occurred in the past, and often. I consider that a radical change of values – from exploitation to respectful, modest cohabiting – is possible. One thing appears as certain as anything about the social future can be – radical changes *will* happen. The ecological state of the world will see to that (Beddington 2009). I find bathing, and I use this term broadly in relation to human personal cleanliness, to be an excellent specific topic for exposing and analysing the issues mentioned in Sect. 2. I have given brief accounts from this point of view in Cottey (2008, 2012).

Of the many weighty problems we have to consider, in seeking a just and sustainable world, bathing is important. It may not spring to mind immediately as such, for three reasons. At least for most people in a rich, westernised milieu, it has been made so simple that it can be taken for granted; advertising, with which almost the whole world is saturated, plays upon our fantasies and often trivialises our real experiences; and issues of physicality keep bathing partly in a private domain, literally in the closet. A way of thinking, congenial to engineers, that bypasses these obstacles is to think outward and place cleansing in the context of nonequilibrium thermodynamics. Not only humans but all of life is a complex quasi-stable state which is maintained away from equilibrium by many activities, all of which are powered by heat engines of one kind or another (thermochemical, thermomechanical, etc.). All of these engines use available energy that derives ultimately from the nonequilibrium state of the universe, the most important for us being the flux of sunlight upon the earth. Others are the nonequilibrium distribution of the nuclides, which makes nuclear power possible, and the nonequilibrium configuration of local mass (earth-moon system) which makes tidal power possible.

Cleansing This, is one of the many activities that living organisms perform. They may perform it consciously and deliberately (as do humans and the higher animals), or they may have evolved in such a way that it happens naturally and without apparent effort (e.g. as with worms). The skin, or outer surface, of a living organism is complex and serves several functions. This limits the cleansing process. It must not be harsh and thereby do harm. Looking at the matter from this point, we see that many cleansing processes in nature are remarkably efficient, as in the case of the worm. Likewise remarkable is the *lotus effect*, an informal name given to the general phenomenon of superhydrophobicity. The surface of lotus leaves repels water unusually strongly, and particles of dirt are carried away within the water droplets. This is only the most spectacular of self-cleaning processes widespread in nature. In general, all living organisms in an environment to which they are well adapted are, one might say *by definition*, clean. Plants toil not, either to be clean or to grow, though they do what they have to. The lotus effect is now understood at the microphysical scale, and many engineering applications, including the production of self-cleaning surfaces, are in place and under development (Forbes 2008).

These remarks are intended to expand our imaginations as to what may be possible in the future (Neville-Sington and Sington 1993). Already much has been achieved over recent centuries in the efficient production and use of energy and clean water. This may be readily seen from the, often amusing and always informative, accounts and illustrations of bathing in earlier times (Allen 1976; Aschenburg 2007; Friendly Traveller 1775; Lupton and Miller 1992; Scott 1939; Smith 2007; Wright 1960).

4 Social and Personal Aspects of Bathing

Here I attend first to the political, economic and personal aspects of bathing, since these are fundamental. In a later main section, I will address the technical aspects of bathing. It is the engineer's *specific* job to find the best possible technical solutions and if something is not technically possible, to say so. This is, however, not to say that engineers can leave the political, economic and personal aspects wholly to others. They have the usual citizen's responsibilities but weighted in a way that reflects their expertise and also, as far as possible, avoids that ever-present danger for all specialists, the misuse of expertise in self-interested pleading or lobbying.

4.1 Political

The main political point is that, in the currently dominant ideology of neo-liberalism, net growth of the existing kinds of economic activity is a necessity. It follows that any reductions from gains in efficiency *must* be compensated by even greater growth than would otherwise be 'sufficient'. Therefore, no proposals for achieving, or even moving nearer to, a just and sustainable world can have any net positive effect until the dominant political ideology of the last half-century is decisively rejected. The world has, indeed, come to a condition that demands a basic change of attitude, as indicated earlier – from one of exploitation to one of cohabitation. The relevance of this for the later parts of this chapter is that some of the simple suggestions I make about frugal bathing are to be understood in the spirit of *ideas do not have to make sense in the world in which they are proposed. They have to make sense in the world in which they will be used* – a slight adaptation of an aphorism attributed to Ray Kurzweil (O'Reilly 2003).

4.2 Economic

Apart from the general economic implications of the basic political shift indicated above, there are two specific economic propositions I make here which will underlie all that follows about bathing. A large reduction in the profligate use of energy and water is necessary, yet a certain amount of water and of energy are fundamental necessities of life. It follows that their price structures should be steeply progressive.

Each person should have ready access, for free or at a low cost, to a sufficiency of water and energy. (By ‘a sufficiency’ I mean enough for a simple, convenient and dignified life. This will depend strongly on personal circumstances and physical infrastructure, e.g. availability of grey water filtration for toilets and gardens. Bathing water should however be potable, for safety in case of ingestion by children.) The price should thereafter rise, gradually at first but then steeply. I suggest that the price could rise eventually to one or two orders of magnitude above cost price, to dissuade profligacy. Easy routine monitoring of consumption, or, better, a warning system, to give early warning of a high rate kicking in, would be needed, especially in case of a leak.

Yet in today’s extreme disparity between the poorest and the richest, no reasonable water and energy price structure will, by itself, affect the richest. Moderation in the usage of these vital utilities is essential. Two solutions to this problem come to mind. One is rationing (averaged over several years, to allow for fluctuations in circumstances) and the other is maximum income (Cottey undated; Pizzigati 2004). This would depend on the individual’s circumstances. Some multiple of a basic income for all, such as one order of magnitude (~10), has been suggested for the sake of an example (Pizzigati 2004). As for obstacles to this proposal, which apparently seems utopian to most, one must consider that the near future is likely, due to the ecological state of the planet, to see rapid changes in any case, making the developments since the beginning of civilisation (agriculture, writing, cities, empires) seem gradual.

4.3 Personal

Safety Safe bathing is largely a matter of public attitude and knowledge. The engineer’s task is to design systems and artefacts that are as safe as possible, subject to cultural constraints over which the engineer, like the citizen, does not have individual control. In the present culture, marketing has a powerful effect in creating public desires (Barber 2008), and the engineer’s concern for safety is sometimes in conflict with the marketeer’s concern for image. This is especially noticeable in the design of showers. They, together with other bathing equipment and the space itself, ought to be designed with the needs of all potential users in mind. These include people who are impatient, clumsy, old and young and have disabilities of numerous kinds, as well as the mature, fit athletic person.

The main safety issue for bathing today is surely slipping in the shower. One might expect it to be easy to find adequate statistics on this but such is not the case. This would appear to be because only serious accidents are recorded, such as death or admission to an accident and emergency centre. Nevertheless, one can assert that slipping in the shower is a major issue from everyone’s personal experience. Even if everyone has not had an actual fall in the shower, everyone has had a near miss or else has noted when a shower floor is slippery and taken care and also recognised the risk for a less agile person.

The other danger in a bathroom is mains electricity. Nowadays, professional electrical standards are high (in prosperous countries), and do-it-yourself electrical work in bathrooms is rightly deprecated. It is good to educate children about water and electricity not mixing, especially that no one should use a mains-powered portable device (radio, heater or hairdryer) in a bathroom.

Care of Our Feet In the UK at least, whence comes most of my experience, it is easy to observe that many people allow their feet to be in a remarkably poor condition. This is true even of people in their twenties, and they are storing up problems for later years which are then hard if not impossible to eradicate. Care of the feet is an important aspect of self-care, and it is a significant factor in bathing. For many people, including most of the elderly, reaching their feet well enough to wash and dry them is an issue. Being able to keep the hard skin from thickening, by frequent gentle abrasion, can also be a challenge. Sitting down, on a stool or on a folded towel on the edge of the bath or on the toilet cover, and using a bowl and a corn-and-callus file (strigil) is the easiest, safest and most effective method. Attending to one's feet in the shower, unless one is agile (supple and with good balance), is dangerous. A seat or grab handle is essential. Shower cubicles should be designed to be safe for everyone who may visit. The awkwardness and danger of washing our feet in the shower are not generally remarked. It can hardly be by chance that images advertising showers leave the lower part of the body out of frame.

Washing Hair A simple point for those with long hair is to avoid washing it more than necessary. It increases greatly the environmental impact of a shower, through the creation of more dampness and through the considerably longer time – thus more energy and more water needed, especially for rinsing. (Here and in the following, I use 'dampness' as a qualitative term that includes condensation and excess humidity and is a problem when it compromises human health and the durability of room structures and decoration.) Hair care advice in any case often says that excessive washing is bad for the hair by removing natural oils. There is also the subsequent need to dry wet towels or to use electricity for a hairdryer (quantified in Sect. 6). The solution is an appropriate mixture of shower with hair wash, shower with shower cap, and basin wash. Llewellyn (2002), p 16, advises 'We all need to wash our hair once or twice a week' and (pp 18–19) 'Drying your hair: After you have washed your hair, pat it gently with a towel. Try not to rub it or it will tangle … It's best for hair to dry on its own. Hairdryers are so hot they can scorch it'.

Preserving the Skin's Natural Oils Cooler and shorter bathing does have this benefit for the skin, but the energy, water and air quality benefits are rarely mentioned at the same time. On the contrary, one author emphasises the perceived difficulty:

> Those long, hot showers feel especially good in this winter weather but the longer you soak; the more oils escape from your skin. Taking shorter cooler showers will prevent dry skin. (Dhanda 2011)

One may add to this that using soap sparingly (not at all if only rinsing off sweat) is beneficial to the skin and the environment.

Aesthetics Lupton and Miller's (1992) *The Bathroom the Kitchen and the Aesthetics of Waste: A Process of Elimination* has much of interest to architects and engineers. Aside from the aesthetics of equipment and rooms, the aesthetics of our bodily appearance, unclothed and clothed, has always been important (Faxon 1998, pp 110–115) and can remain so, whilst the adverse impacts of consumption are minimised.

Pleasure Slavin and Petzke's (1997) *The Art of the Bath* is a paean to luxurious bathing, but there is no recognition of outer realities. Likewise, Witberg and Field's (2000) *Clean and Serene: Meditations for the Bath* betrays a solipsistic concept of pleasure. Part of the aim of the present chapter is to argue that varied mindful bathing habits would still be pleasurable in a just and sustainable world.

Health and Impairment This chapter is concerned with promoting hygienic and pleasurable bathing for all whilst using much less water, energy and toiletries than are used in prosperous countries today. This may be regarded as a small part of a grand project, in which humanity changes from an ethos of domination and exploitation to an ethos of sharing our earthly home with its other living and nonliving parts. Part of this is understanding and special help for people with physical and other/or impairments, particular illnesses or health issues. These can be extremely varied, and therefore no attempt will be made in this chapter to specify what responses might be best for this or that condition. In any case the person herself or himself has the right to decide, and usually has the best insight into, what suits them. All the suggestions in the following are subject to the consideration that what may suit most does not have to suit all. This remark takes on a special significance in the present world of global technical design and production. One of the many challenges for the conscientious engineer working for a better world is to combine efficient production for gigantic markets without squeezing out specialist markets. Products for the latter will be more expensive, but this should be minimised as far as technical design allows. The late Meredith Thring was one of the first engineers who 'challenged engineers to provide a decent quality of life for the disabled and underprivileged' (Crookes 2007; Fitzgerald 2006, Ch 8 of Thring 1980, Ch 10 of Thring and Blake 1973).

5 Learning Together

I prefer this expression to 'education'. By learning together I mean skill sharing, knowledge sharing and wisdom sharing. In this dysfunctional world, adults have much to learn from babies and children. Young and old need a functional intellectual, practical and emotional environment, something that could exist in what Ted Trainer (1995) called a conserver society. Whether education remains conventional or gains a learning together character, connected written expositions will remain important. I present now a potted review of current and earlier books on washing. They give an understanding of where we are now, in respect of bathing values, technology and practices, and of how we got to this place.

Books on Washing These fall roughly into three genres:

- Scholarly, and also wry but not jokey, books for adults: In the development of our understanding of the connections between culture and technology, *Mechanization Takes Command* (1948), by the historian and critic of architecture Sigfried Giedion (1948), has a special place and is the forerunner of new ideas, continuously developed to this day, about these connections. Part VII, *The Mechanization of the Bath*, is about much more than its title suggests. I will mention a few of the books on the subject which are, in my opinion, among the most significant and relevant to the present study. In the 'pre-Giedion' period is an early report, *The Ensign of Peace, showing how the health, both of body and mind, may be preserved and even revived by the mild and attenuating power of a most valuable and cheap medicine* by Friendly Traveller (1775). Friendly Traveller is identified on p 404 of Smith (2007) as 'medical author and sailor Peter Crosthwaite'. Another early account is George Ryley Scott's (1939) *The Story of Baths and Bathing*, which is interesting for its information, its illustrations and its insight into ideas and practices of the early twentieth century. Moving forward, an early 'post-Giedion' offering is Lawrence Wright's (1960) *Clean and Decent: The Fascinating History of the Bathroom and the Water Closet and of Sundry Habits, Fashions and Accessories of the Toilet, Principally in Great Britain, France, and America*. This book was influential in reinvigorating a genre of wryly humorous but informative books about cleanliness, a recent example being Katherine Ashenburg's (2007) *The Dirt on Clean: An Unsanitized History.* This genre played into an interest in 'the body' from academics in the humanities. This has led to a number of studies in recent decades, notable ones being Timothy Burke's (1996) *Lifebuoy Men, Lux Women: Commodification, Consumption, and Cleanliness in Modern Zimbabwe* and Virginia Smith's (2007) *Clean: a history of personal hygiene and purity.*
- Jokey books: In Kay Woodburn and Aggie MacKenzie's (2004) *Too Posh to Wash*, I sense that, even when all over-the-top humour is acknowledged, there remains an extreme fastidiousness – a great fear, perhaps even hatred, of nature. This way of thinking precludes awareness of the grossly unsustainable consumption of water and energy required by the authors' demands.
- Child education books: There are a very large number of such books of which I will mention just a couple. Eleanor Allen's (1976) *Wash and Brush Up* is a straightforward account, not arch or edgy like so many others, of washing and bathing through the ages. Thompson Yardley's (1990) *Down the Plughole: Explore Your Plumbing* has a blokeish style, presumably aimed at interesting primary school boys of western culture, imbued as they are with a mechanistic worldview, in caring for the earth and ourselves.

Engineering in a Learning Together Culture The education system as it now exists is in a deep two-way relationship with many distortions of our unjust and unsustainable culture. Those drawn to engineering or technology have to make their way, as best they can, in a milieu oriented to private monetary gain. Their creation of new useful arts and development of existing ones achieve only a part of its potential. In this chapter, bathing is considered an example with a past, a present and a future. To all of these, the engineer, or ingenious person, has contributed, does so and will do so.

6 Technical Aspects of Bathing

In this section I will consider those technical aspects of water, energy and CO_2e (carbon dioxide equivalent, or greenhouse gas) emissions that are common to all bathing methods. Method-specific details will come in Sect. 7.

6.1 Water

In the USA 'About 17 percent of residential indoor water use goes to showering, which adds up to more than 1.2 trillion [that is, 1.2×10^{12}] gallons of water consumed each year' (Bennett 2008, p 59). Since 1 US gallon is 3.79 l (National Physical Laboratory undated, a) and the US population was estimated to reach 300 million in 2006 (United States Census Bureau 2006), this means that the average US person takes 42 l/day for showering and 244 l/day for all residential indoor use. Bathing in the USA usually means a shower, although hot tubs, Jacuzzis and similar bathing facilities are also popular. Further, water use has probably increased a little since the date of the research, the economic glitch from 2008 notwithstanding. Using a rounded figure, as is appropriate in this hard-to-quantify subject area, I therefore assume that the US water use for bathing is at least 50 l/day. This is a national average and the USA is strongly inegalitarian. Many will be using much more than 50 l/day for bathing and much more than 250 l/day for all residential indoor use.

There is an enormous disparity between the availability of water to the richest and poorest individuals. I largely avoid country-by-country comparisons because it is people as individuals who matter. There are people suffering from multiple deprivation in all countries and superrich, profligate, people in all countries. 'More than one billion people worldwide can't get the safe, clean water they need' (Practical Action undated, a). Further information may be found on the Practical Action document pages (Practical Action undated, a). These statistics reinforce the earlier proposition that humanity must embrace a qualitatively different attitude to its own kind and to the rest of life and to our planetary home. The significance of the suggestions made in later sections of this chapter on frugal bathing is intended, not particularly as exhortations to individuals to behave in a way that, within the existing culture, is eccentric but rather as experiments to discover some of what may be possible when deep cultural changes have occurred. The suggestions are intended to liberate thinking about change.

The Water Label This scheme is operated by The Water Label Company (undated). (Until recently this UK scheme was operated by the Bathroom Manufacturers Association and called the Water Efficient Product Labelling Scheme.) The distinctive and simple label states the maximum flow of taps, flow limiters and other accessories and also places each in one of five bands, according to maximum flow – Max 6, Max 8, Max 10, Max 13 and Max >13 l/min. There are 13 scheme partners, including the UK government's Department of Environment, Food and Rural Affairs (Defra), the Chartered Institute of Plumbing and Heating Engineering (CIPHE) and Waterwise. There are 38 registered companies (manufacturers) and I believe this includes all of the major ones. The scheme is currently being expanded into Europe by the European Association for the Taps and Valves Industry (CEIR undated) and known as the European Water Label. Yet from my investigations, I find that the scheme is practically unknown among retailers and the public. The contrast is stark, between worthy, money-saving conservation advice on the one hand and the overwhelming profile of new and more profligate – and profitable – products on the other hand.

Hard Water If one lives in a hard water (apt to deposit limescale) area, the use of a water softener can be justified (Lower 2011). I have found such use very effective in prolonging the life of boilers and showers, in greatly reducing the amount of soaps and detergents needed, improving the bathing experience and avoiding unsightly limescale stains. The disadvantages are expense and embodied energy of equipment, expense and environmental effect of the needed salt and slight increase in water use because of the resin regeneration stage. There should be a separate plumbing route, not through the softener, for drinking water.

6.2 Energy

The general remarks about water apply in a similar way to energy, in that energy is also a necessity of life, access to it is currently grossly unequal and unjust and rich people are responsible for the globally unsustainable amounts used. It is also true that some impoverished communities use energy in an unsustainable way, by cutting down the few remaining trees in a devastated area, but they can hardly be called *responsible* for this, as they have no choice.

Global Energy Use To appreciate the need for a reduction in our energy use, we may note the historical data (1970–2000) and the projections (2000–2030) in de la Rue du Can and Price (2008), based on the estimates of the IPCC Special Report on Emissions Scenarios (SRES). At the beginning of their paper, p 1386, de la Rue du Can and Price explain 'We distinguish between final and primary energy consumption. Final energy consumption represents the direct amount of energy consumed by [the] end user, while primary energy consumption includes final consumption plus the energy that was necessary to produce secondary energy, such as energy transformation losses. An alternative designation to primary energy consumption is the term source energy consumption as opposed to site energy consumption that refers to final consumption'. The energy data are presented in EJ per annum (EJ = exa-Joule = 10^{18} J). On p 1397 of the same paper, Fig. 11 shows the estimates of annual global primary energy to have risen from about 220 EJ in 1970 to about 400 EJ in 2000, having risen fairly steadily by 2.0% per annum. The projections to 2030 of two of the SRES scenarios, A1 (a 'baseline' scenario) and B2 (a 'mitigation' scenario), are shown. According to projection A1, the global primary energy will rise linearly from the 2000 value to 900 EJ per annum in 2030, that is, with an increase of 2.7% pa, and according to projection B2, the global primary energy will rise approximately linearly to 650 EJ per annum in 2030, that is, with an average increase of 1.6% pa.

Testing the Projections How have these projections fared in the light of knowledge of subsequent years? Global energy use for 2005 is reported on p 110 of Johansson et al. (2012). The corresponding figure (primary energy) is 496 EJ. This is slightly larger than the interpolated value, 483 EJ, of the worse scenario (A1). The less bad scenario (B2) was far from the mark, predicting only 442 EJ.

Average Global Energy Use per Person EJ per annum is hardly a unit of power congenial to all engineers, and the figures are more intuitive if expressed in GW (gigawatts), as in Table 7.1, since the electrical power output of a large power station is typically of this order. One EJ per annum is equal to a continuous power output, 32 GW.

'Population is forecast to grow by 34% in the A1 scenario and 37% in B2 scenario, lower than the 65% growth experienced during the past 30 years' (de la Rue du Can and Price 2008, pp 1395-1396). Using the figure of 6.1 billion for the global population in 2000 (United Nations Department of Economic and Social Affairs, Population Division 2004, p 4), we find the results in Table 7.1.

Following this summary of the global energy situation, aimed at reinforcing the proposition that profound change, for good or ill, is inevitable, I turn to the bathing-related aspects of energy.

Energy Use in the Water Sector In their Abstract, Rothausen and Conway (2011) state 'Energy use in the water sector is growing, yet its importance is under-recognized, and gaps remain in our knowledge'. On p 1 of the online PDF document, they say 'Water and energy are inextricably linked within what is often referred to as the water–energy nexus'. And on p 2 of the same document, 'in the UK the water industry uses around 3% of total national electricity consumption. Its energy use has

Table 7.1 Global energy use and population

Year	Global primary energy use (GW)	Population (billions)	Average continuous power per person (kW per person)
1970	7,000	3.7	1.9
2000	13,000	6.1	2.1
2030 (scenario A1)	29,000	8.2	3.5
2030 (scenario B2)	21,000	8.4	2.5

increased substantially over the past 20 years, with power costs making up 13% of total production costs and only 10% of power originating from renewable sources. Wastewater collection and treatment have caused the biggest increase as a result of higher standards for water quality and environmental regulation'. Concerning end use (mainly disposal), they say, on p 3, 'LCA [Life-cycle assessment] studies often fail to include end use because it occurs outside the water industry. Yet end-use processes often have the highest energy intensity of all water-sector elements and deserve far greater attention'. From these remarks, we may conclude that the embodied energy in the life cycle of potable water is a factor the environmentally conscientious citizen will want to be aware of. Related data, on greenhouse gas emissions, will be presented in the next subsection, CO_2e.

Heating the Water This is the principal and most obvious energy input in bathing. The starting temperature of the water is independent of the bathing methods. In the UK 'In summer the cold water mains temperature may reach as high as 20 °C whilst in winter the temperature may fall as low as 4 °C' (Zenex Energy undated). The annual average is about 12 °C.

$$\text{The direct energy needed to heat } 100\,\text{l of water by } 10\,°\text{C is } 1.17\,\text{kWh.} \tag{7.1}$$

In other words, this is energy embodied in the warm water; boiler and transmission losses would be accounted for separately as necessary. This conversion factor will be used frequently in the later discussions of Methods of Bathing. A local electric heater operates at virtually 100% efficiency, but for other arrangements, the efficiency of the heater and the plumbing, and a portion of the slug of cold water in the plumbing that may have to be wasted, should be allowed for, even if only by rough estimate.

The kind of domestic heating apparatus is often a given, decided by other factors than bathing, notably space heating. There are many systems – old non-condensing boiler (in which case the question of when it is desirable and possible to trade in for an efficient condensing type arises); condensing boiler (mandatory in the UK for new systems); wood or other biomass burner; electrical night storage; radiator, convector or underfloor heat distributors; and ventilation and heat recovery systems of various degrees of sophistication. Discussion of all this, as well as of insulation, is obviously fundamental in the search for a just and sustainable future for all, and the solutions depend strongly on many local climatic and cultural variables. It is a huge topic and lies beyond the scope of this chapter. One aspect concerning energy, including the embodied energy of equipment and repairs, does however relate strongly to bathing. I refer to maintaining, as well as possible, a suitable level of humidity.

Energy and Dampness Discussions of energy saving in relation to bathing almost always assume that the issue is one of water heating. Yet bathing creates dampness in the atmosphere. Some kinds of lengthy bathing with hot water (and occasional luxury is not being ruled out as part of a mindful totality) create a lot of dampness, as water vapour and as condensation.

Water Vapour For water at 40 °C, the heat of vaporisation is 2.40 kJ/g (Kaye and Laby 1973, p 225) or 0.67 kWh/l. Without moisture in the form of fine droplets, the humidity problem would be easily dealt with. At ambient temperature of 21 °C, the mass of water vapour in 1 m^3 of saturated air is 18 g (Kaye and Laby 1973, p 27), so the excess water if the normal relative humidity were 60% is 7 g. In a small bathroom, volume 10 m^3 (this figure is estimated to be typical in the UK; in other prosperous countries, bathrooms are usually bigger), the energy embodied in the excess vapour is 0.05 kWh. This shows that water vapour itself is not a major energy term, although it is important for health and for the longevity of buildings and fabrics, on which more later.

Condensation Only a small fraction of the dampness produced in bathing is water vapour. Presumably because the production of droplets and the condensation of water on cold surfaces are hard to quantify in a usefully realistic way, either by theory or experiments, they receive little attention compared with the great deal of attention accorded to embodied energy. A bather who is not energy conscious may produce a wet bathroom and a large amount of sopping towels. The towels might hold 1 kg of water (estimated by simulating profligate bathing and weighing the towels dry and wet). Drying these in a tumble drier uses 0.67 kWh. This is a large amount, equivalent to using an 8 kW electric shower for 5 min. And, as discussed in the following main section, the carbon dioxide emission per unit of energy is high for mains electricity. I estimate that a frugal user can – by using less water and a slightly lower temperature, spending a minute or so mopping up afterwards and drying self by shaking and rubbing the body using a small towel (washcloth sized) and finally a medium-sized towel – produce less dampness by an order of magnitude.

Condensation on the Bathroom Walls A small bathroom $2 \times 2 \times 2.5\ m^3$ has a total surface area of 28 m^2. If the average thickness of the condensation were 0.1 mm (a rough estimate taken by inspection following a typical shower in winter without fan extraction), the volume of condensation would be 2.8 l. The energy needed to evaporate this would be 1.9 kWh. In fact one does not, or should not, evaporate so much dampness in the dwelling but rather extract it.

Extracting Moisture The DIY World (undated) has useful advice about bathroom condensation and recommends an extractor fan sufficiently powerful to extract the moisture immediately from the air before it condenses on cold surfaces.

> Are you plagued by condensation in your home? By running a bath or by having a shower, the bathroom produces high levels of moisture in a very short period of time, which will quickly condense unless conditions are such so as to prevent it. To create an environment that prevents this from occurring, an extractor fan capable of extracting fifteen to twenty air changes per hour is essential (The DIY World undated).

(An air change is the extraction of a volume of air equal to the volume of the room.) The same source also makes the valid but rarely mentioned point that ‘Due to the potentially large volume of moisture that could be produced by any member of the family bathing or using the shower, consideration may not always be given to condensation as being a problem. For this reason, the bathroom can be a difficult room to control and it may be well worth considering a fan that is activated by the light switch, coupled with an 'overrun timer' facility, better still a humidity sensor'.

Energy Required to Heat Exchanged Air I find that in the (UK) winter, about three air changes are needed to clear dampness, that is, about 30 m^3 in the case of a small bathroom. (My studies have mainly been in Norwich, latitude 52° 37′ N, which is about an average latitude, weighted by population, for the UK.) The density of ambient air is 1.20 kg/m^3. Making a small correction for humidity and assuming for this purpose a relative humidity of 60%, one may find that, from data in National Physical Laboratory (undated, a), p 124 of Zemansky (1957) and section D p 180 of Weast (1975), the constant pressure specific heat capacity of the replacement air is 1.02 J/(g K). Then energy of 0.13 kWh is needed to warm, from 8 to 21 °C, the incoming air which replaces the extracted air. So the 'air exchange' contribution is relatively small, compared with heating the water and also compared with a lavish person's use of drying energy, but it is not negligible. It will be much smaller if there is a heat recovery system (heat exchanger between outgoing and incoming air) in place. Such a system is important because the whole of any habitable building needs heating and air changes.

Energy Used by Extractor Fan A fan I have used in two dwellings and is satisfactory has a power of 14.5 W, so the energy used is small: 15 minutes of use would take 0.004 kWh. A more powerful fan, such as what is recommended in The DIY World (undated), would run for a shorter time (unless inadvertently left running) and use about the same energy. With some fans, noise is an issue. A fast flow of air almost inevitably is noisy. A quiet fan – some are inaudible if positioned suitably – with humidity sensor is generally best.

Energy Recovery In an airtight building, that is, one in which the necessary air changes are nearly all controlled, so that windows are not generally opened and walls do not breathe, the issue of dampness from bathing (also from drying laundry) becomes especially important, particularly in a cool, damp climate such as the UK has. For energy efficiency such a building must have heat recovery ventilation. Also known as mechanical ventilation heat recovery, this system uses a heat exchanger between the inbound cold and outbound warm air, thereby warming the incoming air and saving some of the heat which would otherwise be lost. For more detail from a US perspective, see NAHB Research Center (undated).

Hairdryers The power is usually about 2 kW (on maximum setting) and drying last typically 10 min (my estimate of others' use). Assuming 5 min on full power and 5 min on low power (assumed to be about 1 kW) means 0.25 kWh of electricity, a significant amount in comparison with that needed for the washing itself.

Qualitative Summary

- Avoiding long bathing in general, reserving it as something special, helps to save vaporisation energy and air exchange energy as well as embodied energy.

- Water hotter than necessary produces much more moisture and has a high ecological cost.
- With careful bathroom design and bathing practice, the production of dampness and the difficulty of restoring a normal level of humidity can be minimised. This will increase the life of bathroom structure, fittings and decoration and preserve a healthy indoor environment. A quick wipe and wring on the wettest surfaces are easy and useful. The growth of mould is an important factor which depends strongly on the length of time that damp conditions prevail and can be avoided. Drying oneself can be done with a shake and wipe and wring with washcloth, followed by drying with a small towel. This sends most of the dampness straight down a plughole as water and leaves very little dampness to be evaporated.
- Wet rooms are ecologically a bad idea as well as dangerously slippery.

6.3 CO_2e

In order to compare the greenhouse contributions of various kinds of bathing, we need conversion factors from energy to CO_2e for the different kinds of domestic energy. This section presents a simple summary of those factors. Greenhouse gas (GHG) emissions are usually measured in terms of mass of carbon dioxide equivalent (kgCO_2e, or an SI multiple thereof), that is, of the mass of carbon dioxide (CO_2, nowadays often informally written as CO2) that would have the same greenhouse effect as the mixture of GHGs under consideration. CO_2 is the principal GHG on account of the huge mass of it emitted which more than compensates for the great potency per unit of mass of other GHGs.

Energy to CO_2e Conversion Factors I have taken the factors displayed in Table 7.2 from Defra/DECC (2012). The electricity figure is from Annex 3 and the others from Annex 1. In Annex 1 I have taken the figures for ‘Scope 3’, which include **‘**Indirect emissions associated with the extraction and transport of primary fuels as well as the refining, distribution, storage and retail of finished fuels. Emission factors are based on data from the JEC Well-To-Wheels study …’. I have also selected the ‘net CV [calorific value] basis’; ‘Gross CV or higher heating value (HHV) is the CV under laboratory conditions. Net CV or lower heating value (LHV) is the useful calorific value in typical real world conditions (e.g. boiler plant). The difference is essentially the latent heat of the water vapour produced (which can be recovered in laboratory conditions)’.

Table 7.2 Energy to CO_2e conversion factors

Energy source	Consumed electricity	Natural gas	Fuel oil	Coal (domestic)
Energy to CO_2e conversion factor (kgCO_2e/kWh)	0.59	0.23	0.34	0.41

Water-Related GHG Emissions Anglian Water (2012), the largest water and water recycling company in England and Wales by geographic area, states that its total (treated water plus wastewater) annual net emissions for 2011 were 1.23 gCO_2e/l. This is fairly small but still significant compared with the main contribution in bathing, namely the emissions cost of the energy needed to heat water. It is allowed for in the CO_2e column of the comparison table in Sect. 7.5.

7 Methods of Bathing

> The manner in which a civilization integrates bathing within its life, as well as the type of bathing it prefers, yields searching insight into the inner nature of the period. (Giedion 1948, p 628)

Human ideas and practices have varied remarkably over history, and the current ones will likely come to be seen, in historical perspective, to be radically mutable, the more so when we allow for the planetary ecological changes which are in train. In this section I will describe observations, experiences and ideas about the various kinds of bathing which are generally practised or can easily be tried out, in today's technical and cultural milieu. What may be possible in a conserver society is yet to be developed by society in general, with engineers playing a creative role.

7.1 Shower

I start my discussion of various methods of bathing with showering because it has been for some decades, in rich countries, the principal way of bathing. Already by the late 1990s in the USA, showers accounted for nine times as much as baths for the indoor water use in a typical single-family home (Alliance for Water Efficiency 2010). Advertising, sustainability campaigns and the combination of the two – most appropriately named in this context, greenwash – pay a great deal of attention to showering. But showers have not swept the board solely on the basis of advertising. Modern showers are convenient and pleasurable, and they can be economical. The potential for economy has however not been realised. The market for simple showers was showing signs of saturation a couple of decades ago in rich, westernised countries (earlier in North America), and showering has become profligate in water, energy and embodied materials (through persuading people that they need the latest equipment). This trend has been led by capitalism's unending need for new markets (Brown 2002). Advertising creates the desire for new products. 'Triton Power Showers mean no one need be without the forceful and invigorating experience of a high flow rate shower' and 'you can be sure that the power is a force to be reckoned with' and 'up to 14 litres of beautifully warm water per minute' (Triton undated). Alongside this kind of advertising copy, with its fantasies of limitless vigour, comfort and well-being, there is also publicity for eco-products and innovations, for example, in BBC News (2005), 'Eco-aware shower recycles water. A shower which recycles water promises to save householders money and energy … The system recirculates and cleans used water, with the potential to save families around £170 each year'. Overall, however, the 'eco' profile is swamped by the 'consume' one, and this has its effect on our desires and fantasies. There is relatively little detailed information available on efficiency and showers. One exception is the useful project report *Water and Energy Efficient Showers* by R. Critchley and D. Phipps, dated 2007, which is, as far as I know, unfortunately not in the public domain but may be requested from the copyright holders, United Utilities. I would extend to sustainable bathing in general the observation of Rothausen and Conway (2011), on p 2 of the online PDF version – 'The low recognition of the relationship between water and energy use is reflected in the lack of peer-reviewed publications on the subject. Our review shows the literature is dominated by government agency, private sector and non-governmental organization reports ('grey literature')'.

Examples of the effect this produces in society at large may be found in the book *Bathroom DIY* by Tommy Walsh (2004), who writes on p 50 'For me a proper powerful shower is an absolute necessity' and 'The whole principle of a shower is to wash you with pressurized water - this is what cleans and revitalises you' and on p 51 'There are some wonderful shower fittings which can give you that fabulous drenching shower'. This attitude to showering, or to bathing and cleansing, is however not inevitable. Indeed, it is entirely unsustainable and cannot last long. An attitude of peace, rest and relaxation has a great role in other cultures and other times and it could be so again, everywhere. In developing a typology of bathing, Giedion (1948) devotes a long section, pp 628–644, to *Types of Regeneration*. Following these remarks on showering in general, I will discuss a few features common to all technical designs and then discuss the principal designs themselves.

Water Temperature The temperature control of the mixer I use has, between its physical minimum and maximum rotation, a mark labelled MIN, a mark labelled 38 and a mark labelled MAX, which suggests that 38 °C is the recommended temperature. I find by measurement at the rose that the corresponding five temperatures are 17 °C (equal, in July, to the incoming mains temperature, so the mixer is taking no hot water), 29 °C, 35 °C, 40 °C and 43 °C. My own comfortable range for temperature at the rose is 35–38 °C.

Showering temperatures are significantly higher in the USA. It is stated in Rusty Bee (2011) that the average American adult takes a bath or shower at about 41 °C, the average bath or shower temperature should be around 40 °C, and anything over 46 °C can be dangerous.

Since the range of safe and comfortable temperature is narrow, it has little effect on the energy needed, but it is still important because even a small change of water temperature in this range has a big effect on the amount of dampness produced.

Electric showers usually have only flow and power controls. This makes it more difficult to find the correct temperature. Although it adds to the price, a proper temperature control is a desirable feature.

Time This is important because, if other factors are constant, the water and energy used are proportional to the time that the shower is on and the dampness produced is roughly proportional to time. Advice, from industry, government and NGO sources, used to recommend 5 min under the shower as enough, and now there is more talk of reducing from five to four. In recent years, 4-min hourglass shower timers have been available. See, for example, Save Water Save Money (undated) and Welsh Water (undated).

My own conclusions on showering duration are:

- Many people do indeed spend longer than the environmentally recommended amount of time under the shower, but this is hardly surprising in view of the great mismatch between our culture and what would be sustainable. According to Welsh Water (undated), 'In Wales most people spend around 10 minutes in the shower every day'.
- Many people with a 'hectic lifestyle' rush into and out of the shower, and indeed get from bed to work, very quickly.
- The time for showering can vary greatly. A thorough wash, including proper foot care and washing of long hair, might need 10 min (or less with a fast water flow).
- A quick rinse, with hair protected by a shower cap and minimal foot care and little or no soap, needs only a minute or two but is still effective if alternated with more thorough washes.
- A cold gentle shower in hot weather is wonderfully refreshing and makes all the difference between enjoying and suffering the heat. It takes only a minute and uses no energy and only a few litres of water. It is a continual astonishment to me that so many people suffer real discomfort and even threat to health in hot weather, but when this remedy is suggested, they cannot even engage with the idea. In very hot and humid weather, several such quick cool-offs are effective and still use little water.

Mixer Shower with Combi Boiler This is a common type in modern use as it combines the advantages of using cheaper fuel than electricity with the ability to offer a high flow rate. If it is a power shower, that is, it pumps the water through the rose, the flow rate can be higher again, up to 20 l/min or even more for multi-spray showers. Like other designs, the products available are subject to formal and informal industry norms. The industry claims that its norms reflect what the public wants, which is surely true, but omits to say that what the public wants is in part created by advertising aimed at creating new markets. The disadvantage of this design, or at least of the existing industry norms, from a serious sustainability point of view, is that 6 l/min is generally considered a minimum flow rate, although some equipment, including flow limiters, do specify a somewhat lower minimum flow rate.

Minimum Hot Water Flow Rate of Combi Boiler and Implication for Shower The gas combi boiler I use cuts out if the flow at the kitchen hot tap is less than 1.3 l/min and is definitely above the cut-in/cut-out point with a flow rate of 1.7 l/min. The shower needs a greater flow, because the shower mixes cold and hot water to achieve the desired comfortable and safe showering temperature. This flow is greater in summer, when the cold water is less cold. For an approximation to the temperature of the hot supply to the mixer, I assume a temperature equal to that of the bathroom basin hot supply, which is 54 °C. Likewise the basin cold tap delivered at 21 °C (this was in May, so the water presumably reached house temperature through the plumbing). The shower spray exit temperature I measured to be 38 °C. Consequently, the mixer delivers 2.5 l/min if the combi is just above cut-out and 3.3 l/min if the combi is safely above cut-out. These results agree with measurements of the actual flow rate. In fact I set the flow at a little more than 3.3 l/min because the cold water supply is not good and can be affected by other users.

It is understandable that the industry should choose a normal minimum flow rate conservatively in order to accommodate numerous manufacturers and to avoid risk. Nevertheless, some mixers and flow limiters do refer to *maximum* values of 6 l/min. I would recommend cautious experimentation by users with reducing flow rates. It is not wise to operate regularly close to the limit where the combi will cut out, both for comfort and for longevity of the combi.

Mixer Shower with Hot Water Tank This system has the disadvantage of heat loss from the permanently hot water in the tank, but it has the advantage that hot water may be taken as slowly as one wishes. A notable example of a low-flow mixer shower of which I had experience had the unusually low mixed water flow rate of 1.7 l/min. This was because its rose was clogged with limescale. The owner was happy with it, probably because the flow had diminished gradually. It was gentle and relaxing and I liked it too. Later the flow became too low and the rose was cleaned, and the flow returned to its design value which was higher but still gentle and economical.

Electric Shower Electricity has, as noted in the 'Energy' subsection, a high energy to CO_2e conversion factor. (This factor will come down, relative to other sources of energy, if in the future more electricity is generated from renewable sources.) In any case, electric showers have some compensating advantages. Even apart from the argument for continuing to use good equipment rather than change before its end of life, there can be a case for installing a new electric shower. In the first place, an electric shower is virtually 100% energy efficient. Almost all the energy is turned into heat delivered at the shower rose. There are no burner or flue losses and virtually no transmission losses. (In effect, all of these occur before the energy is delivered at the household, which partly accounts for the high energy to CO_2e conversion factor.) The second advantage for the energy-conscious bather is exactly the reason why the profligate user dislikes electric showers – sometimes passionately, as Walsh (2004) probably does, judging from the quotation earlier in this subsection. For whilst a combi-heated shower cannot run very slowly, an electric shower cannot produce heat at a great rate, and in late winter and early spring, when the incoming mains water is cold, this limits the flow rate for an acceptable warmth of water. The upper limit of power of an electric shower is limited by wiring and safety standards, and the power available in the UK is in the range of 7.5–10.8 kW with the higher powers heavily promoted and 7.5 kW showers now having very little profile. I used a 7.5 kW electric shower for many years. I did find it adequate in cold weather, but it did take some experience to use it correctly, mainly because of the heat capacity of the water in the shower's heating tank, which meant that one had to make flow adjustments slightly and wait to see it if was right.

The relation between flow rate and power is simple:

$$\begin{aligned}&\text{Flow rate / l per min}\\&=14.3\times\left(\text{power / kW}\right)/\left(\text{temperature increase / °C}\right)\end{aligned} \tag{7.2}$$

and a graph of this relationship may be found on p 8 of Mira (2006). As noted in the subsection on Energy, Zenex Energy (undated) states that 'in winter the [incoming mains water] temperature may fall as low as 4 °C'. I believe this is an extreme. I have lived several decades in East Anglia and I believe that the incoming mains water has never been that cold. Nevertheless, accepting this worst case and the standard temperature of 38 °C for the warmed water and power of 7.5 kW, one finds the flow rate to be 3.2 l/min. This will clearly give an economical shower. The canonical 5 min would use 16 l of water and 0.63 kWh of electrical energy. Is it acceptable? Certainly it does require an adequately heated bathroom for comfort. Beyond that, there is no objective answer to the question. It depends on the person. Those, however, who answer with an emphatic 'no' and use a power shower at 16 l/min should be confronted with the larger implications of their lifestyle.

The electric shower I used had a medium power setting which I measured to be approximately 4.5 kW. I was able, due to the warmer incoming water, to use the shower on the medium power setting from sometime in May to mid-November. Through the year the flow when I showered was about 4 l/min in cold weather, 5 l/min in cool weather with power = maximum and about 2.6 l/min in mild weather with power = medium. The temperature rise versus flow rate graph (for 7.5 kW) shown in Mira (2006) covers flow rates from 2 to 11 l/min. I think that 2 l/min is indeed a lowest flow rate for a 7.5 kW electric shower, for reasons of safety. At lower flow rates, a small reduction of flow rate could lead to a dangerous increase of water temperature. On medium power, 4.5 kW, a lower flow rate could be used. One can understand, within the currently dominant culture, why electric showers are disliked by many and also why the trend with electric showers is to ever higher powers, the flow for a given temperature rise being proportional to the power. Still, the ecological issue will not go away and a change to sustainable values is literally vital.

7.2 Bath

The mantra 'take a shower instead of a bath', endlessly repeated over many years and continued still (e.g. see Royal Borough of Kensington and Chelsea 2012), is misleading in three ways: (1) shower and bath are not equivalents, (2) it leaves 'basin/bowl' unspoken and (3) many people now take a daily shower, whereas few (other than children) take a daily bath. In Sect. 7.3 I will return to point (2) and in Sect. 7.4 I will return to point (3). Concerning (1), a bath is not an alternative to a shower. It is not as effective for getting clean as a shower, but it is good for relaxation and pleasure. Excepting the small children's evening bath routine, which is practical (small children do not like showers), relaxing and fun for all, a bath is a luxury, to be taken occasionally, when one is already sufficiently clean, perhaps with candlelight, possibly with just one alcoholic drink to hand, possibly with perfume and a partner.

Volume of Water The canonical value, given in many places – for example, Anglian Water (undated) – representing an average for the UK, is 80 l, and I have confirmed that this is about right. In addition, one can have a decent bath with somewhat less water and two can have a generous bath with the same amount.

Water Temperature A bath thermometer has marks 'warm' at 37 °C and 'hot' at 41 °C, which is indeed the comfortable range. 'Warm' is better for the skin and in addition produces significantly less dampness. Note however that this range does not apply to babies; Babycentre (undated) states that 37 °C is the safe maximum for them.

Energy Assuming that 80 l of water is used altogether; that the incoming mains water is at the annual average temperature (12 °C); that the initial temperature is 37 °C, but subsequent topping up with hot makes the average 38 °C; that the boiler (of condensing type) is 90% efficient; and that 5% of the energy is lost in transmission from boiler to bath (an estimate), one finds that the energy needed is 2.8 kWh. I have experimented with keeping the clean warm water in the bath for a second use the next day. The temperature falls to the interior house temperature after 24 h. On one occasion that was 19 °C (usually it would be rather warmer than this), and the embodied bath energy recovered as space heating was 73% of the original. I took a quick cool bath (the water was quite clean), and it was refreshing and nothing like the shock of a cold (mains water temperature of 12 °C) bath. Rather it was more like a quick dip in a heated swimming pool. Thus, a warm bath one morning and a cool one the next make an energy and water efficient, interesting and pleasurable combination. One gets two baths for 80 l of water and only 0.75 kWh of energy. This might however not always be compatible with general household activities and other users, and it is not recommended during damp weather.

Time and Safety When the bath is prepared, the energy and water have been taken. Then it is the bather's turn to make the most of it. Enjoy a nice long soak, for which the lower end of the quoted temperature range is better for the skin, with an occasional top-up of hot water. A couple of safety points: by all means take a bath for regeneration (that is what it is for) but not if you are dog-tired; a small amount of alcohol may be nice but a large amount is not a good idea.

7.3 Basin/Bowl

A second reason why the mantra 'take a shower instead of a bath' is misleading is that it leaves 'basin/bowl' unspoken. This method of washing would appear, from the mass media (in which I include marketing and advertising) and public discourse, to be a thing of the past, to the point that it does not even reach consciousness, except as history. My studies and conversations with many people reveal that, for a remarkable number of older and not so very old people, a basin wash still is a part of their bathing pattern. From conversations and a lot of personal experimentation with different kinds of bathing, I find that a basin wash has a number of advantages, quite apart from being economical with water and energy. It is flexible, in that one can have an all-over wash, a partial wash or just a quick wipe according to need. It is quick. Foot care can be done with a little water in a light plastic bowl on the ground. One can sit down and safely wash one's feet, including the gentle regular use of a corn-and-callus file. I have also discovered that I am not the only person of a certain age who does not need the bowl because I can, comfortably and safely, put my leg over the edge of the basin to wash my feet. In fact doing so regularly has improved my balance and flexibility. Do not, of course, do this if you are not confident that you are comfortable and safe and have a suitable balancing support at hand.

Water Temperature The mixed cold and hot water has to start a little hotter than for a shower or bath, at about 41 °C, because heat is soon transferred to the basin, bringing the temperature down to a safe and comfortable 38 °C. In winter, even this heat is not wasted as it contributes to space heating. As for the slug of cold water in the hot water plumbing, some or all of it may be used so that the final temperature is as desired. If the pipe from the boiler is long, excess cold can be saved in a jug for second or third mixes. In the case of a very long slug, boiling water in a kettle and taking it to the bathroom might be acceptable to some, but there is a safety issue so it is unlikely to be widely used.

Water I find that a good hygienic wash and rinse can be had with three lots of water, four plus two plus two litres, that is, eight litres altogether. Numbers and methods, as with the other means of washing, can, however, vary greatly. Bathing is a varied, personal matter, even within the current times and within westernised prosperous societies.

Energy Assuming an efficient (90%) boiler and a loss of 5% in the plumbing (an estimate and separate from the 'cold slug' effect), 8 l volume of water and temperature raised from an average incoming mains temperature of 12 °C to 41 °C, one finds that the energy needed is 0.32 kWh.

7.4 *Camping*

I have for about 7 years taken an interest in bathing at camp – not usually at the pre-established permanent campsites with all mod cons but at alternative camps designed to have a low environmental impact or protest camps set up without conventional authority. A huge range of types of keeping clean is possible, adapted to a wide range of situations. A few of the many things I learned from these experiences are:

- Young people, including dedicated environmental activists, equate bathing with showering. One year we had a quite extensive showering facility, courtesy of a plumber who brought a large, used solar water-heating system. The next year we did not have it and I, with the help of others, set up what I still believe was a very nice facility – screened al fresco communal basin washing areas (M and F separate). It was popular with many, and when the sun came out, a jolly time was had. But if the area was empty, there were young people who would enter, look at the bowls with an exaggeratedly louche expression and depart. From various conversations I am sure that many genuinely did not know what to do, although all facilities were available. So much has showering become the way of bathing that despite my promotion of the concept of eco-bathing, I could not shake off the unwanted sobriquet Mr. Shower.

- Bag showers (flattish black plastic bags, fillable with 20 l of water but best only half filled, laid in the sun to heat the water, with a hose, tap and rose) rarely work in the UK climate. They have other drawbacks – all of the models I have used are badly constructed; a simple hoisting tackle is likely to tangle in the wind; users tend to use the tackle incorrectly.
- Flower showers work well. These, as the name indicates, are designed for plant watering or spraying, but they work well as camp showers if users accept a low flow rate. One must not, of course, use one that has ever contained any fluid other than clean water. They hold 5 l of water and there is an easy-to-use pressurising pump. If a modest amount of hot water is available, a comfortable shower can be had. The maximum flow rate is 2 l/min and there is a trigger so that a good wet, soap and rinse shower can be spread over 5 min. The filling temperature can be got right with only one or two trials, and it is not nearly as critical as with fast-flow showers or a bath. If the water is too hot, just hold the rose a little further away from yourself.
- Plastic bottle showers are a neat example of minimal engineering and they work. With nail, hammer and block of wood, punch holes in the cap of a clean used 2 l drink bottle. Use one of the holes to tie the cap to the bottle neck, so it does not get lost. Fill with warm water and replace the cap. To promote the flow, shake the inverted bottle over yourself. When you want the flow to cease, stop shaking and atmospheric pressure does the rest. Even better are clean used plastic milk or juice bottles as they can be somewhat bigger and have an easy-grip handle. An even more simple version comes ready made – a few of those smaller drink bottles with a blue cap that looks like a teat.
- Bottle shower as a toy: A small version of the bottle shower, made from a one pint clean, used plastic milk bottle, is a good toy for children, in the domestic (bath or outside in hot weather) situation as well as the camping situation. Young and old can learn much from this simple example, which undercuts the idea that the good life and gross domestic product (GDP) go together. The engineer can also learn from thinking about the extreme simplicity of such a device and the technologies appropriate for a future different from the past but not necessarily worse.
- In a temporary camp, disposal of grey water is an issue and is a strong reason for bathing with a small amount of water.

7.5 Comparing Methods

> Consumer needs are no less real for having a history, no less deeply felt for having been part of the world that global capitalism and colonialism have made. Needs, once made, do not casually go away and cannot be legislated or ordered out of existence. Their making and unmaking is beyond the capacity of any one institution or power. (Burke 1996, p 216)

Let us start this section by returning to the mantra 'take a shower instead of a bath'. The third way in which it is problematic is the assumption that everyone, in the prosperous westernised countries, takes a daily shower, whereas there are few who, now or in the past, have been able to take a daily bath.

The Energy Saving Trust (2014) has recently published its report 'At Home with Water' on the results of voluntary responses to a questionnaire. 'Launched in 2010, the Water Energy Calculator is an online self-completion tool that takes respondents through a series of questions about their household water consumption habits' (p 7). The analysis finds (p 18) that 'On average, respondents reported that each person takes 4.4 showers and 1.3 baths each week'. Of course, quite apart from the voluntary self-reporting bias, these numbers conceal substantial variation within the sample. I find from many conversations and general discourse and observation that, nowadays, taking a bath is predominately done by those who are elderly, are very young or in other ways have special needs. For the rest of the population, domestic bathing has *become* showering – alternatives are hardly thinkable, or at least at the margin. Virginia Smith (2007, p 330) in her scholarly history 'Clean' goes so far as to say 'The history of twentieth-century personal hygiene could easily be written as the rise of the cheap and convenient domestic shower …'.

Yet the true comparison, for those wishing not to contribute to an environmental perfect storm, is between shower, bath, basin and any other methods that changed environmental and social conditions may bring into play.

Comparison Table Table 7.3 gives approximate numerical values of energy use and CO_2e emissions for the main kinds of bathing. The season is winter with incoming mains water temperature of 8 °C assumed. The CO_2e figure includes the contributions from the energy utility and, at the rate of 1.23 gCO_2e/l, from the water utility. The production of dampness with the need to extract it is important but hard to quantify and has simply been noted qualitatively in the last column. The embodied energy, and attendant CO_2e, in the production, maintenance, disposal and replacement or upgrading of equipment, is also an important term which cannot be quantified.

Comments on This Table and the Earlier Discussions

- The current popularity of fast-flow showers is ecologically very harmful.
- One can learn to appreciate the gentle sensation of a low-flow shower.
- A basin (possibly plus bowl) wash is ecologically much more benign.
- A bath is a special occasion.
- Moisture and how to minimise its production and extract it effectively are important considerations.

Table 7.3 Comparison of bathing methods, using expressions [7.1] and [7.2] and Table 7.2

Bathing method	Water heating	Final mixed temp (°C)	Water used (l)	Direct energy (kWh)	CO_2e emission (kg)	Notes
Basin/bowl	Gas combi	41	8	0.36	0.09	Very little dampness
Shower (modest)	Electric 7.5 kW	38	20 (5 min × 4 l/min)	0.70	0.43	Moderate dampness
Shower (modest)	Gas combi	38	20 (5 min × 4 l/min)	0.82	0.21	Moderate dampness
Shower (lavish)	Gas combi	41	160 (10 min × 16 l/min)	7.23	1.87	Much dampness
Bath (economical)	Gas combi	37	60	2.38	0.62	Little dampness
Bath (normal)	Gas combi	38	80	3.28	0.85	Little dampness
Bath (lavish)	Gas combi	41	90	4.06	1.04	Moderate dampness

- If the energy supply is oil rather than gas, the CO_2e emissions are greater by a little over 40%.
- Ringing the changes, always mindfully, between basin, shower and occasional bath is hygienic and pleasurable.

8 Context Revisited

> Utopias never, as their authors usually hope, remake society in their own image. Instead, elements of the utopia are gradually assimilated by the outside world, altering it in subtle but sometimes profound ways … Utopias are realized piecemeal, but realized they frequently are. (Neville-Sington and Sington 1993, p 255)

Profound change is indeed needed but, as the above quotation indicates, it will not come quickly or easily. This study is not meant to be an addition to the great pile of advice that can appear to hold the isolated individual responsible for what is happening but rather an invitation to practise and reflect – to explore what may be possible in a future when a total rejection of the current profligacy becomes the norm. Humanity's millennia-old ascent to domination has been achieved, and now the wisdom of the adage *be careful what you wish for* is becoming clearer. Attitudes change all the time, often in surprising ways. Overarching norms, such as attitudes to authority and to what is good, change. Attitudes to practical matters also change. Attitudes to bathing change over decades, centuries and millennia and by no means smoothly in the direction 'dirty to clean to cleaner'. Our present practices could be described as the dirtiest ever, in that we are befouling the only home we have.

I hope that these remarks and the preceding notes show that, with a radical change of economic ideas (household management that is simultaneously grand and modest) and with some simple (appropriate technology) developments of equipment, effective and pleasurable bathing is possible using resources at a level far below what is the norm today.

Reductions in the current increases of resource use are not enough; modest reductions in the absolute levels of consumption by the prosperous are not enough. A radical change of values, which becomes a norm for the times, and not a fringe attitude, is the essential requirement. In an aphorism which has been expressed in various ways – some actually traceable to Einstein (undated) and some attributed to him – *a deep problem cannot be solved by using the thinking that has created it*. Various measures – such as using resources more sparingly, generating energy renewably, recycling, reusing and repairing – are important elements of the new world and of the way towards it. Engineers concerned about the current ecological state of the planet will find many interesting and valuable applications of their ingenuity and art. Yet, still we need to return to the most important practical thing that all, including engineers, need to be doing forthwith which is to consciously engage with the reality of the current human effects on the planet's ecology. It is to admit to and reject what Norgaard (2011) has identified and described in fieldwork as living in denial. Many engineers, among others, in history have thought ahead of their time. So it is that, in this Anthropocene epoch, *creativity* of engineers, among others, is called for – to work *with* the rest of nature towards a sustainable and beautiful twenty-first century.

References

Allen E (1976) Wash and brush up. Black, London

Alliance for Water Efficiency (2010) Residential shower and bath introduction. www.allianceforwaterefficiency.org/Residential_Shower_Introduction.aspx. Accessed 22 Jan 2015

Anglian Water (2012) Greenhouse gas emissions report 2011. www.anglianwater.co.uk/_assets/media/greenhouse-gas-emissions-annual-report2011.pdf. Accessed 22 Jan 2015

Anglian Water (undated) Welcome to your home. http://www.anglianwater.co.uk/_assets/media/Drop20_KS2_activity5_30_05_12_FINAL.pdf. Accessed 22 Jan 2015

Aschenburg K (2007) The dirt on clean: an unsanitized history. North Point, New York

Babycentre (undated) Bathing your baby safely. http://www.babycentre.co.uk/a40/bathing-your-baby-safely. Accessed 22 Jan 2015

Barber BR (2008) Con$Umed: how markets corrupt children, infantilize adults, and swallow citizens whole. Norton, New York

BBC News (2005) Eco-aware shower recycles water. http://news.bbc.co.uk/1/hi/technology/4219890.stm. Accessed 22 Jan 2015

Beddington J (2009) The perfect storm. http://webarchive.nationalarchives.gov.uk/20121212135622/ http://www.bis.gov.uk/assets/goscience/docs/p/perfect-storm-paper.pdf. Accessed 22 Jan 2015

Bennett C (2008) Greening your home. McGraw-Hill, New York

Brown D (2002) Insatiable is not sustainable. Praeger, Westport

Burke T (1996) Lifebuoy men, Lux women: commodification, consumption and cleanliness in modern Zimbabwe. Leicester University Press, Leicester
CEIR (undated) The European water label. www.europeanwaterlabel.eu/. Accessed 22 Jan 2015
Chamberlin S (2008) The climate science translation guide. www.darkoptimism.org/2008/09/03/the-climate-science-translation-guide/. Accessed 22 Jan 2015
Chew SC (2001) World ecological degradation. Altamira, Walnut Creek
Cottey A (2008) The CO2 and H2O costs of bathing. SGR Newsletter, Issue 35, pp 13–13. (This issue of the SGR Newsletter may also be downloaded from www.sgr.org.uk/publications/sgr-newsletter-no-35. Accessed 22 Jan 2015)
Cottey A (2012) Clean people in a clean world. Policy Futures Educ 10(3):362–365
Cottey A (undated) Asset and income limits. www.uea.ac.uk/~c013/v2/ail/ail.xhtml. Accessed 22 Jan 2015
Craig PP, Jungerman JA (1986) Nuclear arms race: technology and society. McGraw-Hill, New York
Crookes R (2007) Obituary: Professor Meredith Thring 1915–2006. www.combustion.org.uk/newsletter/newslettermar07/thring.html. Accessed 22 Jan 2015
Dhanda P (2011) Easy tips to help your dry skin. http://www.drpauladhanda.com/5-easy-tips-to-help-your-dry-skin. Accessed 22 Jan 2015
Defra/DECC (2012) Guidelines to Defra/DECC's GHG conversion factors for company reporting (2012), produced by AEA [UK atomic energy authority] for the department of energy and climate change (DECC) and the department for environment, food and rural affairs (Defra). www.defra.gov.uk/publications/files/pb13773-ghg-conversion-factors-2012.pdf. Accessed 22 Jan 2015
de la Rue du Can S, Price L (2008) Sectoral trends in global energy use and greenhouse gas emissions. Energy Policy 36(4):1386-1403. Also at www.sciencedirect.com/science/article/pii/S0301421507005502. Accessed 22 Jan 2015
Diamond J (2011) Collapse: how societies choose to fail or survive, revised edn. Penguin, London
Dickens C (1859) A tale of two cities. www.gutenberg.org/ebooks/98. Accessed 22 Jan 2015 (This volume is readily available also in many print editions, for example, 2007, Penguin, London)
Edwards M, Timberlake L, Dylan B (2006) Hard rain: our headlong collision with nature. Still Pictures Moving Words, London
Einstein A (undated) Wikiquotes - Einstein. http://en.wikiquote.org/wiki/Einstein. Accessed 22 Jan 2015
Energy Saving Trust (2014) At home with water. http://www.energysavingtrust.org.uk/reports/home-water. Accessed 22 Jan 2015
Faxon AC (1998) Bath/bathing. In: Roberts HE (ed) Encyclopedia of comparative iconography: themes depicted in works of art. Fitzroy Dearborn, Chicago, pp 110–115
Fitzgerald F (2006) Obituary - Meredith Thring, early advocate of sustainable energy programmes. www.guardian.co.uk/obituaries/story/0,,1944163,00.html. Accessed 22 Jan 2015
Forbes P (2008) Self-cleaning materials. Sci Am 299(2):68–75
Friendly Traveller (1775) The ensign of peace. Shewing, how the health, both of body and mind, may be preserved, and even revived by the mild and attenuating power of a most valuable and cheap medicine. Wilkie, London. Facsimile reprint-to-order edition by Gale ECCO print editions; for suppliers, see amazon.co.uk or amazon.com
Giedion S (1948) Mechanization takes command: a contribution to anonymous history. Oxford University Press, Oxford
Johansson TB et al (2012) Global energy assessment (GEA). Cambridge University Press, Cambridge
Kaye GWC, Laby TH (1973) Tables of physical and chemical constants, 14th edn. Longman, London
Llewellyn C (2002) Your hair. Franklin-Watts, London
Locke J (1690) Second treatise of government. Project Gutenberg. www.gutenberg.org/ebooks/7370. Accessed 22 Jan 2015

Lower S (2011) Hard water and water softening. www.chem1.com/CQ/hardwater.html. Accessed 22 Jan 2015
Lupton E, Miller JA (1992) The bathroom the kitchen and the aesthetics of waste: a process of elimination. MIT List Visual Arts Center, Cambridge, MA
Macpherson CB (1962) The political theory of possessive individualism. Oxford University Press, Oxford
Maxwell N (2007) From knowledge to wisdom: a revolution for science and the humanities, 2nd edn. Pentire, London
McEwan I (2005) Saturday. Jonathan Cape, London
Media Lens (undated) Media Lens. www.medialens.org/. Accessed 22 Jan 2015
Mira (2006) Mira Zest electric shower: installation and user guide. www.mirashowers.com/onlin-ecatalog/pdf/1057732_w2_a.pdf. Accessed 22 Jan 2015
NAHB Research Center (undated) Energy and heat recovery ventilators. www.toolbase.org/TechInventory/techDetails.aspx?ContentDetailID=748. Accessed 22 Jan 2015
National Physical Laboratory (undated, a) Kaye and Laby tables of physical & chemical constants. www.kayelaby.npl.co.uk/units_and_fundamental_constants/1_1/1_1_3.html. Accessed 22 Jan 2015
National Physical Laboratory (undated, b) Kaye and Laby tables of physical & chemical constants. www.kayelaby.npl.co.uk/general_physics/2_3/2_3_6.html. Accessed 22 Jan 2015
Neville-Sington P, Sington D (1993) Paradise dreamed: how utopian thinkers have changed the modern world. Bloomsbury, London
Norgaard KM (2011) Living in denial: climate change, emotions, and everyday life. MIT Press, Cambridge, MA
O'Reilly T (2003) Open source paradigm shift. http://oreilly.com/tim/articles/paradigmshift_0504.html. Accessed 22 Jan 2015
Pizzigati S (2004) Greed and good: understanding and overcoming the inequality that limits our lives. Apex, New York
Ponting C (2007) A new green history of the world: the environment and the collapse of great civilisations, revised edn. Vintage, London
Practical Action (undated, a) Practical action: water and sanitation. http://practicalaction.org/water-and-sanitation-14. Accessed 22 Jan 2015
Practical Action (undated, b) Practical action: water and sanitation documents. http://practicalaction.org/document-library-11. Accessed 22 Jan 2015
Raghavan B, Ma J (2011) The energy and emergy of the internet. www1.icsi.berkeley.edu/~barath/papers/emergy-hotnets11.pdf. Accessed 22 Jan 2015
Rothausen SGSA, Conway D (2011) Greenhouse-gas emissions from energy use in the water sector. Nat Clim Chang 1(4):210–219. Also online doi:10.1038/NCLIMATE1147
Royal Borough of Kensington and Chelsea (2012) Saving water. www.rbkc.gov.uk/environmentandtransport/domesticrecyclingandrubbish/savingwater.aspx. Accessed 22 Jan 2015
Rusty Bee (2011) What is the best temperature for a bath or shower? http://www.http://rustybee.com/what-is-the-best-temperature-for-a-bath-or-shower. Accessed 22 Jan 2015
Savewatersavemoney (undated) Shower timers. www.savewatersavemoney.co.uk/s/shower-timer. Accessed 22 Jan 2015
Scott GR (1939) The story of baths and bathing. Laurie, London
Shostak AB (2003) Viable utopian ideas: shaping a better world. Sharpe, Armonk
Slavin S, Petzke K (1997) The art of the bath. Chronicle Books, San Francisco
Smith V (2007) Clean: a history of personal hygiene and purity. Oxford University Press, Oxford
The DIY world (undated) The bathroom. www.thediyworld.co.uk/the_bathroom.html. Accessed 22 Jan 2015
The Water Label Company (undated) Water label. www.water-efficiencylabel.org.uk/home.asp. Accessed 22 Jan 2015
Thring MW (1980) The engineer's conscience. M W Thring, Brandish
Thring MW, Blake A (1973) Man, machines and tomorrow. Routledge and Kegan Paul, London

Trainer T (1995) The conserver society: alternatives for sustainability. Zed Books, London
Triton (undated) Power showers. www.tritonshowers.co.uk/media/324930/consumer_power_showers.pdf. Accessed 22 Jan 2015
United Nations Department of Economic and Social Affairs, Population Division (2004) World population to 2300. www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf. Accessed 22 Jan 2015
United States Census Bureau (2006) US Population Reaches 300 million. http://www.census.gov/main/.in/php_module/lightbox/media.php?I_5169a2c933e2c239c8216f15a2065d8a. Accessed 22 Jan 2015
Walsh T (2004) Bathroom DIY. Collins, London
Weast RC (1975) Handbook of chemistry and physics, 56th edn. CRC Press, Cleveland
Welsh Water (undated) Can you shower in 4 minutes? www.dwrcymru.com/4minuteshower/index.asp. Accessed 22 Jan 2015
Witberg A, Field A (2000) Clean and serene: meditations for the bath. Melcher Media, London
Woodburn K, MacKenzie A (2004) Too posh to wash. Michael Joseph, London
World Meteorological Organization (2013) The global climate 2001–2010: a decade of climate extremes. http://library.wmo.int/opac/index.php?lvl=notice_display&id=15110. Accessed 22 Jan 2015
Wright L (1960) Clean and decent: the fascinating history of the bathroom and the water closet and of sundry habits, fashions and accessories of the toilet principally in Great Britain, France, and America. RKP, London
Yardley T (1990) Down the plughole: explore your plumbing. Cassell, London
Zemansky MW (1957) Heat and thermodynamics, 4th edn. McGraw-Hill, New York
Zenex energy (undated) GasSaver. www.zenexenergy.co.uk/Zenex1/index.php?option=com_content&view=article&id=9&Itemid=5. Accessed 22 Jan 2015

Part IV
Ethical Engineering and International Security

Chapter 8
Engineering Ethics Problems in a Developing Country

Jozef Bohdan Lewoc, Antoni Izworski, Slawomir Feliks Skowronski, Antonina Kieleczawa, Marion Hersh, and Iwona Chomiak-Orsa

Acronyms

ABB	Asea Brown Boveri
CIMMs	Computer-integrated manufacturing and management system
IASE	Institute for Power System Automation
KWP	Switched measurement display (komutowany wyświetlacz pomiarów)
MSK	Interuniversity computer network (miedzyuczelniana siec komputerowa)
PGUM	Power-generating unit monitor
PoP	Power of people
ProSter	For control (pro sterowanie)

J.B. Lewoc (✉)
BPBIT Leader LLC, Newark, DE, USA
e-mail: leader@provider.pl

A. Izworski
Electronic Department, Wroclaw University of Technology, Wroclaw, Poland

S.F. Skowronski
Informatics and Management Department,
Wroclaw University of Technology, Wroclaw, Poland

A. Kieleczawa
Institute for Power System Automation IASE, Wroclaw, Poland

M. Hersh
School of Engineering, Biomedical Engineering, University of Glasgow,
Rankine Building, Glasgow, Scotland

I. Chomiak-Orsa
Management, Informatics and Finance Department,
Wroclaw University of Economics, Wroclaw, Poland

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SAPI ODMs	Regional power control centre automatic data processing systems (systemy automatycznego przetwarzania informacji okręgowych dyspozycji mocy)
SOSAPI	Operating system for automatic data processing system (system operacyjny systemu automatycznego przetwarzania informacji)
SVDU	Semigraphic visual display unit
SWIIS	Supplemental Ways for Improving International Stability
TECIS	Technology, Culture and International Stability
WPR	Who has got power is right

Overview

The paper draws on case studies of the experiences of successful leading designers in the areas of hardware, software, applications and research to discuss ethical issues related to working in the ICT and automation industry in Poland. The situation both before and after the political and economic changes in 1989 is considered, with developments in the subsequent period based almost exclusively on technology transfer. A number of ethical theories are applied to analyse the action of leading designers, large corporations post-1989 and the authorities in the state-owned firm Elwro pre-1989. Similarities and differences in the experiences of leading designers in the two periods are noted, and various suggestions for surviving while behaving ethically are made.

1 Introduction

The conditions in industry in Poland after World War II were largely determined by the political conditions of the time. Poland belonged to the Communist Bloc and the industrialised countries of the West restricted access to many modern industrial products through the use of embargoes. Therefore, new industrial products in Poland had to be developed there rather than purchased from the industrialised countries of the West. In theory, there were no such barriers in the internal markets of the COMECON (Council for Mutual Economic Assistance) countries. However, in practice, a similar embargo policy was in operation in COMECON as well, and relatively few interesting modern industrial products were available there.

Almost all modern automation and information and communication technology (ICT) products were restricted by various embargoes, both official, for instance, for modern computers, and unofficial, for instance, for up-to-date technical information. Therefore, domestic ICT education and industrial centres were developed in the 1950s. Elwro, the first Polish computer manufacturer, played a major role in the Polish ICT industry and designed, manufactured and implemented most of the domestic ICT equipment in Poland. Ethical issues related to the activities of Elwro are therefore characteristic of the ICT industry in Poland as a whole and are relatively easy to observe in the large scope of Elwro's activities. In addition, Poland provides a good example of ethical issues in the ICT industry in former communist countries due to the relative strength of this industry in Poland compared to other COMECON countries during the communist era.

It will be assumed in this chapter that the actual political system in Poland during this period can be characterised as WPR (who has got power is right), leading to very arbitrary decisions and acts. This system was introduced into Poland together with the Red Army from the Soviet Union at the end of World War II. It was based on the misrepresentation that the system operated for the benefit of the people, whereas in practice, it operated for the benefit of power structures and elites. Before the war, Poland was a democratic country (by the standards of the time). The WPR system was introduced into the political and economic systems. As a result, important decisions were taken in the interests of power structures rather than the people. The situation was similar at lower levels of the hierarchy, for instance, in industry and agriculture. The WPR system acted everywhere for the benefit of the power structure and associated elites, and its actions were considered to be correct, regardless of how they would be considered from a more objective perspective.

The WPR system made use of the so-called power of people (PoP) teams to support it in ruling the country. A PoP team is a fuzzily defined set of people, in charge of a particular area or domain of activity. The concept was introduced by the WPR system to give the impression that it was the people who ruled the country. However, in reality, almost all power was held by PoPs, who were empowered to make all political, technical and economic decisions. The members of PoPs rarely had any official status. Instead they generally had unofficial authority for specific technical or social projects.

It is also important to recognise that not all PoPs were communists. Non-communists, including both Catholics and atheists, were granted power for specific projects or over particular enterprises or administration districts. PoPs were defined fuzzily in accordance with the standard practice of the WPR system. This involved all organisational structures having a degree of ambiguity to enable the WPR system to intervene and make decisions when it was interested in a particular case. This also allowed the system to easily replace any PoPs who violated the system rules.

The chapter discusses the ethical issues in the domain of ICT and automation. These issues have been considered by the SWIIS (Supplemental Ways for Improving International Stability), now TECIS 9.5, theoreticians and practitioners for a long time (e.g. Argadona 2003; Bulz 2010, personal communication; Bulz et al. 2009; Bynum 2000; Dimirovski 2001; Hersh 2001a, b; Hersh et al. 2005; Jancev and Cernetic 2001; Magebheim and Schulte 2006; Nordkvelle and Olson 2005; Stahk 2009; Tavani 2001). The problems of ethics in ICT and automation in Poland have been discussed by Lewoc et al.(2005, 2006a, b, 2008a, 2009, 2010a, 2011a, b, c), Izworski et al. (2001) and Han et al. (2008). This involved the investigation of ethical issues through consideration of the experiences of actual Polish pioneers in ICT and automation.

It should be noted that the overwhelming majority of ICT and automation projects in Poland in the communist period were intended to solve emerging problems there. Generally, ICT design teams consisting of specialists in various areas relevant to ICT and automation worked on these problems. The team members needed to be able to work together and develop an appropriate solution, which was often multidisciplinary. The leading designer generally had a very important role in projects and was generally required to be able to both substantially solve the problem and lead the team effectively. This required understanding of all the domains involved in the project. In addition, project managers under the WPR system were generally not very competent and had little interest in technical matters. As members of PoPs, they were allowed to direct projects without the need for technical or other competence. Therefore, the leading designer frequently had to take responsibility for a significant component of project management to ensure problem-free execution of the project.

Thus, the demands on leading designers were very high and not all of them were able to meet them. However, those that did became ICT pioneers or leading designers of a pioneering project involving hardware, software, applications, research, educational or other aspects of ICT and/or automation which was successfully implemented. These pioneers had a particularly significant role in developing the domain in Poland, thereby leading it into the twenty-first century. The chapter will draw on the experiences of some of these pioneers to discuss ethical issues related to technology transfer and technology change and to provide suggestions as to how to avoid some of the associated problems.

Ethical issues characteristic of the WPR system are discussed in the first part of the chapter. In the second part, ethical aspects in the period subsequent to the political and economic changes in 1989 are considered. During this later period, developments in ICT and automation were based mainly on technology transfer. In both cases, case studies of the experiences of leading designers are used as the basis for the discussion of these issues.

2 Ethical Issues Pre-1989 in Poland

2.1 General Working Conditions in ICT and Automation

The so-called Cold War between the 'communist' and 'capitalist' countries had a significant impact on working conditions in ICT and automation in Poland in the second part of the twentieth century. In particular, several capitalist countries established formal and informal embargoes on hardware and software and detailed scientific and technical information, respectively. These embargoes were unethical, as they hindered the legitimate development of civilian industry. However, they had a minimal effect on the Soviet Union's military capacity, since, for instance, the Red Army was able to obtain the world's best electronics for its fighters and missiles, while civilian employees were not able to obtain good computers. It has been suggested that the Red Army received electronics from a country that was concerned about ensuring non-interference by the Soviet Union. It is possible that the embargoes were a component of economic warfare against the COMECON countries.

Consequently, although similar systems were readily available in the West, Polish pioneers had to develop complete solutions from scratch. Paradoxically, the embargoes had a very positive impact on the development of ICT and automation in Poland, as it meant that everything had to be produced locally. Therefore qualified staff needed to be trained and a local ICT and automation industry set up. This resulted in the establishment in 1959 of Elwro, the first Polish computer manufacturer, where many Polish pioneers in ICT and automation were educated.

In addition to the problems resulting from the lack of access to hardware and software manufactured in the West, leading designers in Poland had to deal with various problems resulting from the WPR system. They usually behaved ethically and their objective was to design, manufacture and implement good ICT solutions which were required by prospective users, within the framework of the projects they led. These projects generally involved large teams of people. The leading designers needed to behave ethically to achieve technical success, since only ethical behaviour could motivate the whole team to participate fully in the project. The PoPs in charge were generally interested only in the benefits, including money, promotion and recognition, or even fame associated with developing a leading system and therefore did not have any motivation to behave ethically. Although they claimed to be working for prospective system users, they had a much greater interest in maximising their own advantage. Fortunately, the PoPs in many firms involved in solving advanced technical problems realised that they would receive the greatest benefits for successful projects and that competent leading designers were required for successful project completion. They therefore observed the 'rule' that there are people who like working and should not be disturbed at work. This 'rule' was observed in Elwro, particularly during its early days.

However, this 'rule' was only observed during the development phase of an ICT solution. After successful implementation of the solution, the PoPs behaved totally unscrupulously and got rid of leading designers to avoid having to share the benefits with them. This was, of course, highly unethical. It involved taking credit for other people's work and profiting from this, preventing the people with the greatest involvement in this work from receiving due recognition and removing people with knowledge, skills and experience who were required to solve future problems. Several case studies about the experiences of these leading designers will now be presented.

2.2 General Discussion of Conditions in Poland

Leading designers of advanced technical systems in Poland generally had difficult working conditions. In particular, the official and unofficial embargoes imposed by the political, technical and scientific authorities of the Western countries meant they had to develop their solutions almost from first principles and could use knowledge available in the West to only a very limited extent. This meant that they had to work much harder than they would have had to otherwise. From the perspective of deontological ethics (see Chap. 2), applying embargoes or other forms of pressure is ethical when the motivation is based on, for instance, human rights considerations. However, when these embargoes are motivated by the self-interest of, for instance, wealthy elites in the countries applying them, they are not ethical. From the perspective of positive utilitarian ethics, benefits should be assessed against risks and costs, whereas negative utilitarianism requires present or future harms to be offset or mitigated. The embargoes resulted in disadvantage to Poland and its leading ICT designers. Discussion of the Cold War is clearly beyond the scope of this paper. However, it can be noted that despite the real concerns that motivated actions such as embargoes in some cases, the embargoes of technical equipment to Poland should be considered counter to both deontological and utilitarian ethics. After successful completion of the design and implementation, the POPs in charge of the firm generally intervened to make it very difficult for the designers to continue working in ICT and automation in any significant way. This is very unprofessional and counter to most ethical principles (see Chap. 2) and resulted in disadvantage to society as a whole, as well as the designers and potential users of the system. Their behaviour was also hypocritical, since they claimed to be acting on behalf of society as a whole.

It might be thought that a change in political and economic system to a capitalist one with a similar type of pseudo-democracy to those prevalent in the West would have led to the lifting of embargoes. However, this did not happen following the political and economic changes in Poland at the end of the 1980s. The position of ICT pioneers in Poland did not improve, and political embargoes were replaced by economic and technical persecution by the large corporations supplying advanced technology to Poland. These firms even implemented unethical and illegal bullying and harassment actions against the pioneers, whom they feared as possible competitors. For instance, none of the Western firms involved in the technology transfer process employed these ICT and automation pioneers. A number of unsubstantiated reasons were given for this, but in practice bullying and harassment was used to exclude them. As well as being unethical and harming a number of highly skilled individuals, this was counterproductive. Removal of some of the most highly educated and experienced people naturally resulted in implementation problems for new technologies and a number of technology transfer projects failed (Wojsznis 2013, private communication). This problem could only be resolved by ICT technology providers realising that successful projects required the involvement of the best available local ICT people to solve the implementation problems associated with technology transfer.

3 Case Studies

The following case studies involve discussion of the negative experiences of several typical leading designers of this period. The information for these case studies comes from the direct knowledge of the first author of the chapter, who was one of the successful leading designers at Elwro in this period. The leading designers selected played a very important role in the development of computers and computer applications in Poland. Unfortunately, a number of other ICT pioneers of the period, both in Poland and other countries under the WPR system, had similar negative experiences. The discussion is also relevant to other countries where there are elements of the WPR system, even if, on the surface, they have very different political and economic systems.

3.1 Case Study 1: Odra 1204 Computer

This first Polish computer was developed and launched in the late 1960s. Its hardware architecture is depicted in Fig. 8.1. Odra 1204 (Kamburelis 2012, private communication) was intended for numerical data processing and industrial control applications. It used a number of novel and very good technical solutions. For instance, it proved to be very reliable and served its users well for up to 20 years, despite using discrete germanium components and a ferrite core memory. The interrupt system was simpler, faster and more reliable than that of the PDP-11 computers, which were the world standard in industrial control applications at that time.

The leading designer of the Odra 1204 hardware (subsequently referred to as Leading Designer 1) is commonly recognised as the best leading designer of the computers manufactured by Elwro. However, shortly after the successful launch of Odra 1204, he was promoted to a managerial position rather than being assigned to another computer development and implementation project. Consequently, he lost his engineering work and his influence as an excellent leading designer. As an engineer, he did not enjoy management and soon returned to Greece where he became a professor of ICT at the University of Crete.

Depriving Leading Designer 1, who was recognised as the best leading designer of computers in the history of Elwro, of any possibility of working on computer design was a considerable loss to both present and future computer users in Poland. This allowed some PoPs involved in the project to obtain undeserved benefits at the

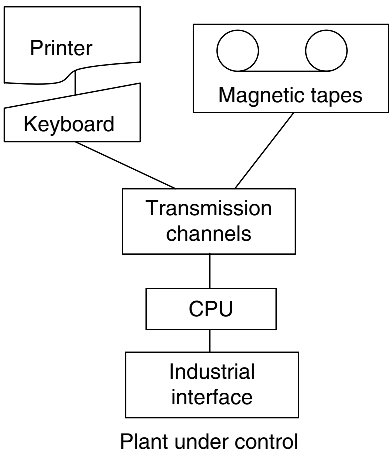


Fig. 8.1 Hardware architecture of Odra 1204

expense of computer users and the leading designer. This is counter to most ethical principles and hypocritical.

After Leading Designer 1 was forced to return to Crete, production of in-house computers at Elwro totally ceased which disadvantaged the firm as well. However, the PoPs' attempt to be given the credit for the leading designer's work was unsuccessful, and they were not subsequently assigned to computer projects of equal importance.

3.2 Case Study 2: Rod Steel Mill Traffic Control System

The steel mill traffic control system (Fig. 8.2) (Wojsznis 2013, private communication), developed in the late 1960s, was the first Polish application of computers to complex industrial process control. Its functionality included monitoring and control of work (billets, rods) traffic, processes and characteristics, as well as some process coordination functions. Although the system had a similar degree of complexity to present-day systems developed by teams of a dozen or so designers, this pioneering solution was designed by two designers.

Leading Designer 2, who was in charge of the steel mill control system, was promoted out of design after the system passed the commissioning run. He was appointed to the so-called general designer position, which unfortunately did not involve any design work. He therefore lost the power resulting from being the sole computer control system designer in Poland. He was eventually forced to resign by local PoPs who were jealous of his experience and expertise. For a while he worked as a lecturer in Nigeria and subsequently as an engineer for a private Polish company. He finally emigrated to the USA, where he joined Fisher-Rosemount. After successfully completing a difficult test project, he was appointed to a prominent technical position.

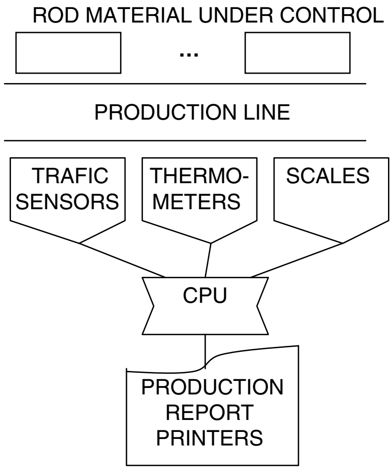


Fig. 8.2 Rod steel mill material traffic control system

As a result of successfully leading the first computer process automation and coordination project in Poland, Leading Designer 2 obtained very wide experience in the areas of ICT and automation. However, his promotion and subsequent emigration meant that this experience and expertise was lost to Elwro and the country as a whole. As a result of the loss of his expertise, his younger colleagues experienced problems while developing computer automation systems for the next computer in the Odra family, Odra 1325, using the then novel silicon-integrated circuit technology. These computer automation projects failed, with a resulting significant disadvantage to prospective users, Elwro and Poland. Leading Designer 2 tried to transfer his experience and expertise to these younger colleagues but was not able to.

Leading Designers 1 and 2 were removed through promotion to management, which was relatively mild treatment. The experiences of most pioneers were much worse, as described in Case Study 3.

3.3 Case Study 3: Process Control Computer KON-10

Leading Hardware Designer 3 obtained his professional experience on the Odra 1204 computer described in Case Study 1 (Fudala 2013, private communication). In the 1980s, reliable computers were required for process control applications in Poland. Leading Designer 3 was appointed to the position of the hardware leading designer for the KON-10 computer, the first computer in Poland intended to be used for process control applications. Unfortunately, the local PoP was greedy and wanted his undeserved benefits early. Although Leading Designer 3 performed his work well, this local PoP started severely harassing him, including false accusations of poor and unpunctual work, at the end of the design and testing period, and forced him to resign. Since the leading designer was forced to resign well before the KON-10 was launched into production, production of this series of computers never took place. The leading designer eventually obtained employment in a private company and became a hardware designer of small-scale computer peripherals (Fig. 8.3).

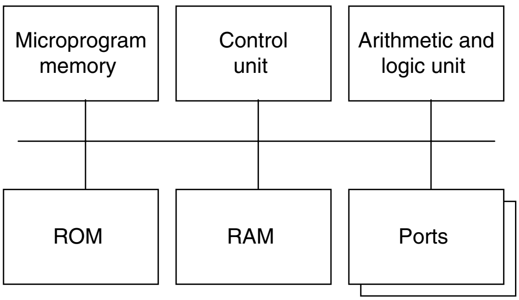


Fig. 8.3 Hardware architecture of KON-10 process control computer

4 Evaluation of the Systemic Ethical Issues Illustrated by the Case Studies

4.1 Basic Motivations of PoPs

In accordance with the rhetoric of the political and economic system, PoPs were established in order to act for the benefit of the people of Poland. However, in practice, there were few restrictions on their power, and the WPR system authorities rarely checked the use they made of this power. Consequently, PoPs frequently took advantage of their subordinates.

However, in successful firms, particularly those working in emerging technological domains, such as Elwro, local PoPs realised that they had to let competent people work to develop some products in order to obtain greater benefits. Therefore, they usually refrained from interfering with the leading designers in charge of technical projects until these products had been successfully commissioned. However, the PoP in Case Study 3 was both impatient and incompetent, even from the perspective of the WRP system. It acted too early and consequently production of the KON-10 computer was not started and the benefits to the PoP and WPR system were very significantly reduced.

When a firm, such as Elwro, successfully implemented a new product, the following benefits generally resulted:

1. Financial benefits: An implementation bonus was generally paid for the successful implementation of products. The amount depended on the official evaluation of the product benefits. It was not an enormous sum (the equivalent of less than €100 thousand today between about a dozen people) but equally not trivial and considered worthy of action by some PoPs. The lists of recipients of implementation bonuses are full of PoPs, but actual leading designers are rarely represented.
2. Possible promotion: This benefit was more important to PoPs than immediate financial benefits, since it could lead to an increase in their influence. The position in the hierarchy was very important to PoPs and could result in financial benefits. However, in the COMECON countries, money was not able to buy desired positions.
3. The recognition of being the creator of an important product: This benefit was particularly important for PoPs, especially in the case of the new technology products designed and manufactured by firms such as Elwro. This could lead to high popularity or even glory, which could result in significant financial benefits and promotion.

4.2 PoP Actions

When it was clear that a new technology product was successful, generally after it was successfully commissioned, PoPs took action to achieve the benefits listed in the previous section. This generally involved doing whatever they could to remove their main competitor to these benefits. This was the leading designer, as the leading creator of the product.

The gentlest approach involved promotion out of engineering and design, consequently removing the designer from the project, as in the case of Leading Designers 1 and 2. This was rarely used, as it required the PoPs to give up some power to the leading designer. A more common approach, as in the case of Leading Designer 3, was harassment, with the aim of forcing the resignation of the leading designer.

In theory, the PoPs in charge of a project could dismiss the leading designer. In practice, they avoided doing this and instead used harassment to force their resignations, as the leading designers of large-scale systems were popular and the PoPs needed to maintain at least the appearance of fairness and justice in order to not risk a reduction in popularity and influence.

The lack of good equipment and technical information meant that successful leading designers of large-scale projects were generally used to having to fight for resources and the other battles of the WPR system and did not give in easily. However, the very strong position of PoPs in the WPR system meant that the leading designers had little chance of winning. The PoPs generally took revenge on them for their resistance and their resulting loss of influence by preventing the leading designers from leading any other significant projects. The one exception is the Leading Designer 4.

4.3 Ethical Aspects of PoP Actions

The WPR system and PoPs claimed in public that they acted for the benefit of the people. However, in practice, their motivation was self-interest. In addition to the negative impacts on the leading designers, their actions disadvantaged both Elwro or the other firms the leading designers worked for and the whole country, due to the importance of ICT and automation projects at that time. The removal of leading designers generally meant that they needed to be replaced with designers with less experience. Equally important, their expertise was no longer available for training the next generation. ICT and automation pioneers of the time considered that a good designer required about a dozen years of technical experience before they could successfully lead a large-scale project and not all experienced designers were able to do this. Therefore, the actions of PoPs resulted in the loss of a very important human resource and may have had a significant negative impact on development and prosperity in Poland.

Many PoPs used the idea that there are no irreplaceable people to support getting rid of experienced leading designers, though they would probably not have appreciated this concept being applied to them. Although every individual is unique and in that sense irreplaceable, individuals can be replaced in well-resourced systems where it is always possible to find other people with similar experience and expertise. However, in poorly resourced countries, such as Poland before 1989, it can be very difficult to find other people with sufficient experience and expertise, and in that sense, the leading designers were not replaceable. At that time, working on large-scale ICT and automation projects for Elwro was very popular with graduates of many universities. This meant that PoPs could propose several competent candidates to replace each dismissed leading designer. However, these recent graduates lacked the experience of the leading designers and would require a number of years to acquire it. The use of less experienced leading designers resulted in several project failures. Since many leading designers were removed before they were able to fully train their successors, there are both a loss of tacit knowledge and a reduction in the total experience and expertise available (Wojsznis 2013, private communication).

The PoPs also set a bad example to the rest of the management of Elwro, who came to devalue hard professional work and specialised knowledge. As a result, bad rather than good management practices became the norm. They promoted inexperienced leading designers who did not yet have the experience or expertise to successfully lead important projects and interfered in the work of the technical staff. During the subsequent difficult period of free competition, these managers were unable to select the attractive and competitive products required for the survival of Elwro in the changed commercial and political conditions or to choose an appropriate partner from the many big corporations interested in establishing a joint venture with Elwro. In the end, Elwro was sold to a very big corporation and soon after was liquidated. This resulted in the loss of many jobs and the only benefit, of dubious value gained by the corporation was the remove of competition in Poland.

The PoP actions were unethical in terms of most theories of ethics (see Chap. 2) and would probably also be considered unethical by most ordinary people. In terms of deontological ethics, which considers the intention and innate virtue of a course of actions, the PoP actions were motivated by pure self-interest, and the PoPs were willing to sacrifice other people in order to benefit themselves. In terms of utilitarianism, which considers the consequences of action, these were purely negative, with significant disadvantage resulting to the leading designers, potential users of the systems they were developing, Elwro and the country as a whole. The actions of the PoPs to further their own self-interests at the expense of everyone else would hardly build good character and were therefore contrary to virtue ethics. Their actions violated the fundamental moral rights of the leading designers to recognition for their work and therefore were counter to rights ethics. The PoPs showed no interest in maintaining relationships, particularly those between the leading designers and their teams, and their actions were therefore counter to the ethics of care. They also acted counter to the principles of beneficence, justice and autonomy and consequently to normative ethics. For instance, their actions did not respect the autonomy of leading designers to carry out their work, justice with regard to recognition and the award of benefits or beneficence in terms of concern for the impacts on the people of Poland.

5 Further Case Studies

5.1 Radio-Astronomy Centre Control and Data Processing System

The radio-astronomy centre control and data processing system was the first project led by Leading Designer 4. The system was intended for the radio-astronomy centre to be developed in Poland. The basic system requirements were controlling the set of dishes, receiving remote signals and processing them into a legible form. The Automation Design Office employing Leading Designer 4 won the contest to design and implement the system against two leading Polish institutes. Unfortunately, the First Secretary of the Polish Communist Party cancelled the funding of the radio-astronomy project in response to mismanagement of an optical astronomy project which resulted in significant financial losses (Fig. 8.4).

Due to the embargoes mentioned in Sect. 8.2, Leading Designer 4 had to use home-made equipment, which had been obsolete for 5–10 years in the West. He therefore designed and developed a computer system simulator (Lewoc 1971) (see Fig. 8.5) of the type called several years later an event-driven simulator, in order to verify that the performance of the systems designed using these components would meet the system requirements.

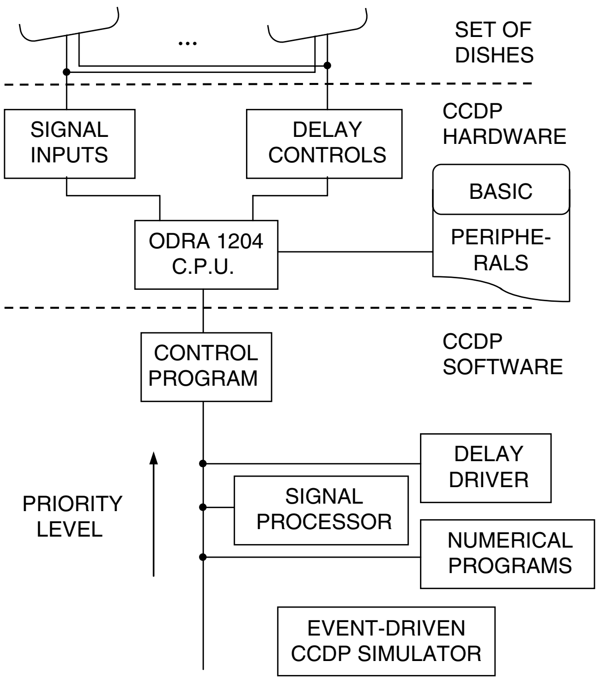


Fig. 8.4 Radio-astronomy centre control and data processing system

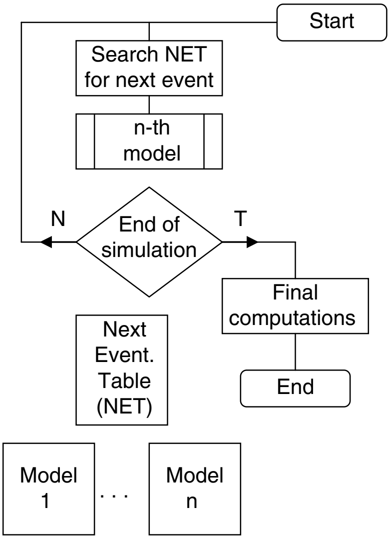


Fig. 8.5 General diagram of the event-driven simulator

5.2 *Regional Power Distribution Centre System (SAPI ODM)*

The regional power distribution centre systems (SAPI ODMs from Polish systemy automatycznego przetwarzania informacji okręgowych dyspozycji mocy = regional power control centre automatic data processing systems) (see Fig. 8.6) were intended to be used as computer aids for the control of power systems in Poland. The only computer available for this design task, despite its very high importance to the whole economy, was Odra 1325. This computer was originally intended to only be used for numerical computing and had several major design faults. However, due to the additional work of the SAPI ODM design team (in particular, development of the automatic restart unit), the system functioned satisfactorily. It supported the control of power systems for over half the power in the Polish grid for nearly 20 years, at a mean availability factor exceeding 92%. The less than 100% availability was due to planned and unplanned computer inspections and maintenance and not problems with the control system. According to the official formulae used for evaluating benefits in the power industry in Poland at that time and information supplied by Dr. Kowalski, the chief coordinator and project manager of the project, SAPI ODM produced benefits exceeding five billion euros.

5.3 *Control Application-Oriented Operating System SOSAPI*

To ensure the development of reliable software structures for control applications, Leading Designer 4 used the process control-oriented specialised operating system SOSAPI (from Polish system operacyjny systemu automatycznego przetwarzania

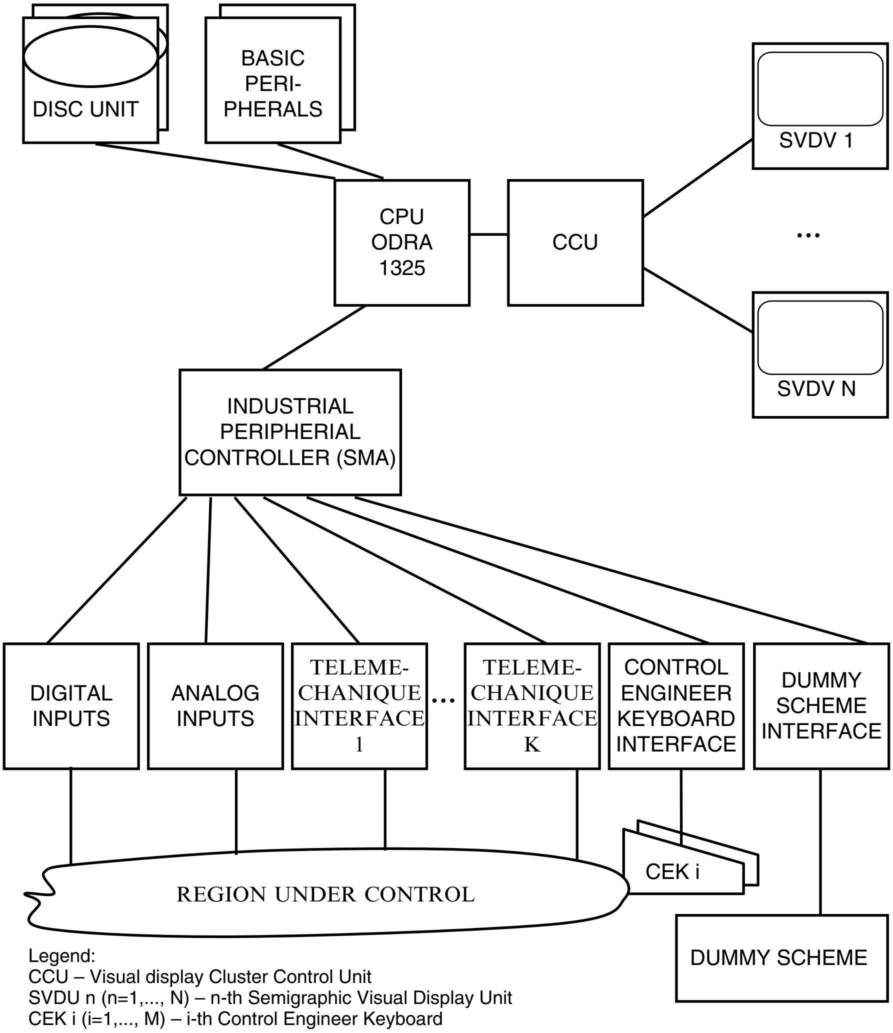


Fig. 8.6 Hardware architecture of SAPI ODM

informacji = operating system for automatic data processing system). This approach proved to be well founded and made the work of the application programmers, who were generally power industry specialists rather than professional programmers, much easier. SOSAPI was successfully applied to other applications, including a large power-generating unit monitor, lower-level power distribution centres and a power grid training simulator. This was made possible by Leading Designer 4 fulfilling his ethical responsibility to educate and train the next generation of designers and programmers. This is important both because young designers and programmers are entitled to benefit from the expertise of their more experienced colleagues and because these more experienced colleagues will at some point retire and the next generation will need to take over (Fig. 8.7).

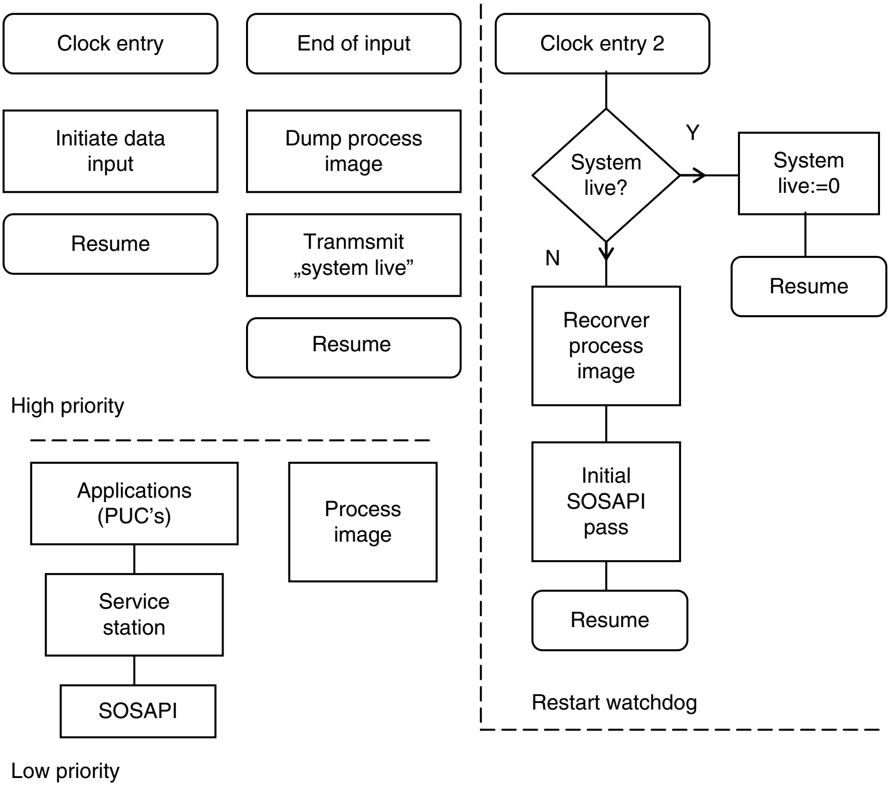


Fig. 8.7 General architecture of SOSAPI operating system

5.4 Visual Display System for Power Industry Applications

The available imported SVDU (semigraphic visual display unit) clusters were very good from the technical point of view, but their cost was too high for use in SAPI ODM applications other than regional power distribution boards. Therefore, Leading Designer 4 led the project for the development of the first Polish two-computer online coupled system operating SVDUs (see Fig. 8.8). The system was successfully applied in a power grid training simulator, power-generating unit monitor and computer systems testing laboratory, amongst other applications.

While waiting for the Odra 1325 computer for SAPI ODM, Leading Designer 4 led a test project of the first Polish PGUM (power-generating unit monitor), which was implemented and tested on a 200 MW power-generating unit (Fig. 8.9).

Fig. 8.8 General architecture of the semigraphic visual display unit (SVDU) cluster

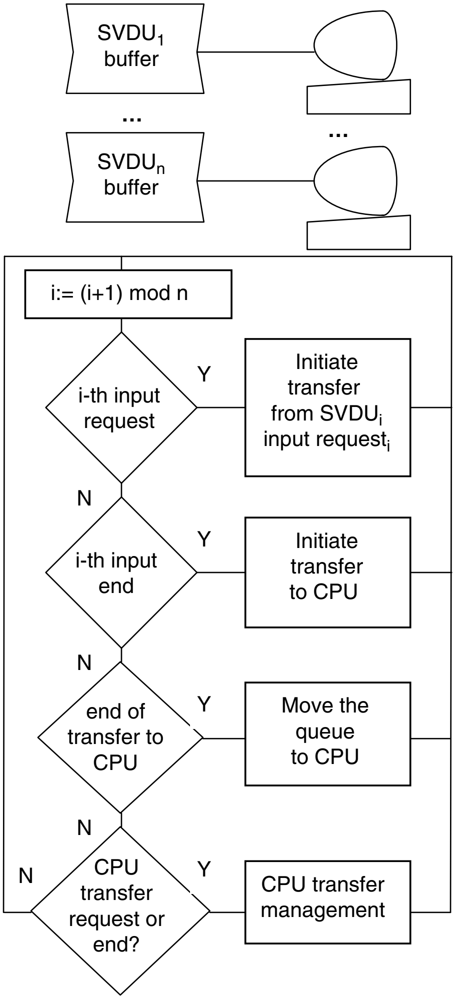


Fig. 8.9 General architecture of the power-generating unit monitor (PGUM)

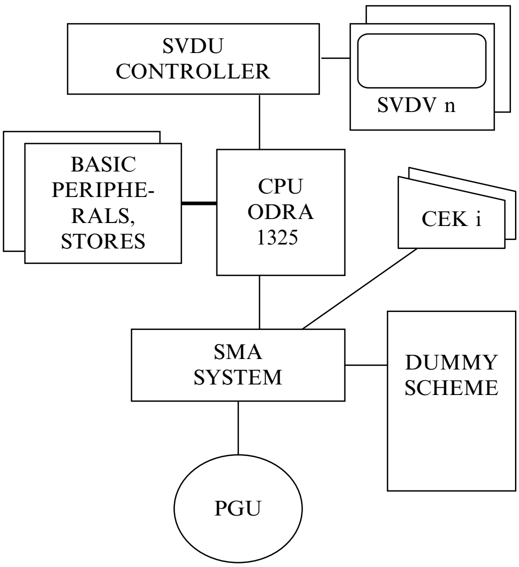
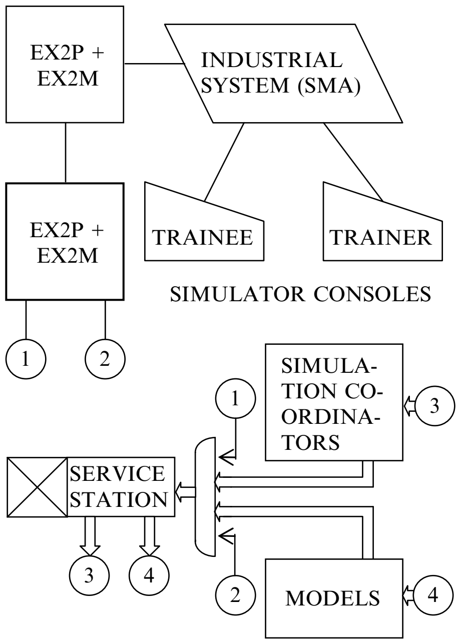


Fig. 8.10 Power network simulator architecture



5.5 Power Network Simulator

The lack of sufficient computer power led to the failure of a number of projects for the development of training simulators for complex facilities. The design team for the power network simulator project led initially by Leading Designer 4 did not try to implement the detailed online simulation model, as this would not have been feasible with the computers then available in Poland which lacked sufficient processing power. Instead, they used their knowledge as experienced power network control engineers to derive a simulation based on characteristic power network responses. The project was very successful. The simulator operated for about 12 years, and during this time the overwhelming majority of power network control engineers in Poland were successfully trained on it (Fig. 8.10).

5.6 Microprocessor-Based SAPI Realisation

The demanding requirements of the Odra 1325 computer, particularly the need for air-conditioned rooms and the associated high costs, especially for the lower levels of the power distribution system, led to the development of a simplified version of SAPI ODM, which was realised using microprocessor-based technology (Fig. 8.11).

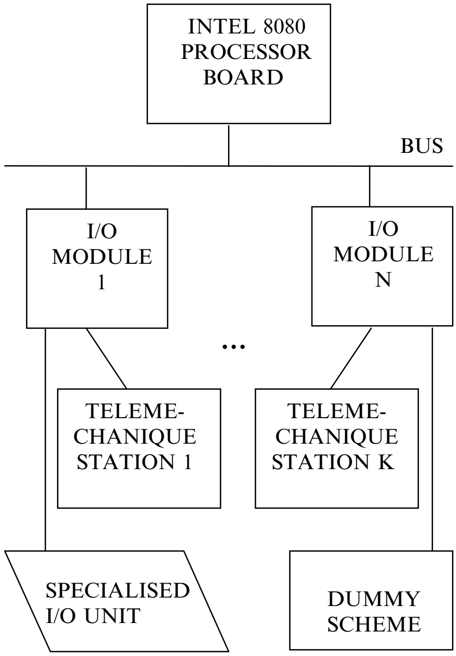


Fig. 8.11 Hardware structure of KWP

The resulting measurement display (KWP (from Polish komutowany wyświetlacz pomiarów = switched measurement display)) was implemented at the aerial (lowest) and utility levels of the power industry.

5.7 Communication Network of the Interuniversity Computer Network (MSK from Polish Miedzyuczelniana Siec Komputerowa)

At the start of the 1970s, Poland decided to follow the trend in Europe for the development of heterogeneous computer networks. Leading Designer 4 was appointed as leading designer for the communication network (Fig. 8.12), which was one of the main components of MSK. In spite of the very difficult conditions for the design and development of advanced technical systems in academia, including very limited engineering experience and opposition from some research groups, all the main design goals were achieved and the communication network was successfully developed and implemented.

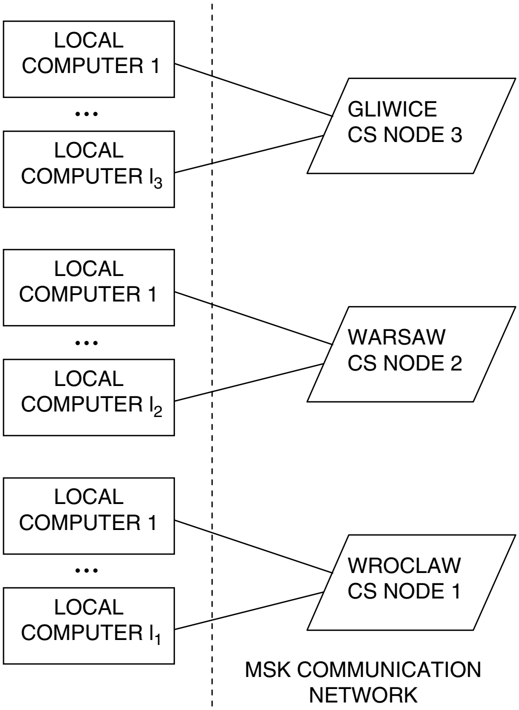


Fig. 8.12 General architecture of the MSK network

5.8 *Internal Network Measuring Tool*

The MSK communication network project involved research, such as the verification of the network solution characteristics, including performance evaluation. Leading Designer 4 therefore designed an internal traffic generation and performance measuring tool (Lewoc et al. 2006a, b, c), called Sitwa (Fig. 8.13). The tool was then successfully developed and commissioned by a team of three students. Sitwa was used to make performance measurements of MSK, which were used to tune and validate the analytical performance tool.

5.9 *Approximate Network Analytical Performance Evaluation Tool (Anapaest)*

In support of the project research goals, Leading Designer 4 designed and developed Anapaest for performance evaluation of computer networks (Lewoc et al. 2010c). Anapaest is a heuristic method which was developed using existing networking knowledge and validated with the available analytical methods, internal

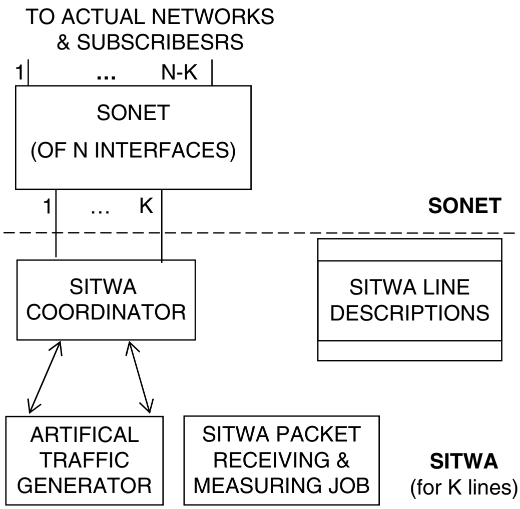


Fig. 8.13 Functional block diagram of the Sitwa internal measuring tool

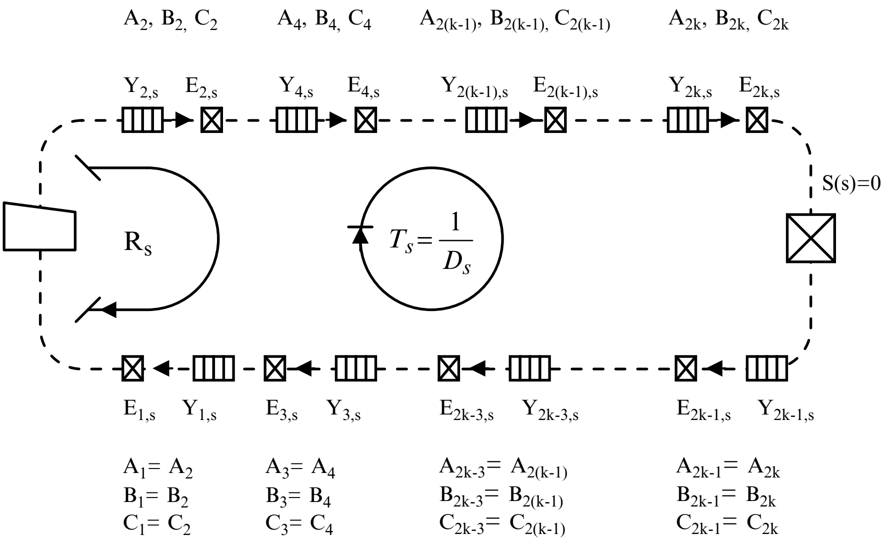


Fig. 8.14 A closed circuit in a network, investigated by Anapaest

network traffic generation, the measuring tool Sitwa and a number of simulation runs. It treats a computer network (with end-to-end acknowledgement) as a collection of closed circuits of the form depicted in Fig. 8.14, i.e. as isomorphic mappings of virtual calls, irrespective of the type of implementation, for instance, with datagrams. Anapaest has been successfully applied to evaluate the performance of many computer network configurations.

5.10 Power Plant Database

This project (Fig. 8.15) was intended to facilitate the computer integration of the manufacturing and management domains in power plants. Development of the first application power plant was stopped after completion of the first phase of Badel. However, when construction of this plant was resumed, a team of people educated

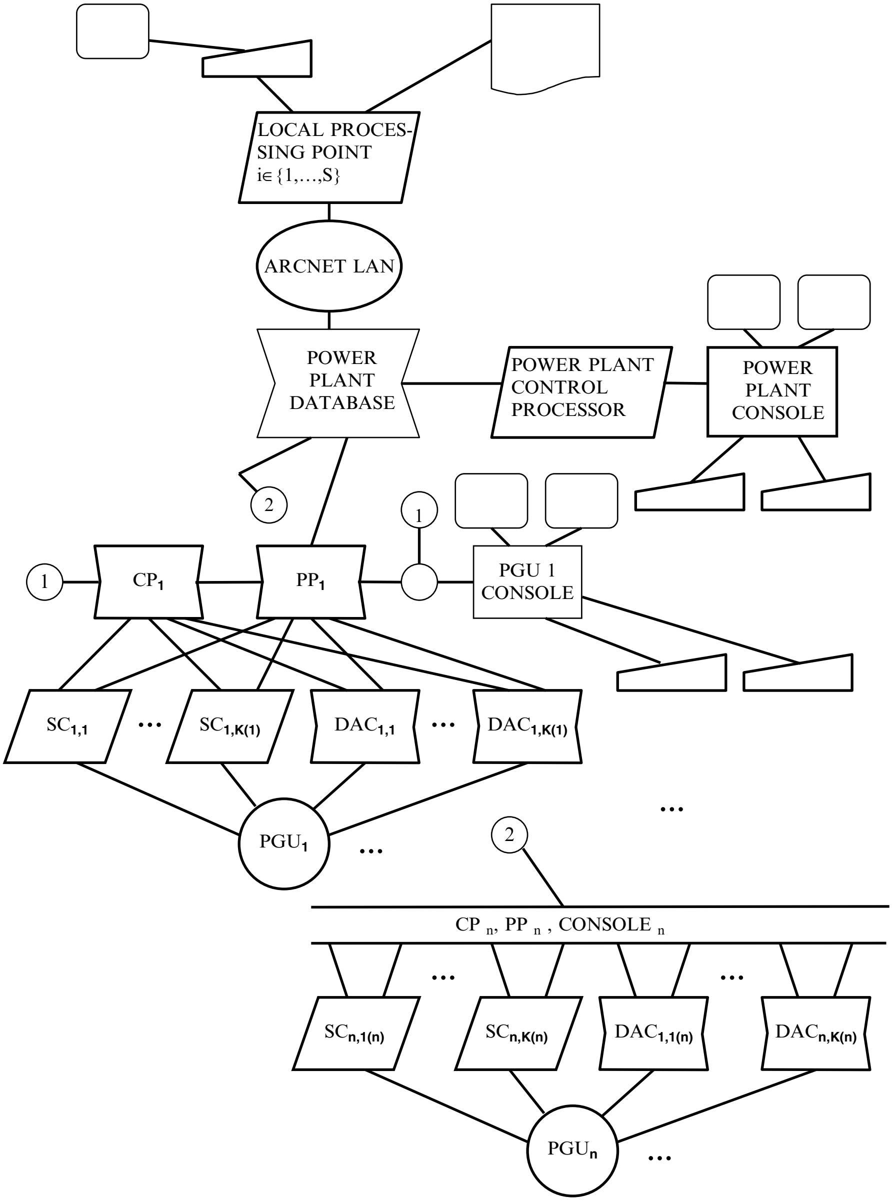


Fig. 8.15 Hardware architecture of Badel (Lewoc et al. 1989)

on Badel successfully developed the process level of Badel in the power plant and another team adapted the Badel solutions to the QNX® environment and created the ProSter (from the Polish pro sterowanie, for control) system, which was successfully implemented in several power- and heat-and-power-generating plants.

6 The Methods Used by Leading Designer 4 to Ensure a Continuing Career as a Successful Leading Designer

The approaches discussed here include a pretence of naivety, the combined design of software and hardware, good technical documentation, educating successors and undertaking additional work to ensure financial independence.

6.1 The Pretence of Naivety

From the start of his professional career, Leading Designer 4 recognised that working at his full capabilities to benefit the people of his country was more important to him than the money, promotion and recognition valued by the PoPs. Doing this requires designers to be very clear about their values and to resist the temptations of material benefits and status, which is not always easy.

Therefore, when it was clear a system he had been leading designer for would be implemented successfully, he intentionally changed project, laboratory, department and even employer and made it clear that he was not interested in the benefits due to the leading designer. In this way, he avoided both involvement in the battle for benefits and the risk of serious harassment or being promoted out of engineering and design. The PoPs falsely assumed he was naïve and other PoPs were happy to employ him as a leading designer, as they would have liked everyone to be equally 'naïve' and uninterested in personal benefits.

To ensure successful continuation of projects after he left, Leading Designer 4 had to assume from the very start that he would not be involved in the extension of the implemented system functionality or adaptation of the system for new or similar applications. This meant educating the next generation of designers to continue his work in accordance with his professional and ethical responsibilities to support, educate and train younger colleagues.

As illustrated in Case Study 3, PoPs were often both greedy and impatient and sometimes tried to remove leading designers before the system was successfully implemented. Leading Designer 4 was dismissed three times by his direct superiors but was always reinstated by higher-level PoPs, who realised that the dismissals damaged the WRP system. However, he was aware of this possibility and tried to plan accordingly.

6.2 Solving Hardware and Software Problems Together

Leading Designer 4 was educated in computer hardware. Most of the projects he led involved advanced applications of ICT. A major part of the design and development work involved programming, but some hardware design and development work was generally also required. This work was carried out under the control of Leading Designer 4. Despite the narrow specialisations common in the West, this was generally not very difficult for people educated and skilled in computer hardware.

Where possible, hardware and software designers were involved in each other's work. The detailed design and development work was carried out by competent staff with the appropriate specialisation. However, their awareness of the problems and perspectives of their colleagues improved and speeded up the overall design process and avoided unnecessary conflicts between hardware and software designers. The lack of these conflicts had the further advantage of avoiding the need to involve the PoP managers with limited knowledge and experience of either software or hardware in solving them. The involvement of managers without appropriate expertise led to the failure of a number of large-scale ICT and automation projects in both the COMECON and other countries. However, none of the projects led by Leading Designer 4 ended in failure and the resulting systems were all low cost.

6.3 Adequate Technical Documentation

Good technical documentation should be considered part of standard good practice. It is required to enable both the designers and others to return to and understand the work at a later date. This is particularly important, as in the case of Leading Designer 4, when a designer may not be available for the full duration of a project. Therefore Leading Designer 4 was careful to ensure proper documentation to facilitate the work of his successors in modifying or extending the system.

In the case of hardware, the prerequisite functional, block and circuit diagrams were drawn up without any objections. However, young and inexperienced programmers sometimes protested about the need for program flow diagrams on the grounds that (1) they were not needed to write the program, (2) drawing them was time consuming, (3) a code in a high-level language is the equivalent of a flow diagram and (4) flow diagrams are obsolete.

However, flow diagrams are required to support the final debugging phase rather than for writing the initial version of the program. Debugging might take place a year or more after writing the program, particularly for large-scale systems, and probably in the difficult conditions of the actual application. After this length of time, even the original programmers are unlikely to remember their solutions and therefore to find flow diagrams very useful. This is even more important when further development of programs is carried out by other programmers, for instance, by the users of the application. The availability of detailed flow diagrams facilitates their work, which would be very difficult or even impossible otherwise. The time involved in drawing flow diagrams is easily balanced out by the time (and money) that would be unnecessarily lost in the program writing, debugging, commissioning and modifying phases if flow diagrams were not available.

The use of high-level languages was relatively limited in real-time applications in automation. In addition, the resulting records are less easy to understand than flow diagrams and consequently a less useful tool for the development of software for large-scale high-tech applications.

Flow diagrams proved to be a very useful tool in the development and modification of software for the projects led by Leading Designer 4 and irreplaceable when major changes were made to the software solutions. Examples include the power-generating unit monitor, power network training simulator and switched measurement display (KWP) developed from SAPI ODM and the ProSter system designed on the basis of Badel system flowcharts adapted for a different environment under the QNX® real-time operating system. In all these cases, the major changes were implemented successfully and did not require the participation of Leading Designer 4, showing the value of the approach.

6.4 Educating the Younger Generation

Educating and training younger colleagues can be considered an ethical and professional responsibility. However, some of the Polish ICT and automation pioneers failed to educate their younger colleagues on the basis that they personally needed to solve all problems. However, Leading Designer 4 recognised the importance of doing this to ensure that the work could continue even after he was no longer involved. He therefore did his best to ensure that each member of the design and development team had full knowledge of the project and therefore could potentially replace him as leading designer if necessary.

At that time, the main approach to teaching about design was based on the use of design recipes. However, this approach does not enable designers to think creatively, develop designs for new problems or be able to respond appropriately to the unexpected. A better approach, as used for instance by Leading Designer 4, is to teach design principles and ways of thinking about design in order to give young designers the prerequisite skills to respond to challenges and new design problems. One of his techniques involved drawing flowcharts of the required solutions and allowing his younger colleagues to analyse them and derive their own solutions. In order to give these younger colleagues ownership of their work and the project, where their solutions were feasible, they replaced those of Leading Designer 4. This approach worked well and resulted in the completion and successful launch of a number of important projects, including the power-generating unit monitor, the power network training simulator and the switched measurement display (KWP) for the power industry.

The Badel project deserves a special mention. It involved both the technical (power manufacturing) and management domains in a large combined heat-and-power plant under development and a computer-integrated manufacturing and management system (CIMMs). The design and development team was very large, involving about 100 designers. Several dozen of these designers attended the Leading Designer 4's design classes. However, a downturn in the economy led to a reduction in the demand for electric power and construction of the plant was halted. When the economic situation improved, a group of Badel designers used the expertise they had obtained from these classes to set up their own firm and successfully develop the measurement and primary data processing systems for the Badel plant under subcontract to a large international corporation.

A few years later another group of Badel designers obtained the commission to design and develop the computer aid for the operator of the combined heat-and-power- and power-generating units. They adapted the original Badel flow diagrams to the QNX operating system. Thus, they designed and launched the ProSter system, which was implemented successfully, by a small, privately owned firm now an institute (IASE, the Institute for Power System Automation), in about 200 Polish combined heat-and-power- and power-generating plants against severe competition from the world's biggest corporations, which were trying to enter the Polish power industry market. Where the designers were unsure of which option to use, they considered what Leading Designer 4 would do in similar circumstances (Kieleczawa 2013, private communication). It is always a matter of great satisfaction to good educators when their students draw on and develop further their techniques and/or apply them to obtain success in their careers.

Considerations of commercial confidentiality and the desire of large multinational firms, in particular, to make enormous profits mean that it is generally very hard if not impossible to find detailed information about the system design or the approach adopted. It is therefore refreshing to see this information being made publicly available with resulting benefits to the design of subsequent systems and their users. For instance, after the successful launch of SAPI ODM, another successful real-time implementation of the Odra 1325 computer was realised, namely, a computer control system for research laboratory applications. The design was based on the detailed SOSAPI flowcharts published earlier. There is an increasing expectation that the results of publicly funded research should be made publicly available. It is to be hoped that this approach will also affect work financed by private firms with a resulting benefit to society. This more ethical approach based on the distribution of knowledge will probably require a move from competition to cooperation as the dominant paradigm. However, it should not be assumed that the sharing of knowledge will necessarily lead to disadvantage for highly competitive private firms.

6.5 Carrying Out Additional Work to Ensure Financial Independence

Underpayment and/or overwork are typical of many exploitative political and economic systems. In particular, underpayment is used in WPR systems, probably to enable PoPs to maximise their profits. Exploitation of workers also makes them feel vulnerable and probably less likely to question the system. As a result, many workers in WPR systems, including ICT and automation pioneers, needed an additional job in order to survive (Wojsznis 2013, private communication).

Leading Designer 4 could have easily obtained additional work in ICT and automation, similarly to most of the other pioneers. However, he preferred to continue the practice of working as a freelance translator that he had started while a student. This had a number of advantages and, in particular, made him financially independent of the PoPs in ICT and automation. Fortunately, PoPs in different areas of work were totally independent of each other. He was accepted by the local PoP in translation, as his main motivation was financial and therefore comprehensible to PoPs.

This financial independence meant that Leading Designer 4 was in a position to reject incompetent decisions of the PoPs in ICT and automation without needing to worry about his family's financial security. He obtained approximately equal incomes from design and translation but spent only about a quarter of his time on translation, as it was much better paid. This solution is not suitable for all designers, since it requires possession of another totally unrelated skill in an area of work that pays relatively well. Otherwise, too much time would lost from design work. However, the need to reduce the amount of time spent on design in order not to experience overwork was the other main problem.

In the late 1970s, IASE obtained a large order to provide automation for the Żarnowiec nuclear power plant which was then under construction. Leading Designer 4 was invited to join the project by the local PoP. However, he soon realised that the design teams included a mixture of competent and incompetent designers. Although at that time he had too little knowledge to recognise the ethical and other problems associated with nuclear power, he was aware that competent designers were essential for this type of safety critical application. Leading Designer 4 withdrew his whole team from the project as he recognised that the design approach was unsatisfactory and therefore highly dangerous and courting disaster. He was therefore not surprised by the subsequent accident at Chernobyl. A local PoP tried to put pressure on him through the threat of losing his job but desisted when he realised that this would enable Leading Designer 4 to earn twice as much by working full time on translation. His colleagues who worked full time in ICT and automation were totally dependent on the PoPs in this domain for their continuing employment. Action taken against them by PoPs would therefore also result in the inability to obtain any work in automation and ICT and therefore total loss of income. They were consequently vulnerable to pressure from PoPs.

As a professional English translator, Leading Designer 4 had to ensure that his knowledge of English remained current. This knowledge was also valuable in enabling him to access English language materials and thereby improve the quality of his work on ICT and automation. In order to obtain sufficient income from translation, Leading Designer 4 had to translate about 500 pages or 100,000 words a month of technical, scientific and business material. As a result, he also significantly increased his general knowledge in these areas with associated benefits both to his design work and to himself.

Thus, the resulting benefits in terms of independence and increased knowledge were very significant and outweighed the disadvantages of having to learn another profession and the opportunity costs of the time involved. However, it should be noted that this type of solution is not possible for everyone.

6.6 Ethical Aspects of Leading Designer 4's Conduct

As discussed above, the behaviour of the various PoPs was generally both unethical and hypocritical. While Leading Designer 4's behaviour was ethical, it focused more on the professional ethics of how work is carried out than consideration of the applications, for instance, in the case of the Żarnowiec nuclear power plant. However, he recognised the likely consequences of the inappropriate design approaches used and resigned from the project in accordance with utilitarian ethics.

A significant ethical aspect of his work was his concern for the education and training of his younger colleagues and his relationships with them, in accordance with the ethics of care. The design team approach under a leading designer could easily become exploitative and hierarchical. However, he ensured this did not happen by, for instance, using designs obtained by his younger colleagues in order to motivate them and give them ownership of the work.

He also recognised and valued the contribution of resources by the citizens of Poland to enable him to obtain the software and hardware he required to design, develop and implement his projects. In the end, the benefits obtained were worth several times this investment, but at the start of the projects, it was not apparent that they would even repay the investment, never mind bring additional benefits. Therefore, in accordance with principles of justice, Leading Designer 4 recognised that the benefits achieved by his projects did not cancel his debt of gratitude to the citizens of Poland.

There are many reasons why people behave unethically, including the temptations of personal benefits from such behaviour, pressure from colleagues and superiors and/or threats of reprisals in organisations in which unethical behaviour is prevalent. Leading Designer 4 resisted the pressures by prudently ensuring that he was financially independent in the sense of being able to obtain a sufficient income outside the ICT and automation domain, thereby making it much easier to resist pressure. He resisted the temptations of money, power and glory through recognition of his real values and being able to carry out the engineering and design work he loved was what was important to him, not these other benefits. In this way, he acted in accordance with virtue ethics by behaving in a way that improved his character.

7 Final Remarks on Ethical Issues in a WPR System

The WPR system is independent of any particular political and economic system and is unfortunately widespread. It is found wherever there are ruthless and arbitrary power systems, for instance in some multinational corporations, including in countries with a façade of democracy. The case studies in this chapter have focused on leading designers. However, other ICT and automation personnel, particularly highly qualified ones, had similar negative experiences.

7.1 Survival and Ethical Behaviour in a WPR System

The following suggestions for survival and ethical behaviour are relevant to highly qualified personnel in particular, but also other workers in highly technical areas. They include the following:

1. Recognition that useful work in the area of one's specialisation and which benefits society is of much greater value than any personal benefits. This requires an understanding of one's own values and the ability to resist temptation and pressure. This may also require designers and other professionals to resign from projects if they have successors able to continue the work and they can obtain other work in order to avoid battles over benefits.
2. An integrated approach with hardware and software under the control of one designer. This will avoid the adverse consequences of allowing managers who may have little technical knowledge to coordinate projects.
3. Good technical documentation, particularly for large-scale projects involving new technologies. In particular, software flowcharts are vital for successfully debugging and modifying software, especially when there is a considerable time gap between writing the original programs and subsequent debugging and modification.
4. Educating the younger generation and ensuring that competent successors have been trained. This is both of value in itself and essential in systems where personnel may be replaced during the course of a project. This requires responsibility to colleagues and the project.
5. If possible, securing financial independence through work in another reasonably paid area outside the remit of the authorities having control over the main area of work. One option is freelance translation, which may have the further benefits of improving general education and communication skills.
6. Resisting the temptations for both undeserved benefits and benefits at the expense of others with regard to money, power and recognition and acknowledging that only earned benefits bring true satisfaction.

8 Ethical Issues in Post-1989 Poland

In the opinion of the authors, the political and economic changes that took place in Poland in 1989 were welcomed by most of the population. However, many of the subsequent developments were much less desirable. The ICT and automation domain was opened up to technology transfer from Western countries, while the share of work carried out in Poland was reduced. It was initially expected that the Western firms delivering high-tech solutions would make use of highly qualified local personnel to facilitate a smooth, effective and profitable technology transfer process. In particular, the ICT and automation pioneers possessed considerable valuable knowledge which could have been of great value to these firms. Unfortunately, what happened in practice was rather different.

8.1 The Downfall of Elwro

As indicated earlier, one of the negative effects of the exploitation of ICT and automation pioneers by PoPs in Poland was a reduction in the quality of management, with managers using a variety of dirty tricks to obtain promotion. This led to a downgrading of actual management ability. Poor management resulted in the further disadvantages to the firm of an inability to choose profitable products to be manufactured by Elwro or appropriate partners from the many firms interested in joint ventures. The owner of Elwro, the government, motivated by free market policies did not intervene, for instance to replace the apparently incompetent management, and allowed the country's largest computer manufacturer to fail.

Finally, Elwro was sold to a very large corporation, which obtained 80% of Elwro's shares with the employees purchasing 20%. The sale contract stipulated that Elwro should continue to work in the ICT and automation domain. Unfortunately, the corporation retained the incompetent managers responsible for Elwro's collapse but did not employ any of the ICT and automation pioneers. It seems probable that this was the intention from the start.

Less than a year later, the corporation successfully encouraged the government to sell the 20% of shares which the employees had earlier bought. Although the employees were the legal owners of these shares, they were not consulted and did not receive the payment or even any compensation for the loss of the shares. This shows both a total lack of respect towards the workers, as well as dishonesty by the government and large corporation. Most of the employees were encouraged to resign by high severance payments. The remaining Elwro assets were used briefly for mechanical and chemical work and subsequently sold.

8.2 *The Experiences of ICT and Automation Pioneers Post-1989*

After 1989, the situation for ICT and automation pioneers was in many ways worse than it had been previously. Under the previous system, they had been at least allowed to lead one technical project, generally to successful completion, before being forced out. Subsequent to 1989, none of them obtained a satisfactory technical position. The case of Leading Designer 4 will now be discussed briefly.

Four large Western corporations tried to establish their operations in Wroclaw, the former centre of ICT and automation activity. Leading Designer 4 was open to possible cooperation with them to facilitate the technology transfer process with resulting benefits to both the people of Poland and these firms. Unfortunately, they were not willing to collaborate with him, as discussed below.

Corporation 1 was involved in the application of ICT to power system automation, an area in which Leading Designer 4 has extensive experience and expertise. It was also employing several IASE workers, who were well aware of his achievements. However, it was not interested in using his expertise, for instance, as a consultant. Corporation 1 also tried to exclude Leading Designer 4 from translating its technical power industry documents into Polish, despite his considerable experience in this area and knowledge of the Polish terminology. It even went so far as to forbid other translation agencies to subcontract this work to him. However, these firms realised that this requirement was unreasonable and possibly illegal and so ignored it in the interests of producing high-quality translations and greater profits.

Leading Designer 4 offered his services to Corporation 2 when it was setting up in Wroclaw. He submitted his CV in response to a request but was not given any work. It is possible that the firm objected to the fact he led the TV Solidarity system in the 1980s, a project which was then illegal. If this is the case, which is by no means definite, it seems they may have been opposed to any form of political protest. This would be very worrying but possibly not surprising. Some large corporations are WPR systems in their approach to dissent.

The Wroclaw office of Corporation 3 ordered translations from Leading Designer 4 and the cooperation was initially mutually beneficial. However, when they learned of his experience in ICT and automation, they ended the relationship and did not even pay for the last piece of work, despite Leading Designer 4 contacting their head office.

The Lower Silesia office of Corporation 4, which was the world's leading supplier of electrical and electronic systems, also commissioned translations from Leading Designer 4. Despite receiving good-quality translations, they ended the relationship when they learnt about his ICT and automation expertise. However, they behaved correctly and paid everything that was owed. Needless to say, they did not invite Leading Designer 4 to participate in the technology transfer process.

8.3 Ethical Issues in the Post-1989 Period

The ICT and automation technology providers in Poland generally ignored the best available people in the country and employed people with limited technical expertise and not very competent managers. This approach is typical of colonialism with its lack of respect for local people. The methods used, including bullying and harassment, false allegations and even theft, are reminiscent of those used by the WPR system. Discrimination against and the refusal of overseas firms to use local experts on account of their knowledge and expertise pushed Poland into the position of a colonised country which was totally dependent on foreign countries.

This does not meet any of the conditions of good practice in technology and knowledge transfer described below and can be considered to be based on bad rather than good practice. Good practice should involve the following factors (Roberts 2000; Souder et al. 1990; Thrupp 1989; Wanderson 2003):

Local Issues

- Active role for local individuals, organisations and individuals.
- Use of local knowledge.
- Consideration of and adaptation to the context.

Relationship Between the Transfer Agency and Recipient

- Full commitment by the transfer agency to the technology and appropriate technical ability.
- Long-term partnership between the transfer agency and the recipient.
- Transfer of complete and useful information about the technology, including tacit knowledge.
- Appropriate transfer mechanisms, which may require face-to-face meetings to transfer tacit knowledge.

Recipient

- A plan and adequate resources and business acumen by the technology recipient.
- The technology is low cost and low risk for the recipient and will perform reliably in their applications.

Benefits

- The technology has positive impacts.
- The technology is transferred in a way that builds on and adds to local capacity.

The technology transfer process in Poland resulted in what can be characterised as a lose-lose situation. Pioneers and other technical experts were prevented from doing the work they loved, and rather than benefiting from the technology transfer process, the country was disadvantaged by it and there was no resulting increase in prosperity. Even the overseas corporations lost out, since their projects failed or were less successful than they could have been due to not using the best local people.

For instance, the four corporations discussed in Sect. 8.8.2 all failed to establish operations in Wroclaw and had to move out.

Like those of their WPR predecessors with whom they have a lot in common, the actions of these corporations were again unethical in terms of many of the theories of ethics. With regard to deontological ethics, there is little of innate virtue or laudable intentions in actions based on making a profit while undermining local technical capacity. In terms of utilitarianism, the lose-lose nature of the consequences of these actions has already been mentioned. With regard to virtue ethics, undermining local technical capacity and engaging in serious harassment hardly build good character. In terms of rights ethics, the fundamental moral rights of the pioneers to work in the ICT and automation domain and the country to benefit from their expertise were undermined. With regard to the ethics of care, they had no interest in preserving relationships, including those between pioneers and the country. With regard to normative ethics, their actions were counter to the principles of justice, for instance, for the ICT pioneers and beneficence, for instance, to the people of Poland who were deprived of the benefits of these pioneers' expertise.

8.4 The ENES Company

ENES was established by two designers from Elam, an enterprise involved in automation systems, which separated earlier from Elwro. Elam's early experiences were rather difficult since its only capital was the knowledge and experience of its founders. A lack of premises meant that they had to develop their designs in their not very large flats. However, their belief in their own expertise as automation system designers helped them to survive the difficult initial years, and now their reference list includes several hundred computer control systems, which have been implemented in working media control applications, anti-burglary and staff monitoring systems, industrial boilers, waste and wastewater treatment as well as power-generating units.

It is interesting that this very small company with minimal resources succeeded while the large corporations failed. The large corporations sometimes blamed their failure on the recession at that time, but it is strange that the recession did not affect ENES in the same way. A better explanation for the success of ENES and the failure of the large corporations is their different approaches to the technology transfer process. The designers of ENES used experienced local staff whenever possible for design and programming work, though they imported any necessary equipment, particularly high-tech equipment. The local staff were best able to implement new technologies in Poland due to their experience of local conditions and the expectations and requirements of end users. This enabled them to customise and/or develop the hardware and software structures required in an efficient and low-cost way. This approach was both successful and ethical. It was motivated by the desire to use and develop local capacity and had positive consequences.

8.5 The Case of Leading Designer 4

After the changes in the political and economic systems in Poland, the doors to technology transfer were opened wide, at least in theory. In practice, a very restrictive technology transfer process took place, as described above. Again, as described above, Leading Designer 4's attempts to work with the large corporations involved in technology transfer as either an ICT and automation expert or a translator were unsuccessful. He therefore decided to continue to work as a translator and to use the resulting income to finance his work in ICT and automation.

He determined appropriate projects through visits to numerous people in the industry to learn their needs and expectations with regard to ICT and automation and defined appropriate problems. The design and research teams had a social orientation and developed the designs up to the feasibility study level of the extended or detailed technical design. They also aimed to solve the associated research problems. To validate the resulting solutions and disseminate the results, a number of presentations were made at prestigious scientific conferences. Some of the main project themes are discussed briefly below.

8.5.1 Computer-Integrated Manufacturing and Management System (CIMMs)

Drawing on numerous talks with representatives of industrial manufacturing firms (in particular, metallurgical plants), Leading Designer 4 and his teams developed a proposal for a safe approach (with a low risk of high financial losses in the case of design mistakes) to the design and development of CIMMs. The approach involved thinking about the design and learning first and only subsequently standardising. This is counter to the more commonly used approach of standardising first and thinking later, if ever. This latter approach is generally expensive and rarely leads to the best results for users of the system. However, it can lead to very high profits.

The general structure of the System Media, which Leading Designer 4 used to develop CIMMs, is depicted in Fig. 8.16.

8.5.2 E-Train-Diabetes

This project involved the development of a distance learning system to provide rapid education in the principles of diabetes to about 20,000 basic healthcare nurses to enable them to provide significant support to the diabetes diagnosis and treatment process (Abramczyk et al. 2005). Leading Designer 4's design and development team was supported in this work by the technical and research communities,

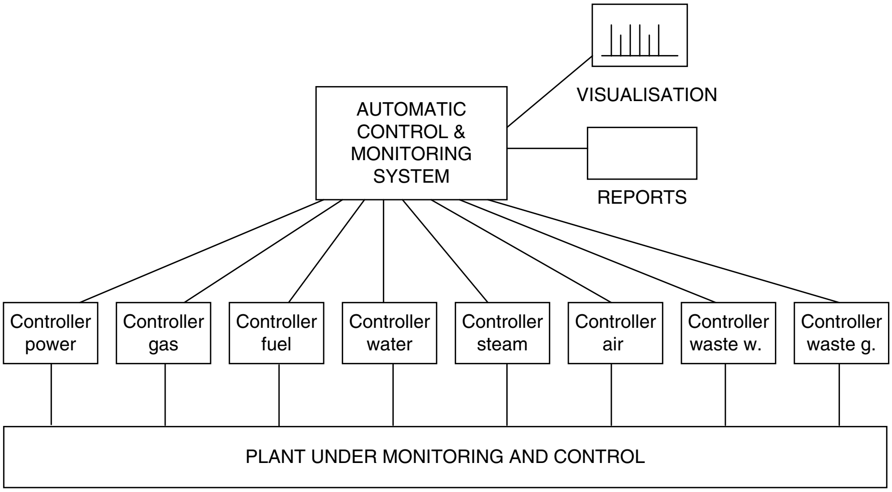


Fig. 8.16 General structure of System Media

particularly the IFIP Summer School in Karlstad (Abramczyk et al. 2004). This summer school played an important role in the development of this project and helped disseminate the results.

The basic flow diagram of e-Train-Diabetes is shown in Fig. 8.17.

8.5.3 Building Automation

This project involved an approach to building automation which was developed using the experience gained in the Polish power industry (Lewoc et al. 2007a, b). The building automation system software architecture is shown in Fig. 8.18.

8.5.4 Computer System Robustness Evaluation

The problem of the data acquisition/control system topology for distributed control systems is usually solved in a rather arbitrary way. This project involved the development of a more logical approach based on the evaluation of the system robustness, using the μ function as the measure of robustness (Doyle 1982; Maciejowski 1989). The μ function is a measure of the system's ability to respond in the presence of disturbances. The research team proposed a method which can be used by system designers and has the advantage of low computational effort for communication

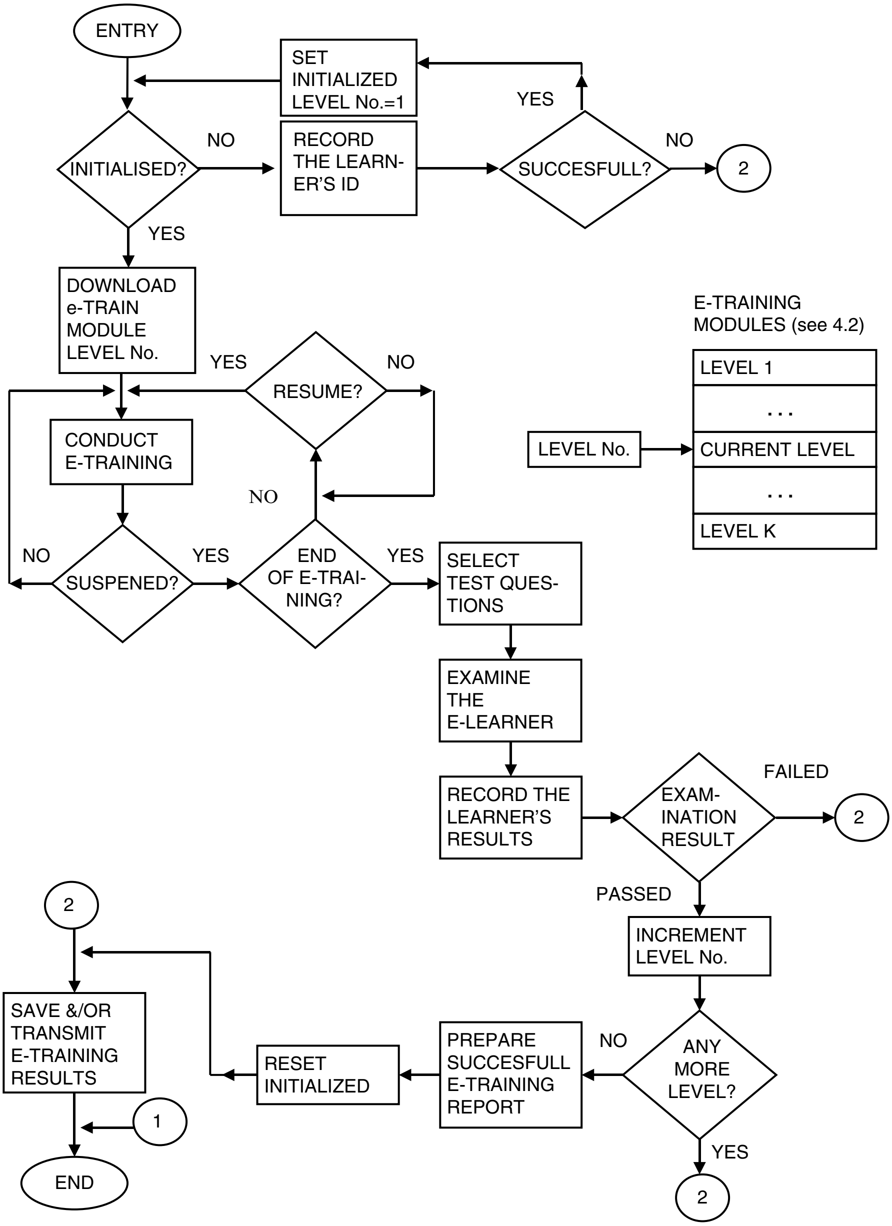


Fig. 8.17 General flow diagram of e-Train-Diabetes

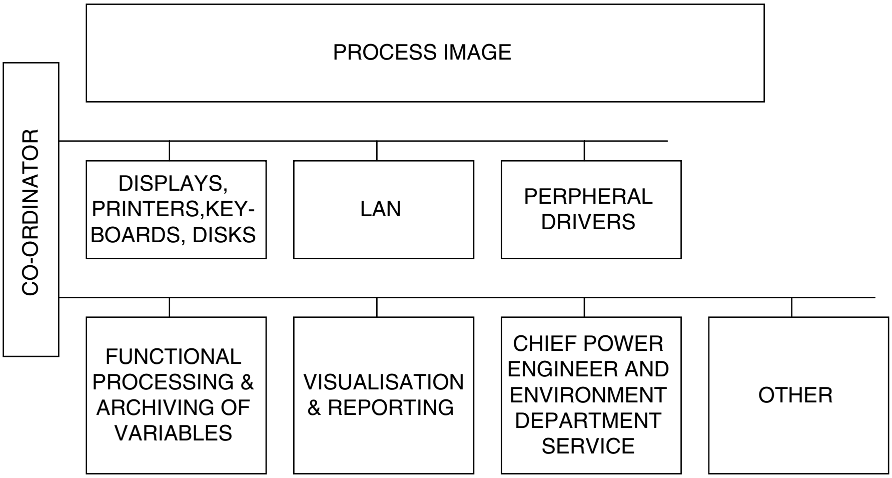


Fig. 8.18 Building automation system software architecture

systems described by time-delay members only (Lewoc et al. 2010b). The formulae for the basic robustness value, the Doyle's μ function, are given by Eqs. (8.1) and (8.2), with:

s: index of the star configuration
r: index of the ring (common medium) configuration
Δ: small perturbation
G: transfer matrix
ω: frequency
t_i: time delay limitation
τ_i: time delays
T_i: time delay components

The formulae are fairly simple, facilitating efficient evaluation of the robustness measures:

$$\mu_S(\mathbf{G}) = \left(\min_{i=1,\ldots,n} \sqrt{\mathbf{2}\left(\mathbf{1} - \cos\omega\left(t_i - \tau_i\right)\right)} : \mathbf{det}\left(\mathbf{1} + \mathbf{G}\boldsymbol{\Delta}_S\right) = \mathbf{0}\right) \tag{8.1}$$

$$\mu_R(\mathbf{G}) = \left(\min_{i=1,\ldots,n} \sqrt{\mathbf{2}\left(\mathbf{1} - \cos\frac{\omega}{i}\omega\left(t_i - \sum_{m=1}^{i} T_m\right)\right)} : \mathbf{det}\left(\mathbf{1} + \mathbf{G}\boldsymbol{\Delta}_R\right) = \mathbf{0}\right) \tag{8.2}$$

8.5.5 Ongoing Continuation of Leading Designer 4's Work

The design and implementation work of Leading Designer 4 are currently being continued, primarily by Leading Designer 5/Commissioning Engineer 1 and IASE (Lewoc et al. 2012). Leading Designer 5 gained her professional experience in the International Nuclear Research Institute in Dubna and at IASE, on the Badel project. Subsequently, a team of IASE designers and commissioning engineers transferred the solution for the operator level of Badel into the stand-alone system MASTER-ProSter. ProSter is a very large-scale system compared to the typical computer automation systems applied in other industries. For instance, it may be processing about 60,000 digital signals and several thousand analogue signals over a period of a minute. A typical ProSter automation cabinet is depicted in Fig. 8.19, and some graphical displays are shown in Figs. 8.20, 8.21, 8.22 and 8.23.

In the Badel project, Leading Designer 5 designed and developed the operator level communication subsystem and further developed this design specifically for ProSter. She was also an informal leading designer of the overall ProSter system. In addition, she has designed and implemented more than 50 software interfaces for power systems for other manufacturers, mainly ABB (Asea Brown Boveri) and Procom (a Polish power industry automation provider based primarily on engineers and programmers educated on the Badel project).

The ProSter system was very successful in the power industry in Poland. It won the contracts for implementation in more than 200 power plants and combined heat-and-power plants against very strong competition from some of the world's largest corporations providing high technology for the power industry. According to information supplied to the authors by the Badel project manager, Dr. Tomczyk, the ProSter installations have had significant benefits for Poland, valued to date at more than one billion euros.

In theory, the Polish regulations on implementation bonuses allowed the design and implementation teams comprising a few dozen people to share a bonus of about 100 million euros for their work. In practice, they received nothing. It is also worrying that this large sum of money seems to have disappeared without trace and meetings between leading designers and project managers were not able to elucidate what happened to it.

From the perspective of ethics, there are both individual and systematic factors. Individuals should behave ethically regardless of the temptations and whether or not other people behave ethically. However, collective support is important. Ethics is not just a matter for individuals but for society as a whole. It is much easier to behave ethically in a society which encourages ethical behaviour and does not present temptations to unethical behaviour. Education is also important. When educating the younger generation of designers, including Leading Designer 5, Leading Design 4 focused on technical competence and contributing to society. He was right not to encourage them to engage in battles for large bonuses, which are anyway ethically questionable and could probably have been better used to support other design projects to benefit the country and people of Poland or improve their salaries and conditions of work. However, he should probably have educated them to demand better salaries and conditions of work and transparency in all expenditure, including any bonuses.

Fig. 8.19 Front panel of an automation cabinet

8.6 Ethical Evaluation

The case studies involving Leading Designer 4 and ENES show that their approaches were based on solving relevant problems and using local technical and other staff. Consequently, they developed and empowered local experts and technically qualified people and contributed to the prosperity of the country, unlike the overseas

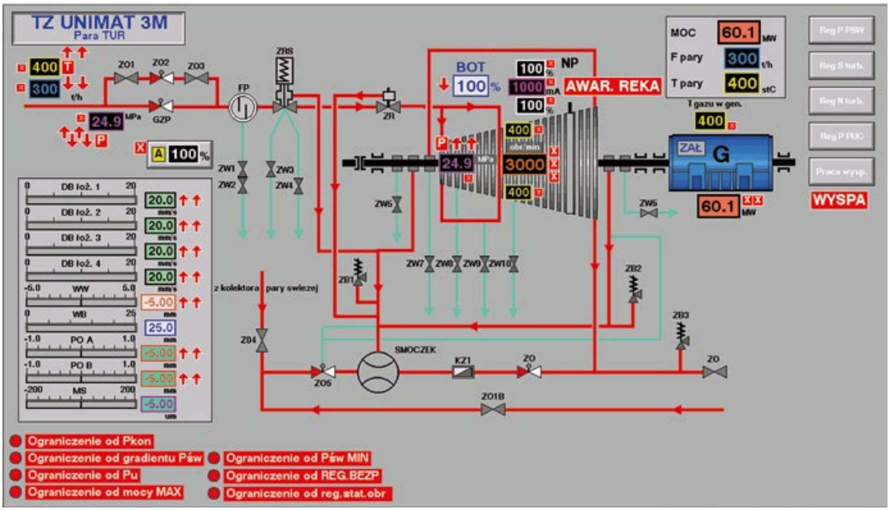


Fig. 8.20 Editable synoptic display of a steam turbine system

Fig. 8.21 Operator station plot window example

corporations, whose approach ignored and undermined local technical capacity. This is in accordance with various ethical theories (see Chap. 2). With regard to deontological ethics, the motivation and intrinsic virtue of their actions were positive, as they were based on developing local capacity. With regard to utilitarianism, the consequences of their actions were positive and, for instance, increased benefits

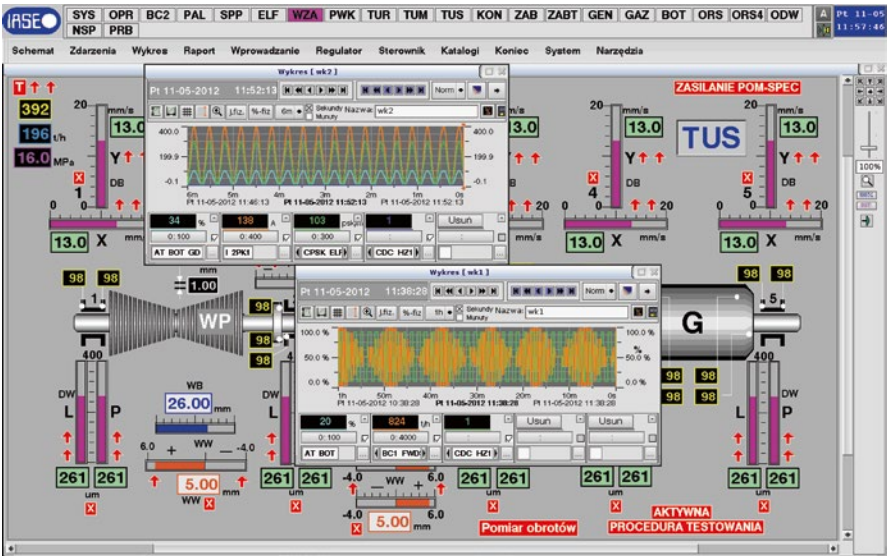


Fig. 8.22 Another operator station plot display example

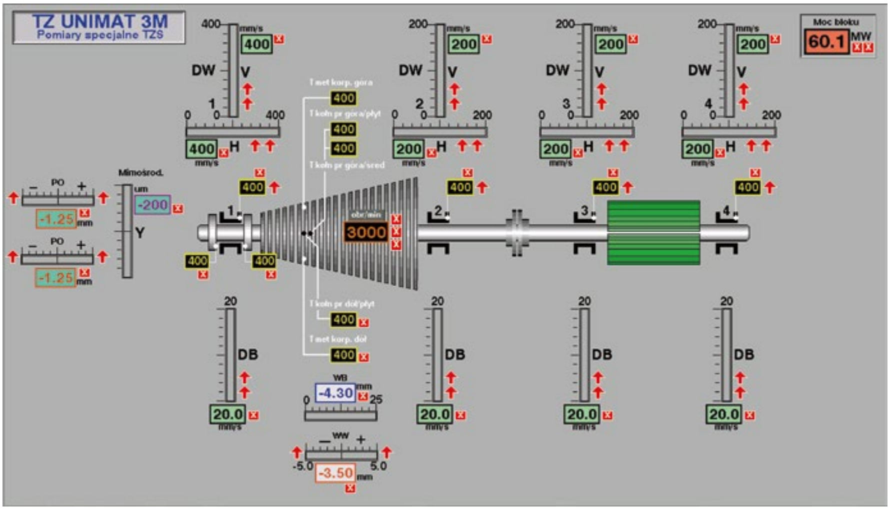


Fig. 8.23 Specific measurements for a turbine

to technically qualified people, users of the systems they developed and the country as a whole at minimum cost, as well as increasing the likelihood of future prosperity and reducing the risks of a political or economic catastrophe. In terms of rights ethics, their actions respected the rights of both technical experts and the people of the country to benefit from their expertise. In terms of virtue ethics, respecting local people and using their skills in a positive way are a sign of good character.

8.7 Suggestions for Survival and Ethical Behaviour in a Period of Brutal Technology Transfer

The large corporations involved in technology transfer have very significant financial, technical, political and other resources. As discussed above, they are often ruthless and not concerned about ethics, though they may be concerned about presenting a positive image. On the other hand, their lack of knowledge of local conditions is a disadvantage, and their lack of ethical behaviour can sometimes be counterproductive, for instance, as discussed above with regard to not using and even alienating the local technical experts.

It may seem very difficult for small local firms or individuals to have any chance of surviving in a situation of technology transfer dominated by these large corporations. However, these small local firms also have strengths on their side that they can use. In particular, they have knowledge of the local situation and a range of local contacts. They are also in a good position to find out what will work locally if they do not know already. While they may not be able to compete with large corporations with regard to pay and other benefits, they are in a position to treat their workers respectfully and enable them to use their technical skills. Small firms can also be more democratically and less hierarchically organised with everyone having a say in decision-making. All these factors can be attractive to potential employees and help small firms to obtain experienced and expert personnel, which is important for success. Individual technical experts are advised to find others with a similar perspective to provide mutual support and to exchange information and ideas. Collectives are generally stronger than individuals, and there is, for instance, a need for organisations of technical experts concerned about ensuring an ethical technology transfer process which benefits the majority and preferably the whole population.

Carrying out high quality work is also important. Small firms and groups of experts are in a good position to do this, whereas large firms which deliberately ignore the best local talent are unlikely to produce high-quality work. A certain amount of hard work is always necessary to achieve anything, particularly in the initial phases. However, there is also a need for an appropriate balance between work and other aspects of life. It is also not just a case of hard work but effective work. In general, even small organisations which employ the best local talent will work much more effectively than very large organisations which do not.

The nature of the overall technology transfer process is largely determined by the extent to which governments give over power to foreign corporations, which are largely motivated by profit and less interested in the development and prosperity of the countries they are transferring technology to. In the Polish case, a free market approach was very damaging and gave over too much control to foreign corporations leading to exploitation rather than benefits to the people of the country. Once such companies are given a foothold, it is much more difficult to dislodge them or at least reduce their influence and bring their activities under national control than if they had not been admitted or better controlled in the first place.

Local technical experts and other local personnel are advised to be very careful in their dealings with such corporations. This is particularly important in situations where there are no or only limited controls on these firms on the part of governments and other regulatory authorities. Such experts are advised to, if at all possible, aim to obtain employment from local firms or institutes. They are also in a potential position to draw on their technical expertise to support campaigns for greater national control of the technology transfer process and control and restriction of the activities particularly of large overseas corporations.

9 Conclusions

This chapter has drawn on the Polish experience to discuss ethical issues associated with the technology transfer process, as well as those associated with carrying out technical work in exploitative WPR (who has power is right) systems. These ethical issues have been introduced through case studies of the experiences of several leading designers of ICT and automation both before and after the political and economic changes which took place in Poland in 1989. The actions of some of the leading designers, authorities under the pre-1989 WPR system and large corporation post-1989 have been evaluated using some of the ethical theories presented in Chap. 2 of this book.

It should be noted that, despite the differences on the surface in their political and economic philosophies, there is considerable similarity between the behaviour of the pre-1989 authorities and the post-1989 large corporations. The results of the ethical analysis of their actions were also very similar. However, it should be noted that the experiences of leading designers post-1989 was even worse than that pre-1989. Pre-1989, most of them were at least allowed to lead one project before being pushed out, whether through promotion out of engineering and design or through bullying and harassment. Post-1989, they were not even allowed to lead one project and bullying and harassment started much earlier. Naturally, the prosperity of Poland suffered in both periods.

While a number of ethical theories are relevant to the experiences both pre- and post-1989, virtue ethics and the ethics of care are probably particularly relevant. Virtue ethics is about ethical behaviour which develops good character and which is typical of someone of good character. A narrow focus on self-interest at the expense of a whole country, never mind individual experts, is clearly not associated with good character. The ethics of care is based on maintaining relationships. The experiences both pre- and post-1989 showed a total lack of respect for technical experts and the country as a whole, as well as the relationships within design teams.

The case studies in this chapter relate to the specific experiences of leading designers in the area of ICT and automation in Poland. However, it is of much wider relevance to other domains of expertise and professionals other than leading designers. It can also be extended outside Poland, though some of the details will differ.

The literature on technology transfer, including its ethical aspects and good practice, for instance (Roberts 2000; Souder et al. 1990; Thrupp 1989; Wanderson 2003), shows that an ethical technology transfer process is possible. Unfortunately, as indicated by the Polish example, it frequently does not occur. The discussion also shows that it is feasible for technical experts to remain independent of large corporations and other exploitative systems and to carry out high-quality technical work. However, in such circumstances it can be important for these experts to be motivated by the work itself rather than any possible resulting rewards.

This chapter draws on work carried out within the framework of the International Federation of Automatic Control (IFAC) Supplemental Ways for Improving International Stability (SWIIS) Technical Committee (now TECIS 9.5). It brings together presentations given at SWIIS, IFAC and IFIP conferences (Izworski et al. 2001; Lewoc 2005; Lewoc et al. 2008a, 2009). The first work was presented at an SWIIS event in Vienna in 2001 and therefore too late to affect the experiences of the ICT and automation pioneers. The intention was rather to draw attention to the dangers associated with unethical technology transfer and change processes.

However, SWIIS and subsequently TECIS 9.5 also work towards bringing about change in the way technology is applied to ensure it benefits both humanity and the environment and improves international stability. This gives rise to the question of the potential role of TECIS 9.5 in ensuring ethnical technology transfer processes which benefit the people of the country the technology is transferred to rather than just large corporations.

References

Abramczyk A, Izworski A, Lewoc JB (2004) A case study: risks & challenges for training nurses in diabetes problems. In: Duquenoy P, Fisher-Huebner S, Holvast J, Zuccato A (eds) Second international summer school: risks & challenges of the network society. IFIP, Karlstad

Abramczyk A, Lewoc JB, Izworski A (2005) Nurse training case study: e-training of nurses in diabetes problem. Nurse Educ Pract 5(2):70–77

Argadona A (2003) The new economy: ethical issues. J Bus Ethics 44(1):3–22.

Bulz N. et al (2009) Inquiry on triad generosity-creativity-solidarity as a turning point within international crisis state: does creative partnership matter? In: Kopacek P, Dimitrachi I, Caramihai S (eds) IFAC SWIIS 2009, Bucharest. Elsevier, Oxford, pp 86–91

Bynum TW (2000) The foundation of computer ethics. ACM SIGCAS Comput Soc 30(2):6–13

Dimirovski GM (2001) Technology transfer to developing countries and technology development for social stability. In: Kopacek P (ed) IFAC/SWIIS ‘01, Vienna. Elsevier, Oxford

Doyle JC (1982) Analysis of feedback systems with structured uncertainties. Proc Inst Electr Eng D 129:42–50

Han M-W, Lewoc JB, Izworski A, Skowronski S, Kieleczawa A (2008) Power industry computer control system design and implementation problems: a case study. In: Chung MJ, Misra P (eds) The world congress of IFAC. IFAC, Seoul, pp 6703–6708

Hersh MA (2001a) Technology change, technology transfer and ethics. In: Kopacek P (ed) IFAC/SWIIS ‘01, Vienna. Elsevier, Oxford

Hersh MA (2001b) Whistleblowers – heroes or traitors? Individual and collective responsibility for ethical behaviour. In: Kopacek P (ed) IFAC/SWIIS ‘01, Vienna. Elsevier, Oxford

Hersh M, Stapleton L, Duffy D (2005) Application of narrative ethics to engineering. In: Zitec P (ed) IFAC world computer congress, Prague. Elsevier, Oxford

Izworski A, Lewoc JB, Piwowar B (2001) Some aspects of technology transfer – a case study. In: Kopacek P (ed) SWIIS'01 (IFAC), Vienna. Elsevier, Oxford

Jancev M, Cernetic J (2001) A socially appropriate approach for managing technological change. In: Kopacek P (ed) IFAC/SWIIS '01, Vienna. Elsevier, Oxford

Lewoc J (1971) Simulation of a computer control system. Appl Math XII:1–9

Lewoc JB (2005) Practical ethical aspects for technology transfer and change in computer control system development. In: Zitec P (ed) IFAC World Computer Congress. Elsevier, Oxford/Prague

Lewoc JB, Slusarska E, Tomczyk A (1989) A distributed data base for real-time control/monitoring of power plants. In: Knuth E, Rodd MG (eds) Distributed databases in real time control (IFAC/IFIP), Budapest. Pergamon Press, Oxford

Lewoc JB, Izworski A, Skowronski S (2006a) Control and supervision of combined heat and power systems: a case study of poland. In: Kopacek P (ed) SWIIS through automation ISA'06, Prishtina, Kosovo. Elsevier, Oxford, pp 83–87

Lewoc JB, Kieleczawa A, Izworski A, Skowronski S (2006b) Control and supervision of combined heat and power systems: a case study of poland. In: Kopacek P (ed) SWIIS through automation ISA'06, Prishtina, Kosovo. Elsevier, Oxford, pp 89–94

Lewoc JB, Izworski A, Skowronski S (2006c) An internal internet traffic modelling/performance measuring tool. In: Troch I, Breitenecker F (eds) 5th Vienna symposium on mathematical modelling MATHMOD. Agresim, Vienna, pp 91–99

Lewoc JB, Izworski A, Skowronski S, Kieleczawa A (2007a), Some problems with technology transfer in Lower Silesia. DECOM-TT. In: Dimirovski GM (ed) A proceeding volume from the 5th IFAC Workshop DECOMPT-TT 2007, Cesme-Izmir, Republic of Turkey. Dokuz Eylul University Press, Izmir, pp 261–266

Lewoc JB, Izworski A, Skowronski S, Kieleczawa A (2007b) A case study: an approach to building automation. In: Dimirovski GM (ed) A proceeding volume from the 5th IFAC workshop DECOMPT-TT 2007, Cesme-Izmir, Republic of Turkey. Dokuz Eylul University Press, Izmir, pp 415–420

Lewoc JB, Izworski A, Skowronski S, Kieleczawa A (2008a) A case study: history of Polish computer applications in power system control. In: Impagliazzo J (ed) History of computing and education 3 (HCE3), IFIP World Computer Congress, Milan. Springer, New York, pp 23–36

Lewoc JB et al (2008b) The role of IASE in design and development of pioneering ICT systems for the power industry in Poland. In: Józefczyk TW, Turowska M (eds) 14th international congress of WOSC, Wrocław, Poland. Oficyna Wydawnicza Politechniki Wrocławskiej, Warsaw, pp 946–954

Lewoc JB et al (2009) Technology proliferation and transfer ethical aspects: a case study of Wroclaw, Poland (2009). In: Kopacek P, Dimitrachi I, Caramihai S (eds) IFAC SWIIS 2009, Bucharest. Elsevier, Oxford, pp 12–17

Lewoc JB et al (2010a) Technology change and transfer costs: a case study of Poland. In: Kopacek P, Hajrizi E (eds) IFAC SWIIS 2010, Prishtina, Kosovo. Elsevier, Oxford

Lewoc JB, Izworski A, Skowronski S, Kieleczawa A, Dimirovski GM (2010b) Power generation/distribution control systems topology selection based on robustness evaluation. In: Mittinen K, Neittnmaki P (eds) IFAC workshop on control application of optimization, CAO'09, Jyvaskyla. Elsevier, Oxford

Lewoc JB, Izworski A, Skowronski S, Kieleczawa A, Czachórski T, Dimirovski GM, Ojleska V (2010c) A case study: performance evaluation for a computer integrated power plant network. In: Eurosim 2010 Congress, Prague

Lewoc JB et al (2011a) Social and political impacts of real time ICT systems and networks. a case study of Poland. In: Al.-Dabas D, Yunus SJ, Saad I, Giriantari D, Abraham A (eds) Computational systems and networks CICSyN 2011. IEEE, Bali, pp 205–208

Lewoc JB, Izworski A, Skowronski S, Kieleczawa A (2011b) Knowledge management collaboration case study: computer science technology transfer in Wrocław. In: IJIIP 2011, vol 2, no. 4, pp 32–39. Available at: http://dx.doi.org/10.4156

Lewoc JB, Izworski A, Skowronski S, Kieleczawa A, Dimirovski GM (2011c) Barriers to ethical behaviour: a case study of Poland. In: Bittani S, Cenedese A, Zampieri S (eds) 18th IFAC world congress, Milan. Elsevier, Oxford

Lewoc JB, Izworski A, Skowronski S, Kieleczawa A, Kopacek P (2012) Emerging smart engineering: an integrated manufacturing and management system. In: APMS (IFIP) conference, Rhodes

Maciejowski JM (1989) Multivariable feedback design. Addison-Wesley, Wokingham

Magebheim J, Schulte C (2006) Social, ethical and technical issues in informatics – an integrated approach. Educ Inf Technol 11(3–4):319–339

Nordkvelle YT, Olson J (2005) Visions for ICT, ethics and the practice of teachers. Educ Inf Technol 10(1–2):21–32

Roberts J (2000) From know-how to show-how? Questioning the role of information and communication technologies in knowledge transfer. Tech Anal Strat Manag 12(4):429–443

Souder WE, Nashar AS, Padmanabhan V (1990) A guide to the best technology transfer practices. J Technol Transf 15(1–2):5–16

Stahk BC (2009) Ethical issues of information and business (chapter 13). In: Himma KE, Tavani HT (eds) The handbook of information and computer ethics. Wiley, Hoboken

Tavani HT (2001) Information and communication technology (ICT) ethics: a bibliography of recent books. Ethics Inf Technol 3(1):77–81

Thrupp LA (1989) Legitimizing local knowledge: from displacement to empowerment for third world people. Agric Hum Values 6(3):13–24

Wanderson A (2003) Community science: bridging the gap between science and practice with community-centered models. Am J Community Psychol 31(3/4):227–242

Chapter 9
Rebuilding Hope in Post-conflict Regions: Telemedicine in Kosovo

Anita Kealy and Larry Stapleton

Acronyms

AUSA	Association of the US Army
CSIS	Centre for Strategic and International Studies
GT	Grounded theory
HIC	Humanitarian Information Centre
ICT	Information and Communications Technology
IVeH	International Virtual e-Hospital
KLA	Kosovo Liberation Army
KPC	Kosovo Protection Corps
MIS	Management information system
NATO	The North Atlantic Treaty Organization
NGO	Non-governmental organization
OECD	The Organisation for Economic Co-operation and Development
TCK	Telemedicine Centre of Kosovo
UNMIK	United Nations Interim Administration Mission in Kosovo
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
WHO	World Health Organization

Overview
Studies from both developed and developing regions show that developing and implementing medical informatics or e-health is becoming a crucial part of effective health care and health education. Developing and implementing large-scale, technologically enabled infrastructures such as health services is notoriously difficult,

A. Kealy (✉) • L. Stapleton
Centre for Information Systems and Technoculture, Waterford Institute of Technology, Waterford, Republic of Ireland
e-mail: akealy@wit.ie

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even in stable regions. Post-conflict regions are extreme situations with many additional complicating features for large-scale technology projects. This chapter sets out findings of a grounded theory case study of a successful, complex telemedicine ICT system project in Kosovo. A grounded theory case study was used to explore the success of the technology project, through the lens of Ciborra (Labyrinths of information: challenging the wisdom of systems. Oxford University Press, Oxford, 2002) who puts forward the theory that the technology was a guest and the organisation was a host.

1 Introduction

Post-conflict regions are territories where there has been a severe, recent violent conflict which has fundamentally destabilised a society; however, there is no accepted definition. Whilst the post-conflict situation may be stable (compared to all-out war), this stability may be fragile and tentative. Lund described an 'unstable peace' or 'negative peace' where tension and suspicion run high (Lund 1996: 11). Collier and Hoeffler (2002) define post-conflict regions as having experienced civil war in the last two decades and recorded some incidents of rebellion (incidents of rebellion defined as when people engage in violence where perceived or actual grievances are acute enough (Collier and Hoeffler 2004). Junne and Verokren (2005) identify post-conflict as a 'conflict situation in which open warfare has come to an end. Such situations remain tense for years or decades and can easily relapse into large-scale violence'. Brahimi (2007: 3) describes post-conflict as 'an absence of war, but not necessarily real peace' adding that 'the end of fighting does offer an opportunity to work towards lasting peace, but that requires the establishment of viable institutions, capable of ensuring lasting security for the entire Population' (Brahimi 2007: 3). Walter (2010) found that the likelihood of recurrence of conflict in a region has increased dramatically since the 1960s where 43% of conflict occurred in a region with previous conflict, to the 2000s where this figure rose to 90%. Post-conflict regions include Rwanda, Sierra Leone, Sudan and Angola.

Post-conflict regions comprise a particular set of features which differentiate them from other, more stable, regions. The Organisation for Economic Co-operation and Development (OECD) for conflict, peace and security spending was US $1868 million in 2006, rising to US$ 3545 million in 2012 (OECD 2014). A large portion of donor funding is dedicated to providing important medical and related services to those injured in the conflict, whilst simultaneously re-establishing a working health system for the ongoing medical needs of the population. In the aftermath of a major conflict, health service infrastructures are severely damaged. The opportunities provided by the need to rebuild the collapsed economy and infrastructure should make aid particularly effective in the post-conflict years (Mallaye and Urbain 2013).

E-health is the 'use of information and communications technologies (ICT) in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research'

(WHO 2005: 2). Studies from both developed and developing countries show that developing and implementing medical informatics or e-health is becoming a crucial part in providing patient-friendly access to efficient, effective health-care services. Information technology and the Internet access are crucial to this development and implementation (Harteloh 2003; Chiasson and Davidson 2004; Gonzalez et al. 2006; Chiasson et al. 2007; Blaya et al. 2010; Chen et al. 2013; Sultan et al. 2014).

Systems engineers have an important role to play in setting up sustainable health systems which can provide for health services in post-conflict regions. A sustainable health system contributes to the stability of the region and helps reduce the likelihood of a return to conflict. In spite of this the systems engineering literature has largely overlooked post-conflict regions as a particular context with special features.

Developing and implementing large-scale, technologically enabled infrastructures such as health services is notoriously difficult, even in stable regions. Post-conflict regions are extreme situations with many additional complicating features for large-scale technology projects. What are the features of a successful advanced technology project aimed at providing important medical services?

The primary contribution of this study is to set out factors present in the case organisation which have received little attention previously and which were important in the successful implementation of a large-scale telemedicine system in the Balkans. The study shows that the post-conflict context loads additional factors into an already complicated systems development process. Particularly important factors include the relationship between the technology project and underlying human processes at work. This has implications for our understanding of the dynamics of systems development generally and in post-conflict, developing regions in particular.

2 Conflict in Kosovo

The significance of Kosovo in the expression of the Serbian identity can be traced back to the Battle of Kosovo in 1389. In this battle Serbian forces were beaten by Turkish forces, on a battlefield which lies just 5 km north of the Kosovo capital Pristina. This battle and the myths and legends that surround it are at the heart of Serbian identity. During the centuries which followed, Kosovo came under Serbian rule, the Ottoman Empire and later became part of the new state of Yugoslavia after World War I (Wilson 2009).

Albanians began to move into Kosovo in large numbers in the fifteenth century, and by the late seventeenth century, with increasing Ottoman Empire activities, many Serbs had left the region and relocated north to Belgrade, now the current capital of Serbia. During this time the population of Kosovo was very low, and many Albanians resettled the region.

The early nineteenth century saw the beginning of a stronger Serbian presence in Kosovo, and at the end of the first Balkan war in 1912, Serbia were in control of the region. This led to much anti-Serbian feeling in Kosovo from the now majority Albanian community.

After World War I (1914–1918), the state of Yugoslavia was formed. Yugoslavia consisted of the republics of Serbia, Croatia, Slovenia, Montenegro and Macedonia. Kosovo remained an integral part of Serbia. At this time it is estimated that 64% of the population were Albanian.

During World War II (1939–1945), Germany had conquered Kosovo, but it was put under Italian control along with Albania. As the war neared a conclusion, Albania and Kosovo came under German control. The Albanian community increased as Serbs fled. In the aftermath of World War II, Serbs who had fled were not allowed to return.

The end of World War II marked the beginning of the communist era in Kosovo, as Tito (Josip Broz Tito: 1892–1980) came to power. Kosovo was defined as an autonomous region of Serbia, under Yugoslav rule. Diplomatic ties to Albania were cut in 1948 and closer ties built with Russia.

Albanian nationalism within Kosovo increased in the decades which followed. Throughout this time Serbs continued to leave the region, and Albanians to move into the region (Malcom 1998).

Kosovo retained a high level of autonomy up to the late 1980s, with estimates of between 80 and 90% of its population ethnic Albanian (Ron 2001; Wilson 2009). In 1989–1990 the issues arising from the disintegration of Yugoslavia resulted in the abolition of Kosovan autonomy. Many of the regions in different provinces accused each other of discrimination, violent unprovoked attacks and political repression. This era was marked by a celebration of the 600th anniversary of the Battle of Kosovo, during which the Serbian leader Slobodan Milosevic made a speech at the Gazimestan monument (a tower built in 1953 to commemorate the Battle of Kosovo which took place in 1389) to rally Serbian nationalist feeling. Anti-ethnic Albanian sentiment escalated, Kosovan Albanian public servants were removed from their posts, and a repressive society resulted for the next decade (Kubo 2010). Kosovan Albanians set up parallel systems such as education, medical care and a shadow government, but were effectively cut off from the outside world.

When the international community brokered the Dayton peace talks to stop the violence which had broken out throughout Balkan region in the 1990s, the issues in Kosovo were not addressed. This led to frustration amongst Kosovan Albanians that the non-violent resistance was not leading to change. During this time the Kosovo Liberation Army (KLA) emerged. Opportunity arose to acquire previously unavailable arms from neighbouring Albania in 1997. This was due to the collapse of the Albanian government following the collapse of a pyramid investment scheme. This led to chaos, and vast quantities of looted arms and ammunition became available (Kubo 2010).

The conflict between ethnic Albanians and Serbs escalated in 1998–1999. An estimated 100,000 people were ethnically cleansed from the region within a few weeks in 1999. Many people became the victims of genocide. Mass graves have been discovered, and thousands of people are officially missing (Krähenbüh 2000). The North Atlantic Treaty Organization (NATO) led a military campaign in March 1999 to drive Serbian forces from the region and end the conflict. The conflict officially ended in June 2000. Kosovo was placed under the UN administration.

The KLA were disbanded, but many of them were retrained as the Kosovo Protection Corps (KPC) (UNMIK 2009). Following the collapse of negotiations between Belgrade and the largely pro-Kosavan Albanian civil administration in Pristina in the late 2007, Kosovo declared independence in 2008, with a new constitution coming into force on 15 June 2008. As of 2013, there is still a strong UN presence in Kosovo.

3 Post-conflict Need for Hope

The immediate post-conflict situation in Kosovo found people striving to escape the horror of war and to find some sense of normality. The region was in severe economic and political turmoil. There was also the continuing threat of violence or of tensions re-escalating (Turner et al. 2008; Lund 1996). A post-conflict society is a traumatised society. Cardozo et al. (2000) conducted a study in the early post-war Kosovo, which found that 25% of the adult population over the age of 15 showed signs of post-traumatic stress and rising levels of anxiety and depression. Research by Farran et al. (1995) has shown that hope is an essential element in coping with adverse events. Opposites of hope are hopelessness, helplessness, despair and depression. In extreme circumstances, for example, mass social inequalities, the aftermath of war or genocide, entire societies may struggle with a deep sense of a loss of hope.

Frankl (2004) found that one human trait is to survive by looking to the future. He termed the need to have something or someone to live for as 'the self-transcendence of human existence' (Frankl 2004: 115). This encompassed the idea that if a person, regardless of the extreme circumstances they are exposed to, can find hope in finding a meaning to their existence: either a task to fulfil or a person other than themselves to care for. This hope for the future could be found through elements of a 'normal' life: family, sociocultural activities, religion and participation in economic activities (Summerfield 2002).

ICT can have an impact in the immediate aftermath of the conflict and in the rebuilding post-conflict. ICT can sustain the process of peace building and 'empower grassroots communities and bring cohesion to a range of activities on multiple tiers that are an intrinsic part of peace building and conflict transformation' (Hattotuwa 2004: 52). The Centre for Strategic and International Studies (CSIS) and the Association of the US Army (AUSA) developed a framework for tasks necessary for reconstruction in a post-conflict region. These are referred to as the four pillars of reconstruction: security, justice and reconciliation, social and economic well-being, governance and participation (CSIS/AUSA 2002). Examples of ICT that can assist in carrying out these tasks include Humanitarian Information Centres (HICs), which are run by the UN Office for the Coordination of Humanitarian Affairs (OCHA). These are established in conflict and post-conflict zones and are open access. HICs provide information resources to coordinate non-governmental organizations (NGOs), the UN and government actors. Information resources for planning, assessing and implementing humanitarian assistance can include contact lists, maps, databases, incident reports, etc. Examples include the Sierra Leone Information System (March 2001–January 2004), a management information system (MIS) to organise previously collected data and the Humanitarian Information Centre for Darfur (July 2004–May 2006) used to provide technical assistance to the humanitarian community involved in relief efforts in the region (HIC 2014). The 'Justice System Programme' in East Timor provided an electronic case management system for the office of East Timor's Prosecutor General. This was one of many e-government systems implemented in East Timor (UNDP 2010). Mobile phone technology, along with the Internet and social media, is also having a huge impact in rebuilding after conflict. Applications (Apps) can be used to share information, even distribute food vouchers, as a pilot programme in Iraq aimed to do in 2009. A mobile money platform M-Pesa, successfully introduced in Kenya in 2007 to facilitate microfinance, was also rolled out in Afghanistan (OECD 2013).

4 The Organisation as a Host

The metaphor of hospitality allows for the study of the interaction between two previous strangers, a host organisation and technology, and the effects on them of the interaction. Derrida (1996) conceptualises hospitality, as '…opening up my home … and give, not only to the foreigner (guest), but to the absolute, unknown, anonymous other, and that I give place to them, that I let them come, that I let them arrive, and take place in the place I offer them, without asking of them either reciprocity (entering into a pact) or even their names' (Derrida 1996: 25). Ciborra (2002) argues that ICT is more than a combination of hardware and software. ICT creates a backdrop for human actors that work with it and can both reflect and impact on the organisation it has become part of. Ciborra (2002) goes on to compare adoption of ICT to the interaction of a host and a guest, where the hosts are the organisation, company or facility which is adopting the technology and technology is the guest (Ciborra 2002). By hosting the technology two previously unknown worlds are linked. The foreign visitor has the ambiguity of a stranger: it is either a friend or an enemy. By accepting the stranger the host and guest are both reaching across a boundary, but that boundary remains in place. This acceptance of the stranger can also help the host build a new identity (Ciborra 2002).

The hosting process reveals a number of features:

1. Hosting technology successfully will redefine the identity of the host: successful hosting creates symmetry between the host and the guest; when the host becomes the server of the guest, they adopt rituals to do so, which are culturally dependent.
2. Any attempt to control the technology leads to failure – this can be seen in unexpected results. The concept of cultivation (Dahlbom and Janlert 1997) suggests that if a developing and adopting technology is a natural process which needs support and monitoring, control of the technology is impossible. According to this approach, technology can be shaped by the culture in which it is adopted into.

3. Different cultures have different codes, norms and rituals for hospitality, the technology must accept them. Callon (1991) argues that if the cultures of the host and guest are too far apart, mediators play a crucial role.
4. The technology has a right to visit but not to stay (the right to say yes or no to technology).
5. If the technology is perceived as hostile, the host will treat it as an enemy: communication across languages and cultural modes could lead to misunderstandings. The ambiguity of the guest can exacerbate this Ciborra (2002: 113).

Are these features present in a successful post-conflict large-scale technology adoption? Is hope a feature of this success?

5 History of Telemedicine Centre of Kosovo (TCK)

The first phase of Telemedicine Centre of Kosovo (TCK) was funded by the European Agency for Reconstruction and was opened in 2002. The centre was located on the fifth floor of the emergency building of Pristina University Clinical Centre. The second phase of the centre was funded by the Bureau of Educational and Cultural Affairs of the US Department of State. This was inaugurated in 2007 and consisted of regional centres around Kosovo; in Mitrovica, Peja, Prizren, Gjilan and Gjakova; and later a main family centre in Skenderaj which link into the main centre in Pristina. Plans to expand the project to other parts of the Balkans have been realised, with the opening of 14 centres in neighbouring Albania. There have also been successful expansions into other regions such as Cape Verde in Africa (IVEH 2013).

Due to the conflict many of Kosovo's basic infrastructural, medical and educational needs had been adversely affected. Doctors may not have been fully aware of medical issues suffered by a patient, for a variety of reasons: printed medical literature was out of date and was difficult to access for many years due to ethnic segregation and conflict in the region. There was no access to the Internet or any online journals or databases. Doctors had no access to surgery or in-hospital experience during their training. For many years Kosovan Albanian doctors were excluded from medical education and practice on ethnic grounds. Hospital access was difficult for remote patients due to infrastructure collapse.

The Telemedicine Centre of Kosovo (TCK) provided basic but up to date medical care and education facilities to a severely under-resourced region. Medics could attend lectures and view surgery live via e-conferencing facility. Access to online search engines and email was provided by the e-library. Training and access were provided to gain access to online medical journals. Equipment (called 'MedVizer') to consult with doctors via online links and to obtain and share patient data was also available.

6 Methodology

Grounded theory (GT) and the single case study are established research approaches in ISD research (e.g. Ovaska and Stapleton 2010; Matavire and Brown 2008). Grounded theory generates theory from data and is classified as an inductive approach to theory building. Data may be gathered through interviews, questionnaires, observations, documentation, images, video, etc. The researcher enters their chosen field and collects data and induces theory from that data (Corbin and Strauss 2008). According to Robson (2002), the researcher typically makes a series of visits to the field, until analysis of the data has reached a point where no new information from the data is gleaned (called 'saturation' in GT).

Grounded theory and the single case study were the methodologies chosen to investigate if the effects of hosting the technology were present in a successful post-conflict large-scale technology adoption and if hope was a feature of this success. The investigation is of the telemedicine centre itself and the technology which formed an intrinsic part of the centre.

To date the researchers have conducted three visits to the Telemedicine Centre of Kosovo. The principal researcher was a PhD candidate, from the southeast of Ireland. The second researcher was the research supervisor of the principal researcher and also from the southeast of Ireland. The principal researcher had no previous connections to Kosovo; the second researcher had conducted research in the region previously. Both researchers contributed to this research. The language used for all interviews was English. All interviewees at the centre were Kosovan Albanian. No interpreter was necessary as the interviewees had sufficient English language (to be accepted to work at the centre, English language was required). This did not limit the choice of respondents. As the interviewees were non-native English speakers, some minor grammatical errors in interviewee responses were corrected in the presentation of the findings. More detail on this is covered in Kealy and Stapleton (2012a, b).

The ethnic division in the region was also highlighted by the absence of Serbian and other ethnic minorities at the centre.

It was evident in stories which told of a reluctance of, and difficulties for, different ethnic groups to take advantage of the full range of TCK services despite TCK's willingness to engage with ethnic minorities, 'TCK is free for all…including all minorities…and its resources have been in use for all minorities in Kosovo apart from Serb minority…although in few occasions we did have them as well participating to a lecture presentation' (male doctor and director). Their reluctance to engage was described by interviewees as 'one hundred percent political barriers', 'fully political issue' and 'I have had much contact with ethnic groups – when political issues rise from their side it is problem' (male doctor and director). This perception was corroborated in the fact that Serbian medical personnel were reported to have needed permission (which was denied) from Serbian authorities in Belgrade to engage with TCK, 'Serbs in Mitrovica rejected us we must connect to Belgrade' (male doctor and director). In spite of these tensions, moves were made by TCK managers to engage Serbian doctors. In the early days of the e-learning facility, some Serbian doctors attended lectures at the centre, only to fall away later. One interviewee described meeting 'colleagues from Serbia' at a medical conference in Austria in 2008 and their surprise that she graduated in the Serbian capital Belgrade in 1992, 'In Austria I met colleagues from Serbia, they asked where I graduated, they were surprised' (female doctor). There was no knowledge if telemedicine was even in Serbia; they had no way of knowing, 'as for Serbia, I am not sure, but we do not have access' (female doctor). Because of these issues all interviewees from the study were Kosovan Albanian only. The interviewees admitted it is a difficult situation for all involved. Referring to the ethnic tensions between Serb and Albanian, one interview described that it is 'not easy for them or us' (male doctor and director).

The ethnic divisions in the region are reflected in the data gathered in this study. In spite of the attempts TCK described to reach across ethnic divides, especially to Serbs, Serbian interviewees were not available. We can speculate that Serbian or people of other ethnicities might respond differently to technology, but as all interviewees were from the Kosovan Albanian community, it was not possible to gather evidence on this point during this investigation.

6.1 *Visits to Telemedicine Centre of Kosovo*

The following section details the three visits carried out by the researchers to date. Summaries of the visits and interviews are listed in Tables 9.1 and 9.2.

Visit One: The Telemedicine IT team provided a tour of the facility to both researchers, in Pristina, including a detailed view of the technology involved in the

Table 9.1 Visit summary

Visits	Date	Activities
1	November 2008 (5 days)	Tour of facilities in TCK Pristina
		Short interview in TCK Pristina
2	November 2009 (1 week)	Tour of facilities in TCK Pristina
		Interviews with a variety of personnel at TCK Pristina
		Tour of facilities in Gjakova
		Interview with personnel in Gjakova
3	October 2012 (1 week)	Tour of facilities in TCK Pristina
		Interviews with a variety of personnel at TCK Pristina (including new interviewees and those previously interviewed)
		Visit to Gazimestan monument
		Visit to Serbian enclave and monastery of Gračanica
		Tour of facilities in Gjakova
		Interview with personnel in Gjakova

Table 9.2 Interview summary

Visit number	Interviewee	Location	Researcher present	Duration in hours
1	Tour with IT manager	TCK facilities – Pristina	Principal and second	1
	Coffee	TCK, coffee room, Pristina	Principal and second	.5
2	Tour with IT manager	TCK facilities – Pristina	Principal and second	.5
	Interview with IT manager	Executive director's office, TCK, Pristina	Principal and second	1
	Interview with executive director	Executive director's office, TCK, Pristina	Principal and second	1
	Interview with e-librarian	e-librarian's office, TCK, Pristina	Principal	1.5
	Gjakova: interview with female doctor	Telemed room – Gjakova hospital	Principal	2
	Gjakova: photos + tour	Gjakova hospital	Principal	.5
	Car journey to Gjakova		Principal	2
3	Interview with executive director	Executive director's office, TCK, Pristina	Principal	1.5
	Interview with director of programme development and monitoring			
	Interview with director of programme development and monitoring	Director of programme development and monitoring's office, TCK, Pristina	Principal	1
	Interview and tour with IT worker	IT worker's office, TCK, Pristina	Principal	2.5
	Interview with e-librarian	e-librarian's office, TCK, Pristina	Principal	3
	Gjakova: interview with female doctor	Coffee shop outside of Gjakova	Principal	2.5
	Gjakova tour	Gjakova hospital	Principal	1
	Interview with IT worker	IT worker's office, TCK, Pristina	Principal	1
	Interview with IT manager	IT manager's office, TCK, Pristina	Principal	1
	Interview with executive director	Executive director's office, TCK, Pristina	Principal	1

project. The finished system consisted of a server room with multi-conferencing capability for up to 25 users, grade 5 level server with 1.5 terabytes capacity. A teleconferencing room complete with all of the facilities needed to teleconference to other centres is located around Kosovo, Europe and the USA. The telemedicine room itself consisted of the telemedicine unit called MedVizer. This device had a vital signs monitor, could measure blood pressure and has many peripheral devices, all accessible through MedVizer software, including a camera for documents that can then be sent ‘live’. The main feature was a camera and computer screen, which provided a link to other hospitals/surgeries to create a ‘virtual’ consultation facility. This also connects to the emergency room located on the ground floor of the University Clinical Centre. There were also an e-library and a lecture theatre consisting of teleconferencing facilities, for ongoing education and training. This tour lasted for 1 h. Open interviews were conducted during and after the tour, with both the IT team and the executive director who were on-site. At the end of the tour, the researchers spent a 30 min coffee break with the IT team. The visit provided the opportunity to observe the location and surrounds of the telemedicine centre, as well as insights into the environment where the telemedicine centre was based. It also provided an insight into the team working with telemedicine and how the organisation and the technology interacted. Visit One is summarised in Tables 9.1 and 9.2.

Visit Two: A semi-structured interview protocol was then developed based on analysed data gathered in the first set of interviews. Themes for these interviews introduce a new system, culture and ethnicity, post-conflict context, relationships and power and shifting perceptions. This provided a basis for the second set of interviews in Visit Two. Visit Two is summarised in Tables 9.1 and 9.2. Four key players participated in the second set of interviews, the executive director, who was interviewed in his office for 1 h. The IT manager (who was present for some of the executive directors’ interview) was then interviewed alone for 1 h. Both researchers were present for these interviews. Following this an e-librarian in the Pristina centre was interviewed by the principal researcher at his office in the e-library for 1.5 h. The lead doctor from the hospital in the city of Gjakova (1 h car journey from Pristina) was interviewed in her telemedicine room, as seen in Fig. 9.1. This interview involved tour of the facilities in Gjakova, which took 30 min. The interview itself lasted 2 h; again the IT manager was present for some of this interview. This interview was also carried out by the principal researcher only. Documentation (an unpublished paper on the centre and an information leaflet on the centre) and over 80 photos of the centre and the surrounds of the hospital in both Pristina and Gjakova were also gathered. Video was also taken of the entrance to the telemedicine centre. This visit lasted one week in total.

Visit Three: The data from the second visit was analysed, and findings led to the next set of semi-structured interviews, to enable the researchers to further explore the centre and reach saturation point. Themes for these interviews were the technology at the centre, staff, hope and conflict. Visit Three is summarised in Tables 9.1 and 9.2. The third set of interviews was conducted by the principal researcher only. The executive director was interviewed for 1.5 h, sometimes in the presence of the director of programme development and monitoring. The director of programme development and monitoring was then interviewed separately for 1 h. The researcher then had a tour of the facilities and an interview with an IT worker who had not been previously interviewed. This lasted in a total of 2.5 h. The e-librarian was then interviewed for 3 h in his office and in the e-library. Follow-up interviews with the

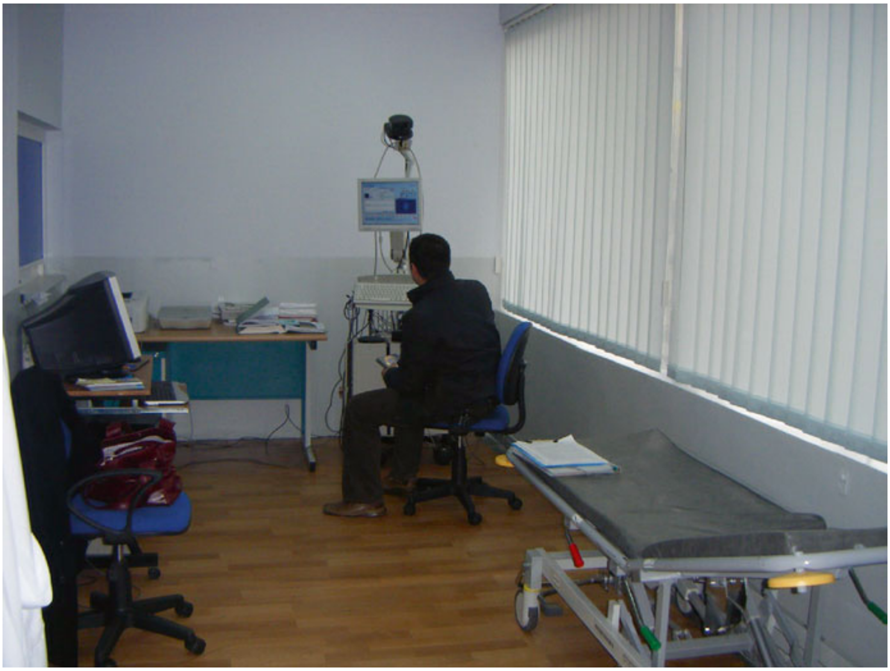

Fig. 9.1 Telemedicine room in Gjakova

executive director and the IT worker lasted 1 h each, both interviews took place in their offices. The IT manager was interviewed for 1 h in his office. The researcher revisited the city of Gjakova to interview the lead doctor in the facilities there. This tour and interview lasted 2.5 h. Visit Three also included a visit to the Gazimestan monument, 7 km outside Pristina, and a visit to Serbian enclave and monastery of Gračanica, also a short distance from Pristina. Over 180 photos were gathered, and documentation for equipment ordered was also made available to the researcher on this visit which lasted 1 week.

Data from these visits was analysed. The findings from this analysis are detailed in the next section.

7 Findings

Ciborra (2002) put forward five features of the host revealed by hosting technology, and these are the order in which the findings are presented:

1. Hosting technology successfully will redefine the identity of the host.
2. Any attempt to control the technology leads to failure.

3. Different cultures have different codes, norms and rituals for hospitality, the technology must accept them.
4. The technology has a right to visit but not to stay (the right to say yes or no to technology).
5. If the technology is perceived as hostile, the host will treat it as an enemy Ciborra (2002: 113).

In this case study the staff of the centre and medical community are the hosts, and the centre itself and the technology it contains are the guests. Some of the staff could also be seen as mediators between the doctors and the guest.

7.1 Hosting Technology Successfully Will Redefine the Identity of the Host

The importance of hope was evident in the comments from the interviewees. During the conflict they could only hope for change in their circumstances, 'we knew and hoped something is going to change', 'hope was all we had left' (*male IT manager*). The IT manager described the region as being in a *dark place* during the conflict, with nothing left but hope. The telemedicine centre and the technology that were part of it provided a tangible purpose to the people who took part in building it. By installing equipment, encouraging doctors to engage with the centre and the technology and running it from day to day, they were no longer victims of war; hoping for better things, they were workers in a cutting edge facility. Improving the medical education and facilities for patients was a visible sign of change that had been previously hoped for.

When the centre first opened, some doctors were described as being fearful that the gaps in their training could be exposed by using it, 'afraid of not knowing what they should know' (*male IT manager*). The technology was so new and such a leap forward for a medical system that had been isolated for over ten years that it was described as science fiction; however, as confidence grew the use of the technology in the centre was described as a normal part of a doctor's working life, 'Is not science fiction any more – it is part of what they do' (*male IT manager*).

The educational advantages of the technology redefined how the doctors could carry out their work; access to journals and new literature encouraged them to keep using the centre, 'this brings them back' (*male doctor and director*). 'Then told about lecture happening, they come back one after another' (*male doctor and director*). The doctors recruiting each other could be argued as the host becoming a server of the guest, bringing their colleagues in to use the technology. The technology also assisted in building new connections with other doctors, 'very interesting to have a second opinion with colleagues' (*female doctor*). This allowed for continuous medical education (CME).

7.2 Any Attempt to Control the Technology Leads to Failure

Evidence also suggested that the freedom of doctors to engage with telemedicine in their own way contributed to the success of the centre. Whilst the workers at the centre provided training and seminars, doctors learned how to use the technology but then used it according to the environment they were in. Doctors spoke of colleagues who used their mobile phones to consult with their peers, some using technology from the centre, 'Saw colleague take ultra sound in phone and send to colleague – was surprised – but people are using these things' (*female doctor*). The director also used his mobile phone to consult with a doctor in neighbouring country Albania, 'smart phones and camera phones developing so fast' (*male doctor and director*). The female doctor also discussed a case where she consulted with a dermatologist in Turkey about a patient, and how she could use the link she had built with them to work around the cost of using the 'official' equipment, 'Cost to use Vital net but email no costs' (*female doctor*). The doctor could use the knowledge she had learned working with telemedicine but was able to choose how she utilised the technology and make it work for her situation.

7.3 Different Cultures Have Different Codes, Norms and Rituals for Hospitality, the Technology Must Accept Them

The telemedicine centre was conceived at a time of great upheaval and conflict in Kosovo. Following 10 years of segregation and a conflict ended by a US-led North Atlantic Treaty Organization (NATO) bombing campaign, there was a sense of freedom and the beginnings of independence. This is reflected in the attitudes of doctors to the technology. One doctor who embraced the new technology described the introduction of the Internet through the telemedicine centre in terms of freedom and being able to consult with doctors worldwide, 'Internet, the idea you are free. Then international symposium – good for you – you can consult doctors in another part of the world' (*female doctor*).

The female doctor stressed the importance of hope and the role of technology in providing it, 'Telemed – provides link which gives knowledge which gives hope'. She also highlighted the importance of not giving up and the need for 'Constant hope and motivation – the future is in technologies, no reason to go back or to be disappointed' (*female doctor*). The lack of access to medical education prior to and during the conflict, and the culture this created, can be seen in the different reactions to the telemedicine centre. For some doctors the technology represented knowledge and hope, and it was welcomed as such. For other doctors it was a something to tolerate and partially use, but not fully embrace. The doctors who reacted to the technology in this way were described as proud. Their choice of interaction with the centre and the technology within it was to not interact, 'very proud professors do not come to telemed' and 'email so they do not have to come here' (*male trainee doctor and e-librarian*).

The workers and doctors available to the researcher were all Kosovan Albanian; after the war in the region, the Albanian and Serbian communities were much divided. The centre and the technology were introduced at a very sensitive time, 'not easy for them – us' (*male doctor and director*). Where mediation between the workers at the centre and the doctors played a role in closing the gap between the medical community and the technology in the centre was not as successful with the Serbian medical community, '100% political barriers', 'fully political issue' (*male doctor and director*). Initially there was interest from the Serbian medical community, 'Serbian doctors nurses came to lectures but not as much'. However, permission was not granted from the Serbian authorities in Belgrade, 'So keen to have this but had to get green light from Belgrade' (*male doctor and director*).

7.4 The Technology Has a Right to Visit but Not to Stay (the Right to Say Yes or No to Technology)

The interviewees who embraced the technology described it as a tool to be used if they wished to use it, demonstrating their right to say yes or no to the technology, 'More than an Internet connection – can be very useful good tool in our hands as a doctor. I can see professor in Tirana, talk to them, consult with them if I have the desire' (*female doctor*). The female doctor also described how they could use email to consult with doctors in other countries rather than more expensive specialised equipment they had been exposed to in the earlier days of the centre, 'costs to use Vital Net, but email, no costs' (*female doctor*).

7.5 If the Technology Is Perceived as Hostile, the Host Will Treat It as an Enemy

The doctors who embraced the technology saw it as a means to educate themselves in their chosen medical field and be part of a previously longed-for future. There was no perceived hostility. Before the war there was no means for the Kosovan Albanian community to obtain a complete medical education, 'Pre-war we were in a deep sleep – not well educated as country with someone on top of you'. The telemedicine centre and the technology within it became a means to obtain this education, 'This (telemedicine) is a sign that we are in the future', 'enables you to think deeply, this is the future of the world' (*female doctor*).

Working at the centre allowed them to be part of the rebuilding for the future of Kosovo. This rebuilding went beyond medical future; the benefits were educational and cultural also, ‘everything comes – clinical educational cultural – back to benefit’ (*male doctor and director*), ‘benefits are huge’ (*male IT manager*).

There was evidence of doctors who did not want to engage with telemedicine perceiving the new technology as an enemy. It was reported as a fear of using the technology, ‘fear of using this high technology’ (*female doctor*). Older doctors reacted by holding onto their way of doing things, ‘impose their own way – this is like this, you cannot tell me otherwise’ (*male trainee doctor and e-librarian*).

The power that older doctors had over their younger colleagues was also a factor in the perception of the technology. Whilst the older established doctors had depended on outdated books, the newer technology-driven doctors were engaging with the technology, ‘seminars done by young assistant professors more up to date but exam must be taken from old books....and must be word for word’ (*male trainee doctor and e-librarian*). This influx of new information could also provoke problems between older and younger doctors, ‘cases where younger professors got very up to date information older professors became jealous and afraid of him – more famous than him’ (*male trainee doctor and e-librarian*).

8 Conclusions

The successful implementation of a large-scale ICT project in a post-conflict region can load additional complications to an already complex situation. Ciborra (2002) argues that ICT creates a backdrop for human actors that work with it and can both reflect and impact on the organisation it has become part of. This is evident in the findings from the successful implementation of TCK. The hosts’ identity changed with the hosting of the technology, both through the realisation of previously hoped for changes and through losing fears associated with gaps in their skill sets. Not controlling the technology and allowing it to be utilised in different ways can be seen, as the technology is used in ways that differ from its original purpose. The new confidence the hosts developed with the technology enabled them to say yes or no to the technology and to the centre. The perception of the technology and the centre dictated how the centre and its technology were received. Some welcomed the technology as part of hope for change. Others resented the sudden influx of new technology and the changes it brought. The impact on the organisation of hosting the technology emerges as one of the main factors which influenced the success of the centre. These findings suggest that to examine the success rate of large-scale technology projects in post-conflict developing regions, this impact of the technology should be explored.

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References

Blaya JA, Fraser HS, Holt B (2010) E-health technologies show promise in developing countries. Health Aff (Millwood) 29(2):244–251

Brahimi L (2007) State building in crisis and post-conflict countries. http://unpan1.un.org/intradoc/groups/public/documents [viewed February 2014]

Callon M (1991) Techno-economic networks and irreversibility. In: Law J (ed) Sociology of monsters, essays on power, technology and domination. Routledge, London

Cardozo LB, Agani F, Vergara A, Gotway C (2000) Mental health, social functioning, and attitudes of Kosovar Albanians following the war in Kosovo. J Am Med Assoc 284:569–577

Chen S, Cheng A, Mehta K (2013) A review of telemedicine business models. Telemed e-Health 19(4):287–297

Chiasson M, Davidson E (2004) Pushing the contextual envelope: developing and diffusing IS theory for health information systems research. Inf Organ 14:155–188

Chiasson M, Reddy M, Kaplanc B, Davidson E (2007) Expanding multi-disciplinary approaches to healthcare information technologies: what does information systems offer medical informatics? Int J Med Inform 7(6S):89–97

Ciborra C (2002) The Labyrinths of information: challenging the wisdom of systems. Oxford University Press, Oxford

Collier P, Hoeffler A (2002) Aid, policy and growth in post-conflict societies. WB Policy research working paper 2902. World Bank, Washington, DC

Collier P, Hoeffler A (2004) Greed and grievance in civil war. Oxf Econ Paper 56:563–595

Corbin J, Strauss A (2008) Basics of qualitative research: techniques and procedures for developing grounded theory, 3rd edn. Sage, Thousand Oaks

CSIS/AUSA (2002) Post conflict reconstruction a joint project of the Centre of Strategic and International Studies (CSIS) and the Association of the United States Army (AUSA). http://csis.org/files/media/csis/pubs/framework.pdf [viewed September 2012]

Dahlbom B, Janlert S (1997) Computer future. Göteborg University, Göteborg

Derrida J (1996) Foreigner question: coming from abroad/coming from the foreigner. In: Of Hospitality: Ann Duformantelle invites Jacque Derrida to respond (trans: Bowlby R). Stanford Press, Stanford

Farran CJ, Hearth KA, Popovich JM (1995) Hope and hopelessness: critical, clinical, constructs. Sage, Thousand Oaks

Frankl VE (2004) Man's search for meaning: the classic tribute to hope from the Holocaust. Rider, London

Gonzalez M, Quesada G, Urrutia I, Gavidia J (2006) Conceptual design of an e-health strategy for the Spanish health care system. Int J Health Care Qual Assur 19(2):146–157

Harteloh PPM (2003) Quality systems in health care: a sociotechnical approach. Health Policy 64:391–398

Hattotuwa S (2004) Untying the Gordian knot: ICT for conflict transformation and peacebuilding. Dialogue 2:2

HIC (2014) Humanitarian information centres and partners. http://humanitarianinfo.org/ [viewed March 2014]

IVEH (2013) International virtual e-hospital connects five islands of Cape Verde through robust telemedicine program. http://www.iveh.org/index.php?id=29&p=79 [viewed March 2014]

Junne G, Verokren W (ed) (2005) Post-conflict development: meeting new challenges, Boulder

Kealy A, Stapleton L (2012a) Telemedicine systems development in post-conflict contexts: a country case study of the role of symbols of conflict in systems engineering. In: Stapleton L (ed) Proceedings of the IFAC conference in international stability and technology (SWIIS), Waterford, Ireland

Kealy A, Stapleton L (2012b) Symbols of hope: a case study of telemedicine projects in post conflict regions. J Inf Technol Case Appl Res (JITCAR) 14(3)

Krähenbüh P (2000) Conflict in the Balkans: human tragedies and the challenge to independent humanitarian action. International Review of the Red Cross, No. 837. http://www.icrc.org/eng/resources/documents/article/other/57jqcl.htm viewed [May 2014]
Kubo K (2010) Why Kosovar Albanians took up arms against the Serbian Regime. Eur–Asia Stud 62(7):1135–1152
Lund MS (1996) Preventing violent conflicts. A strategy for preventive diplomacy . United States Institute of Peace Press, Washington, DC
Malcom N (1998) Kosovo: a short history. McMillan, London
Mallaye D, Urbain YT (2013) Foreign aid and mobilization of growth factors in sub-Saharan Africa. WIDER working paper no. 2013/103
Matavire R, Brown I (2008) Investigating the use of G. T in IS research. In: Proceedings of conference of South African Institute of Computer Scientists & Info Technologists on IT Research in Dev Countries, Wilderness, South Africa, pp 139–147
OECD (2013) Fragile states 2013: resource flows and trends in a shifting world. http://www.oecd.org/dac/incaf/ [viewed March 2014]
OECD (2014) Aid (ODA) by sector and donor [DAC5]: stats.oecd.org [viewed March 2014]
Ovaska P, Stapleton L (2010) Requirements engineering during Complex ISD: case study of an international ICT company. J Info Technol Case Appl Res 12(2)
Robson C (2002) Real world research. Blackwell, Oxford
Ron J (2001) Kosovo in retrospect. Int Stud Assoc 3(3):103–115
Sultan F, Azizb MT, Khokhar I, Qadri H, Abbas M, Mukhtar A, Manzoor W, Yusuf MA (2014) Development of an in-house hospital information system in a hospital in Pakistan. Int J Med Inform 83:180–188
Summerfield D (2002) Effects of war: moral knowledge, revenge, reconciliation and medicalised concepts of "recovery". BMJ 2002(325):1105–1107
Turner N, Aginam O, Popovski V (2008) Post-conflict countries and foreign investment. United Nations University Policy Brief, November 8, 2008
UNDP (2010) UNDP justice system programme – Programme Areas. Dili.
UNMIK (2009) On the establishment of the Kosovo protection corps. http://www.unmikonline.org/regulations/1999/re99_08.pdf [viewed May 2014]
Walter B (2010) Conflict relapse and the sustainability of post-conflict peace. World Development Report 2011
Wilson G (2009) Self-determination, recognition and the problem of Kosovo. Netherlands Int Law Rev 445–481
World Health Organization (WHO) (2005) 58th world health assembly report, 16–25 May 2005. WHO, Geneva. http://www.who.int/healthacademy/media/WHA58-28-en.pdf

Chapter 10
Beyond Traditional Ethics when Developing Assistive Technology for and with Deaf People in Developing Regions

William D. Tucker

Acronyms

ACM	Association of Computing Machinery
AT	Assistive technology
BCS	British Computer Society
CBCD	Community-based co-design
CIRN	Community Informatics Research Network
CODA	Children of Deaf adults
CoE	Centre of Excellence
DCCT	Deaf Community of Cape Town
DEAFSA	Deaf Federation of South Africa
DEV	Computing for Development, an ACM conference
DPO	Deaf People's Organisation (dedicated organisation similar to a non-governmental or non-profit organisation)
ECLD	European Computer Driver's License
HCI	Human computer interaction
ICDL	International Computer Driver's License
ICT	Information and communication technology
ICTD	ICT *and* Development, a conference (and flavour of research and practise related to ICTD; see Sterling and Rangaswamy 2010)
ICT4D	ICT *for* Development
IEEE-CS	Institute of Electronic and Electrical Engineers Computer Society
IM	Instant Messaging
IRB	Institutional review board
ITU	International Telecommunications Union

W.D. Tucker (✉)
Department of Computer Science, University of the Western Cape,
Cape Town, South Africa
e-mail: btucker@uwc.ac.za

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LMIC	Low- and middle-income country
MRC	Medical Review Council (South Africa)
MXit	A popular South African mobile instant messaging tool that targeted low-end feature phones, unlike WhatsApp being targeted to smartphones
NRF	National Research Foundation (South Africa)
PC	Personal computer
PD	Participatory design
RLE	Resource-limited environment
SANPAD	South Africa Netherlands research Programme on Alternatives in Development
SASL	South African Sign Language
SIMBA	Softbridge Instant Messaging Bridging Architecture
SMS	Short message service, or mobile text
THRIP	Technology and Human Resources for Industry Programme
TU Delft	Delft University of Technology (Netherlands)
UCT	University of Cape Town
UWC	University of the Western Cape (also in Cape Town)
VoIP	Voice over Internet Protocol
VRS	Video Relay System

Overview
There are limitations to traditional ethical approaches and procedures when engaged in assistive technology (AT) research for Deaf people in a developing region. Nontraditional issues arise as a consequence of employing action research, including but not limited to how informed consent is construed and obtained; empowerment of participants to become involved in co-design; awareness of unfamiliar cultural issues of participants (as opposed to subjects); and accommodating community-centred, as opposed to person-centred, nuances. This chapter describes AT research with an entity called Deaf Community of Cape Town (DCCT), a disabled people's organisation (DPO) that works on behalf of a marginalised community of undereducated, underemployed and semi-literate Deaf people across metropolitan Cape Town. We describe how nontraditional ethical concerns arose in our experience. We reflect on how these ethical issues affect AT design, based on long-term engagement, and summarise the themes, what we have learned and how we modified our practise, and, finally, offer suggestions to others working on AT in developing regions.

1 Introduction

We conduct assistive technology (AT) research with and for a local Deaf community in Cape Town, South Africa. The capital 'D' calls attention to a cultural identity and a preference for using signed language to communicate, in our case South African

Sign Language (SASL). Our understanding of Deaf *vs.* deaf is that deaf and hard-of-hearing people prefer to use the written and spoken language of the surrounding majority even when they struggle to hear, e.g. using amplification, reading lips and via text. Deaf people, on the other hand, are those who prefer to use SASL as a 'mother tongue' including hearing children of Deaf adults (CODA). Thus people can be both Deaf and/or deaf; and the cultural considerations become very interesting in developing regions.

Given this context, allow us to relay a short anecdote that serves to highlight the kind of issues we encounter that push us beyond traditional ethics concerns:

> We learned that Deaf people in the community were somewhat embarrassed by their use of text to communicate with hearing people. We also observed that they had no such inhibition texting to one another in broken and misspelled English. Since instant messaging and other forms of Internet-based texting were thousands of times cheaper than SMS (short message service), we began an informal awareness campaign to champion the use of MXit and Facebook. While the majority of the DPO staff was keen to embrace these cheap services to communicate with one another, one leader was adamant that neither was appropriate for Deaf people. The explanation was as follows: There was a high profile tabloid story about MXit and pornography; that MXit could be commandeered to send pornography to people. Regarding Facebook, the concern was that someone could use a PC at the DPO to say something negative about someone on Facebook and the DPO could be sued for libel because of the physical placement of the computer. Our initial reaction was that these concerns were not entirely valid since with either service, one can choose one's friends, and therefore control incoming and outgoing messages. We went ahead and encouraged the others to learn how use MXit and Facebook, and tried to inform this leader that the concerns could be addressed by knowledge of how to better use the tool. We continue to try and understand where the concerns are coming from. However, many Deaf people in the community have made the plunge, especially on Facebook, where all comments are somewhat public, i.e. some felt empowered and used the services, whilst others did not and declined to do so. We must accept both ways as valid.

The anecdote brings to light several interventionist ethical issues that arise during the course of conducting action research which are not necessarily covered by traditional codes of ethics or institutional review board (IRB) type evaluation: the Deaf leader's aversion to MXit and Facebook and how we nonetheless encouraged others to learn how to use those applications and even told that reluctant person we were doing so. This is a situation that can arise in action research and interventionist information and communication technology for development (ICT4D) work that an IRB, at least for computer science or engineering, does not and cannot address. This chapter argues that these types of issues also have ramifications for technical systems design.

A strong argument for ICT4D was made by Brewer et al. (2005), in particular the leveraging of Computer Science for the task (Dias and Brewer 2009). The challenges of ICT4D research are technical, environmental and cultural (Brewer et al. 2006). The non-technical aspects often tend to dominate in resource-limited environments (RLEs), particularly in low- and middle-income countries (LMICs), requiring the formation of multidisciplinary teams and the deployment of mixed methods. For this reason, some may question if it is even Computer Science research (Toyama and Ali 2009). Despite these disciplinary squabbles, the 'field' of ICT4D has soldiered on, amassing a convincing collection of conferences and journals that accommodate a continuum of contributions from both technical and social sciences. Several dominant themes have emerged. One of them is HCI (human computer interaction) for development research. Examples include Ramachandran et al. (2007), Kam et al. (2006) and Anokwa et al. (2009) who all in one way or another advocate that traditional participatory design (PD) is not sufficient where one must consider and incorporate a social context that is often alien and unfamiliar to researchers performing fieldwork in developing regions.

Information and communication technology (ICT) and AT for disability and accessibility in RLEs is a relatively small niche research area (Samant et al. 2013). Research papers on disability in RLEs and LMICs are extremely rare. Consider full papers in two flagship conferences on ICT for development: ICTD (International Conference on Information and Communications Technologies and Development) and DEV (Annual Symposium on Computing for Development). There were six ICTD conferences from 2006 until 2013. Out of 115 full papers in total, only 2 concerned disability, and both were on AT for blind people (Lauwers et al. 2007; Pal et al. 2013). There were four DEV conferences from 2010 until 2013. Of the 68 full papers, only 2 concerned AT for disability, and both were co-authored by this chapter's author (Tucker and Blake 2010; Motlhabi et al. 2013b). Outside of these conferences, ICT research with and/or for Deaf people in developing regions appears to be quite scarce. Notable examples include a comparison that identified a huge gap in ICT usage between deaf people in developed and developing regions (Agboola and Lee 2000), DeVelle's (2011) short paper on mobile devices for Deaf people, and Mbulamwana's (2011) short and contradictory discussion about the merits of SMS while noting that 80% of Deaf Ugandans are illiterate and their English skills are therefore very low. Then there are numerous outputs by members of our research team, including but not limited to Glaser (2000), Glaser and Aarons (2002), Glaser et al. (2005), Zulu et al. (2005), Glaser and Lorenzo (2006), Mutemwa and Tucker (2010), Blake et al. (2011), Chininthorn et al. (2012), Henney and Tucker (2013), and Motlhabi et al. (2013a, b). We feel we have much experience in this niche area, especially concerning Southern Africa, with developing regions that are not unlike many others across the globe, although they retain notably African characteristics, such as 'ubuntu' (see Sect. 2.5 below).

Many researchers in the ICT4D realm work within an action research paradigm, with explicit goals of socio-economic development and empowerment via interventionist and transformative participation. Action research is essentially a post-positivist approach that is criticised by positivist scientists for being non-replicable, unobjective and non-scientific. However, the scientific basis of action research has been argued by Susman and Evered (1978) and Checkland and Holwell (1998), and many practitioners in the fields of Information Systems and ICT4D adhere to action research tenets. At its heart, action research concerns leveraging research for empowerment, emanating from a Scandinavian tradition of worker empowerment (Stringer 1997; Carr and Kemmis 1991). A major challenge of action research is to achieve both community empowerment and academic research outputs. McKay and Marshall (2001) called this the 'dual imperative', which manifests a tension between praxis and theory.

There are many forms, or interpretations, of action research. Participatory action research emphasises, as its name suggests, participation with end users (Kemmis and McTaggart 2000). Action research is compatible with development studies and ethnographic action research in particular (Tacchi et al. 2003). Sterling and Rangaswamy (2010) discuss how action research in development brings challenges to IRBs, particularly for informed consent, and this topic will be addressed in more detail below. Dearden and Rizvi (2008) discuss action research and related methods from two different perspectives: participatory interactive systems design and participatory approaches to international development. Following on this, Dearden (2013) discusses action research as a mechanism to conduct interventionist work. Action research has also been championed in ICT4D work by Tucker and Blake (2010) and Doerflinger and Dearden (2013). Action research has only recently been embraced in the field of contemporary HCI, an area of Computer Science that has long resisted the non-positivist leanings of action research, e.g. Hayes (2011, 2012) who stresses the *social* intricacies and relevance of HCI research via engagement with end users.

Social relevance is a key driver for development studies, including ICT4D, and a main component to achieve that is participation. Both Dearden and Rizvi (2008) and Anokwa et al. (2009) survey the ICT4D reporting on participation. Anokwa et al. (2009) argue that participation happens over a continuum from weak to strong. In weak participation, the participant is merely an advisor rather than a co-instigator or designer. For example, participants provide feedback on a prototype as opposed to helping design it. Strong participation, on the other hand, is a project driven primarily by a given community. There are many cases where participative reality differs from intention. Anokwa et al. (2009) derived the weak-strong take on participation from Michener (1998), who comes from a development studies perspective and examined a case study in Burkina Faso in terms of several categorisations of participation. We have taken the liberty of organising two of these categorisation schemes on a continuum, together with Anokwa et al.'s (2009) (see Fig. 10.1), because we feel it is possible to position, and indeed to move, an ICT intervention from weak to strong participation in a developing region context.

One end goal could be empowerment of the community whereby they can drive and take on the initiative by themselves (in other words, we research ourselves out of a job). What Michener (1998) intends, however, is that despite empowerment being the end goal, 'Development planners and academics are at a point where they must adjust participatory frameworks to be more responsive to field-level realities'. Heeks (1999, 2002) and Dearden and Rizvi (2008) would agree: there is often a design-reality gap or participation-reality gap where participation is not fully realised.

We argue that community-based co-design (CBCD, see Blake et al. 2011), our take on action research, can provide ways of bridging that gap. 'Community-based' conveys the fact that we deal with groups of people rather than individuals. In the developed world, computers are geared to an individual's requirements, i.e. PC stands for *personal* computer, that a given device is meant for a single person. In many of the communities in Africa, devices, even cell phones, are shared, and possess communal properties, e.g. in hearing communities it is common to play music

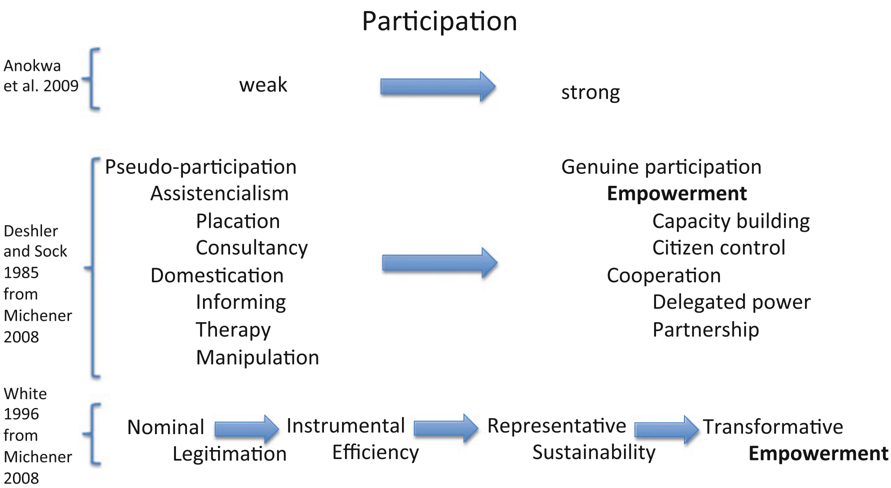

Fig. 10.1 From weak towards strong participation, emphasising empowerment

loudly on a cell phone to share with others. 'Co-design' derives from the application of the action research paradigm in a design setting: both the computer experts and the community members are designers on an equal footing and work cooperatively. Of course, this is an ideal approach, and the reality of performing co-design is fraught with challenges, as will be discussed below. Being based in academia, we are also involved with conveying this methodology, stressing its rewards and obstacles, to students (Blake and Glaser 2013; Blake et al. 2014). Of particular concern in this chapter are the ethical issues that arise when conducting CBCD. This entails addressing standard IRB concerns and the consequences of performing CBCD that takes ethics concerns beyond the traditional.

2 Traditional Ethics and Limitations

Before delving into the ethical peculiarities of interventionist research, such as alternative views of informed consent and community rather than individual orientation, this chapter first reviews the basics of conventional codes of conduct prevalent in computing-related professional bodies and also for scientific research in tertiary institutions. Then the chapter explores related literature and work that both criticise traditional approaches and/or offer extensions to the traditional canon in order to deal with the consequences of conducting community-based and driven interventions.

The computing disciplines offer a collection of professional codes of ethics. The Association of Computing Machinery (ACM) and Institute of Electronic and

Electrical Engineers Computer Society (IEEE-CS) have a joint software engineering code of ethics and professional practice that prescribes how to make software development 'a beneficial and respected profession' (ACM/IEEE-CS 1999). This code covers eight principles: public interest, the interests of client and employer, product standard, professional judgement, management of the software development life cycle, profession reputation, concern for colleagues in the field and lifelong learning for practitioners. This code of ethics is similar to that of the British Computer Society (BCS) which has fewer but similarly worded categories including public interest, professional competence and integrity, duty to relevant authority and duty to the profession (BCS 2011).

These two, and others, are covered by Bott (2005) whose chapter headings give an indication of where the ethical concerns are situated: e.g. law and government, nature of a profession, professional bodies in computing, what is an organisation, financing a start-up company, management accounting, investment and appraisal. Therein are codes of ethics for professional services and societies that are related yet different from codes of ethics for academic research. The former pertain to business issues, the latter mostly to medical research, although primary data collection from human interviews, surveys and the like is also included. It is notable that these codes of ethics focus on how research is carried out, yet not whether it should be carried out. The same distinction often holds for academic research codes.

In computing academia, researchers are governed by both types of codes, yet research projects requiring ethics approval are ultimately approved by an IRB based on research-oriented rather than professional ethics, i.e. on the rights of the subject rather than on how professional responsibilities are carried out. This subject orientation is interesting because (a) an IRB does not necessarily decide whether research should be pursued or not, just that it is done correctly; (b) an IRB typically does not deal with technology research, if humans are not (directly) involved; and (c) an IRB tends to be concerned with a human as opposed to the community in which that human may inhabit (we come back to this last point again several times below). Because of the human orientation, though, research codes of ethics mainstays include voluntary informed consent, right to withdraw and avoiding deception. The Singapore Statement on Research Integrity (Steneck et al. 2010) is a high-level 'global guide to the responsible conduct of research' that states five basic ethical principles which are similar to the professional codes – honesty, accountability, professional courtesy and fairness and good stewardship – but then moves on to clarify these in terms of research activities, e.g. research methods, research findings, authorship, publication acknowledgement, peer review and conflict of interest. The Singapore Statement intends support from 'appropriate national bodies and organisations' (Steneck et al. 2010). These are most likely based or at least linked to a clinical and/or medical code of ethics, e.g. Emanuel et al.'s (2000) highly cited 'What Makes Clinical Research Ethical?'. For example, in South Africa, the local ethics guidelines are issued by the South African Medical Review Council (MRC 2006). Therefore, when an academic research project is deemed to have ethical concerns, the principal investigator must secure ethics permission or certification from an IRB.

For the most part, traditional ethics codes, both professional and academic, are sufficient to govern the IRB gatekeeping process, although that gatekeeping can also exclude research that is controversial either politically or because it challenges paradigms. Nonetheless, limitations of applying traditional ethics codes can appear, especially in technical scientific disciplines when nontraditional research methods are chosen, e.g. action research or CBCD. This is not to say that these established codes are not relevant. Their concerns must be addressed. However, some aspects can be lacking in applicability and/or relevance to interventionist and transformative participatory research. In addition, the IRB as gatekeeper raises the issue of the responsibility to exclude research that has negative impact on 'subjects' or other aspects, such as the subject's community, as is often the case with interventionist methods. While medical-oriented ethical concerns tend to focus on the subject, usually an individual, Emanuel et al. (2004) extend that further to address the subject's community and possibly an entire community itself. Emanuel et al. (2004) also question whether it is ethical or not to pursue a given research agenda, in addition to stipulating guidelines about how to conduct the research.

2.1 Sociocultural Assumptions

A first concern with intervention-driven research is that traditional and established codes of ethics are only partially applicable to work in developing regions. In our view, these codes can be written with assumptions about end users and their environments and can also be read with similar tacit assumptions. For example, the ACM/IEEE-CS code is oriented from and towards the developed world or global North. It is not that this code of conduct does not address ICT4D issues. It is more that the education and practice of Western-schooled technical researchers do not necessarily give consideration to sensitive and non-tacit social and cultural aspects of development issues. These issues can lead to the 'design-reality gap' (Heeks 2002), where a researcher's tacit cultural assumptions can cause disconnect between perceived and actual user needs. This can result in a 'partial failure' or 'white elephant'. The 'tyranny of participation' (Heeks 1999) is another manifestation of disconnect where a researcher may feel that methods employed are participatory yet the reality may be very different due to power relations (Michener 1998). Cultural assumptions come with neocolonialism even, and especially, if unintended. These issues are well-known traps that can be difficult to grasp by the unaware or unprepared researcher. This applies to both novice and experienced researchers, especially those schooled in the global North conducting research in the global South or even those schooled in the global South in North-styled institutions.

2.2 Dynamic and Community-Driven Research Agenda

A second concern for applying traditional research ethics to ICT4D projects, especially interventionist action research projects, is that an ethics approval by an IRB is not flexible for ongoing negotiation, e.g. changing of research goal posts based on input and direction from a participating community (Sterling and Rangaswamy 2010). This issue is also noted by Emanuel et al.'s (2004) revision of their original document (Emanuel et al. 2000) to specifically address clinical research in developing regions, especially along the theme of the negotiation between stakeholders, which serves as the main reason for their revision. In some communities, decisions on participation and who participates and how may be made by the community and/or its elders or traditional leadership. This can be counter to formal and bureaucratic IRB ethics processes and may or may not be appropriate for a community. One can envisage a scenario where the ethics processes are governed by the community rather than an IRB. On the other hand, not everyone, possibly even the researchers, must blindly adhere to the values of a given community, although those values must still be respected. A situation can also be envisaged whereby people are pushed by their own community into being participants; and they might not accept that way of decision making (see Kaplan 1996 for some interesting examples of this in rural South Africa). Another way of looking at it is that IRB-orientation imposes a fixed process upon the iterative and evolving cycles of research as prescribed by interventionist action research. The terrain is fraught with permutations, from all sides: the researcher, community members, informal and formal leadership and government. The point here is that community-driven research agendas can change in unexpected ways.

2.3 Informed Consent

A third concern is how informed consent is explained and recorded. An IRB requires a research (team) to define informed consent issues up front and have participants acknowledge these up front, too, in writing. Sterling and Rangaswamy (2010) are particularly critical of this traditional notion of both proscribing and recording informed consent because of how (a) stakeholder relations change over time and (b) traditional informed consent can harm community involvement and trust of community (for the researchers) simply due to its alienating mechanisms such as signing official forms that participants may not fully comprehend, e.g. if they are Deaf and possess limited text literacy, or putting an 'X' when participants cannot write. Sterling and Rangaswamy (2010) make suggestions such as not using pen and paper to collect informed consent signatures, e.g. recording oral consent or video recording signed language consent along with explanation of the consent form in signed language. Emanuel et al. (2004) would agree, stating that 'researchers should use consent procedures that are acceptable within the local community'. Emanuel et al. (2004) go further on the topic of informed consent to recommend that 'the local community should help to establish recruitment procedures and incentives for participants'; 'disclosure of information should be sensitive to the local context'; 'spheres of consent', ranging from village elders to leaders . . . may be required before researchers can invite individual participation'; and 'special attention must be given to ensure that individuals are aware of their right to and actually are free to refuse to participate'. Thus, informed consent is itself a concept arising out of a particular cultural context and may not be relevant in other cultural contexts. What may be useful, then, is an ethical approval and overview process defined in the local community by the people being researched such that issues of concern to a particular community are raised.

2.4 Informed Participation

For another perspective on informed consent, consider the notion of informed participation, which can be considered complementary to informed consent (Hersh and Tucker 2005). Informed consent refers to an acknowledgement of the ramifications of participation in a given research project, yet not necessarily being privy or even involved with its formulation and execution. Informed participation, according to Hersh and Tucker (2005), is conceived such that in order to achieve true action research, the research agenda must be open from the start, with no hidden motives or objectives hidden behind clever data collection. Several well-known examples, such as the Milgram experiment, are described by Hersh and Tucker (2005) to demonstrate that some research should not be granted permission to be carried out in the first place (again, an issue that an IRB does not contend with for myriad reasons, e.g. political). The assertion is that 'ethical behaviour is a pre-requisite for obtaining meaningful results' and that informed participation, in addition to informed consent, is fundamental to achieving ethical behaviour. Going beyond this initial basis of 'no hidden agendas' for informed participation, this chapter argues that one way to do this effectively is to enact community engagement in the conception of and strategy for the research project before the process even begins. Thus the community also helps to define the concerns of the informed consent process itself, rather than 'putting the cart before the horse', or in this case, the consent form before actually engaging community members. Traditional processes, including those frequently governed by an IRB for computing and/or engineering science, fail to address this, as an IRB expects researchers to define an information sheet and consent form so that participants can grant permission for a predefined research process before it begins. With community-based co-design and other forms of action research, the research agenda and process are constantly evolving based on the consequences of continual engagement between stakeholders and can indeed be initiated by and with participants.

2.5 Beyond Traditional Ethics

These concerns move the discussion beyond traditional ethics procedures and concerns. All of the above involve aspects of conducting scientific research, be it positivist or post-positivist, or some combination, that are peculiar to technology research interventions in developing regions. For example, Dearden (2013) discusses the ethical tension between 'detached enquiry' and 'help'. These differences cause us to critically question our understanding of the role of researchers. For example, to what extent should researchers get involved or distance themselves? Help and involvement also raise ethical issues related to who sets the agenda, power and control, as well as the possibility of dependence upon researchers and their funding, and additional questions of researchers imposing their views and/or providing assistance that is not required and/or appropriate.

There are many other questions that arise as a consequence of conducting research in developing regions. For example, what constitutes fair subject selection and even selection of entire study populations? Another overriding concern is how to make unaffordable solutions more affordable. Affordability is not something that is fixed; it is affected by inequality due to socio-economics (see Bhutta 2002) and also gender concerns such as patriarchy. Consider how political issues and power dynamics can also affect affordability – not only in the technology arena, e.g. communications cartels. Consider HIV drugs that are deliberately kept expensive by large pharmaceutical firms that do not like the fact that African countries can produce their own much more cheaply. None of these issues are easily addressed or static; and any or all can be changed. Many such issues are addressed by bridges.org's Real Access/Real Impact criteria (see Tucker and Blake 2010 because the bridges.org website is now defunct). There is also the balance between person and community – this is different in different cultures, e.g. in Africa, one interpretation of the concept of 'ubuntu' is that it can mean that an individual is defined by membership in a community, which is very different from the Western 'looking glass self'. In Africa, shared devices such as mobile phones are quite common. And in Africa particularly, researchers and practitioners often innovate to deal with frequent power outages and very expensive communication costs.

Because of practical, socio-economic and cultural issues, particularly the community orientation, Averweg and O'Donnell (2007) saw the need to define and classify the ethics peculiar to development informatics, similar to how Emanuel et al. (2004) modified their previously developed world orientation from Emanuel et al. (2000). Effort to widen the scope of clinical research ethics for the context of RLEs in developing regions and LMICs is the topic of the next section.

3 Ethical Frameworks for Developing Regions

As pointed out by Dearden's (2013) survey of ethics in the ICT4D literature, there is a dire lack of research publications with respect to ethics in ICTD/ICT4D[1] literature. This section briefly covers some examples that contribute to this small niche area. Even amongst that literature, there are, in our opinion, too few pertaining to Deaf or AT studies in developing regions.

Emanuel et al. (2004) adapted their highly referenced standard of Emanuel et al. (2000) to include items and extensions specifically for clinical research in developing regions. The shifts are notable in the recognition of collaboration via communities and social relationships; clearly beyond the scope of subject-oriented IRB processes. Examples of the changes include the addition of collaborative partnerships, value came to emphasise *social* value, fair subject selection become fair selection of study population and respect for enrolled subjects became respect for recruited participants and study communities. This reworked framework explicitly recognises that researchers are coming from very different backgrounds and perspectives from the developing regions in which the work is being done. In addition to 'explicating a previously implicit requirement for collaboration', the 2004 version also provides a set of 'specific and practical benchmarks to guide researchers and research-ethics committees in assessing how well the enumerated ethical principles have been fulfilled in particular cases' (Emanuel et al. 2004). Their goal for the social reorientation and the benchmarks is to minimise exploitation in developing regions, by adding additional concerns to standard IRB processes, which could lead to tensions and conflicts with those processes.

Bhutta (2002) also advocates several nontraditional points with respect to conducting health research in developing regions. Bhutta emphasises that health research ought to promote equity and local capacity building. Bhutta does not offer specific solutions, rather that health and research issues must be linked to equity and that we develop local research capacity together with capacity to determine and enforce ethical standards locally. Thus, there is a need to involve stakeholders such that ethical standards set in the North do not just necessarily get applied in the South. In other words, Bhutta (2002) is saying that research ethics mandate empowerment of participants in developing regions. This could lead to methodological tensions, especially for pure objective positivism that sees participant as subject. Bhutta asks questions such as: is it ethical to research solutions that are not yet affordable for a community, even though they may indeed work? Perhaps, as Buttha suggests, it is best to rather go for lower-tech solutions that are affordable and still work. It is also worth noting that research can bring costs down and, furthermore, that costs can also be political and are not absolute.

Another perspective comes from Averweg and O'Donnell (2007), who presented a draft code of ethics for community informatics researchers based on a need identi-

[1] Note that in the community, there is a nuanced distinction between ICTD and ICT4D which is very effectively explained by Sterling and Rangaswamy (2010) and is considered beyond the scope of this chapter's purview.

fied at the second annual conference of the Community Informatics Research Network (CIRN) in 2005. The draft code repeatedly stresses consideration of community (in addition to individual) and was intended to evolve. It contained explicit requests and suggestions for comments and appeared in the Journal of Community Informatics 2 years later. Somewhat apathetically, no one has commented on it and only two authors have cited it (according to Google Scholar). Several years later, the journal editor repeated a plea to examine this code (Gurstein 2010), but there seems to be very little interest, as the draft code does not yet appear to have been modified. The draft code is notable for several bullet points contextualised for community-based research:

- Respect for human dignity, e.g. ‘protect the interests of the person and community’.
- Subject-centred perspective, e.g. ‘active involvement by research participants’, ‘researchers and research participants may not always see the harms and benefits in the same way’.
- Respecting vulnerable[2] persons, justice and inclusiveness, e.g. ‘the CI [community informatics] researcher should reflect on the consequences of research engagement for all participants and attempt to alleviate potential disadvantages for any individual, category of person or community’.
- Ensuring appropriate use and ownership of research data, e.g. ‘ownership of information . . . shall vest jointly with the community’ and ‘research protocol negotiated with the community’.

4 Experience in the Field

Keeping these issues in mind, we now turn to our experience in the field. We portray illustrative examples from our fieldwork and tie them to both traditional and nontraditional ethical concerns as outlined above.

4.1 Background

According to our provincial Deaf Federation of South Africa office (DEAFSA 2014, Personal communication, Western Cape Provincial Director, Cape Town, South Africa), there are approximately 1.4 million who have some degree of hearing loss, out of 55 million South Africans. Of these, roughly 600 000 are ‘profoundly Deaf’, thus, 1% Deaf and 2.5% hard of hearing, of the South African population, respectively. Others estimate the number of Deaf people who use SASL between

[2] The word ‘vulnerable’ is problematic; it can be used to protect or to disempower. Note ‘protection’ can also be problematic.

500,000 and 1.5 million Deaf people (SignGenius undated), while Druchen (2007) put the number of SASL users at one million in 2007. We can surmise that European numbers are considerably smaller.

In South Africa, as is worldwide, many literate and illiterate Deaf people prefer to communicate in their own signed language, in our case, SASL. If one takes into account general demographics from the South African census data (see www.statssa.gov.za), more than half of the population is rural and the majority are poor. These characteristics translate to the Deaf population quite literally. Deaf South Africans experience poor text literacy (in any of the 11 official South African languages) due to limited educational opportunities. However, despite poor text literacy, many South African Deaf people appear to be entirely literate in SASL. There is currently a lobby to make SASL the 12th official language of South Africa (Druchen 2007). If successful, it would oblige the government to provide full service in this language. It is believed that the expense is currently a major stumbling block to approving this officialisation.

We work with a Deaf DPO (Disabled Persons Organisation) called Deaf Community of Cape Town (DCCT, see www.dcct.org.za). Most Deaf adults associated with DCCT are semi-literate, at best (Glaser and Aarons 2002; Glaser and Lorenzo 2006). Many are unemployed, but those who are employed are often underemployed in menial jobs. This adversely affects the socio-economic level of the community as a whole. The Deaf community is underdeveloped in terms of ICT access and participation (Glaser 2000; Glaser and Tucker 2004). Recognising these gaps, grass-roots DPOs, such as DCCT, have arisen to take action on their community's behalf. There are not enough of these DPOs, and they themselves are resource-constrained. DCCT is staffed almost entirely by Deaf people and serves the needs of a large Deaf community in the province. It was founded by members of the community in response to a dearth of services and support from mainstream and official sources.

Factors that characterise the Deaf Community's ICT ecosystem include very expensive Internet, fixed and mobile communication costs[3] and no commercial relay services; and even if a video relay service (VRS) were available, it would be prohibitively expensive. Civic engagement is difficult when police, doctors and government officials, for example, are unable to converse in SASL; and interpreters are rare,[4] expensive and beyond the reach of most Deaf people (rates start at R350 per/h, currently about £20). We cannot possibly address all of these issues with our

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[3] Note that according to the International Telecommunications Union (ITU, see www.itu.int), this applies across the board to everyone in South Africa – that prices here are more in line with developed countries in the global North rather than with countries like India, Sri Lanka, Senegal and Brazil. Therefore, the use of standard communication services is prohibitively expensive for all poor South Africans.

[4] There are only 84 SASL interpreters on the DEAFSA registry in the entire country, of which 43 have no formal training, 31 with 240 study hours of training and 10 with a further 480 study hours; and only 7 of the total of 84 are actually accredited by DEAFSA; and only 19 of the 84 are resident in the Western Cape province where DCCT is based.

research programme, so we start by addressing needs prioritised by DCCT where we have expertise, such as designing appropriate and accessible AT and building ICT capacity.

Academic researchers from Computer Science departments at two local universities, University of the Western Cape (UWC) and the University of Cape Town (UCT), have been involved for many years with DCCT. Our initial intent was to support remote communication between Deaf people and hearing people, e.g. voice relay with instant messaging (Glaser and Tucker 2004; Yi and Tucker 2009); between Deaf people, e.g. with PC-based video (Ma and Tucker 2008; Ramuhaheli 2011) and mobile-based video (Wang and Tucker 2010; Erasmus 2012); and then, with collaboration from Industrial Design Engineering at Delft University of Technology (TU Delft), from Deaf people to officialdom, e.g. with a doctor (Looijesteijn 2009) and pharmacist (Chininthorn et al. 2012; Motlhabi et al. 2013a, b).

While the technical goals of these research projects have been achieved to a certain extent, of equal interest has been the way the research-provided computer systems have been appropriated, in a positive sense, by the Deaf community for other purposes. This relates to the unexpected uptake in the use of the computers for general access to information and social networking, e.g., the prolific use of Facebook. Included in these spin-off uses was the demand by the community for the training of Deaf people in ICT literacy. We facilitated this by the introduction of the internationally accredited ICDL programme[5] which recently saw three Deaf people at DCCT receive e-Learner certificates (see Fig. 10.2). While three appears a small number, we are not aware of anyone associated with DCCT, with approximately 2,000 members, possessing even a high school matriculation (diploma). Thus, this accomplishment truly stands out (and all three granted permission to use this photo). In addition a Deaf person was trained to maintain the computers at the DPO. Our research efforts provided access to hardware, software and network[6], and over time the system has been adapted for advocacy and empowerment. A clear mandate of engaging the Deaf community at all stages in the research process, as defined by action research and community-based co-design (see Sect. 6), is the role for researchers to educate communities on the possibilities of technology. Otherwise communities are not in a position to set the agenda and decide what technologies they want, as they do not know what is available. By engaging with communities in this manner, they become empowered to enact these activities in an informed way. The remaining subsections call out various aspects of our experience while doing this together with the Deaf community.

[5] ICDL (International Computer Drivers License), www.icdl.org.za, is an internationally recognized computer skills certification programme run by the (European) ECDL foundation (www.ecdl.com).

[6] The network costs are now being borne by the community itself.

Fig. 10.2 Several DCCT staff members received e-Learner certificates from ICDL

4.2 Timing

The initial phase of the ICT interventions dealt with a variety of text relay systems. The first to be trialled with a Deaf user revealed that Deaf people were very self-conscious about their typewritten text (Tucker et al. 2003). A later iteration, called SIMBA (Sun and Tucker 2004), was installed at DCCT's PC lab. This lab was funded by industry and governmental research donors. The ethical issues of such funding in terms of control have been minimal as our funders allow DCCT and us to drive the research agenda independently. On the other hand, the nature of the business practices deployed in order to provide such 'social responsibility' funding could raise additional ethical questions. Regardless, the funding was provided for the purpose of introducing and trialling alternative and exploratory ICT interventions. Along with members of DCCT, we identified Thursday afternoons as a good time to trial the instant messaging (IM) and SMS-based text relay. We ran into the problem that actually, the Deaf people could not call anyone since the people they wanted to call were working and could not take calls. Travel to and from DCCT was also problematic (see Sect. 4.8). This highlights issues covered by Sect. 2.1.

4.3 Setting the Research Agenda

This section highlights issues covered by Sect. 2.2. In truth, the Deaf community did not ask for the text relay phase of projects or any of our projects up until SignSupport. The ICT interventions, and the research funding, started because of a perceived overlap between Voice over Internet Protocol (VoIP) research and the Teldem, a locally produced text telephone, both of interest to the primary donor, Telkom. We perceived the need for such technology and proceeded with a series of projects that ultimately ended up unused. However, the requirements for the SignSupport project, a mobile tool to assist communication between a Deaf person and a medical doctor, were initiated from DCCT participants (Looijesteijn 2009). This project was further refined by Chininthorn et al. (2012) to focus on a more limited communication domain, with a pharmacist.

Because of the long-running nature of the wider project on AT with and for this Deaf community since 2001, we are able to devise a number of future work ideas each year and are able to take in new postgraduate students each year to continue work on the project. However, even with the underlying requirements set by the Deaf community, we still encounter the dilemma of whether each particular project is acceptable by the community or not. For example, we know by interviewing both Deaf and pharmacist participants after a mock trial that SignSupport may indeed require a VRS when the pre-recorded dialogue on the phone is unclear or insufficient to convey critical communication. Thus we enlisted a PhD student to include the relay work and mobile video work we had done with earlier projects. His particular spin, though, for a research topic was to secure the relayed communication. So, the need for mobile relay has emerged from participants, and not the security aspect of it. Is it right to pursue security as a priority when it was not identified as such by the Deaf community? We are working under the premise that by educating Deaf people about Internet and mobile security, there might be a good offshoot of the technical development. But then, the Deaf community had not asked for such instruction either. We therefore view part of the research programme to empower our Deaf partners to be able to participate more strongly, e.g. with English and computer literacy training and accreditation. With regard to this particular decision, we have decided to continue with the project because a video relay service was prioritised by the community, and the security aspect provides both community empowerment and Computer Science research merit, illustrating a parallel research agenda that aims to satisfy and empower both major stakeholders.

Consider another example illustrating a similar decision. A postgraduate student had modified a pattern passcode for SignSupport as a final year project. The pattern passcode enhancement was identified by observing that Deaf trainees for the ICDL course routinely forgot text-based passwords. We thought that a more visual passcode, more similar to the visual nature of signed language, would be more appropriate for them. However, the Deaf users had not explicitly asked for this, perhaps because they did not possess enough computer literacy to warrant requesting such a modification. When the pattern passcode was shown to Deaf people, we received encouraging feedback. This particular student wanted to continue with the project for an MSc, yet we convinced him to switch to a project more prioritised by the Deaf community: to enable SignSupport for other scenarios, as multiple scenarios were identified by Looijesteijn (2009). Then it becomes our challenge, as computer scientists based at a tertiary institution, to devise a research topic out of needs prioritised by the Deaf community and to recognise and accommodate that their priorities can and do change. We achieve this by engagement and awareness activities, both formal, e.g. workshops, and informal, e.g. regular weekly visits.

4.4 Informed Consent

We experienced problems with getting consent forms signed as prescribed by the UWC ethics committee. The consent forms were alienating, incomprehensible and full of ‘legalese’. They were accompanied by a full-page information sheet describing the project. Even when first translated into SASL by an interpreter, the Deaf participant typically took the sheets home. It was very difficult to retrieve them signed. By the time of Mutemwa and Tucker’s work (2010), we rendered the information sheet and consent form in point form and translated each point into SASL. This was a huge improvement in terms of Deaf participant understanding, and consent was collected visually with video recording and was much more natural for them. This illustrates how such problems, as identified by Sterling and Rangaswamy (2010), can be easily overcome (see Sect. 2.3). In our view, informed consent forms are often about ‘ticking’ boxes. We take the position that participants should have relevant information, communicated to them in their preferred language, in order to ensure that they do not feel they are being exploited.

4.5 Satisficing Feedback

Our method of ICT development is based on cycles of training, intervention, collecting feedback and reflection. The collection of objective and useful feedback remains problematic as one can safely assume that participants will satisfice answers, i.e. tell the researchers what they think the researcher wants to hear (related to issues covered in Sect. 2.1). There are ways to triangulate data to identify satisficing, e.g. we can instrument software to collect usage or performance metrics and then compare that data to answers collected with questionnaires, structured interviews and focus groups.

During the most recent round of feedback collection on the SignSupport app at a mock pharmacy, no actual medication was dispensed or used by Deaf patients. Does this have an effect on the objectivity and completeness of the feedback voiced by Deaf and pharmacist participants? This is not easy to address.

This brings up the question: is feedback on prototypes enough to drive a project forward, e.g. SignSupport? While some participants voiced some concerns, the results of feedback from the latest SignSupport trial in a mock pharmacy (Motlhabi et al. 2013b) indicate that SignSupport should be trialled next at an actual pharmacy. To some, this may be construed as weak participation (see Sect. 2.2 and Fig. 10.1). Even though together with the Deaf community we envisioned how SignSupport could become a tool of empowerment, at this stage, we are still in feedback mode. The transition to empowerment will only come when the research project moves out of the mock pharmacy into an actual pharmacy and from there into some sort of sustainable, if not commercial, operation.

One way we have identified to help ‘spread the word’ more widely is to also move from dealing only with DCCT staff to the wider Deaf community. Fortunately for us, this community meets on a monthly basis, on the third Sunday of each month, and we can tap into this for (a) data collection and (b) publicity of the ICT that is available to the community. After tapping into the third Sundays several times, however, we have had to withdraw because DCCT staff recently informed us that Deaf people prefer not to have data collection activities during that time because their main purpose to attend third Sunday is social. The DPO staff recommended we rather perform data collection on a Saturday and also pay for transport to and from the centre (see Sect. 4.8).

4.6 Creating Expectations

Because of the useful and innovative nature of our work, we are often approached to disseminate our work more widely than customary academic venues. We now feel we can only bring attention to the wider community of a particular intervention when it can actually be used by them. We made the mistake of creating false expectations in the early days of the text relay phase. We had developed a prototype in the lab that worked one way between a Teldem text telephone and a telephone, i.e. it converted text to speech with Festival, an open source text to speech engine. We had published a paper (Penton et al. 2002) and received attention from the media. There was a magazine article, an online report and several radio interviews. However, the fallout was that the public exposure generated false expectations for marginalised Deaf people who wanted to use our work right there, right now. A university will often exercise pressure to highlight community-engaged research projects publicly and possibly prematurely. We recently declined to do this with the SignSupport project based on previous experience with the automated relay and turned down offers for newspaper and magazine articles, and radio and television interviews. However, we did allow ‘public’ notice on the university website where our project can be portrayed as research and not a commercially available product. The current thinking is that we can go public after SignSupport for the pharmacy context has been trialled at an actual hospital pharmacy with real users and drugs. In reality, we should only do so when we have a mechanism online to allow Deaf people to download, install and use the application.

4.7 Challenging the Status Quo

As the anecdote at the start of this chapter highlighted, a consequence of action research can entail challenging the status quo, especially if people, e.g. elders, self-appoint themselves as gatekeepers (or indeed as roadblocks). We kept encouraging staff members to use Facebook and MXit despite disapproval from some of the DPO staff. Facebook can make communication in text for Deaf people problematic, considering the attendant problems of literacy and even online etiquette. There are also complicated privacy concerns, especially with Facebook, and we can understand the objecting viewpoint to some extent. Yet the anecdote shows (a) how we can intervene to effect social change and (b) empower the community to make more informed decisions on their own by increasing ICT capacity, e.g. whether or not, and even how to use something like Facebook. It is not that we tell people to use Facebook but rather that we educate them on the advantages, disadvantages and more importantly the security concerns of any given social media application. In fact, based on casual observation (being Facebook friends with various DCCT staff members), Facebook has become an outlet for increased English text literacy and demonstrates these people's aspirations and goals to fully participate and engage with a hearing, and often text-based, world.

A related issue is embarrassment from poor text literacy, e.g. mobile texting to hearing users. We encountered this very early with text relay (Tucker et al. 2003) yet we persisted with automatic text recognition and generation for several years until video prototypes commenced with Tucker and Ma's work (Ma and Tucker 2007, 2008). We have noticed how the embarrassment of Deaf users that we have engaged with has changed as DCCT staff progress with English literacy, e.g. compare someone's emails or Facebook posts from even two years ago and today. It is remarkable, albeit subjectively, how much progress they have made in terms of English fluency and confidence with increased use of text within social media.

4.8 Participant Remuneration

An ongoing dilemma is how to remunerate extremely poor participants for feedback and data collection exercises. The two local universities have different approaches: UWC gives food and UCT pays attendees cash. At UWC, we recently opted to provide money to enable people to attend a data collection section. Many of our participants can barely afford the bus, train or taxi fare to get to DCCT premises. Money was given up front, but many attendees simply did not attend. Providing money after the session is a problem, since participants can legitimately ask 'How can I attend if I don't have the train fare?'. We have recently changed the UWC remuneration protocol to use food vouchers at local grocery stores instead of cash unless, of course, DCCT is already providing lunch, e.g. on a Saturday. Another option could be mobile airtime/recharge vouchers (but there are four dominant mobile providers). This change in remuneration has proven successful for several weeks, and the issue of travel fare has lost significance because (a) the Deaf people surely know that the pay-up-front was a failure and (b) we can only hope that the allure of participation in the project is seen as a vehicle towards improved quality of life, i.e. the message getting around that something interesting is happening at these sessions.

On another level of participation, we employ Deaf research assistants to help manage the DCCT PC lab and collect data. These people have no formal training, and none of them have even graduated from high school. These people are often doing part-time work elsewhere. Instead of setting an hourly, weekly or monthly rate ourselves, we consult with the DCCT leaders to set pay scales to be in line with their other jobs, because our assistants only work for us part-time. We adhere to their recommendations.

4.9 SASL Interpretation

Even though postgraduate students and their supervisors take at least a basic introduction to SASL class, we rely on professional SASL interpreters for all data-gathering sessions. However, many times when we visit, both formally and informally, with the Deaf Community, we often request and/or rely on informal interpretation. We rely on informal interpretation sometimes due to budget constraints, yet more often because we make weekly visits. The latter is categorically different from traditional data collection exercises because weekly visits stimulate spontaneous forms of relationship building and reflect the dynamic nature of the project. This is simply because we need to communicate and at DCCT's premises or at one of their functions, there will usually be someone who can interpret, although they might not be an official interpreter. At times, however, an informal interpreter can get uncomfortable with a given situation, e.g. when he or she feels we should hire a professional interpreter. There are few professional interpreters, as noted above; and in the past few years, we could call upon four experienced interpreters associated with DCCT, but they are very expensive. At least with basic SASL training, e.g. see www.sled.org.za, researchers can interact informally in the native 'tongue'. However, for data collection, research is bound to approved methods, and Deaf people are familiar with indirect communication via an interpreter, who is bound to a code of professional conduct. Furthermore, Deaf people, at least in the community with whom we work, know and trust certain interpreters so as to not cause problems with data integrity. There is another issue that researchers new to collecting data with interpretation also need to be 'skilled up' to learn that an interpreter is not meant to facilitate.

A related issue is the use of Deaf people from the community in recorded videos for prototypes rather than filming an interpreter. The main reason to do this is because DCCT is run by Deaf people, and interpreters are not necessarily considered Deaf even though they 'speak' a signed language (recall the cultural attachments of the capital 'D'). Thus, for all recording exercises, we involve an additional person. We read text to an interpreter; the interpreter informs and/or clarifies what the Deaf person must sign, which could be relayed differently by the Deaf person; and finally we record the Deaf person signing what we need for the application.

4.10 Writing About the Project

It is important to use appropriate language when reporting on studies related to disability. We now routinely follow the suggestions outlined by Cavender et al. (2014) on the ACM special interest group on access (SIGACCESS) website. For example, we write for ‘Deaf people’ rather than for ‘the Deaf’. We always explain what we mean by ‘Deaf’ vs. ‘deaf’. We try to avoid words like ‘target community’ and ‘human access points’ (originally defined by Chetty et al. 2004) because of their dehumanising connotations. The Deaf community is not a target; it is a stakeholder in the action research. Likewise, calling a person an access point, like a piece of technology, is also not copacetic.

5 How Ethical Issues Affect Technical Design

Most if not all of these issues are dynamic and ever changing, which is part of action research. This means that roles and projects need to be continually negotiated and necessitates continual communication between stakeholders. Many of these issues lie at the fringes or beyond the reach of conventional and traditional notions of research ethics, as discussed in the opening sections of the chapter. An example is changing research priorities midstream as dictated by the Deaf community, from text- to video-based. Does that mean that the ethics approval has to be changed and/or resubmitted because the media for the consent form and/or data collection has changed? Another example is challenging the elders in the Deaf community regarding Facebook. Does that warrant explicit acknowledgement in a proposal sent to an IRB, because it affects primary and secondary data collection by virtue of influencing people’s behaviour. These examples highlight why some traditional IRB-driven ethics considerations may even be irrelevant.

As it turns out, such issues also have ramifications for technical design and evaluation of ICT artefacts, especially the iterative engineering of prototypes. For example, we moved from text-based to signed language-based prototypes because of our evolving and deepening understanding of what Deaf people want. Most of the text prototypes, culminating with SIMBA (Softbridge Instant Messaging Bridging Architecture), went unused for a number of social rather than technical reasons. Despite this, the involvement of Deaf people led to a number of innovations. For example, when we built SIMBA, we used an ‘is typing’ presence indicator for the Deaf person, on an instant messaging interface, to represent when a hearing person was speaking. Because of the lag converting speech to text, and vice versa, we realised we also needed a similar ‘audio is typing’ interface for the hearing user and implemented that with a musical passage.

When we started with video prototypes, our main concern was with video codec manipulation and sign language intelligibility. However, a simple yet striking piece of feedback from Deaf participants was that they preferred to have side-by-side video (see Fig. 10.3) instead of picture-in-a-picture, because they wanted to see themselves more clearly when signing, i.e. the sender’s image is too small with picture-in-a-picture like in a Skype call. We came to this innovation because of answers to open-ended questions to Deaf participants with the use of an SASL interpreter (as noted in Ma 2009). Even though we implemented this 50–50 screen split, i.e. divide a landscape screen into two equally large areas, the idea came from Deaf

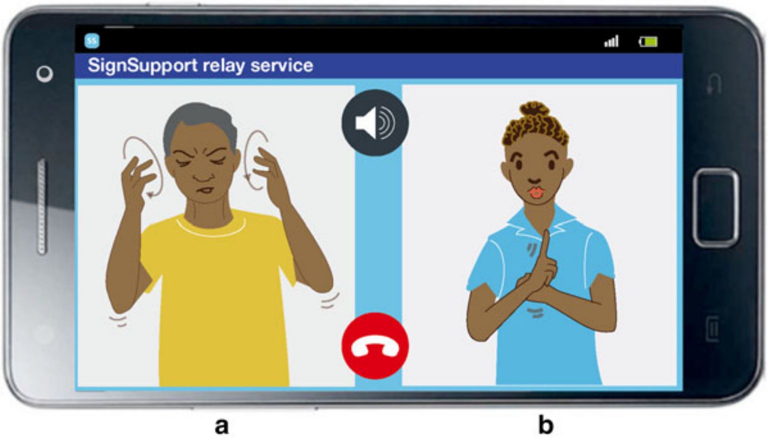

Fig. 10.3 Side-by-side video orientation instead of picture-in-a-picture. User (***a***) is the deaf person, and user (***b***) is the signed language interpreter (Figure adapted from Ma 2009)

people not us. This is a classic example of Deaf participants helping to drive the technical agenda as well as the research agenda. This user interface novelty was carried over onto subsequent mobile prototypes (Wang and Tucker 2010) and we intend to continue using it in the future because Deaf people came up with the idea, and they like it.

The SignSupport project was initiated on results obtained with participative generative sessions. In our opinion, the experience that DPO staff had with us during previous ICT studies, even though they were not being used, increased ICT awareness to the extent that they were able to provide more informed feedback and decisions during these sessions. This led to focussing solely on mobile devices, and also solely on SASL interfaces for Deaf end users, including visual passcodes and video reminders. This included investigation into icons meaningful to Deaf people (Chininthorn et al. 2012) and also careful attention to ensuring that recorded sign language videos said exactly what they were supposed to say and were placed in exactly the correct places (Motlhabi et al. 2013b).

We also incorporated the code of ethics for pharmacists into the design of the SignSupport application (SAPC 2010). Integrating their code of ethics meant changing the ordering of the user interface and introduced specific sections within the application, e.g. the background information and confirmation of identity. Details of this can be found in Motlhabi et al. (2013a, b).

The eventual generality of SignSupport, in terms of scenarios, is going to support self-determination even more because the Deaf community can decide what is important to put into the application next. To do this, we are busy designing an authoring tool to help domain experts create new SignSupport scenarios. The authoring tool is an example of a technical research problem crafted by computer scientists (because this is how we think – to generalise applications for wider usage).

It must be noted, however, in making this technical design decision to increase the generality of SignSupport to provide participant-driven scenarios, we are also empowering the Deaf community even more to choose and prioritise more scenarios, as well as the technical research agenda, in the future.

6 Reflection on Community-Based Co-design

So how participatory are we really? Motlhabi's (2014) pyramid of weight of influence (see Fig. 10.4) represents an ideal situation, where the most input comes from Deaf and pharmacy communities, then from a Deaf education and communication specialist, to design engineers to computer scientists who did the programming. Such participation would surely be 'strong' according to Anokwa et al. (2009) and indicate a great deal of empowerment according to Michener (1998).

Yet the reality is that our participatory process lies somewhere between 'weak' and 'strong' (see Fig. 10.1), as we try to avoid the 'tyranny of participation' (Heeks 1999), as described above. We, and here we means the researchers, clearly still possess a great deal more sophistication in the ICT realm than our Deaf collaborators and must endeavour to take actions to address this. To quote Dearden and Rizvi 2008:

> In creating a participatory approach to interactive systems design for development, it is important to recognise participation as going beyond simply engaging people as informants in design. Instead, participation must be framed as an ongoing engagement that supports learning and development of a wide range of knowledge and transferable skills. The goals of participation should be wider than the individual project and should aim for learning and long term empowerment.

The technical, and indeed socio-economic and cultural, disparity between Deaf participants and researchers will not likely change all that much despite the success of the English literacy and ICDL training. As we are mostly computer scientists and engineers pursuing technical research, we can only realistically attempt to address the technical disparity while simultaneously attempting to minimise the power

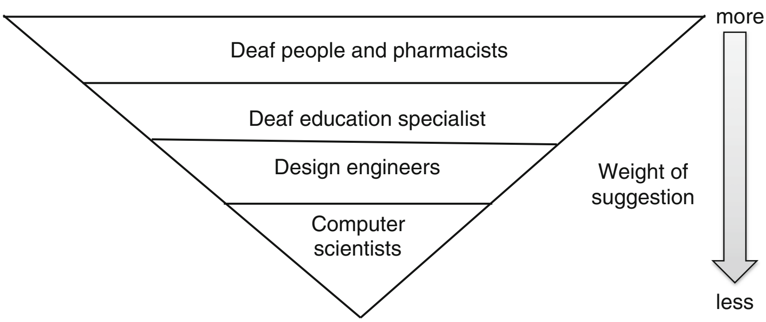

Fig. 10.4 Inverse pyramid of involvement: fact or fantasy? (Drawing adapted from Motlhabi (2014) to emphasise participation from the Deaf community)

disparity by fomenting mutual respect. The Deaf participants' increased capacity enabled them to come up with the ideas for SignSupport. Further, we have learned to recognise, acknowledge and appreciate the expertise that Deaf people have with respect to how they communicate and want to communicate in signed language. We do this by pursuing the ideal of community-based co-design and engagement with them, e.g. weekly visits and interpreted data collection, both formal and informal; generative sessions; and incorporating ethnographic methods into technology design and evaluation. One danger in particular for us now is that patterns of participation were originally established in weak mode, commencing with the text relay prototypes. Perhaps, as evidenced by the recent suggestion to conduct data collection outside of third Sundays, DCCT staff and members have internalised a particular way to deal with us. Or perhaps that is a misunderstanding – that the Deaf community wishes to separate their third Sunday from the ICT project. Perhaps the case would be different if researchers possessed SASL fluency. They have rather suggested we engage larger groups of Deaf people to collect data and ideas on other days considered more convenient and less intrusive to community goings-on.

Overall, we have seen, with the SignSupport project, that through the capacity building, via formal training and also via exposure to our long-term series of research interventions, the Deaf community has developed the capacity to better help drive our research agenda. We hope that those experiences are what enabled the research agenda resulting from generative sessions with key DCCT staff members, aligning research projects to a strategic trajectory. We now endeavour to develop SignSupport in a way that it can accommodate the needs defined by the Deaf community to address multiple scenarios where the tool can provide even more communication bridges for Deaf people in their everyday lives.

7 Conclusion

This section summarises the main themes of this chapter, what we have learnt and how we have changed our practise and offers advice for researchers faced with similar challenges. A danger of following a code of ethics without taking into consideration additional sociocultural issues can entail that technical outputs of design and research may not actually address the needs of Deaf people in developing regions. We speak from experience and learned the hard way by working with a Deaf community in a resource-limited environment for quite a number of years. It was only when we started incorporating modifications to the standard traditional approaches that we started making more genuinely accessible and impactful innovative in-roads with respect to technical development. Therefore, in our opinion, the approach to ethics can and does have direct ramifications for technical outputs. The challenge is to adhere to ethics fundamentals while at the same time espousing a context-awareness to address and/or handle ethical situations that arise beyond the reach of traditional approaches, such as those that come from extensive, dynamic and continual interventions as is common in action research projects.

7.1 Main Themes Summarised

The main themes covered by this chapter are as follows: *Tacit cultural assumptions*, as opposed to cultural and value relativism (see Sect. 2.1), can get in the way of providing 'real access and real impact'; the *community must be empowered* and allowed to drive the research agenda via stronger, as opposed to weaker, participation (see Fig. 10.1 and Sect. 2.2); *informed consent* is fraught with procedural challenges when dealing with communities in developing regions (see Sect. 2.3); *informed participation* should be understood, considered and pursued (see Sect. 2.4); and lastly, *traditional ethics processes*, such as those associated with an IRB, are not wrong; they just are not entirely sufficient when pursuing AT research in developing regions (see Sect. 2.5).

7.2 What We Have Learnt

Based on iterative ICT interventions with a particular Deaf community since 1999, we have learnt the following: the *Deaf community prefers to communicate in SASL*, not text, even though they also want to improve their text literacy; *improved textual and ICT literacy has empowered* the Deaf community to convey innovative ideas to help drive an AT research programme to mutual benefit, e.g. SignSupport; *the Deaf community is a source of innovative ideas*, and research projects can flow from these (postgraduate theses and publications); *stronger participation*, as opposed to weaker, culminates in community empowerment; and *awareness of tacit cultural assumptions enables one to move beyond them*.

7.3 How We Have Changed Our Practise

We fully understand that our lessons apply to the single case study that is portrayed in this chapter. However, the themes listed in Sect. 7.1 and the lessons from Sect. 7.2 have changed our practise, and we feel it beneficial to share how this has happened, because it has wider implications for AT design in developing regions.

We shifted from informal to formal, and certified, ICT training to build capacity with noticeable results in both communicability in written digital communication (notably email, SMS and Facebook) and input into the research programme, e.g. the mobile sign language for doctor and pharmacy scenarios. We moved from textual to SASL-based research goals and outputs/prototypes. All information relayed to the Deaf community is now in signed language, including information sheets, consent forms, questionnaires and focus group data collection exercises. We came to prioritise community-driven goals within our tertiary research programme, e.g. choosing to prioritise the authoring tool (now addressed by a team of three postgraduate students) over the 'cooler' visual password interface.

7.4 Advice for Researchers Working in This Domain

Based on the above, we can therefore offer the following advice when engineering AT solutions for Deaf people in developing regions:

- Implement a certified ICT training programme, in addition to local written language literacy, alongside an AT/ICT intervention programme to empower the community to truly enact community-based co-design such that the community can drive the research agenda.
- Train researchers in signed language, also certified and/or accredited.
- Use professional signed language interpreters during official data collection exercises to effectively communicate with participants in their preferred language.
- Informed consent ought to be augmented by informed participation, shedding detached objectivity-styled positivism, and seen as an ongoing and dynamic process.
- Become aware of, and embrace, cultural and value relativism, including but not limited to differences in individual vs. community-based orientation(s).
- A community-driven agenda, when combined with capacity building, engenders strong participation and empowerment for all stakeholders.

Acknowledgements This chapter is dedicated to the memory of Prof. Adinda Freudenthal, who tragically passed away in early 2014. A native of the Netherlands, Adinda was an associate professor of Industrial Design Engineering at TU Delft with a background in medical devices and user interfaces. Adinda became our SANPAD collaborator (South African Netherlands research Programme on Alternatives for Development – funding from the Dutch embassy; see www.sanpad.org.za). She felt a true passion for working with the Deaf community in South Africa and through supervision of two MSc research projects and a PhD, in collaboration with DCCT, UWC and UCT, sparked and guided the realisation of the SignSupport project. She is deeply missed by collaborators and beneficiaries alike.

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References

ACM/IEEE-CS (1999) Software engineering code of ethics and professional practice. In: ACM/IEEECS Joint Task Force on Software Engineering Ethics and Professional Practices

Agboola IO, Lee AC (2000) Computer and information technology access for deaf individuals in developed and developing countries. J Deaf Stud Deaf Educ 5(3):286–289

Anokwa Y, Smyth TN, Ramachandran D, Sherwani J, Schwartzman Y, Luk R, Ho M, Moraveji N, DeRenzi B (2009) Stories from the field : reflections on HCI4D experiences. Inform Technol Int Dev 5(4):101–115

Averweg U, O'Donnell S (2007) Code of ethics for community informatics researchers. J Commun Inform 3(1). http://ci-journal.net

BCS (2011) The BCS code of conduct. British Computer Society, Swindon, UK

Bhutta ZA (2002) Ethics in international health research: a perspective from the developing world. Bull World Health Organ 80(2):114–120

Blake E, Glaser M (2013) Computer science students learning co-design with a deaf community. In: Ohajunwa C, Mckenzie J (eds) Beyond "if" to "how": disability inclusion in higher education University of Cape Town case study, vol 4. Disability Studies Programme, School of Health and Rehabilitation Sciences, University of Cape Town: Disability Innovations Africa, pp 86–99

Blake EH, Tucker WD, Glaser M, Freudenthal A (2011) Deaf telephony: community-based co-design. In: Rogers Y, Sharp H, Preece J (eds) Interaction design: beyond human-computer interaction, 3rd edn. Wiley, Chichester, pp 412–413

Blake E, Glaser M, Freudenthal A (2014) Teaching design for development in computer science. Interactions 21(2):54–59

Bott F (2005) Professional issues in information technology. The British Computer Society, Swindon

Brewer E, Demmer M, Du B, Ho M, Kam M, Nedevschi S, Pal J, Patra R, Surana S, Fall K (2005) The case for technology in developing regions. Computer 38(6):25–38

Brewer E, Demmer M, Ho M, Honicky RJ, Pal J, Plauché M, Surana S (2006) The challenges of technology research for developing regions. Pervasive Comput 5(2):15–23

Carr W, Kemmis S (1991) Becoming critical – education, knowledge and action research. The Falmer Press, London/Philadelphia

Cavender A, Trewin S, Hanson V (2014) Accessible writing guide. In: Special interest group on accessibility in computing. Retrieved March 11, 2014, from http://www.sigaccess.org/welcome-to-sigaccess/resources/accessible-writing-guide/

Checkland P, Holwell S (1998) Action research: its nature and validity. Syst Pract Action Res 11(1):9–21

Chetty M, Tucker WD, Blake EH (2004) Developing locally relevant applications for rural areas: a South African example. In: Marsden G, Kotze P, Adesina-Ojo A (eds) Annual research conference of the South African Institute of Computer Scientists and Information Technologists (SAICSIT). SAICSIT (in association with ACM), Stellenbosch, pp 239–243

Chininthorn P, Glaser M, Freudenthal A, Tucker WD (2012) Mobile communication tools for a South African deaf patient in a pharmacy context. In: Cunningham P, Cunningham M (eds) Information society technologies – Africa (IST-Africa). Dar es Salaam May 9–11. IIMC International Information Management Corporation, Dublin

Dearden A (2013) See no evil? Ethics in an Interventionist ICTD. Inform Technol Int Dev 9(2 ICTD2012 Special Issue):1–17

Dearden A, Rizvi H (2008) Participatory IT design and participatory development: a comparative review. In: Tenth anniversary conference on participatory design 2008 (PDC'08) Bloomington Oct 1–4. ACM Press, New York, pp 81–91

DeVelle S (2011) Mobile devices as assistive technologies. In: Mobiles for education alliance series. USAID and Education Alliance, Washington, DC. http://works.bepress.com/sacha_develle/8/

Dias MB, Brewer E (2009) How computer science serves the developing world. Commun ACM 52(6):74–80

Doerflinger J, Dearden A (2013) Evolving a software development methodology for commercial ICTD projects. Inform Technol Int Dev 9(3):43–60

Druchen B (2007) Memorandum towards recognition of South African Sign Language as the 12th official language. DEAFSA, Johannesburg

Emanuel EJ, Wendler D, Grady C (2000) What makes clinical research ethical? JAMA 283(20):2701–2711

Emanuel EJ, Wendler D, Killen J, Grady C (2004) What makes clinical research in developing countries ethical? The benchmarks of ethical research. J Infect Dis 189(5):930–937
Erasmus D (2012) Video quality requirements for South African sign language communications over mobile phones. Unpublished MSc thesis, University of Cape Town, Department of Computer Science
Glaser M (2000) A field trial and evaluation of Telkom's Teldem terminal in a deaf community in the Western Cape. In: 2nd South African Telecommunication Networks and Applications Conference (SATNAC). Telkom, Stellenbosch
Glaser M, Aarons D (2002) A deaf adult literacy collective. Stellenbosch Pap Ling 34:1–18
Glaser M, Lorenzo T (2006) Developing literacy with deaf adults. In: Watermeyer B, Swartz L, Lorenzo T, Schneider M, Priestley M (eds) Disability and social change: a South African agenda. HSRC Press, Cape Town, pp 192–205
Glaser M, Tucker WD (2004) Telecommunications bridging between deaf and hearing users in South Africa. In: Conference and workshop on assistive technologies for vision and hearing Impairment (CVHI), Granada, Spain
Glaser M, Young P, Porteous L (2005) An information and communication technology (ICT) needs analysis and training programme for deaf people. In: 20th international congress on the education of the deaf, Maastricht, p 231
Gurstein M (2010) The ethical responsibility of academics. Commun Inform 6(3). http://ci-journal.net
Hayes GR (2011) The relationship of action research to human-computer interaction. ACM Trans Comput Hum Interact 18(3), Article 15
Hayes GR (2012) Taking action in your research. Interactions 19(4):50–53
Heeks R (1999) The tyranny of participation in information systems: learning from development projects. In Development informatics working paper series (paper 4). Institute for Development Policy and Management, Manchester
Heeks R (2002) Information systems and developing countries: failure, success, and local improvisations. Inform Soc 18(2):101–112
Henney AJ, Tucker WD (2013) Information protection in video relay services. In: 4th annual symposium on computing for development (DEV-4) (Article 24, 2 pages). Cape Town Dec 6–7. ACM Press, New York
Hersh MA, Tucker WD (2005) Ethics and mono-disciplinarity: positivism, informed consent and informed participation. In: Zítek P (ed) 16th international federation of automatic control world congress (Vol 16(1)), Prague Jul 4–8. Elsevier, Amsterdam
Kam, M., Ramachandran, D., Raghavan, A., Chiu, J., Sahni, U., & Canny, J. (2006). Practical considerations for participatory design with rural school children in underdeveloped regions: early reflections from the field. In: Interaction design and children, Tampere Jun 7–9. ACM Press, New York, pp 25–32
Kaplan A (1996) The development practitioners' handbook. Pluto Press, London, p 128
Kemmis S, McTaggart R (2000) Participatory action research. In: Denzin NK, Lincoln YS (eds) Handbook of qualitative research, 2nd edn. Sage, Thousand Oaks, pp 567–606
Lauwers T, Kalra N, Dias MB, Dewey D, Stepleton T (2007) Iterative design of a Braille writing tutor. In: Proc. IEEE/ACM international conference on information and communication technologies and development (ICTD2007), Bangalore, Dec 15–16
Looijesteijn K (2009) The design of a deaf-to-hearing communication aid for South Africans. Unpublished MSc thesis; Delft University of Technology, Delft, Netherlands
Ma ZY (2009) semi-synchronous video for deaf telephony with an adapted synchronous codec. Unpublished MSc thesis. University of the Western Cape
Ma ZY, Tucker WD (2007) Asynchronous video telephony for the deaf. In: Browne D (ed) Southern African Telecommunication Networks and Applications Conference (SATNAC), Mauritius, Sep 9–13. Telkom, Pretoria, pp. 134–139
Ma ZY, Tucker WD (2008). Adapting x264 to asynchronous video telephony for the deaf. In D. Browne (Ed.), Southern African Telecommunication Networks and Applications Conference (SATNAC), Wild Coast Sun, Sep 7–10. Telkom, Pretoria, pp. 127–132

Mbulamwana J (2011) Technology and deafness in Uganda: accessibility and appropriateness. Itupale Online J Afr Stud III. http://www.cambridgetoafrica.org
McKay J, Marshall P (2001) The dual imperatives of action research. Inform Technol People 14(1):46–59
Michener VJ (1998) The participatory approach: contradiction and co-option in Burkina Faso. World Dev 26(12):2105–2118
Motlhabi M (2014) Usability and content verification of a mobile tool to help a deaf person with pharmaceutical instruction. Unpublished MSc thesis, University of the Western Cape
Motlhabi MB, Glaser M, Parker M, Tucker WD (2013a) SignSupport: A Limited Communication Domain Mobile Aid for a Deaf patient at the Pharmacy. In: Volkwyn R (ed) Southern African telecommunication networks & applications conference, Stellenbosch, Sep 1–4. Telkom, Pretoria, pp 173–178
Motlhabi MB, Tucker WD, Parker M, Glaser M (2013b) Improving usability and correctness of a mobile tool to help a deaf person with pharmaceutical instruction. In: 4th annual symposium on computing for development (DEV-4) (Article 13, 10 pages), Cape Town Dec 6–7. ACM Press, New York
MRC (2006) Guidelines on ethics in medical research: general principles. Medical Research Council. Retrieved Mar 11, 2014, from http://www.sahealthinfo.org/ethics/
Mutemwa M, Tucker WD (2010) A mobile deaf-to-hearing communication aid for medical diagnosis. In: Browne D (ed) Southern african telecommunication networks and applications conference (SATNAC), Stellenbosch Sep 5–8. Telkom, Pretoria, South Africa, pp 379–384
Pal J, Ammari T, Mahalingam R, Alfaro AMH, Lakshmanan M (2013) Marginality, aspiration and accessibility in ICTD. In: Proc sixth international conference on information and communication technologies and development full papers (ICTD'13), volume 1 Cape Town Dec 7–10. ACM Press, New York, pp 68–78
Penton J, Tucker WD, Glaser M (2002) Telgo323: an H.323 bridge for deaf telephony. In: Miklos Z (ed) Southern African Telecommunication Networks and Applications Conference (SATNAC), Drakensberg Sep 1–4, vol 2. Telkom, Pretoria, pp 309–313
Ramachandran D, Kam M, Chiu J, Canny J, Frankel JL (2007) Social dynamics of early stage co-design in developing regions. In: Human factors in computing systems, San Jose Apr 28–May 3. ACM Press, New York, pp. 1087–1096
Ramuhaheli T (2011) Gesture based interface for asynchronous video communication for deaf people in South Africa. Unpublished MSc thesis. University of Cape Town, Department of Computer Science
Samant D, Matter R, Harniss M (2013) Realizing the potential of accessible ICTs in developing countries. Disabil Rehabil 8(1):11–20
SAPC (2010) South African Pharmacy Council. Good Pharmacy Practice in South Africa. Printed By S.A. Council
SignGenius, Disability Statistics: South Africa (undated) SignGenius Sign Language Software. Available at http://www.signgenius.com/info-statistics.shtml. Accessed 10 Mar 2014
Steneck N, Mayer T, Anderson M (2010) Singapore statement on research integrity. In: 2nd World Conference on Research Integrity. Singapore. www.singaporestatement.org.
Sterling SR, Rangaswamy N (2010) Constructing informed consent in ICT4D research. In: ICTD 2010 (Article 46, 9 pages). London Dec 13–15. ACM Press, New York
Stringer E (1997) Action research: a handbook for practitioners. Sage, USA
Sun T, Tucker WD (2004) A Softbridge with carrier grade reliability using JAIN SLEE. In: Browne D (ed) Southern African Telecommunication Networks and Applications Conference (SATNAC), Stellenbosch Sep 6–8, vol 2. Telkom, Pretoria, pp. 251–252.
Susman GI, Evered RD (1978) An assessment of the scientific merits of action research. Adm Sci Q 23(4):582–603
Tacchi J, Slater D, Hearn G (2003) Ethnographic action research. In: A user's handbook developed to innovate and research ICT applications for poverty eradication. UNESCO, New Delhi
Toyama K, Ali M (2009) Computing for global development : is it computer science research ? ACM SIGCOMM Comput Commun Rev 39(5):40–43

Tucker WD, Blake EH (2010) Abstractions for designing and evaluating communication bridges for people in developing regions. In: First annual symposium on computing for development (DEV). ACM Press, Cambridge/New York

Tucker WD, Glaser M, Lewis J (2003) SoftBridge in action: the first Deaf telephony pilot. In: Miklos Z (ed) Southern African Telecommunication Networks and Applications Conference (SATNAC), George Sep 7–10, vol 2. Telkom, Pretoria, pp 293–294

Wang YY, Tucker WD (2010) Browser-based sign language communication. In: Browne D (ed) Southern African Telecommunication Networks and Applications Conference (SATNAC) Stellenbosch Sep 5–8. Telkom, Pretoria, pp 71–76

Yi L, Tucker WD (2009) Automatic voice relay with open source Kiara. In: Browne D (ed) Southern African Telecommunication Networks and Applications Conference (SATNAC), Swaziland Aug 30–Sep 2. Telkom, Pretoria, pp. 143–148

Zulu TAZ, Le Roux KF, Glaser M (2005) A preliminary investigation into Text-To-Speech (TTS) software in a semi-automated relay service for Deaf telephony. The Division of Communication Sciences and Disorders, Department of Health and Rehabilitation Sciences, Faculty of Health Sciences. Unpublished thesis. University of Cape Town, Cape Town, South Africa

Chapter 11
Ethics, Scientists, Engineers and the Military

Marion Hersh

Overview
The chapter discusses the ethical issues arising from military work by scientists and engineers. It includes an overview with some depressing statistics of global military expenditure and its consequences and a presentation of a three-part model of the causes of conflict. The different types of military technology are presented from nuclear weapons to small arms and the various arms control agreements and the arms trade, including corruption in it, are discussed. Further contributions are a case study of military research in the UK and discussion of the (large negative) impacts of military expenditure on the economy.

1 Introduction

National security is generally focused on military preparedness, including highly sophisticated weapons technologies (Jackson 2011) rather than peace building and resolving underlying problems (Abbott et al. 2006). Engineers and scientists have a critical role in developing weapon technologies and maintaining military preparedness. However, this raises a number of ethical issues, including the ethics of military research and development and the diversion of resources from other important areas, such as education and health, and the contribution of new military technologies to arms races. There are also the questions of the type of society we want to live in, the undue influence of the military on political decision making and whether military applications are the best or an appropriate use of human creativity. These questions are particularly relevant in the context of the existing large stockpiles of

M. Hersh (✉)
School of Engineering, Biomedical Engineering, University of Glasgow,
Rankine Building, Glasgow, Scotland
e-mail: marion.hersh@glasgow.ac.uk

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nuclear and conventional armaments and whatever biological and chemical weapons have not yet been destroyed.

However, despite the devastating nature of existing military technology and its great diversity from small arms to nuclear-armed and power submarines and the enormous stockpiles of both nuclear and conventional weapons and military technologies, research and development work on new weapons systems is still underway. In addition, many scientists and engineers work on the production and maintenance of existing weapons systems.

This chapter will consider these and related ethical issues. It has eight sections, with the last section comprising discussion and conclusions. Section 2 presents some of the statistics on global military expenditure, types and prevalence of conflicts and the resulting deaths. Section 3 presents a three-part model of the causes of conflict developed by the author (Hersh 2013) and discusses different approaches to security and conflict avoidance. Section 4 considers military hardware, including nuclear, chemical and biological weapons, armed drones and cyberweapons. Section 4.5 presents some of the arms control agreements. Section 5 discusses the arms trade, including its volume and the associated corruption. Section 6 presents a brief case study of the military research links of UK universities and discusses some of the associated ethical issues. Section 7 discusses the impacts of military spending on the economy.

2 Global Military Expenditure and Its Consequences: Some Depressing Statistics

Global military expenditure remains at high levels despite reductions in some countries due to austerity measures. The value of global military expenditure peaked in the cold war and has subsequently gone up and down, as follows:

1. Increases leading to a peak in 1987 as a result of the cold war build-up (SIPRI 2001).
2. A drop in real terms between 1987 and 1997.
3. Increases from 1998, with the maximum rate of annual increase of, on average, 5% between 2001 and 2009.
4. A slowing down in rates of growth with an insignificant increase of only 0.3% in 2011 due to reductions in military expenditures in many countries as a result of austerity measures.
5. A 0.4% real terms reduction in military expenditure in 2012, the first real reduction since 1998 (Perlo-Freeman et al. 2013).

Despite austerity measures in some countries, total military spending remained very high at about $1,756 billion in 2012 (Perlo-Freeman 2013a). In addition, Africa (other than sub-Saharan Africa), Asia and Eastern Europe, particularly Russia, increased their spending in 2011 and 2012, and a shift in military spending from the

West to Eastern Europe and some of the majority world (developing) countries may be occurring (Perlo-Freeman 2013a). In the previous period of high economic growth, military spending generally increased more slowly than overall spending. Austerity measures have affected military spending less than other types of spending. Therefore, the percentage of general domestic product (GDP) devoted to military spending has generally increased in the current period of reduced growth (Perlo-Freeman and Solmirano 2012a).

Overall military spending was an estimated 2.5% of global GDP in 2012, a small increase from 2.4% in 2001 (Perlo-Freeman and Solmirano 2012a; Perlo-Freeman et al. 2013). The USA was the largest spender, accounting for 39% of global military expenditure. While this has reduced from 41% in 2010 and this is the first time since 1991 that it has dropped below 40%, US military spending in 2012 was still roughly equivalent to that of the next 11 countries combined (Perlo-Freeman et al. 2013). The USA has maintained expenditure on a number of large-scale programmes, including the Ground Combat Vehicle, tactical wheeled vehicle, the C/MV-22 aircraft programmes and the F35 joint strike fighter programme (Jackson 2012a), and its total spending of $685.3 billion in 2012 was 69% higher in real terms than that in 2001, showing the effects of the ‘war on terrorism’ (Sköns and Perlo-Freeman 2012). However, the real-term reductions of 1% in 2011 and 5.6% in 2012 indicate the possibility of a new approach by the USA, though this could also be a short-term response to austerity and the political process of reducing high and rising government debt (Sköns 2013). Russian military expenditure has been increasing since 1999, and the rate of increase jumped to 16% in real terms in 2012 with proposed nominal increases of over 40% for 2013–2015, giving a real-term increase of 17% between 2012 and 2015 (Perlo-Freeman 2013b).

The 15 largest military spenders accounted for 82% of world military spending in 2012 and the five largest spenders, the USA, China, Russia, UK and Japan for 60% (Perlo-Freeman et al. 2013). Saudi Arabia, which increased its military expenditure by 90% between 2001 and 2011 devoted 8.7% of GDP to military expenditure, though this also includes expenditure on ‘public order’ and ‘safety’. Other countries with large percentage increases in their military expenditure between 2002 and 2011 include Afghanistan (36%), India (59%), Vietnam (82% since 2003), Indonesia (82%) and Mexico (52%). European historical and recent data show a relationship between occurrences of war and the strength of armed forces and between the total number of military personnel and the number of casualties (Brusaco-Mackenzie 2002), illustrating the importance of reducing military expenditure and the size of armed forces.

The nature of armed conflict has been changing, with a reduction in conflicts between states. Conflicts within states (sometimes also involving outside intervention) now generally account for 70–80% of all conflicts. Changes in the nature of armed conflict have led to changes in the Uppsala Conflict Data Program, which has recorded data on ongoing violent conflicts since the 1970s. The previous data collection category of major armed conflict involving at least 1,000 battle-related deaths in a calendar year and with at least one of the parties a state government is now defined as a war. Data is now collected for the following three types of violent conflict (Themnér and Wallenstein 2012):

1. State-based conflicts, which involve at least 25 battle-related deaths in a calendar year with at least one of the parties a state government.
2. Non-state conflicts which involve only non-state armed groups, whether formally or informally organised.
3. One-sided violence which involves the intentional targeting of civilians by a state or an organised group.

While there has been a slow decline in the number of conflicts and their scale and the resulting deaths, the rate of successful conflict resolution has also dropped, leading to increasing numbers of protracted or recurring conflicts (Melvin 2012). All three types of violence are most prevalent in Africa. Armed conflict leads to the largest number of deaths due to the facts that state governments are more organised and have more resources (Themnér and Wallenstein 2012).

Some statistics on the numbers and types of conflicts will now be presented:

1. In 2011 there were 37 armed conflicts in 30 locations and six major conflicts or wars.
2. This is a considerable reduction from the peak of 16 major conflicts or wars in 1988 (Themnér and Wallenstein 2011) and over 50 conflicts in the early 1990s (Themnér and Wallenstein 2012).
3. There have been 248 armed conflicts in 153 locations worldwide between the end of World War II and 2011.
4. There were 73 state-based conflicts, 223 non-state conflicts and 130 organisations carrying out one-sided violence in the decade 2002–2011 (Themnér and Wallenstein 2013).
5. There was a small decline in violent conflicts over the decade 2001–2010, with the greatest decline in the number of wars.

The consequences of these conflicts have also been very serious and include the following:

1. Mortality due to war or conflict, including noncombat civilian mortality, has been estimated at 50–51 million for the period 1945–2000 (Leitenberg 2001).
2. Mortality due to war or conflict, including deaths in German concentration camps, has been estimated as 130–142 million for the whole of the twentieth century (Leitenberg 2001).
3. Mortality due to national political decision making (Hobsbawn 1996), including genocide, starvation and deaths in prison camps, as well as conflict has been estimated at 214–226 million for the twentieth century (Leitenberg 2001).
4. Changes in the nature of war mean that about three quarters of those killed are now civilians, many of them children (Langley 2006).

The number of non-state conflicts can vary significantly from year to year, whereas changes in state-based conflicts occur slowly (Themnér and Wallenstein 2013). The longest lasting wars were between the Afghan government and the Taliban and the Iraqi government and a number of 'rebel' groups. In 2001–2010 there were three conflicts between states: India and Pakistan (2001–2003), Iraq and the USA and its allies (2003) and Djibouti and Eritrea (2008). However, although interstate conflict is becoming increasingly rare, it can easily escalate to a devastating level. Internal conflicts with international involvement are becoming increasingly common. This includes both conflicts linked to the USA's war on 'terror', such as the conflicts in Afghanistan and Iraq, and government intervention in their neighbours' internal conflicts, such as Namibian troops supporting the Angolan government in its conflict with UNITA (National Union for the Total Independence of Angola) (Themnér and Wallenstein 2012). A fragile peace of 30-year duration is continuing in East and South East Asia, but there have been increasing tensions and rapid military build-ups since 2008, particularly in East Asia (Tønneson et al. 2013). There were armed conflicts in Mali, Syria and Yemen in 2012 related to the Arab Spring, and these conflicts could escalate (Allansson et al. 2013).

In addition to its costs in lives, war has had significant economic costs and negative impacts on development. For instance, it has been estimated that armed conflict between 1960 and 2007 reduced GDP by $9.1 trillion or 12.5%. To select just a few depressing statistics relating to inadequate development:

1. Half the world's population, nearly three million people, live on less than $2.50 a day (Shah 2013).
2. 21,000 children die each day due to poverty (Shah 2011).
3. Nearly a billion people were unable to read a book or sign their names at the start of the twenty-first century (UNICEF 1999).
4. Meeting the millennium goal of providing all children with schooling by the year 2000 would have taken less than one percent of spending on weapons (Brazier 1997), but 72 million children of primary school age, 57% of them girls, were not even enrolled in school in 2005 (Anon 2007a).

In the case of one well-known example, the war in Iraq, violent deaths have been variously estimated as 151,000 and 655,000 between March 2003 and June 2006. In addition, over three million people have been displaced as refugees or internally since 2003, basic services such as electricity are still disrupted, public health has deteriorated and unemployment is about 28% (Perlo-Freeman and Solmirano 2012b).

The prevalence of armed conflict in Africa has had serious consequences for development, with an estimated loss of €18 billion per year or 15%, amounting to €284 billion since 1990. This sum could have alternatively been used to solve the problems of HIV and AIDS in Africa or provide education, clean water and sanitation and prevent tuberculosis and malaria (Anon 2007b).

3 Preparation for War and Different Uses of Military Force

It is useful to consider the issues relating to preparation for war and the use of military force in terms of the three-component model of the causes of violent conflict (Hersh 2013), with the following three components:

1. Issue: This includes both issue(s) of dispute and concerns of different types that could lead to disputes or serve as a pretext for the use of force.
2. Context: A context which favours instability, discourages dialogue and the peaceful settlement of issues of concern and encourages moves towards violent 'solutions' and the use of force to achieve objectives.
3. Trigger: A trigger event or circumstance, such as the approach of a significant anniversary or the assassination of an important personage, which results in the actual outbreak of violent conflict or declaration of war.

The flow structure of the diagram (Fig. 11.1) indicates the stages that can lead to conflict. There is increasing instability and likelihood of conflict moving down the left-hand side of the diagram, as the number of factors related to conflict increases. Similarly moving up the diagram on the right-hand side leads to a reduction in the likelihood of conflict. Moving across the diagram to the right shows a reduction in instability as particular factor related to conflict is not present. However, the lack of trigger events in the presence of issues of dispute and a context favouring violent conflict may just lead to the postponement of conflict rather than its resolution.

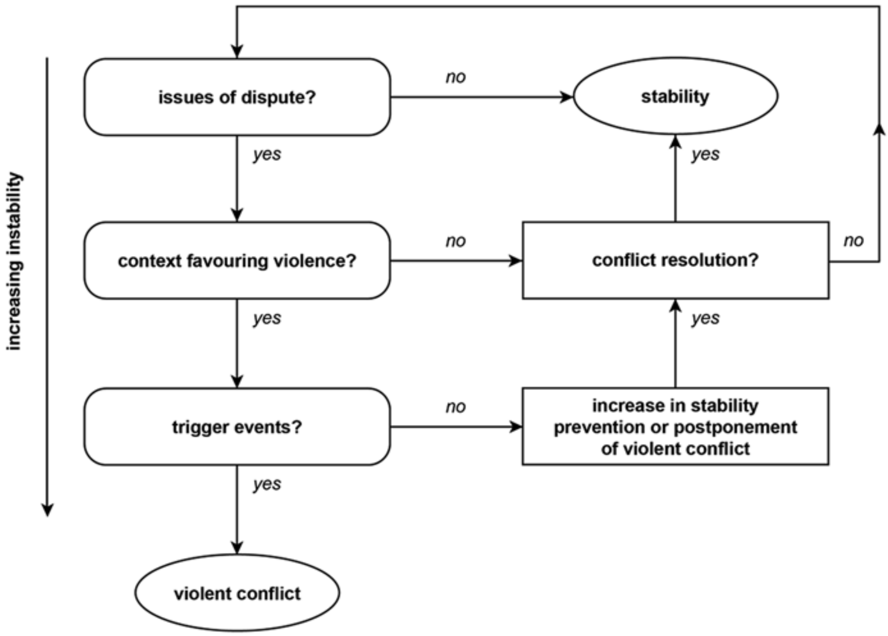

Fig. 11.1 A three-part model of the processes leading to violent conflict and war

Examination of this model shows the importance of resolving the underlying issues which could lead to conflict and working on the context to discourage conflict as an approach to resolving problems. However, many countries, including the USA, are still focusing on high-technology weapon-based approaches to security rather than peace building or trying to resolve underlying problems. This is despite evidence of the inadequacies of this approach, both with regard to avoiding or solving current major conflicts and for long-term security. This tendency has been increased by the US so-called war on terror, leading to the marginalisation of non-offensive approaches to security (Langley et al. 2007).

Non-offensive or defensive defence (Schofeld 2002) involves armed forces which are able to provide a ‘credible defence’, but excludes nuclear weapons and long-range aircraft, missiles and warships which can be used to threaten other countries. Humanitarian intervention (Roth 2004) involves using limited military force to try to prevent mass killing or genocide when there is an imminent threat, other measures have been exhausted, and approval of the UN Security Council has been obtained. Recognition of the vulnerability of civilians in modern conflicts and the importance of protecting them has led to the related concepts of the ‘protection of civilians’ and the ‘responsibility to protect’ (Evans 2012). This then raises the issue of how these principles are translated into action (Evans 2012). In addition, there are the contradictions associated with the use of force to protect people and the possibility of the extension or diversion of interventions with the initial or purported aim of protecting civilians to carry out unrelated aims. For instance, the North Atlantic Treaty Organisation (NATO) action in response to the killing of civilian protesters in Libya and the high probability of many more being killed is credited with saving a large number of civilian lives. It is also criticised for subsequently continuing operations to achieve regime change and attacking both fleeing personnel from the air and locations without military significance (Evans 2012).

There are also so-called peacekeeping operations, frequently involving military forces and sometimes political and observer operations. While the United Nations has remained the main conducting organisation and responsible for 38% of the 52 peace operations in 2011, NATO provided 52% of the personnel (Fanchini 2012). This highlights the potential problems with peacekeeping operations. These include the likelihood of peacekeeping being used as a screen to achieve narrow national or NATO objectives and unnecessary extensions of operations to achieve other objectives.

Real security (Langley et al. 2005) requires the solution of underlying serious problems, including climate change, global poverty, access to clean water and energy sources, loss of biodiversity and environmental degradation. Scientific and technological expertise have a role in resolving these problems. However, a change in political priorities will also be necessary, and achieving this will probably require sustained campaigning by a range of organisations, including those representing (ethical) scientists and engineers.

A range of issues can lead to conflict (Hersh 2013; Stewart 1998), including resources, environmental and economic issues, land disputes, human rights violations and inequalities between different social groups, clashes of ideologies and/or cultures and ethnic tensions, particularly when the minority group is between 10 and 40% of the population (Burton 1990). It has been suggested that the main threats to global security are climate change, competition over resources, growing inequality and marginalisation and global militarism and that a total reshaping of global priorities will be required to prevent these problems leading to conflict (Abbott et al. 2006). Oil and water are both important resources about which conflict could occur. Oil security has been important in US military thinking since the 1970s, whereas conflicts over water have occurred throughout human history (Pacific Institute 2009). Water was a major factor in the conflict in Darfur, Sudan, and solutions to the water crisis are an important component of conflict resolution there (Parkinson et al. 2013).

The importance of water and the likelihood of increasing shortages mean that existing tensions over water use could develop into full-scale armed conflict unless water laws are strictly observed and there is a multilateral approach to water management (Abbott et al. 2006). However, it has been found that it is often competition for control over income-generating resources or more equal access to the income from resource extraction, rather than resource scarcity, that leads to conflict (Collier 2000; de Soysa 2000, 2001). A move to renewables and energy efficiency would reduce the security and political risks associated with nuclear power and fossil fuels from increasingly unstable parts of the world (Abbott et al. 2006), including the risk of diversion of enriched uranium to weapons. It would provide a secure long-term energy supply and reduce the environmental risks associated with the use of nuclear power and fossil fuels.

On the one hand, 'terrorism' is being posed as the major security threat, whereas on the other, current military forces are not particularly suited to fighting 'terrorists'. In many ways, the 'war on terror' is being used as a pretext by the USA to increase its influence and secure access to resources (Abbott et al. 2006). US State Department data reported in Abbott et al. (2006) show that international terrorism is only a minor cause of death, with a couple of dozen people killed each year and the highest death toll of 2,500 in 2001, whereas in the same year, the following deaths occurred in the USA:

1. 3,500 from malnutrition.
2. 14,000 from HIV/AIDS.
3. 62,000 from pneumonia.
4. 700,000 from heart disease.
5. Over 30,000 people committed suicide.
6. Over 42,000 were killed in traffic accidents.
7. Nearly 30,000 people were killed by firearms.
8. Nearly 20,000 people were killed by homicide.

4 Military Technology

There is a very wide range of military technology. It can very loosely be divided into (1) weapons, (2) transportation and propulsion systems, (3) sensors and communication systems and (4) fortifications, though the distinctions are not always clear and a given military technology may have more than one of these functions. Weapons are designed to kill or injure people or animals and damage or destroy structures and systems. They include nuclear, biological and chemical weapons, cyber weapons and small arms. Transportation and propulsion systems are intended to transport armed forces and/or weapons to their destinations or targets. They can be divided into land, sea and airbased systems, though some systems are deployed in more than one medium. Sensors and communication systems can be used to communicate between armed forces and/or to obtain information about 'enemy' positions and activities, to coordinate armed forces and weapons deployment and to guide weaponry. Fortifications are military constructions used largely for defence. Only the first two categories will be discussed further in this chapter. Weapons will be discussed first.

4.1 Nuclear, Chemical and Biological Weapons

Nuclear, chemical and biological weapons are sometimes referred to as weapons of mass destruction. For instance, Trident replacement is still aimed at 'flattening Moscow at the press of a button'. Research by the Scottish Campaign for Nuclear Disarmament (Ainslee 2013) indicates what 'flattening Moscow' would mean. An attack on Moscow by the 40 nuclear warheads normally carried by a Trident submarine would lead to 5.4 million deaths, with 95% casualties within 1.6 km of each explosion. Nearly 800,000 of the deaths would be children and young people under 18. There would be extensive fires within 3 km of each explosion, and most of the city and much of the Moscow region would have very high levels of radioactive contamination, leading to deaths and serious illness. Several of Moscow's largest hospitals would be completely destroyed and others severely damaged, and the casualties would include large numbers of doctors and nurses. It would be very difficult to bring any medical or other aid and assistance to the city due to the very high levels of radioactivity, leading to further deaths and increased suffering from lack of treatment. Schools across the city would also be flattened. It is likely that all normal life in the city would come to an end and that the traumatised survivors would not be in a position to provide any assistance to those in greatest need or start rebuilding, particularly without assistance from outside. The destruction of both public and private transport and deaths of transport personnel would also make it difficult to leave the city subsequent to such an attack, leading to further deaths. Deaths and injuries would be reduced if there was some warning, and residents were able to flee or take shelter in underground bunkers and the subway. However, in the event of a firestorm, many of those taking shelter would be killed by carbon dioxide poisoning. They would also have to emerge while radioactivity levels were still very high. This example illustrates the horrendous potential of nuclear weapons. It should also be noted that the nuclear warheads carried by a Trident submarine are only a small component of the world's nuclear arsenal.

Despite the Nuclear Non-Proliferation treaty, stockpiles of nuclear weapons still remain, only limited progress has been made towards disarmament and the nuclear

Table 11.1 The nuclear states and their nuclear weapons (Kile 2012; Kile and Kristensen 2013)

	First nuclear test	Deployed warheads	Other warheads	Total	Types of delivery system
USA	1945	2,150	5,550	~7,700	Bombers, intercontinental and submarine-launched ballistic missiles, nuclear-powered ballistic missile submarines (strategic); gravity and reserve bombs (nonstrategic)
Russia	1949	~1,800	6,700	~8,500	Bombers, intercontinental and submarine-launched ballistic missiles (strategic); air force, navy and army weapons, antiballistic missiles, air/coastal defence (nonstrategic)
UK	1952	160	65	225	Submarine-launched ballistic missiles
France	1960	~290	~10	~300	Land- and carrier-based aircraft, submarine-launched ballistic missiles
China	1964		~250	~250	Land-based missiles, submarine-launched ballistic missiles, aircraft, cruise missiles
India	1974		90–100	90–100	Aircraft, land- and sea-based ballistic missiles
Pakistan	1998		100–120	100–120	Aircraft, land-based ballistic missiles, ground-launched cruise missiles
Israel			~80	~80	Aircraft, ballistic missiles
N Korea	2006			6–8	
Total		~4,400	~12,865	~17,270	

weapon countries seem to have very little sense of their obligations towards total nuclear disarmament and little intention of disarming in the foreseeable future (Kile 2012). Nine states possessed over 17,000 nuclear weapons at the start of 2012, of which 4,400 were operational (see Table 11.1 for more details). These are the five nuclear states recognised in the 1968 Non-Proliferation Treaty, China, France, Russian, the UK and the USA, and three states with 'illegal' nuclear weapons, India, Pakistan and Israel. In addition, North Korea carried out nuclear test explosions in 2006 and 2009 and has sufficient plutonium for eight nuclear weapons (Kile 2012). Very significant reductions in the number of weapons and warheads have occurred since the end of the cold war. However, the reduction in capacity is not quite as great as the reduction in numbers indicates, due to significant 'improvements' in nuclear delivery systems, warheads and production facilities. Even when agreed, nuclear disarmament will take a number of years to implement. In the case of the UK, plans drawn up in the case of a vote for independence in the Scottish referendum indicate that de-activation of the Trident warheads and their removal from Scotland would take 2 years (Ainslee 2012). Nuclear disarmament of the USA and Russia in particular would take very significantly longer.

First- and second-generation nuclear weapons comprise atomic and hydrogen bombs developed in the 1940s and 1950s, whereas the third-generation nuclear weapons, such as the neutron bomb, have not been added to military arsenals. Fourth-generation nuclear weapons involve advanced triggering technologies, such as superlasers, magnetic compression and nuclear isomers, of relatively small thermonuclear explosions with yields between a fraction of a ton and several tens of tons of high explosive equivalent. They are generally not considered 'weapons of mass destruction' or covered by the Comprehensive Test Ban Treaty. They can also be portrayed as 'clean' nuclear weapons due to their limited radioactive fallout, as little nuclear fission will be involved (Gsponer 2008).

Long-range ballistic missiles were first deployed by the USA in the late 1950s and early 1960s and have been the basis of the US nuclear weapon system and enabled the USA to threaten the whole of the Soviet Union, as well as other nations from the USA or sea-based submarines. Both the US navy and air force are now investigating the deployment of conventional warheads on long-range ballistic missiles, called Prompt Global Strike (Woolf 2011), and have received some funding to do this, though considerably less than asked for. Serious concerns have been addressed that this would lead to misunderstandings that nuclear missiles are being used. While this risk could be reduced by appropriate information measures, this would not eliminate it, particularly if the missiles are used at short notice, which seems likely. Prompt response in the event of an unanticipated conflict is one of the main proposed 'benefits', as this would potentially enable the USA to attack targets across the globe in a much shorter time than moving forces to the region or using bombers (Woolf 2009). In addition to the worrying possibility of these missiles being mistaken for a nuclear attack, the speed of 'response' could also lead to conflict escalation.

Russia and the USA, the states with the largest number of weapons, are both modernising their nuclear forces and slightly reducing the total under the bilateral 2010 New Start Treaty (Kile 2012). Table 11.1 summarises some of the information about the different nuclear states.

Both ballistic and cruise missiles are able to deliver missiles over a long distance to a target. The main difference is that cruise missiles are guided and travel at approximately constant velocity, whereas ballistic missiles are only guided initially and follow a ballistic path.

The availability of additional information through the opening of archives and meetings between former opponents shows that crises involving a major confrontation between the USA and USSR, such as the Cuba missile crisis in 1962, were even more dangerous than previously realised. There have also been incidents involving the loss and non-recovery of nuclear weapons or their damage and very narrow avoidance of accidental detonation (Abbott et al. 2006; Schlosser 2013). There is also some international concern, including by the International Atomic Energy Agency, that Iran may be developing nuclear weapons. The lack of success in agreeing a framework for resolving these concerns (Kile 2013) illustrates the problems in trying to prevent nuclear proliferation while the 'legal' nuclear powers are making no moves to fulfil their commitments to nuclear disarmament under the Non-Proliferation Treaty.

Depleted uranium weapons were first used in Iraq in 1991 and subsequently in Yugoslavia, breaking a 46-year taboo on the intentional use or induction of radioactivity in combat despite the fact that they do not have any significant advantages over tungsten in anti-tank weapons. In addition, they should be classified as low radiological impact nuclear weapons and not as conventional weapons (Gsponer 2003).

Chemical weapons (Walton 2008) use chemicals which can be widely dispersed in gas, liquid or solid form, to inflict death or harm on people. They may affect others rather than the intended victims. Modern examples include nerve gas, tear gas and pepper spray. Nerve agents are the most dangerous form of lethal unitary chemical weapons that can be used on their own without mixing with other chemicals. They include GA, GB, VX and blister agents based on sulphur mustard which are liquid at room temperature and become gases when released. Pepper spray is commonly used, including in a purely self-defensive role by individuals, and is potentially lethal, but does not seem to have been used recently in war. Despite the total ban, a number of states have stockpiles of chemical weapons, including nerve agents. The largest-scale use of chemical weapons against combatants in the twentieth century dates back to World War I and against civilians to the holocaust (Walton 2008). The largest-scale use against an area populated by civilians was the attack by Iraq against the Kurdish city of Halabja in 1988 at the end of the Iran-Iraq war (Anon 2014a). 3,200–5,000 were killed and 7,000–10,000 were injured, with thousands more dying subsequently of complications, diseases and birth defects. Multiple chemical agents were used, probably including sulphur mustard (mustard gas), nerve agents and possibly hydrogen cyanide.

Biological weapons (Walton 2008) involve toxins, bacteria, viruses and other pathogens that can be used as weapons. Their affects on human health vary from mild allergic reactions to death. Although biological weapons have been used for thousands of years, modern uses are fortunately rare, with the main example dating back to World War II (Walton 2008). Some biological weapons can cause long-term contamination. For instance, Gruinard Island in Scotland was contaminated by biological weapons test involving anthrax in 1942. It was eventually decontaminated in 1986 by spraying formaldehyde diluted in sea water over the total island surface (fortunately only 196 ha) and removal of the worst contaminated top soil and finally declared safe in 1990 (Anon 2014b).

4.2 New Technologies

A number of new and newish technologies have potential military applications. One example of this is nanotechnology or the design of engineering systems at the molecular level. Its development was initially largely motivated by interest in very rugged and safe arming and triggering mechanisms for atomic shells and other nuclear weapons, and there is continuing interest in miniaturising nuclear weapons and very low yield nuclear explosions. ‘Improvements’ to existing nuclear weapons can be obtained from the application of nanotechnology to materials engineering to increase ‘safety’ and ‘usability’ and the range of applications (Gsponer 2008). This is potentially very dangerous, as it reduces the barriers against the use of nuclear weapons.

Cyberweapons involve the use of computer and information technology to inflict injury, death and destruction, ranging from web vandalism to the destruction of critical infrastructures, including electricity, water, transportation, communications and fuel networks, and the infiltration of information networks. The Russian military used cyberwarfare to support its invasion of Georgia and deactivated the site of the Georgian Ministry of Foreign Affairs and other government websites (Hoisington 2009). Active ‘defence’ mechanisms which are ‘legal’ in international law require the attacker’s identity and intent to be determined, but the speed of cyber attacks makes it almost impossible to do this in sufficient time to take action. However, proposals, e.g. (Hoisington 2009) to allow good faith responses in the absence of this information are likely to lead to conflict escalation.

Stuxnet, which became available in 2010, is the first cyber weapon which is able to physically destroy a military target. Stuxnet attacks industrial controllers, and the attack in 2010 seems to have been targeted at Iran’s Natanz uranium enrichment plant. It works by loading code onto particular Siemens controllers, but this code is only activated when triggered by complex timer and process conditions. Microsoft security patches do not resolve the problem, and requiring a digital signature to verify legitimacy would be the best solution (Langner 2011).

4.3 ‘Conventional’ Weapons

There are no internationally agreed definitions of small arms and light weapons, but they comprise portable weapons, with small arms generally operated by individuals and light weapons by a crew. They are used by all armed forces, including for self-protection, short range combat and against tanks or aircraft at relatively short distances. There are more than 600 million small arms and light weapons in circulation worldwide, and they have had a significant role in most major conflicts (Pike 2013), particularly in Africa, though there has also been some use of heavy weapons. A wide variety of different small arms have been found in African arms collection programmes, but the most commonly used weapons are the Kalashnikoff assault rifle and its derivatives. These weapons are generally imported from outside Africa (IANSA et al. 2007). Despite their small size, small arms and light weapons have been responsible for between 60 and 90% of direct conflict deaths (Wille and Krause 2005). The proportion of direct deaths is generally greater when civilians are directly targeted and small arms and light weapons are more readily available than other weapons. They also contribute to a large number of indirect conflict deaths through disease, starvation and the destruction of health infrastructure (Krause and Mutimer

2005). Guns are the main tool used to force villagers to flee their homes (Shah 2006).

Artillery (Anon 2014c) involves the use of stored mechanical, chemical or electromagnetic energy to send projectiles well beyond the range of personal weapons. Modern artillery comprises very flexible and highly mobile weapons which contain most of the army's firepower. Artillery can be classified as (1) towed and self-propelled or permanently mounted on a vehicle with space for crew and ammunition, (2) by the velocity at which the projectiles are fired or (3) by the context of use, e.g. field artillery, naval artillery and coastal artillery. Self-propelled artillery is more easily mobile and can be moved and ready for action much faster than towed artillery, but is more expensive to build and maintain. Artillery was responsible for the large majority of combat deaths in the Napoleonic Wars and World Wars I and II (Bellamy 2004) and more recently in the conflict in Syria.

Cluster munitions are airdropped or ground-launched explosive weapons that release or eject smaller submunitions. Most of them are cluster bombs that eject small explosive bomblets over a wide area. They are therefore a danger to civilians both during and after attacks. Unexploded bomblets can kill or maim civilians long after the end of a conflict and are costly to locate and remove. During attacks they frequently kill and injure indiscriminately, particularly in populated areas (Anon 2014d).

Landmines (Anon 2014e) are explosive devices concealed under or on the ground. They are generally classified as anti-personnel or anti-vehicle weapons. The term is generally reserved for manufactured devices designed for use by recognised military services, whereas the term improvised explosive device is used for makeshift devices, including those that could be classified as landmines, used by other armed groups. The use of landmines is indiscriminate and they can remain dangerous for many years.

4.4 Transportation and Propulsion Systems

Transportation systems can be divided into those which transport military personnel and systems for later use and those which can fire the weapons they carry. The first category includes transport aircraft, such as the Hercules, and aircraft carriers, whereas the second category covers armed 'drones', strike or attack aircraft, warships, submarines and tanks. Armed 'drones' are robotic planes flown by ground-based pilots and guided by space satellite technology from computer terminals, which may be separated by several million kilometres from the conflict site and the resulting deaths and injuries. They are used in a range of applications, including spying and surveillance, and have also been used by the USA to kill 'militants' and 'terrorists', particularly in Pakistan. Drones range in size from toy plane to corporate jet size, with the larger drones costing about $60 million and requiring a support team of 20–30 people. Larger US drones are armed with cluster bombs and missiles, and the US government plans to use them to replace bombers, including nuclear bombers and fighter planes, and for artificial intelligence to be used in decisions on when, who and how to attack (Webb et al. 2010). Most automated systems identify people by heat sensors, which cannot distinguish between civilians and combatants. Therefore, the use of automated fighter drones is likely to both increase the number of civilian casualties and remove a sense of responsibility for the resulting (civilian) deaths from their controllers.

Moves to one person monitoring a large number of drones with little power to intervene may be part of phasing out human controllers (Sharkey 2008). The use of drones distances both governments and the military from the consequences of the use of military force and feelings of responsibility. Increasing automation of drones and reduction in human control of them will further increase this distancing and reduce feelings of responsibility, thereby lowering the barriers to the use of military force. A distinction can be made between CIA use of drones outside the battlefield and military use of drones within the battlefield, with the former probably illegal and the later probably legal. There is some controversy about the numbers of civilian and military casualties. However, the Bureau of Investigative Journalism (2014) has estimated that there were 381 strikes between 2004 and January 2014, leading to 2,537–3,646 deaths, including 416–915 civilian deaths and 168–200 deaths of children. Therefore, between 11 and 36% of those killed by drones were civilians.

Strike or attack aircraft are tactical military aircraft that mainly attack targets on the ground or sea and with greater precision than bombers. They are also able to counter stronger low-level air defences. While they are not generally used in combat with other aircraft, they frequently have air-to-air missiles for self-defence. They include ground attack aircraft, generally helicopters, and light attack aircraft (Anon 2014f).

Submarines can work at greater depths than human divers and have a very wide range of types and capabilities from small autonomous and one- or two-person vessels operating for a few hours to those that can remain submerged for 6 months. Military submarines were first used in World War I, and the first nuclear cruise missile was launched from a US submarine in 1953 (Anon 2014g). Both the USA and Soviet Union launched ballistic missile submarines in 1959–1960 during the Cold War. Until the end of World War II, submarines were mainly used against surface ships, as well as for mine-laying and inserting and removing covert military forces. The development of submarine-launched ballistic and cruise missiles enabled submarines to attack long-range land and sea targets with a variety of weapons from cluster bombs to nuclear weapons. A submarine's main defence is its ability to remain concealed. Early submarines could be detected by the noise they made, whereas modern submarines are designed to be difficult to detect and have noise levels that fade into the ambient ocean sound. Most submarines are military, but civil submarines are used in tourism, exploration, oil and gas platform inspections and pipeline surveys. All large submarines are nuclear-powered with backup diesel generators, whereas smaller submarines have diesel-electric propulsion. Nuclear submarine accidents have led to serious radiation incidents, some of which have resulted in several deaths (Johnston 2007).

Armoured fighting vehicles (Anon 2014h) are armed, mobile and protected by strong armour and may be tracked or wheeled. They are classified according to their intended battlefield role and characteristics, though the same vehicle may be used in different roles in different countries at different times. Modern classifications include (1) armoured cars, (2) tanks, (3) troop carriers, (4) amphibious vehicles (which can be used both on land and in water), (5) armoured engineering vehicles (which carry out obstacle breaching, earth moving and engineering work on the battlefield), (6) air defence vehicles (which have self-propelled anti-aircraft weapons or defence systems), (7) self-propelled artillery (including self-propelled guns or howitzers and rocket artillery) and (8) armoured trains.

Tanks are all terrain vehicles which fire directly on ‘enemy’ forces in a frontal assault and are therefore offensive weapons. Modern tanks have a main artillery gun mounted on a rotating turret on top of a tracked automotive hull and various additional machine guns. Modern main battle tanks are the most expensive to mass produce and have very high levels of precision-guided weapons able to attack ground and air targets, mobility and armour protection. They can cross rough terrain at speed, are versatile and valued for their shock value, high firepower and high survivability, though they are vulnerable to anti-tank warfare and have high fuel, ammunition and maintenance requirements. Self-propelled artillery may superficially resemble tanks, but is too lightly armoured to survive direct fire.

4.5 Arms Control Agreements

There are a number of different agreements on the control of conventional, nuclear, chemical and biological weapons, to which varying numbers of countries have signed up. However, a number of factors impede arms control agreements. In the case of conventional weapons, the dominant military position of the USA makes agreements based on balance impossible. Continuing technological developments, such as cyberweapons and missile defences, makes it more difficult to evaluate the impact of arms control and the capabilities associated with different weapons. In the case of anti-personnel mines and cluster munitions, some states have found it difficult to balance humanitarian concerns and their perceived security needs (Anthony 2012).

Chemical and biological weapons have been totally outlawed. The Chemical Weapons Convention and the Biological and Toxin Weapons Convention forbid the development, production, acquisition, transfer, stockpiling and use, respectively, of chemical weapons, and biological agents and toxins of types and in quantities not required for peaceful purposes, as well as weapons and delivery systems. The majority of states have signed and ratified both the chemical and biological weapons conventions. Chemical weapon stockpiles are supposed to have been destroyed by April 2012. However, only three of the seven parties who had declared stocks of chemical weapons met this deadline. Iraq, Libya, Russia and the USA are continuing to destroy chemical weapons (Bodell 2013). Although the budget of the Organisation for the Prohibition of Weapons is being reduced as it winds down its activities, it was still nearly €71 million in 2011, divided 53:47 between administration and verification of destruction activities. The USA had spent $23.7 billion on destroying its chemical weapons stocks by the end of November 2011, though it had still not destroyed the total stockpile (Hart 2012). The high costs of disarmament, including the associated verification programmes, and the resulting diversion of resources from social and environmental programmes, are a further argument against militarisation and in particular the development of new weapons systems.

The 2008 Convention on Cluster Munitions impose a total ban on cluster munitions. By the start of 2013, 111 states had signed it and 77 ratified it (Grip and Patton 2013), with these numbers increasing to 112 and 83 by 2014 (Anon 2014d). However, there is still opposition to a total ban from a number of powerful states, including China, Russia and the USA (Grip 2012), The Convention entered into force and became binding on states which had ratified it in August 2010. Eight of the parties have completely destroyed their cluster munitions stockpiles. However, credible reports of the use of cluster munitions by two states which have not signed the Convention, Sudan in 2012 (Grip and Patton 2013) and Syria from 2012 onwards (Human Rights Watch 2014), clearly demonstrate the need for it.

The 1997 Convention on the Prohibition of the Use, Stockpiling, Production And Transfer of Anti-Personnel Mines and on their Destruction totally bans anti-personnel mines and requires the destruction of existing stocks, but allows some stocks to be retained for use in mine detection, clearance or destruction techniques. One hundred and sixty one states have ratified or acceded to the Convention and one has signed, but not ratified. More than 46 million stockpiled mines have been destroyed since the Convention's entry into force in 1999. Eighty seven countries have completed the destruction of their mine stockpiles, other than those retained for use in training, and another 64 have declared that they did not possess any stockpiles. Seventy two countries are retaining mines for use in training (Anon 2014i).

The 1981 Convention on Prohibition or Restriction of Certain Conventional Weapons, with 114 parties to the original convention and protocol, is an umbrella treaty with a number of different protocols introduced at different times. It prohibits or restricts the use of a number of different types of conventional weapons (Bodell 2012). The Conventions on the Prohibition of the Development, Production, Stockpiling and Use of Bacteriological (Biological) and Toxin Weapons, and Chemical Weapons, and on their Destruction entered into force in 1975 and 1997 respectively. They have 166 and 188 parties respectively (Bodell 2012).

The Treaty on the Non-Proliferation of Nuclear Weapons, with 190 parties entered into force in 1970. It divides states into nuclear weapons states, which manufactured or exploded a nuclear weapon or nuclear explosive device before 1 January 1967, and non-nuclear weapons states. The nuclear weapons states are forbidden to spread nuclear weapons technologies to non-nuclear weapons states and agree to cease the nuclear arms race at an early date and to nuclear disarmament. The non-nuclear weapons states agree to prevent the diversion of nuclear materials from 'peaceful' uses to weapons (Bodell 2012).

Subsequent agreements on nuclear weapons have largely involved the USA and Russia, formerly the Soviet Union. The most recent of these is the Treaty on

Measures for the Further Reduction and Limitation of Strategic Offensive Arms (New START). It limits each of Russia and the USA to no more than 1,550 accountable nuclear weapons deployed on strategic missiles and bombers. This is a nominal reduction of 30% from the 'SORT' limit of 2,200 accountable warheads in 2002 and nearly 75% from the START limit of 6,000 accountable warheads in 1991. The total limit on deployed and undeployed delivery systems (intercontinental and submarine-launched ballistic missiles and long-range heavy bombers) for each side is 800, of which no more than 700 can be deployed. Russia wanted a lower limit of 500 delivery vehicles to counter the US advantage of a greater number of delivery vehicles with fewer warheads on each onto which it could redeploy stored warheads. The limits cover conventionally armed ballistic missiles. However, the treaty does not restrict the use of missile 'defences' (Kile 2011) or require missile dismantling, and the USA met the START limitations largely by removing and storing warheads (James Martin Center 2010).

There were 29 mandatory multilateral arms embargoes in force in 2010, directed at 16 targets. These included 12 United Nations embargoes, one from the Economic Community of West African States and 16 European Union embargoes, of which 10 implemented UN embargoes, two had different coverage and four had no UN equivalent. There were also a number of violations of these embargoes (Wezeman and Kelly 2011).

Attempts to regulate the international trade in conventional weapons have not been particularly successful. The Arms Trade Treaty (Holtom and Bromley 2013a) was adopted by the UN General Assembly in 2013, and came into force in December 2014. 62 states have ratified it and a further 68 have signed, but not ratified it (Anon 2015). The treaty is not particularly strong. Its scope is limited to the seven types of weapons listed in the United Nations Register of Conventional Arms plus the additional category of small arms and light weapons. There are three categories of prohibited transfer, largely based on existing obligations under international law. States are required to carry out a risk assessment of the likely use of the arms to commit or facilitate a breach of human rights or terrorism and a general assessment of whether their export will contribute to or undermine peace and security. States are also required to consider measures to avoid (1) diversion to illicit markets or organised crime, (2) use to commit violence against children or women, (3) corrupt deals and (4) negative impacts on the importing states. However, existing defence cooperation agreements have primacy over the Treaty. As a result of very strong opposition from the USA to the inclusion of ammunition in the treaty, it only requires a national control system to regulate the export of ammunition with such exports not allowed if in the prohibited categories or if they could be used to commit or facilitate human rights violations or terrorism, but no requirements to take measures to prevent diversion or to keep records.

The Treaty on Conventional Armed Forces in Europe (Bodell 2013) was negotiated and signed by the members of the Warsaw Treaty Organisation and NATO under the framework of the Conference on (later Organisation for) Security and Cooperation in Europe. It entered into force in 1992 and was modified to take account of the states emerging which replaced the Soviet Union. It had 30 parties, but Russia suspended participation in 2011. It sets limits on battle tanks, armoured combat vehicles, artillery of at least 100 mm, combat aircraft and attack helicopters in an area from the Atlantic to the Urals.

5 The Arms Trade

The arms trade is still significant, though cuts in military expenditure as part of austerity measures in many of the richer countries are having an impact. In addition, disagreements on how to reduce the US budget deficit and the (planned) withdrawals from Iraq and Afghanistan are causing some uncertainty. The SIPRI Top 100 lists the 100 largest arms producers and military services companies, excluding those in China (based on their sales). Their sales totalled $410 billion in 2011, a decrease of 5% in real terms from 2010, but a massive 51% increase from 2002. The list of companies also changed slightly, the sales of the company at the bottom of the list more than doubled, whereas the percentage of sales of the top 10 reduced from 60% in 2002 to 54% in 2011 (Jackson 2013). A number of factors have caused this decrease in sales, including the withdrawal from Iraq, postponements due to austerity measures and military spending cuts. Other factors include the United Nations embargo on sending arms to Libya and the weakness of the US dollar in many countries. Seven of the ten largest arms companies in 2011 were based in the USA and one each in the UK, Italy and involving several European countries (SIPRI 2013). India and several countries in the Middle East have large arms procurement projects, leading to them being targeted by West European and North American arms companies (Jackson 2012a).

International arms transfers increased by 17% from 2003–2007 to 2008–2012 (Holtom et al. 2013). The five largest suppliers, USA, Russia, Germany, France and China, accounted for three quarters of exports of major weapons in 2007–2011, reduced slightly from 78% in 2002–2006 (Holtom 2013). China and Spain have also become significant suppliers. China is continuing to reduce its significance as a recipient (Holtom et al. 2012), possibly because it is now increasingly able to produce its own weapons. It is in the five largest arms traders for the first time since the Cold War, having displaced the UK, which has been in this group since 1950 (Holtom 2013). The USA is still the largest arms supplier, accounting for 30% of transfers of major conventional weapons in 2008–2012 (Holtom et al. 2013).

Changes in political alliances mean that armaments have been used against the forces of the country that sold them on a number of occasions. For instance, before the Falklands/Malvinas conflict, more than £180 million of British arms were sold to Argentina, including an aircraft carrier, destroyers, ship-to-air and surface-to-air missiles, armoured cars and sub-machine guns. Many of the 255 British servicemen who died in the Falklands/Malvinas were killed by British weapons (Evans et al. 1991). Changes in alliances can happen very quickly. For instance, during the Gulf

War, Iraq was transformed almost overnight from an ally to which the west had sold a wide range of military equipment into an enemy. The USA provided Afghanistani mujahideen with Stinger anti-aircraft missiles in the 1980s for use against the Soviet military. When the USA subsequently invaded in 2001, some of these missiles were in the hands of the Taliban (CAAT 2010).

At one time, majority world countries were totally dependent on imported major weapons systems with associated high costs, a reduction in the ability to make independent ‘defence’ decisions and political constraints. However, a number of these countries, such as China, Israel, South Korea, South Africa and Taiwan, are now developing their own weapons systems (Jan and Jan 2000) and in some cases also exporting them. Having their own arms production capabilities protects smaller countries from arms embargoes and dependence on imports and associated political constraints (Jackson 2011). Military R&D is complicated and expensive and requires scientists and engineers (Jan and Jan 2000), and this can divert them from important civilian areas. The establishment of military R&D capacity in minority world countries draws on and further ingrains the focus on national security based on well-armed military forces (Jackson 2011) rather than peace building and solving underlying problems. India was the largest recipient of arms in 2008–2012 followed by China (Holtom et al. 2013). Arms imports by states in Western and Central Europe have decreased significantly due to reduced military spending and increasing economic uncertainty, with domestic arms producers preferred (Holtom 2013).

Since the Arms Trade Treaty, which is anyway weak, has only very recently come into force (Holtom and Bromley 2013a), other than a number of arms embargoes and restrictions resulting from international agreements, such as the Nuclear Non-Proliferation Treaty, there has been little regulation of the arms trade. Therefore, the majority of arms sales, including to conflict areas or countries with serious human rights abuses, have been legal. Arms sales can facilitate human rights abuses by direct use of the arms, indicating international approval and thereby lending legitimacy and prestige (Williamson 1990) to governments which practice internal repression and torture and increasing the military capacity of governments. For instance, Syria modernised its forces prior to 2011 with imports of conventional weapons increasing by 330% between 2001–2005 and 2006–2010 (Wezeman 2013). There have been international differences in response to the conflict in Syria, with the EU, Turkey and USA maintaining arms embargoes, calling for a UN embargo and trying to prevent the delivery of arms by other states when legally possible and Iran, Russia and the Ukraine continuing to supply arms to the Syrian government (Wezeman 2013). Opposition and ‘rebel’ groups have largely used arms captured from Syrian forces. The USA has provided communications and other equipment and the UK communications equipment and body armour to the ‘rebels’. It is difficult to measure the volume of foreign military ‘aid’ to the ‘rebels’, and no state has admitted directly to supplying them, though there are reports of states either supplying them directly or providing funds to obtain weapons on the black market (Wezeman 2013). The UK government approved arms export licences in 2010 to 16 of the 26 ‘countries of concern’ (CAAT 2011) on that year’s human rights report (UK 2011). UK arms have been used in the suppression of protests in Bahrain and

Libya in 2011, and the UK sold arms to 12 of the 16 countries identified by the Stockholm Institute of International Peace Research as locations of major conflict in 2009 (SIPRI 2009).

Many US arms companies have large cash reserves and are interested in sometimes large-scale acquisitions in related commercial sectors, such as aerospace manufacturing. The financial context has led to discussion of greater cooperation in weapons production in the European Union and particularly Western Europe with the aims of reducing costs and infrastructure duplication and having cheaper military services. However, national arms industries are prestigious. There are also bilateral arms industry cooperation agreements, including between the UK and France, and Germany and Italy (Jackson 2012a).

Military services can be divided into research and analysis, technical services such as information technology and maintenance, operational support such as logistics and training, and armed forces. Outsourcing of military services is likely to continue due to assumptions that private firms are cheaper and more efficient than government agencies, but the rate of growth is likely to decrease due to saturation as a result of previous rapid increases and decreasing US military activities in Iraq and Afghanistan (Jackson 2012b). The privatisation and outsourcing of armed force illustrates the fact that economic rather than humanitarian concerns often determine the use of force and may raise concerns with regard to human rights issues. There has been significant growth in private military services over the last two decades, and there were 20 largely military services companies in the SIPRI top 100 in 2011 (Jackson 2012c).

5.1 The Arms Trade and Corruption

The arms trade is associated with high levels of corruption, estimated at 40% of the total corruption in world trade (Roeber 2005). Corruption has been defined as 'the abuse of entrusted power for private gain' (Transparency International undated) to which has been added the act of corrupting or offering an 'inducement' to obtain an 'unfair advantage' (Feinstein et al. 2011). The methods used to acquire undue influence in the arms trade include bribery, failure to declare conflicts of interest, promises of subsequent employment (the 'revolving door') and offers of preferential business access. Bribery occurs in all types of weapons transactions and frequently involves a network of international banks and third parties to hide payments and relationships. Failure to declare conflicts of interest is common to arms deals involving governments and includes public officials making contracts with a supplier in anticipation of a personal financial reward. The 'revolving door' involves an arms company employing a public official when they leave office, with the offer of employment often made while the official is making decisions to award contracts to a future employer (Feinstein et al. 2011). For instance, 80% of US three- and four-star generals retiring between 2004 and 2008 became employees or consultants in the arms industry (Bender 2010). Many of them were offered employment before retirement and/or retained advisory roles to the US government after retirement (Feinstein et al. 2011).

The features of the arms trade that encourage corruption include the following (Feinstein et al. 2011):

1. Secrecy relating to national security and commercial confidentiality. This reduces transparency, makes arms deals secretive and protects participants from scrutiny.
2. The close relationships and blurred boundaries between arms trade firms and government agencies resulting from the importance of the arms trade to national security. This gives the arms trade access to inside information and enables it to shape policy.
3. The global nature of the arms trade and the complex and opaque nature of transactions and the various parties involved in them. Many arms deals involve both official and black market trades.
4. The technical specificity of the trade, often involving high-tech equipment and a very small number of knowledgeable experts who influence the final decision. Together with the few politicians and officials involved, this means that potential corrupters only need to unduly influence a few people.
5. Pressure to obtain arms rapidly in situations of active or imminent conflict.
6. The enormous monetary values of a small number of contracts each year, leading to high levels of competition.

While some of these features are present in other types of trade, they are generally all present in the arms trade, increasing the likelihood of corruption. In addition, considerations of national security mean that investigations or legal proceedings rarely occur and are often halted when they do. Transparency in arms transfers may be decreasing. The number of states reporting their arms imports and exports to the UN Register of Conventional Arms decreased by 40% from 86 in 2011 to an all time low of 52 in 2012. However, an increasing but still low number (35 as of January 2013) of governments, have published at least one national report on arms exports (Holtom and Bromley 2013b).

In addition to the financial costs of corruption, there are the costs of resources lost to health, education and social services and the undermining of justice and oversight institutions (Feinstein et al. 2011). A particularly unfortunate example is the purchase of BAE/Saab jets by the South African government, involving the payment of £115 million in ‘commission’ to ‘overt’ and ‘covert’ advisors (Feinstein et al. 2011). This was despite the fact that the jets did not meet the technical requirements and cost two and a half times as much as the aircraft preferred by the Air Force Technical Committee. In addition, there was no real need for them, since the air force had at least 15 unused jets. To stop the investigation of corruption, the main anti-corruption body was excluded and then closed and investigation by the other bodies was limited. This corruption and its cover-up has had a devastating impact on the South African parliament and resulted in conditions in which corruption is increasingly pervasive. In addition, there was the unnecessary expenditure of £8 billion on weapons at a time when the country allegedly could not afford life-saving antiretroviral medication for five and a half million South Africans with HIV and AIDS (Feinstein 2010).

Another depressing story of corruption surrounds the 1985 Al-Yamamah arms deal between the UK and Saudi Arabia for the supply of a range of military hardware. This included Tornado aircraft, helicopters, tanks and armoured vehicles from British Aerospace (now BAE Systems) at a cost of over £40 billion with payment largely in oil (Webb 1998, 2007). Saudi Arabia has a history of serious human rights violations. Its government was described in a briefing prepared by a top UK Ministry of Defence (MoD) civil servant in 1985 as 'authoritarian and highly undemocratic' and the US Central Intelligence Agency (CIA 2007) noted that 'workers from South and Southeast Asia … are subjected to … involuntary servitude, including being subjected to physical and sexual abuse, non-payment of wages, confinement… children [are] trafficked into Saudi Arabia for forced begging and involuntary servitude as street vendors'.

A subsequent deal announced at the end of 2005 involved Saudi Arabia purchasing 72 Eurofighter Typhoon aircraft, which few other countries were interested in, for about £5 billion. Other than the project partners, only Austria had agreed to buy the plane, but had subsequently realised the cost and discovered that a company controlled by the wife of the Austrian air force chief had received €87,600 from a lobbyist (Webb 2007). Payments by BAE to Saudi princes were on an even larger scale, with a fund estimated at £60 million for this purpose, including a three-month holiday alleged to cost £2 million and a £170,000 Rolls-Royce (Webb 2007). A then labour councillor found it 'very embarrassing' that some of the young women he procured for visiting Saudi pilots came from his area. The Serious Fraud Office started investigating the Al-Yamamah contract bribery allegations in 2004, but encountered pressure from the Saudi and UK governments and BAE and the inquiry was dropped at the end of 2006 (Webb 2007).

6 Case Study of Military Research in UK

The UK had the world's fourth largest military budget of $60.8 billion in 2012, behind the USA, China and Russia, with military spending per person twice that of Russia and eight times that of China. Spending per person and per unit GDP is much greater than the EU average. UK military spending in 2012 was 22% of the EU total (Parkinson et al. 2013), but its GDP was only 18% of the total (Anon 2014j). It has the world's third largest arms company, BAE systems, and is the sixth largest arms exporter (Parkinson et al. 2013). Recent recipients of UK arms include Algeria, Bahrain, Libya, Saudi Arabia, Tunisia and Yemen. However, criticism has been more vocal following the brutal action by the governments of Libya and Bahrain to suppress uprisings in 2011 (Committees on Arms Export Controls 2011).

The Ministry of Defence (MoD) spends about £15 billion per year on military technology (Parkinson et al. 2013), including £1.8 billion on research and development (R&D). This is about a sixth of government R&D spending and a much higher percentage than in most other industrialised countries (Parkinson 2014). Spending on health R&D is now close to that on military R&D, having increased over the last couple of years, while that on military R&D has fallen, with a considerable drop from the approximately 50% at the height of the cold war (Parkinson 2012a). Most military R&D, including government funded R&D, takes places in industry, resulting in a subsidy of £500 million annually (Parkinson 2012b). In many cases, the government purchases the technology resulting from military R&D funding, thereby effectively paying twice, once for the research and the second time when it buys the resulting technology.

The main areas of UK military R&D are offensive not defensive, namely, (1) nuclear weapons systems, including warheads, 'successor' submarines and submarine nuclear propulsion systems (£980 million); (2) strike planes, such as Typhoon, F35 lightning II and Tornado (£771 million); (3) attack helicopters, mainly Future Lynx/Wildcat (£559 million); and (4) unmanned aerial vehicles or drones, including Mantis and Taranis (£195 million). These expenditure figures are for 2008–2011. They are minimum figures due to missing data, so the real figures may be higher (Parkinson 2014). About a tenth of UK military R&D spending goes to nuclear weapons. A recent expansion of the Atomic Weapons Establishment at Aldermaston involving new research facilities on supercomputers and the Orion Laser may undermine the Nuclear Proliferation and CTB treaties.

Public relations exercises tend to focus on de-mining and other 'life-saving' R&D projects, but their contribution is in fact only a very small percentage of military R&D, and 76% of the programmes for which data was available were for technology with offensive uses. Changes to a less aggressive defence policy could save £1 billion per year. In addition a quarter of military research spending of about £500 million is undocumented at the programme level by the Ministry of Defence (Parkinson et al. 2013). However, this high level of militarisation is taking place at a time when even the prime minister admits that the UK does not face the threat of attack by conventional forces and the use of conventional military power could only deal with one the eight risks in the first two tiers of the national security strategy (HM Government 2010). Surprisingly a considerable proportion of R&D spending is for equipment that has already been deployed, often including large overspends. For instance, several hundred F-35 Joint Combat Aircraft have already been produced, although testing will continue until 2019 (Parkinson et al. 2013).

The current phase of military involvement in UK universities dates back to the start of the century at a time of privatisation of government research labs and the early days of the so-called war on terror. 42 out of 43 UK universities investigated in four studies received funding for military objectives and research by Scientists for Global Responsibility, and other organisations has not yet identified a UK university which definitely does not receive military funding (Langley et al. 2008). It is therefore highly likely that the overwhelming majority of UK universities receive at least some military funding, and a number of them definitely receive very large amounts. In the period 2008–2011, 16 leading universities received over £83 million in military funding, with another six universities not providing any information in response to Freedom of Information Act requests from the Huffington Post newspaper. The highest funding was received by Imperial College (£15.2 million), followed by Sheffield and Cambridge Universities (each £13.8 million). 28% of the total came directly from the government and the majority from private companies. However, much of the apparently private funding was not in fact private, but from the government through Ministry of Defence and other government agency R&D contracts. The largest company funders were Rolls-Royce (at least £36.8 million) and BAE Systems (10.6 million) (CAAT 2012). The total military R&D funding of universities is believed to be about £200 million, though it is difficult to obtain accurate information, and despite a number of studies, clear data on the extent of military involvement in universities is not available (Parkinson 2012a). This lack of openness and transparency is one of the many problems associated with military and military-funded research.

Many UK university websites have statements about the importance of openness and corporate responsibility. However, not one of the 16 university vice chancellors approached by Scientists for Global Responsibility accepted SGR's invitation to 'describe [their university's] … vision of the challenges and opportunities that they faced in a commercialised environment' (Langley et al. 2008). Several of the senior members approached expressed concerns about commercialisation and excessive workloads, and many academics felt that the subject of military funding was 'too difficult' to discuss 'publicly' though information had already been obtained through Freedom of Information Act requests. Most universities provided only partial information, omitted answers and took the permitted 20 days for subsequent responses, further indicating the lack of transparency (Langley et al. 2008).

There are also indications that the UK government is not being particularly open about the extent of military funding for universities. For instance, two recent studies both found average annual military funding per university of over £2 million (Langley et al. 2008; Street and Beale 2007) and total funding of £56 million for 26 of them. This is significantly greater than the government's admitted total military funding to universities of £44 million in 2004 or an average of about £400,000 per university. This is a significant discrepancy even after correcting for a particularly significant 22-year military contract for Cranfield University. The fact that many of the universities studied by Street and Beal had higher than average military funding does not explain this discrepancy.

The major military funders BAE Systems, QinetiQ (former UK government 'defence' labs) and Rolls-Royce have also been unresponsive about their relationships with universities, indicating that the reality is very different from their website claims of openness and honesty about these relationships (Langley et al. 2008). However, military research is increasingly dependent on university expertise, which is funded by taxation, i.e. members of the public. This would seem to give an entitlement to know how this expertise is being used (Langley et al. 2008).

The details of the types of available military funding have changed over time with some initiatives closing and others starting up. The main military research funding mechanisms include (1) joint grant schemes with UK research funding councils on either an opt-in or opt-out basis, (2) large programmes run by Rolls-Royce and QinetiQ and (3) joint government-industry schemes run in conjunction with Defence

Science and Technology Labs and the Engineering and Physical Sciences Research Council, namely, defence technology centres (Parkinson 2012a). Researchers who are willing to accept joint MoD funding probably have a greater chance of obtaining funding than those who are not, since this reduces the amount required from the research councils. Thus, the joint funding schemes may have the unintended effect of reducing the funding available for civilian research projects.

Military-university consortia involved in joint grant schemes and research centres have included (1) 'towers of excellence' in guided weapons, radar, underwater sensors and electronic warfare; (2) defence and aerospace research partnerships; (3) defence technology centres in data and information fusion, electromagnetic remote sensing and systems engineering for autonomous systems and robotics; (4) and the counterterrorism science and technology centre (Langley et al. 2007). However, towers of excellence and defence and aerospace research partnerships have apparently been discontinued (Parkinson 2012a). Ten UK universities have been involved in research on robotic aircraft or drones as part of the FLAVIIR programme, and BAE Systems is developing two armed drones. They were originally used in reconnaissance, but since 2007 the UK has used them in Afghanistan and had carried out 200 drone strikes by the end of 2011 (Parkinson 2012b).

UK universities tend to justify military funding on the grounds that it is only a small percentage of total funding, contributes to national security and the research also has 'spin-off' civilian applications. However, military funding may form a large part of the support of particular engineering and computer science departments and therefore shape their research priorities (Parkinson 2012a). UK military equipment is often exported to governments with poor human rights records and used in the suppression of protests, e.g. in Libya, Bahrain and Saudi Arabia (HCC 2011). This is likely to reduce rather than increase security, both in the UK and globally.

Civilian benefits from military research have generally been disappointing, particularly when the very higher levels of investment are considered (Langley et al. 2005). This is probably to be expected, since military and civilian needs are very different, and directly targeting resources at the civilian applications of interest would seem a much more effective approach than hoping they will emerge as a result of military work or making them one potential outcome of joint work. Thus, for instance, the development of more accurate precision targeting systems for depleted uranium weapons seems unlikely to result in a cure for the common cold or a bicycle wheel that cannot be punctured. The systemic shortcoming of the military-industrial sector makes it questionable that military R&D has any net economic benefits (Dunne and Coulomb 2008). Military R&D diverts resources and expertise from civilian projects, thereby reducing the likelihood of advances in desired directions. The greater openness and flexibility of civilian research projects generally also make them more effective in producing innovation (Parkinson et al. 2013). In addition, costly downstream technical efforts and additional resources are generally required to develop a viable commercial product from military R&D. When spin-offs do occur, this raises ethical issues of the diversion of government funds to private firms (Alic et al. 1992).

Military R&D raises issues of open publication. While the different Defence Technology Centres vary in their degree of openness, they all screen publications for ‘military sensitivity’ and they are required to satisfy the Ministry of Defence’s research output goals. However, it is not clear how these requirements affect the non-military research of participating departments or the nature and types of research publication (Langley et al. 2008). Other concerns expressed by researchers without military funding included the prioritisation of high-technology approaches to global issues despite the lack of evidence to justify this; research becoming more ‘conformist’ and less open, accountable and able to address difficult ethical issues as a result of increasing commercial and military involvement; and the inability to express these concerns openly (Langley et al. 2008). Military and commercial pressures, for instance, through the abuse of national security and commercial confidentiality arguments, have the effect of suppressing debate and dissent about ethical issues in science, engineering and technology. There are also some indications, though the evidence is limited, that the publications resulting from military-funded work are of lower quality (Langley et al. 2008).

The military sector has a large and disproportionate effect on science, engineering and technology and is focusing particularly on engineering and physical science departments in ‘high prestige’ universities (Langley et al. 2008). The extent of military funding may be diverting skilled researchers from important civilian work and threatening the availability of civilian science and technology skills, for instance, for cleaner technologies. Science, engineering and technology programmes on conflict prevention, environmental protection and poverty alleviation have been shown to have the potential for significant benefits at relatively low cost, but like disarmament and peace building initiatives, their funding amounts to only a small percentage of the military budget. Similarly, renewable energy R&D, required for dealing with climate change, receives only a fraction of the funds devoted to military R&D (Langley et al. 2005). Total R&D spending on sustainable security, including climate change, by the Department of Energy and Climate Change in the period 2008 was only £42.5 million, a very meagre 2.8% of the £1,497 million MoD R&D spending (Parkinson et al. 2013).

However, annual MoD R&D spending in the UK has reduced by 40% over the last 10 years in real terms and from 33% to 17% of the total public R&D budget. At the same time, government spending on renewable energy R&D has increased 20-fold but is still less than one tenth of military R&D expenditure. Largely as a result of austerity measures, total military spending, including warships, tanks and fighter planes, is to be cut by 8% between 2010 and 2014. There is also some recognition of the need for a broader approach to security, including attention to factors such as climate change that drive insecurity, as well as the threat from environmental problems, disease and accidents.

There have been a number of government initiatives to transfer military technology to civilian applications. This has included the combination of 30 separate laboratories and other establishments, such as the Porton Down chemical and biological research centre and the Malvern radar and signals research establishment, into the Defence Evaluation Research Agency (DERA). DERA was the largest government ‘defence’ research establishment of its kind in Europe, with only Los Alamos in the USA of a similar size. DERA has since been split (with a further proliferation of acronyms) into the Defence Science and Technology Laboratory (DSTL) and QinetiQ. This was accompanied by the loss of a considerable number of jobs, many in science, engineering and technology, as well as opposition, including from parliament, to the creation of privatised ‘defence’ research organisations (Langley et al. 2005). One of the aims of the privatisation of DERA was the demilitarisation of some of the scientific, engineering and technology workforce, since military research budgets were reduced by 50% between 1990 and 2000. However, QinetiQ remains firmly military (Langley et al. 2005).

7 The Economy and Military Spending

It is often assumed that reductions in military spending lead to increases in unemployment. However, this is in fact not the case (if appropriate compensatory measures are taken), and military expenditure generally leads to fewer jobs than the same public expenditure in expanding civil markets (Voss 1992). A number of studies have shown (Anderson et al. 1991; Knight et al. 1996; Medoff 1993; Melman 1988; Winn 1984) that military spending reduces economic growth and productive investment and creates fewer jobs and lower total income than spending on education, public transport, health care and construction for home weatherproofing, and that increased non-military spending encourages new technologies and raises living standards. In particular, education and public transport spending create twice as many jobs as the same amount of military spending, and education spending leads to both a greater number of jobs and jobs with higher wages (Pollin and Garrett-Peltier 2009). Therefore, high military expenditures could be seen to overall reduce rather than create jobs, and it could be argued that through military work, scientists and engineers are indirectly and probably unwittingly contributing to reducing the availability of employment. It has been suggested that (significant) cuts in military spending in Eastern Europe and the Middle East could lead to 50% long-term increases in growth, with smaller but still significant increases in other regions (Knight et al. 1996).

An inverse relationship has also been found between the share of gross domestic product allocated to military research and development and international competitiveness (Kaldor et al. 1986), though the authors are cautious about arguing for a causal relationship (Evans et al. 1991). However, the study suggests that high military research and defence spending adversely affect (UK) civilian industry for a number of reasons including the following:

1. The loss of significant opportunities in the civilian markets, as the military take up an excessive share of the limited pool of highly qualified and skilled labour.
2. The erosion of knowledge and a reduction in the ability to compete in increasingly competitive high-technology civilian markets, due to military markets being less competitive than civilian ones.

3. The small number of civilian products or technological spin-offs originating from military technology and the limited relevance of military technology to civilian technology (Kaldor 1981).

Arms sellers are increasingly being required to reinvest (‘offset’) part of the proceeds of arms sales in the purchasing country. It has been suggested that these offsets are beneficial to majority world (‘developing’) countries. However, in practice, the use of offsets generally increases the cost of arms trade deals compared to off-the-shelf purchases, including through the associated 7–10% administrative costs. Other disadvantages include the lack of technology transfer, even in the military sector, the lack of significant contributions to economic development and the lack of new or sustainable employment (Brauer and Dunne 2004).

8 Discussion and Conclusions

Developments in military technology have transformed the nature of conflict, led to a focus on weapons-based security rather than peace building and resolving underlying problems and in practice heightened insecurity. Although it is sometimes argued that nuclear weapons have kept the peace since the end of World War II, the data on deaths in armed conflict presented in Sect. 2 indicates that this is not the case. This includes an estimated 11 million people who died in proxy wars during the Cold War, in which the USA and Soviet Union supported opposite sides (White 2011). Since the development of military technology is not possible without the involvement of engineers and scientists, decisions made by them can have an important role in determining whether we move to security based on peace building or further arms races.

However, there are still varying views about the ethics of military work and the arguments against it have not yet been won. Some engineers and scientists may still believe in a duty to carry out military work, based on arguments such as (Kemp 1994) the justness of government foreign policy and the legitimacy of preparedness for war as a means of pursuing these policy objectives, the role of military research in reducing the destructiveness of war and the duty of governments to protect their citizens from aggression, including by waging war if necessary. However, beliefs of this type are based on a number of false assumptions. In particular, as discussed in Sect. 2, the majority of armed conflicts are now within rather than between nations, negating the idea of the need for military preparation for defence against an outside aggressor. It is often not clear what particular enemy, if any, a particular weapons system is intended to be used against. For instance, the UK government is being rather coy about the nature of the threat the multi-billion pound UK trident nuclear submarines stationed at Faslane in Scotland are intended to counter, and they are currently not targeted anywhere specific (SCND 2000, Private communication, Scottish Campaign for Nuclear Disarmament). Thus, it could be suggested that these very expensive nuclear submarines are not required for ‘defence’ against an external aggressor.

Most countries with a well-developed military capacity, including most of the industrialised countries, engage in the arms trade and export a sizeable percentage of military production. For instance, in the UK an estimated one third of military production was exported in 2011/2012 (CAAT 2014, Private communication). However, it should be noted that the data on UK arms exports is of very poor quality, so this estimate is not at all accurate. As discussed in Sect. 5, there are few controls or real restrictions on the export of arms to conflict zones and countries with serious human rights abuses where they may be used in repression. Thus, the idea that governments require military capacity and research to defend or improve their ability to defend their citizens against external enemies seems not to be supported by the evidence. Instead it is likely that weapons are either not used, an irresponsible use of scarce resources, or traded, possibly to be used in internal conflicts and repression, or are used in outside intervention in such conflicts. Therefore, for many countries, rather than military preparedness being required to defend against an external aggressor, the threat of an external ‘enemy’ is required to justify military spending, which is desired for other reasons, such as power, status and prestige.

Therefore, the real ethical question for scientists and engineers is not whether it is ethically justified to do military work in support of the defence of one’s country, but whether it is ethically justified to do military work:

- Which may lead to the production of weapons which will be traded, including to conflict zones and countries with poor human rights records and which may be used in internal repression.
- Which are very expensive both in financial terms and in consumption of (scare) resources, thereby diverting resources from other important areas.

Engineers and scientists have also played a major role in developments in armaments technology, including long-range missiles, military aircraft, armed drones, landmines, cluster bombs and chemical, biological and nuclear weapons and cyberwarfare, as well as in the development of information and communication technologies which form an essential part of modern military forces and conflict, just as of all other aspects of modern society.

These developments have had the following important negative impacts: (1) significantly increasing the speed of action or response, (2) significantly increasing the lethality or number of people killed and injured at one time, (3) significantly increasing the range of weapons and the distance over which they can spread death and destruction and (4) significantly increasing the distance of military personnel from the resulting death and destruction. Thus, rather than military R&D reducing the potential destructiveness of war, it has significantly increased it. In addition, the potential for much faster responses at a much greater distance may lead to escalations of actual or potential conflicts, with the use of military force before there has been time to really think whether its use is necessary or desirable or investigate alternative approaches. The ability of many modern weapons systems to kill at great distances, as well as the increasing automation of armed drones, distance military personnel from the death and injury consequent on their actions and probably also reduce the need to confront ethical issues.

The development and continued existence of modern military forces is totally dependent on the participation of scientists and engineers in research and development, training and production and maintenance of weapons systems. The increasing sophistication and high-tech nature of modern weapons systems mean that the withdrawal of engineers and scientists from military work would bring into question the safety and effectiveness of existing weapons systems as well as prevent the development and production of new or replacement weapons systems, including more advanced nuclear weapons. While arms races may be motivated and fuelled by political factors, they are crucially dependent on the involvement of scientists and engineers to develop and construct totally new types of weapons systems and weapons systems with additional high-performance features.

Justifications for military R&D are sometimes presented in terms of the associated spin-offs, but as discussed in Sect. 6, these arguments have little substance. The other side of this is the funding or use of the results of civilian R&D by the military. Some of the problems and ethical issues associated with military involvement in universities (in the UK) have been discussed in Sect. 7. Acceptance of military funding for apparently civilian research may raise many of the same issues with regard to transparency and open publication and determination of the type of research that takes place by the military. It can also contribute to increasing the acceptability or respectability of military work, particularly if the researcher is known to be concerned about ethical issues.

The social context of the research and the mission of the agency supporting it generally have an effect on its goals, making it desirable that civilian research is carried out in civilian institutions and with civilian funding. This is likely to result in a higher degree of public accountability and scrutiny, whereas military-funded research may be classified (Lappé 1990) and is more easily co-opted. In addition, military establishments are not charitable organisations and therefore generally fund work because they expect it to have some military benefit. For instance, the UK Ministry of Defence (MoD) considers that its work in universities and polytechnics is 'a vital contribution' to its military research programme (MoD 1990). One of the problems is, of course, the lack of civilian funding for civilian research. However, increasing acceptance of military funding, involvement and eventual militarisation of civilian research will only worsen this problem.

Finally, there is the need to develop security policies based on peace building and resolving underlying problems rather than based on fear and increasingly high-tech weapons. As well as being more effective, this is likely to lead to societies which are more human and better to live in.

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References

Abbott C, Rogers P, Slaboda J (2006) Global responses to global threats. In: Sustainable security for the 21st century (Briefing Paper). www.thebreakingnews.com/files/articles/globalthreats.pdf. Accessed 26 June 2013
Ainslee J (2012) Disarming Trident, a practical guide to de-activating and dismantling the Scottish-based Trident nuclear weapon system. http://www.banthebomb.org/index.php?option=com_content&view=category&layout=blog&id=80&Itemid=144, Accessed 7 May 2013
Ainslee J (2013) If Britain fired Trident. The humanitarian consequences of a nuclear attack by a Trident submarine on Moscow. http://www.banthebomb.org/index.php/publications/reports. Accessed 18 Apr 2014
Alic JA et al (1992) Beyond spinoff: military and commercial technologies in a changing world. Harvard Business School Press, Boston
Allansson M, Sollenberg M, Themnér L (2013) Armed conflict in the wake of the Arab Spring. In: SIPRI yearbook 2013. Oxford University Press, Oxford, pp 19–27
Anderson M, Bischiak G, Oden M (1991) Converting the American Economic: the economic effects of an alternative security policy. Employment Research Associates, Lansing
Anon (2007a) Millennium development goals report. United Nations Department of Economic and Social Affairs DESA, New York. ISBN 97 8–9 2-1-101-153-1
Anon (2007b) Africa's missing billions, international arms flows and the cost of conflict. IANSA, Oxfam International and Saferworld, Oxford
Anon (2014a) Halabja chemical attack. https://en.wikipedia.org/wiki/Halabja_poison_gas_attack. Accessed 19 May 2014
Anon (2014b) Gruinard Island. https://en.wikipedia.org/wiki/Gruinard_island. Accessed 19 May 2014
Anon (2014c) Artillery https://en.wikipedia.org/wiki/Artillery. Accessed 18 Apr 2014
Anon (2014d) Cluster munition. https://en.wikipedia.org/wiki/Cluster_bomb. Accessed 28 Feb 2014
Anon (2014e) Land mine. https://en.wikipedia.org/wiki/Land_mine. Accessed 15 Apr 2014
Anon (2014f) Attack aircraft. https://en.wikipedia.org/wiki/Strike_aircraft. Accessed 26 Feb 2014
Anon (2014g) Submarine. https://en.wikipedia.org/wiki/Submarine. Accessed 26 Feb 2014
Anon (2014h) Armoured fighting vehicle. https://en.wikipedia.org/wiki/Armoured_fighting_vehicle. Accessed 18 Apr 2014
Anon (2014i) Ottawa treaty. https://en.wikipedia.org/wiki/Ottawa_Treaty. Accessed 17 Apr 2014
Anon (2014j) Economy of the European Union. https://en.wikipedia.org/wiki/Economy_of_the_European_Union. Accessed 28 Feb 2014
Anon (2015) Arms Trade Treaty. https://en.wikipedia.org/wiki/Arms_Trade_Treaty. Accessed 17 Feb 2015
Anthony I (2012) Conventional arms control overview. In: SIPRI yearbook 2012. Oxford University Press, Oxford, pp 415–416
Bellamy C (2004) Artillery. In: Holmes R, Strachan H, Bellamy C, Bicheno H (eds) The Oxford companion to military history. Oxford University Press, Oxford
Bender B (2010) From the Pentagon to the private sector. Boston Globe, 26 December
Bodell N (2012) Arms control and disarmament agreements. In: SIPRI yearbook 2012. Oxford University Press, Oxford, pp 455–485
Bodell N (2013) Arms control and disarmament agreements. In: SIPRI yearbook 2013. Oxford University Press, Oxford, pp 471–500
Brauer J, Dunne JP (2004) Arms trade offsets and development. In: 8th international conference on Economics and Security, Bristol
Brazier C (1997) State of the world report, issue 287. In: New Internationalist. http://newint.org/features/1997/01/05/keynote/. Accessed 13 June 2013
Brusaco-Mackenzie M (2002) Environment and security. In: Dodds F (ed) Earth summit 2002: a new deal. Earthscan, London, pp 179–201
Bureau of Investigative Journalism (2014) January 2014 update: US covert actions in Pakistan, Yemen and Somalia. http://www.thebureauinvestigates.com/2014/02/03/january-2014-update-us-covert-actions-in-pakistan-yemen-and-somalia/. Accessed 26 Feb 2014

Burton J (1990) Conflict resolution and prevention. Macmillan, Basingstoke
CAAT (2010) Briefing private gain, public pain, the case for ending the Government's arms selling. http://www.caat.org.uk. Accessed 18 Jul 2013
CAAT (2011) An introduction to the arms trade. http://www.caat.org.uk. Accessed 18 Jul 2013
CAAT (2012) Top UK universities accept millions in arms company funding. http://www.caat.org.uk/press/press-release.php?url=20120823prs. Accessed 25 June 2012
CIA (2007) CIA World Factbook. Government Printing Office https://www.cia.gov/cia/publications/factbook/index.html
Collier P (2000) Economic causes of civil conflict and their implications for policy. The World Bank, Washington, DC
Committees on Arms Export Controls (2011) Scrutiny of arms export controls: UK strategic export controls annual report 2009. In: Quarterly reports for 2010, licensing policy and review of export control legislation. http://www.publications.parliament.uk/pa/cm201011/cmselect/cmquad/686/68602.htm. Accessed 28 Feb 2014
De Soysa I (2000) The resource curse: are civil wars driven by rapacity or paucity? In: Berdal M, Malone D (eds) Greed and grievance: economic agendas and civil wars. Lynne Rienner, Boulder, pp 113–136
De Soysa I (2001) Paradise is a bazaar? Greed, creed, grievance and governance. World Institute for Development Economics Research discussion paper 2001/42
Dunne JP, Coulomb F (2008) Peace, war and international security: economic theories. In: Fontanel J, Chatterji M (eds) Peace, war and international security. Emerald Group Publishing
Evans G (2012) Responding to atrocities: the new geopolitics of intervention. In: SIPRI yearbook 2012. Oxford University Press, Oxford, pp 15–39
Evans R, Butler N, Gonçalves E (1991) The campus connection: military research on campus. CND Publications Ltd, London. http://copac.ac.uk/search?title=The%20campus%20connection%20military%20research%20on%20campus&rn=1. Accessed 26 Feb 2015
Fanchini C (2012) Global trends in peace operations. In: SIPRI yearbook 2012. Oxford University Press, Oxford, pp 91–94
Feinstein A (2010) Undermining South African's young democracy. In: CAAT briefing private gain, public pain, the case for ending the Government's arms selling. http://www.caat.org.uk. Accessed 18 Jul 2013
Feinstein A, Holden P, Pace B (2011) Corruption and the arms trade: sins of commission. In: SIPRI yearbook 2011. Oxford University Press, Oxford, pp 13–35
Grip L (2012) Limiting conventional arms for humanitarian reasons: the case of cluster munitions. In: SIPRI yearbook 2012. Oxford University Press, Oxford, pp 417–424
Grip L, Patton T (2013) Humanitarian arms control initiatives. In: SIPRI yearbook 2013. Oxford University Press, Oxford, pp 391–400
Gsponer A (2003) Depleted-uranium weapons: the whys and wherefores? àrXiv preprint physics/0301059
Gsponer A (2008) Nanotechnology and fourth generation nuclear weapons, Disarm Dipl 67:3–6
Hart J (2012) Reducing security threats from chemical and biological materials. In: SIPRI yearbook. Oxford University Press, Oxford, pp 391–414
HCC (2011) Scrutiny of arms export controls. Report HC 686, 6 April. House of Commons Committees on Arms Export Controls
Hersh MA (2013) Barriers to ethical behaviour and stability: stereotyping and scapegoating as pretexts for avoiding responsibility. Annu Rev Control 37(2):365–381
HM Government (2010) A strong Britain in an age of uncertainty: the national security strategy. https://www.gov.uk/government/publications/the-national-security-strategy-a-strong-britain-in-an-age-of-uncertainty. Accessed 19 May 2014
Hobsbawn E (1996) The ages of extremes: a history of the world, 1914–1991. Vintage Books, New York
Hoisington M (2009) Cyberwarfare and the use of force giving rise to the right of self-defense. Boston Coll Int Comp Law Rev 32(2):439–454
Holtom P (2013) International arms transfers overview. In: SIPRI yearbook 2013. Oxford University Press, Oxford, pp 241–242

Holtom P, Bromley M (2013a). Arms trade treaty negotiations. In: SIPRI yearbook 2013. Oxford University Press, Oxford, pp 423–431
Holtom P, Bromley M (2013b) Transparency in arms transfers. In: SIPRI yearbook 2013. Oxford University Press, Oxford, pp 274–279
Holtom P, Bromley M, Wezeman PD, Wezeman ST (2012) Developments in arms transfers in 2011. In: SIPRI yearbook 2012, Oxford University Press, Oxford, pp 161–274
Holtom P, Bromley M, Wezeman PD, Wezeman ST (2013) Developments in arms transfers, 2012. In: SIPRI yearbook 2012. Oxford University Press, Oxford, pp 243–263
Human Rights Watch (2014) Technical briefing note. Use of cluster munitions in Syria. http://www.hrw.org/news/2014/04/04/technical-briefing-note-use-cluster-munitions-syria. Accessed 17 Apr 2014
IANSA, Oxfam International and Saferworld (2007) Africa's missing billions, international arms flows and the cost of conflict. The International Action Network on Small Arms and Oxfam International, Oxford
Jackson ST (2011) Arms production. In: SIPRI yearbook 2011. Oxford University Press, Oxford, pp 231–248
Jackson ST (2012a) Key development in the main arms-producing countries. SIPRI yearbook 2012. Oxford University Press, Oxford, pp 219–229
Jackson ST (2012b) The military services industry. SIPRI yearbook 2012. Oxford University Press, Oxford, pp 230–246
Jackson ST (2012c) The SIPR top 100 arms producing and military services companies, 2010. In: SIPRI yearbook 2012. Oxford University Press, Oxford, pp 247–258
Jackson, S.T. (2013). The SIPR top 100 arms producing and military services companies, 2011. In: SIPRI yearbook 2013. Oxford University Press, Oxford, pp. 227–240
James Martin Center (2010) New START: preliminary thoughts in Moscow. http://cns.miis.edu/stories/100407_start_pikayev.htm. Accessed 19 Jul 2013
Jan T-S, Jan C-G (2000) Development of weapon systems in development countries: a case study of long range strategies in Taiwan. J Oper Res Soc 51:1041–1050
Johnston WR (2007) Deadliest radiation accidents and other events causing radiation casualties. http://www.johnstonsarchive.net/nuclear/radevents/radevents1.html. Accessed 28 Feb 2014
Kaldor M (1981) The Baroque Arsenal. Abacus, London
Kaldor M, Sharp M, Walker W (1986) Industrial competitiveness and Britain's defence. Lloyds Bank Rev 162:31–49
Kemp KW (1994) Conducting scientific research for the military as a civic duty. In: Erwin E et al (eds) Ethical issues in scientific research an anthology. Garland Publishing, New York, pp 387–396
Kile SN (2011) Nuclear arms control and non-proliferation. In: SIPRI yearbook 2011. Oxford University Press, Oxford, pp 363–387
Kile SN (2012) Nuclear arms control and non-proliferation. In: SIPRI yearbook 2012. Oxford University Press, Oxford, pp 353–375
Kile SN (2013) Iran and nuclear proliferation concerns. In: SIPRI yearbook 2013. Oxford University Press, Oxford, pp 337–344
Kile SN, Kristensen HM (2013) World nuclear forces overview. In: SIPRI yearbook 2013. Oxford University Press, Oxford, pp 283–284
Knight M, Loayza N, Villaneuva D (1996) The peace dividend: military spending cuts and economic growth. IMF Staff Pap 43(1):1–37
Krause K, Mutimer D (2005) Introduction. In: Berman EG, Krause K (eds) Small arms survey. Oxford University Press, Oxford, pp 1–7
Langley C (2006) Scientists or soldiers? Career choice, ethics and the military. Scientists for Global Responsibility, Folkestone
Langley C, Parkinson S, Webber P (2005) Soldiers in the Laboratory. In: Parkinson S, Webber P (eds) Military involvement in science and technology – and some alternatives. Scientists for Global Responsibility, Folkestone

Langley C, Parkinson S, Webber P (2007) More soldiers in the laboratory. The militarization of science and technology – an update. Scientists for Global Responsibility, Folkestone
Langley C, Parkinson S, Webber P (2008) Behind closed doors: military influence, commercial pressure and the compromised university. Scientists for Global Responsibility, Folkestone
Langner R (2011) Stuxnet: dissecting a cyberwarfare weapon. IEEE Secur Priv 9(3):49–51
Lappé M (1990) Ethics in biological warfare research. In: Wright S (ed) Preventing a biological arms race. MIT Press, Cambridge, MA, pp 79–99
Leitenberg M (2001) Deaths in wars and conflicts between 1945 and 2000. In: Conference on data collection in armed conflict, Uppsala
Medoff JL (1993) Smart stimulus: more good jobs. Center for National Policy, Washington, DC
Melman S (1988) The demilitarized society: disarmament and conversion. Harvest House, Montreal
Melvin N (2012) Armed conflict overview. In: SIPRI yearbook 2012. Oxford University Press, Oxford, pp 43–44
MoD (1990) Letter from Ministry of Defence, September 28
Pacific Institute (2009) Water conflict chronology. http://worldwater.org/chronology.html. Accessed 19 May 2014
Parkinson S (2012a) Military-university collaborations – an update on the UK situation. http://www.sgr.org.uk/resources/military-university-collaborations-update-uk-situation. Accessed 25 June 2013
Parkinson S (2012b) UK military R&D: changing times. http://www.sgr.org.uk. Accessed 27 June 2013
Parkinson S (2014) Military R&D: is it helping or hindering our security. http://www.sgr.org.uk/resources/military-rd-it-helping-or-hindering-our-security-feb-2014. Accessed 27 Mar 2014
Parkinson S, Pace B, Webber P (2013) Offensive insecurity: the role of science and technology in UK security strategies. Scientists for Global Responsibility. http://www.sgr.org.uk. Accessed 26 Feb 2014
Perlo-Freeman S (2013a) Military expenditure overview. In: SIPRI yearbook 2013, armaments, disarmament and international security. Oxford University Press, Oxford
Perlo-Freeman S (2013b) Russian military expenditure, reform and restructuring. In: SIPRI yearbook 2013, armaments, disarmament and international security. Oxford University Press, Oxford
Perlo-Freeman S, Solmirano C (2012a) Global developments in military expenditure. In: SIPRI yearbook 2012, armaments, disarmament and international security. Oxford University Press, Oxford, pp 149–155
Perlo-Freeman S, Solmirano C (2012b) The economic cost of the Afghan and the Iraq wars. In: SIPRI yearbook 2012, armaments, disarmament and international security. Oxford University Press, Oxford, pp 156–161
Perlo-Freeman S, Abdul-Shafi W, Buchhold C, Solmirano C, Wilandh H (2013) Military expenditure data, 2003–12. In: SIPRI yearbook 2013, armaments, disarmament and international security. Oxford University Press, Oxford, pp 173–202
Pike J (2013) Small arms and light weapons. http://www.globalsecurity.org/military/systems/ground/small-arms.htm. Accessed 24 July 2013
Pollin R, Garrett-Peltier H (2009) The U.S. employment effects of military and domestic spending priorities. Int J Health Serv 39(3):443–460
Roeber J (2005) Hard-wired for corruption: the arms trade and corruption. Prospect no. 113
Roth K (2004) War in Iraq: not a humanitarian intervention. In: World Report 2004: Human Rights and Armed Conflict. Human Rights Watch, New York
Schlosser E (2013) Command and control. Allen Lane, London
Schofeld S (2002) The UK and non-offensive defence, Report commissioned by the Security Studies Network, London
Shah A (2006) Small arms they cause 90% of civilian casualties. http://www.globalissues.org/article/78/small-arms-they-cause-90-of-civilian-casualties. Accessed 25 Feb 2014

Shah A (2011) Today, around 21,000 children died around the world. http://www.globalissues.org/article/715/today-21000-children-died-around-the-world. Accessed 13 June 2013
Shah A (2013) Poverty facts and stats. http://www.globalissues.org/article/26/poverty-facts-and-stats#fact8. Accessed 13 June 2013
Sharkey N (2008) Grounds for discrimination: autonomous robot weapons. RUSI Def Syst 11(2):86–89
SIPRI (2001) SIPRI yearbook 2001, armaments, disarmament and international security. Oxford University Press, Oxford
SIPRI (2009) SIPRI Yearbook 2009, armaments, disarmament and international security. Oxford University Press, Oxford
SIPRI (2013) SIPRI yearbook 2013, armaments, disarmament and international security, summary. Oxford University Press, Oxford
Sköns E (2013) US military expenditure. In: SIPRI yearbook 2013**.** Oxford University Press, Oxford, pp 135–141
Sköns E, Perlo-Freeman S (2012) United States military expenditure and the 2011 budget crisis. In: SIPRI yearbook 2012**.** Oxford University Press, Oxford
Stewart F (1998) The root causes of conflict some conclusions. Queen Elizabeth House (QEH) working paper series, vol 16, University of Oxford
Street T, Beale M (2007) Study war no more. Campaign Against the Arms Trade and Fellowship of Reconciliation, London. http://www.studywarnomore.org.uk
Themnér L, Wallenstein P (2011) Armed conflicts, 1946–2010. Peace Res 48(4):525–536
Themnér L, Wallenstein P (2012) Armed conflicts, 1946–2011. Peace Res 49(4):565–575
Themnér L, Wallenstein P (2013) Patterns of organized violence, 2002–11. In: SIPRI yearbook 2013, armaments, disarmament and international security. Oxford University Press, Oxford, pp 41–60
Tønnesson S, Melander E, Bjarnegård E, Svensson I, Schaftenaar S (2013) The fragile peace in East and South East Asia. In: SIPRI yearbook 2013. Oxford University Press, Oxford
Transparency International (undated) Frequently asked questions about corruption. http://archive.transparency.org/news_room/faq. Accessed 24 Jul 2013
UK (2011). Human rights and democracy. The 2010 Foreign & Commonwealth Office Report.
UNICEF (1999) The state of the world's children. http://www.unicef.org/sowc99/index.html. Accessed 13 June 2013
Voss T (1992) Converting the defence industry: have we the political will. Oxford Research Group no. 9, London
Walton CD (2008) Weapons of mass destruction. In: Jordan D et al (eds) Understanding modern warfare. Cambridge University Press, Cambridge, pp 293–340
Webb T (1998) The armour-plated ostrich. Comerford and Miller, West Wickham
Webb T (2007) Bribing for Britain, government collusion in arms sales corruption, Goodwin paper #5. http://www.caat.co.uk. Accessed 18 Jul 2013
Webb D, Wirbel L, Sulzman B (2010) From space: no one can watch you die. Peace Rev 22:31–39
Wezeman PD (2013) Arms transfers to Syria. In: SIPRI yearbook 2013. Oxford University Press, Oxford, pp 269–273
Wezeman PD, Kelly N (2011) Multilateral arms embargoes, 2010. In: SIPRI yearbook 2011. Oxford University Press, Oxford, pp 447–455
White M (2011) Atrocitology: humanity's 100 deadliest achievements. Canongate, Edinburgh/New York
Wille C, Krause K (2005) Behind the numbers: small arms and conflict deaths. In: Berman EG, Krause K (eds) Small arms survey. Oxford University Press, Oxford, pp 229–265
Williamson J (1990) Selling death. New Statesman and Society, Sept–Dec
Winn J (1984) The university and the strategic defense initiative, connection. NEA Higher Educ J 1(1):19–32
Woolf AF (2009) Conventional warheads for long-range ballistic missiles: background and issues for congress. Congress Research Service 7–5700, http://www.crs.gov.
Woolf AF (2011) Conventional prompt global strike and long-range ballistic missiles: background and issues. Library of Congress, Congressional Research Service, Washington, DC

Part V
Looking to the Future

Chapter 12
Conclusions and Looking to the Future

David Elliott and Marion Hersh

One of the underlying themes of this book has been the need for engineers to adopt an ethical approach to their work and its impacts. There is a quote attributed (satirically) to World War II German rocket engineer Wernher von Braun: 'Once the rockets are up, who cares where they come down?' It was actually a 1960s fabrication by US comedian (and mathematician) Tom Lehrer, but although extreme, it does capture the risks associated with divorcing technical means from social ends. In von Braun's case, he was presumably solely interested in rockets and space exploration and not too concerned about who paid him, or their aims or what death, injury and other damage the rockets inflicted. Certainly there is a sense in which some engineers like to work on purely technical problems, although most also have wider concerns, often seeing engineering as a socially orientated activity, making the world a better place. Whether this is always achieved is less clear. As this book has illustrated, some technologies arguably do not benefit humankind, or else only some parts of it, at the expense of others, or of the planet. As argued throughout the book, engineers need to be concerned with the overall ethical merits of projects they are working on in addition to ethical professional practice. They therefore need to become more proactive in assessing the ethical merits of the projects they are asked or choose to work on.

However, the ethical responsibility of engineers goes beyond this. It also includes seeking the influence the ways in which technology is developed and used so as to ensure that this benefits humanity and the planet as a whole, rather than benefitting

D. Elliott (✉)
Faculty of Maths, Computing and Technology, The Open University,
Milton Keynes MK7 6AA, England
e-mail: d.a.elliott@open.ac.uk

M. Hersh
School of Engineering, Biomedical Engineering, University of Glasgow,
Rankine Building, Glasgow, Scotland
e-mail: marion.hersh@glasgow.ac.uk

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a small elite of the rich and powerful. As was discussed in Chap. 2, a stand has to be taken against technological determinism and the tendency to develop and implement new technologies because it is possible, regardless of the likely impacts of these technologies.

In the past there have been dubious and unrealistic proposals for a technocracy or society run solely by engineers. However, an ethical society should have equal entitlement of everyone to participate in decision-making. Unfortunately this does not happen in practice. While this limits the influence of engineers, they still have two roles, both as citizens and specifically using their engineering knowledge and expertise. This may mean speaking out in favour of or against particular technologies and projects and engaging in whistleblowing (see Chap. 2). However, in order to be more effective and to reduce the risks of victimization, it is advisable to do this collectively as part of an organization rather than as an individual. Details of a number of organizations of engineers and scientists are provided at the end of this section. Other options are joining a trade union and working with campaigning organizations.

There are many ways to work for positive change as an engineer. Many engineers may not feel comfortable with a wider campaigning role. This is one approach to contributing to the positive transformation of society but not suitable for everyone. However, all engineers do have a responsibility to speak out when they become aware of bad practice, particularly when this is likely to result in risk to humans, animals or the environment. There are a number of examples of smaller- or larger-scale disasters that could possibly have been averted by engineers speaking out in advance. There are also examples, as in the case of the Bhopal disaster, where warnings were made by engineers, in this case a team of US engineers who inspected the plant in 1982, but were ignored. In cases like this, particularly where engineers have a responsibility for inspections, this responsibility should be considered to include working to ensure that their recommendations are acted on.

Another potential role for ethical engineers is in trying to influence the engineering institutions which regulate the profession. Most of these institutions have professional codes, some of which explicitly examine ethical issues. However, the focus tends to be on professional practice with regard to the conduct of activities, with less attention given to whether the aims and overall outcomes are themselves ethical. They also rarely give guidance in the cases of conflicts between different duties. Concerned engineers can stand for committees and governing bodies of institutions for improved professional codes and the provision of training on ethical issues.

One of the strengths of engineering is that it teaches people to make technical compromises or trade-offs in order to solve complex problems given conflicting constraints. This is a useful skill and can be extended to include an assessment of the likely social and environmental impacts of technologies. It is particularly valid when it enables engineers to explicitly set out the trade-offs and costs, including which groups will pay these costs and any factors that have initially been ignored in order to simplify the problem. This can help to highlight the real ethical issues. For instance, in the case of a company tipping waste into a local river, the benefits will be financial savings to the company and the costs will be to the environment and the local population.

Most engineers would no doubt want to work on technologies that they could clearly see will be of wide benefit, but as some of the examples in this book have indicated, that may not be easy or clear-cut. The concept of a potential 'use-abuse' dichotomy has been used to describe the way that it is often not the technology itself which is the issue but the ways in which it is used. Technologies can be developed for socially admirable purposes, but they can also be misused in reprehensible and abhorrent ways. Thus, technologies can probably be divided into three groups: (1) inherently 'good' technologies, with overwhelmingly positive applications; (2) technologies which potentially have both applications which are beneficial to humanity, other species and/or the environment and applications which are damaging; and (3) technologies whose main applications are damaging to humanity, other species and/or the environment and which have few or only trivial beneficial applications.

Different engineers will differ about which technologies fit into which of these categories and it is possible that most technologies are in the second category. For instance, some, possibly most of the authors of this book, consider that specifically military technologies lead to the escalation of conflicts and increase the number of deaths and injuries and the area over which they take place while having no significant positive applications. This is particularly true for chemical, biological and nuclear weapons and the increasing numbers of small arms, but also arguably holds for low-level military technologies even, in some peoples' view, for bows and arrows and swords. Given human history to date, disarmament to this extent may be unrealistic, and certainly not all engineers agree with this premise. Many of them are involved in the so-called 'defence' industry. As discussed in Chap. 11, this is rarely about defence, and there are better ways to reduce the likelihood of conflict by solving underlying problems relating to the environment, justice and distribution of resources.

As discussed in Chaps. 3, 4 and 11, there are also new threats from the use of robots, drones and cyberweapons in warfare and the militarization of space. These raise issues which hopefully many engineers will find worrying and feel moved to take action on. It is much easier to 'outlaw' particular uses of technology before they become established.

In most areas of technology, impacts on the environment and the need for sustainable development are being recognized as important political issues on which action is required. This affects engineers in two important ways: (1) design choices to reduce environmental impacts and (2) involvement in the development of socially and environmentally appropriate technologies. Design choices include those related to the types of materials and processes used, design for low energy consumption, the use of locally sourced materials and components, and design for end-of-life reuse, refurbishing and recycling.

The concept of socially and environmentally appropriate technologies, often seen as 'alternative technologies' to existing technologies, dates to the 1970s when a range of ideas for less-damaging technologies emerged. However, the approach has sometimes been oversimplistic with a division into 'good' and 'bad' technologies. For instance, particular concern was and is still raised by energy technologies.

Nuclear power- and fossil fuel-based technologies, such as coal and oil, were considered 'bad', and renewable technologies, such as wind and solar power, were considered 'good', not least because the latter were seen as more amenable to local community control. There are many very valid arguments for moving from fossil fuels and nuclear power to renewable energy for all energy uses. However, the simplistic categorization into 'good' and 'bad' technologies ignores important issues related to good (engineering) design practice which requires a design to be appropriate to the context and a consideration of all factors, as indicated by the discussion of trade-offs earlier.

While renewable energy sources generally have minimal carbon dioxide emissions in operation, energy and material resources are required to construct them, leading to emissions in the construction and implementation stages. Although most renewable energy devices generate significantly more energy than was used to produce them, this may not be the case for some micro-wind turbines in low-wind-speed urban environments. So small is not always beautiful. But big can also be bad. The construction and implementation of very large-scale hydropower and tidal barrages may have very significant negative environmental and social impacts. A case in point is the Three Gorges Dam on the Yangtze River which required 1.24 million people to be relocated, losing their homes, farms and workplaces, and resulted in the loss of one of China's most valued landscapes.

It is often possible to find counterexamples of applications of 'bad' technologies which might be helpful or needed, such as the use of nuclear power sources to power spacecraft, if we want to explore deep space. A counterargument is that we need to resolve the many environmental and social problems that exist on Earth before we start exploring deep space, or we may end up using it as a rubbish dump or rapaciously exploiting extraterrestrial resources in the same way as we have on Earth.

Debate is generally a good thing. Unfortunately though, some of the positions are influenced by vested interests in the status quo. For example, while there is still some debate over the scale and pace of human-induced climate change, there is a consensus that its impacts will be very significant and that an urgent response is needed. However, as Chap. 6 illustrates, there are also vested interests which are trying to suppress evidence and prevent action.

The response to the threat of climate change involves both technology and changes to lifestyle. The technological part of the response is reasonably well developed in terms of the existence of renewable energy sources, low energy technologies of various types and energy saving techniques. However, further research will be required, and, as indicated in Chap. 11, at least some of the highly industrialized countries spend considerably more money on military research and development than on research and development into renewables. This is an area in which engineers and scientists could be involved in lobbying for change.

There are many other areas they can act on critically or supportively. As discussed in Chap. 3, while on one hand, robots have significant potential to improve the lives of various groups of people and carry out boring, dirty and dangerous jobs, on the other hand, they can change social relationships in undesirable ways and, through the use of remotely operated or even fully autonomous drones, can enable the killing of large numbers of people at a distance without direct human involvement or decision-making.

As discussed in Chap. 5, technological change has impacts on employment, with regard to both the number of jobs and their terms and conditions. Despite safety measures, working with technologies which are intrinsically dangerous may pose risks to workers' healths. By contrast, the new greener, cleaner, energy technologies present fewer threats and can support sustainable employment

The implication of the various threats and promises explored in this book is that engineers of all types have a responsibility to take an ethical stance and to adopt a precautionary approach to the introduction of technologies with unknown or unforeseeable impacts. They may also need to challenge what they consider dangerous developments and to support developments they consider positive. However, this does not require engineers to belong to a particular political party or necessarily to adopt a particular position with regard to, for instance, nuclear power or genetically modified organisms. It does, however, require them to consider the wider implications of the projects and technologies they work on and reject involvement in those they consider unethical. It also requires them to try and influence the policies and practices of the organizations they work for. There are also opportunities and an urgent need for engineers to express their views and to act on them, whether it is in relation to energy and water use, climate policy, robotics, telecoms, space exploration, medicine, defence work or overseas development. As discussed in Chap. 7 in the context of domestic bathing, engineers should not restrict ethics to their working lives but behave ethically in all aspects of their lives.

Ethical engineering can involve assisting with the formulation of new regulatory regimes or policies, speaking out against specific threats or abuses and a hands-on practical role, related to everyday work and producing good technology. Ethical engineering may also seek to implement new technologies in areas where they are thought likely to be beneficial. Some examples of the positive applications of ICT in a telemedicine centre in Kosovo and to support Deaf people in South Africa were discussed in Chaps. 9 and 10, respectively. However, as these chapters illustrate, even these positive interventions raise ethical issues and have to be carried out very carefully to avoid negative impacts on local communities. As these chapters illustrate, the key issue is not just the choice of technology, in environmental and social impact terms, but also how this technology is developed and implemented. This point also emerged strongly in the historical studies of ICT/automation systems development in Poland in Chap. 9 and in the forward-looking study of renewable energy system options in Chap. 5, in terms of the nature and conditions of work and power relationships within society.

A parallel lesson is that new technologies cannot simply be 'parachuted' into host communities in a development context. The classic case of failure to understand local needs is the case of solar cooking, using cheap parabolic dish mirrors to focus sunlight. At one time this was offered, for example, in India, as a seemingly obvious alternative to the use of increasingly scarce wood fuel or the use of dung, the burning of which has environmental and health issues. However, it was not appreciated that most cooking took place after sunset when people typically came home from work in the fields and it was cooler. Simple implementation errors like this can be compounded by more subtle failures to understand local requirements and expectations, as some of the examples in this book have illustrated. One of the conclusions that emerges is the need for wide community participation in and control over the implementation process and indeed in the whole process of technology choice, design and deployment. Ideally the aim should be to support the host communities in becoming self-sufficient with regard to developing and maintaining new technologies so as to strengthen local economies, encouraging the education and development of local people and supporting local employment.

This need for the involvement of and understanding of the community of end users is relevant to all technologies, not just those in a development context. However, understanding and working with end users, who are rarely engineers and who may include disabled people and/or people from different cultures, are unfortunately rarely covered in engineering curricula. This is again an area for ethical engineers, particularly those involved in education, to exert pressure.

Being an engineer is a great responsibility as well as a great privilege. It involves excitement and challenges, as well as great difficulties. While engineers are not able to resolve all the world's many problems on their own, they are involved in the transformation of the material world and they have a responsibility to do this ethically. It is no small task. However, while the range of issues is very wide, and this book only touches on some of them, the overall ethical aim seems clear. We are all part of nature and need to coexist with it, choosing and using technologies that do not abuse the environment, people or other species. In this, engineers have a special role and responsibility. This book aims to provide some of the insights to help engineers fulfil this responsibility.

Biographies and Contact Details

Dr. Iwona Chomiak-Orsa has a degree from Wroclaw University of Economics and received a PhD degree in 2003. She recently completed her habilitation monograph. She researches on business processes in public organisations and works with businesses and regional governments in Lower Silesia and Great Poland provinces. Dr. Chomiak-Orsa is the co-author of numerous books, course books, monographs and conference papers, a participant in several research projects and has won many rector's prizes. She has been a member, secretary and treasurer of the Economic Informatics Society. She is currently a lecturer at Wroclaw University of Economics.

Alan Cottey is a physicist who in middle age decided 'if not now, when?' and became more active in the ethical issues of science and technology. This activity included study, writing, teaching and campaigning on the obvious and less obvious hazards of nuclear weapons. From this experience, he found a narrow focus to be insufficient and diversified into teaching a course for natural science students on 'science, values and ethics'. He tries to connect everyday living with the big existential questions. This is apparent in many of his writings, including his chapter of this book. He is a senior fellow in the School of Chemistry, University of East Anglia.
Email: a.cottey@uea.ac.uk; Web: www.uea.ac.uk/~c013/v2/index.xhtml

David Elliott is an Emeritus Professor of Technology Policy at the Open University. He worked initially with the UK Atomic Energy Authority at Harwell and then for the Central Electricity Generating Board in Bristol, before moving in the early 1970s to the Open University, where he carried out research and developed courses on technological innovation, focusing in particular on renewable energy technology development policy.

Prof. Elliott has written extensively on sustainable energy policy and is an editor of Palgrave Macmillan's *Energy, Climate and Environment* monograph series and also of the long-established journal, *Renew* (http://renewnatta.wordpress.com). Over the years, he has been closely involved with grass-roots trade union work on energy, technology and employment, building on his early work with the Lucas

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Aerospace shop steward committee on the Lucas workers' diversification plan, and more recently, he helped produce the Campaign against Climate Change booklet *One million Green Jobs*. His latest book, *Renewables: A Review of Sustainable Energy Options*, is published by the Institute of Physics, for whom he produces a weekly blog 'Renew your energy'.
Email: d.a.elliott@open.ac.uk; Blog: blog.environmentalresearchweb.org/author/dxe/

Wiebina Heesterman is Dutch but has been a resident in the United Kingdom since the mid-1960s. She is fully conversant with the latest climatological data. Having read extensively on the subject, she also followed the University of Exeter online climate course. She has a PhD in law from the University of Warwick on human rights, those of children in particular, as well as degrees in information science and IT. Now retired, she used to work in a nonacademic capacity at the School of Law of Warwick University. Happily, the school took a 'law-in-context' approach, with an emphasis on the importance of an ethical perspective. Her publication record includes several papers on children's rights as well as a book, *Rediscovering Sustainability: Economics of the Finite Earth*, written jointly with Aart Heesterman, published in 2013.

Lately her research has focused on the ways in which the methods used by those who stand to lose financially from the curtailment of the fossil fuel economy are eagerly embraced by people scared of facing reality. From visits to various less affluent countries, such as Tanzania and Zimbabwe, where she assisted in the creation of human rights databases, Wiebina gained a perspective on north-south relations other than that of a transient tourist. These visits reinforced her interest in issues such as the unequal position of women and girls in many parts of the world. Meeting former staff and students of the School of Law of Warwick University in their home countries enabled her to visit shanty towns and take part in debates on land rights. She also spent some time in the Caribbean and Southeast Asia with friends and relations. There too, she saw with her own eyes how poverty is being aggravated by erratic weather patterns.
Email: W.Heesterman@btinternet.com; Web: www.RediscoveringSustainability.org.uk

Dr. Marion Hersh is a senior lecturer in biomedical engineering at the University of Glasgow. She is both a chartered engineer and a chartered mathematician with a first degree in mathematics and a PhD in control engineering. She currently carries out interdisciplinary research in assistive technology, disability studies, engineering ethics and accessible and sustainable design. Her current and prospective teaching includes 'understanding ethics' to future teachers of technology and ethics in biomedical engineering.

Her previous books include *Mathematical Modelling for Sustainable Development* and two books on assistive technology, for blind and deaf people, respectively. She has organised and chaired a series of six international conferences on Assistive Technology for People with Hearing and Sight Impairments and an international conference on Using New Technologies for Inclusive Learning and is organising an international conference on Barriers and Enablers to Learning Maths to take place in 2015. She recently researched the travel experiences and need for new technologies of blind, visually impaired and deafblind people in 10 different countries on a Leverhulme Trust Research Fellowship. Her assistive technology development projects include a communication glove for deafblind people, smart travel aids for blind people and devices to support leisure travel for blind people. She has developed a three-component model of the causes of conflict, a three-component model of the travel processes of blind people and a classification and evaluation framework for ICT-based learning technologies for disabled people and co-developed the comprehensive assistive technology (CAT) model.

Dr. Hersh is also active in her trade union and a member of a number of campaigning organisations against racism, fascism, war and climate change and for nuclear disarmament and the rights of disabled and LGBT people, as well as a member of SGR and the vice-chair of International Federation of Automatic Control Technical Committee Tecis 9.5. She speaks seven languages fluently and has basic to moderate knowledge of a number of others, including British sign language.
Email: marion.hersh@glasgow.ac.uk; Web: http://web.eng.gla.ac.uk/assistive/

Dr. Antoni Izworski obtained a degree in electronics from the Electronic Faculty of Wroclaw University of Technology in 1982 and a PhD degree from the Institute of Technical Cybernetics of this university. He is the author of numerous designs and implementations of automatic control and modelling in military, industrial, scientific and educational plants. He works with the National Education Ministry on the development of examination standards for the electrical, electronic and mechatronic engineer professions. Dr. Izworski is the author or co-author of more than a hundred research works.

Anita Kealy (MSc) is an assistant lecturer (2006–present) and a PhD candidate and senior researcher in Waterford Institute of Technology. She is investigating the success factors in the implementation of a telemedicine centre in Kosovo in the context of a post-conflict developing country. She successfully completed a Masters by Research (2007) in the area of Irish users' perceptions of Internet privacy using virtual firms. She has presented her work at conferences throughout Europe and has published work in IJAA and JITCAR.

Anita assisted in the EU project MSMMK delivering high-quality higher education in technology and engineering studies. She is a member of the International Federation of Automatic Control Technical Committee (TC) for Technology, Culture and International Stability (Tecis 9.5) and was on the International Programme Committee of its 2013 conference. She has acted as a reviewer for several IFAC conferences and workshops on Technology, Culture and International Stability.
Email: akealy@wit.ie

Dr. Antonina Kieleczawa graduated from the Electronic Faculty of Wroclaw University of Technology and has been with the Institute for Power System Automation since 1977. From 1983 to 1988, she was delegated to the *Joint Institute* *for Nuclear Research* (JINR) in Dubna where she was employed on the Data Processing and Analysis Team in the Nuclear Reaction Laboratory. She was a co-author of the Polish automation system MASTER and the disturbance logger RZ-SPEEDY 4 and involved in many of their implementations in the power industry. She is an expert in the conceptual solutions of the MASTER operator system and its network communication and time synchronisation subsystems. Dr. Antonina Kieleczawa is a member of IFAC Technical Committee Tecis 9.5 and the Scientific Council of the Institute for Power System Automation (IASE).

Prof. Peter Kopacek graduated from the Vienna University of Technology in automatic control in 1966 and obtained a cum laude doctor's degree in control in 1971. He was an assistant professor at the Vienna University of Technology until 1985 when he became a full professor in systems engineering and automation at the University of Linz, Austria. In 1990, Prof. Kopacek became the head of the Institute for Handling Devices and Robotics at the Vienna University of Technology. He is the president of the Austrian Society for Systems Engineering and Automation and has been the general secretary of IFAC/Austria and of ÖGART since March 1985. He was scientific supervisor of the Scientific Academy of Lower Austria from 1988 to 1995.

He has three doctor honoris causae degrees and is a corresponding member of the Saxonian Academy of Sciences and the German Academy of Technical Sciences. He is a member of IFAC, IFR, and IEEE and received in 2006 the Engelberger Award from the Industrial American Robotics Society. His main research interests are in robotics for process and manufacturing automation, mechatronics, systems engineering, engineering management and postgraduate education. He has published six books and more than 250 scientific articles.
Email: kopacek@ihrt.tuwien.ac.at

Dr. Jozef Bohdan Lewoc obtained an MSc in electronic engineering from Wroclaw University of Technology in 1967, a Master of Mathematical Science with distinction from Wroclaw University in 1970 and a PhD in technical sciences from Warsaw University of Technology in 1973. Since 1966, he has been a designer/researcher and, since 1969, a leading designer/researcher of many Polish pioneering automation computer systems, in particular for the metallurgical and power industries, computer networks and databases. His professional work covered design, commissioning and implementation as well as scientific research on the systems he designed. He has worked for a number of different organisations in Wroclaw, including Elwro (computer manufacturer), Elam (supplier of automation systems), IASE (supplier of power industry automation), Polar (manufacturer of household appliances), Wroclaw University of Technology and the University of Wroclaw. His work includes more than 280 Polish and international publications in Poland.

He currently leads an American limited liability business, BPBIT Leader LLC, Design, Research and Translation Agency Leader (Leading Designer). In order to finance his professional activities as a designer and researcher, Dr. Lewoc has worked as a freelance translator between English and Polish in both directions since

1963 and has translated more than 300,000 pages. Cross-fertilisation occurred between his translation and ICT work with regard to feeding technical terms from his design work into translation and knowledge from a range of fields in which he carried out translations into his design work.
Email: leader@provider.pl; Web: http://leader.wroc.pl

Slawomir Feliks Skowronski obtained a degree in electronics from the Wroclaw University of Technology in 1971 and a PhD from the Institute of Technical Cybernetics at this university. His research initially involved automatic programming using artificial intelligence and has now moved into computer network design and evaluation, operating systems of computers and distributed data processing.

Dr. Larry Stapleton is a senior academic in advanced information systems, organisational culture and business. He received his PhD for large-scale enterprise information systems development research. He has published over 80 peer-reviewed academic publications. He is a member of numerous professional and academic committees and currently chairs the International Federation of Automation and Control Technical Committee for Technology, Culture and International Stability (Tecis 9.5).

Following five years as a manager in a large multinational company, Dr. Stapleton has lectured at Waterford Institute of Technology for 24 years. He has worked as an advisor to business development agencies, Enterprise Ireland and FAS. He has advised the European Commission and national governments both inside and outside the EU. He holds a number of international academic positions in information systems and engineering management, regularly speaking at major conferences. He is the founder and director of the Centre for Information Systems and Techno-culture (INSYTE) at Waterford Institute of Technology. Since 2001, the centre has graduated 21 postgraduate researchers at MSc and PhD levels and participated in 10 international projects. Published research topics and advisory work include advanced systems analysis, business culture and IT, knowledge systems, engineering and technology management, supply-chain systems, ICT policy in developing countries, ethics in the information society and higher education. He has participated in seven European funded projects under various programmes since 1995 and has lead national and international research projects involving dozens of partners in Europe, USA, and Asia.

William D. Tucker, known as Bill, is an Associate Professor of Computer Science at the University of Western Cape (UWC) in South Africa. He is founder and director of the Bridging Application and Network Gaps (BANG) research group that conducts applied research into information and communication technology for development. BANG launched and maintains two long-running community-based studies in partnership with local NGOs and informal governance structures: a telephony project for poor deaf people in metropolitan Cape Town with a focus on mobile sign language video and a rural telephony project in the remote rural Eastern Cape with a focus on voice and Internet provision with wireless mesh networks.

Bill has a Bachelor's Degree in Sociology, Business Administration and Computer Science from Trinity University in Texas, a Master of Science in Computer Science from Arizona State University and a PhD in Computer Science from the University of Cape Town. An American expatriate, he has lived in Cape Town since 1997. Before moving to Cape Town, he spent 6 years as a software engineer for a start-up called UniKix Technologies. Based at UWC since 1998, he has led BANG research since 2000 and served on programme committees for many local South African conferences, e.g. SATNAC and SAICSIT, and recently co-chaired the 4th ACM Annual Symposium on Computing for Development (DEV-4) and also helped co-chair ICTD, both held in Cape Town in December 2013. He is also an associate editor for the *Information Technology and International Development* (ITID) journal.
Email: btucker@uwc.ac.za

Dave Webb is an Emeritus Professor of Peace and Conflict Studies at Leeds Metropolitan University where he was also previously professor of engineering and co-founder and ex-director of the Praxis Centre (for the 'Study of Information Technology for Peace, Conflict and Human Rights'). He is currently the chair of the UK National Campaign for Nuclear Disarmament (CND), the convenor of the Global Network Against Weapons and Nuclear Power in Space and a member of Scientists for Global Responsibility.

Dave obtained a PhD in Space Physics in 1975 from the University of York in the United Kingdom and worked as a postdoctoral research fellow in space physics at Bell Laboratories in New Jersey, USA, and at the University of York from 1976 to 1978. From 1978 to 1979, he was employed as a senior scientific officer in the Directorate of Scientific and Technical Intelligence at the Ministry of Defence in London. He then moved to Leeds Polytechnic (now Leeds Metropolitan University) in 1979, where he joined the Engineering Department in 1985 and became a principal lecturer in 1995. He was appointed a reader in 2000 and a professor of engineering in 2003. In 2010, he became professor of peace and conflict studies in the Faculty of Health and Social Sciences. He was granted emeritus status after his retirement in July 2012.

His research interests focus on space security and issues in peace and conflict resolution. In September 2008, he chaired an international multidisciplinary conference on 'Imaging War' funded by the European Science Foundation and his recent publications include 'Space Weapons – Dream, Nightmare or Reality?' in *Securing Outer Space* (Jan 2009) – in the Routledge series on critical security studies. Other publications include 'On the Edge of History: the Nuclear Dimension' in *History at the End of the Word?* (2010); 'Space Weapons – Dream, Nightmare or Reality?' in *Securing Outer Space* (2009); 'Echelon and the NSA'*, in Encyclopedia of Cyber Warfare and Cyber Terrorism* (2007); and 'Missile Defence – The First Steps Towards War in Space?' in *Cyberwar, Netwar and the Revolution in Military Affairs* (2006), which he also co-edited.
Email: d.webb@space4peace.org

Resources: Addresses of Organisations of Engineers and Scientists Working for Change

Engineers for Social Responsibility

Web: https://sites.google.com/site/test4esr/
PO Box 6208, Wellesley Street, Auckland 1141, New Zealand

Engineers Without Borders

Web: http://www.ewb-international.org/
Secretariat: Cathy Leslie, EWB-USA Cathy.Leslie@ewb-usa.org
1031 33rd St., Suite 210 Denver, CO 80205, Tel 1-303-772-2723
101 Constitution Avenue, Suite 375 East, Washington DC 20001, Tel: 1-855-381-3517

Forum Wissenschaft & Unwelt

Email: office@fwu.at Web: www.fwu.at
Palmgasse 3/2 1150 Vienna, Austria. Tel: +43 01 2164120 20

Grup de Cientifics i Tecnics per un Futur No nuclear (Group of Scientists and Engineers for a Nuclear-Free Future)

Web: http://www.energiasostenible.org/ca/
Bustia verda, Apartat de Correus 10095, 08080 Barcelona, Catalunya
Tel: +34 629 932 908

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Interdisziplinäre Arbeitsgruppe Naturwissenschaft, Technik und Sicherheitspolitik – IANUS (Interdisciplinary Working Group on Science, Technology and Security Policy)

Email: mail@ianus.tu-darmstadt.de
Web: http://www.ianus.tu-darmstadt.de/home/index.de.jsp
Technische Universität Darmstadt, Brigitte Schulda, Sekretariat S3/04 103 Alexanderstr. 35
64283 Darmstadt Tel: +49 6151 16–4368, +49 6151 16–6039

International Network of Engineers and Scientists for Global Responsibility

Web: http://www.inesglobal.com/ines-home.phtml
Marienstr. 19–20, D-10117 Berlin, Germany
Tel: +49 (0)30 31 99 66 86
Programme director Lucas Wirl, email: lucas.wirl@inesglobal.com

International Network of Engineers and Scientists Against Proliferation

Email: mail@inesap.org Web: www.inesap.org
INESAP e.V. c/o IANUS Darmstadt University of Technology Alexanderstraße 35-37
D-64289 Darmstadt, Germany
Tel: +49 6151 16–4468

Japan Scientists Association

Web: http://www.jsa.gr.jp
Chasu Blg. 9F, 1-9-15 Yushima, Bunkyo-ku, Tokyo, 113–0034 Japan
Fax: +81-3-3813-2363

Science for Peace

Email: sfp@physics.utoronto.ca Web: www: http://scienceforpeace.ca/
045 University College, 15 King's College Circle, Toronto, Ontario, Canada, M5S 3H7
Tel: 416 978 3606

Science Unstained

Web: http://www.scienceunstained.co.uk/

Scientists for Global Responsibility, Australia

Email: Chris Hamer c.hamer@unsw.edu.au Web: www.sfgr.net
PO Box 6505, University of New South Wales, Sydney NSW 1466

Scientists for Global Responsibility, UK

Email: info@sgr.org.uk Web: www.sgr.org.uk
Unit 2.8, Halton Mill, Mill Lane, Halton, Lancaster LA2 6ND, UK
Tel: +44 1524 812 073

Sociedad Mexicana de Física (Mexican Physics Society)

Emails: smf@hp.fciencias.unam.mx, smf@unam.mx, smf@ciencias.unam.mx
Web: http://www.smf.mx/
A.P. 70–348 México, D.F. Departamento de Física, 2do piso, Facultad de Ciencias
UNAM, C.P. 04510 Delegación Coyoacán, Ciudad Universitaria, México, D.F.
Tel: y fax: (52–55) 5622–4946, 5622–4848.

Unione degli Scienziati Per Il Disarmo (Union of Scientists for Disarmament)

Web: http://www.uspid.org/index.html

Additional Reading

Climate Change

American Association for the Advancement of Science (AAAS) (2014) What we know: the reality, risk and response to climate change. http://whatweknow.aaas.org/get-the-facts/

de Mooij RA, Keen, M, Parry IWH (2012) Fiscal policy to mitigate climate change a guide for policy makers. International Monetary Fund, Washington, DC. Factsheet online at www.imf.org/external/np/exr/facts/pdf/enviro.pdf

Heesterman ARG, Heesterman WH (2013) Rediscovering sustainability: economics of the finite earth. Gower Publishing Ltd, Farnham/Burlington

Houghton J (2009) Global warming: the complete briefing, 4th edn. Cambridge University Press, Cambridge

Intergovernmental Panel on Climate Change (IPCC) (2014) Climate change, fifth assessment report, Working Group III, *Mitigation of climate change*, Summary for policymakers. http://www.ipcc.ch/report/ar5/index.shtml. Accessed 1 Feb 2015

Lucena J, Delborne J, Johnson K, Leydens JA, Munakata-Marr J, Schneider J (2011) Integration of climate change in the analysis and design of engineered systems: barriers and opportunities for engineering education. In: Proceedings of the ASME 2011 international mechanical engineering congress & exposition. 11–17 November 2011, Denver, CO. In New York: ASME, Proceedings of ASME. 54914, vol 5, Engineering education and professional development, pp 199–206

McKlintock J (2012) Lost Antarctica: adventures in a disappearing land. Palgrave Macmillan, New York

Met Office, Climate guide. http://www.metoffice.gov.uk/climate-guide. Accessed 1 Feb 2015

NASA, Global climate change: vital signs of the planet. http://climate.nasa.gov/evidence. Accessed 1 Feb 2015

NASA, Global climate change: vital signs of the planet, Key websites. http://climate.nasa.gov/key_websites. Accessed 1 Feb 2015

NASA, Jet Propulsion Laboratory, Global climate change: earth right now: your planet is changing: we are on it right now. http://www.jpl.nasa.gov/earth/. Accessed 1 Feb 2015

National Oceanic and Atmospheric Administration (NOAA), *Ocean carbon* uptake, at: http://www.pmel.noaa.gov/co2/. Accessed 1 Feb 2015

NOAA, Climate change: evidence and causes. http://nas-sites.org/americasclimatechoices/events/a-discussion-on-climate-change-evidence-and-causes/. Accessed 1 Feb 2015

Parkinson S (2003) Tackling climate change – the role of the engineer. In: Women's engineering society annual conference, 'Proper Practice: Professionalism and Ethics in Engineering and Science'. SGR. http://www.sgr.org.uk/resources/tackling-climate-change-role-engineer

M. Hersh (ed.), *Ethical Engineering for International Development and Environmental Sustainability*, DOI 10.1007/978-1-4471-6618-4

Preston CJ (ed) (2012) Engineering the climate: the ethics of solar radiation management. Lexington Books, Lanham
Taylor AT (2011) The dance no air & sea; how oceans, weather & life link together. Oxford University Press, Oxford
The Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) (2014) http://www.apegm.mb.ca/pdf/PD_Papers/cc-eng.pdf. Accessed 1 Feb 2015
The Royal Academy of Engineering (2011) Infrastructure, engineering and climate change adaptation – ensuring services in an uncertain future. http://www.theiet.org/policy/collaboration/etf/infrastructure.cfm
U.S. Department of Commerce| National Oceanic & Atmospheric Administration| NOAA Research 'Education and Outreach'. http://www.esrl.noaa.gov/gmd/outreach/. Accessed 1 Feb 2015
World Bank (2012) Turn down the heat: why a 4 °C warmer world must be avoided. World Bank, Washington, DC. http://documents.worldbank.org/curated/en/2012/11/17097815/turn-down-heat-4%C2%B0c-warmer-world-must-avoided. Accessed 1 Feb 2015

Engineering and Science Ethics

Bowen WR (2014) Engineering ethics: challenges and opportunities. Springer, Berlin
Committee on Assessing Integrity in Research Environments (US) (2002) Integrity in scientific research: creating an environment that promotes responsible conduct. National Academies Press, Washington, DC
Hersh MA (2000) Environmental ethics for engineers. Eng Sci Educ J 9(1):13–19
Kearnes M, Klauser F, Lane S (2012) Critical risk research: practices, politics, and ethics. Wiley-Blackwell, Oxford
Rollin BE (2006) Science and ethics. Cambridge University Press, Cambridge
Sandel MJ (2009) The case against perfection: ethics in the age of genetic engineering. Belknap, Cambridge
Spier R, Bird SJ (Series Editors) Science and engineering ethics. ISSN: 1353–3452 (print version), 1471–5546 (electronic version)
Straughan R, Reiss M (1996) Ethics, morality and crop biotechnology. BBSRC, Swindon
Thring MW (1992) The engineer's conscience. Brandish, Brandish

Ethics and Development

Burrell J, Toyama K (2009) What constitutes good ICTD research? Inf Technol Int Dev 5(3):82–94
Kaplan A (1996) The development practitioners' handbook. Pluto Press, London, p 128
Loudon M, Rivett U (2011) Enacting openness in ICT4D research. Inf Technol Int Dev 7(1):33–46
Marsden G (2008) Toward empowered design. Computer 41(6):42–46

Green Energy

Abramsky K (ed) (2010) Sparking a world-wide energy revolution. AK Press, Oakland
Barnham K (2014) The burning issue. Weidenfeld & Nicolson, London

Elliott D (2003) Energy, society and environment. Routledge, London
Elliott D (2010) Nuclear or not? Palgrave Macmillan, Basingstoke
Elliott D (2012) Fukushima: impacts and implications. Palgrave Macmillan, Basingstoke
Elliott D (2013) Renewables: a review of sustainable energy supply options. Institute of Physics Publications, Bristol. http://iopscience.iop.org/book/978-0-750-31040-6
Sovacool B (2013) Energy and ethics. Palgrave Macmillan, Basingstoke
Sovacool B, Sidortsov R, Jones B (2014) Energy security, equality and justice. Routledge, London

Methods

Law J (2004) After method: mess in social science research. Routledge, Abingdon

Outer Space

Bormann N, Sheehan M (eds) (2009) Securing outer space. Routledge, Abingdon/New York
Dickens P, Ormrod J (2007) Cosmic society: towards a sociology of the universe. Routledge, Abingdon
Diederiks-Verschoor I, Kopal V (2008) An introduction to space law. Kluwer Law International, Alphen aan den Rijn
Dolman E (2002) Astropolitik: classical geopolitics in the space age. Frank Cass Publishers, Southgate, London
Johnson-Freese J (2007) Space as a strategic asset. Columbia University Press, New York
Johnson-Freese J (2009) Heavenly ambitions: America's quest to dominate space. University of Pennsylvania Press, Philadelphia
Masson-Zwaan TL, Stephan Hobe S (eds) (2010) The law of outer space – an experience in contemporary law-making. Brill Nijhoff Publishers, Leiden/Boston
McDougall W (1985) The heavens and earth: a political history of the space age. The John Hopkins University Press, New York
Mindell DA (ed) (2009) The future of human spaceflight. The MIT Space, Policy, and Society Research Group. http://web.mit.edu/mitsps/MITFutureofHumanSpaceflight.pdf
Norris P (2010) Watching earth from space: how surveillance helps us – and harms us. Springer, New York
Secure World Foundation (2013) Space security index 2013. http://swfound.org/media/121668/SSI_Full_Report_2013.pdf
Sheehan M (2007) The international politics of space. Routledge, Abingdon
Vereshchetin VS, Vasilevskaia EG, Kamenetskaia EP (1987) Outer space–politics and law. Progress Publishers, Moscow
Wright D, Grego L, Gronlund L (2005) The physics of space security. Union of Concerned Scientists. http://www.ucsusa.org/assets/documents/nwgs/physics-space-security.pdf

Transport

Low N (ed) (2013) Transforming urban transport: the ethics, politics and practices of sustainable mobility. Routledge, London

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