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Luciano Maiani · Said Abousahl
Wolfango Plastino *Editors*

International Cooperation for Enhancing Nuclear Safety, Security, Safeguards and Non-proliferation—60 Years of IAEA and EURATOM

Proceedings of the XX Edoardo Amaldi Conference, Accademia Nazionale dei Lincei, Rome, Italy, October 9–10, 2017

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Keynote Speeches by
H. E. Yukiya Amano–IAEA Director General
H. E. Federica Mogherini–HR/VP European Commission

Preface

The XX Edoardo Amaldi Conference—*International Cooperation for Enhancing Nuclear Safety, Security, Safeguards and Non-proliferation*—has been held in Rome, Italy, 9th–10th October 2017, organised by the Accademia Nazionale dei Lincei and the European Commission—Directorate-General Joint Research Centre, under the patronage of the Italian Ministry of Foreign Affairs and International Cooperation.

The Conference was opened by a letter of appreciation and support of the President of the Italian Republic, Sergio Mattarella. The opening session has been broadcasted by RAI News to international audience and by RAI Scuola to a wide audience of high school classes.

Nuclear Safety, Security and Safeguards (the "*3S*") and Non-proliferation play a key role for the build-up and maintenance of the verification regime and the progress towards a nuclear-weapon-free world. The year 2017 marked two important anniversaries: the 60 years of IAEA Atoms for Peace and the 60 years of the EURATOM Treaty. The importance of these anniversaries has been underscored in the keynote speeches by two very exceptional personalities:

H. E. Yukiya Amano, IAEA Director General, in *60 Years of IAEA: Atoms for Peace and Development.*

H. E. Federica Mogherini, High Representative for Foreign Affairs and Security Policy—Vice-President of the European Commission, in *60 Years of Euratom Treaty: Disarmament and Non-Proliferation, New Challenges and Opportunities.*

We are very much honoured to present their talks at the very beginning of this book.

Organised in four plenary sessions with 18 plenary speeches and two panels, the XX Amaldi Conference has involved officials and scientists from international organisations—European Commission, International Atomic Energy Agency, Comprehensive Nuclear-Test-Ban Treaty Organization, Pugwash Conferences on Sciences and World Affairs—and from fifteen countries—Canada, China, Finland, France, Germany, Egypt, Iran, Israel, Italy, Japan, Pakistan, Russia, Turkey, UK and USA.

In the spirit of Amaldi's intuition, the Conference was proposed as a forum where eminent scientists, diplomats and policy makers could compare national perspectives and update international collaborations, while discussing how "*Science beyond Boundaries*" may enhance nuclear non-proliferation policies.

Talks have illustrated the political, institutional and legal dimension of the nuclear "*3S*", of the Non-Proliferation Regulation Systems, of the Nuclear-Test-Ban Treaty, and have addressed the current challenges by attempting to identify possible solutions and future improvements.

The role of international cooperation and of the scientific community actions has been considered, in connection with the effectiveness in the implementation of international controls in critical areas, on technology foresight and the ongoing evaluation of current capabilities.

The XX Amaldi Conference has been characterised by the preoccupations materialised in the last two years, concerning the worsening of the international relations and the possibility to make progress, or at least not to step back, on the fronts of International Security and Arm Control and of the non-proliferation process.

Under the name of "modernisation" of the armaments, a new arms race may have restarted between the superpowers. Added to this, the reciprocal accusations advanced in the USA and in Russia of violating the Intermediate Nuclear Force Treaty (INF) and the uncertainties on the future of the New Strategic Arms Reduction Treaty (START), due to expire in February 2021.

During the last Amaldi Conference, in 2015, great hopes had been raised by the Vienna talks for a non-proliferation agreement with Iran. Signed shortly after between Iran, China, France, Germany, Russia, UK, USA and the European Union, the Joint Comprehensive Plan of Action (JCPOA) has been tested in the following two years but it has been contested, during the last year, by the new US Administration.

The issue has emerged strongly in XX Amaldi Conference, first in the keynote speeches where

- IAEA DG Amano has explicitly stated that Iran has indeed complied with the obligations foreseen by JCPOA, and
- The High Representative Mogherini has clearly stated the intention of the European Union to proceed supporting the agreement.

The position of Iran has been reported at the Conference by Dr. A. A. Salehi, Vice-President and Head of the Atomic Energy Organization of Iran, and the issue has reappeared in the panel on The Future of Nuclear Disarmament and Non-Proliferation, with several interventions from the floor.

The Conference has stressed that the global security is a fundamental target for scientists, diplomats and policy makers, and in the context offered by the Accademia Nazionale dei Lincei, participants have been able to compare different experiences and discuss future strategies for an effective international cooperation, along the lines advocated long ago by Edoardo Amaldi.

The editors convey their sincere appreciation to all officials of the International Atomic Energy Agency, European Commission Joint Research Centre, Ministry of Foreign Affairs and International Cooperation, Ministry of Education, Universities and Research, Roma Tre University and Radiotelevisione Italiana (RAI), for supporting this Conference.

Special thanks go to all authors for their effort during the preparation of the papers and to the President of the Accademia Nazionale dei Lincei, Prof. Alberto Quadrio Curzio, to the Director General, Dr. Ada Baccari, to Dr. Marco Zeppa, Dr. Pina Moliterno, Dr. Giovanni Anzidei and all Lincei staff, for their commitment and efforts to promote the Conference.

Rome-Brussels
February 2018

Luciano Maiani
Chair, XX Edoardo Amaldi Conference
Said Abousahl
Co-Chair, XX Edoardo Amaldi Conference
Wolfango Plastino
Scientific Secretary, XX Edoardo Amaldi Conference

Keynote Speeches

Yukiya Amano and Federica Mogherini

60 Years of IAEA: Atoms for Peace and Development

Yukiya Amano
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Good morning, Ladies and Gentlemen.

I am very pleased to speak at this 20th Edoardo Amaldi Conference in the Accademia Nazionale dei Lincei, the oldest scientific academy in the world.

Italy was a founding member of the IAEA in 1957 and works closely with us in many areas of our work. Last month, at the IAEA General Conference in Vienna, Italy presented us with a bust of Enrico Fermi, who is often seen as an architect of the nuclear age.

As you know, Fermi was a collaborator of Edoardo Amaldi, after whom this series of conferences is named.

The European Commission Joint Research Centre, our co-organizer today, is a very important partner for the Agency. It provides significant financial and technical support for our work.

Ladies and Gentlemen,

In the past 60 years, the IAEA has helped to improve the health and prosperity of millions of people by making nuclear science and technology available in health care, food and agriculture, industry and other areas.

We also contributed to international peace and security by verifying that nuclear material stays in peaceful uses.

Our work was given special recognition in 2005 with the Nobel Peace Prize, which was awarded jointly to the Agency and to my distinguished predecessor Dr. Mohamed ElBaradei.

We are probably best known in the public mind for our work to prevent the spread of nuclear weapons, and especially—in recent years—for our activities concerning the nuclear programmes of North Korea and Iran.

I will talk about both of these issues in a moment. But first I would like to tell you about the development side of our *Atoms for Peace and Development* mandate.

Ladies and Gentlemen,

Nuclear science and technology have many peaceful applications which can help countries to produce more food, generate more electricity, treat diseases such as cancer, manage water supplies, protect the seas and oceans and respond to climate change.

These are all areas covered by the Sustainable Development Goals, which were adopted by world leaders in 2015. Helping developing countries to achieve the SDGs, using relevant nuclear technology, is an important part of our work.

Let me give you a few examples.

First, birth control for insects.

This is important in combating pests such as mosquitoes, tsetse flies and fruit flies. These cause nasty human and animal diseases and can destroy entire crops of fruit and vegetables.

The IAEA makes available something called the sterile insect technique, which involves sterilising male insects by applying radiation.

These sterilised males are released in a targeted location. They mate with females, but no offspring are produced. Over time, the wild population declines and the insect pest is greatly reduced, or completely eliminated in certain areas.

The sterile insect technique saves countries many millions of dollars per year and protects farmers' livelihoods. It also helps to improve human health. With generous support from the European Union, we have made the technique available to countries affected by the Zika virus to help them combat the Aedes mosquito, which spreads the virus.

Second, food security.

The IAEA helps to increase food supplies by developing new varieties of crops such as rice and barley. These are higher-yielding and more resistant to drought and disease.

By applying radiation in the laboratory, scientists accelerate the spontaneous mutation process that occurs in nature all the time. They can develop new varieties of crops very quickly. This does not involve genetic modification of the plants.

As a result, farmers in Peru are growing abundant crops of new varieties of barley at high altitudes, while farmers in Myanmar are growing more rice. Producing the new plants involves sophisticated science, but farmers do not have to change traditional growing methods.

The IAEA has a Joint Division with the Rome-based Food and Agriculture Organization of the United Nations, which focuses on nuclear techniques in food and agriculture.

The *third* area I want to mention is human health, and, in particular, cancer control. This is an important focus of our work.

Cancer used to be thought of as a disease of wealthier nations, but, in fact, it is reaching epidemic proportions in developing countries.

It is estimated that, by 2030, over 21 million people will be diagnosed with cancer every year. Around 60% of all new cancer cases will be recorded in developing countries, and that is where around 70% of cancer-related deaths will occur.

Unfortunately, many developing countries lack both equipment and the trained medical and technical experts needed to treat cancer effectively. In Africa alone, there are 28 countries which do not have a single radiotherapy machine.

The IAEA is working closely with partners such as the World Health Organization to change that.

Our technical support focuses on radiotherapy, nuclear medicine and imaging technology. We provide education and training for health professionals and sometimes supply equipment.

We have developed innovative e-learning initiatives which offer high-quality training for specialists in areas such as radiotherapy, medical physics and nutrition.

Finally, the IAEA is unique within the UN system in having eight specialist nuclear applications laboratories near Vienna.

These train scientists, support research in human health, food and other areas, and provide analytical services to national laboratories. The laboratories are now undergoing a long overdue modernisation. We also have environmental laboratories in Monaco which work on marine pollution and ocean acidification.

Since 1958, more than 48,000 scientists and engineers have held fellowships and scientific visitor positions through the IAEA technical cooperation programme, both at our laboratories, and in the facilities of our partners around the world.

Ladies and Gentlemen,

The best known peaceful application of nuclear technology is nuclear power.

At present, 30 countries are using nuclear power. But many more countries, especially in the developing world, are interested in introducing it. In fact, global use of nuclear power continues to grow, despite the Fukushima Daiichi accident in Japan six years ago.

Nuclear power makes a significant contribution to reducing greenhouse gas emissions and improving energy security, while delivering energy in the growing quantities needed for development.

It is up to each country to decide whether or not to introduce nuclear power. The IAEA does not attempt to influence their decision. But if countries opt for nuclear power, our job is to help them use it safely, securely and sustainably.

Nuclear safety and security are national responsibilities, but the IAEA serves as the forum for international cooperation in these areas.

For example, the IAEA establishes international nuclear Safety Standards. These are not legally binding, but they are used voluntarily by almost all countries to protect people and the environment from harmful effects of ionizing radiation.

The Agency sends peer review missions, made up of top international experts, to give countries professional advice on safety issues.

The IAEA coordinated the international response to the most serious accidents at nuclear power plants—at Chernobyl in 1986 and Fukushima Daiichi in 2011.

After the Fukushima Daiichi accident, we quickly convened a ministerial conference which led to the *IAEA Action Plan on Nuclear Safety*. This helped to bring about a significant improvement in nuclear safety throughout the world.

As far as security is concerned, the IAEA helps countries to prevent nuclear and other radioactive material from falling into the hands of terrorists.

We train police and border guards, provide radiation detection equipment and advise on nuclear security at major events such as the Olympic Games and World Cup soccer championships. The EU is a major supporter of the IAEA's nuclear security programme.

Ladies and Gentlemen,

I will now turn to the nuclear verification work of the IAEA.

We implement safeguards in 181 countries, sending nuclear inspectors all over the world to check that States are not secretly developing nuclear weapons. We use advanced technology that enables us to detect even minute particles of nuclear material.

We have state-of-the-art safeguards laboratories near Vienna which analyse samples of material brought back by our inspectors. Wherever possible, we monitor nuclear facilities remotely, in real time, using permanently installed cameras and other sensors.

The IAEA and EURATOM have for decades applied safeguards jointly in Europe, including through joint team inspections.

This brings me to the very topical issue of Iran's nuclear programme.

The IAEA worked from 2003 onwards to try to resolve a number of outstanding safeguards issues in Iran. For years, little or no progress was made. But, a few years ago, we started to see some movement.

In July 2015, I signed a *Road-map* with Iran for the clarification of possible military dimensions to its nuclear programme. At the same time, Iran and the group of countries known as the P5+1—plus the EU—agreed on the *Joint Comprehensive Plan of Action*, the JCPOA.

As a result of the IAEA Roadmap, I was able to present a final assessment of Iran's past nuclear activities to the IAEA Board of Governors in December 2015.

Our assessment was that Iran had conducted a range of activities relevant to the development of a nuclear explosive device before the end of 2003. However, these activities did not advance beyond feasibility and scientific studies, and the acquisition of certain relevant technical competences and capabilities.

Based on my report, the IAEA Board decided to close its consideration of outstanding issues related to the Iranian nuclear programme.

Ladies and Gentlemen,

Implementation of the JCPOA began in January 2016. The IAEA is not a party to the agreement. We were asked by the UN Security Council to verify and monitor that Iran is implementing its nuclear-related commitments under the agreement. Our Board of Governors authorised us to do so.

The JCPOA represents a real gain for nuclear verification.

Iran is now subject to the world's most robust nuclear verification regime. Our inspectors have expanded access to sites, and have more information about Iran's nuclear programme. That programme is smaller than it was before the agreement came into force.

Iran is provisionally implementing the additional protocol to its safeguards agreement with the IAEA. This is a powerful verification tool which gives us broader access to information and locations.

As a result, I can state that the nuclear-related commitments undertaken by Iran under the JCPOA are being implemented.

The IAEA will continue to implement safeguards in Iran with a view to being able to draw what we call the "broader conclusion"—that *all* nuclear material remains in peaceful activities—in due course. This is likely to take many years.

But we can already point to some valuable lessons from the process so far.

The first is that even complex and challenging issues can be tackled effectively if all parties are committed to dialogue—not dialogue for its own sake, but dialogue aimed at achieving results.

My second observation is that the IAEA was able to make a vital contribution, and maintain the confidence of all sides, by sticking to its technical mandate and not straying into politics.

Ladies and Gentlemen,

Unfortunately, it is not possible to report progress on the issue of North Korea.

I remain seriously concerned about North Korea's nuclear programme. North Korea continues to conduct nuclear tests, launch missiles and threaten other countries, in complete disregard of the repeated demands of the international community.

The fact that North Korea is testing nuclear weapons with a large yield, as well as long-distance delivery systems, means this is no longer just a regional threat. It is a grave threat to global peace and security.

The IAEA used to have inspectors in North Korea, reporting on its nuclear programme, but they were required to leave in 2009. North Korea declared its withdrawal from the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). It is no longer a Member State of the IAEA.

We are still working hard to collect and evaluate information regarding North Korea's nuclear programme, including by monitoring satellite imagery as well as open-source and trade-related information.

Without direct access, the Agency cannot confirm the operational status of North Korea's nuclear facilities or what exactly is going on there. But all the indications suggest that North Korea is pressing ahead with its nuclear programme. When it comes to its nuclear programme, North Korea generally does what it says it is going to do.

In the present circumstances, it is difficult to be optimistic about possible solutions. The most important thing for now is that the international community gets united. Clearly many parties—key countries, the UN and the IAEA—have important roles to play.

Ladies and Gentlemen,

As you can see, the Agency has a remarkably broad mandate, covering many disparate areas, which needs to be implemented in a balanced manner.

Our work is unique—no other organization offers the range of services related to nuclear science and technology that we do.

In the coming decades, we will continue to focus on delivering concrete results for our Member States and improving the well-being and prosperity of the people of the world through the clever use of that technology.

Thank you.

60 Years of EURATOM Treaty: Disarmament and Non-Proliferation, New Challenges and Opportunities

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Dear friends,

I am really sorry I cannot be with you in Rome today. Non-proliferation is not only very close to my heart: it is also one of the most urgent issues of our times. Once again we have to deal with nuclear tests, and the threat of a nuclear attack. The only wise thing to do in a moment like this, is to invest all our political capital in the power of diplomacy, multilateralism and international cooperation. We should open new channels for dialogue and mediation, and we definitely shouldn't destroy the channels we already have—even more so, if they are delivering. We should protect and expand all international agreements on nonproliferation. This is certainly not the time to dismantle them.

The lesson of Edoardo Amaldi and his generation is more relevant than ever, and too often forgotten.

People like Amaldi understood better than anyone else the risk of nuclear proliferation. Amaldi knew the power of the bomb, and he always worked to prevent a new Hiroshima. The one and only way to do so, was (and still is) investing in international cooperation.

His generation understood the need for cooperation on a global scale. Exactly sixty years ago, Amaldi and others gave birth to a global movement of scientists for nuclear disarmament. And in the same year, the International Atomic Energy Agency also saw the light.

Just a few months before, in March 1957, Amaldi was among the founding fathers of Euratom—one of the original building blocks of our European Union. Our founding fathers and mothers believed that only a united Europe could survive in a world of superpowers. They believed that without European unity, we would be irrelevant on the global stage. And they knew that together, we could be a scientific superpower, and we could contribute to shaping the rules of a more cooperative global order.

Sixty years on, we know that our founding fathers and mothers were right. International cooperation and European unity are still interlinked, and both essential to global non-proliferation and disarmament.

Just look at the nuclear deal with Iran. It would have been impossible, without a strong European Union.

We put all our power to the service of peace, and this was crucial for the success of the negotiations.

At the same time, the Iran nuclear deal has also shown the power of international cooperation. Through diplomacy and dialogue we achieved a win-win solution, we set a milestone for non-proliferation, and we prevented a dangerous, devastating military escalation.

And since we reached the deal two years ago, the International Atomic Energy Agency has been monitoring the implementation of the deal, including with inspections and it has certified Iran's compliance eight times.

Sixty years after the birth of the IAEA, the Agency is a guarantee for all of us. Because the deal as anything related to nuclear non proliferation does not belong to one or two countries—but to the whole world, to the whole of us. In fact, the Iran Nuclear Deal is a UN Security Council Resolution.

The deal with Iran has concluded one of the worst nuclear crises of our times. Now, as we face a different new nuclear threat, from North Korea, we really cannot afford to open another front. We have an interest, and a responsibility, a duty, to preserve the nuclear deal with Iran, and to work to strengthen, not to weaken, the global non-proliferation regime.

Right now, we are putting maximum pressure on North Korea: we in the European Union are leading by example on the implementation of all the UN sanctions, and on top of them we have imposed our own European measures. At the same time, we are working to build the unity of the international community. We believe the only option is to build together, and in particular with our partners in the region, a peaceful pathway towards a complete, verifiable and irreversible de-nuclearisation of the Korean peninsula.

In a moment like this, we must explore all possibilities to prevent the proliferation of nuclear weapons. With all our energy, with all our determination. This is the most serious security threat the world is facing today. We all need to be extremely serious about it.

Some of you may know that I am personally involved in the work to universalise the Comprehensive Nuclear Test-Ban Treaty, as a member of the Group of Eminent Persons supporting it.

The Treaty has already provided us with an unprecedented mechanism to control nuclear tests all around the world. This has allowed us to independently assess the nature and magnitude of North Korea's tests.

But the Treaty has not entered into force yet. This prevents the use of on-site inspections—which would be an essential tool to guarantee non-proliferation, which means security, and peace.

Today, an effective universal nuclear test ban may sound like a dream. But this was also the case when Amaldi and others launched the campaign in support of the Non-Proliferation Treaty.

The NPT is now the cornerstone of the global non-proliferation regime. And we will do all we can to ensure the success of the Non-Proliferation Treaty Review Conference in 2020.

Our Union will continue to be a global force for non-proliferation and disarmament. We will continue to work to relaunch the Conference on Disarmament, and to conclude negotiations on a Treaty banning the production of fissile material for nuclear weapons.

The two EU Member States who possess nuclear weapons have already declared a moratorium on the production of fissile material. We invite all other nuclear weapon States to do the same.

In the meanwhile, thanks to our support to the G7 Global Partnership and the International Science and Technology Centre, we have contributed to destroy the stockpiles of fissile material, and to re-direct scientific expertise towards peaceful purposes.

In a difficult moment like this, we must stick to our previous commitments. For instance, the United States and Russia are due to reduce their deployed warheads by February 2018. Respecting this deadline will send a powerful message not only of peace and cooperation but also of increased security, to the whole world.

But we must also work for bold and visionary solutions, such as turning the Middle East in a nuclear weapon free zone. Today it seems impossible—but Nelson Mandela used to say: “It always seems impossible, until it’s done”.

Sixty years ago, the peaceful use of nuclear energy was a cornerstone in the process of building our European Union. Today, the European Union is a leading global force and an indispensable partner for nuclear non-proliferation and disarmament.

So my message today is this: the world can count on us. The world can count on the European Union. We will preserve the deal with Iran. We will seek a peaceful, secure and de-nuclearised Korean peninsula.

And we will work for making a world finally free from nuclear weapons, a dream coming true.

Thank you.

Opening Addresses

Alberto Quadrio Curzio, Luca Giansanti, Vladimír Šucha and Luciano Maiani

Opening Address of the Accademia Nazionale dei Lincei

Alberto Quadrio Curzio
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Excellencies and Authorities, Scientists and Friends,

It is an honor for the Accademia Nazionale dei Lincei to host the XX edition of the Edoardo Amaldi Conference on International Cooperation for Enhancing Nuclear Safety, Security, Safeguards and Non-Proliferation which also marks the 60th anniversary of the International Atomic Energy Agency (IAEA) and of the European Atomic Energy Community (EURATOM). The conference opens with the satisfaction of knowing that the Nobel Peace Prize 2017 has just been awarded to ICAN (International Campaign to Abolish Nuclear Weapons), which even more enhances the significance of the previous Nobel Peace Prizes award for similar reasons to Pugawash, to IAEA, to EU.

For the Amaldi Conference a warm thank you goes to the institutions which have contributed in different ways to promoting this initiative. The relevance of such institutions is evident, as well as the personalities who will open the conference: Vladimir Sucha—Director General of the Joint Research Centre of the European Commission, Luca Giansanti—Director General for Political Affairs and Security at the Italian Ministry of Foreign Affairs and International Cooperation, and, last but not least, my Lincei colleague Luciano Maiani, Chair of the Amaldi Conferences, who has given new impulse to this important initiative which is at the same time scientific and political, coherent also with a sustainable development along the strategies of the UN Agenda 2030.

The great significance of the Conference is also noted by its distinguished speakers, starting from Yukiya Amano and Federica Mogherini who have high responsibilities for international peace. Before these outstanding personalities deliver their speeches, allow me to say a few words on the Accademia dei Lincei and Edoardo Amaldi.

The Accademia dei Lincei was established in three phases, in the four centuries of its life. At the end of the *Rinascimento*, Prince Federico Cesi founded the Academy and soon received everlasting glory by one of its first fellows, Galileo Galilei. During the *Risorgimento*, when Rome became the Capital of the Italian Kingdom, the Lincei Academy was re-founded and for 65 years gave a remarkable contribution to consolidate the national and international cultural development of the new State. In 1944 the Academy was formed once again, after the fall of the fascist dictatorship had shut it down in 1938 and after the war. The *Republican* period then began, in particular after the initial impulse of Benedetto Croce and Luigi Einaudi. The latter was the President of the Class of Moral Sciences of the Lincei between 1946 and 1948, the year in which he became the first President of the Italian Republic. Since then the relationship between our Academy and the Italian Head of the State has been excellent, contributing to elevating the role of Italy in the EU.

In four centuries, the Lincei have pursued 'science for sciences', 'sciences for policies', 'policies for sciences'. This multiple combination can contribute a lot to peace and human development; Amaldi has been an outstanding example and pioneer of this multiple approach. With freedom of research the Lincei Academy has promoted natural and social sciences not only for the importance of free research, but also for the progress of humanity and for the development of societies, which requires also the contribution of historical wisdom. Along these lines, the Lincei always acted in a proper way being conscious that their role was also that of providing both advice to Institutions and reliable information to Society. This is also one of the aims of this conference, as was also the aim of the successful G7 of scientific academies meeting held last spring, which received appreciation from the President of the Italian Republic.

In the 1980s the Amaldi initiative on peace, disarmament and human progress was launched, inspired also by the Pugwash and Panofsky initiatives. Over the years, the event has received great support from Francesco Calogero, Carlo Schaerf, Giorgio Salvini and Edoardo Vesentini, and again from Luciano Maiani. To all these colleagues goes my warmest thanks for their contribution, not only in strengthening the historical mission of the Lincei but also for their scientific contribution to promote peace and development worldwide.

Opening Address of the Italian Ministry of Foreign Affairs and International Cooperation

Luca Giansanti
Italian Ministry of Foreign Affairs and International Cooperation, Rome, Italy
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Presidents, Chairpersons, Director General Amano, Excellencies, Ladies and Gentlemen,

It is an honour to deliver this opening address to the twentieth edition of the "Amaldi Conference", to which the Italian Ministry of Foreign Affairs and International Cooperation has lent its support, together with other institutions.

This year, the “Amaldi Conference” falls within the celebration period that the International Atomic Energy Agency has dedicated to the 60th anniversary of its foundation. Let me thank Director General Amano for being here with us today.

Italy highly values the vital role of the Agency in strengthening capacities worldwide for the safe, secure and peaceful use of nuclear science and technology, in line with the 2030 Agenda for Sustainable Development.

Nuclear science and technology can be applied in a number of sectors, far beyond nuclear power, and in critical domains, such as medical therapy. In this respect, Italy is committed to making the added value of nuclear science and technology available for the entire world.

We contribute to the technical cooperation fund of the Agency, which helps countries across the globe to benefit from atomic technology, and we host in Trieste the Abdus Salam International Centre for Theoretical Physics (ICTP), which is a driving force behind global efforts to advance scientific expertise in the developing world.

I am particularly pleased that each year a number of foreign researchers are hosted in our laboratories and medical facilities in the framework of fellowships financed under the Agency’s technical cooperation fund and managed in cooperation with the ICTP.

The proliferation of nuclear weapons represents a major threat to international security. The existence of programmes to develop such weapons and of criminal proliferation networks, the difficulty of securing sensitive materials and the risk that non-state actors and terrorist groups might get access to them, remain major challenges to cope with.

In this respect, the IAEA’s system of safeguards represents a fundamental guarantee for our common security. In all relevant international fora, Italy promotes the universalization of the IAEA Comprehensive Safeguards Agreements together with an Additional Protocol as the international verification standard. Italy systematically calls on all States who have not yet done so to sign and bring into force an Additional Protocol and, where relevant, adopt the modified Small Quantities Protocol.

In this context, let me commend the successful history of EURATOM in the 60th anniversary from its Treaty signed in Rome in 1957. The EURATOM and IAEA cooperation modalities in relation to the application of the safeguards envisaged under article III of the Nuclear Non-Proliferation Treaty is widely recognized as an international best practice. During these six decades, EURATOM has also represented an effective institutional model for advancing scientific research in the field of nuclear power and for managing nuclear fuel materials with a common approach.

In our view, the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) remains the cornerstone of the global non-proliferation regime and the essential foundation for the pursuit of nuclear disarmament, as well as the basis for the further development of nuclear applications for peaceful purposes.

These three mutually reinforcing pillars are still valid today. The 2010 NPT Review Conference Action Plan remains a very good basis to progress in all of them, including nuclear disarmament.

Italy shares concerns about the catastrophic consequences of nuclear weapons' use and we are aware of the continuing nuclear risks for humanity. We consider the award, a few days ago, of the Nobel Peace Prize to the International Campaign against nuclear weapons, as a demonstration of the growing international awareness towards nuclear disarmament.

Our desire for a safer world for future generations underpins our efforts for effective progress on nuclear disarmament and non-proliferation. We are convinced that the best approach towards nuclear disarmament remains the one enshrined in article VI of the NPT, which provides the only realistic legal framework to attain a world without nuclear weapons in a way that promotes international stability. Our approach is based on the idea that the goal of a nuclear-weapons-free world can be reached gradually, with the involvement of all relevant actors, through a series of concrete and progressive steps, and based on the principle of undiminished security for all.

In terms of concrete and effective measures towards this goal, Italy has always been a staunch supporter of the entry into force of the Comprehensive Test Ban Treaty and has always strongly promoted the start of negotiations of a treaty prohibiting the further production of fissile material for nuclear weapons or other explosive devices.

In the context of the international efforts in pursuing mutual confidence, peace and security, the Joint Comprehensive Plan of Action (JCPoA) concerning the Iranian nuclear programme is an historic diplomatic success.

The solid structure of the JCPoA and its robust verification mechanisms are crucial to uphold mutual trust. In this respect, let me welcome the confirmation by the IAEA in successive reports of Iran's continued implementation of the provisions of the agreement.

The full implementation of the JCPoA and of all provisions of the UN Security Council Resolution 2231 can foster international and regional security. With this approach in mind, Italy has undertaken this year the role of Security Council Facilitator for Resolution 2231 and will make its part to preserve the JCPoA as an achievement of multilateral diplomacy from which all parties involved should benefit from.

The global non-proliferation regime is currently facing one the most dangerous challenges with the on-going developments of North Korea's nuclear and ballistic missile programmes, which violate successive UNSC resolutions and the international moratoria on nuclear tests.

As also demonstrated by the continuous missile launches, including those overflying Japan, North Korea's nuclear and ballistic missile programmes have reached such an advanced dimension, which have become an imminent threat to regional and international peace and security.

As chairman of the UN Security Council Sanctions Committee for North Korea, Italy continues to promote outreach activities with the various UN geographic groups to help countries in the implementation of the comprehensive package of measures adopted by the Security Council.

The aim remains to trigger a change in North Korea's behaviour and to convince it to desist from its self-inflicted path of international isolation.

Let me finally state that Italy remains fully committed to the achievement of a better nuclear security environment and will continue to support all international efforts to this end.

For the safety of its nuclear installations, Italy will continue to implement its national policy for decommissioning and safe management of spent fuel and radioactive waste in strict cooperation with the International Atomic Energy Agency.

Last July, the IAEA's very first ARTEMIS Peer Review mission on a national decommissioning and radioactive waste-management programme was carried out in Italy, covering the entire set of relevant facilities.

At the end of last year, the Italian National Institute for Environmental Protection and Research (ISPRA), our national regulatory authority, had also the chance to undertake an evaluation against the IAEA Safety Standards in the framework of an Integrated Regulatory Review Service (IRRS) mission.

The two missions resulted to be a key opportunity for our national stakeholders to reinforce international cooperation and exchange best practices. Italy will remain at the forefront in the implementation of international standards for nuclear safety.

Presidents, Chairpersons,

I would like to pay tribute to you and your staff for the excellent organization of this Conference. The exceptionally high level of the keynote speakers and panelists is a clear evidence of your success in preparing a debate, which I am confident will be fruitful, intense and thought provoking.

Thank you for your attention.

Opening Address of the European Commission Directorate General Joint Research Centre

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The past 60 years of peace and development in the use of nuclear energy, ensured by the synergic actions of the Joint Research Centre, created under the EURATOM Treaty, and the International Atomic Energy Agency can be considered as important achievements. Moreover, they also entail our responsibility for the future and represent an even stronger commitment towards enhanced nuclear safety, security, safeguards and non-proliferation.

The Treaty establishing the European Atomic Energy Community (Euratom), signed on 25th March 1957, is the basis of the EU engagement in the nuclear field. By celebrating the 60th anniversary from the signature of the Euratom Treaty, we also celebrate the 60th anniversary of the European Commission's Joint Research Centre.

Stemming from article 8 of the Euratom Treaty (originally "the Joint Nuclear Research Centre"), the JRC has the mandate to carry out research programmes, ensure a standard system of measurements and perform other tasks assigned to it by the Commission.

In 60 years, the JRC underwent gradual transformation and expanded its scope beyond nuclear activities. However, the commitment to ensure the highest standards of safety, security and safeguards for peaceful uses of nuclear energy and technologies firmly stays among our priorities.

It is not by coincidence that we also celebrate the 60th anniversary of the International Atomic Energy Agency (IAEA).

The Euratom Community and the IAEA, during their 60 years of existence, have established a long-lasting fruitful cooperation in different important areas. At first, the focus of the cooperation was enhancing nuclear safeguards worldwide. After the Chernobyl accident in 1986, the two institutions started working jointly to improve nuclear safety. As a consequence of the global security challenges that followed 9/11 terror attacks, this cooperation gradually developed in the field of nuclear security. More recently (2016) the European Commission and the IAEA joined forces through the signature of a Practical Arrangement on Nuclear Science Applications. Finally, in the margins of this year IAEA General Conference (September 2017), a new collaboration was launched with the signature of a Practical Arrangement on Human Resources in support to Nuclear Decommissioning.

International political and technical cooperation is a crucial instrument to build a peaceful and united world, where disputes are solved through negotiations, and not through force.

In that respect, on 14 July 2015 the EU/EU+3 (China, France, Germany, the Russian Federation, the United Kingdom and the United States with the High Representative of the European Union for Foreign Affairs and Security Policy, Federica Mogherini) and the Islamic Republic of Iran reached an agreement on a Joint Comprehensive Plan of Action (JPOA).

The JRC is contributing to the implementation of the JPOA, which will ensure the exclusively peaceful nature of Iran's nuclear programme.

The responsibility of scientists for peace should be taken seriously. Einstein was a pioneer. The IAEA at international level and the JRC at EU level operate in the framework of that legacy.

I believe the Amaldi Conference represents an important step in the direction of scientific and political cooperation to discuss different approaches and promote progress towards enhanced nuclear safety, security, safeguards and non-proliferation.

In the framework of the cooperation with the Italian "Accademia Nazionale dei Lincei" the JRC is proud to co-organise this XX edition of the Edoardo Amaldi Conference. We have also previously co-organised with the Accademia dei Lincei the XIX edition of the Amaldi Conference (Rome, 30–31 March 2015), and the 1st Edoardo Amaldi Lecture (Brussels, 26 October 2016).

In my quality of President of the Organizing Committee of this Conference, I would like express my deepest appreciation to the distinguished speakers, chairs and panellists for bringing their experience and perspectives to the different sessions of the Conference; and welcome all of you to this prestigious venue and encourage you to profit from the stimulating discussion throughout these two days.

My gratefulness and admiration goes of course to the prestigious Accademia Nazionale dei Lincei that, since 1603, promotes, coordinates, integrates and spreads scientific knowledge in its highest expressions: I am very honoured to be here today and to co-chair this important keynote session.

To conclude, and by leaving the floor to the Director General of the IAEA Mr. Amano, I would like to warmly thank him for his presence and intervention to the XX Amaldi Conference. My gratitude also goes to the EU HR/VP Mogherini for her contribution to the Conference and her firm commitment towards peace and non-proliferation. The keynote lectures from DG Amano and HR/VP Mogherini confer additional prestige to the Conference.

Opening Address of the Organizing Committee of the XX Edoardo Amaldi Conference

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Il Presidente della Repubblica

PROF. LUCIANO MAIANI
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DESIDERO ESPRIMERE IL MIO PARTICOLARE APPREZZAMENTO PER LA CONFERENZA DI OGGI, INSERITA NELLA SERIE DI INCONTRI INIZIATI NEL 1988 DA EDOARDO AMALDI E A LUI INTITOLATI, SUI TEMI, PARTICOLARMENTE ATTUALI E DELICATI, DEL DISARMO E DELLA NON PROLIFERAZIONE NUCLEARE.

IL GRANDE SCIENZIATO, ALLIEVO E COLLABORATORE DI ENRICO FERMI, ILLUSTRE RICOSTRUTTORE DELLA SCUOLA DI FISICA IN ITALIA NEL SECONDO DOPOGUERRA, DA ULTIMO PRESIDENTE DI QUESTA PRESTIGIOSA ACCADEMIA, CHE OGGI OSPITA LA "*XX EDOARDO AMALDI CONFERENCE*", È STATO, FIN DAGLI ANNI OTTANTA, CONVINTO SOSTENITORE DEI LAVORI DEL *WORKING GROUP ON INTERNATIONAL SECURITY ARMS CONTROL*.

IL PARTICOLARE RILIEVO DI QUESTO APPUNTAMENTO SCIENTIFICO, CHE OGGI GIUNGE AL RAGGUARDEVOLE TRAGUARDO DELLA VENTESIMA EDIZIONE, ASSUME UNA ULTERIORE VALENZA IN OCCASIONE DELLA RICORRENZA DEI 60 ANNI DELLA *INTERNATIONAL ATOMIC ENERGY AGENCY* (IAEA) E DEL TRATTATO EURATOM.

NELLA CONSAPEVOLEZZA CHE IL CONTRIBUTO DELLA SCIENZA COSTITUISCE UN INDISPENSABILE FATTORE DI PROGRESSO DELLA NOSTRA SOCIETA' E DI CRESCITA E VALORIZZAZIONE DEL CAPITALE UMANO, MI È GRADITO RIVOLGERE ALLE PERSONALITÀ E AGLI STUDIOSI PRESENTI UN SENTITO AUGURIO DI BUON LAVORO.

SERGIO MATTARELLA

Letter from the President of Italian Republic, H. E. Sergio Mattarella

Excellencies, Authorities, Ladies and Gentlemen,

It is a great honour and pleasure to open the XX Amaldi Conference on *International Cooperation for Enhancing Nuclear Safety, Security, Safeguards, and Non-Proliferation*, organised jointly by the Accademia Nazionale dei Lincei and the European Commission, DG Joint Research Centre, with the support of Ministero degli Affari Esteri, Italia.

This year, the Conference celebrates the 60th anniversary of two very important international Organisations: the International Atomic Energy Agency (IAEA) and the EURATOM Treaty-European Union.

We gratefully acknowledge the patronage of the Conference by the President of the Italian Republic, expressed in the letter reproduced above.

A few notes on the origin and development of the Edoardo Amaldi conferences.

In 1980, Wolfgang Panofsky establishes CISAC (Committee on International Security and Armament Control) at the United States National Academy of Sciences, to maintain bilateral contacts with an analogous group at the Soviet Academy of Science.

In 1986, the CISAC meeting was extended beyond the limitation of a direct link between the USA and the USSR. About ten scientists from European countries participated. The possibility of establishing in Europe a group of scientists with a role analogous to that of CISAC was discussed. Francesco Calogero and Carlo Schaerf took part in this meeting and reported to Edoardo Amaldi, then Vice President of Accademia Nazionale dei Lincei.

In 1987, Edoardo Amaldi sets up SICA (a working group on International Security and Arms Control), at Accademia dei Lincei. A first informal SICA meeting was held in Rome at Lincei on 23–25 June 1988, the *Workshop on International Security and Disarmament: The Role of the Scientific Academies*.

On 5 December 1989, Edoardo Amaldi dies unexpectedly in Roma, while preparing the third Meeting. He was then President of Accademia Nazionale dei Lincei. The *International Conference on Security in Europe and the Transition away from Confrontation towards Cooperation* was held in Rome in June 1990. Participants in the 1990 meeting decided to dedicate future meetings to the memory of Edoardo Amaldi, hence the name Edoardo Amaldi Conferences.

Since then, Edoardo Amaldi Conferences have been held regularly at Lincei and in Hamburg.

The SICA chair was attributed to Edoardo Vesentini, president of the Accademia in 1997–2003.

In 2015, a new format for the Conference was inaugurated by the SICA group (Francesco Calogero, Carlo Schaerf, Luciano Maiani, Wolfango Plastino, and Edoardo Vesentini). The XIX edition obtained the support of Ministero degli Affari Esteri and of the Joint Research Centre, European Commission, thanks to the vision of Luca Giansanti, Director of Political Affairs and Security, and of Vladimír Šucha, the JRC Director General.

The struggle of scientists and of associations of the civil society towards the reduction of nuclear weapons and a peaceful world has been recognised several times by the Nobel Peace Prize.

The Nobel Peace Prize 1995 to Joseph Rotblat and to Pugwash Conferences on Science and World Affairs.

For their efforts to diminish the part played by nuclear arms in international politics and, in the longer run, to eliminate such arms.

The Nobel Peace Prize 2005 jointly to International Atomic Energy Agency and Mohamed Elbaradei.

For their efforts to prevent nuclear energy from being used for military purposes and to ensure that nuclear energy for peaceful purposes is used in the safest possible way.

The Nobel Peace Prize 2012 to European Union.

For over six decades contributed to the advancement of peace and reconciliation, democracy and human rights in Europe.

We have been happy to learn, few days ago, of the last recognition.

The Nobel Peace Prize 2017 to International Campaign to Abolish Nuclear Weapons (ICAN).

For its work to draw attention to the catastrophic humanitarian consequences of any use of nuclear weapons and for its ground-breaking efforts to achieve a treaty-based prohibition of such weapons.

The *Edoardo Amaldi lectures on International Cooperation for enhancing Nuclear Safety, Security, Safeguards and Non-Proliferation* are held every two years in alternation with the Edoardo Amaldi Conferences on the same subject.

The Edoardo Amaldi lectures take place in alternation with the Edoardo Amaldi Conferences and are delivered by internationally recognised personalities from the scientific, political and diplomatic world, at the Accademia Nazionale dei Lincei, Roma, Italy, or in other Institutions dedicated to International Collaboration.

The first Edoardo Amaldi Lecture, organised by Accademia dei Lincei in collaboration with the Directorate-General of the Joint Research Centre, was delivered at the European Commission, Bruxelles, October 26, 2016, by H. E. Amb. Tibor Tóth, Executive Secretary Emeritus of the Comprehensive Nuclear-Test-Ban Treaty Organization, with title *Super-positioned realities of Nuclear Safety, Security, Safeguards and Stockpiles: is Schrödinger's cat dead or alive?*

The Second Edoardo Amaldi Lecture, with the title: *The Evolution and Future of Nuclear Security Leadership in Europe* will be given by the Rt Hon. the Lord Browne of Ladyton, Chair of European Leadership Network, on October 2018.

After the pioneering work of Joseph Weber, Edoardo Amaldi launched in Italy the construction of a series of cryogenic antennae, made by massive aluminum bars, to search for gravitational waves produced in catastrophic cosmic events, like supernovae explosions or the coalescence of two massive stars (neutron stars or black holes). With his characteristic enthusiasm and drive, Amaldi was able to give a large momentum to this difficult research line, attracting resources and brilliant young people like Guido Pizzella, Massimo Cerdonio, Adalberto Giazotto, Fulvio Ricci and others, who built several massive cryogenic antennae, in Italy and at CERN.

During the 1980s a new approach emerged, based on Long Baseline Laser Interferometers, realised in the US with the construction of the two Ligo interferometers, conceived and proposed by Reiner Weiss of MIT, and in Europe with the Virgo Interferometer, built in Italy, near Pisa, by a French-Italian collaboration under the leadership of Adalberto Giazotto and Alain Brillet.

The first observation by LIGO in 2015, of the gravitational waves emitted during the coalescence of two black holes has created enormous excitement in the physics community all over the world.

VIRGO in 2017, has joined successfully LIGO in the observation of a further event, which could be identified as the merging of two neutron stars thanks to the precise indication given by the gravitational observatories to the conventional telescopes.

The Nobel Prize for Physics 2017 has been attributed one half to Rainer Weiss, the other half jointly to Barry C. Barish and Kip S. Thorne *for decisive contributions to the LIGO detector and the observation of gravitational waves*.

It was very rewarding for us, former students and collaborators of Edoardo Amaldi, to assist to the spectacular developments of a line initiated in Italy by him.

In conclusion, I would like to express may gratitude to my colleagues of the Scientific Organising Committee (Said Abousahl, Maria Betti, Jacek Bylica, Francesco Calogero, Götz Neuneck, Wolfango Plastino, Carlo Schaerf and Edoardo

Vesentini), for their continuous advice in the preparation of the program, and to the Staff of Accademia dei Lincei for the very efficient support.

A special recognition goes to Wolfango Plastino, our Scientific Secretary, who has been essential for the realisation of the prestigious Keynote Speeches, which will now open the Conference, and for their broadcasting in the Italian National TV Network.

Contents

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Part I
Nuclear Safety and Security—1

Carlo Schaerf, Gustavo Caruso, Alexandre Bilodeau and Jari Luoto

Chapter 1
Introduction

Carlo Schaerf

The first session of this XX Amaldi conference is devoted, as in the previous conference, to the dual existential problem of Nuclear Safety and Nuclear Security.

The IAEA (International Atomic Energy Agency) defines Nuclear Safety as "The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards".

Nuclear Security is defined as the physical protection of nuclear materials from theft or sabotage with particular reference to the protection of fissile materials that could be used to produce a nuclear bomb. This problem has been emphasized by the preoccupation that rogue states or sub-state actors might acquire by violent or illegal means enough quantity of nuclear fissile materials to produce even a rudimentary nuclear explosive device.

Three presentations by distinguished speakers illustrate particular aspects of the worldwide commitment to reduce the risk of emergencies deriving from the uses of nuclear materials for peaceful or aggressive purposes:

- IAEA's Central Role in International Cooperation for Strengthening Nuclear Safety and Nuclear Security Worldwide by Gustavo Caruso, Director of the Office of Safety and Security Coordination of the IAEA;
- Nuclear Security Summits and Legacy by Alexandre Bilodeau, a Canadian career foreign service officer Counsellor and Deputy Permanent Representative at the Canadian Permanent Mission to the International Organizations in Vienna;
- The GICNT Contribution to Nuclear Security by Jari Petteri Luoto, Ambassador, Ministry for Foreign Affairs of Finland, Coordinator for the Global Initiative to Combat Nuclear Terrorism—Implementation and Assessment Group (GICNT IAG).

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L. Maiani et al. (eds.), *International Cooperation for Enhancing Nuclear Safety, Security, Safeguards and Non-proliferation–60 Years of IAEA and EURATOM*, Springer Proceedings in Physics 206, https://doi.org/10.1007/978-3-662-57366-2_1

Starting from the obvious premise that nuclear safety and security are the responsibility of individual countries, Gustavo Caruso has illustrated the role of IAEA in fostering scientific cooperation among countries and between countries and the IAEA to improve their nuclear and radiation safety and security standards in the peaceful uses of nuclear science and technology. This field is regulated by several legally binding international conventions adopted under the IAEA auspices and the Agency supports Member States in fulfilling their obligations. Moreover, it encourages them to commit politically and implement several Codes of Conduct that are not legally binding but improve nuclear safety and security also in the eventuality of nuclear accidents like Chernobyl and Fukushima Daiichi.

The communiqué of the fourth Nuclear Security Summit (NSS) held in Washington DC in March 2016, outlines the commitments to the principles and the Action Plans agreed by the participants states to enhance nuclear security. This important but complicated process has been illustrated by Alexandre Bilodeau who has also emphasized the specific activities engaged by States to reduce their stockpiles of Highly Enriched Uranium and Plutonium, and improve the physical protection of nuclear facilities. To improve their collaboration each State has designated a senior official to participate in a Nuclear Security Contact Group that convened for the first time in Canada in September 2016. In his conclusion, the speaker has stressed the very unsatisfactory financial situation of the organizations responsible for these problems. As an example, 85% of IAEA Nuclear Security Activities rely on extra-budgetary voluntary unpredictable contributions of Member States.

The last presentation of the session by Jari Luoto was devoted to the Global Initiative to Combat Nuclear Terrorism (GICNT), a voluntary collaboration of 88 nations co-chaired by Russia and the USA. Presently Finland chairs its Implementation and Assessment Group (IAG) and Ambassador Luoto is its coordinator. The main goal of GCINT is to promote the exchange of information about the dangers of nuclear terrorism and discuss the rules and best practices that are recommended gathering information from a wide community: technical experts, law enforcement officers, custom and border guards, policy makers, etc. GCINT has organized table top and field exercises, workshops and seminars to promote an interdisciplinary approach that helps national and international officers to prevent, detect and respond to the use of nuclear and radioactive materials by terrorist groups.

Short questions were addressed to each speaker after his presentation and a larger discussion developed at the end after all presentations. Participants raised several problems that were partly answered: the conversion of research and propulsion nuclear reactors from operating with Highly Enriched Uranium (HEU) to operation with Low Enriched Uranium (LEU); the impact of the New and Emerging Technologies on the mitigation and the enhancement of nuclear risks; the difficulty of national government of exchanging information on terrorist groups for the fear of jeopardizing the sources of such information; the similarity between the risk of dispersion in the environment of radioactive and chemical and biological agents versus the risk of terrorist groups acquiring a nuclear explosive device and exploding it in a city with the consequent risk of provoking a nuclear exchange at the international level; how to deal with the increasing worldwide stockpiles of Plutonium; etc.

The general consensus was for measures to improve international cooperation both at the bilateral and multilateral level.

Chapter 2
IAEA's Nuclear Safety and Nuclear Security Worldwide

Gustavo Caruso

The International Atomic Energy Agency is the world's central intergovernmental forum for scientific and technical co-operation in the nuclear field. It works for the safe, secure and peaceful uses of nuclear science and technology, contributing to international peace and security and the United Nations' Sustainable Development Goals.

Strong nuclear and radiation safety and security underpin all Agency activities. The IAEA's Department for Safety and Security fosters cooperation to enhance nuclear and radiation safety and security worldwide. The Agency promotes the widely accepted principle of 'safety first' in nuclear and radiation matters.

This paper highlights the key role of global cooperation in nuclear and radiation safety and security. It does so by first explaining the context into which the IAEA's safety and security work fits, with a special focus on conventions and codes. It then discusses the lasting impact of nuclear accidents on the Agency's safety work and concludes by highlighting some of the ways the IAEA fosters cooperation to enhance nuclear and radiation safety and security.

Nuclear safety and security are the responsibility of each individual country. The IAEA, and particularly its Department for Safety and Security, support Member States fulfil that responsibility. All support is provided only at States' request in line with the Agency's mandate.

The IAEA promotes adherence to and implementation of international legal instruments on nuclear safety adopted under its auspices.

Legally-binding Conventions include:

- Convention on Nuclear Safety

The Convention on Nuclear Safety was adopted in Vienna on 17 June 1994. Its aim is to commit participating States operating land-based civil nuclear power

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L. Maiani et al. (eds.), *International Cooperation for Enhancing Nuclear Safety, Security, Safeguards and Non-proliferation–60 Years of IAEA and EURATOM*,
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plants to maintain a high level of safety by setting international benchmarks to which States would subscribe.

The Convention is based on the Parties' common interest to achieve higher levels of safety that will be developed and promoted through regular meetings. It obliges Parties to submit reports on the implementation of their obligations for "peer review" at meetings that are normally held at IAEA Headquarters. This mechanism is the main innovative and dynamic element of the Convention.

The Convention entered into force on 24 October 1996. As of October 2017, it had 83 parties.

- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was adopted in Vienna on 5 September 1997. It is the first legal instrument to address the issue of spent fuel and radioactive waste management safety on a global scale. It does so by setting international benchmarks and creating a similar "peer review" process to the Convention on Nuclear Safety.

The Convention applies to spent fuel resulting from the operation of civilian nuclear reactors and to radioactive waste resulting from civilian applications. It also applies to spent fuel and radioactive waste from military or defence programmes if such materials are transferred permanently to and managed within exclusively civilian programmes, or when declared as spent fuel or radioactive waste for the purpose of the Convention by the Contracting Party concerned. In addition, it covers planned and controlled releases into the environment of liquid or gaseous radioactive materials from regulated nuclear facilities.

The Joint Convention entered into force on 18 June 2001. As of October 2017, it had 76 parties.

- Convention on the Physical Protection of Nuclear Material and its Amendment

The Convention on the Physical Protection of Nuclear Material was signed at Vienna and at New York on 3 March 1980. The Convention is the only international legally binding undertaking in the area of physical protection of nuclear material. It establishes measures related to the prevention, detection and punishment of offenses relating to nuclear material.

The Convention went into force on 8 February 1987. As of October 2017, it had 155 Parties.

A Diplomatic Conference in July 2005 was convened to amend the Convention and strengthen its provisions. The amended Convention makes it legally binding for States Parties to protect nuclear facilities and material in peaceful domestic use, storage as well as transport. It also provides for expanded cooperation between and among States regarding rapid measures to locate and recover stolen or smuggled nuclear material, mitigate any radiological consequences of sabotage, and prevent and combat related offences.

On 8 July 2005, the Parties to the Convention adopted by consensus an Amendment to the CPPNM.

The Amendment aims to improve the physical protection of nuclear material and facilities. Whereas the obligations for physical protection under the CPPNM covered nuclear material during international transport, the Amendment to the CPPNM makes it legally binding for States Parties to protect nuclear facilities and material in peaceful domestic use, storage and transport. It also provides for expanded cooperation between and among States regarding rapid measures to locate and recover stolen or smuggled nuclear material, mitigate any radiological consequences of sabotage, and prevent and combat related offences.

The Amendment entered into force on 8 May 2016. As of October 2017, it had 115 parties.

- Convention on Early Notification of a Nuclear Accident

The Convention on Early Notification of a Nuclear Accident aims to strengthen international cooperation in providing relevant information about nuclear accidents so that transboundary radiological consequences can be minimized. States Parties commit that, in the event of a nuclear accident that may have transboundary radiological consequences, they will notify the IAEA along with countries that may be affected and provide relevant information on the development of the accident. The IAEA will in turn inform States Parties, Member States, other States that may be physically affected and relevant international organizations of the notification received and will, upon request, promptly provide other information.

The Convention went into force on 27 October 1986. As of October 2017, it had 121 parties.

- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency sets out an international framework for co-operation among States Parties and the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies. The IAEA serves as the focal point for such cooperation. It helps channel information and supports the efforts of States Parties and other partners involved.

The Convention went into force on 26 February 1987. As of October 2017, it had 115 parties.

In addition, the IAEA encourages Member States to express political commitment to and implement non-legally binding Codes of Conduct.

These include:

- Code of Conduct on the Safety and Security of Radioactive Sources

This Code aims to help national authorities ensure that radioactive sources are used within an appropriate framework of radiation safety and security. The Code is a well-accepted, non-legally binding international instrument and has received political support from more than 130 Member States.

Two documents supplement the Code. The Guidance on the Import and Export of Radioactive Sources supplements the Code and aims to provide for an adequate transfer of responsibility when a source is being transferred from one State to another. The Guidance on the Management of Disused Radioactive Sources provides further guidance regarding the establishment of a national policy and strategy for the management of disused sources, and on the implementation of management options such as recycling and reuse, long term storage pending disposal and return to a supplier.

- Code of Conduct on the Safety of Research Reactors

This Code strengthens the international nuclear safety arrangements for civil research reactors. It sets out parameters for the management of research reactor safety and provides guidance to governments, regulatory bodies and operating organizations for the development and harmonization of the relevant policies, laws and regulations.

Its objective is to achieve and maintain a high level of safety in research reactors worldwide, which is achieved by proper operating conditions, the prevention of accidents and, should accidents occur, the mitigation of their radiological consequences.

The IAEA is a resource and partner to all Member States as they work to fulfil their responsibility for nuclear and radiation safety and security, including by adhering to these Conventions and Codes.

The Chernobyl and Fukushima Daiichi accidents profoundly impacted the IAEA's nuclear safety work.

The 1986 Chernobyl accident sparked discussions that eventually led to the 1994 adoption of The Convention on Nuclear Safety, described above. This key instrument fosters cooperation among its parties, and it promotes transparency: CNS country reports are available on the IAEA website.

The Convention on the Early Notification of a Nuclear Accident, and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency were adopted in the immediate aftermath of the Chernobyl accident. Both are based on cooperation. The Notification Convention strengthens international cooperation in order to provide relevant information about nuclear accidents as early as necessary to minimize transboundary radiological consequences. The Assistance Convention sets out an international framework for co-operation among States Parties and with the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies.

The IAEA Response and Assistance Network helps countries fulfil their obligations under the Assistance Convention. Countries that participate in this Network have informed the IAEA about the assistance they could offer upon request in an emergency. A country that contacts the IAEA seeking support then can be swiftly assisted. This Network is just one example of concrete cooperation fostered by the IAEA to enhance nuclear and radiological safety and security.

In the aftermath of the 2011 Fukushima Daiichi accident, IAEA Member States endorsed the IAEA Action Plan to Make Nuclear Power Safer. The Action Plan was a programme of work to strengthen the global nuclear safety framework in light of the accident. As part of this programme, Member States and the IAEA took action in 12 areas, including safety assessments, capacity building and radiation protection.

In 2015, the IAEA Director General's Report on the Fukushima Daiichi Accident and its five technical volumes was published. This comprehensive report considers human, organizational and technical factors to provide an understanding of what happened, and why, so that the global nuclear community can apply its lessons. The report notes that the accident underlined the vital importance of effective cooperation. The IAEA is where most of that cooperation takes place.

The Action Plan elements and observations and lessons from the Fukushima Report have now been incorporated into the Agency's regular work. Following a systematic analysis and prioritization, we identified methods to further strengthen nuclear safety. These are highlighted in the IAEA's Nuclear Safety Review 2017.

Years have passed since the Fukushima Daiichi accident, but its legacy—a sharper focus on nuclear safety everywhere—remains. There can be no grounds for complacency about nuclear safety anywhere—safety comes first. The IAEA is working to ensure that this principle will continue to guide work.

The Chernobyl accident led to the development the safety culture concept, and the Fukushima Daiichi accident further underlined the need for a robust safety culture. Continuous questioning and openness to learning from experience are key to safety culture and essential for everyone involved in nuclear power. This somewhat intangible concept can be a challenge to implement in practice, but we offer resources to help Member States: assessments, reviews and courses. For example, in October 2017, the IAEA holds a Pilot International School of Nuclear and Radiological Leadership for Safety in Nice, France, to show junior and mid-career professionals an opportunity to learn how they can lead for safety throughout their careers.

The IAEA fosters cooperation in many ways. The Agency's meetings, workshops, courses, peer review missions and other events bring together participants and experts from many countries, enabling both formal and informal cooperation that strengthens nuclear safety and security globally.

In addition, the IAEA supports networks to promote intensified cooperation. The IAEA Global Nuclear Safety and Security Network comprises almost 20 networks that help Member States connect, collaborate and communicate to strengthen nuclear safety and security. These networks are specialized on a particular topic or function, or they bring stakeholders from a region together. A regional example is the European and Central Asian Safety Network brings together countries that face common regional issues so that they can exchange information and experience, coordinate work and cooperate.

A topical example is the Small and Modular Reactor Regulators' Forum, which enables cooperation, learning and experience exchange among regulators who are facing similar challenges as they regulate this type of reactor.

The statute tasks the Agency with creating standards of safety and to provide for the application of these standards. The IAEA safety standards are a set of more than 100 documents that reflect a consensus on what is considered a high level of nuclear and radiation safety.

The standards outline the basics of how to establish, maintain and continuously improve governmental, legal and regulatory frameworks for nuclear and radiation safety. They are not binding, but we encourage Member States to apply them. The document titled 'Fundamental Safety Principles' lay the groundwork for all standards. Documents called Safety Requirements support these principles by highlighting requirements that must be met to ensure the protection of people and the environment, both now and in the future. Safety Guides explain how to comply with the safety requirements.

We draw upon the expertise of Member States to create and update the standards. Member States take part in Committees that provide feedback on the standards, and in a Commission that endorse the standards. Finally, the Board of Governors establishes the safety requirements and authorizes the Director General to issue them as part of the IAEA safety standard series. It is a cooperative and consultative process that takes time and results in well-founded documents that reflect international consensus.

Security is accepted as a fundamental requisite for the safe and peaceful use of nuclear energy. There is a risk that nuclear or other radioactive material could be used in criminal or intentional unauthorized acts, creating a threat to international security.

Member States have asked the Agency to assume the central and leading role in nuclear security globally in IAEA General Conference resolutions and in statements delivered at our Board of Governments meetings. This wish was also expressed at the 2016 IAEA International Conference on Nuclear Security.

To support Member States in nuclear security, the Agency has developed the Nuclear Security Series, which provides international consensus guidance on all aspects of nuclear security. The series comprises Nuclear Security Fundamentals, Recommendations, Implementing Guides and Technical Guidance.

The Agency also fosters cooperation and carries out activities as states' request to strengthen global nuclear security. In addition, it offers training, equipment and tools as well as technical advice and advisory services in the field of nuclear security.

For example, in June 2017, the IAEA launched a mobile application that helps customs officers determine whether radiation alarms going off at border crossings are sparked by naturally occurring radioactive material in goods such as ceramics, fertilizer and soy beans, or whether the alarm could indicate smuggled material, warranting further inspection.

To help Member States assess how their practices and frameworks compare to those recommended in the IAEA Safety Standards and Security Guidance, the

Agency offers peer reviews and advisory services. These are built on and foster cooperation: a peer review team typically includes experts from several Member States who work together to review another country's practices. A mission is a beneficial experience for hosts and reviewers alike. Everyone learns from each other to the benefit of nuclear safety and security.

Nuclear safety comes first is a principle that is widely adhered to in the nuclear community.

Maintaining a high level of nuclear safety and security are challenging responsibilities for all countries, and the IAEA offers wide-ranging support.

The IAEA fosters international cooperation to strengthen nuclear safety and security.

Chapter 3
Nuclear Security Summits and Legacy

Alexandre Bilodeau

Excellencies, Ladies and Gentlemen, please allow me at the outset to thank the President of the Academia Nazionale dei Lincei, M. Alberto Quadrio Curzio, and M. Luciano Maiani and M. Said Abousahl, Co-Chairs of the XX Edoardo Amaldi Conference, for having organised this event and having invited me to present Canada's perspective on the Nuclear Security Summit (NSS) process and its Legacy.

I will first provide a brief overview of the NSS process and detail some of its outcomes. Second, I will focus on one of the key deliverables of the NSS: the Nuclear Security Contact Group (NSCG), which in the true sense of a "legacy" was established to continue the work of the Summit process after it ended. Then, I will offer some final observations on key challenges and next steps in efforts to reinforce the international nuclear security architecture.

The Nuclear Security Summit (or NSS) process was an unparalleled mechanism to convene world leaders to ensure the highest level of political focus and to create momentum towards building and strengthening an international nuclear security architecture that could adequately mitigate the threat of nuclear terrorism.

The Summit process has been praised for having reduced the amounts of dangerous nuclear materials in the world, enhanced the physical protection of nuclear facilities, and to have helped to further coordinate the efforts of the key international organizations and initiatives: the IAEA, UN, INTERPOL, Global Initiative to Combat Nuclear Terrorism (GICNT) and Global Partnership.

Attended by 52 States and 4 observer organizations (UN, IAEA, INTERPOL and the EU), the fourth and final Summit in Washington D.C. in March 2016 was an important turning point.

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It has been characterized as a transition Summit, as it marked the transition to our current post-NSS context, where there's a need to ensure that the political momentum generated by the Summit process is sustained to further enhance the international nuclear security architecture.

The outcome documents—consensus-based documents negotiated by all NSS States—outline commitments to principles and concrete actions to enhance nuclear security.

The 2016 NSS Communiqué overviews the commitments to principles, and links to the five "Action Plans" that outline actions for States in helping the transition of NSS commitments to the five key international organizations and initiatives working on nuclear security: the IAEA, UN, INTERPOL, GICNT and Global Partnership.

Smaller groups of States also committed to more specific concrete actions through joint statements or "gift baskets", one of which saw 40 states commit to the establishment of the Nuclear Security Contact Group. This emerged as a key Summit deliverable and provided an opportunity for Canada to exercise international leadership in the efforts to maintain momentum post-NSS.

Domestically, States undertook specific commitments to engage in activities such as reducing their Highly Enriched Uranium or Plutonium stocks, enhancing the physical protection of nuclear facilities, etc.

There was a clear realisation, as the NSS process was winding down, that there was an inherent risk in losing the pulling power of leaders and that there was a need to find ways to avoid the dissipation of focus and find ways to advance the implementation of the NSS' key objectives, specifically its five Action Plans.

It is against this backdrop, that the US proposed a "gift basket" called "Joint Statement on Sustaining Action to Strengthen Global Nuclear Security". Voluntary in nature, this "gift basket" was originally supported by 40 countries (i.e. Argentina, Armenia, Australia, Belgium, Canada, Chile, China, Czech Republic, Denmark, Finland, France, Georgia, Germany, Hungary, India, Israel, Italy, Japan, Jordan, Kazakhstan, Lithuania, Mexico, Morocco, the Netherlands, New Zealand, Nigeria, Norway, Republic of Korea, Romania, Poland, Singapore, Spain, Sweden, Switzerland, Thailand, Ukraine, United Arab Emirates, United Kingdom, United States, Vietnam) and the following international organizations: INTERPOL and the United Nations. The aim of this Gift Basket was to facilitate cooperation and sustain activity on nuclear security after the 2016 Nuclear Security Summit, and commit to:

1. Establish a Nuclear Security Contact Group; and
2. Designate an appropriately authorized and informed senior official or officials to participate in the Contact Group.

This Contact Group, which was first convened by Canada in September 2016, is as a mechanism to help ensure that work continues after the Summit process in order to maintain a global nuclear security architecture that is strong, sustainable and comprehensive.

Statement of Principles: At its initial meeting, the contact Group formalised itself by issuing a Statement of Principles which matches the NSS Joint Statement and outlines the aims and objectives of the Contact Group:

Aim: To facilitate cooperation and sustain engagement on nuclear security following the conclusion of the NSS process.

Objective: To advance the implementation of nuclear security commitments and build a strengthened, sustainable and comprehensive global nuclear security architecture.

In accordance with the group's wishes, the Statement of Principles was published as IAEA INFCIRC/899, and shared in the UN context in New York, so as to welcome a broader membership.

The Group is currently supported by the leaders of 44 countries and 3 international organizations—the UN, INTERPOL, EU (the IAEA has been invited to participate regularly).

The membership remains open to new members who publically commit to the goals of the NSCG outlined in the statement of principles, namely through:

1. Contributing to the work of the NSCG, including through participation in NSCG meetings;
2. Discussing a broad range of nuclear security-related issues, including new and emerging trends that may require more focused attention;
3. Promoting and assessing the implementation of nuclear security commitments, including those made in the NSS process;
4. Maintaining a "culture of deliverables" that characterized the NSS process (where leaders took stock of efforts to implement commitments and, importantly, made new commitments going forward); and
5. Developing and maintaining linkages to non-governmental experts and nuclear industry.

While the establishment of such a group may have appeared pretty straightforward at the outset, it was clear early on that maintaining the momentum and focus achieved throughout the Summit process, without the "pull" of leaders and within a relatively large group of countries with different approaches, was going to be challenging.

In this context, the Group shaped itself around three strategic objectives:

1. sustaining momentum on strengthening nuclear security in a context of competing concerns and demands;
2. maintaining engagement among senior levels;
3. continue a culture of deliverables which typified the NSS process/in other words focus on both practical steps and policy positions that serve to support and enhance a strengthened international nuclear security culture, stressing the importance of achieving concrete results.

> Quote: “A breeding ground for new ideas to address nuclear security threats and challenges”—Heidi Hulan—first NSCG Convener.

Worth noting that the NSCG is not a decision-making body; its actions and commitments are based on the NSS Action Plans and national commitments.

During the course of its first year of existence, and more recently during its meeting in May on the margins of the NPT PrepCom the Group saw specific NSCG Members take lead roles to advance nine key “Action Items” arising from the discussions in London, for focused efforts to implement key NSS commitments, which have been outlined in thematic “non-papers”; in some cases (#3 and 9) there are ‘sub-groups’ that have emerged to help advance these issues:

- Core messaging across fora (Canada)
- Industry Cooperation (Germany)
- Resources for nuclear security (Netherlands)—sub-group exists
- Concentrated support to the IAEA (US)
- Outreach and diplomacy on global nuclear security architecture (Korea)
- Emerging challenges to nuclear security (UK)
- Regional Capacity Building and Cooperation (China)
- IPPAS Missions (UAE)
- CPPNM/A 2021 RevCon (Australia)—sub-group exists

Some of the NSCG’s key accomplishments can be described as follows:

First, the NSCG succeeded in achieving participation of a wide array of regional groups, stemming from all continents, a true manifestation of the global importance of nuclear security and the potential impact of nuclear threats.

Second, the forum established post-NSS allowed the action items to further mature and the emergence of thematic leads, dealing—for example—with issues of resources, messaging and legal instruments. In turn this created sub-groups of interested countries focusing on issues of particular interest or concern in a more coordinated manner. This approach also helped reinforce the fact the Summit Chair or the NSCG convener cannot be driving the process, ownership and engagement by members is key to progress and success.

Third, the Group “cohered”—not an easy task nor a given in light of the diversity of views represented through the broad membership. The Group now thinks of itself as a forum where some strategizing can take place, albeit still modest.

Finally, the group has remained pragmatic and collegial in its approach—despite differences of views—and has also managed to achieve some durability, having already identified its next covener (Jordan) as well as the following (Hungary), meaning that the Group will have an established presence for at least two more years.

Canada has completed the first year as the inaugural “Convener”, and has transitioned to Jordan as the new Convener. Hungary will follow as the Convener for 2019. The Group will need to strike the right balance between maintaining high level political attention to the issues while also going down into the weeds of efforts to advance technical elements of the NSS Action Plans in the relevant fora.

While Canada during its convenership sought to focus on the implementation of the IAEA Action Plan—given that the Agency was in the process of developing its next Nuclear Security Plan (NSP 2018–2021)—Jordan has already indicated that it will seek to advance the Interpol Action Plan.

Almost two years after the 2016 NSS and notwithstanding the establishment of the NSCG, there is a risk of losing the political momentum necessary to maintain focus on threats to nuclear security.

Key Challenge—Obama on work beyond 2016: key focus was to be “able to sync up the efforts of the [NSS process] with existing institutions like the IAEA, INTERPOL, UN”—so far, it has been a major challenge getting key institutions such as the IAEA to take on board the commitments in the IAEA Action Plan—especially in the area of predictable resources for the Agency to undertake its work on nuclear security.

There is a continued need for NSCG members and others involved in the NSS to deploy consistent messaging to dispel the perception/narrative of nuclear security being characterized as an impediment rather than an enabler of peaceful uses of nuclear energy. This narrative continues to be counter-productive and in fact has already limited our collective ability to ensure that the IAEA has sufficient and predictable resources to implement its Nuclear Security Plan for 2018–2021.

Importance of engaging all partners, including industry and civil society to achieve an effective nuclear security architecture with buy-in from these key stakeholders who can help implement concrete commitments, and help with horizon-scanning efforts, such as certification for nuclear security professionals (ref. WINS).

Given the nature of terrorist actors and their adaptability, there are constantly evolving and emerging threats to nuclear security, which requires the need for constant vigilance and a constant lookout without being alarmist!

In closing, I would like to offer some thoughts on NSS legacy and particularly in response to the questions: Has the nuclear security architecture improved as a result of these collective efforts?

Canada would say “yes”, particularly as the NSS process brought about the focus of 53 World leaders to coordinate actions to address challenges of enhancing nuclear security. Canadian action domestically and internationally was certainly galvanized by the NSS process and this is certainly true for most, if not all, NSS countries.

The “culture of deliverables” that characterized the Summit process galvanized efforts to enhance physical protection of vulnerable nuclear facilities, enhance nuclear security capacities at border crossings to prevent nuclear smuggling, and to overall enhance the global nuclear security architecture and its associated legal framework.

Minimizing sensitive nuclear materials (HEU and Pu) is another key outcome: the US supported efforts for removal or disposition of hundreds of tonnes of material (enough for over 7,300 nuclear weapons Citation: https://static1.squarespace.com/

static/568be36505f8e2af8023adf7/t/56fd4bbc40261d3687221733/1459440572253/NSS+At+A+Glance+-+ENGLISH.pdf)

The Summit process also elevated the profile of key legislative instruments, resulting in the entry into force of the Amendment to the CPPNM, and helped increase the number of signatories to ICSANT—strengthening the international legal framework—though work remains to be done to universalize these instruments.

However, it is also important to maintain a healthy dose of self-criticism in order to avoid complaisance, in particular the issue of resources remains one of particular concern, not only on a national basis for a number of States, but particularly for the IAEA where more than 80% of its nuclear security activities rely on extra-budgetary contributions made by a group of Member States on a voluntary basis. This is not the kind of predictability and sustainability we collectively need to ensure that the Agency can continue to effectively play its central coordination role in assisting its members in meeting their nuclear security needs.

Efforts to address this discrepancy must be sustained and will require effective international mobilisation and consistent countering of the notion, advanced by some countries, that the focus on nuclear security is intended to hinder some States' access to the peaceful use of nuclear energy and technology. On the contrary, nuclear security, likely nuclear safety, underpins the peaceful uses and must be seen as an enabler. The politicization of this issue poses a high risk that, like any nuclear security accident, can have significant negative consequences for any State, beyond any border.

It is also important to maintain a healthy dose of self-criticism in order avoid complaisance. In that regard, the issue of resources remains of particular concern, not only on a national basis for a number of countries, but also for the IAEA where approximately 85% of its nuclear security activities rely on extra-budgetary contributions made by Member States on a voluntary basis. This is not the kind of predictability and sustainability we collectively need to ensure that the Agency can continue to effectively play its central coordination role in assisting Member States in addressing their nuclear security needs.

Efforts to address this discrepancy must be sustained and will require effective international mobilization and consistent countering of the notion—advanced by some countries—that nuclear security hinders some of States' access to the peaceful uses of nuclear energy.

On the contrary, nuclear security, like safety, underpins the peaceful uses of nuclear energy and must be understood as an enabler.

The politicization of this issue poses a high risk, which—like any nuclear security event—can have significant negative consequences for any state, beyond any borders. The international community cannot wait for a major nuclear security event before mobilising to effectively reinforce the architecture and related international nuclear security norms.

Chapter 4
The GICNT Contribution to Nuclear Security

Jari Luoto

Global Initiative to Combat Nuclear Terrorism is a voluntary partnership of 88 nations and five international observer organizations. Both the partners and the observers work together to improve international capacity to prevent, detect and respond to nuclear terrorism. The network is co-chaired by the Russian Federation and the United States. The Implementation and Assessment Group (IAG) is led by a coordinator, and Finland serves in this role in years 2017–2019. Three formal working groups are dedicated to nuclear detection (chaired by the United Kingdom), forensics (chaired by Canada) and response and mitigation (chaired by Argentina).

Important cross-disciplinary themes are currently sustainability of nuclear security architecture, law enforcement investigations and legal frameworks. GICNT's activities have been lately directed towards organizing table-top and field exercises, workshops and seminars and meetings that enhance national capabilities and encourage international cooperation. The GICNT has also produced several foundational documents and key resources that are tangible, practical outcomes from the networks activities. The GICNT is unique in that it draws from a broad range of communities of expertise in all of its work; policy, law enforcement, technical experts on radiation safety, border guards and customs officers and scientists. The result is an exchange of best practices between countries and across fields of expertise, the formation of relationships between and within authorities, and stronger relationships between and within nations. This contributes to the global nuclear security architecture and our shared objective of preventing, deterring and responding to the threat of nuclear terrorism.

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Mr. Chairman, Dear Participants of the Conference, Ladies and Gentlemen,

Thank you for inviting me to join you today; it is a great honor to be here and participate with the distinguished speakers and panelists at this conference. I want to congratulate both the IAEA and the European Commission/Euratom for the first 60 years during which they have contributed to nuclear safety and security.

My own country, Finland was actually the first country in the world to sign in 1971 and ratify in 1972 the Comprehensive Safeguards Agreement with the IAEA, required from countries joining the Treaty on Nuclear Non-proliferation of Nuclear Weapons or NPT. When Finland joined the European Union in 1995 the agreement was replaced with the current arrangement in force between the IAEA, Euratom and the non-nuclear-weapon member states of the European Union. With a developing program of peaceful use of nuclear energy, our collaboration with the relevant international bodies remains strong.

Today I want to share with you my reflections on how the Global Initiative to Combat Nuclear Terrorism, or GICNT, contributes to the global nuclear security architecture.

As many of you are likely already aware, the GICNT is extremely **unique in its structure**—it is a voluntary partnership of 88 nations and five international organizations, including the European Union, IAEA and Interpol, serving as official observers. Both the partners and the observers work together to improve international capacity to prevent, detect and respond to nuclear terrorism.

Partner nations join the initiative through a political endorsement of eight core nuclear security principles, which are very closely *aligned with this event's focus* on international cooperation to enhance nuclear safety and security. GICNT is *co-chaired* jointly by the Russian Federation and the United States and has three formal *Working Groups* dedicated to nuclear detection, response and mitigation, and forensics. In addition to these priority areas, during our high-level Plenary meeting in Tokyo this past June, there was agreement that GICNT should continue to put emphasis on furthering the dialogue where there are interfaces between working groups, including on *sustainability, law enforcement investigations, and legal frameworks.*

As the *Implementation and Assessment Group Coordinator of the GICNT*, one of my responsibilities is to oversee the activities of the working groups, to find the nexuses between them, and to find ways to ensure *our work is complementary* to that of other nuclear security entities *without being duplicative*. I'll serve in this role, for Finland, until 2019.

Some of the key priorities we will work on include, for example:

- Maintaining the strong work of the three technical working groups in detection, forensics and response;
- Continuing the strategic direction of the GICNT; strengthening our work and ensuring continuity and implementation of proposals made at the 2015 and 2017 Plenaries and 10th Anniversary meeting; and
- Focusing on interfaces between working groups and the cross-disciplinary area of sustainability, law enforcement investigations, and legal frameworks.

The GICNT has a “hands-on” approach to nuclear security. In the past few years the activities have been directed even more than previously to organizing table-top and field exercises, workshops and seminars that enhance national capabilities and *encourage international collaboration.*

Through the events the GICNT wants to *promote the exchange of information*, and to share views on the implementation of nuclear security *guidance and best practices.*

It is a remarkably flexible partnership and one of its many *strengths is its convening power.* A lot can be accomplished, and a lot has been accomplished through GICNT, because we are able to get technical experts, policy makers, and decision-makers all in the same room. The GICNT is unique in that it draws from a broad range of communities of expertise in all of its work: policy, law enforcement, technical experts, border guards and customs officers, and scientists.

My own country, Finland has participated actively in the work of the GICNT in the course of past years. The close cooperation between authorities involved in nuclear security is a familiar way of operating in Finland and we have been encouraged and benefitted from GICNT’s activities which bring together relevant experts to work with the challenges of preventing, detecting and responding to nuclear security events.

As we all know, improving *information exchange to support coordination in a crisis* is a never ending process and remains one of the most significant challenges to nuclear security. So often what we find during GICNT events and exercises is that one of the best ways to improve information exchange is to *build and strengthen relationships,* including interagency, between countries and across international partnerships. This is an important part of building sustainable nuclear security architecture and something that has to be done before there is an unwanted event where effective and immediate coordination is required.

In our events, we bring together communities that might not have previously had a forum in which to meet and, when we get these different communities together in a room, the ensuing *dialogues are truly invaluable.* We work hard to make sure that national delegations to GICNT exercises include representatives from a range of organizations and disciplines. Most of our events include a diverse international audience. Some are focused on a specific regional challenge and we emphasize regional participation.

The result is an exchange of best practices between countries and across fields of expertise, the formation of relationships, between and within authorities, and at the most basic level—*stronger relationships between and within nations.* This enhances the global architecture and our shared objective of preventing, deterring and responding to the threat of nuclear terrorism.

For example, last November we held a *workshop on medical response in Panama* to address challenges in deploying and coordinating medical and public health resources in response to a terrorist incident involving radioactive materials.

Countries from throughout the region attended and the conversations between law enforcement, the medical community, and border authorities helped *establish new relationships that are critical to have in place in advance* of an incident. This event was conducted under the Response and Mitigation Working Group, now chaired by Argentina.

Argentina was also host to a successful regional Radiological Emergency Management Exercise "Paihuen II" held in Bariloche, Argentina just two weeks ago. And next week our focus will be on similar type of a regional exercise in Central Asia, hosted by the government of Tajikistan.

This past March, the GICNT collaborated with European Commission's Joint Research Centre to hold "Magic Maggiore", a workshop bringing together technical, scientific, and operational experts with specific expertise in the area of technical reachback. This is a great example our how our *collaboration with official observer organizations adds value* to the initiative and its events.

I would like to personally *thank the European Union*, and all of our observers and partners, for their ongoing commitment to work together.

Magic Maggiore built upon the success of recent GICNT exercises, "NORTHERN LIGHTS" held in Helsinki, Finland, "RADIANT CITY," held at the JRC in Karlsruhe, Germany, and "Exercise Olympus," held in Bucharest, Romania. These exercises stressed that nuclear detection requires a whole-of-government approach that incorporates technical and non-technical capabilities in support of an investigation into illicit trafficking of nuclear and other radioactive material.

Ultimately, outcomes from GICNT activities like Magic Maggiore can help *to mitigate common challenges* to information sharing and technical reachback support to Front Line Officers. The workshop raised awareness about the importance of established channels to access technical expert support and promoted the exchange of models and mechanisms to share best practices among all European Union and GICNT partner nations. This event fell under the Nuclear Detection Working Group, now chaired by the United Kingdom.

The Nuclear Forensics Working Group, now chaired by Canada, focuses on raising awareness of nuclear forensics among policymakers and decision makers. As you know, *nuclear forensics* is a burgeoning field and there is a real need to *build capacity and expertise around the world.*

Next month, the Nuclear Forensics Working Group will hold an exercise in Bucharest, Romania for countries in the *Black Sea region* focused on how *nuclear forensics may support an investigation* into a nuclear security incident. This builds on the other activities aimed at identifying best practices to support efforts to deter and prosecute illicit acts involving radioactive material.

Other past events on this theme have included the 2015 Glowing Tulip Mock Trial and 2017 Vigilant Marmot legal frameworks workshop which focused on the importance of adopting national legislation criminalization penalties for illicit acts outlined in international legal frameworks.

Exercise Sentinel was held in Sofia, Bulgaria in May 2017 and aimed to *promote nuclear security exercise capabilities* among partner nations through the development and implementation of national level exercise programs. GICNT partners Bulgaria and the United Kingdom hosted the workshop jointly to identify best practices to establish a national exercise program, sustain and enhance national capabilities through exercise programs, and promote best practices for exercise evaluation and feedback. GICNT plans future activities to enhance national capabilities to develop, conduct and evaluate nuclear security exercises; in particular, the Nuclear Detection Working Group is spearheading efforts to develop a virtual community of experts to share and promote national level exercise programs.

Through organization of more than 90 events, the GICNT has been able to develop a strong knowledge on how to facilitate cooperation and coordination at national and international level. The work continues with several planned activities that will take place in Europe, where the GICNT has organized already nearly 40 events, and in the Asia region.

In addition to advancing information exchange and technical dialogue in the Working Group areas of Forensics, Detection and Response and Mitigation, GICNT has produced several *foundational documents and key resources that are tangible, practical outcomes.* For example, the GICNT Exercise Playbook contains fictional yet realistic scenarios, problem statements and discussion questions for partners to "play" on their own and test national protocols.

Ultimately, GICNT's strength and what allows it to contribute to the bigger picture of global nuclear security and non-proliferation lies in its *network of partners and observer organizations.*

As the IAG Coordinator, I will promote efforts within our network to further our collaboration with the European Union, United Nations Office on Drugs and Crime, INTERPOL, United Nations Interregional Crime and Justice Research Institute and the IAEA. I will draw attention to key challenges in nuclear security through exercises, workshops and other practical activities that engage a range of subject matter experts and promote a coordinated, interdisciplinary approach at national and international levels to respond to any threat by terrorists involving nuclear and radioactive materials.

I feel it is imperative to our success that we keep the key political decision makers acutely aware of the dangers of nuclear terrorism, and get their support both for the development of sustainable national capabilities and for fostering international efforts to combat nuclear threats.

As we all know, the only effective way to respond to the threat of nuclear terrorism, and to strengthen the global nuclear security architecture, is to *work together*. I *thank you* for your time and for the continued collaboration through the GICNT.

Part II
Nuclear Safety and Security—2

Umberto Vattani, Michael Kuske and Tatsujiro Suzuki

Chapter 5
Introduction

Umberto Vattani

This 20th edition of the Edoardo Amaldi Conference is dedicated to International cooperation, security, safeguards and on the processes of non-proliferation of nuclear weapons.

The Italian physicist Edoardo Amaldi (one of the main collaborators of Enrico Fermi at the research institute in Via Panisperna) was the first to promote the Conferences (which started in June 1988), so that the principle of peaceful use of nuclear energy would be acknowledged by people and nations.

We are grateful to:

The High Representative of the European Union for Foreign Affairs and Security Policy, Federica Mogherini;

The Director-General of the International Atomic Energy Agency (IAEA), Yukya Amano;

The Accademia Nazionale dei Lincei, for hosting this conference today at Palazzo Corsisni, and to its President Alberto Quadrio-Curzio; for inviting representatives from 15 countries (China, USA, Russia, Iran, France, Germany, Japan, Israel, Italy, Pakistan, United Kingdom, Turkey, Canada, Egypt, and Finland) to discuss and analyse—in the context of international cooperation—the problems relating to nuclear non-proliferation and disarmament.

To emphasize the topical issue of this conference, I wish to point out that just four days ago the Norwegian Nobel Committee awarded the Nobel Peace Prize to ICAN, *International Campaign to Abolish Nuclear Weapons.* And I am pleased to recall that the Nobel Peace Prize was also awarded to the European Union in 2012, to the International Atomic Energy Agency in 2005, and to the non-governmental organization PUGWASH in 1995.

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The XX Amaldi Conference, named after Edoardo Amaldi from the third edition on (the Conference, which was held in 1990, was being organized by the great physicist before his untimely death) coincides with the 60th anniversary of the IAEA and the EURATOM Treaty.

Through the EU Joint Research Centre in the nuclear field, Euroatom was established in 1957 to promote the peaceful use and exploitation of energy from nuclear fusion, so as to produce safe, sustainable and environmentally-friendly energy supply to be used not only in industrial applications, but also in the medical field.

The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) was approved in 1968 by the United Nations General Assembly, and came into force in 1970. The Treaty states that countries possessing nuclear weapons shall not transfer to a third party fissile material and nuclear technology.

The non-nuclear weapon States, on the other hand, shall not develop nor obtain mass destruction weapons. Moreover, the transfer of nuclear technology to be utilized for peaceful purposes must take place under the strict control of the International Agency for Atomic Energy (IAEA). The Treaty was originally signed by 3 nuclear-weapon States (USA, URSS, and United Kingdom) and by 40 non-nuclear weapon States. France and China signed in 1992. In 1995 the Treaty was renewed for an indefinite period; every 5 years a Conference monitors its implementation. North Korea, which joined the NPT in 1985, announced its withdrawal in 2003; but, more controversial is the position of Iran, whose development programme has been defined as potentially dangerous by the AIEA. Nonetheless, Iran did not give up its programme and continues to sustain that it is oriented solely towards the peaceful use of nuclear power.

The earthquake and tsunami that devastated the Tohoku region of Japan on 11 March 2011, and triggered a series of accidents at the Fukushima nuclear power plant, are unfortunate events which demonstrate that security issues—dealing with the exploitation of nuclear Energy—are of fundamental importance for the future of humanity.

This will be presented shortly by Professor Suzuki.

The term "information security", often used interchangeably with the term "cybersecurity", refers to a problem concerning the growing information technology that is being employed by the modern society, as well as to the parallel diffusion and specialization of attackers, the so called "hackers".

Therefore, there are two problems connected to security: the first is that of *prevention* (that is, measures aimed at reducing the probability of accidental damage or events, such as unforeseen malfunctioning of the system, also those caused unknowingly by the user, or by fires, floods or other catastrophic events); the second is that of *protection* (that is, preventing that unauthorized users gain access to restricted information or data and modify or destroy them).

These problems will be presented by Dr. Neuneck.

The first presentation of this session will be by Dr. Michael Kuske on the topic of "Euroatom Nuclear Safety Framework". He will take the place of Professor

Massimo Garribba, Director—General For Energy, European Commission, who was not able to leave Geneva due to institutional commitments.

Prof. Tatsujiro Suzuki, from the University of Nagasaki, will follow with a presentation on the topic of "Updating from Lessons Learnt from Fukushima".

The session will conclude with a talk by Dr. Götz Neuneck, University of Hamburg, on the topic of "Cybersecurity and Nuclear Security: How are They Related—an Overview".

Chapter 6
Euratom Nuclear Safety Framework

Michael Kuske

The choice of whether or not to use nuclear energy and to what extent is up to each Member State of the European Union. Member States who decide to use nuclear energy in their energy mix have to apply the highest standards of safety, security, waste management and non-proliferation as well as to diversify nuclear fuel supplies.

The Euratom Community has set up over the last decade a nuclear legal framework which is the most advanced legally binding and enforceable framework of this kind in the world.

Its first cornerstone was the Directive on Nuclear Safety, adopted in 2009 and revised in 2014.

The so-called 'Waste Directive' (2011) regulates safe and responsible management of spent fuel and radioactive waste.

The Directive on transboundary shipments of radioactive waste and spent fuel lays down a Community system of supervision and control and complements the Waste Directive.

The obligation to develop basic safety standards to protect the health of workers and the general public against the dangers of ionizing radiation goes back directly to the Euratom Treaty—60 years ago. The first Directive was adopted in 1959 and it has been updated several times, most recently in 2013.

The Directive on Drinking Water and the Regulation on Radioactive Contamination of Food and Feed complete the EU legal framework in the nuclear field.

ECURIE and EURDEP are emergency preparedness arrangements put in place by the Euratom Community following the Chernobyl accident in 1986.

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The choice of whether or not to use nuclear energy and to what extent is up to each Member State of the European Union. Nevertheless, the European Union, and—within it—the Euratom Community, plays an important role in the fields of nuclear safety, safeguards, nuclear security, nuclear non-power applications as well as fission and fusion research.

When deciding on their national energy mix, Member States have to take into account several considerations: they have to apply the highest standards of safety, security, waste management and non-proliferation as well as diversify nuclear fuel supplies, as emphasized also in the Energy Union strategy, launched in 2015, and the European Energy Security Strategy (2014).

In October 2014, the European Council agreed on a 2030 climate and energy policy framework for the EU, setting an ambitious domestic target of an at least 40% reduction in greenhouse gas emissions for 2030. Last year, the European Commission prepared a set of legislative proposals called the 'Clean Energy for All Europeans' package with a view to implementing these policy objectives. These proposals are currently under discussion.

As a low-carbon energy source, nuclear energy has a role to play, alongside renewable sources, which are mostly intermittent. The EU is consolidating the enabling environment for the transition to a low-carbon economy through a wide range of interacting policies and instruments reflected under the Energy Union strategy.

The Euratom Community has been setting up over the last decade a nuclear legal framework which is the most advanced legally binding and enforceable framework of this kind in the world.

Its first cornerstone was the Directive on Nuclear Safety, adopted in 2009 and revised in 2014.

By adopting the so-called 'Waste Directive' in 2011, the Euratom Community and its Member States have demonstrated their commitment to ensure safe and responsible management of spent fuel and radioactive waste.

The Directive on Transboundary Shipments of Radioactive Waste and Spent Fuel lays down a Community system of supervision and control and complements the Waste Directive.

For many years, the Euratom Community has established a set of basic safety standards to protect workers, members of the public and patients against the dangers arising from ionizing radiation. The new Directive on Basic Safety Standards, which entered into force in 2014, updates the requirements based on the latest scientific developments and knowledge.

The Directive on drinking water and the regulation on radioactive contamination of food and feed complete the EU legal framework in the nuclear field.

ECURIE and EURDEP are emergency preparedness arrangements put in place by the Euratom Community following the Chernobyl accident in 1986.

Ensuring a high level of nuclear safety is a key component of the regulatory framework governing the civil uses of nuclear power. Euratom's competence in nuclear safety was recognized by the European Court of Justice some 15 years ago.

The Nuclear Safety Directive was first adopted in 2009. It establishes a common binding framework for the safety of nuclear installations, defining basic obligations and principles governing nuclear safety throughout the EU. It made international safety principles legally binding and enforceable.

This Directive was amended in 2014 to reflect the lessons learned from the Fukushima accident and the 'stress tests' as well as recent technical developments. The amended Directive is based on various sources of technical expertise, such as the Western European Nuclear Regulators Association (WENRA) and the technical provisions of the IAEA, and has been drawn up in close cooperation with national regulators.

The deadline for transposition of the amended Directive into national legislation was 15 August 2017.

The implementation of the EU safety framework at national level will entail a major effort by Member States, and will be a challenge also for national Nuclear Safety Regulators. The Commission is working closely with Member States to facilitate this process.

The amended Directive aims to ensure *continuous* improvement of safety and reinforces the nuclear safety framework in six key areas:

- Introduces a high-level EU-wide safety objective

An ambitious EU-wide safety objective for all types of nuclear installations has been introduced, with the aim of reducing the risk of accidents and avoiding large radioactive releases.

This objective, applicable to new nuclear installations (licensed for construction after 14 August 2014), calls for significant safety enhancements in the design of new reactors, for which state-of-the-art knowledge and technology should be used, taking account of the latest international safety requirements. In particular, such installations must be designed, sited, constructed, commissioned, operated and decommissioned with the objective of preventing accidents and, should an accident occur, mitigating its consequences.

For existing nuclear installations, this objective enshrines the principle of continuous improvement of nuclear safety by indicating the need to identify and implement in a timely manner reasonably practicable safety improvements.

The objective fully applies to nuclear installations in the context of long-term operation. All possible nuclear safety issues related to ageing of the installations and their designs have to be properly assessed and all identified safety improvements have to be implemented to the installations by the licence holder, under the supervision of the national regulator.

The EU-wide safety objective has a global dimension via the recent Vienna Declaration on the Convention of Nuclear safety.

- Sets up a European system of peer reviews on specific safety issues

The European Topical Peer Review (TPR) is a cooperation and coordination mechanism amongst the EU Member States with the aim of building confidence, developing and exchanging experience, and ensuring the common application of high nuclear safety standards.

The introduction of the TPR was inspired by the peer review process during the ‘stress tests’ after the Fukushima accident.

TPRs will focus on specific safety topics. They will complement the already existing reviews according to which the Member States must, at least every ten years, arrange for periodic self-assessments of their national framework and competent regulatory authorities and invite an international peer review of relevant segments of their national framework and/or authorities with the aim of continuously improving nuclear safety.

National regulators (ENSREG) selected ‘ageing management’ as a common topic to be examined within the 1st TPR this year, particularly in view of plans for long term operation.

- Strengthens the rules concerning the role and independence of National Regulatory Authorities

The Directive further enhances the independence of Regulatory Authorities from undue influence in their regulatory decision making and ensures that they have appropriate means and competencies to properly carry out their responsibilities.

Regulatory Authorities shall have sufficient legal powers, sufficient staffing with necessary qualifications, experience and expertise, and sufficient financial resources for the proper discharge of their responsibilities.

The Regulatory Authorities should be involved in the definition of national nuclear safety requirements so that possible conflicts of interest are prevented.

- Increases transparency requirements on nuclear safety matters, informing and involving the public

The Directive requires both the competent regulatory authority and license holders to provide the public with information on normal operating conditions of nuclear installations as well as prompt information in case of incidents and accidents.

Moreover, the public is given the opportunity to participate in the decision making process relating to licensing of nuclear installations.

- Promotes an effective nuclear safety culture

The Directive includes provisions to enhance an effective nuclear safety culture which aim at promoting the commitment to nuclear safety and its continuous improvement at all levels of staff and management within an organization.

These provisions, related to the human factor, complement the more technical provisions also included (nuclear safety objective, defense-in-depth concept, initial assessments and periodic safety reviews of nuclear installations), reflecting the two pillars of nuclear safety.

- Regulates *on-site* emergency preparedness and response

The Directive enhances accident management as well as on-site emergency preparedness and response and provides for regular safety reassessments of nuclear installations to identify further safety improvements which take into account various issues, including ageing issues.

The adoption in 2011 of a Directive on the safe and responsible management of spent fuel and radioactive waste[1] was a major step towards achieving a comprehensive and legally binding framework at EU level. Through the implementation of this Directive, Member States are required to demonstrate that they have taken reasonable steps to ensure that radioactive waste and spent fuel is managed safely and that no undue burden is passed to future generations.

The safe and responsible management of these materials is of particular importance. This is especially the case now as many existing nuclear power reactors are reaching the end of their operational lives and will need to be decommissioned. The radioactive waste generated in this process will need to be stored and/or disposed of.

In May 2017, the Commission adopted its first report providing a comprehensive overview to the Council, European Parliament and European Union (EU) citizens on this important issue. Such a report will be submitted every three years, on the basis of Member States' reports to the Commission on the status of their implementation of the Directive. Member States will also have to update their national programs when needed and report any significant changes to the Commission.

Having reviewed all national reports, as well as the national policies, frameworks and programs submitted to date, the Commission recognizes Member States' efforts in implementing the Directive and encourages Member States to continue these efforts.

All Member States have reported full transposition of the Directive and the Commission is working on finalization of the conformity assessment.

To date, all Member States have submitted their national reports and most of them also their final national programs.

Three Member States have concrete plans to develop geological disposal facilities in the 2022–2030 period, while other twelve Member States have plans for such facilities in the next decades. Nevertheless, the specific challenge remains in the development of geological disposal facilities, in particular their location. While this is a complex, long-term process in which transparency and public participation will be of great importance, the Directive clearly requires Member States to engage in this process without delay.

The Commission noted that half of Member States are considering the possibility of shared solutions for disposal either as a preferred or as an alternative option

[1]Council Directive 2011/70/EURATOM of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.

(the 'dual track' approach[2]). However, none of the Member States' programs or reports set out concrete milestones or measures towards the implementation of such a solution.

Although international peer reviews of the national frameworks, and/or programs is one of the challenges until 2023, less than half of Member States have specific plans for such reviews: the first ARTEMIS review took place in Poland in October, to be followed by France, Bulgaria and Spain (2018) and Germany (2019).

The Commission is planning a workshop on the Waste Directive on 7 November 2017 in Brussels.

Council Directive 2006/117/EURATOM[3] lays down a Community system of supervision and control of transboundary shipments of radioactive waste and spent fuel, so as to guarantee an adequate protection of the population. It ensures that Member States concerned are informed about shipments of radioactive waste and spent fuel to or via their territory, with the obligation to give either their consent or reasoned refusal to the shipments. This Directive complements the 'Waste Directive'[4] which focuses on the policy and responsibilities for long term management of radioactive waste and spent fuel.

According to Article 20(1) of the Directive, as of 25 December 2011 Member States have to report every three years on the implementation of the Directive to the Commission.

The Commission is finalizing its second report on the implementation of the Directive, providing an overview of the shipments and related aspects for the period 2012–2014. This report will also provide complementary information to the Commission report on the implementation of the 'Waste Directive'.[5]

The Commission notes that the overall number of authorizations has increased (15%) compared to the previous reporting period (2008–2011).

In the context of this second report, the Commission has not been informed about reshipments related to non-authorized shipments of undeclared radioactive waste (as per Article 4), shipment failures (as per Article 12) or prohibited exports that would fall under the provisions of Article 16(1)c of the Directive. There were only two refusals of authorization linked to contaminated scrap metal and, in one case, incomplete information for shipment. All the cases of refusal were solved by the concerned Member States.

[2]In this case, Member States are continuing with the development and implementation of their own national programmes, while leaving open the option of a shared solution.

[3]Council Directive 2006/117/EURATOM of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel, OJ L 337, 5.12.2006.

[4]Council Directive 2011/70/EURATOM of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, OJ L199, 2.8.2011.

[5]Report from the Commission to the Council and the European Parliament on progress of implementation of Council Directive 2011/70/Euratom and an inventory of radioactive waste and spent fuel present in the Community's territory and the future prospects, COM(2017)236 final of 15.5.2017.

The next reports of Member States will need to be submitted by 25 December 2017.

The obligation to develop basic safety standards to protect the health of workers and the general public against the dangers of ionizing radiation goes back directly to the Euratom Treaty—60 years ago. The first Basic Safety Standards Directive was adopted in 1959.

It was successively updated, most recently in 2013. This new Directive has to be transposed into Member States law by February 2018.

It is based on scientific progress in the radiation protection area. The new Directive provides for:

- Better protection of the public, in particular with regard to radon in dwellings, exposure from naturally occurring radioactive material (NORM) activities, exposure from building materials, exposure from existing exposure situations, exposure from emergency situations, and deliberate exposure for non-medical purposes.
- Better protection of workers, in particular for medical staff, workplaces with indoor radon, workplaces with NORM, and emergency workers.
- Better protection of patients, in particular with a view to put more emphasis on the justification of medical exposures, to strive for enhanced safety culture in the medical area, and with measures aiming at a minimization of probability and magnitude of accidental or unintended exposures.
- Strengthened requirements on emergency preparedness and response, especially with a view to the lessons learned from the Fukushima accident.

It provides a framework for the implementation of the internationally recognized main principles of radiation protection:

- justification, or do more good than harm;
- optimization, or maximize the benefit over the detriment; and
- dose limitation, or do not exceed the pre-determined dose limits.

The new Directive provides a coherent framework for radiation protection, in one piece of legislation, to implement these key principles across a range of areas, including regulatory control, specific fields of application, education and training and emergency preparedness and response.

The Euratom Drinking Water Directive[6] provides a framework for controlling radioactivity in drinking water and the radiation dose received from the consumption of different forms of drinking water.

The Directive applies to tap water and to water in bottles or containers intended for human consumption. It does not apply to natural mineral waters and to small private supplies. The Directive deals with natural as well as with artificial

[6]Council Directive 2013/51/Euratom of 22 October 2013 laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption, OJ L 296, 7.11.2013, pp. 12–21.

radionuclides. It lays down general principles for monitoring and gives technical details (frequencies of sampling, analysis methods, measuring methods, etc.).

The recent adaptation of the Directive allocates all radioactivity matters under this Directive. The transposition deadline was 28 November 2015.

All Member States have provided their transposing legislation to the Commission.

The Commission is in process of checking transposition and implementation of the Directive.

Post Chernobyl Arrangements. Following the Chernobyl accident in 1986 emergency preparedness arrangements were put in place by the Euratom Community aiming to improve the exchange of information and to facilitate common responses in case of radiological emergency.

ECURIE (European Community Urgent Radiological Information Exchange) is the emergency communication network between Member State authorities and the Commission.

The Council Decision 87/600/EURATOM requires the Commission and the Member States to establish and maintain a system of rapid alert and information exchange for nuclear and radiological emergencies.

EURDEP (EUropean Radiological Data Exchange Platform) was set up as part of ECURIE arrangements to ensure that effective environmental monitoring is always available. This allows a country to quickly determine when there is a significant rise in the radiation levels either from within its boundaries or from outside.

EURDEP makes radiological monitoring data from most European countries available in nearly real-time: http://eurdep.jrc.ec.europa.eu.[7]

ECURIE and EURDEP together form the technical implementation of Council Decision 87/600/EURATOM.

Following the nuclear accidents of Chernobyl (1986) and of Fukushima (2011), specific EU regulations on import conditions into the EU of agricultural products, food and feed have been put in place.

The European Commission (Directorate-General for Energy) has a direct role in protection of the population by activating Euratom Foodstuffs Regulations to prevent contaminated food or feed reaching the internal market.

The revised 'Food and Feed Regulation',[8] which was adopted in January 2016, is a framework to quickly adopt emergency measures related to foodstuffs. The regulation:

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[7]Missing countries, probably soon on-line: Ukraine, Albania, Bosnia-Herzegovina, Moldova, and Montenegro.

[8]Council Regulation (Euratom) 2016/52 laying down maximum permitted levels of radioactive contamination of food and feed following a nuclear accident or any other case of radiological emergency and repealing Regulation (Euratom) No 3954/87 and Commission Regulations (Euratom) No 944/89 and (Euratom) No 770/90.

- consolidates existing Euratom legislation;
- brings the procedure in line with the new Comitology system (set of procedures through which EU countries control how the European Commission implements EU law);
- provides more flexible procedures allowing specific reactions to any nuclear accident or radiological emergency in the EU, in the vicinity of the EU or in a remote country.

Chapter 7
Updating from Lessons Learnt from Fukushima

Tatsujiro Suzuki

After six years of the Fukushima Dai-ichi Nuclear Power Plant accident, the situation in Japan's nuclear power program is still very uncertain. Decommissioning of the Fukushima reactors are making slower progress than expected, and technical difficulties remain challenging. Recovery of contaminated areas and reconstruction of life of affected residents is also facing social-political problems. Loss of public trust is one of the major impacts of the Fukushima accident, and even after six years of the accident public trust has not been recovered. One of the main challenges is the economics of nuclear accident. Total costs of the Fukushima accident estimated by the government are now 22 trillion yen, but independent analysis suggests that total costs may reach 45–70 trillion yen. Therefore, competitiveness of nuclear power is very uncertain despite the claim made by the government that nuclear power is still the cheapest energy source among alternatives.

The Pacific Ocean earthquake and resulting tsunamis that struck the Tohoku District and Fukushima Daiichi and Daini nuclear power stations at 14:46 on 11 March 2011 (3/11) were followed by a nuclear accident unprecedented in both scale and timeframe. Since then, 3/11 has become a historic day for all nuclear experts to remember not only in Japan but also in the rest of the world. Although the earthquake occurred in 2011, the effects of the accident continue. About 60,000 evacuated residents in Fukushima still live in temporary housing and are uncertain as to when they will be able to return to their original hometowns. Although conditions at the Fukushima power stations have improved, it will take more than 40 years to remove melted fuel debris from the site and decommission the plant. We need to draw lessons based on the knowledge and information available to ensure the safety of existing nuclear facilities as much as possible and to understand possible implications for future nuclear energy policy. Especially, this paper discusses the economics of the Fukushima disaster, including the total estimated costs of the

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accident and revised cost estimate for newly constructed nuclear power plant compared with other alternative power sources.

According to the latest “Mid-long term” roadmap towards the decommissioning of Tokyo Electric Power Company (TEPCO)’s Fukushima Dai-ichi nuclear power station,[1] it delayed the first phase (removing spent fuel from the storage pools of Unit 1–3) by more than three years. TEPCO has been struggling with the management of with the management of a huge amount of contaminated water (roughly 400 tons per day) which is being stored and the amount of stored water is steadily increasing. And it is suspected that some contaminated water leaked into the sea. In order to contain the contaminated water, TEPCO and the Ministry of Economic Trade and Industry (METI) decided to install a so-called ‘frozen wall’ to stop water flowing in and out of the site. The wall is almost complete, but the Nuclear Regulatory Authority concluded that its effectiveness is limited and that alternative methods (such as pumping out underground and contaminated water) need to be continued [1].

Contaminated water is just one of the unprecedented challenges that TEPCO and METI face. The roadmap for decommissioning Fukushima Daiichi estimates that it will take at least 30–40 years to complete decommissioning. The first stage involves removal of the spent fuel from the pools in all four units (in two to three years), the second stage involves removal of the melted core debris from Units 1–3 (in at least 10 years), and the third stage encompasses decontamination of the whole plant (in 30 to 40 years). Removal of spent fuel (1,331 spent fuel assemblies and 202 un-irradiated fuel assemblies) from Unit 4’s storage pool was successfully completed on 22 December 2014. Operations to remove spent fuel from Units 1–3 are now underway. For removal of the melted cores, the information available on melted debris is very limited and no-one is sure where they are or what form they now take. It is not possible to get close to the reactor buildings of Units 1–3 due to high radiation and it is necessary to develop remote control equipment or sophisticated, radiation-resistant robots.

However, there are still concerns about a lack of transparency and independent oversight in regard to the whole decommissioning process. The Japan Atomic Energy Commission (JAEC) recommended that the government should establish an independent (third party) organization with overseas experts as members to assess and audit the entire measures in order to maximize transparency [3]. However, such an independent organization has not been established by the government.

There are three different levels of evacuated zones designated by the government, depending on the level of monitored radiation levels: a ‘difficult-to-return’ zone (above 50 milli Sieverts (mSv) per year); a ‘preparation for return’ zone (below 50 mSv per year and above 20 mSv per year); and a ‘possible to return’ zone (below 20 mSv per year). Due to natural radiation decay and decontamination

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[1] [2]. Mid-and-long-term roadmap towards the decommissioning of TEPCO’s Fukushima Daiichi nuclear power station. 12 June. http://www.meti.go.jp/english/earthquake/nuclear/decommissioning/pdf/20150725_01b.pdf.

efforts, more areas are now designated as ‘possible to return’ zones. In June 2015, the government announced its policy to accelerate the recovery efforts in order to cancel the evacuation instructions over all the zones except the “difficult-to-return zones”. However, the criteria of 20 mSv per year has been a source of public debate as it is much higher than the 5 mSv per year level which was the evacuation criteria for the Chernobyl accident five years after that accident.

The issue of returning to the hometown is connected to the compensation issue. Under current rules, once the town is no longer considered as an evacuated zone, citizens are no longer eligible for compensation. More importantly, there is not enough public participation in the decision-making process which will lead to a loss of public trust, as discussed below. As a result, at the end of March 31, 2017, only 13.5% of the residents returned to the hometown, and roughly 20–40% of the evacuated people said that they would return home even after the zones are determined to be safe by the government [4].

Lack of trust is a fundamental problem that underlies the challenges facing Japan’s nuclear industry since the Fukushima disaster. The public has lost faith in nuclear safety regulation. Faith has not been fully restored even though a newly independent Nuclear Regulation Authority was established in 2012, and much tougher regulatory standards were introduced. According to poll results, the proportion of the public that want to shut down all nuclear power plants immediately increased from 13.3 per cent in June 2011 to 30.7 per cent in March 2013. The same polling data also suggested that about 80 per cent of the public still believed that serious nuclear accidents would occur again in Japan [5].

In polling undertaken in April 2015, the proportion of the public who oppose restarting the existing reactors rose to 70.8 per cent, an increase of 6 percentage points from previous polling on this question [6]. According to the poll conducted by the Japan Atomic Energy Relations Organization (JAERO 2016), it indicated that government agencies and nuclear industry organizations were considered to be the ‘most untrustworthy’ (24.2% and 24.6% respectively) organizations of those that were listed. This loss of trust is the most serious challenge that nuclear policymakers and the nuclear industry now face in Japan. Six years after the accident, it has not been addressed adequately.

On 11 April 2014, the new Strategic Energy Plan was adopted by the Japanese cabinet [7]. The plan stated that the government would not only decrease its dependence on nuclear energy as much as possible, but also that nuclear power should be used as an important base-load energy source and thus the necessary level of nuclear energy should be maintained. Based on the Strategic Energy Plan, the government set a target of nuclear power’s share in total electricity production at around 20–22% by 2030. In order to achieve this goal, electric utilities need to build new reactors replacing old and retiring nuclear power plants.

But, utilities need to get new operating license to meet newly established regulatory standards. As of end of September 2017, only 5 reactors are operating, 9 received the license, including Kashiwazaki-Kariwa, the first BWR and reactors owned by TEPCO, 12 are under licensing process, but still no action for the rest (18) reactors. Even if a reactor gets license, it is not clear when the reactor can be operated because utilities need an approval from local governments under the so-called "Safety Agreement" in which local governors have veto power on the operation of nuclear facilities. Safety Agreement is not a legally binding document, but it is politically essential to get governor's approval before start operation. Due to lack of public trust described above, future of nuclear power program is thus not certain at all.

In May 2015, Ministry of Economy, Trade and Industry (METI) published the latest estimate of power generation costs for various power sources [8]. The cost estimate is for a hypothetical new plant. For a nuclear power plant, three new categories are added after the Fukushima accident. They are; (1) Additional safety costs, (2) Policy measures costs, and (3) Accident costs.

For additional safety costs, average expenditure of 24 nuclear reactors is about 100 billion yen per year. For the cost estimate, it is assumed that about 60% of the expenditure can be considered as "additional construction costs". So, 60.1 billion yen/reactor was added to the construction cost, which is equivalent to 0.6 yen/kWh, considering 70% capacity factor, 40-year reactor life.

Policy measures costs include government expenditures on nuclear power, including R&D budget, taxes, and other budgetary items. METI used the figure of FY 2014 nuclear energy budget, and the total expenditure is about 345 billion yen/year, which can be translated into about 1.3 yen/kWh.

The most difficult cost estimate was Accident costs. Although the total costs of the Fukushima accident are still unknown, based on the information available then, METI used the figure of 12.2 trillion yen as a total accident costs (including decommissioning of the Fukushima reactors, compensations and decontamination costs). Then, METI estimated that possible accident cost for a typical nuclear plant would be 9.1 trillion yen per reactor. Since the actual frequency of severe accidents in Japan (about once in 2,000 reactor-years), METI assumed that the frequency of new reactor which passed tougher regulatory standards is only half of the past frequency, i.e. once in 4,000 reactor-years. Thus, the accident cost is now estimated to be 0.3 yen/kWh. (see below)

$$\frac{\text{(1)Damage } \textit{costs} \text{ (}\textit{Yen}\text{) /(2)} \textit{basis for calculation} \text{ (}\textit{reactors}\cdot\text{year))}}{\text{(3)} \textit{Annual power generated by model plant} \text{ (kWh)}} = \frac{\text{(1)9.1 } \textit{trillion} \text{ (}\textit{Yen}\text{) /(2)4,000(}\textit{reactors}\cdot\text{year)}}{\text{(3)7.36 } \textit{billion}\text{(kWh)}} = \text{0.3 yen - /kWh}$$

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However, the total accident costs can be much higher. So METI added the following sentence to this accident cost estimate. If total accident cost increases by 1 trillion-yen, accident cost would increase 0.04 yen/kWh.

Based on those newly added cost estimates, total nuclear power generation cost is estimated to be 10.1 yen/kWh minimum. This is still competitive against other power generation sources such as coal (12.3 yen/kWh) and natural gas (13.7 yen/kWh).

But, as noted above, total accident costs are still unknown. In December 2016, TEPCO revised the total accident costs would be 22.2 trillion yen, double of previous estimate [9]. Comparing the previous cost estimate, decommissioning cost of Fukushima reactors increased from 2 trillion yen to 8 trillion-yen, compensation cost to 8.2 trillion yen from 5.0 trillion yen, and decontamination cost increased to 6.0 trillion yen from 4.0 trillion yen.

Still, these cost estimates may be underestimated. Japan Center for Economic Research, an independent economic think tank, published new estimates in 2017 [10]. According to their estimate, decommissioning cost could go up to 11.0 trillion yen to 32.0 trillion yen, including the final disposal costs of waste coming from the decommissioning and tritium treatment cost. Decontamination costs can also increase to 30 trillion yen, including the final waste disposal cost which is not included in the TEPCO's estimate. So, the total accident cost can increase to about 50 to 70 trillion yen. JCER also estimated the total nuclear power generation costs to be about 15.0 yen/kWh, assuming the high capital cost based on US and European experience.

In short, cost of nuclear power generation is uncertain at best, and could be Therefore, competitiveness of nuclear power is very uncertain despite the claim made by the government that nuclear power is still the cheapest energy source among alternatives.

After six years of the Fukushima nuclear accident, the situation in Japan's nuclear program is still very uncertain. The progress of decommissioning of Fukushima Dai-ichi reactors is slower than expected and its technical challenges are unprecedented. While except for "difficult-to-return area", evacuation was cancelled, still about 60,000 people are living away from their home. Lack of trust in nuclear safety and in nuclear energy policy remains, and it is not clear when and how many reactors can be put back on line in the next decade. Finally, the total accident cost is still unknown, and it could reach up to 50 to 70 trillion yen. As a result, nuclear power's competitiveness is not certain at all.

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Part III
Nuclear Safeguards

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Tapani Honkamaa, Paula Karhu, Mikael Moring, Olli Okko,
and Kari Peräjärvi**

Chapter 8
Introduction

Maria Betti

During this Session, safeguards verification activities, implemented since the signature of the EURATOM Treaty, have been reviewed and discussed.

Both the IAEA and the EC DG ENER illustrated the effectiveness of the safeguards implementation and the benefits of the close cooperation in jointly conducted verification activities.

IAEA stressed the need for innovation, state of the art software and analysis tools and to strengthen the capabilities to detect anomalies, especially because the amount of information available to nuclear safeguards is steadily growing from a variety of sources. Another key message was the need of partnering, for the IAEA, with state authorities, academia, industry etc.

DG ENER reported to have four areas of priorities: the operational capability to analyse samples, the evolutionary development of new measurement and containment/surveillance technologies, the more revolutionary introduction of new sensors, robotics and use of Commercial Off The Shelf (COTS) technologies and finally the necessity to explore better the world of data with intelligent analysis tools.

During the session the contribution of JRC in supporting nuclear safeguards inspection were highlighted w.r.t technological innovations, in field support, training and education. It is clear that the Member States themselves deliver a crucial contribution to the implementation of new safeguards initiatives. A significant example of this joint effort is the safeguards developed for the Final Repository of spent nuclear fuel in Finland run by the STUK, the Nuclear Safety Authority and including contributions by JRC with a 3D-laser system for design information verification.

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As representative of a Member State-based organisation, STUK illustrated the technical synergies between security and safeguards of managing the regulatory control of the new nuclear power plants and the new type of facility, based on the Authority's experiences. Practical examples and possibilities to use of novel technology, research and development work to confirm the safe and peaceful use of nuclear energy have also been provided.

The objective of the state regulatory authority is to ensure that the use of nuclear energy is implemented in compliance with nuclear safety, security and safeguards. While nuclear safety measures aim to ensure the safety of normal operations, a low probability of accidents, and effective emergency preparedness, nuclear security and safeguards approach the joint fundamental objective from another angle, by combating unlawful and other intentional unauthorized acts. These objectives apply not only to the operating power plants but also to planning, designing, constructing and commissioning of the new nuclear installations and nuclear waste facilities as well as the decommissioning old facilities. Coordination of safety, security, safeguards, their interfaces, synergies and conflicts is essential for achieving the objectives. New technologies, research and development are supporting verification and other measurement activities by the regulator. Close cooperation between research and development assist in confirming the safe and peaceful use of nuclear energy.

One of the major outcomes of the presentations given during this session as well as of the following discussion has been the recognition of the successful implementation in the past years of technical synergies between safeguards and security. Unanimous consensus was reached in confirming the importance of fostering safeguards and security initiatives for the future.

As stated by the representative of DG ENER, EURATOM Safeguards are an important cornerstone of global non-proliferation of nuclear materials and verification of their civil use.

After 60 years of operations, EURATOM Safeguards are as important as in the beginning, but the steady growth of nuclear activities and the enlargement of the EURATOM Community have created several challenges for the years to come. New facility types and new technologies can be addressed, but the changing geopolitical situation, new asymmetric threats and the changing public perception of nuclear energy altogether will require new strategic thinking. Along the technical lines, a solid political positioning of EURATOM Safeguards is required, respecting international relations as well as the context of Energy Union, Security Union and Clean Energy for all Europeans.

Chapter 9
Sixty Years of Nuclear Verification

Frédéric Claude

The IAEA's primary purpose is to seek to accelerate and enlarge the contribution of nuclear energy to peace, health and prosperity, while ensuring that nuclear energy is not used in a way that furthers any military purpose. The Agency pursues the non-proliferation element of its work through the implementation of a set of technical measures, or "safeguards." These serve as important confidence building measures and help to ensure that nuclear material and technology are used only for peaceful purposes. Without safeguards, there would be far less nuclear cooperation and transfer of technology. This paper outlines the history of the Department of Safeguards, the importance of the Department's activities today, and the challenging future ahead.

Widely known as the world's "Atoms for Peace" organization within the United Nations family, the International Atomic Energy Agency (henceforth IAEA or "the Agency") is the international centre for cooperation in the nuclear field. The Agency works with its Member States and multiple partners worldwide to promote the safe, secure and peaceful use of nuclear technologies.[1]

The Agency's Department of Safeguards carries out the IAEA's responsibilities as the world's nuclear inspectorate, supporting global efforts to stop the spread of nuclear weapons. It does so through the implementation of safeguards. In essence, safeguards are aimed at being able to detect and, therefore, deter:

- The diversion of nuclear material,
- The misuse of nuclear material and facilities, and
- Any undeclared nuclear material and activities.

[1]https://www.iaea.org/about.

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Such safeguards are based on legally-binding international agreements: in particular, all non-nuclear weapon States that are party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) are required to conclude safeguards agreements with the IAEA.

Before describing the Department of Safeguards more specifically and outlining the work carried out by the Department today, I will sketch a brief history.

In the year following the end of World War Two, a proposal was made—under the so-called 'Baruch Plan'—to bring atomic energy under United Nations (UN) control. This idea did not get very far until, in 1953, US President Eisenhower delivered his famous "Atoms for Peace" speech at the UN. This speech, in turn, led to proposals which formed the basis of the Statute of the IAEA, which was then established in 1957.

From there, the first Safeguards agreement was concluded in 1959, the first inspection conducted in 1962, and the first comprehensive set of safeguards applied from 1965–1967.

In 1968, negotiations for the Non-Proliferation Treaty (NPT) The negotiation were completed, and the agreement entered into force in 1970. Non-nuclear weapon States who agreed to the NPT agreed that in return for nuclear weapon abstinence, they would have full access to peaceful uses of nuclear energy. Under the NPT, all such State parties agreed to accept safeguards by the IAEA with the objective of preventing the diversion of nuclear material from agreed peaceful uses. It also states that safeguards shall be applied on all source and fissionable material within States' territories.

The NPT established a safeguards system under the responsibility of the IAEA, which began to implement safeguards in line with Article III of the treaty.

As Professor Lawrence Scheinman put it, "the entry into force of the NPT gave the IAEA a tremendous boost, making it the keystone of the non-proliferation regime." This non-proliferation regime Scheinman mentions is a loose collection of predispositions, understandings, agreements and treaties that have been evolving for the last half century—all intended to avoid the further spread of nuclear weapons. The Safeguards system is a core component of that regime. The Agency does have enforcing powers—but instead relies on the UN Security Council for enforcement or action.

The IAEA's primary purpose is to seek to accelerate and enlarge the contribution of nuclear energy to peace, health and prosperity, while ensuring that nuclear energy is not used in a way that furthers any military purpose. The Agency pursues the non-proliferation element of its work through the implementation of a set of technical measures, or "safeguards." These serve as important confidence building measures and help to ensure that nuclear material and technology are used only for peaceful purposes. Without safeguards, there would be far less nuclear cooperation and transfer of technology.

In order to implement safeguards within a Member State, the IAEA needs to conclude a safeguards agreement with that state. There are three primary types of Safeguards agreements, each serving a specific purpose in the implementation of safeguards for Member States.

1. Comprehensive Safeguards Agreements (CSAs)
2. Item-specific Safeguards Agreements (INFCIRC 66)
3. Voluntary Offer Agreements (VOAs)

Each of the agreements is subject to a legal framework. Most of the States with safeguards agreements in force have a CSA, under which the State accepts safeguards on all nuclear material in all peaceful activities within its territory, jurisdiction or control. The State and the IAEA work together, where the IAEA is required to maintain confidentiality and the State, in return, provides information concerning nuclear material and facilities and access to the IAEA for inspections and design information verification.

Before 1991, Safeguards was traditionally focused on **declared** facilities and verifying the correctness of State declarations. This meant there were only limited detection possibilities regarding **undeclared** activities elsewhere in the State. *In other words, the IAEA was unable to verify the completeness of State declarations*.

Between 1991 and 1995, Nuclear-weapon-related activities in Iraq, Libya and the DPRK demonstrated the inadequacies of safeguards implementation and the need for strengthening measures, including complementary legal authority, to address possible **undeclared** nuclear material and activities.

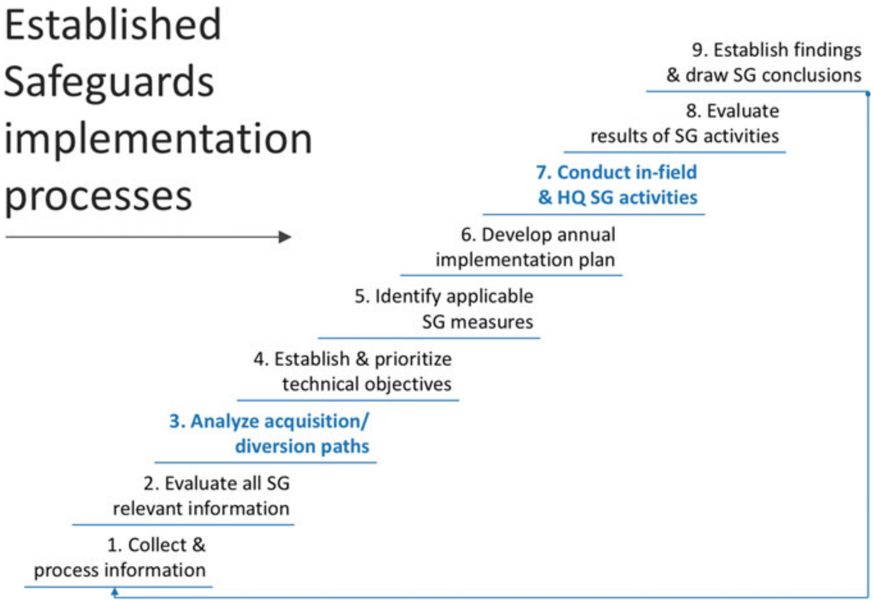
As a consequence, efforts to strengthen IAEA Safeguards got underway. The Department began to consider the State as a whole. This required increased access to information and locations (including beyond nuclear facilities). Further, the Department would use advanced technology (for example, environmental sampling, remote monitoring, and satellite imagery) and expect enhanced transparency from, and cooperation with, States.

As a way to achieve the strengthened Safeguards, the Additional Protocol (AP) was introduced. This new legal instrument was approved by Board of Governors in May 1997 and provides the Agency with more rights of access to information and locations. Unlike the CSA, an AP is voluntary. Overall, the AP supplements a State's Safeguards agreement by providing:

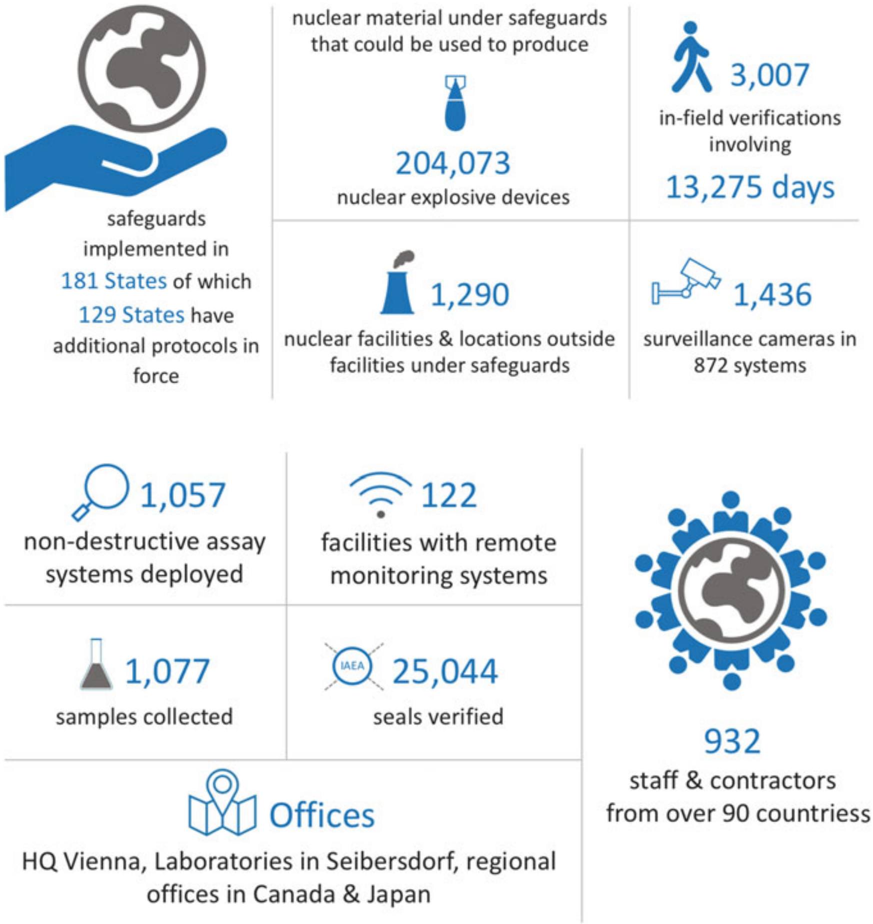
1. Broader information: A State's nuclear fuel cycle research and development activities, all parts of a State's nuclear fuel cycle, from uranium mines to nuclear waste, and the manufacturing and export of sensitive nuclear-related equipment and material.
2. Broader access: Any building on a declared site at short-notice (access within as little as two hours), a State's declared locations or other locations where nuclear material is present, and other locations for the collection of environmental samples.

The combination of the CSA and AP enables the Agency to draw a 'Broader Conclusion' that all nuclear material remains in peaceful activities.

The Department of Safeguards has a distinct and well established implementation process: from the collection and processing of information to the point when the Department establishes findings and draws a Safeguards conclusion (see Figure below).



Safeguards are implemented in 182 States, of which 129 have Additional Protocols (AP) in force. The Department of Safeguards employs over 900 staff and contractors from more than 90 countries at our HQ in Vienna, at our laboratories in Seibersdorf and at our two regional offices—in Canada and Japan. In 2016 there were:



The Safeguards environment is changing fast. Over the last decade, we have had an ever-growing increase in demand, including more nuclear material as well as facilities and outside locations under safeguards. States with safeguards agreements and Additional Protocols in force are also increasing year-over-year. We add to that—accelerating changes in technology, global connectivity (globalization) and an ever increasing volume and complexity of safeguards-relevant information. However, there is still a growing gap between the demand for Safeguards and our available resources. And, of course, it is our legal obligation to implement safeguards—it is not a matter of choice. Our legal obligations determine our workload, and our workload continues to increase. Unfortunately, the budget Member States provide each year for safeguards does not rise at the same rate as the demands.

The challenges to the safeguards system are more profound and varied today than they have ever been. To succeed, the IAEA will need to be agile in response to the unexpected, without diluting the credibility of the safeguards conclusions it draws. I am confident that working together with Member States, we can meet those challenges, preserve our credibility and continue to make the world a safer place for future generations.

Chapter 10
Euratom Safeguards System

Stefano Ciccarello and Stephan Lechner

EURATOM Safeguards are an important cornerstone of global non-proliferation of nuclear materials and verification of their civil use. After 60 years of operations, EURATOM Safeguards are as important as in the beginning, but the steady growth of nuclear activities and the enlargement of the EURATOM Community have created several challenges for the years to come. New facility types and new technologies can be addressed, but the changing geopolitical situation, new asymmetric threats and the changing public perception of nuclear energy altogether will require new strategic thinking. Along the technical lines, a solid political positioning of EURATOM Safeguards is required, respecting international relations as well as the context of Energy Union, Security Union and Clean Energy for all Europeans.

Let me start by saying that it is an honour for me to speak about EURATOM Safeguards at this year's prestigious Amaldi Conference. And this even more so in the year of the anniversary of the EURATOM Treaty which was signed here in Rome 60 years ago, in 1957.

Before addressing future challenges in nuclear safeguards, it is my intention to look back briefly at those 60 years of EURATOM history, a history marked by a balance between progress and stability.

As we are going to see, there has clearly been a lot of progress in the development of nuclear energy since 1957, but it is only fair to say that also the world around us has changed significantly.

Through all these sixty years, the EURATOM Treaty has been an element of stability, and the articles of its Chap. 7 are still the cornerstone to nuclear safeguards in the EU.

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But how is the European Commission involved? The role of the European Commission with respect to safeguards is clearly laid out in Article 77 of the Treaty.

The Commission shall satisfy itself that in the territory of the Member States:

- ores, source materials and special fissile materials are not diverted from their intended use as declared by the users and that
- the provisions relating to supply and any particular safeguarding obligations assumed by the Community under an agreement concluded with a third State or an international organisation are complied with.

So the role of the European Commission is complex, and it is two-fold, covering on one side non-diversion and on the other side non-proliferation aspects of international agreements with the IAEA and Supplier Countries. At the same time, this role is very operational and highly technical.

In implementing this role, the European Commission has developed a well-established and fully recognized safeguards system. This system, which in the sixties was only controlling 29 mines in operation and approximately 140 installations, currently monitors around 700 installations and more the 1,500 small holders of nuclear materials.

The secondary legislation on nuclear materials accountancy entered into force in 1959 and was further updated in 1976 and 2005. From the initial 350 monthly inventories and balance sheets, the European Commission now verifies around 9,000 accountancy declarations per year.

The EURATOM body of inspectors was established in May 1960. At the end of the same year, inspections were already carried out in all the Member States that had nuclear installations.

Today, more than 130 EURATOM Inspectors of different nationalities are working for this system. In 2016, they have performed 1 167 onsite inspections. Almost 10% of them were unannounced.

All of them are permanent EU officials, all of them are security cleared and all of them are formally accredited at all EU Member States.

Almost 60 percent of these inspectors have an experience on the job of more than 15 years. This rich experience is continuously passed-on to younger colleagues to ensure continuity.

EURATOM inspectors are verifying a number of nuclear installations globally holding 99.99% of all materials under safeguards every year. The remaining 0.01% is scattered in very small quantities over a large number of small holders for which special safeguards approaches are applied depending on the sensitivity of material and activity.

All across this time, ad hoc technology has been developed and deployed, at Headquarters or on-site, from measurement techniques to containment and surveillance tools, from automatic processing of declarations to remote data transmission of monitoring devices on site.

But we could not do this job all on our own or in splendid isolation.

EURATOM Safeguards are performed in close partnership with the IAEA. The Comprehensive safeguards agreement of 1973 acknowledged the existing EURATOM safeguards system and clearly spelled out that "the Agency Shall Take Due Account of the Effectiveness of the Community System of Safeguards". Today's collaboration is discussed and designed in formal working groups and committees and it manifests itself on the ground by hands-on collaboration in the field. As an example, around 60% of EURATOM inspections are performed jointly with the IAEA. Verification equipment costs are shared.

EURATOM Safeguards also are maintaining a large number of stakeholder relationships, including Member States authorities, supplier states, technology research centres such as the Joint Research Centre of the EU, Universities and United States Laboratories, international associations and the EURATOM Supply Agency.

But there is no reason for resting on the laurels of a success story of 60 years, as we know that the world around us is in continuous development.

Safeguards also need to adapt to the changing world around them. The State Level Concept is an example for such adaptation on the part of our partners in the IAEA.

Also EURATOM Safeguards are in a process of continuous improvement. Heavily dependent on technology, EURATOM continuously enhances and modernises its tools. The internal procedures are currently being updated, addressing how to deal, inter alia, with occasional measurement uncertainties and inconclusive results.

In addition to addressing well-known issues, there are new challenges for nuclear safeguards from various directions:

- A new emphasis will have to be devoted to the back-end of the nuclear fuel cycle. Ending nuclear energy production does not put an end on safeguards requirements. In the EU, there is more and more activity on intermediate or long-term storage of spent fuel and nuclear waste particularly in connection with the phasing out of nuclear energy, closing down and decommissioning of nuclear plants.
- New types of nuclear installations need to be addressed: long term and final repositories for spent-fuel and waste are being built in the EU, and they require a specific approach.
- New technologies need to be assessed: tomography might be used successfully for future verification activities.
- New threats will have to be addressed as terrorist plots have related to nuclear installations and drone overflights have been sighted in the EU. This adds a new dimension to the importance of safeguards and non-proliferation of nuclear materials.
- In addition to all of the above, the digital era has also arrived at nuclear safeguards: On one hand, we are making good use of digital tools, equipment, and nuclear material accountancy systems, on the other hand this digitization has created new cyber security threats.

Obviously, new technologies form part of our challenges. Thus, we need to look ahead, and technology research is an important element for future safeguards.

In 2016, EURATOM Safeguards have defined four priorities for areas of research and technology support:

- Number one is the maintenance of an operational capability to analyse samples from the nuclear fuel cycle, currently mostly performed in two major on-site laboratories in Sellafield and La Hague. In the short run, we cannot provide reasonable and substantiated safeguards without this capability.
- Number two is the traditional development of new measurement tools or the improvement of existing tools, including equipment for containment and surveillance. This is an evolutionary approach on well-known research pathways.
- Priority number three is to get a better understanding of the applicability of standard off-the-shelf technologies for nuclear safeguards. New sensors, digital CCTV systems, robotics, integrated encryption and similar areas have made major progress in the last decade, and technologies that were completely unthinkable for safeguards application years ago might soon be promising candidates.
- The last priority is even more revolutionary, and is connected to the world of data. The wealth of data in EURATOM's nuclear materials accountancy system could be used more systematically than today for intelligent analysis.

The existing data checks for coherence and completeness of nuclear declarations are already extremely helpful, but the world of big data around us has much more to offer. Obviously, we cannot put sensitive EURATOM data out into the open cloud, but there are also ways to develop better analytical tools and instruments inside our secured environment.

In a world of scarce resources, it should be noted that findings from data analysis are usually more efficient than extensive site visits or changes of equipment in the field.

In the area of technology, there are well known risks from the dependency on single technology suppliers and we need to tackle them in a structured way.

There are additional risks from the fact that the nuclear expertise in the EU might be more difficult to maintain as a number of our Member States are planning less nuclear power in the future.

We are currently also preparing the departure of one of our Member States from the EU as well as from EURATOM and we are fully aware that this will have its implications also for the EURATOM safeguards.

We need to keep in mind that in its last Illustrative Programme for Nuclear Energy and Investment (PINC), issued in 2016, the European Commission is underlining that while EU countries are free to decide their energy mix, those EU countries which decide to use nuclear energy have to apply the highest standards of safety, security, waste management and non-proliferation as well as diversify their nuclear fuel supplies.

Given this enormous evolution of our wider technological, economic, and political context, it is clear that we need to better connect our nuclear safeguards approach to the emerging policy landscape, if we want to make it future-proof.

Safeguards and non-proliferation require collaboration and exchange of information all across the European Union, and beyond. The concept of a European Security Union, recently introduced on European level, also foresees a respective approach.

Other policy areas relevant to nuclear (and also to safeguards) include cyber security, trade, climate and energy or industry, all four of them among the five priorities presented by President Juncker for the European Commission's Agenda in 2018.

So technically, politically and internationally, there is a lot to be done—and we might not have another 60 years to get it all addressed.

A discussion process on all these new developments has, of course, already started, partly at ESARDA, partly at the INMM conference in the US. There was a very positive echo on new and fresh thinking in safeguards opportunities, and I am convinced that some of the proposed strands will lead to even better and more efficient safeguards in the future.

On political level, the President of the European Commission, in the letter to the Presidents of European Parliament and European Council accompanying his State of the Union Speech of September 13th has underlined his intention to present a communication in order to further advance the discussion on energy and climate—and, in this context, to also discuss about the future of the EURATOM Treaty. This discussion will start with the Council meeting in June 2018.

Looking at all of the challenges, the political uncertainties, the pace of change, the complexity of issues—should we start worrying about future safeguards?

I do not think so. Instead, we should make sure that we have a clear understanding of the challenges around us and get them addressed appropriately.

This conference unites representatives of the stakeholders of the EURATOM Treaty, one of the most successful and lasting nuclear agreements in the world. So here in Rome, once again, we have all the competencies it takes to shape the future ourselves.

I would thus like to finish my intervention with a quote of Marie Curie:

> Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.

So let's never stop in our efforts to understand more and fear less.

Chapter 11
Technical Synergies Between Safeguards and Security

Elina Martikka, Tapani Hack, Marko Hämäläinen, Tapani Honkamaa, Paula Karhu, Mikael Moring, Olli Okko and Kari Peräjärvi

The objective of the state regulatory authority is to ensure that the use of nuclear energy is implemented in compliance with nuclear safety, security and safeguards. While nuclear safety measures aim to ensure the safety of normal operations, a low probability of accidents, and effective emergency preparedness, nuclear security and safeguards approach the joint fundamental objective from another angle, by combating unlawful and other intentional unauthorized acts. These objectives apply not only to the operating power plants but also to planning, designing, constructing and commissioning of the new nuclear installations and nuclear waste facilities as well as the decommissioning old facilities. Coordination of safety, security, safeguards, their interfaces, synergies and conflicts is essential for achieving the objectives.

New technologies, research and development are supporting verification and other measurement activities by the regulator. Close cooperation between research and development assist in confirming the safe and peaceful use of nuclear energy.

This paper discusses technical synergies between nuclear security and safeguards in the regulatory control of new nuclear power plants and new types of facilities, based on our experiences. Practical examples and possibilities to use new technologies, research, and development to confirm the safe, secure, and peaceful use of nuclear energy are given.

Nuclear energy has played an important role in electricity production in Finland since the beginning of the 1980s. In 2016, one quarter of Finland's electricity production was generated by nuclear power. The nuclear power plants (NPPs) in Finland are operated by Fortum in Loviisa and TVO in Olkiluoto. Each NPP has two operational reactors. TVO's third reactor OL3 is in commissioning. A new nuclear power company, Fennovoima, has also been granted a positive decision in

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principle by Parliament for a nuclear power reactor, which it plans to construct in Pyhäjoki in the northern part of Finland.

It was legislated in 1980s that all spent nuclear fuel produced in Finland would be disposed of in Finland. The companies with operating NPPs, TVO and Fortum, cofounded the company Posiva to handle this task. The concept and a site for disposal of spent nuclear fuel was approved by a Decision in Principle in 2001. In November 2015 the Government granted the construction license. It was the first license for a geological repository for spent nuclear fuel in the world. The company Posiva is expected to apply for the operating license in 2020.

STUK is the regulatory authority for nuclear and radiation safety, nuclear security, and nuclear safeguards in Finland. Operators or licensees of a nuclear facility are responsible for fulfilling requirements stipulated in legislation and regulations as well as conditions and regulatory requirements set by STUK. In other words, operators are responsible for the necessary implementation of nuclear safety, security, and safeguards, and for enabling regulatory supervision in their facilities.

According to the IAEA Safeguards Agreement, the State has many responsibilities. In the Agreement, it is noted that the State also has many rights when the IAEA is implementing safeguards in the state. It is a duty of the regulatory authority to enable effective implementation of IAEA safeguards, while also ensuring that national security is not compromised.

Nuclear safety, security, and safeguards share the same fundamental objective: to protect people, society, the environment and future generations from the harmful effects of ionizing radiation.

The objective of nuclear security is to protect nuclear facilities and nuclear materials against unlawful and other unauthorized activities, primarily against theft and sabotage. A graded, risk-informed approach is applied to design, implementation, and assessment of nuclear security. Nuclear materials and facilities, including their systems, structures, and components, are categorized according to their significance to safety and security. The categorization is traditionally safety-based and security-based categorization is a somewhat newer concept, in particular with regard to cyber security considerations, which have become increasingly important.

The Design Basis Threat (DBT) in Finland consists of progressive levels of physical and cyber threats, and includes non-proliferation considerations. The scope of nuclear security in Finland is broad in comparison to the IAEA definitions. For example, nuclear security responsibilities and inspection programs in Finland cover other nuclear items in addition to uranium and plutonium, such as sensitive nuclear technology, including sensitive information.

The objective of nuclear safeguards is the prevention of the proliferation of nuclear weapons. The worldwide basis for safeguards is the Non-Proliferation Treaty (NPT) to which Finland is a party. The practical implementation of safeguards is based on the Safeguards Agreement between the State and the IAEA. Finland was the first state which had a comprehensive safeguards agreement

(INFCIRC/155) with the IAEA. In the European Union, the Euratom Treaty is also part of the overall safeguards structures.

Nuclear safeguards, the regulatory control of nuclear materials, is a prerequisite for the peaceful use of nuclear energy. The national system for the regulatory control of nuclear materials and activities forms the basis of nuclear safeguards. Nuclear safeguards are applied to both large- and medium-sized nuclear industry and to small-scale nuclear material activities. Along with safeguards, the regulatory process for nuclear non-proliferation includes transport control, export control, border control, international cooperation, and monitoring compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT).

As mentioned before, safeguards and nuclear security share a common goal. Nuclear security is mainly concerned with the acts of non-state actors such as individuals or groups, while the main concern of safeguards is the actions of the State itself. Often nuclear security measures can be used for both purposes. E.g. compartmentalization of duties may help to protect nuclear material from being diverted from its original purposes, both at State and non-state levels.

For facilities handling nuclear material only as items, such as nuclear power plants, interfaces between safeguards, security and safety should be taken into account when considering possible control measures, such as item monitoring, use of radiation portal monitors and, if appropriate, metal detectors. The systems that are used for mainly one purpose, can be used for other purposes too.

Nuclear security is a national responsibility and binding requirements are not common. Convention of Physical Protection of Nuclear Material, as Amended (CPPNME) is the key document for nuclear security. Safeguards is much more regulated by international agreements and conventions. However, at the national level it should be carefully assessed, how these requirements can be fulfilled to achieve the common goal.

For new nuclear facilities, it is typically easier to design systems, structures, and components taking into account both security and safeguards requirements than for old facilities where modifications may be difficult to implement. In the design process of a new facility, it is important to share information between safety, safeguards and security experts and other stakeholders (e.g. rescue personnel). A need-to-know principle is commonly used, but there is also a need-to-share. If the information is not shared between these two parties, the common objective is more difficult to achieve.

The traditional concept of implementing safeguards is that safeguards measures are put in place by the authorities and international inspectorates, once the facility is built and ready for operation. Our experiences of the current demands on the safety and security of new nuclear power plants and new types of nuclear facilities, show that adding safeguards measures late can become very difficult and costly, so early consideration of safeguards and security is very important. Safeguards and security measures are now a part of the design process of both the Hanhikivi NPP and Posiva repository projects.

After Parliament has made the Decision in Principle, that states that the construction and operation of a new nuclear facility is for the overall good of Finnish society, the operator can start the planning and the bidding process. During that process, there is classified information, which requires export or import licenses, end user statements, Nuclear Suppliers Group (NSG) obligations, and bilateral agreements on a state level as well as on an operator level. The operator must have an information security management system (ISMS), which also covers the information security of relevant third parties, such as its supply network. This includes contractual measures, such as information classification and handling rules, and non-disclosure agreements. Facility security clearances and personnel security clearances may be performed by authorities. In a case where there is a general security agreement (GSA) between the States, the agreement may cover the clearances to be mutually recognized. In the absence of a GSA, there may be other state-level arrangements. As a general rule, the operator must convert any classified regulatory requirements into its own design specifications. Some of this information remains classified, and is managed by the aforementioned operator's ISMS, contracts, and state-level arrangements. Information security is therefore the earliest encountered task for a State or an operator embarking on a NPP program. This is also the very first stage of nuclear safeguards. During that phase, the operator needs a person responsible for safeguards, who has the required knowledge and who is able to coordinate the process.

An important document at the early planning stage is the IAEA Safety Standards, Safety of Nuclear Power Plants: Design, Requirement 8: Interfaces of safety with security and safeguards. This IAEA Standard supports the states in the coordination of safety, security, and safeguards. The standard is also among the first IAEA document that the nuclear suppliers and vendors read, ensuring that the interactions on safety, security and safeguards start between the State, supplier and IAEA. Thus, nuclear regulations in Finland stipulate that the operators must provide the preliminary design information questionnaire (DIQ) within 30 days of the Decision in Principle. This takes the full spectrum of international nuclear safeguards officially on board at a very early phase.

After receiving the preliminary Design Information Questionnaire (DIQ), the IAEA prepares a Material Balance Area (MBA) code for a new facility, and the Safeguards by Design dialogue with the State can start. This is essential for new nuclear power plants and even more important for new types of nuclear facilities, like the geological repository for spent nuclear fuel in Finland. This process enables the State to discuss national security measures with the IAEA and to take them into account when the IAEA implements its safeguards activities in the facility.

Starting the safeguards measures during the planning and design phase has many benefits: cost efficiency, cabling taken into account, placing the IAEA equipment such as cameras and seals, routes for nuclear material movements, etc. This will improve the overall quality of safeguards. All stakeholders will also become more familiar with safeguards and its international obligations in a timely manner.

Safeguards by Design is voluntary for the states. A practical example of Safeguards by Design, based on the experiences of Finnish operators, is to get all safeguards requirements included as early as the design phase in the request for tender, and it is necessary to keep regular contact with the authorities (national and international).

In accordance with national requirements and in line with the IAEA Nuclear Security Series (NSS) recommendations and guides, the operator must ensure the security of information, including the cybersecurity of third parties who have potential access to its classified information. This obligation encompasses such systems as safeguards' remote monitoring where, for example, the security of technical interfaces, transmission, and use of information at the recipients' systems are considered. The necessary information and cyber security measures must be implemented following the normal graded, risk-informed approach.

Security and safeguards inspectors should cooperate closely. Security and safeguards inspectors should notify each other of, their findings also from the other S's point of view.

As practical example, STUK's radiation safety, security and safeguards inspectors cooperate when verifying small amounts of nuclear materials. Responsible personnel from these smallholder organizations are usually limited in number and the practical implementation of safety, security and safeguards is the responsibility of just a few persons. It is important to ensure that all aspects of all S's are taken into account as appropriate and required.

Site walk, covering security and safeguards is an activity where safeguards and security experts make observations at the facility. Optimally, safety observations are included. The observations are recorded and assessed, and corrective actions are taken and followed up as necessary. One objective is to increase awareness and knowledge in a multidisciplinary manner.

Technology development has been fast in recent years. This is also evident in safeguards. The goal of using new technology is to make safeguards implementation more effective. A good example is the development of safeguards cameras. The first cameras in the 1970s were film-based. This technology has been replaced by technically advanced digital cameras, which makes the handling and storing of data much easier. On the other hand, digital data and data processing including image analysis can be much more easily manipulated than the original films and printed pictures, which increases the importance of information security and tamper-resistant methods. The storage capacities of digital memories are increasing and costs are falling. Digital imaging also makes it possible to use Remote Data Transmission (RDT), where data from the site under surveillance is sent to the inspectorates by various data transmission means. RDT has been discussed since the 1990s when the Internet made its breakthrough, and it was implemented in safeguards surveillance systems at Finnish NPPs in recent years.

These safeguards issues must be considered in a balanced manner together with potential security risks. The nuclear operator is in charge of the safety and security of its facility, so the operator must know what kind of electronic systems are being used within the perimeter of its facility. In accordance with national regulation and international nuclear security guidance, the operator is responsible for ensuring appropriate information security levels at third parties that have access to its sensitive information. The safeguard cameras monitor the nuclear materials and their flows, which is sensitive information and as such subject to information security requirements. A surveillance system is also a potential vector for a cyber attack and should be protected accordingly. Espionage and the leaking of confidential commercial information can also occur. In practice, these risks cannot be completely avoided. There are administrative and technical ways to efficiently manage the risks, for example batching the transmission.

Laser 3D scanning has been used by international inspectorates for the Design Information Verification of nuclear facilities. The scanners create point clouds accurate to a level of 1 mm that are processed to present accurate 3D models of the targets scanned. For safeguards, this methodology is very effective and makes it possible to verify and document the built infrastructure of the facility in a reliable and repeatable manner. The point clouds and 3D models are digitally stored for further review. If the scanning is repeated, detection of changes is possible.

However, this data is, again, very sensitive. In the processed 3D models, even the smallest details of the physical protection systems, ventilation, pathways, etc. can be identified and accurately located. From a security point of view, this information must not be leaked to unauthorized persons. One possible technical solution is that the scanned data does not leave the site, but is only assessed during inspections on-site. This, however, limits the usability of the method as an inspection tool and induces additional cost to all parties as a result of keeping inspectors on-site for longer periods.

IAEA inspector access to the declared facilities is clearly mandated in the Comprehensive Safeguards Agreements. The Additional Protocol also grants wider access to the sites and locations outside the facilities where nuclear materials are used. The access of safeguards inspectors to a facility can be limited, if it conflicts with safety or security, for example, if access to areas of high radiation cannot be arranged due to radiation safety. Access by an intoxicated inspector can be restricted for occupational safety and security reasons.

Modern nuclear facilities have many different information systems that have interfaces to other systems, and the chain can only be as strong as its weakest link. For example, to ensure that there are no attack vectors through less important systems to more important systems, information and cyber security must be taken into account. This is part of the normal information security management, where sensitive information assets are identified, classified and protected according to their significance.

The legislation regarding the documents of the government authorities in Finland stipulates that they are public unless, based on the legislation, there is a reason and need to classify the document. There are four levels of classification with corresponding requirements for information security measures during the lifetime of the document. State security, relationships with international organizations, and facility security arrangements are the most relevant classification reasons within the nuclear safeguards and security regime. Business secrets may also be a valid classification reason.

Radioactive materials out of regulatory control (MORC) have been among the concerns that both international and national institutions have addressed in recent years. Many countries build, operate, and maintain their national nuclear detection architectures. The activities include radioactivity screening at the borders and at major public events. The activity is considered to be a part of nuclear security since the focus is on combating nuclear terrorism and other unlawful activities. However, it also has much to do with nuclear safety and safeguards. When the material is found, an appropriate organization can start to investigate the root cause of the event, which can then lead to corrective actions. The activities within nuclear detection architecture are also an extra layer to verify that there are no undeclared nuclear materials or activities in the state. A considerable part of MORC is nuclear material, which should be under safeguards.

One important aspect of traditional nuclear safeguards is the concept of reverification. All declared nuclear materials can be verified at any point in time and if continuity of knowledge (CoK) or containment and surveillance (C/S) is broken. The disposal of nuclear fuel in bedrock excludes this possibility, as it is not possible or feasible to verify the fuel after it has been placed underground and the access routes, e.g. emplacement holes and tunnels closed. This adds to the challenge and importance of safeguards during the process of encapsulation and disposal. It is imperative that there is knowledge of all nuclear fuel that is being disposed of. From a security point of view, long-term information security needs are an interesting feature related to final disposal. Integrity and availability of information must be ensured through technical, administrative, and cultural solutions.

Application of new technologies can also introduce synergies between safeguards and security. The IAEA safeguards requirement before spent fuel goes to 'difficult to access' storages is that verification should be done at partial defect level. Partial defect means that the diversion of a given percentage (by default 50%) of the nuclear material should be reliably detectable. Recent development in Passive Gamma Emission Tomography (PGET) has shown that pin-level verification is possible. The position of STUK is that the PGET method should be developed to a fully operational level, so that it can be used in the Finnish disposal project from the very beginning. This kind of technological development is also valuable for security. It is not possible to build a nuclear weapon from a single pin, but a single pin could easily be used for other criminal purposes. With precise verification, the possibility of using irradiated fuel for illegal purposes can be excluded.

In safeguards, sampling and measurements are employed to verify the declarations of the licensee. In nuclear security, detection activities can be divided into two components: (1) preventive surveillance measurements and (2) forensics studies related to nuclear security incidents. Nuclear forensics analysis can also be seen as a preventive measure since one of its goals is to prevent crimes in the future.

Nuclear forensics has greatly benefited from the developments made in safeguards, since many of the techniques used in safeguards can also be employed in nuclear forensics analysis. Detection, sampling, and analysis in safeguards and nuclear security can be further advanced through general scientific developments or through tailor-made developments in either one of the fields. The next chapter presents some trends and developments that may potentially influence both fields in the future.

Integrated digital nuclear electronics is advancing rapidly. New scintillation detector materials are also under intensive development. As an example, a detector capable of simultaneous gamma-ray spectroscopy and neutron counting is now technically possible. Among the drivers behind these developments are the large nuclear security markets. Such new detectors could also be useful for safeguards inspectors during on-site inspections.

Both bulk and individual particle analysis techniques are important for security and safeguards as well as for radiation protection. NDA particle analysis techniques based on multi-detector setups and coincidence analysis have been extensively studied at STUK. Such studies could, for example, be continued with the nanotomographic investigation of isolated particles. Nanotomography produces a 3D density map of a microscopic particle. Nuclear reference materials and nuclear material libraries can serve both safeguards and nuclear security. Coordination of technical developments is important.

In our experience, there are many technical synergies between nuclear safeguards and security. One of the differences is the international framework. Safeguards are based on international agreements. The IAEA and the EC safeguards requirements for Member States are very detailed and are binding. While there are also binding international agreements on nuclear security, the implementation of nuclear security is mostly based on national legislation and regulation. In general, there are no conflicts between safeguards and security. It is essential that we learn from each other, share information and understand each other's needs when implementing nuclear safeguards and security. In practice, it is challenging to find and develop methods to work with confidential information in a flexible way, but it is possible to find an appropriate way. Novel technologies are available for safeguards and security measures. Research and development efforts are expected to bring us new technical tools, which will provide improved, more efficient and effective implementation for both safeguards and security.

Part IV
Nuclear Safeguards Challenges

Said Abousahl, Anne Harrington and Willem Janssens

Chapter 12
Introduction

Said Abousahl

This panel addresses future perspectives in the field of nuclear safeguards and identifies the main current and upcoming challenges from a technological viewpoint, but also in terms of human resources availability and capacity.

Listening to the former speakers and the panel discussion of the previous session on nuclear safeguards, one challenge can be easily identified. It is on the increasing amount of nuclear materials and number of nuclear facilities to be verified/inspected by the IAEA.

Another challenge is related to the new type of materials and facilities that will need to be verified/inspected in the near and mid-term future.

The second challenge (that has not been pointed out in the former sessions) is on understanding the emerging and future nuclear energy technologies and the innovative processes that would impact the nuclear fuel cycles. Small and modular reactors will be very soon a reality. Generation IV reactor will start to be demonstrated in the coming decade before it becomes a reality in two/three decades. What will be the nature of the fuel that will be used by these concepts? What will be the nature of the spent fuels? The wastes generated? Most of the Gen. IV systems are closed cycle systems. What reprocessing scheme will be developed (Pyro? Advanced Purex?,…)? Which fuel fabrication process will be developed? Which enrichment process will be developed and used in the future (Laser technology? Plasma?…)? Are we prepared for safeguarding the nuclear of the future?

Although technologies and methodologies will be at the heart of tackling these challenges, the two challenges deserve different approaches and strategies. The first challenge is mainly on the optimisation and maximising of the resources e.g. automatization of the processes in order to cope with workload generated by the

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increasing inspection missions and activities. This can be done by using adapted new technologies and new approach such as the one based on the State Level Concept. Different Gen IV systems and related advanced fuel cycles will bring their own specific safeguards related challenges e.g. Molten salt reactors.

The third challenge is on nuclear safeguards human resources. Safeguards are implemented by inspectors using technologies. How the inspectors are prepared to carry out their missions? Do we have enough vision for the future on human resources capacities in the field of safeguards?

Although the nuclear safeguards mission (the "what") remains unchanged, i.e. to detect and deter the diversion of nuclear materials through accountancy and verification, some open issues as well as new developments oblige us to rethink the "how" and the "who" of nuclear safeguards.

Thanks to the intervention of the three panellists, the three main challenges were identified: 1—new technologies for effective and efficient verification of the current and increase amount of nuclear materials and number of facilities, 2—new technologies to cope with verification of future new types (physical and chemical) nuclear materials and advanced nuclear fuel cycle facilities, 3—the availabilities of competent human resources to implement current and future safeguards with the mentioned challenges.

The panellists have addressed the challenges in their presentations:

Anne Harrington and Yosuke Naoi's interventions mainly focused on the crucial importance of the "human factor".

With specific reference to the central role of the IAEA safeguards system, Anne Harrington underlined how competence of the inspectors is a key factor for the efficiency and excellence of the whole system. The focus should be then put on training, communication and outreach in order to create a young generation of professionals in this discipline.

Yosuke Naoi presented the activities of the Integrated Support Center for Nuclear Nonproliferation and Nuclear Security (ISCN) of the Japan Atomic Energy Agency (JAEA), stressing the importance of the capacity building and of the international and regional dimensions for the harmonization of Human Resource Development.

William Janssens's intervention focused on new technological developments, however putting more emphasis on the opportunity that they represent for enhanced nuclear safeguards. The use of virtual reality, the access to big data as well as laser measurements, pattern recognition and similar advancements, represent an important contribution to better prepare the inspections. Moreover, these tools can improve the outcome of the inspection while at the same time attenuating the human resources scarcity. Nevertheless, the intuition and empathy of the inspector, together with the capacity to analyse and revise the data obtained, will continue to play a central role.

In conclusion, the session identified two main areas of potential concern to nuclear safeguards: availability and competence of human resources, namely inspectors; and new technological developments. The "human factor" can be seen as a crosscutting issue for the whole nuclear domain, as highlighted by the results of the *European Human Resources Observatory for the Nuclear Sector* (EHRO-N), to be urgently addressed also for areas such as nuclear safeguards.

From the perspective of new technologies, it can be concluded that they remain a key element in the challenge to the implementation of nuclear safeguards. Innovative technology provides a valuable opportunity for enhancing the safeguards performance and compensating for some of its weaknesses. The development of Innovative safeguards technologies for the innovative fuel cycle concepts is crucial and the big support programmes to the IAEA in safeguards (US, EC, Japan,..) have an important responsibility in this regard.

Chapter 13
The "What" and "Who" of Nuclear Safeguards

Anne Harrington

The speakers in the previous session have highlighted the history and importance of nuclear safeguards, and, very importantly, the synergies between safeguards and security.

I will begin my comments with a quote from Taro Varojanta, the IAEA Deputy Director General for Safeguards, who spoke last summer at the 50th Anniversary of Los Alamos National Laboratory's role in safeguards. This is what I consider to be the "What" of safeguards:

> …we all agree that deterring the spread of nuclear weapons is one of the top security priorities of the international community, and that IAEA safeguards must and will continue to make an indispensable contribution to this effort. The safeguards mission will remain the same: to detect and deter the diversion of nuclear energy. Nuclear material accountancy and verification in the field remain at the core of this effort.

He then provided the following statistics that capture the IAEA's activities during 2016. This list illustrates what a very heavy workload the IAEA has; one that has only grown in recent years with no corresponding increase in resources:

- implemented safeguards in 181 states, 129 of which have Additional Protocols
  - this includes over 204,000 significant quantities of nuclear material under safeguards at 1290 nuclear facilities and locations outside of facilities are under safeguards
- IAEA conducted 3007 inspections, including 13,275 verification days in the field
- 1077 samples were collected
- 1057 Non-Destructive Assay systems were deployed
- 1436 cameras were installed.

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If nuclear material accountancy and verification are the “what” of safeguards, then the “who” becomes a very critical question. For there to be confidence in the safeguards system, experts are needed at the facility, national, and IAEA levels to carry out these important tasks.

Certainly, the safeguards mission is supported by a growing array of technologies, many of which are capable of feeding data to directly to national authorities or to the IAEA.

But given the number of kilos of material to safeguard, the expanding numbers of facilities holding that material, the challenges of decommissioning growing numbers of aging nuclear facilities, and the ultimate need for human judgment, I suggest that we look particularly at the question of “who.” How do we as an international community ensure that each facility with a safeguards responsibility fully understands what that entails, has trained and experienced experts who understand and implement that responsibility, and interact with a team of experts at the national level, who, in turn, interact with the IAEA. On top of this we can add what DDG Varojanta called “extraordinary events.” The Joint Comprehensive Plan of Action (JCPOA) could fall under such a category; eventual access to the DPRK would be another.

Facilities, nations, and the IAEA are increasingly challenged to produce enough qualified people to fill the requirements for safeguards experts. The IAEA has documented for years that it is being asked to do more with less. We have all experienced similar situations. In my last position at NNSA, we prioritized based on what actions were legally required—what was captured in a domestic law or fell under an international treaty or agreement.

In the case of safeguards, the requirements at nearly every level meet the test of being legally required: facilities are required by their regulators; regulators have their requirements stipulated by law; and the IAEA safeguards are required by treaty. If there are all of these layers of requirements, should we be very concerned about the future of safeguards expertise?

The IAEA Safeguards Traineeship Programme provides an important channel for building that expertise, focusing particularly on candidates from developing countries and qualifying them for a position as safeguards inspector in the IAEA or in their respective national nuclear organizations. It is an important programme, but it has its PROS and CONS:
PROS:

- Focuses particularly on candidates from developing countries and qualifying them for a position as safeguards inspector in the IAEA or in their respective national nuclear organizations
- Traineeship develops technical skills and competence; gives trainees opportunities to broaden their knowledge of the peaceful nuclear applications.

CONS:

- Many applicants lack basic qualifications
- Very small throughput compared to need—6–8 every 2 years
- Many successful individuals often take jobs at IAEA or other places and do not return to share their expertise with their home countries.

Countries with larger fuel cycles may already have personnel familiar with State Systems of Accounting and Control (SSAC) who are up to speed and qualify more easily for the traineeship. Unfortunately, if these individuals are successful in the traineeship programme, they often take extended appointments at the IAEA or other places and do not repatriate their newly developed expertise.

Safeguards resources are also being strained by the importance of the JCPOA mission and other special teams—for example, for the DPRK—and will require more dedicated personnel. These special missions often absorb the best and brightest, giving rise to the concern that with so many of the most competent people focused on one or two countries, is enough expertise left for the other 180 countries.

Dedicated country teams also mean that experts are not following the usual pattern of rotating to different teams and sharing experience and ideas with others. Loss of this kind of instituitonal memory can have a long-lasting impact on the safeguards mission.

In addition, the geographic and gender distribution requirements for the IAEA also present challenges. Diversity is very important for personnel development, especially in an international organization, but safeguards expertise is not the result of a few months of training. For example, an infectious disease epidemiologist once recounted that it takes about 10 years for a qualified life scientist to become a qualified epidemiologist. The expertise, field work, and instincts are something that only come with time. The same could be said in the safeguards field.

When DDG Varajanta was asked recently: what keeps you up at night? He responded: "Not having qualified staff at all levels, not just inspectors, but those who review and analyze the data."

So what can we do in the future to address this challenge and find a way to help the IAEA and individual countries develop a larger talent pool to fill the current and future safeguards needs?

One idea that I have heard from my European colleagues is to have IAEA Member States—or groups of Member States—with experience and facilities offer a kind of preparatory course for those interested in safeguards. The experience would aim initially at better preparing personnel with facility or national responsibilities, and make them more competitive when applying to the IAEA traineesship programme. The immediate result would be to strengthen national systems, but ultimately such an effort could reinforce the IAEA system.

Some of this is already happening through the network of nuclear centres of excellence—and we will hear about the Japanese experience in the next talk.

In closing, I want to emphasize how important it is for our safeguards experts to be fit for purpose: they must have the training, expertise, and experience necessary.

Fig. 13.1 IAEA News & Events *Source* (https://www.iaea.org/newscenter/news/a-day-in-the-life-of-a-safeguards-inspector)

And with an aging workforce, we also need to keep in mind that inspecting a nuclear facility also requires days of walking around sometimes vast buildings, climbing ladders, and other similar physical tasks.

I was reminded of this by a slide from an IAEA presentation that outlined what a routine inspection of a nuclear power plant would be (Fig. 13.1).

So when we say that safeguards experts need to be fit for purpose, that may also include being physically fit.

Thank you and I look forward to our discussion.

Chapter 14
Nuclear Safeguards Challenges from a JRC Perspective

Willem Janssens

Nuclear Safeguards is a well-established activity which at the same time continues to be under constant evolution and challenges, both at world level by the International Atomic Energy Agency in Vienna and at regional level e.g. by the European Commission Nuclear Safeguards Directorate (Euratom). This paper presents some of the major challenges, both for the nuclear safeguards inspectors and for the inspection regime itself, and hints towards potential solutions, based on currently ongoing research and development and several in-field trials and validations.

Because the continued increase of nuclear fuel cycle facilities to be safeguarded and the amount of nuclear materials under international control cannot be matched with a proportional increase of human resources or even operational budget, a number of innovative solutions are required to support the nuclear inspectors in their job, and new approaches for the more efficient and effective implementation of safeguards need to be tested and validated [1, 2].

This paper describes first a series of challenges for the nuclear safeguards inspectors and then proposes a number of potential solutions. Also several challenges for the safeguards implementation are described including proposals how to address them.

When analyzing the required skill-set for a high quality nuclear safeguards inspector, based on the authors perspective, an impressive amount of requirements come together. Table 14.1 provides an overview of a number of characteristic requirements for a nuclear safeguards inspector.

Other challenges that can be identified for the inspectors are e.g.: the pressure on delivering high performance and deliver proof of the inspection findings, having to use multiple equipment types, being confronted with complex installations with many Material Balance Areas, different reporting standards, only limited analysis

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Table 14.1 Characteristic requirements for a nuclear safeguards inspector: an author's perspective

Skills set	Topics
Technical expertise	Nuclear Materials & Measurements Nuclear fuel cycle installations/technologies Controlled commodities & Knowledge
Legal expertise	NPT Safeguards agreements Additional Protocol
Safeguards instruments	Normal inspections Complementary access Short Notice/Unannounced inspections
Soft skills	Observation skills: situational awareness/spot anomalies Synthetical mind: connect the dots Negotiation capabilities: diplomacy and assertiveness
Cultural sensitivity	Language specificities Habits & traditions Power distance etc.

tools and thus a major challenge for data integration and evaluation. In addition, the information dealt with is often confidential and can be highly sensitive.

The proper training, in-field assistance and constant wish for improvement of nuclear safeguards skill and competences are thus key features for an effective and efficient "inspector". Such capabilities do not come overnight and require a medium term investment in the gathering of experience, through dedicated training, in-field work and discussions and/or joint analysis with the safeguards analysts in the inspector head-quarters [3].

With respect to the technical expertise, both the knowledge of the available measurement and surveillance technologies and type of facilities in the nuclear fuel cycle, are typically quite well developed and covered in detail in the mandatory training courses. The same does not hold true necessarily w.r.t. the expertise on controlled commodities (i.e. technologies, know-how etc. as they are e.g. in the Nuclear Supplier Guidelines). Focused training and increased capabilities for the "standard" nuclear safeguards inspector to gain additional insight in these matters is thus highly recommended [4].

On the legal side, perhaps the most challenging part for the nuclear safeguards community is the verification on the required declarations under the additional protocol. Two examples are the declarations to be provided under article 2, (annex I and II) and how to verify completeness of a state declaration, and the obligatory export declarations. In this respect, a direct contact with industry could be efficient and effective, but this is practiced typically only at voluntary level, as the official/legal interlocutor is the State Authority for safeguards.

Another area where further improvements can be considered concerns the full use of the different safeguards instruments and the way of implementing them in the field. Specific training courses are e.g. provided to the nuclear safeguards inspectors, in dedicated facilities offering a variety of nuclear fuel cycle operations, on the way to implement complementary access.

The latter connects immediately to the requirements to continue developing further the soft skills of nuclear safeguards inspectors, while e.g. during a complementary access inspection, the inspector might have to negotiate a lot with the operator w.r.t. correctness of documents, access to specific locations, clarification of inconsistencies etc.

Finally, it is deemed very beneficial if the safeguards inspector, taking into account the variety of the above listed challenges, has the required cultural sensitivity, starting of course from some (basic) knowledge of the language and safeguards vocabulary [5], the way of behavior (incl. role of hierarchy) in a country etc. This aspect is not always recognized to the full extent and it is thus recommended to assure at least a minimum exposure and awareness rising of nuclear safeguards inspectors to these issues. This could possibly be integrated in the tools and approaches for the improved preparation of future inspection missions, which is covered in the next chapter.

A number of tools have been either recently developed or in the process of being validated in the R&D facilities supporting safeguards.

Before physically visiting a site, new technologies that are currently under investigation can facilitate the inspection preparation phase, when studying the site from the office, e.g. by relying upon the wealth of information that can be provided by open source information, review of the history of the site, looking at the trends of previous inspections and studying “typical anomalies” that can occur in such facilities. One example is the geotagging of social media activity of a particular site to distinguish between open and closed buildings. Also the use of virtual reality and 3D Vision to familiarize with all features of the site-interior can make the inspector much more confident about where to go, what to observe, which barriers to face etc. An illustration is provided in Fig. 14.1 below. To upfront be aware of the changes in between two inspections, satellite imagery, aerial monitoring and use of specialized software to spot the changes can be very useful.

When an inspector goes on site, his or her work could be supported and enhanced by the use of several different sensors (nuclear measurements, laser monitoring, volume and density, ultrasonics, particle collectors/analysers etc.). Automatic reconstruction and intercomparison with the 3D model of the facility visited earlier should become the standard. Similarly, the opportunities offered by augmented reality and ambient intelligence during the physical inspections should be fully exploited. When these multiple signals can then in real-time be compared to the “expected operations” based on a realistic model of the plant processes and operational practices, this can immediately lead to the almost real time registration of anomalies, which might then be able to be addressed on the spot. To allow the testing and validation of such approaches, dedicated laboratories are required, such as the one set-up by JRC in Ispra, called Advanced Safeguards Measurement, Monitoring and Modelling Laboratory [6, 7].

From both physical inspections and from the gathering of open source data, a vast amount of data is accumulated in the inspection head-quarters. The analysis

Fig. 14.1 Illustration of use of 3D model vision, reconstructed based on laser measurements

and exploitation of this valuable set of data could benefit from the use of advanced technologies like those developed in the area of Big-data and Data-analytics tools, both for enhanced visualization of the data and enhanced analysis (including finding issues, based on these data, which one is not necessarily a priori looking for). Multiple approaches like pattern recognition, neural networks, machine learning etc. and be deployed in this field including the analysis of variations/trends etc. over time and location and also the influence of the human element in the chain.

There are aspects that might potentially prevent the full exploitation of the inspectors skills and capabilities. Some of these aspects could be prevented and/or mitigated via solutions aiming at:

- Preventing stove-pipe thinking based on preconceived opinions
- Confronting all-information sources to seek for inconsistencies/signals
- Exploiting full information as allowed in the Safeguards Agreement (incl AP)
- Using of physical model or other guidance tools to structure information
- Enhancing collaborative platforms and assure regular updating of files
- Optimizing the open source data gathering process and tailor to specific needs

Both because of human resources constraints and because of the experience and potential in remote controlling and operating very sophisticated equipment and tools, it is proposed to also consider a paradigm shift in nuclear safeguards inspections, from the limited (de facto) independent safeguards verifications, to a monitoring of the full processes of a nuclear fuel cycle facility to guarantee its proper operation. While independent verification is crucial and at the core of safeguards verification activities, the possibility to complement it via a broader process monitoring could be beneficial in gaining a better and more consistent characterization of the big picture of the state's nuclear fuel cycle activities.

This proposal is based first of all upon a number of shortcomings of the current in-field inspections and the full exploitation of its results i.e.

- For the independent control it is difficult to work in "partnership" with operators and/or states
- Independently measured data are prone to inherent differences with operator
- There is a limited number of measurement points/sample taking opportunities
- Individual measurements do not show full picture
- There is a lack of full/complete insight in the installation
- Often there are no real-time warning/control in case of deviations
- It is difficult to quantify the overall contribution of a finding to "satisfactory" confidence.

For all of the above reasons, and some additional potential benefits to be identified still in the approach, it is proposed to move toward and/or complement the current approach with a full process monitoring of the facility. The benefits are manifold:

- Have a proper model of the "normal"/authorized operation of the plant
- Integrate maximum amount of process control parameters in the monitoring
- Combine COTS equipment with specific "safeguards grade" tools [8]
- Remote data transfer in (near) real time (respecting security and commercial sensitivity concerns without undue restrictions: WIN-WIN with the operator)
- Analyse (in)consistencies between signals/detect anomalies etc. [9].
- Optimize statistical data treatment to focus on data reduction/filtering
- Define intervention/alert levels based on multiple signals (risk based) (mixed hierarchy and intervention levels (unannounced inspections/direct halt of certain paths/need for a posteriori verification of certain steps etc.).

In Fig. 14.2, a set of different levels of challenges and focus points for current safeguards R&D are listed, starting from issues with the direct measurement of the nuclear materials (e.g. in spent fuel) which continues to pose challenges and requires adequate tools, training and experience [10]. At the next level comes the understanding and monitoring of the processes where these nuclear materials are used, idem at the level of the facilities to finally address challenges at the level of the state as a whole. Clearly, at the interface between these different levels, there are a number of issues also which can be addressed with the approaches, schematically referred to in Fig. 14.2 such as:

- fingerprinting of nuclear materials, i.e. uniquely identifying them based on the content (isotopic composition, impurities, microscopic structure etc.) also depending upon their production process

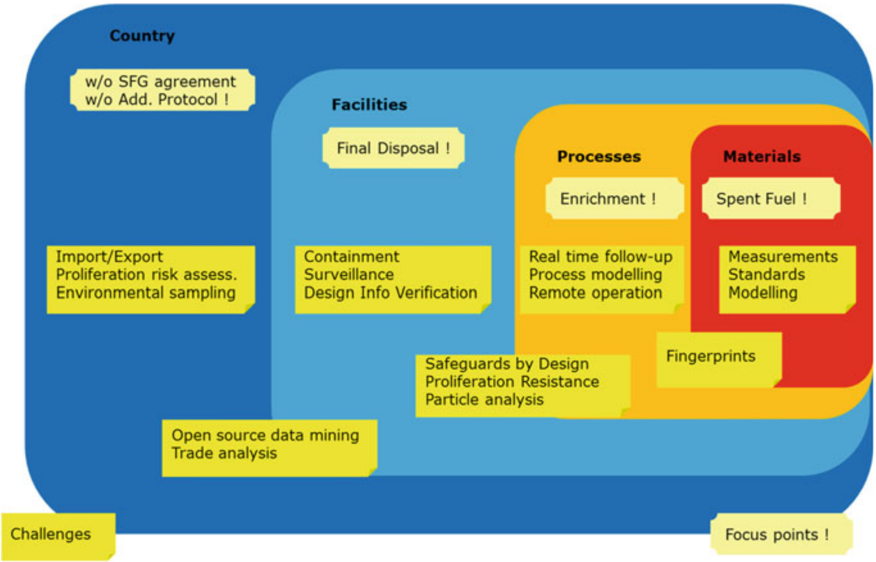

Fig. 14.2 Schematic overview of nuclear safeguards & non-proliferation challenges and focus points

- analysis of proliferation resistance, which apart from the materials themselves, also depends on the processes used and of course on the design of the facility and its safeguardability
- trade analysis as a tool to verify or identify specific commodities being traded which might refer to existing and declared nuclear fuel cycle technologies in a country but could also serve as indicator for clandestine activities [11, 12].

A large variety of challenges remain in the area of nuclear safeguards, both from the human perspective (inspector/analyst) and from the technology side. This short paper provides a succinct overview of a number of these challenges and refers to the potential of research and development to contribute in addressing these. Two key messages are that continued investment is needed in the development of the multi-disciplinary skills of the inspectors and that innovation, new sensors and data handling tools can significantly enhance nuclear safeguards efficiency and effectiveness in the future.

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Part V
Topics of Nuclear Non-proliferation: Present and Future Challenges—1

Wolfango Plastino, Paolo Cotta-Ramusino, Remo Chiappini and Merav Zafary-Odiz

Chapter 15
Introduction

Wolfango Plastino

This session was focused to overviews by Professor Paolo Cotta Ramusino of the Status of Nuclear Nonproliferation, by Dr. Remo Chiappini of the French National Perspective on Nuclear Non-Proliferation, and by H.E. Amb. Merav Zafary-Odiz of the Israeli National Perspective on Nuclear Non-Proliferation.

In the first part—chaired by Min. Plen. Gianfranco Incarnato—Professor Paolo Cotta-Ramusino provided an overall perspective of the various worldwide risks of nuclear-weapon proliferation and of the perspectives of complete elimination of nuclear weapons, also in the light of the recent introduction and progress in the United Nations context of the Treaty to Ban Nuclear weapons.

Then Dr. Remo Chiappini reported in some detail on the progress and motivations of the French nuclear nonproliferation policy and its control and verification aspects, with particular focus on French official views—including recent pronouncements by President Emmanuel Macron—on how to face current risks of proliferation, including those posed by North Korea.

Finally, H. E. Amb. Merav Zafary-Odiz provided a detailed report of the Israeli policy concerning the nonproliferation of nuclear weapons, underlining the strong commitment of Israel to this goal and its respect for all norms—including, in particular, all international regimes of export controls—aimed at preventing any support to the development of nuclear weaponry by other States. She also devoted a sizable part of her analysis to the specific challenges associated with the Middle East region, focussing specifically on Iran and Syria; and concluded her presentation by emphasizing the related risk of terroristic uses of nuclear materials, underlining that "Israel has taken comprehensive measures to reduce the risk of theft or sabotage in its nuclear centers, as well as radiological materials used in medicine, industry and other sectors".

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Chapter 16
Status of Nuclear Non-proliferation

Paolo Cotta-Ramusino

The risks of nuclear proliferation are summarily discussed. First, we consider the risks of nuclear proliferation that are related to the structure of the Non-proliferation Treaty. Then we discuss the risks specifically related to the Middle East and to North East Asia. The uncertain status of the Iranian nuclear deal, and its implications for nuclear proliferation, are considered. There are also specific proliferation risks associated with the practice of deploying nuclear weapons on territories of non-nuclear-weapon states. Finally, the relation between the NPT and the Nuclear Ban Treaty is considered.

The Non-proliferation Treaty (NPT) is quite obviously a very important treaty, having prevented significantly any increase in the number of nuclear-weapon states (NWS). We must not forget that, in the late 1940s and early 1950s, the general forecast was that most states of any significant size and political/military relevance would eventually acquire nuclear weapons. This did not happen. On the other hand, no one at that time would have predicted that either the US or the USSR would have arrived at such huge arsenals of nuclear weapons (32,000 the former, 45,000 the latter).

The two superpowers always believed that the number of NWS should have been kept to a "minimum", also to preserve their nuclear supremacy. This was reinforced following the Cuban Missile Crisis (1962), where it took some exceptional good sense by the American and Russian leaders, and certainly a very significant amount of good luck, to avoid a nuclear catastrophe. It was obvious that any further crises similar to the Cuban Missile Crisis could have been, so to say, less fortunate. A larger number of NWS would have been a significant factor in increasing the nuclear risks. Hence, in the mid 1960s, there were intense discussions between the nuclear superpowers on how to shape a non-proliferation treaty.

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The structure of the NPT was finally defined, and the treaty opened for signature, in July 1968, and entered into force on 5 March 1970.

As we said, the NPT, in the years since its entry into force, has been extremely successful in limiting the number of NWS, which now stands at nine (five defined as such by the NPT itself, and four that are not party to the NPT). Now, all States—with the exception of the four mentioned above (India, Pakistan, Israel, and North Korea) and of South Sudan—are members of the NPT.

Nevertheless, the NPT is a very *imperfect* treaty. Not only does it discriminate between the "haves" and "have-nots", but it contains articles and defines procedures that could possibly present serious problems in the future. Moreover, the set of NWS as defined by the NPT is the same set of permanent members of the UN Security Council (UNSC). In this way, the NPT identifies the prestige associated with being a permanent member of the UNSC, with the possession of nuclear weapons.

In general, the non-proliferation regime is under stress on various accounts. Here we would like to discuss the problems and the risks associated with the non proliferation regime.

a. Article 6 requires that the NPT-recognized NWS (i.e. USA, Russia, China, UK, and France) should proceed to nuclear disarmament, without giving any time limit or defining any specific procedure. This is de facto interpreted by the said NWS as the right to maintain indefinitely the possession of nuclear weapons, and this creates resentment and tensions, particularly among some non-NWS. The situation has worsened as a result of the recently revived antagonism between the US and Russia, that has not only blocked the arms-control process, but created some nuclear "irritants" such as the deployment of US Ballistic Missile Defense near Russian borders, or the movement of Russian nuclear-capable missiles to Kaliningrad, etc.
b. Article VIII (paragraphs 1 and 2), which defines the procedure for amendments, de facto makes any amendment impossible. So "improving the treaty" is not an option.
c. Article VIII (paragraph 3) establishes that every five years a Review Conference of States Parties to the NPT Treaty should be held with the purpose of reviewing the operation of the Treaty. Of the nine NPT Review Conferences held to date, five have concluded with no final document, and four have concluded with a final document whose suggestions and recommendations have in general *not* been implemented. In particular, the 2000 Review Conference proposed 13 steps that have been not implemented, and the 2010 Review Conference proposed the convening of a conference on the establishment of a weapons-of-mass-destruction-free zone (WMDFZ) in the Middle East by 2012, a conference that has never been convened. The 2005 and 2015 Review Conferences concluded without a final document. The poor results of these quinquennial review conferences decrease the effectiveness and "prestige" of the NPT itself in the eyes of many member states.

d. Article X of the NPT requires only a modest three months of advance notice for withdrawal from the treaty, a decision that can be made when a state decides that membership in the treaty jeopardizes its supreme interest. While this may be a standard rule for international agreements, in the case of the NPT, this means that there are, in principle, no insurmountable obstacles for a non-NWS to acquire nuclear weapons. And while North Korea's withdrawal from the NPT has been a singular case, it is nevertheless a significant one.

The technological skills needed to build (simple fission) nuclear weapons are certainly not particularly sophisticated. The main problem for a State wanting to build nuclear weapons will be the acquisition of (weapon-grade) fissile material. The NPT defines the right to have a civilian nuclear program as an *inalienable right*. Now, 3.6% is about the minimum enrichment required for civilian (light water) nuclear reactors. Yet enriching uranium with centrifuges to a level of 3.6% U-235 is about half way (in terms of energy required) to enriching it to 90%. Moreover, using heavy water reactors that do not require uranium enrichment will produce significant amounts of plutonium (that certainly needs to be separated if one wants to use it for nuclear weapons).

So a possible military use of peaceful nuclear energy facilities can only be prevented by constant inspections and monitoring by international institutions such as the International Atomic Energy Agency (IAEA). An effective control of nuclear activities can be critically facilitated by instruments that provide additional tools for verification, such as the Additional Protocol, which is nevertheless a voluntary agreement between individual states and the IAEA. Furthermore, several states (such as Argentina, Brazil, Egypt) have refused to sign the Additional Protocol as a matter of principle, since it is an extra burden for non-NWS that already feel discriminated by the NPT.

Additional Protocol apart, some states have produced significant amounts of separated plutonium (Japan is the typical example) that could be used immediately to build nuclear weapons if such a decision were to be made. And the further spread of nuclear energy facilities worldwide could in the future facilitate several nuclear military options. The idea of building international fuel cycle facilities is certainly a very good idea that could be very helpful in avoiding proliferation risks. But this is a very slowly developing idea.

One worrisome aspect of not having convened the aforementioned conference on the creation of a WMDFZ in the Middle East has been the influence of Israel (which is not a party to the NPT) in convincing the US, and possibly also the UK, not to convene it. This has only put more emphasis on the fact that the only nuclear weapons in the Middle East belong to Israel. How long other Middle Eastern countries will accept the Israeli nuclear monopoly in the Middle East is not clear. But certainly the presence of Israeli nuclear weapons is a worrisome factor in assessing the nuclear proliferation risks in the region.

Iran started working on nuclear energy at the time of the Shah, and took it up again well after the end of the Iran-Iraq war. With centrifuges acquired from Pakistan, Iran started enriching uranium in its own facilities, which it failed to report to the IAEA. When news about the Iranian enrichment facilities became public after 2002, Iran was referred to the IAEA. Following some meetings with European powers, Iran accepted to suspend its uranium enrichment and signed (but did not ratify) the Additional Protocol. Despite its suspension of uranium enrichment, Iran, on recommendations by the IAEA, was referred to the UNSC and sanctioned. At this point the new President, Mahmoud Ahmadinejad, suspended the implementation of the Additional Protocol and restarted work on uranium enrichment. The story was supposed to end with the signature and entry into force (2015) of the Joint Comprehensive Plan of Action (JCPOA), also known as the Iranian Nuclear Agreement, between Iran, the US, Russia, China, the UK, France and Germany. With the JCPOA, Iran accepted constraints on its nuclear program that are not applied to any other country (i.e., a limit on the number of centrifuges, a maximum enrichment level of 3.6%, the transfer outside the country of large quantities of already enriched uranium, the transformation of the Arak heavy water reactor, etc.). Iran also accepted full supervision of its nuclear program by the IAEA (including the Additional Protocol). Iran's main interest was its reintegration into the world market, and the end of the financial sanctions/constraints. The history of the Iran nuclear program and of the JCPOA is well known and well documented. Here we are interested in the possible (future) consequences of the Iranian nuclear program, and the impact on non-proliferation of the possible collapse of the Iranian nuclear deal.

The new US administration may decide to suspend the JCPOA and/or keep sanctioning Iran based on its nuclear as well as missile programs, denying (at least in part) Iran access to the international (financial) market. It could also pressure European countries by establishing secondary sanctions against those countries who are not aligned with the US. President Trump recently refused to certify that Iran is respecting the agreement, claiming that Iran is not abiding to the "spirit" of the agreement. Iran has claimed that it will stick to the JCPOA if the Europeans (and China and Russia) do so as well.

In any case, there are logically two main possibilities:

a. Iran, despite its having been certified up to now by the IAEA as having respected the JCPOA, will lose the economic advantages it expects from the agreement, with the result that within Iran, there will be pressure to not respect the nuclear constraints and return to the pre-JCPOA situation.
b. Iran will continue to respect the JCPOA, proceed with its limited nuclear program, and still have access to international markets, at least the European ones.

Things could be further complicated if sanctions against Iran were to be imposed not on the basis of the JCPOA, but on the basis of its missile program and its alleged support for so-called terrorist activities.

In any case, if Iran is able to retain its access to the international market, and if the JCPOA can preserved, then Saudi Arabia, the UAE and others will be unhappy and may decide (as they have already announced) that they will carry on the exact

—if not more—same nuclear activities that Iran is, thus bringing into the region a sort of nuclear competition in slow motion.

If, on the other hand, Iran is denied access to international markets, then, as we said, the pressure inside Iran for abandoning the JCPOA could grow, with the risks for nuclear proliferation in the region becoming very significant.

Needless to say, the best option for preserving nuclear non-proliferation in the region would be the preservation of the JCPOA in substantial terms. But at the same time, it would be useful to try to soften the regional antagonism between Saudi Arabia/UAE and Iran.

The US began deploying nuclear weapons in other NATO countries well before the entry into force of the NPT. There were several motivations for this decision. One was related to the issue of making the so-called US nuclear umbrella more visible and clear, and another was to persuade some NATO countries, particularly Germany, not to acquire nuclear weapons on their own. A further expansion of this idea took place in the 1960s with the proposal of creating a multinational (naval) NATO force, the so-called multilateral force (MLF), with direct control of nuclear weapons. The MLF was deemed to be unacceptable by Russia, so it was abandoned by the US in order to establish the NPT. But the de facto agreement with Russia was that the previous deployments of US nuclear weapons on the territory of allied countries would not be considered an obstacle to the establishment of the NPT. US nuclear weapons deployed on the territories of allied countries were, and are, classified as "dual-key" (meaning the US retains possession of the nuclear weapons, while the host country provides the relevant delivery system in the case of use of such weapons), and as "single-key" (when both the nuclear weapons and the delivery systems belong to the US). Note that, mainly in the case of dual-key weapons, there is still a question concerning the compatibility of such arrangements with the NPT requirement that the control of nuclear weapons cannot be assigned to non-NWS. The dual-key arrangement is also referred to as "nuclear sharing". The non-NWS that host US nuclear weapons are Italy, Germany, Turkey, the Netherlands, and Belgium. By any standard, the military utility of either the single-key or dual-key weapons deployed in Europe is absolutely negligible.

Such weapons are relevant only for political symbolism, but are nevertheless very problematic for many other aspects. The problems related to the deployment of nuclear weapons on the territories of other countries can be summarized as follows:

a. The existence of a (ill-defined) nuclear umbrella gives the message that there are nuclear states, non-nuclear states, and some kind of intermediate category of non-nuclear states protected by nuclear weapons. This is, to say the least, confusing, and can become a specific proliferation problem.
b. Nuclear weapons deployed on other countries' territories can, sooner or later, present specific security problems, especially if the host countries are located in critical neighborhoods. A typical example is Turkey, which hosts US nuclear weapons on the Incirlik Air Base, which lies very close to Syria. The Incirlik Air Base has also been used for the anti-ISIS campaign, and was recently subjected to a power blackout. The US would like to withdraw these weapons for security

reasons, but this is problematic since they do not want to possibly upset the Turks by singling out Turkey, perhaps inducing them to acquire nuclear weapons on their own. The US could alternatively, and more wisely, withdraw all nuclear weapons located in NATO countries, but then it would give a controversial message to those NATO countries that are more worried about Russia's intentions and most interested in maintaining a nuclear umbrella.

c. Most importantly, from the point of view of proliferation risks, is the fact that if deploying US nuclear weapons in NATO countries is deemed compatible with the NPT, then it should also be deemed compatible with the NPT if some other nuclear-weapon countries (including Pakistan, India, etc.) deploy nuclear weapons on the territory of non-nuclear NPT parties. Thus, the NPT could be de facto circumvented if nuclear weapons were to be spread around the globe with arrangements similar to those established in NATO. One example often cited is the possible deployment of Pakistani nuclear weapons in Saudi Arabia, although this does not appear likely as of now.

The dangers related to North Korean nuclear activities are very serious in terms of a possible use of nuclear weapons. Even if the use of nuclear weapons by North Koreans would most likely imply the destruction of their country, the possibility of such use cannot be ruled out, as the North Korean leader may at some point even decide to "sacrifice" the country for the "cause". Remember that in 1992 (30 years after the Cuban Missile Crisis), Robert McNamara, talking with Castro, learned that the Cuban president was ready to accept the destruction of the island if the US-USSR crisis was unable to be defused.

There is in any case also a significant dimension related to proliferation in North East Asia. President Trump suggested the possibility of re-deploying US nuclear weapons on South Korean territory. Moreover, even before becoming President, he had suggested that South Korea (and Japan), faced with the North Korean threat, should consider building their own nuclear weapons. Recent opinion polls[1] suggest that in South Korea, 60% of the population may support building nuclear weapons as a defense against the North Korean nuclear threat, and 70% of the population even support the reintroduction of U.S. nuclear weapons into South Korean territory. Faced with the possible spread of nuclear weapons on the Korean peninsula, Japan itself may very well consider the nuclear option.

A general argument could be made here that, if we were to ever again witness the use of nuclear weapons against cities or military targets, then the global non-proliferation regime would be shaken to its core.

The policy of no first use by states possessing nuclear weapons means that nuclear weapons will not be used against states that do not possess them. But unfortunately, very few states have a policy of no first use, India and China among them. Russia had a policy of no first use when, as the USSR, it possessed a large conventional superiority, but this is no longer the case. The US had made an effort to move towards a position of non-use of nuclear weapons against states that do not

[1]*N.Y. Times*, October 28, 2017.

possess them, but in the 2010 Nuclear Posture Review, it added that the US will not use nuclear weapons against states that are members of the NPT and "in good standing" with it. The reference to Iran at that time was obvious. In this way, the US retained the right to decide which states are in good standing with the NPT and which are not. We should not forget that, in general, the motivation to acquire nuclear weapons is connected with a) the "prestige" associated with the possession of nuclear weapons (i.e., the fact that the permanent members of the UNSC are also the NPT-defined nuclear weapon states), and b) the sense of being under threat by some state possessing nuclear weapons. If NWS do not give up the possibility of threatening non-NWS with nuclear weapons, then the latter may sooner or later decide to go nuclear as an act of "self-defense".

Nuclear security is generally intended as the definition of procedures and safeguards that could prevent the spread of nuclear material to non-authorized users (typically non-state actors or terrorist groups). These are reasonable goals aimed at preventing the possible spread of nuclear weapons and nuclear material in general. Four large Nuclear Security Summits have been held (2010, 2012, 2014, 2016), all attended by many world leaders, and while as a whole they were very useful initiatives, there were also some problems. First of all, these summits did not address the security of nuclear weapons per se (obviously a classified matter for each state possessing nuclear weapons). Secondly, there was "political discrimination", as some countries like Iran, with civilian nuclear programs, were not invited. Thirdly, there was apparently no discussion on how non-state actors could exacerbate a nuclear exchange between NWS (like India and Pakistan), nor what initiatives NWS should take in order to avoid similar risks. In any case, it is unlikely that these Nuclear Security Summits will continue under the new US Administration.

On 7 July 2017, the Nuclear Ban Treaty (NBT) was opened for signature. One-hundred-and-twenty-two countries approved the text of the treaty at the UN. It will enter into force after 50 countries have signed and ratified it (more than 50 countries have already signed it, and their ratification is expected soon). The NBT defines more clearly several points that are dealt with in the NPT. In particular, it does not distinguish between NWS and non-NWS. A State that becomes a member of the NBT renounces any possession of nuclear weapons. Any state party to the NBT will be committed to not hosting any nuclear weapon on its territory. NATO countries that rely on nuclear weapons will have to give up this reliance if (ever) they were to sign the NBT. NATO countries, NWS, and countries that rely on a "nuclear umbrella", are in general not expected to sign the treaty, at least for now. Some NATO countries argued that the NBT is in contrast with the NPT since it does not acknowledge the existence of NWS. In reality, the NBT is the logical step forward with respect to the NPT. It takes the disarmament issue (Article 6) seriously since NWS would be required to disarm before becoming members of the NBT. The NBT does not allow confusion about the nuclear sharing issue: this will not be allowed. The NBT hence wipes out several controversial issues that we mentioned while discussing the NPT. What remains to be seen now is how many countries in the long run will become members of the NBT.

Chapter 17
The French National Perspective on Nuclear Non-proliferation

Remo Chiappini

As a permanent member of the United Nation Security Council and nuclear weapon state under the terms of the NPT, France has particular responsibilities for the preservation and the strengthening of international peace and security. Actions are conducted, in the first instance, through multilateral mechanisms. In this regard, France consistently supports efforts made to implement and reinforce, as appropriate, multilateral treaties and agreements on non-proliferation. France recognizes the strength of those multilateral treaties and agreements but considers that they are not sufficient. There is also a need for integrated and coordinated approach at national level, dedicated organization and a strong nuclear expertise. Any strategic decision in the nuclear field (program funding's, export policy, cooperation's…) is taken by a specific council, at the President level. Among all issues taken into account, non-proliferation is the central one. The CEA: the Atomic Energy Commission, the French government technical expert, is part of this specific Council. The CEA has developed a five steps methodology which takes its fuel and weapon cycles knowledge into account, in order to anticipate, assess, monitor and prevent the risk of proliferation. Ultra-trace sample analysis and satellite imagery are two key tools, as well as export control and bibliometry. Beside those capabilities, CEA has also supported MFA negotiators for E3/UE + 3 Iran deal, providing technical support for political decisions. CEA has also developed seismic and radionuclides capabilities for nuclear tests detection and characterization.

France consistently supports efforts made to implement and reinforce, as appropriate, multilateral treaties and agreements on non-proliferation. Even if France recognizes the strength of those multilateral treaties and agreements, there is also a need for an integrated and coordinated approach at national level, dedicated organization and a strong nuclear expertise to efficiently anticipate, assess, monitor and prevent the risk of proliferation. This paper describes the five steps methodology

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developed by CEA, focusing on specific tools like ultra-trace sample analysis, satellite imagery but also seismic and radionuclides capabilities for nuclear tests detection and characterization.

As a permanent member of the United Nation Security Council and nuclear weapon state under the terms of the NPT, France has particular responsibilities for the preservation and the strengthening of international peace and security. In this context, the French President stated in Istres, 19 February 2015: "*France has decided to fight against one of the major threats, the proliferation of massive destruction weapons. Any increase in the number of nuclear weapon states is a major risk for peace: not only in the regions around but also for international security*."

Recently President Macron reiterated these commitments in the context of North Korea provocations. French action to combat proliferation and promote arms control and disarmament takes this dual responsibility fully into account. It is guided by a set of unchanging principles: the development of friendly relations between states; the prevention of threats to peace; respect for the right of self-defense; renunciation of the arms race and progress towards general and complete disarmament. France pursues these principles through multilateral mechanisms, legal regimes and, where necessary, ad hoc initiatives. In doing so, it takes into account developments in the international security situation and the evolving strategic context, while always seeking the broadest possible international consensus.

Actions are conducted, in the first instance, through multilateral mechanisms. In this regard, France consistently supports efforts made to implement and reinforce, as appropriate, multilateral treaties and agreements on nonproliferation. France supports in particular those multilateral institutions charged with the task of verifying compliance with such treaties and agreements. France also contributes fully across the spectrum of European initiatives in the fight against proliferation. France became party to the NPT on August 1992 and attaches particular importance to the central role of the IAEA's safeguards. France has signed and ratified the CTBT on April 1998 and supports the provisional technical secretariat (PTS) in its work to set up the verification regime. France is a member of the Nuclear Suppliers Group.

France recognizes the strength of multilateral treaties and agreements on non-proliferation and supports them. France also considers that they are not sufficient. In the past, countries who signed the NPT conducted clandestine activities. North Korea is an emblematic case. There is a need for integrated and coordinated approach at national level, dedicated organization and a strong nuclear expertise.

Any strategic decision in the nuclear field (program funding's, export policy, cooperation's…) is taken by a specific council, at the President level. Among all issues taken into account, non-proliferation is the central objective (as an example, the proliferation resistance of nuclear processes and plants). Beside the President, the council members are: The prime minister and different ministries, the SGDSN (National secretariat for national defense and security) as well as the CEA: the Atomic Energy Commission, the French government technical expert.

This methodology is based on a five steps approach (see Figs. 17.1 and 17.2). The Atomic Energy Commission uses its fuel and weapon cycles precise knowledge to identify which are the indicators and signatures for the different steps of the cycles: ore extraction and uranium concentration, uranium conversion. Then, for the plutonium path, fuel manufacturing, reactor irradiation and plutonium extraction from reprocessing and, for uranium path, uranium enrichment and uranium metal manufacturing. Finally, high explosives, physic, detonic for device manufacturing and weaponization. This gives the opportunity to identify which kind of sensors devoted to those indicators and signatures detection could be needed. Those sensors could be highly sensitive detectors but can also be based on export control or visas identification. Then, CEA goes to data fusion including open sources and intelligence.

CEA is part of the NWAL (Network of Analytical laboratories, see Fig. 17.3). The french laboratory is, like the United States, Russian and Japanese laboratories, certified by the International Atomic Energy Agency (IAEA), both for particulate analysis and bulk plutonium and uranium analysis. France obtained this certification in 2000.

The French laboratory has performance in the femtogram range for plutonium.

Also, France has advanced capabilities in the field of satellite imagery (see Fig. 17.4), both for optical, infrared, radar and hyperspectral techniques. Satellite imagery plays a key role in the detection and characterization of plants, facilities and site. Its gives information related to the stages of construction, the starting of operations and the monitoring of ongoing activities.

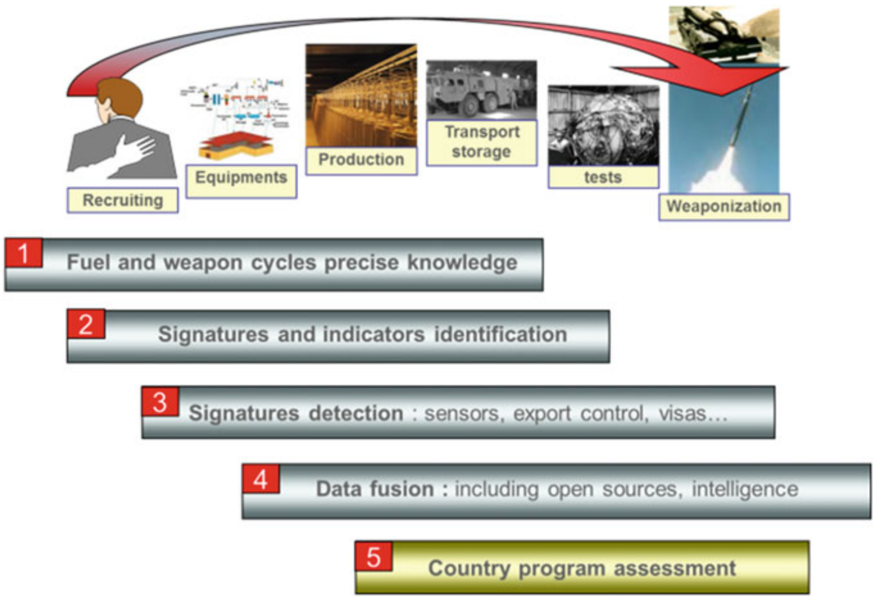

Fig. 17.1 The atomic energy commission methodology for country nuclear program assessment

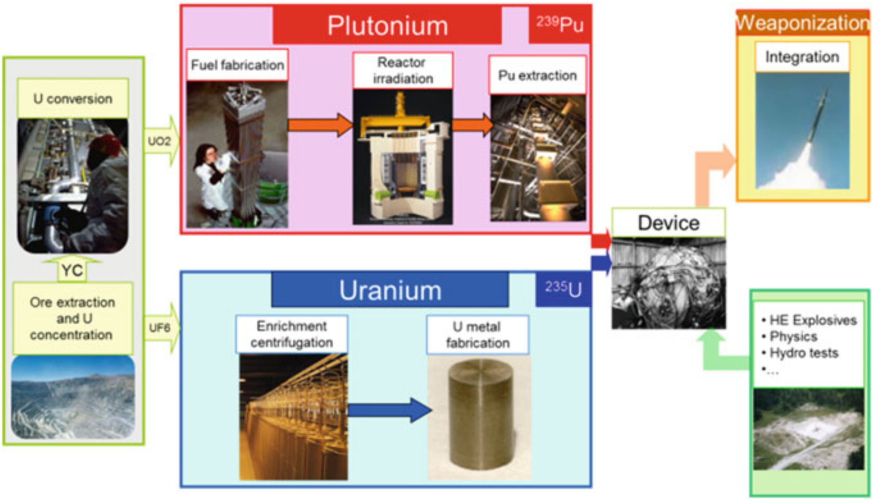

Fig. 17.2 Nuclear materials and weapons development scheme

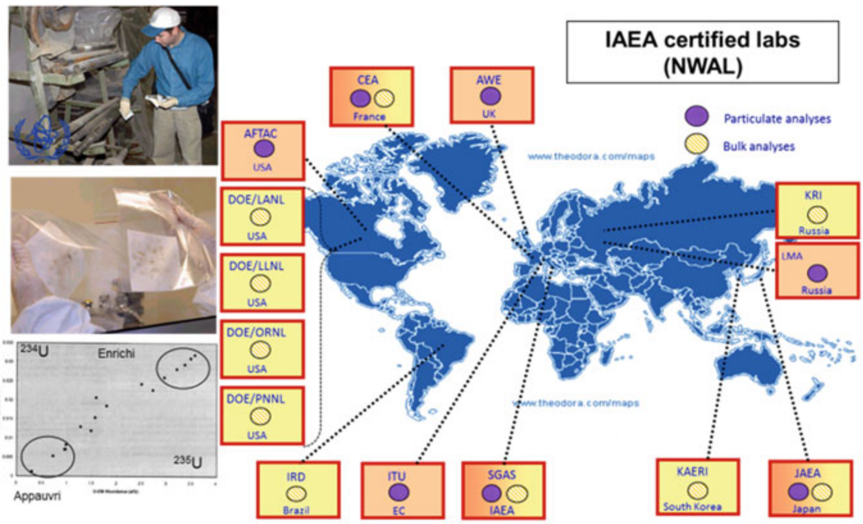

Fig. 17.3 Sample analysis to support the IAEA (NWAL) since 2000

In the field of export control, there is a clear need for a national organization where all national agencies are involved. In France, about ten agencies, all together takes part in the weekly instruction of demands, under the supervision of the SBDU which is: "Service des Biens à Double Usage". About 50 to 80 demands are examined every week. At national level, monthly decisions for export are taken by the CIBDU which is the: "Commission Interministérielle des Biens à Double

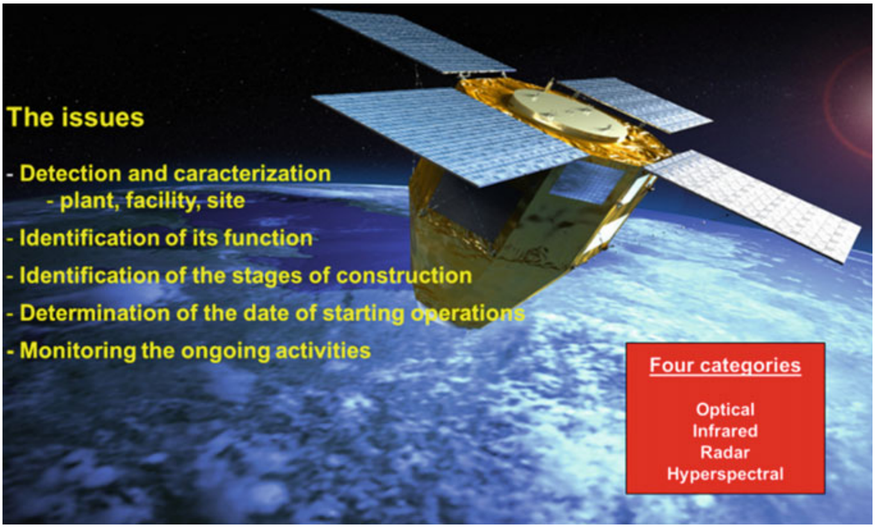

Fig. 17.4 The key role of satellite imagery

usage". The atomic energy Commission also provides sensibilisation for the private companies. Many meetings are held in order to inform about the risks. France also considers that there is a need for International cooperation.

The methodology described above has been implemented in France for many decades. It has been reinforced in 2010 when SBDU and CIBDU were created.

France considers that bibliometry (see Fig. 17.5) is a very efficient tool for scientific investigation. It gives the opportunity to identify topics of interest, collaboration networks, change with time of the topics of interest, check information from various sources, detect training centers and evaluate the potential of a country. This way, one can constitute a knowledge catalogue.

Starting from October 2013, the CEA supported the French MFA negotiators for the interim deal (JPOA, Joint Plan of Action). Then, in April 2015, the CEA contributed to the definition of the key parameters for the Joint Comprehensive Plan of Action (JCPOA), related to Natanz, Fordo, Arak, reprocessing, and the civil nuclear cooperation. The JCPOA was agreed in Vienna, the 14 July 2015 and implemented the 16 January 2016 (Fig. 17.6).

More precisely, the CEA technical support for political decisions dealt with the uranium enrichment processes in Natanz and Fordo, the cascade configuration definition, the number of machines needed, the infrastructure definition and the break-out time calculation. On enrichment R&D, advanced centrifuge performance were evaluated and advanced centrifuge program phasing was precisely defined. Also, low enriched uranium stockpiles for a 12 months break out time, taking 3.67 and 19.75% stocks limitations into account were quantified. With respect to Arak reactor redesign, the reactor configuration for plutonium production limitations was described and regarding section T of JCPOA, the prohibition measures for the

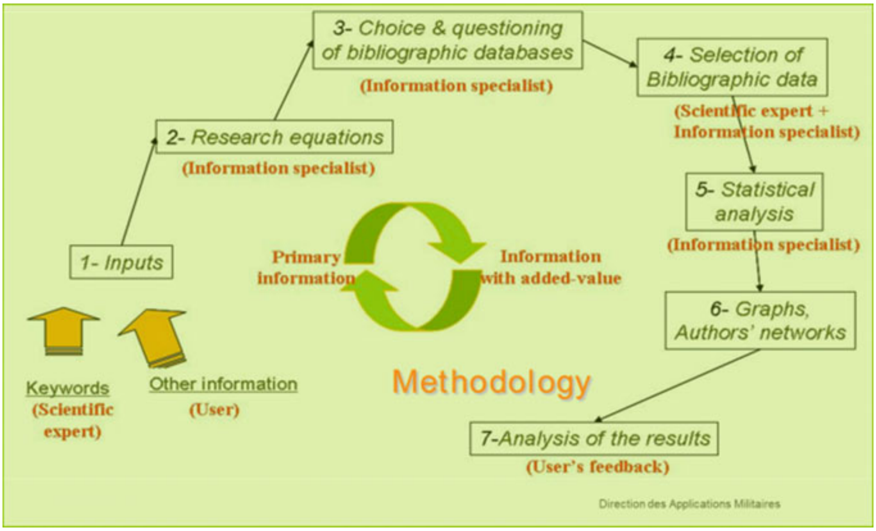

Fig. 17.5 A tool that helps: the bibliometry on scientific and technical literature

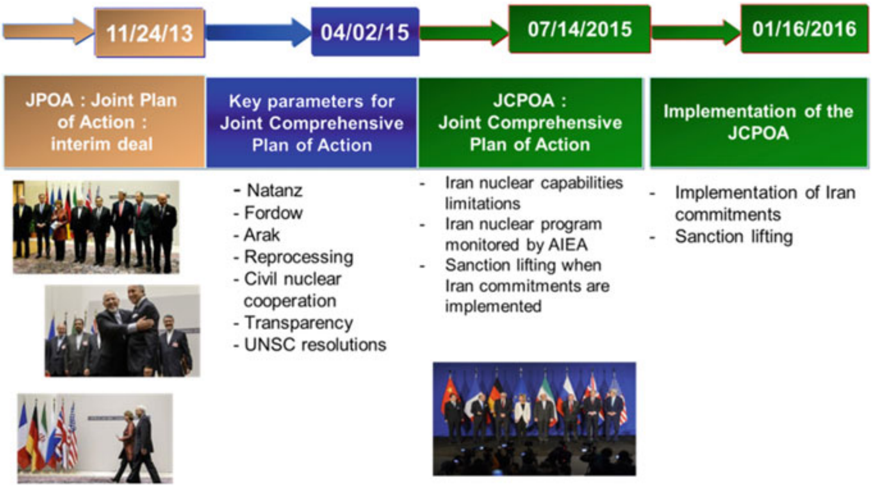

Fig. 17.6 CEA support to French MFA negotiators for E3/UE + 3 Iran deal: starting from JPOA to implementation and surveillance of JCPOA

development of a nuclear device were identified: metallurgy, computer codes, multi-point explosive detonation systems, diagnostic systems and neutron sources.

The first phase of the methodology for nuclear test monitoring is based, first, on pre-event monitoring, using intelligence information, open source and satellite imagery. The detection of a nuclear test uses national technical means but also incorporate CTBT (see Fig. 17.7) and other raw data on selected stations. To locate and identify if it is an explosion or an earthquake, other stations of interest are incorporated and satellite images (pre and post event) are acquired if necessary. Then, to characterize the magnitude, depth and yield, available data (seismic, imagery …) are fused. Finally, radionuclide data are used to assess the nuclear nature of the event.

Figure 17.8 compares two waveform spectra registered from 2016 and 2017 nuclear tests carried out by North Korea. This comparison helps for rapid and robust seismic detection, characterization, depth determination, yield estimation and assessment of DPRK’s statement There are large uncertainties on the North Korean nuclear weapons program. The nuclear material used, uranium or plutonium, is still unknown, as well as the nature of the device, even if Kim Jong-un claimed (see Fig. 17.9) that a thermonuclear device was tested on September 3 2017.

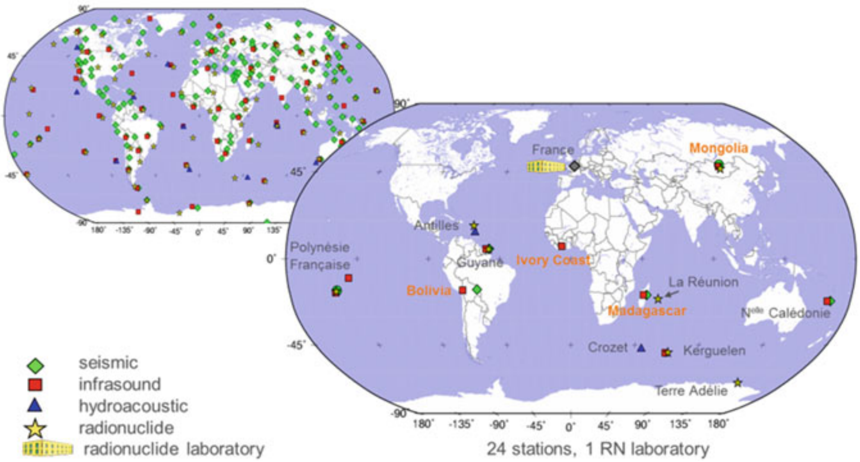

Fig. 17.7 CTBT stations operated by France

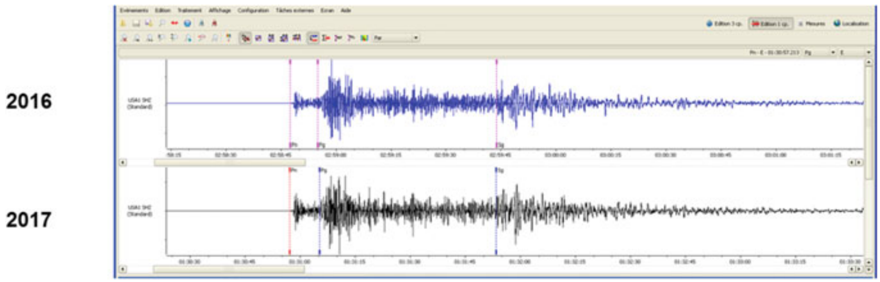

Fig. 17.8 DPRK nuclear tests comparison: detection and characterization

Fig. 17.9 Kim Jong-un

Taking the history of proliferation into account, in particular the current North Korea case, it appears that, to efficiently fight against proliferation, there is a clear need for better anticipation to avoid « le fait accompli » .. Stronger evaluation of the real status of the country's nuclear programs and their real capabilities is needed as well as a more efficient monitoring. Diplomatic action and negotiation, whenever it is possible and as soon as possible, is key and international cooperation, that gives the opportunity to share validated information, is needed. The best nuclear expertise (fuel and weapon cycles knowledge, development of highly sensitive sensors….) is also key. Finally, it is important to stress the central role of the IAEA inspections.

Chapter 18
The Israeli National Perspective on Nuclear Non-proliferation

Merav Zafary-Odiz

Israel is subject to multiple regional threats. In Israel's view, since its threats are regional in nature, non-proliferation issues are closely linked to the regional context. It therefore considers mostly regional considerations rather than global ones when devising its non-proliferation policies. A longstanding policy since the 1960s, supported by all Israeli governments since its inception, is that Israel will not be the first to introduce nuclear weapons to the Middle East. Accordingly, Israel conducts a responsible policy of restraint in the nuclear domain. Israel's approach to nuclear testing is a relevant case in point. Actual and potential regional threats to Israel, as well as Israel's uniquely narrow security margins, mandate that any arms-control-related measure has to be closely linked to regional security, while addressing the threat perceptions of all regional parties.

Israel is fully committed to non-proliferation of nuclear weapons, and to participation in international efforts to prevent their spread. Israel thus recognizes the value of the Non-Proliferation Treaty, and supported its adoption in 1968 in the UN General Assembly. However, a global regime like the NPT has limited relevance in the Middle East. Its weakness in the Middle East has been demonstrated by four cases of violations of the Treaty's basic obligations, namely by Iraq, Libya, Syria and Iran. Syria's use of chemical weapons is another case in point, as this is a recent use by a Middle Eastern country of Weapons of Mass Destruction.

Based on the poor track record of NPT compliance in the region, Israel does not see NPT membership as a goal in and of itself, but rather as potential means for enhancing security for all states. In this regard, Israel does not believe that NPT membership serves or would enhance its national security. Rather, Israel believes that in due course a regional solution lies in the establishment of a mutually, effectively, and comprehensibly verifiable zone free of Weapons of Mass Destruction (WMDFZ). However, this noble idea is unfortunately detached from

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the volatile regional realities. It is clear that the prerequisites for regional discussions on such a zone, such as mutual recognition, do not currently exist in the Middle East, where the majority of Arab States, as well as the Islamic Republic of Iran, do not even recognize the existence of the State of Israel, and some even openly and explicitly threaten to destroy it. Two relevant examples are the non-participation of Israel in its natural geographical regional group in the IAEA, i.e. MESA, as well as the non-functioning of the MESA regional group, to which Israel belongs by Treaty's definition, in the context of the CTBTO Preparatory Commission.

Israel has a strict export control legislation, overseen by the Ministry of Economy and Industry. The Israel Atomic Energy Commission has an advisory role, as well as the Ministry of Defense and the Foreign Ministry. Since 2004, Israel's export control regulations and legislation include relevant export control lists, including the trigger and dual use lists of the Nuclear Suppliers Group (NSG). Israel maintains an interest to become a future Participating Government in the NSG, based on its non-proliferation credentials. It has not yet taken practical steps for this purpose. Israel's basic position has been that membership of non-NPT states in the NSG should be based on a criteria-based approach.

Israel's non-proliferation credentials are many, and include, inter alia, the following:

- Israel fully supports the implementation of UNSC Resolution 1540 and its extension Resolution 1977, and reports in accordance with their requirements.
- Israel endorsed the Proliferation Security Initiative (PSI) aimed to prevent nuclear smuggling.
- Israel signed the Comprehensive Nuclear Test Ban Treaty (CTBT), is participating actively in the work of the PrepCom and its Provisional Technical Secretariat, and supports a moratorium on nuclear testing pending the entry into force of the Treaty.
- Israel has joined the Convention on the Physical Protection of Nuclear Materials (CPPNM) and its 2015 amendment.
- Israel signed the Convention for the Suppression of Acts of Nuclear Terrorism.
- Israel participated in the Nuclear Security Summit (NSS) process. In the context of the NSS process, Israel joined a few initiatives and gift baskets, and submitted national progress reports. Israel is an active participant in the Nuclear Security Contact Group (NSCG).
- Israel joined the Global Initiative to Combat Nuclear Terrorism (GICNT), and has actively participated in a variety of political and technical activities within the framework of its work plan. In 2010 Israel hosted a GICNT workshop on nuclear forensics and legal aspects.
- Israel has provided financial and in-kind contributions in the field of nuclear security, including to the IAEA Nuclear Security Fund, and is a member of the IAEA's Nuclear Security Guidance Committee (NSGC).
- Israel is registered in the IAEA's Response and Assistance Network—RANET.

- Israel is an adherent to the Nuclear Suppliers Group (NSG) and the Missile Technology Control Regime (MTCR).
- Israel joined several IAEA conventions and codes of conduct in the field of nuclear safety and security, including nuclear emergency response. Examples include the Convention on Early Notification of a Nuclear Accident, the Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency, and the Codes of Conduct on the Safety and Security of Radioactive Sources, and the Safety of Research Reactors.
- Israel participates in the IAEA Illicit Trafficking Database (ITDB).
- Israel actively participates in the US Second Line of Defense Initiative, aimed at detecting radiological materials at its sea ports. Operational detection systems are installed in Israel's two major seaports.
- Israel actively participates in the IAEA Safety Standards Committees (NUSSC, RASSC, TRANSSC, WASSC), including the Commission on Safety Standards (CSS).
- The IAEA completed successfully an Integrated Nuclear Safety Assessment of Research Reactors (INSAAR) mission in Israel's IRR-1 in July 2013.

The presentation outlined five major non-proliferation challenges. The first major challenge relates to Iran's persistent strategic aspirations to acquire nuclear weapons, coupled with its ballistic missile program, terror support, and destabilizing regional behavior.

Iran's track record of concealment and engagement in weapons-related activities has been elaborated in the IAEA Director General's reports on the Possible Military Dimensions of Iran's Nuclear Program. It is important to note that those reports detailed many open issues that still remain until this day. The so-called "closure" of this file by the IAEA Board of Governors was merely a political act in order to pave the way for the nuclear deal, and not in any way a judgment made by the IAEA. Against this background, Israel stresses that Iran has not abandoned its strategic goal to acquire nuclear weapons. Israel therefore believes that Iran's decision to join the Joint Comprehensive Plan of Action, known as the JCPOA, is merely a tactical pause. In fact, the JCPOA does not block Iran's path to a nuclear bomb, but creates a path to Iran for having many atomic bombs, by allowing Iran to continue developing advanced centrifuges. This could also provide Iran with the potential and the capability to pursue a clandestine route to nuclear weapons in a short period of time using those advanced, more efficient, centrifuges. JCPOA "expiration" is around the corner. In a few years, there will be no limitations on Iran's nuclear program. This will allow Iran, for example, an industrial-size enrichment capability that could produce the necessary fissile material for dozens of atomic bombs in a very short time. Iran could therefore enrich more uranium to higher levels more quickly, thereby cutting to merely several weeks Iran's breakout time, i.e. the time it will take to accumulate sufficient fissile material for a nuclear weapon. On top of all the above, Iran constantly declares its intention, and explicitly threatens to destroy Israel (even in Hebrew letters on its ballistic missiles). This demonstrates once again the reason for Israel's perspective that places the Iranian nuclear program as the number one non-proliferation challenge, currently and in the future.

The second challenge concerns Syria's nuclear program. This is an unfinished business, since the IAEA's investigation has never been exhausted due to lack of cooperation from Syria. As is well known, Syria built jointly with the DPRK a clandestine nuclear reactor, which was revealed and destroyed in 2007. Had this nuclear reactor been completed and operated, it would have been ideally-suited to produce plutonium for nuclear weapons purposes. Needless to say, the construction of such a reactor was done in blatant violation of Syria's NPT safeguards obligations, as it should have been declared to the IAEA. In June 2011 The IAEA Board of Governors adopted resolution Gov/2011/41, which found that Syria's undeclared construction of a nuclear reactor at Dair Alzour, and failure to provide design information for the facility constituted, "…non-compliance with its obligations under its Safeguards Agreement with the Agency in the context of Article XII.C of the Agency's Statute." As indicated in the Director General's multiple reports, Syria has not engaged substantively with the Agency on the nature of the Dair Alzour site and other relevant locations. Israel views this matter as an urgent one in light of the presence and activities of non-state actors within Syria, and their eagerness to acquire knowledge, capabilities, and equipment, relevant for use in unconventional weapons.

The third non-proliferation challenge concerns potential proliferation from the DPRK to the Middle East. After its cooperation with Syria to build a secret nuclear reactor, Israel is concerned about future potential cooperation in the nuclear domain and other weapons of mass destruction with state and non-state actors in our region.

The fourth challenge in Israel's perspective concerns nuclear energy in the Middle East. In recent years there is a growing interest in the construction of nuclear research and power reactors in our region. There are three possible motivations for this growing interest: The first is a real need by regional countries for a cheaper and clean energy source. The second possible motivation relates to various domestic considerations, such as regimes' interest to talk about energy independence and diversity, including nuclear energy. This also relates to national prestige, to be among the few countries in the region who utilize nuclear energy for peaceful purposes. Lastly, there is a perception of a need to introduce nuclear technology as part of a larger effort to engage with advanced technologies. The final, and most concerning motivation for the growing interest in nuclear energy is to create a potential for a future nuclear military program. In view of the region's negative track record concerning compliance with the obligations of the NPT, we must treat the risk of diversion as a realistic one.

Aside from the obvious risk of a potential diversion from peaceful facilities to military ones, additional concerns are related to safety and security matters, such as the increased risk of illicit trafficking of nuclear materials, as well as a concern that relates to internal stability in some of the countries in the region.

Having said all that, Israel does not object to the peaceful uses of nuclear energy in the Middle East, conditioned upon:

- Its guaranteed exclusive use for peaceful purposes;
- Complete respect by countries that would like to embark on a nuclear energy program for relevant international non-proliferation obligations and commitments. It is Israel's strong view that joining the Additional Protocol is a prerequisite for the supply of nuclear technology to new countries.
- Fuel cycle technologies, which are THE proliferation risk, must absolutely be avoided. First, the suppliers should avoid the sale of any such technologies to new countries. Second, regional countries themselves must commit not to build or purchase such technologies as a condition for the supply of nuclear reactors.
- Certain nuclear reactors should be supplied as a "black box", according to the BOO model (build-own-operate). By certain reactors we mean those that are more proliferation resistant (light water, low enrichment fueled reactors). In order to sustain a black box model, the supplier has to guarantee a life-time fuel supply. It is also necessary to agree in advance on solutions for spent fuel take-back.
- Finally, the buyer country must commit to adopt and implement international standards for nuclear safety and security.

The final major non-proliferation challenge in Israel's view generally concerns the presence and active involvement of non-state actors in our region, which pose a potential nuclear security threat. Non-state actors already pose a direct threat to Israel's national security, having been a victim of terrorist and rocket attacks against civilian population. Some regional non-state actors enjoy state support as they are actively supported, funded and trained by the Islamic Republic of Iran. Additionally, they possess a large number of rockets and missiles, which cover the entire territory of the State of Israel. Non-state actors' interest in getting access to non-conventional weapons is a serious threat and challenge in Israel's view. For its part, Israel has taken comprehensive measures to reduce the risk of theft or sabotage in its nuclear centers, as well as radiological materials used in medicine, industry and other sectors.

Part VI
Topics of Nuclear Non-proliferation: Present and Future Challenges—Part 2

Francesco Calogero, Ali Akbar Salehi, Khalid Ahmed Kidwai and Harald Müller

Chapter 19
Introduction

Francesco Calogero

This session was devoted to an overview by Dr. Ali Akbar Salehi of the Iranian nuclear-weapon nonproliferation policy, by General Khalid Ahmad Kidwai of the nuclear-weapon policy of Pakistan, and by Professor Harald Muller of the general international status of the nuclear nonproliferation issue.

Dr. Salehi-drawing on his detailed knowledge of the nuclear policy of Iran deriving from his position as President of the Atomic Energy Organization of Iran and main negotiator of the Joint Comprehensive Plan of Action (JCPOA), but speaking in his personal capacity as traditionally done at Amaldi Conferences-provided a detailed survey of this topic, including the status of the JCPOA. In answer to a question from the floor, he reiterated the commitment of Iran to complete compliance with the JCPOA-as confirmed by the International Atomic Energy Agency (IAEA)-but also explained that, should another state member of the JCPOA agreement walk out of the commitments implied by that agreement, Iran might also reconsider its position, a final decision on that matter resting with the top authorities of his country.

General Kidwai-drawing on his experience as main supervisor of the development of the Pakistani nuclear forces and of the strategic motivation of that development-provided a clear presentation of the nuclear weapon policy of Pakistan, with particular reference to the need to deter via the presence of nuclear weapons a catastrophic war among India and Pakistan.

Professor Muller provided a lucid survey of the international situation concerning the nonproliferation of nuclear weapons, expressing his concern about the continued reluctance by the nuclear-weapon countries to make significant progress towards the eventual achievement of a nuclear-weapon-free world, thereby demonstrating their reluctance to fulfil their part of the deal underlining the Non Proliferation Treaty (NPT); hence the risk of an eventual, catastrophic collapse of the NPT.

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Chapter 20
The Iranian National Perspective on Nuclear Non-proliferation

Ali Akbar Salehi

Mr. Chairman, Excellencies, Ladies and Gentlemen,

It is a distinct pleasure to join all of you in this important Conference. Let me, at the very outset, seize the opportunity to express my deep appreciation to the organizers of the Conference for the kind invitation. Dedicated to the commemoration of the scientific work and achievements of the late Professor Amaldi, the very title and the work program of the Conference points to its relevance to the wide range of serious issues the international community is grappling with in the field of nuclear industry and related activities.

Mr. Chairman,

Addressing a Conference of this kind and caliber—with quite a strong scientific content and yet placed in the context of on-going political discussions, puts me in a very challenging situation. At one level, finding myself in the company of fellow nuclear physicists gives me an academic feeling to delve into theoretical discussions. Yet at another level, under my current hat at the Atomic Energy Organization of Iran, I have to focus on concrete issues and situations, which, interestingly enough, happen to be a matter of common concern to all of us. Hence, nothing these days appears to be more pressing and critical than the fate of the Iran nuclear deal—JCPOA. So, that constitutes the thrust of my remarks here today; what it means for us and presumably for the international community.

Mr. Chairman,

Despite the fact that Iran's original interest in the nuclear industry dates back to the post-WWII "Atom for Peace Program" era, its nuclear program is yet at a humble stage in comparison with the state of the industry in more advanced countries. At this point, I would only limit myself to presenting a sketchy, broad brush of major turning points in the development of our nuclear program. The construction of Tehran Nuclear Research Reactor in 1967—which is still operative

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—laid the foundation for our nuclear activities in this area. Subsequent commercial nuclear negotiations with the United States in early 1970s and later more serious collaborative efforts with France and Germany, eventually, proved inconclusive, especially in the wake of Saddam's aggression against Iran in September 1980, and thus the program came to a practical halt. Soon after the end of the War in 1988, the interest in reviving the peaceful national nuclear program re-emerged as a matter of priority in the minds of our political leadership.

Drawing on the past experiences, especially in light of the sanctions imposed on the country following the victory of the Revolution in 1979 as well as during the 8-year Iran- Iraq War, the need for achieving self-reliance in most strategic domains including the nuclear one became an important component of Iran's policy making. The efforts towards starting uranium enrichment to provide the needed fuel for the reactors came from those perceptions and convictions, which coincidentally led to serious disagreement with major western countries. The drama that unfolded as of mid-2002 around the alleged enrichment activities at one of our nuclear sites called the Natanz Facility pushed the issue of Iran's nuclear program on the international scene into a highly-politicized propaganda campaign. That episode, and its later developments, in and out of the IAEA, are now history, and fully known to all those in the say.

The 2003–2005 period of negotiations on the nuclear program between Iran and the three European countries, which also involved close working relations with the Agency, tried to resolve the outstanding issues and remove the then existing misunderstanding on and around our peaceful nuclear program. The Supreme Leader's religious decree (fatwa) on the prohibition of production, deployment and use of nuclear weapons, similar to other weapons of mass destruction, also played its critical and determining role in this regard. Looking back, one cannot but lament that the two-year negotiations proved inconclusive, which as everybody knows, came about as a result of the US negative attitude and exertion of pressure on European interlocutors, and also on the Agency, through raising a wide range of contentious issues and allegations, including Iran's involvement in activities with possible military dimensions. Later, however, IAEA reports disproved all those allegations.

The failed negotiations during the 2003–2005 period pushed the nuclear dossier out of the IAEA and into the UN Security Council with its chain of sanctions resolutions, and led to a long, almost 8-year period of subsequent futile negotiations. All throughout this period, the U.S pursued its negative stance and the policy of "zero enrichment"—which was obviously simply unacceptable to Iran and a non-starter for all practical purposes. Iran's actual response to the US obstinate and impractical position and demand was to rely instead on "resistance and strategic endurance."

Distinguished Colleagues,

The US-imposed impasse in the negotiations, with all its ensued negative consequences, finally led to a change of outlook within the American body politics specifically during President Obama's second term. The obviously futile imposition of the so-called "zero enrichment" dogma gave way to a more pragmatic, solution-oriented approach in Washington, which, coincidentally, found its counterpart in Iran following the June 2013 election of President Rouhani. The quite interesting and I should say, equally exciting and challenging negotiations ultimately culminated in a promising, win-win nuclear deal called the JCPOA. A deal that ensured Iran's inalienable statuary rights and privileges as stipulated in the NPT.

Mr. Chairman

That's just a brief overview of what transpired on and around our peaceful nuclear program. The nuclear deal certainly ushered a new era of engagement between Iran and the international community at large. And the way it was achieved signify the irreplaceable reliance on innovative science diplomacy and political negotiations as the preferred option for and means of resolving international disagreements and disputes. It also served as a conduit for confidence-building, in very practical terms, between the Islamic Republic of Iran and the western countries, even including the U.S.—notwithstanding the lack of political and diplomatic relations between the two countries for almost four decades and preponderance of mutual suspicion and mistrust.

Furthermore, the nuclear deal has so far provided the opportunity for Iran to exercise, in accordance with the provisions of NPT, its full peaceful nuclear activities unhampered and expanding further its acquired capabilities in other domains such as agriculture, industry, and health. Given the traditional, and long-standing reliance of the Iranian economy on fossil fuels, and the imperative of gradual and progressive reduction of such reliance, including for globally-shared environmental concerns and considerations, Iran definitely needs to make its basket of energy sources more diverse. Production of clean, safe nuclear energy should play its due and expected role in this regard. Based on such IAEA models as LEP, MESSAGE, ETSAP and WASP, consideration of 8–12% nuclear energy in the mixed energy basket of Iran seems justifiable.

Mr. Chairman

Apart from the overall merits of JCPOA—whether for Iran or for the other parties—it is reasonable to argue that its faithful implementation, as envisioned in the text of the agreement, will serve a set of other purposes, including the strengthening of NPT. In the mean time, it has affected the perception of achieving a better balance among the three main pillars of the Treaty; namely non-proliferation, peaceful cooperation and comprehensive disarmament. The potential contribution to the first two pillars hardly needs any further elucidation; they almost look like fait-accompli, especially in so far as contribution to non-proliferation is concerned. The progress thus far achieved between Iran and other countries with regards to peaceful cooperation is promising and moving in the right direction.

As far as the third pillar is concerned, the JCPOA would be further strengthened if the establishment of a comprehensive disarmament as well as the Nuclear Free Zone in the Middle East is materialized.

Excellencies,

This overall assessment of the merits of the JCPOA brings me to the important and practical point of how to protect and preserve the deal in the interest of the partners as well as the larger international community. The hard-won agreement, in which I was personally engaged, especially at its technical level is simply too precious to be allowed to be undermined or weakened. In contrast to the US administration's negative perception, there is a clear picture and understanding of the accord and its related commitments in Iran. We believe that the entire international community also shares a similar outlook.

The unfortunate trend across the Atlantic since the new American administration took office early this year especially the recent delusionary negative postures do not augur well at all. As stated dubiously, for instance, the US administration pretends that the most glaring flow of JCPOA is its sunset provision. While we believe that a similar negotiation without a sunset or timeline is not a negotiation anymore; rather it is an utter submission.

To conclude, I would like to make solid clear that we do not want to see the deal unravel. However, much more is at stake for the entire international community than the national interests of Iran-where the US wishes to harm- if the deal is dissolved.

Needless to say, that the US withdrawal from the deal would seriously affect Iran's state of politics in this regard. Moreover, it's worth mentioning that the failure of the nuclear deal, undoubtedly, will undermine the political credibility and the international stature of the US in this tumultuous international political environment. Should the JCPOA survive out of the current odds and turmoil the way will be paved for the resolution of other major similar international issues in the future. Let's hope that under these circumstances, commonsense and discretion shall prevail.

I thank all of you for your kind indulgence.

Chapter 21
The Pakistani National Perspective on Nuclear Non-proliferation

Khalid Ahmed Kidwai

I would like to thank the sponsors of the Amaldi Conference for providing me an opportunity to speak on the Pakistani national perspective on nuclear nonproliferation. I shall make a short presentation on the subject including steps that Pakistan has taken in the area of nuclear security, and briefly touch upon the related geo-political aspects arising out of the nuclearization of South Asia. Later, I look forward to answer your questions.

The areas where Pakistan has instituted measures in the broader realm of nuclear non-proliferation and nuclear security are legislative, legal, regulatory, institutional development, operational and enforcement, and international cooperation.

In the contemporary world, for many years now, concerns about nuclear non-proliferation and security have taken center stage as the most potent and potential threat to international order. This forum is fully aware of the serious implications of any weakness in this area anywhere in the world. No amount of effort expended in ensuring the highest standards of nuclear security by countries that are in possession of nuclear materials or capability can ever be enough.

It is with this very clear understanding that Pakistan as a responsible nuclear power, and the Strategic Plans Division or the SPD as the focal arm of the Pakistani Government on all matters nuclear have approached the subject of nuclear non-proliferation and security while planning and implementing various security measures and protocols.

When Pakistan became a nuclear power in May 1998, its first priority was to ensure that its nuclear capability was credible and effective so as to signal the right deterrence messages. Concurrently, an institutional national command and control system was put in place to ensure that all nuclear assets, materials, facilities and personnel were safe and secure under the tightest state control, invulnerable to any

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kind of proliferation. In the last 18 years, this has been the guiding philosophy for Pakistan and its nuclear managers.

By 1999 i.e. within one year of having conducted nuclear tests in response to the Indian nuclear tests of May 1998, Pakistan was successful in institutionalizing all aspects related to the management of our nuclear capability. In this context, we put in place:

- A Command and Control mechanism.
- Strategic Force Development Strategy.
- Strategic Forces in the three services which today are fully equipped, trained and operationalized.

Command and Control Structures. Pakistan's national Command and Control structures are generally familiar by now but I shall briefly recapitulate the essentials. The C2 is structured under three Constituents:

- Constituent 1—National Command Authority (NCA).
- Constituent 2—Strategic Plans Division (SPD).
- Constituent 3—Strategic Forces Commands.

Constituent-1. The NCA comprises of nine important decision makers of the country and includes the political and the military leadership. The Chairman is the Prime Minister. The members include four Federal Ministers i.e. Defence, Foreign Affairs, Finance and Interior, and from the military, the Chairman Joint Chiefs of Staff Committee and the Chiefs of the Army, Navy and the Air Force. The Secretary is the Director General of the Strategic Plans Division. The NCA is the apex decision making body on all nuclear matters.

Constituent-2. The SPD is a one window secretariat to the NCA. It conceives, develops, monitors, and manages Pakistan's nuclear, and space programmes on behalf of the NCA. It is headed by a three star General from the Army.

Constituent-3. Strategic Forces Commands have been raised in all the three services. Their control rests entirely with the NCA through the SPD.

Pakistan attaches the highest importance to nuclear non-proliferation and nuclear security. As generic evidence, in the last 18 years, despite a difficult internal security situation, none of Pakistan's nuclear facilities have faced any threat of proliferation or security because of the extra ordinary professionally conceived and implemented non-proliferation and security measures put in place by the SPD. These measures cover nuclear materials, infrastructure and personnel and have been successful in radiating the necessary deterrence effects against potential threats.

The Strategic Plans Division that I had the privilege of heading for over 15 years, conceived and developed a rigorous nuclear security regime simultaneously with speedy operationalization of the newly demonstrated nuclear capability. This was done comprehensively at the full spectrum levels i.e. strategic, operational and tactical within the broader concept of Credible Minimum Deterrence.

The SPD, through its Security and Intelligence Divisions, has incorporated stringent physical and technological solutions, runs a strict Personnel Reliability

Programme, and has developed security and intelligence capabilities to deal with all aspects related to nuclear security, including non-proliferation, insider and outsider threats and accidents.

A large security force, professional and agile, also includes a Special Response Force (SRF) which has a rapid air lift capability based on SPD's dedicated aviation resources. An integrated intelligence system has been instituted to provide depth in defense. Multi layered defence is the corner stone of Pakistan's nuclear security architecture and deploys a variety of physical and technological systems.

Nuclear security is not just about protecting nuclear assets and forces. It is a complete cycle of threat assessment, vigilance and response mechanisms. Pakistan created a comprehensive nuclear regulatory regime that encompasses not just physical protection of materials and facilities, but also fissile material control and accounting, transportation security, prevention of illicit trafficking, border controls, and plans to deal with possible radiological emergencies.

The Pakistan Nuclear Regulatory Authority (PNRA), an autonomous oversight body established in 2001, has developed a sustainable nuclear safety regulatory system for power reactors, and established response and recovery capabilities for radiological sources. The National Institute of Safety and Security works under the PNRA and trains professionals, technicians and managers in nuclear safety, security and radiation safety. NISAS, which was inaugurated by the DG IAEA in March 2014, conducts a wide range of professional training courses, workshops and on-job-training to build overall competency.

In 2004, Pakistan created a comprehensive export control regime. The legislative, regulatory, administrative and enforcement measures are at par with the multilateral export control regimes. We have revised the National Export Control Lists, on the basis of the European Union's integrated system, and harmonized them with the controls maintained by the NSG, Australia Group and MTCR. The National Detection Architecture also includes use of detection devices at several entry and exit points as well as other random check points to deter, detect and prevent illicit trafficking of nuclear and radioactive materials. The Integrated Cargo Container Control (IC-3) facility at Port Qasim near Karachi is a Container Security Initiative (CSI) compliant port.

When President Obama took the initiative in 2009 to launch a Nuclear Security Summit process, Pakistan welcomed the initiative. Since Pakistan equates nuclear security with national security, any measure to strengthen nuclear security was welcome as long as it remained a national responsibility and non-intrusive. Pakistan played a key role in elaborating the priorities of the Nuclear Security Summits and negotiating their outcome documents. Our contribution during the preparatory processes was positive and constructive. Pakistan participated in each Summit because it believed in the objectives of the NSS process and continues to abide by its obligations as a responsible nuclear weapons state.

As I said, nuclear security is a full spectrum and full cycle business. In 2012, we established Pakistan's dedicated Centre of Excellence for Nuclear Security Training which imparts security training based on international best practices and standards.

Some of the areas of training are Protective Force and Physical Protection, Security and Intelligence, Material Control and Accounting, Delay and Response.

At the Seoul Summit, the Prime Minister of Pakistan made the offer of utilizing the Centre of Excellence as a regional and international nuclear security training center. After some evaluation, the IAEA accepted the offer and today, the Centre of Excellence is functioning as a regional training hub on all nuclear security aspects. Senior international visitors to the Centre have appreciated the high standards of training developed by the Centre. IAEA Director General during a visit to the Centre in March 2014, said, “It is very impressive that you organize the training in a very systemic and operational manner.” The PCENS, the acronym by which the Center is now known, has hosted the annual meeting of Nuclear Security Support Center Network in March 2016, the first time that it was held outside IAEA Vienna. It was attended by 50 participants from 33 countries.

Pakistan has invested heavily in nuclear safety at the plant, corporate and regulatory levels. Following the Fukushima accident, we conducted a detailed assessment of the safety parameters, emergency preparedness and response, and operators’ training protocols and procedures. All authorizations since then require from the licensees to implement lessons learnt from the Fukushima accident.

In collaboration with the IAEA, we are implementing our Nuclear Security Action Plan (NSAP) to manage radioactive sources, secure orphan sources, detect radiation, and prepare for emergencies.

The SPD has also established a Nuclear Emergency Management System (NEMS) to address, respond and manage the complete spectrum of nuclear or radiological emergencies. Covering the entire range of activities, the system has state-of-the-art equipment, mobile labs, technical guidance provided by the PAEC and PNRA, and countrywide connectivity including with the National Disaster Management Authority.

Pakistan has regularly submitted reports to the UN Security Council 1540 Committee that list the measures we have taken for nuclear and radiological security as well as on controls over all forms of transfer of sensitive materials and technologies.

As a party to the Convention on Physical Protection of Nuclear Materials (CPPNM) and its 2005 Amendment, the Nuclear Safety Convention, the Convention on Early Notification of a Nuclear Accident, and the Convention on Assistance in the case of a Nuclear Accident or Radiological Emergency, Pakistan has been contributing to the nuclear security framework. Our consistent observance of the IAEA Code of Conduct and participation in the IAEA Incident and Trafficking Database (ITDB), have been highly useful. Pakistan has also ratified the CPPNM.

In recent years, Pakistan has been working with the Global Initiative to Combat Nuclear Terrorism (GICNT) in different areas, including the development of the Initiative’s guidelines on a nuclear detection architecture, nuclear forensics and response and mitigation.

I would say that, with the possible exception of NPT, no conversation on nuclear nonproliferation and nuclear security would be complete without Pakistan's participation.

Here, I would like to take the opportunity to underline that Pakistan fully qualifies to become a member of the Nuclear Suppliers Group and other multilateral export control regimes. Pakistan's nuclear trade is one hundred percent legitimate and therefore all impediments in its way need to be removed. Pakistan will not accept discriminatory treatment on this account.

Pakistan has a proven record spanning four decades of safe and secure operation of civilian nuclear power plants, which are all placed under IAEA safeguards. Pakistan needs alternative, clean and sustainable civil nuclear energy for its burgeoning industry and to meet growing consumer demand. Our National Energy Security Plan includes a Nuclear Energy Vision—2050 to redress the existing energy deficits and to respond to the future requirements of our economy. Under the Vision 2050, Pakistan has targeted to generate 42,000 MWe. Nuclear energy is therefore an essential part of our national energy mix.

With the foregoing credentials in respect of nonproliferation and nuclear security, Pakistan is justified in asking the international community that a politically discriminatory approach towards Pakistan be discarded and Pakistan be fully integrated in the international nuclear mainstream. This can best be done by removing restrictions imposed on Pakistan. In this regard, Pakistan looks forward to an equitable access to international civil nuclear cooperation. Pakistan has worked with professionalism with the international community to erect strong barriers against nuclear non-proliferation as a preventative measure in order to strengthen international nuclear security.

With its long and varied experience in the nuclear field, Pakistan's mainstreaming in the international nuclear order will enable it to contribute to power generation, non-power application of nuclear technology, nuclear security and nuclear safety, in collaboration with the IAEA. I would add that with an advanced nuclear fuel cycle capability, Pakistan is in a position to provide nuclear fuel cycle services under IAEA safeguards, and to participate in any non-discriminatory nuclear fuel cycle assurance mechanism.

That being said, I would also like to take this opportunity to clear the fog of what we think are biased labels about the future trajectory of Pakistan's nuclear capabilities. I would not go into the skewed studies that would have the world believe that Pakistan's modest nuclear programme is the fastest growing nuclear programme, which it is not. The methodology used by these so called studies to draw conveniently simplistic conclusions is not only seriously flawed, but these also generously ignore the cold realities of an ever expanding conventional, nuclear and, lately, ideological threat on our eastern borders. I shall very briefly flag the serious developments taking place in the neighborhood because of which Pakistan is compelled to take bare minimum safeguards:

- Increasing conventional forces asymmetry.
- Aggressive war fighting doctrines despite the presence of nuclear weapons in South Asia.
- The nuclear arsenal buildup.
- The expanding missile programme including Ballistic Missile Defence.
- Nuclearization of the Indian Ocean.

Suffice to say that Pakistan is compelled to maintain the credibility and effectiveness of its strategic deterrent, which includes a variety of weapons based on the policy of Full Spectrum Deterrence remaining within the larger philosophy of Credible Minimum Deterrence. This Pakistani capability ensures the retention of a strategic equilibrium in South Asia, and has neutralized the use of the military as an instrument of policy, ruling out war as an option. It stands to reason therefore that the credibility of Pakistani nuclear weapons has contributed to deterring war thereby ensuring that peace, howsoever fragile and unstable, will prevail in the region. That the space and opportunity created by the presence of these weapons has not been taken up by dynamic and bold political initiatives for dialogue leading to conflict management and eventual resolution is a reflection of an unfortunate intellectual bankruptcy; acceptance of living with an unstable status quo between two nuclear powers is dangerous policy and strategy. It potentially threatens world peace.

It is therefore important for the international community to realize that feeding and further fueling discriminatory policies into the strategic dynamics of South Asia are dangerous and counter-productive and will only aggravate the existing imbalances. One can take the example of the Indo-US Nuclear Cooperation Agreement of 2008, and the consequent NSG exemption granted to India. Whatever dubious political or commercial benefits the parties to the arrangements may have drawn, these have caused harm to the international nonproliferation norms by legalizing exceptionalism. These have only served to strengthen Pakistan's resolve to find appropriate solutions to offset the fallout of those Agreements.

Similarly, attempts to isolate Pakistan through one sided and discriminatory criteria in judging the applications for NSG membership will not work. Pakistan has worked hard as well as, if not better than, any other country to establish its credentials as a responsible nuclear state and meets the necessary criteria to be a member of the nuclear export control regime. Our continued outreach and fruitful engagement with the NSG Troika has established that. Unfortunately, goal posts continue to be shifted to suit predetermined geopolitical objectives in an export control regime which is governed by technical criteria alone. Such an approach is not only discriminatory but will further introduce negative consequences in South Asia.

If lessons are to be drawn from the policy of exceptionalism of 2008, one of them would be that discrimination doesn't work. Secondly, if discrimination doesn't work, Pakistan will find solutions to offset the effects that the discrimination will generate. Third, efforts to isolate Pakistan will further reinforce the perception that Pakistan is always subjected to double standards and must therefore look out for itself in every which way; which it will.

History bears testimony to the fact that Pakistan has always shown resilience in facing challenges. My submission therefore is that all applications for membership to the NSG should be judged on the basis of non-discriminatory objective criteria alone, and not through the prism of geo-political expediencies.

As the experience of the last 18 years shows, the nuclear capabilities of both India and Pakistan have sufficiently developed and matured to a point where a delicate strategic balance exists in South Asia. In my judgment the era of kinetic hot wars is behind us. A repeat of 1965, 1971 or even 1999 is unlikely. In South Asia today we go through alternating cycles of strategic stability and strategic instability. What is replacing the era of hot wars is a new era of an unnecessary cold war. I doubt if that is a wise way to go. Notwithstanding the interjection of conflicting interests of global powers in Asia with concurrent fallout in South Asia, India and Pakistan as responsible nuclear powers, struggling to develop their economies to fight poverty, must manage and resolve their many differences to move ahead. Zero sum games only lead to zeroes.

In a positive sense, the nuclear capabilities of both sides have put a check on unfettered politico-military options for either side. Pakistan has invested in the development of its Full Spectrum capabilities precisely with the objective of out-lawing war as an instrument of policy. This investment ensures that peace prevails in South Asia. The larger question then is: does this bring about strategic stability? The answer is both yes and no. Yes because outbreak of war is deterred. No because the region remains on edge at the slightest provocation on either side leading very rapidly to the raising of the specter of a nuclear holocaust. Given the foregoing environments, strategic stability in South Asia can at best be described as a mirage, a seriously deceptive mirage, which, if not managed prudently, can be disastrous for the region and for the world.

Having given the Pakistani national perspective on nuclear nonproliferation, nuclear security and the related geopolitical dynamics of South Asia, I would conclude by leaving a question as food for thought.

For how long will a directly affected world allow the stability-instability paradox to persist in nuclear South Asia? Indefinitely, perhaps, in the hope that it will be able to diffuse crisis after crisis each and every time, year after year? Or, definitely by encouraging with far greater political will than that has been displayed so far for both sides to sit together to resolve conflicts through sustained and meaningful dialogue. Sitting on a nuclear powder keg for all times is a dangerous option.

Chapter 22
The Future of the Non-proliferation Treaty

Harald Müller

The Nuclear Non-proliferation Treaty (NPT) is generally regarded as the key pillar of the world nuclear order Walker [1]. With its 188 parties, it is the most universal arms control treaty in world history. Its basic philosophy is that nuclear war is a global calamity that must be avoided and that nuclear war becomes all the more likely the more states possess nuclear weapons and the more dyads of nuclear armed states watch each other with distrust and fear weary that the opponent may try to attack with surprise to disarm the victim's deterrent. In such a world, every single political crisis would open the specter of a nuclear holocaust. The NPT was meant to prevent this world from emerging by stopping the number of nuclear weapon states at five, the number existing officially when the negotiations for this Treaty started earnestly in 1968.[1]

The NPT constitutes a historical anomaly. In the political history of mankind, political units from nomadic hordes to territorial states always strove for the most powerful weapon of their time within the boundaries of their own resources. Through membership in the NPT, in contrast, most states renounce most powerful weapon of their time, while a small minority is permitted to possess them temporarily, and a few more states have acquired them as non-members of the NPT. In other words, the Treaty constitutes an unequal world—at least for the time being.

Such inequality creates the inevitable impulse to get back to a level playing field. This impulse is not uniform and simultaneous for all countries at all times, but occurs with considerable regularity: one or the other government considers, embarks on, and sometimes brings to end, a program of activities geared towards the acquisition of nuclear bombs. In the nuclear age, no less than 37 cases of such

[1] In fact, at the time the real number as already six, as Israel obtained its first operation nuclear weapons most likely not later than 1967.

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consideration, embarking, or completion have become known. The value of the NPT can be deduced from the fact that the overwhelming number of these cases started before the Treaty entered into force, and the overwhelming number of renunciations occurred when he was in force. Obviously, the NPT provides a framework in which renouncing these weapons is supported by the dominant normative and legal framework Müller and Schmidt [2].

Catching up with the nuclear Joneses by the many, however, is not the only way to create equality. Disarmament by the few is the obvious alternative, and this path is prescribed in Article VI of the NPT which obliges all parties to the NPT to terminate the nuclear arms race and to embark in good faith negotiations towards nuclear disarmament. The International Court of Justice (IGJ) has clarified in an Advisory Opinion in 1996 that good faith requires that negotiations are pursued in a way that they are brought to a successful end. It is for this reason that I have mentioned above that the NPT's inequality is "temporary" "for the time being".

The said inequality has three dimensions. First, there is the unequal distribution of rights and duties of the parties to the NPT; this dimension distinguishes the NWS from the NNWS. NWS, as mentioned, are permitted for the time being to possess nuclear weapons, NNWS are prohibited from acquiring and possessing them. Thus, the NPT distributes military power unequally among its membership.

The second dimension concerns the precision by which duties are defined. The prohibition for the NNWS is relatively clear (even though what "development" and what "nuclear weapon" means is not defined). In addition, this prohibition is to be verified by the International Atomic Agency (IAEA), and what verification entails is detailed in two lengthy documents, the Comprehensive Safeguards Agreement which is obligatory for all NPT NNWS, and the Additional Protocol with even farther reaching and more intrusive rights for the inspectors which is yet voluntary. In contrast, the disarmament obligation in Art. VI is vague. Neither the time frame is prescribed, nor are the steps that are obligatory clearly stated.

The third dimension concerns the procedures for addressing non-compliance disputes and enforcement decisions. These procedures empower the NPT NWS through their UNSC permanent seats, since the UNSC, reading the NPT, the Comprehensive Safeguards Agreement, and the IAEA statute in their mutual relationship, is put in the role of the ultimate arbiter in non-compliance cases under international law. This situation has been described sarcastically as the alcoholics empowered to ensure abstinence.

There is a fourth type of inequality which must be noted, an inequality of a regional kind: The inequality in the conflict-ridden region of the Middle East, where Israel is the single nuclear weapons possessor, even though the Israeli government has never officially claimed to be in this position. This regional inequality triggered the same impulse for catching up, and led no less than four regional states to make attempts to do so: Libya, Syria, Iraq and Iran. Like at the global level, there is a regional approach to create equality by disarmament and regional diplomacy. This is the motivation for the regional project of a Nuclear Weapon (or Weapons of Mass Destruction) free zone in the Middle East Müller and Müller [3].

These inequalities and the feelings of injustice they are inducing are at the roots of three crises Becker et al. [4] which characterize the present relationships within the Treaty regime: a crisis of compliance, a crisis of confidence, and a crisis of leadership.

Currently, the NPT is facing two serious compliance problems concerning the core of the NNWS undertakings. The first concerns the Democratic People's Republic of Korea (DPRK), the second one the Islamic Republic of Iran.

North Korea left the NPT in 2004 after having cheated on its undertakings by running a nuclear weapons program while the country was still a party to the Treaty. In response, the international community, led by the United Nations Security Council (UNSC) pursued a double strategy of sanctions and diplomacy. The strategy was compromised by the opposite geopolitical interests of China and the US in East Asia. The fact that the DPRK is an ally of China in the struggle for regional and global leadership dissuaded Beijing from imposing pressure that could lead to regime collapse. Apart from the fear of regional destabilization, the prospect of Korean re-unification under South Korean leadership implied the nightmare of US armed forces in immediate neighborhood of Chinese Borders. China agreed to sanctions, but insisted on limitations. The stubborn pursuit of nuclear weapons by the DPRK and nowadays the brandishing of these arms and utterance of wild threats not only against the United States, but also against South Korea and Japan, two NPT NNWS, constitute the most blatant case of defiant proliferation against the spirit and letter of the NPT so far.

Iran—the second serious non-compliance case, failed to comply with its obligations under its safeguards agreement with the IAEA for more than a decade, after it had re-started its nuclear program in the mid-eighties after the experience that Iraq's use of chemical weapons did not provoke any international response while, to the contrary, East and West continued to prop up Iraq's military power, including supplies which were used in Saddam Hussein's weapons of mass destruction programs.

2002, it became known through the revelations by an Iranian resistance group that the country had started a clandestine program for uranium enrichment. In the following dispute Teheran was first ready to cooperate, but after the election of President Ahmadinejad defied a series of UNSC resolutions and refused to fully cooperate with the IAEA in order to resolve open questions concerning its nuclear activities, particularly its potential weapons aspects.

Significant and increasing pressure and the need to overcome growing sanction costs that threatened to cripple the Iranian economy moved Teheran to seek cooperation. Under the new President Rouhani and a more accommodating US Administration under President Obama, a diplomatic solution became possible. The eventual agreement (JCPoA) presented a triumph of diplomacy and reason by accepting basic requests of either side. It treated Iran with respect and accepted implicitly its right to develop civilian nuclear energy, including enrichment. Iran, on its side, accepted an extra burden to restore lost confidence through extraordinary concessions concerning constraints on its civilian program and unprecedentedly intrusive verification measures. The agreement thus stopped Iran's creep towards the bomb for an extended period of time. The JCPoA includes the most intrusive and comprehensive verification system ever installed Perkovich et al. [5]. Yet, the agreement is threatened by Pres. Trump's hostility and the stubborn opposition of right-wing Republicans. It is unlikely that Pres. Trump has read a single line of the JCPoA, and if so, has understood a single word. Yet he refused to certify that this agreement is in the US interest and opened the opportunity for Congress to kill it.

The two cases of the crisis of compliance are a heavy burden for the existence of the NPT, yet they have not, so far, destroyed the Treaty. It is likely that the North Korean case might be contained as a regional problem and that the combined efforts of China and the USA might eventually halt the further progress of Kim Jon-un's arsenal. It might also happen that President Trump wants to use the remaining, brief window of opportunity before the DPRK can field indeed an operational inter-continental capability to destroy cities at the US West Coast by a devastating (hopefully conventional) strike against North Korea's nuclear (and probably chemical and some conventional) assets, creating havoc on the Peninsula. Or things will just fall apart with North Korea enlarging arsenal and capabilities and the US and China deeply divided and hostile against each other.

The Middle East situation may have even more repercussions. Iran has indicated that a withdrawal of Washington from the JCPoA might not be the end of things if the other parties—China, Russia, France, Germany, the UK and the EU stick to the agreement and help to compensate for losses incurred by Iran for US defection. What this would mean for the Western Alliance, however, remains to be seen. For the NPT and future compliance crises, the experience that US legal commitments to agreements destined to terminate a crisis may have long-term negative consequences.

47 years after the NPT entered into force, there are much less nuclear weapons in the world, between 14 000 and 15 000 instead of over 60 000. Yet, the remaining nuclear weapons are still integral part of national security strategies of NWS and their allies. This situation created seep dissatisfaction among non-allied NNWS which undermines the unity of the Treaty community and threatens to de-legitimize the NPT.

The NWS refusal to disarm is justified b three arguments which look right at the surface but become unconvincing if scrutinized carefully: First, Nuclear abolition needs specific political requirements. On the surface, this argument seems to have something to it: Since nuclear weapons are presumably held to respond to certain perceived security problems, the solution of these problems would help to eliminate the missions for nuclear weapons. But this argument is largely invalid in reality since the political facts which prevent the NWS from disarming are largely the consequences of their own policies: The doctrine of superiority of the US armed forces and Washington's (and NATO's) claim to employ force for "higher objectives" even when there is neither a case for self-defense nor legalization of such military action by a UNSC Resolution under Chap. 7 of the UN Charter.

The second argument maintains that nuclear weapons as deterrent in the hands of rational, "civilized" governments are riskless and, moreover, useful for international security. But this argument is unconvincing in the light of leaders who brandish nuclear weapons like Putin or Trump.

The third argument states that nuclear disarmament can progress only in steps, not in jumps. In principle, an incremental strategy promises the most realistic path of disarmament, because each single step lays the groundwork for the next and enhances mutual confidence which is the condition for more daring progress. But this argument is empty in the light of history because of the present undeniable stagnation in nuclear disarmament. Even worse, the NWS refuse to take steps they have already agreed to. Analyses like the annual Hiroshima report document that compliance with agreed disarmament steps are below 50% Hiroshima Prefecture [6].

We have to look at the facts: There has been no new nuclear disarmament treaty since 2010, the ABM Treaty which prohibited complete national missile defense system, granting the integrity of deterrence arsenals even at very low number has been scrapped by the George W. Bush administration, the plutonium disposition agreement of 2010 has been suspended by Moscow, the CTBT is not in force 21 years after its negotiations were concluded, because states like the US, China, India, Pakistan, India, Israel and North Korea have not become parties. The US and Russia accuse each other of violating the INF Treaty; this pillar of nuclear disarmament might fall by the wayside in the next few years.

Rather than a process nuclear disarmament, we are watching a five-polar nuclear arms competition which involves the US, Russia, China, India, and Pakistan. Not everybody is arming against everybody else, but we have a chain of mutually distrusting nuclear armed dyads so that armament steps of any of these actors engender ripple effects everywhere else. All the while, the NWS improve the quality of their arsenals. China, India and Pakistan increase the number of their nuclear warheads. Russia has announced that it envisages a strategy of nuclear de-escalation; this means the employment of nuclear weapons in wars that go badly for Russia with a view to dissuade the enemy from continuing fighting because of the risk of further escalation. In NATO, nuclear deterrence gains new traction, because the Eastern members are highly nervous about Russian exercises, illegal overflights by Russian military aircraft and nuclear saber-rattling, notably after what happened in Ukraine. As a consequence of these developments many NNWS have lost confidence in the sincerity of NWS commitment to nuclear disarmament.

Frustrated by perceived neglect of the NWS'central NPT duty, repelled by the condescending attitude of the NWS, most NNWS, supported by NGOs, chose a new path: negotiating a Nuclear Ban Treaty (NBT). A movement, initially driven by a few leading governments (e.g. Austria, Switzerland, Ireland, Mexico, South Africa, Costa Rica) started with a focus on humanitarian consequences of NW—as highlighted in the NPT's preamble. Three consecutive conferences in Norway, Mexico and Austria reached the conclusion that nuclear arms are inhumane, incompatible with international humanitarian law and must be prohibited like biological or chemical weapons. From there emerged the demand for a legal ban against nuclear weapons (NBT) Kmentt [7].

The NBT movement proceeded against the opposition of the NWS and allies and without their participation. In 2016, the majority of the UN General Assembly established a negotiation forum for ending the lack of an effective legal instrument against nuclear weapons. During the negotiations in 2017, only the Netherlands joined among US allies the negotiating crowd of 124 states, because the Dutch parliament, driven by a public referendum, ordered the executive to take part in the talks. The NWS and their other allies abstained. Eventually, the NL voted against the ban Potter [8], Mukhatzhanova [9].

The NBT that was adopted by the vast majority constitutes an impressive signal by the majority and a new element into NPT debates whose impact remains to be seen. Given the history since indefinite extension of the NPT, notably the disappointment by broken promises, it was inevitable and justifiable that the majority would seek self-empowerment to break deadlock.

Unfortunately, the NBT is not a very good treaty: it fails to fill NPT gaps concerning prohibition scope by not mentioning nuclear weapons research research, transfer of arms parts, materials and technology in addition to nuclear weapons of which to dispose the NBT members are not permitted anyway, it lacks any clause on export controls beyond the transfer of full weapons, is silent on non-compliance/enforcement but contains only a toothless dispute settlement imperative, lacks institutional. Clarity, because the IAEA and a mysterious "Authority" with competences in verifying nuclear disarmament share authority without clearly distinct mandates. Nevertheless, the NBT is there and will most likely enter into force in the coming years. Opponents will have to learn to live with it. Fundamental opposition will thus prove futile and counterproductive. NWS and their allies appear painfully unprepared to face the facts.

In the current situation, there is no leadership visible on any side in the disputes which would open a new path, cut the Gordian knot, or build bridges between the opposite camps. The US suffers worst domestic political cleavage inside since the Civil War and is led by an incapable, psychically if not mentally defect president without any knowledge of the world who is not, and will never be, up to his job. Many Republicans in Congress are fanatics and ideologues of Bolshevik dimensions and known as little about the world as their president.

Russia is led by a nationalist, corrupt and resentful elites, led by a president socialized as a mediocre intelligence officer of the Soviet Union with the behavior of a strong boy in puberty with minority complexes. Ensuring geopolitical gains, showing military muscles, and taking revenge against the US for perceived past slights take priority over rational, compromising external policy.

China is busy with preserving internal rule by the Communist party, pursuing territorial claims against no less than 8 neighbours, and standing up and getting equal with the US. An ego-orientated president tries to enhance his personal power and extend his personal rule by enlarging the international power of China. In this project, territorial claims against altogether eight neighbors on land and on sea are an apparently non-negotiable part.

The EU is internally divided between NWS/allies and disarmers (Austria, Ireland, and Sweden). Germany as the leading economic power in the EU is compromised in the eyes of many NPT members by its nuclear NATO role. France is, besides Russia, the most uncompromising NWS. It is obvious that in the field of nuclear disarmament, the EU is incapable to function as an unified actor.

In the NAM, South Africa suffers from a weak, corrupt president. Brazil focusses on preserving its Navy‘s plans for nuclear powered submarines. Iran is still busy to stand up to the US, enhance its regional power status, and pacify internal divisions by propping up national pride. Egypt has developed an almost manic concentration on the Middle East theme. That Egypt did not take to offer of Israel, extracted by intense US diplomacy, to address the nuclear subject in a conference on a Middle East Zone Free of Weapons of Mass Destruction under the condition that it will be embedded in the overall regional security situation still strikes me as incomprehensible. As long as this stubbornness persists, Egypt is not up to the task as a NAM leader. Some states, e.g. Mexico, Costa Rica, Indonesia show occasional, but not perpetual leadership qualities. Iran's failure as NAM chair, despite best efforts to rally NAM consensus around positions during the 2015 RevCon and during the 2016 UNGA debate concerning NBT negotiations documents the lack of NAM leadership, and possible the structural impossibility to establish one.

The next phase in the future of the NPT will be, of course, the review cycle which has already begun. Frontlines between the majority of the NWS and their allies, on the one hand, and the vast majority of the NNWS are as sharp and deep as never before.

The NWS resent the NBT and allege that it is hurting the NPT. They try to keep discipline among their allies, which is easier with some (the Easternmost NATO members) than with others ("old" NNWS Europe and the Southern part). They attempt to arms-twist smaller states not to sign and ratify the NBT, because they still maintain the hope that they might be able to prevent the NBT from entering into force because of the quorum: fifty ratifications are needed for the NBT to enter into force. The NWS continue to regard nuclear deterrence, decisions on the nuclear posture, arms control and disarmament as their exclusive turf with no role for NNWS. Because the NBT intrudes this chasse guardee, they take it as offense, as a slight in their face xxx dealt them by countries of minor importance. As far as disarmament is concerned, NWS want moves, if at all, as single small steps, to become obligatory only with their agreement, and to be implemented after such agreement only at their will and with due regard to the national security requirements—as they see them—of the moment.

The majority of NNWS refuses, in retaliation for lacking disarmament, to accept any further improvement of the non-proliferation toolbox (verification, export control, procedures for withdrawal and non-compliance cases, obligatory multilateralisation of fuel guarantees and fuel cycle activities). The weaknesses in the NBT prove this attitude: even for saving the credibility of their commitment to lay the foundations of a nuclear weapons free world, they were not ready to take upon themselves the necessary undertakings beyond present ones. This attitude puts an air of lack of seriousness over the NBT. It is also possible that at least the NAM members are ready to shelter peer NAM states who temper with NPT compliance by their solidarity, as long as the cleavage continues, even though this would remove the realization of a nuclear weapons free world even farther into the future.

If world politics were the realm of reason, both NWS and NNWS would do their best to strengthen the NPT as their common good, given what is at stake. The NWS would agree to take steps towards disarmament, notably those which would enhance safety against nuclear war, accident, or non-state actor attack. The NWS and their allies would accept the NBT as *fait accompli*. They would agree to take note of the NBT, recognize that it is designed to serve the objectives of the NPT's preamble and Art. VI, that it is compatible with the NPT, and that a large number of NPT parties support it. NNWS would accept that agreed disarmament steps, although not leading to nuclear weapons abolition in the short term, serve the common goal and are thus worth supporting. They would agree to improve new non-proliferation measures and to help bring non-compliant states back to good standing, NWS and NNWS would both effectively implement the agreed steps. On the Middle East, the formula which the US extracted from Israel in 2015—address nuclear issue, but in the context of regional security—would be embraced by all regional states.

But international politics is not the realm of reason Bleiker and Hutchinson [10]. NWS are jealously guarding their privileges and pursue their competitive geopolitics which stand in the way of disarmament. NNWS feel offended and humiliated by the NWS' disregard for their cherished positions and thus block measures that would be in their own best interest.

In the past, wise bridge-builders were repeatedly capable to work as katalysts for consensus. Xxx But with the lack of capable leadership in our age of populist emotions, can reason prevail? Hence, unfortunately, my answer to the question about the future of the NPT ends itself with a question mark.

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Part VII
Role of Science in Technical and International Cooperation

Zehra Sayers, Ana Raffo-Caiado, Randy W. Bell, Chris Llewellyn Smith and Gihan Kamel

Chapter 23
Introduction

Zehra Sayers

Session 4 of the XX E. Amaldi Conference was devoted to three invited talks on the role of science in establishing technical partnership and cooperation at the international scale. The invited contributions of the session were (1) Technical Cooperation Programme—Nuclear Technology Contributing to Development, presented by Ana Raffo-Caiado (IAEA), (2) CTBTO Science and Technology for a Safer World, presented by Randy W. Bell (CTBTO) and (3) Science Beyond boundaries: SESAME and the international Cooperation, presented by Chris Llewellyn-Smith. There was also a testimonial by a staff scientist, Gihan Kamel from SESAME. Since papers of the invited speakers are printed in this volume, it suffices for me to draw attention to some of the points in these work which I believe establish the foundations for the role of science in successful international cooperation. Some points that came up in discussions will also be briefly presented.

Technical Cooperation (TC) Programme—Nuclear Technology Contributing to Development (Ana Raffo-Caiado) (IAEA). In this presentation the speaker described the TC Programme, which is celebrating its 60th anniversary this year, as the best "hidden" program of International Atomic Energy Agency (IEAE), because it is not brought to the attention of the general public often enough. The TC programme aims to provide support 'to the member states to build, strengthen and maintain capacities in the safe peaceful and secure use of nuclear technologies' (www.iaea.org/technicalcooperation). The areas covered include human health, water resource management, sustainable energy development, environmental challenges, rural development and agriculture. Through its support of national, regional and interregional projects the programme contributes not only to local capacity building within a partner state but also encourages partnership for exchange of ideas, knowhow and expertise beyond the borders of a single country and strengthens scientific networks. The TC programme, although initially designed for providing

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assistance has, over the years, evolved into a platform for collaborations that helps to share responsibilities to serve the mutual benefits of countries involved. TC activities target mainly needs in four geographical regions: Africa, Asia and Pacific, Europe and Latin America.

In the framework of this programme support have been provided through services categorized as ‘Training Fellowships’, ‘Conferences, Symposia and Seminars’, Scientific Visits’, ‘Expert Assistance’, and ‘Training Courses and Workshops’. Thousands of people have been trained in human resources capacity building activities. In different types of projects funds have been provided also for equipment. Over the years the programme has helped to build competent nuclear regulatory authorities for radiation safety and security implementations. The broad range of services provided have helped to bring governments, private sector and civil society together to improve living conditions, to establish schemes for achieving national goals and for sustaining development.

CTBTO Science and Technology for a Safer World (Randy W. Bell) (CTBTO). In this presentation the speaker introduced the Comprehensive Nuclear-Test-Ban Treaty (CTBT), which, with its 183 signatories, serves as an effective arms control instrument, banning all nuclear explosions in any environment. The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), is built around this treaty, and has as its major component the science-based technical Verification System capable of monitoring, detecting, and reporting nuclear explosions. The Verification System is built on two pillars, namely the International Monitoring System (IMS) and the On-Site Inspections (OSIs).

The IMS is a global network of seismic, hydroacoustic, infrasound (atmospheric pressure wave) sensors, and atmospheric radionuclide sensors that can monitor for signs of testing all around the World. IMS, currently has monitoring stations in about 100 countries and will increase this number to over 330 stations in the coming years. The International Data Center (IDC) where all data are collected is based in Vienna. Here data are processed and analysed by the international staff at IDC and are immediately made available to all Member States. With its stations even in the most remote places around the world, the IMS can credibly verify if countries are complying with the ban on nuclear testing. This operation provides a huge service to its members as well as a validation that individual countries could not have done on their own. Proper functioning of IMS is achieved through a rigorous training programme for local capacity building on scientific and technical applications related to the monitoring systems. This provides an added value to the Member States and adds to the pool of supporters who will carry CTBTO to the coming generations. The OSIs aspect of the verification scheme on the other hand can be launched only after the Treaty enters into force. So far it has been progressing through field exercises, which are life-seize tests of on-site inspections. These operations last over several weeks and test different aspects of on-site inspection.

The structure and the nature of cooperation in the Verification System of CTBTO promotes trust and understanding among members of the Treaty. The data collected n the IMS is transmitted to the members without interpretation, expecting them to use own experts for this purpose. Whenever necessary training in data analysis is provided by the CTBTO. The transparent, open and inclusive features of data sharing provide evidence that the members are complying by the rules of the Treaty and this made the treaty one of the most accepted arms control instrument in the world.

Science Beyond boundaries: SESAME and the international Cooperation (Chris Llewellyn-Smith) (Oxford University). In this presentation we were introduced to SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East), an international third generation synchrotron radiation (SR) laboratory which has recently come into operation in Jordan. Members of SESAME are Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey: countries that are troubled by political, religious and cultural divides. SESAME is conceptually modelled on CERN, which was established to build bridges among countries after the World War II however, SESAME has to operate while wars are still going on among its members.

SR sources offer facilities for a wide range of fields from medicine to archaeology and even to arts, enabling scientists to work in the same environment round the clock. In this scientific environment, SESAME aims to foster not only high quality research but also cooperation among the visiting scientists. The project has grown also through the support provided in different ways by observer countries consisting of Brazil, Canada, China, EU, France, Germany, Greece, Italy, Japan, Kuwait, Portugal, Russian Federation, Spain, Sweden, Switzerland, the UK, and the USA.

A key element in SESAME's activities is local capacity building in the framework of a rigorous training programme. Through international efforts involving Brazil, Canada, China, France, Germany, Italy, Japan, Portugal, Spain, Sweden, Switzerland, UK and USA, IAEA, ICTP, EU, and UNESCO, scientists and engineers have been trained to build, operate and to use SESAME when it is ready.

Despite the financial difficulties it had to face during the establishment phases the experimental programme of SESAME has already begun on a limited scale with minimal supporting infrastructure. There were over 50 applications to the first call for experiments on the X-ray fluorescence and the infrared beamlines reflecting the scientific interest from the region. A unique feature planned for SESAME is the use of solar power for its operation. When it comes to operation When this is realized it will not only put SESAME on a sustainable basis, but will make it the world's first accelerator powered entirely by renewable energy.

Testimonial by Gihan Kamel (SESAME, Egypt). In this presentation the effective role of SESAME in countering brain drain in the region was discussed. Gihan Kamel, a physicist, has returned to the region after spending several years in the early phases of her career in Italy in institutions similar to SESAME. At SESAME she is the beamline scientist for the EMIRA infrared beamline.

This session of the XX E Amaldi conference diverged from others that took place on the same day from the perspective of exploring scientific and technical cooperation as alternative ways of keeping channels of communication open during challenging times such as those that the world is going through currently.

Key elements that emerged from the three presentations as important for successful scientific and technical cooperation are:

- Local capacity building and development of local expertise through cooperation. This is a crucial factor to improve quality of life and also to provide a sustainable basis for development.
- Building trust and credibility in partnerships through openness, transparency and information sharing.
- Development of a neutral/equal footing environment that will be mutually beneficial for the partners and nurture cooperation.
- Support for projects that are driven by scientific curiosity and addressing specific needs in a region.

Some of the points that came up during the discussion period after the talks were:

- Exploration of possible cooperation between Pugwash conferences and SESAME.
- A sobering discussion on the effect of political issues hampering efforts for improving understanding among people through scientific cooperation. Reality of such effects was discussed through real life examples like visa difficulties for some members for attending SESAME Users Meetings, or sanctions on Iran.
- A question prompted discussions on protective mechanisms used by the TC Programme to ensure that projects that do not comply with non-proliferation agreements are not supported or the shared analyses from IDC of CTBTO are not misused. The respective speakers clarified these issues with detailed information on the proposal evaluation process at the TC Programme as well as on data processing at IDC. It was explained that local experts who have access to details to ensure quality guide proposing groups. In the second stage of the evaluation different groups at IAEA come together to evaluate proliferation and safety aspects before the final decision. As far as data analyses at IDC is concerned, it was explained that countries are not given any data interpretation but that they should turn to their own experts to carry out data evaluation.

Chapter 24
IAEA's Technical Cooperation Programme—Nuclear Technology Contributing to Development

Ana Raffo-Caiado

The IAEA is the world's centre for cooperation in the nuclear field, with a mandate "to accelerate and enlarge the contribution of atomic energy for peace, health and prosperity throughout the world." The IAEA's technical cooperation programme has supported development for 60 years. It supports the peaceful application of nuclear science and technology in fields that include human health, food and agriculture, water and environment, sustainable energy, radiation technology and safety and security. The programme provides development assistance and cooperation to IAEA Member States through national, regional and interregional projects, with the goal of supporting socioeconomic impact and contributing to the achievement of the major sustainable development priorities of each country. The programme builds human and institutional capacity, and also supports the procurement of essential equipment. The IAEA is not the lead UN agency in agriculture, health or environment, so the TC programme works with FAO, WHO and UNEP and a range of other partners in implementing projects in these and other development fields. Nuclear science and technology can provide concrete development solutions; data to support the development of policy; and data to assess the efficacy of interventions, or progress towards development objectives.

The IAEA is the world´s centre of cooperation in the nuclear field. It was set up as the world's 'Atoms for Peace' organization in 1957 as an autonomous international organization with a special relationship with the United Nations System. This relationship is regulated by a special arrangement with the UN.

The IAEA's mission is guided by the interests and needs of Member States, strategic plans and the vision embodied in the IAEA Statute. Three main areas of

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work underpin the IAEA's mission: Safety and Security, Science and Technology, and Safeguards and Verification.[1]

The Agency works with its Member States and multiple partners worldwide to promote the safe, secure and peaceful application of nuclear science and technology. The Agency's mandate for technical cooperation is found in Article II of the IAEA Statute: "to accelerate and enlarge the contribution of atomic energy for peace, health and prosperity throughout the world."[2]

The IAEA's technical cooperation (TC) programme is the main vehicle through which the IAEA carries out this mandate—some 70% of the Agency's capacity building activities are delivered through the TC programme. It does this by facilitating access to the peaceful uses of atomic energy; the transfer of nuclear technology; the application and utilization of atomic energy for peaceful purposes in Member States; and the promotion of cooperation between Member States for that purpose. Member States must undertake to use the technology for peaceful use only, in a safe and secure manner. Member States drive the programme, and share responsibility for it. Technical assistance shall be allocated primarily to meet the needs of developing countries. Each Member State of the Agency or group of Member States shall be eligible for technical assistance.[3]

Technical cooperation activities are guided by the *Guiding Principles and General Operating Rules to Govern the Provision of Technical Assistance by the IAEA*, adopted by the Board of Governors in February 1979 in document INFCIRC/267.[4] INFCIRC/267 governs the provision of all Agency technical assistance. The decisions of the IAEA Board of Governors and the annual General Conference resolution: '*Strengthening of the Agency's technical cooperation activities,*'[5] provide guidance for the operation of the programme and its management, and ensure that the programme responds to the current and emerging needs and concerns of Member States. Revised Supplementary Agreements govern the provision of technical assistance by the Agency, and must be concluded by Member States participating in the TC programme.

The main objective of the 2002 Technical Cooperation Strategy is "*to increasingly promote tangible socio-economic impact by contributing directly in a cost-effective manner to the achievement of the major sustainable development priorities of each country*".

There are many stakeholders in the TC programme, and all share responsibility to ensure its success. The programme is the result of the combined efforts of the Member States, the IAEA Secretariat and a range of key strategic partners. All

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[1]https://www.iaea.org/about/about-iaea.

[2]https://www.iaea.org/sites/default/files/statute.pdf.

[3]INFCIRC267 https://www.iaea.org/sites/default/files/publications/documents/infcircs/1979/infcirc267.pdf.

[4]https://www.iaea.org/sites/default/files/publications/documents/infcircs/1979/infcirc267.pdf.

[5]GC(61)/RES/10 https://www.iaea.org/About/Policy/GC/GC61/GC61Resolutions/English/gc61res-10_en.pdf.

Member States are eligible to participate in the TC programme, which is jointly developed through a consultative process. All Member States benefit from the TC programme, whether directly through projects or indirectly through activities for the global good; whether by receiving direct support or by being the source of equipment and experts. In parallel, all Member States share the responsibility for the programme by providing political, financial or implementation support.

The TC programme is managed by the Department of Technical Cooperation, and supported by the technical Departments, who are responsible for the technical integrity of the programme.

The Department of Nuclear Sciences and Applications supports the application of non-power technologies. These technologies make a significant contribution to the achievement of the Sustainable Development Goals in human health, food and agriculture, radioisotope production and radiation technology, water resource management and the marine and terrestrial environment.[6]

The Department of Nuclear Energy focuses on sustainable nuclear energy development by supporting existing and new nuclear programmes around the world.[7] Embarking in nuclear power is a sovereign decision of a Member State. The Agency does not interfere with any decision of Member States on nuclear power. But, if a country decides to go for a nuclear programme, the IAEA will provide assistance to make sure it is safe and secure.

The Department of Nuclear Safety and Security ensures the safe and secure use of nuclear technologies, developing common safety standards for use around the world and promoting the implementation of these standards. Improving safety comes at all stages of the peaceful use of nuclear applications: from the initial planning to waste management and disposal. This also applies to nuclear installation and to radiation, transportation and waste. Work also includes preparation for radiological incidents and emergencies, at the national, regional and international level. While safety refers to avoidance of and protection from accidents, Security refers to avoidance of and protection from malice—things like sabotage, theft and attacks.[8]

The Office of Legal Affairs (OLA) reports directly to the Director General. In addition to providing legal services internally, OLA assists interested Member States establish legislative and regulatory frameworks to address all the legal aspects of safety, security, safeguards and civil liability for nuclear damage. OLA has also developed reference material such as the *Handbook on Nuclear Law, Volumes I and II,* to help Member States to draft their nuclear legislation and to bring such legislation in line with international legal instruments and standards. To face the increasing interest and to meet the demand OLA supports training in the

[6]https://www.iaea.org/about/organizational-structure/department-of-nuclear-sciences-and-applications.

[7]https://www.iaea.org/about/organizational-structure/department-of-nuclear-energy.

[8]https://www.iaea.org/about/organizational-structure/department-of-nuclear-safety-and-security.

field of nuclear law, specifically for drafting legislation, through the Nuclear Law Institute.[9]

The Department of Safeguards applies safeguards in line with the Agency's Statute. It carries out the IAEA's duties and responsibilities as the world's nuclear inspectorate, supporting global efforts to stop the spread of nuclear weapons.[10] The Department of Safeguards is responsible for reviewing all TC projects to ensure that support provided through TC is not used in such a way as to further any military purpose (INFCIRC/267).

The TC programme provides capacity building, supporting a whole range of training mechanisms to build Member State capacities in the safe, secure and peaceful application of nuclear technologies. The programme also supports procurement, helping Member States to specify their needs, and supporting purchases of equipment—for example, machines, equipment for laboratories, radioactive sources for medical use.

The TC programme supports the application of science and technology in the areas of human health, food and agriculture, water and environment, sustainable energy, radiation technology and safety and security. It helps countries to increase their scientific and technical capacities and capabilities in these areas to enhance their socioeconomic development.

For example, in the field of human health, the programme helps Member States enhance prevention, treatment and control of diseases. In the area of food and agriculture, technical cooperation activities assist States to increase productivity and quality. Regarding water and the environment, IAEA support helps States to manage water and other natural resources.

In human health, the Agency aims at improving the diagnosis and treatment of diseases, such as cancer, cardiovascular diseases, as well as in improving monitoring of nutrition programmes.

In food and agriculture, the Agency works in partnership with FAO to expand the use of nuclear technologies to improve livestock production, insect pest control, crop improvement, soil management and food safety.

In the area of radioisotope production and radiation technology, the Agency provides knowledge and expertise for science and industry.

In water resource management the Agency focuses on expanding the use of isotopic techniques by Member States. Through these techniques, the Agency helps Member States better understand their water resources, leading to greater availability and sustainability of water for drinking water supplies, as well as for industrial, energy and agricultural demands.

In environmental protection, the Agency focuses on expanding the use of nuclear techniques to gain a better understanding of the environment and to act efficiently to reduce negative impacts.

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[9] https://www.iaea.org/services/legislative-assistance.

[10] https://www.iaea.org/about/organizational-structure/department-of-safeguards.

The Agency also helps build nuclear science competencies in Member States, and provides information on atomic, molecular and nuclear data. Such data are used in everything nuclear—from safeguards to reactors to medicine. The Department of Nuclear Energy, in collaboration with the Departments of Nuclear Sciences and Applications, and Nuclear Safety and Security, also works on the technological aspects of research reactors.

For Member States interested in nuclear power, the Agency works on all major aspects of the nuclear fuel cycle, cradle-to-grave: from uranium exploration and production, to responsible handling of the waste. Regarding nuclear power plants, the Agency provides support to Member States when they explore or start nuclear power programmes, and while they operate them (in areas like lifetime management, upgrading instrumentation and control, and strengthening knowledge management). At the end of the cycle, support is also provided in the areas of waste management, decommissioning, environmental remediation and final disposal. This also includes the technological aspect of managing and disposing of nuclear waste from non-power applications, like radioactive sources used in medical procedures in hospitals.

Finally, the TC programme ensures that Member States can use nuclear technology safely and securely, by helping countries to strengthen their regulatory safety infrastructure and address their legal nuclear related issues (Fig. 24.1).

S168	IAEA Member States		
146	Countries and territories receiving technical cooperation support in 2016	3114	Participants in regional and interregional training
37	LDCs participating in the TC programme	3777	Expert and lecturer assignments
80%	Of all Member States are non-nuclear power states.	1701	Fellowships and scientific visits
~650	new projects each biennnium	193	Regional or interregional training courses
914	Active projects at end 2016		

TC projects are delivered at different scales, depending on need. Country Programme Frameworks (CPF) are used to identify and prioritise Member State needs. A CPF is not mandatory but is a useful document, as it provides a frame of reference for technical cooperation between a Member State and the IAEA, defining mutually agreed priority development needs and interests that can be supported through TC activities.

National projects involve one single country and focus on supporting national development priorities where the use of nuclear techniques or technologies is essential for the achievement of national objectives or represent the solution to a problem in a cost-effective, safe and secure manner. Examples include national projects to address foot and mouth disease in Mongolia, to support the use of the sterile insect technique to eradicate the cactus moth in Mexico, and to help Kenya to identify its energy needs.

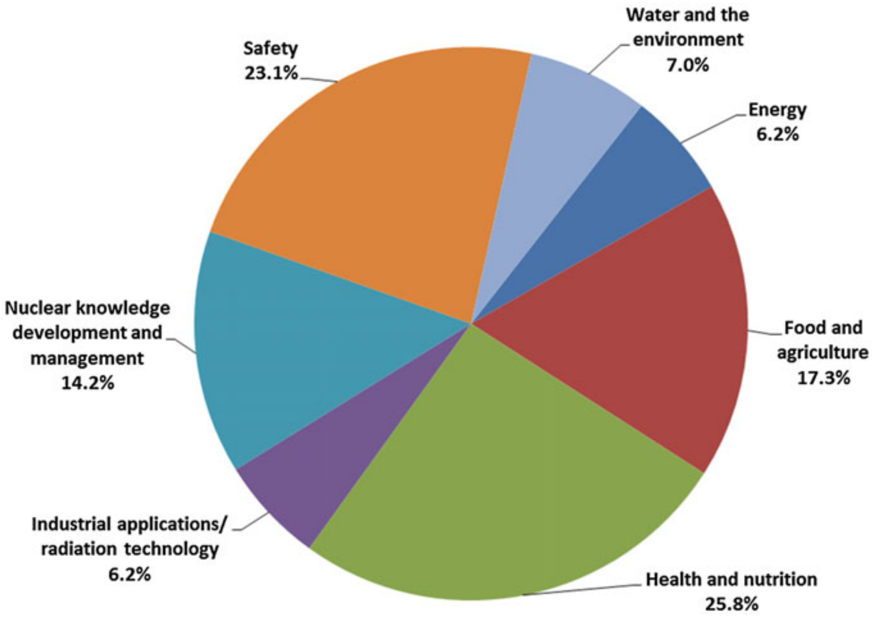

Fig. 24.1. Actuals by technical field for 2016

Regional projects take into account national development objectives but are developed according to regional development priorities established by regional cooperative agreements, strategies and frameworks. They promote Technical Cooperation among Developing Countries, and mainly target human resource development. Regional projects create links between regional institutions, and aim to share information/expertise and experience. For example, regional projects have supported aquifer mapping in the Sahel region, and the establishment and strengthening of radiation safety infrastructure in Latin America.

Interregional projects deliver support across national and regional boundaries, and address the needs of several Member States in different regions. Interregional projects are categorized as trans-regional, global, capacity building or as joint activities with an international entity. Small in number, interregional projects mainly target human resource development. For example, in the Mediterranean region, an interregional project has built capacity in 'cradle to grave' management of sealed radioactive sources, with the financial support of the European Union.

The Agency's technical cooperation activities are supported by the Technical Cooperation Fund (TCF). This is funded by Member State contributions, based on shares established using UN assessment rates. The target for the TC Fund is set by the Board of Governors and finalized in a General Conference resolution.

National Participation Costs also flow into the TCF. These are an expression of Member State commitment to national projects, and are equal to 5% of the national programme value. At least half a project's NPCs must be paid before project implementation can begin.

The TC programme also benefits from generous extrabudgetary contributions from Member States and other international organizations, including extrabudgetary funding provided through the Peaceful Uses Initiative.

Governments may also chose to fund activities in their own countries—funding for activities where the donor is the recipient is commonly referred to as Government Cost Sharing. In-kind contributions to the programme are also possible.

While the TC programme is successful in building capacity in nuclear science and technology in IAEA Member States, the programme does face some constraints.

Limited financial resources are always a consideration, which is why extra-budgetary support and Government Cost Sharing are important. At the same time, IAEA Member State numbers are increasing, and with this growth come increased requests for technical cooperation support. The Agency strives to ensure that TC projects will be sustainable, and work to build self-reliance in project counterparts.

Another challenge is of course achieving recognition of the IAEA as a partner in development. The IAEA is often regarded as a technical agency, primarily concerned with Safeguards and Safety issues. The expanded IAEA slogan, 'Atoms for Peace and Development', adopted in recent years, reflects the importance of the Agency's technical cooperation work.

The IAEA is committed to strengthening engagement with Member States and partners to ensure the effective, sustainable impact of the TC programme. The Agency will continue to seek ways and means to render resources for TCF sufficient, assured and predictable, including working with the private sector and non-traditional donors. Outreach efforts will continue, with the goal of strengthening public awareness of the TC programme and its work.

The IAEA is proud of its capacity to respond quickly to emergencies such as disease outbreaks or natural disasters like earthquakes. For example, the Agency was able to provide immediate emergency assistance in response to the Zika virus outbreak in 2016. This ability to respond quickly is an important strength of the technical cooperation programme: while emergencies are by their nature unpredictable, the programme planning process always takes them into consideration. Other recent emergency support provided through the technical cooperation programme has included assistance to Ecuador and Nepal in the aftermath of earthquakes, and to countries in Africa in response to the outbreak of Ebola virus disease.

The IAEA is also committed to helping Member States achieve important development objectives such as the Sustainable Development Goals (SDGs), and to ensure continuing programmatic flexibility to respond to emerging needs. Agenda 2030, and in particular Sustainable Development Goal 17, recognizes the role of science, technology and innovation as essential enablers for development. Goal 17 places a priority on partnerships as a critical means of implementation. Achieving the Sustainable Development Goals will require collaboration and cannot be achieved in isolation.

TC programme activities are not disconnected from the global development community. Although the IAEA is a specialised technical agency, it contributes to the global development agenda. The TC programme has helped Member States address the Millennium Development Goals (MDGs), and is well placed to contribute to Member State efforts to achieve the Sustainable Development Goals. The Agency has identified nine Goals that it supports directly through technical cooperation programming, providing valuable but highly specific support to larger development goals in health, nutrition, agriculture, water, the environment and climate change.

Because the IAEA is not the lead UN agency in agriculture, health or environment, the TC programme works with FAO, WHO and UNEP in implementing projects in these fields. IAEA cooperation with the FAO is formalized and long established, and cooperation with WHO is also of long standing, particularly in the area of cancer.

In looking to the future, it is worth remembering that the IAEA's technical cooperation programme can help Member States apply nuclear technology to address many of the development challenges identified in the SDGs. Nuclear science and technology can provide concrete development solutions; data to support the development of policy; and data to assess the efficacy of interventions, or progress towards development objectives.

In May 2016, the IAEA organised the first ever International Conference on the Technical Cooperation Programme. This event provided an opportunity to take stock of what has been achieved through the technical cooperation programme and to demonstrate how it can best contribute to the attainment of the SDGs in Member States. The conference brought together over 1200 people from 160 countries and 27 organizations.

Delegates at the Conference noted that achieving the Sustainable Development Goals requires multi-actor collaboration, and cannot be addressed in isolation. The TC programme has established mutually beneficial strategic, technical and financial partnerships with UN sister organizations, including the Food and Agriculture Organization of the United Nations (through the FAO/IAEA Joint Division) and the World Health Organization, and has cooperated with other UN organizations such as UNEP and UNIDO, and other regional and international organizations, development banks and other financial institutions.

Delegates agreed that such long-standing cooperation should be encouraged and reinforced so that, together with its partners, the Agency can build on common strengths and effectively utilise resources for an optimal delivery of their services to Member States. Fostering partnerships that promote integrated approaches to development will support a more effective TC programme, and will also ensure coordination and complementarity of activities. This will enable an efficient and cohesive response to current and upcoming development challenges in Member States. In addition, promoting triangular, South-North and South-South cooperation will promote sustainability, and contribute to effective technical cooperation.

The TC programme has facilitated increased access to nuclear science and technology, supported knowledge sharing, built and reinforced scientific networks, and strengthened Member States' capacities to base their policies and decisions on scientific evidence in a broad range of important areas. It offers key capacity to Member States and partners in the Sustainable Development Goals era, and is ready to build on its six decades of experience as a technical agency.

Chapter 25
CTBTO Science and Technology for a Safer World

Randy W. Bell

Ladies and Gentlemen,

From the outset, I would like to express my appreciation to the organizers for the invitation to this Conference. The theme of this session "Role of science in technical and international cooperation" is very topical as most of you would agree that we are living in particularly challenging times with serious tensions among international actors which can be compounded by mistrust and misunderstanding.

Restoring trust—or more specifically—providing a justifiable basis for trust, and improving common understanding is a key objective of verification regimes. This is exactly what the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) is doing!

Before I enter the main topic of my discussion I'd like to start by noting the status of the CTBTO Verification System, and its accomplishments. The Comprehensive Nuclear-Test-Ban Treaty (CTBT) was opened for signature in 1996 and, since then, it has become one of the most adhered to arms control instruments in the world. The Treaty bans all nuclear explosions in any environment. To date, 183 countries have signed the CTBT and 166 of these have set their commitment to that principal in stone through ratification. The CTBT is underpinned by its science-based technical Verification System capable of monitoring for, detecting, and reporting nuclear explosions. The Verification System is composed of two main pillars: the International Monitoring System (IMS) and the On-Site Inspections regime (OSIs). Also the Treaty outlines a process of consultations and clarifications.

The establishment of the IMS, a system that can credibly verify compliance with a ban on nuclear testing, has been one of the CTBT's key achievements. The IMS is a global network of seismic, hydroacoustic, infrasound (atmospheric pressure wave) sensors, and atmospheric radionuclide sensors that functions as a global nervous system that can monitor for signs of testing in every part of the globe. When completed, it will comprise 337 facilities distributed all around the globe, including

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in many remote locations, meaning every country hosting a station counts and no one country can do it alone.

With monitoring stations in nearly 100 countries, the data from the IMS is transmitted to the International Data Centre (IDC) in Vienna where it is processed and analyzed by staff from all over the world. The raw data and processed results are available to Member States as fast as they are available in Vienna, they provide a level of trust and credibility that no single nation could ever accomplish. This is multilateralism at its finest—a nonproliferation and disarmament model to be proud of. Currently about 90% of the System is up and running. It has already exceeded expectations in terms of coverage and detection capabilities. The System detected all six nuclear tests announced by the Democratic People's Republic of Korea (DPRK). In doing this, the IMS and IDC demonstrated the effectiveness of the verification regime along with the democratic nature of the data collection, sharing and analysis. The international community was provided with reliable, unbiased and verifiable evidence. This transparency, openness, and international inclusiveness in the design of the verification regime is a point that I will further elaborate on in the main part of my discussion.

The OSI leg of the Verification System has also made substantial progress in the recent years. Even though the OSI process can only be launched once the Treaty enters into force, the CTBTO has already conducted two integrated field exercises (2008 and 2014), which are life-seize tests of an on-site inspection. To give you an idea, the second one which took place in Jordan, lasted for five weeks and tested crucial aspects of each phase of an on-site inspection. It entailed shipping 150 tonnes of equipment to Jordan. More than 360 experts and dignitaries from 53 States Signatories and the Secretariat participated in the event in various roles and functions. Those two exercises proved the readiness of the organization to carry out an OSI.

In short, we can state that, by all measures, we have built a deterrent that gives countries peace of mind by demonstrating that the Treaty is verifiable through a global monitoring system that is unique, reliable and efficient.

The CTBTO is an Organization which has science at its core. However one must look closely at differences in Treaty verification regimes to understand different approaches to, and implementations of technology in organizations. Earlier, the transparency, openness, and international inclusiveness of the CTBT was mentioned. The CTBT is a democratic Treaty in that all Member States are equal—having equal access to data and products, equal roles in the operation of the Technical Secretariat, and each is responsible for drawing its own conclusions from the IMS data or IDC products.

> The *International Data Centre shall* apply on a routine
> basis automatic processing methods and interactive human
> analysis to raw International Monitoring System data in
> order to *produce* and archive standard International Data
> Centre *products on behalf of all States Parties*. These

products shall be provided at no cost to States Parties and
shall be *without prejudice to final judgements with regard to*
the nature of any event, which shall remain the
responsibility of States Parties, [Protocol, Part 1, para 18]

The Technical Secretariat does not draw conclusions about Treaty violations, but rather operates a monitoring network, gathers and analyses data and makes information available to Member States who reach national positions on the nature of events detected by the IMS. Thus the verification regime is not just the sensors around the globe and the data processing in Vienna—it includes the national data centres in Member States. This nature has a profound influence on the way technology is selected, validated and employed in the monitoring system, international and national data centres. A key implication of this is that the data *and the methods to analyse the data* must be understood broadly. It's not enough that the CTBTO consists of staff from nearly 100 countries, the data and products must be understood and increasingly re-analysed in 100s of countries. So the data sources, sensor operation, calibration, analysis methods must have broad acceptance. And the analysis methods must be taught to those Member States that do not already have proficiency in these methods. This proficiency must also be evaluated so each Member State has confidence in their ability to fulfil their individual role in the multilateral collective that makes this Treaty effective. Member states want to ensure their own analyst at National Data Centres (NDCs) can produce results comparable to those produced at the IDC. This has resulted in a significant effort to build the capacity of NDCs, including assistance with computer systems to receive, store, process and display IMS information, development of standard analytical software tools (a product called NDC-in-a-Box) and scripts for analysis, and training. As new methods are incorporated into IDC analysis, efforts are also undertaken to incorporate these methods into NDC-in-a-Box and associated training. This capacity building involves hundreds of institutions and thousands of individuals. It involves documentation, videos, on-line support, e-learning in all UN languages, assistance visits, and formal class room training both regionally and in Vienna. In addition to training the analysts in Member States, the CTBTO trains the station operators who provide first-line support ensuring proper function and high availability of the more than 300 stations around the globe. These station operators typically have other functions associated with whatever parent institution is contracted for local operation and maintenance of a station. They provide invaluable and cost-effective means to ensure the monitoring network is serving the needs of all Member States. To be effective, these operators must understand how to service and troubleshoot issues related to the specific equipment at their stations including telecommunications, power and electrical issues, sensor performance, calibration, alignment, adjustment, software updates, etc.… The choice of specific equipment used for monitoring stations takes into account both standardization to achieve logistical and training efficiency, but also diversity to limit common failure or differences in environments.

Paragraph 69 of Part II to the Protocol specifically list techniques a) through h) that may be employed for on-site inspections—but in truth these 7 listed techniques include many subparts so the number of allowed methods is larger. Paragraph 16 of Article 4 of the Treaty states "The International Monitoring System shall comprise facilities for seismological monitoring, radionuclide monitoring including certified laboratories, hydroacoustic monitoring, infrasound monitoring."

These four core global monitoring technologies are what is currently implemented. The Treaty does not specify the methods to be employed in analysis of these four monitoring technologies but there has been some debate among Member States regarding the extent to which environmental background measurements or supplemental information such as meteorology and associated atmospheric transport modelling is within the scope of the Treaty. It is worth noting that what we commonly refer to as the waveform technologies (Seismic, Hydroacoustic, and Infrasound)—or SHI techniques are a minimum set for detecting explosions underground, underwater, and in the atmosphere. Although sometimes an underground explosion causes a hydroacoustic or infrasound detection, these methods could be viewed as addressing non-overlapping environments. Currently there is no redundant method or dual phenomenology built into the monitoring network such as EMP or optical flash for atmospheric tests.

> *Each State Party undertakes to cooperate* with the Organization and with other States Parties *in the improvement of the verification regime, and in the examination of the verification potential of additional monitoring technologies* such as electromagnetic pulse monitoring or satellite monitoring, with a view to developing, when appropriate, specific measures to enhance the efficient and cost-effective verification of this Treaty. *Such measures shall, when agreed, be incorporated in existing provisions in this Treaty* [Article 4, para 11]

However, Paragraph 11 of Article 4 makes it clear that new technology should be considered in the future. It is generally considered additional techniques would only be considered after Entry into Force of the Treaty. Even then several considerations would seem important; Does a proposed new technology address a shortcoming or gap in the existing network? Is it cost-effective? Is it globally equitable? As an example, it has been suggested in technical conferences that an additional technology might be observing small disturbances in GPS satellite signals as a means of measuring waves in the ionosphere which are potentially caused by interaction with explosion infrasound. This method might improve overall infrasound coverage, but perhaps only in regions of the world that are densely populated with GPS reference stations (currently North America, Western Europe, Japan). Would employment of such a technique be globally equitable or would it 'target' some Member States more than others, is it more cost-effective than a current technique or an alternate technique, does the additional coverage it provides warrant a global effort to promote more GPS reference stations everywhere, if developed as an official IMS monitoring technology what would be the support, capacity building and training cost?

Raising these questions is not an effort to discourage exploration of new techniques. In fact the CTBTO actively engages in such exploration as will be shortly discussed.

But being incorporated as an official IMS technology as mentioned in Article 4 paragraph 11 above is not the only means for new technology to be used for CTBT monitoring. The following text of the Treaty may allow for non-IMS technology to be analysed and presented to Member States;

> *The International Data Centre shall*
>
> (c) *Assist*ing *individual States Parties, at their request* and at no cost for reasonable efforts, *with expert technical analysis of International Monitoring System data and other relevant data provided by the requesting State Party,* in order to help the State Party concerned to identify the source of specific events. The output of any such technical analysis shall be considered a product of the requesting State Party, but shall be available to all States Parties. [Protocol Part II, Paragraph 20 (c)]

What could the IDC reasonably do if presented with "other relevant data" by a Member State—especially if this data is of a type different than the four core technologies in which it, by necessity, maintains expertise? The IDC could comment on the pedigree of the data—does it meet modern standards for authenticity, is the data electronically signed by a recognized and verifiable system to give confidence in the integrity of the data source? The IDC could comment on the methods and algorithms applied to the data—are they broadly accepted in scientific literature relevant to the field, have they been tested and validated in relevant similar environments, is their uncertainty understood, are they repeatable? It is unclear if the IDC could implement analytical methods and reproduce results in an unfamiliar technical discipline. However, it is clear that the Treaty encourages the IDC to be broadly conversant in technologies relevant to nuclear test detection and scientifically flexible. As a proactive step, the IDC takes the opportunity to suggest to potential future data providers (such as the remote sensing industry and international standards organizations) that they consider means for data signing in next generation systems.

Sustaining the technical credibility of the monitoring regime is crucial for sustaining confidence in the regime as a deterrence against testing. Neither Member States nor the public would have confidence in a monitoring system that employs out-of-date or discredited sensors or methods. Furthermore, it will be difficult to maintain systems that are archaic—parts, commercial service, and trained personnel will be difficult to find.

Although the CTBTO is not a research organization, it must stay cognizant of technical advances in relevant scientific disciplines. To accomplish this, the CTBTO is active in international scientific societies (e.g. EGU, AGU, and domain specific forums). The CTBTO hosts its own technology workshops in the core IMS technologies, and the biennial Science and Technology Conference series.

The CTBTO engages with national and multinational research centers and other international agencies.

Planned recapitalization is necessary to replace systems prior to catastrophic failure at end-of-life. Ideally, recapitalization would occur on a schedule that best optimizes cost-effective operations and performance—which typically implies upgrading to new technology well before end-of-life when it becomes more cost effective to upgrade than maintaining old technology. The need for recapitalization applies to big hardware systems such as Hydroacoustic arrays, but also to seismometers, infrasound microbarometers, radioxenon sensors, and also to major software systems.

Currently the IDC is engaged in an effort to recapitalize the software infrastructure that supports its primary functions (receipt, archiving, automatic processing, human interactive review, and dissemination of IMS data and IDC products). The current software was designed in the 1980s using then state-of-the-practice software engineering. The software has been migrated to more modern computer hardware at great effort, but the underlying data models and flow control remain the same as the 1980s design. Many modifications, bug-fixes, patches, have been made. This has left the code 'brittle' and increasingly difficult (thus expensive) to maintain or improve further. It is time to re-design the code using modern state-of-the-practice software engineering methods while there are still scientists who understand the old code and can assist in the redesign effort. But the new code will be based on modern languages, data-models, and flow control that will be more flexible, sustainable thus able to more economically persist into the next decade.

In particular cases of recapitalization the CTBTO and the supporting communities in national research institutions must be cautious of market economic practicalities. Currently several national research institutions are developing next generation radioxenon sensors that are hoped to be more sensitive and more cost-effective to operate. However, the business case must be carefully considered —the IMS has limited potential for procurement of such systems, and there is limited market for such systems beyond the CTBTO. It's not clear how many providers can be sustained by the market.

The CTBTO does not exist in a vacuum. As we've seen with each DPRK test, public analysis by academic institutions, think-tanks, and media experts is becoming increasingly sophisticated and rapid. These sources are not constrained in their data sources, data types, or analysis methods. Their results are presented to the public quickly and form the basis for discussion and assessment long before the CTBTO can brief its Member States. Even though the CTBTO has met the timelines specified in the Treaty for issuing standard products and rapidly briefed

Member States after all six declared nuclear tests by the DPRK—it is doubtful the CTBTO will ever compete with these other sources of information in timeliness. Nor should it. The CTBTO should not compete but rather find ways to be synergistic with these public forms of analysis. We are exploring ways to issue our results in formats the Member States and public media can incorporate into their presentations and more easily reference so that they re-enforce the CTBTO data and analysis as an authenticated, credible, international baseline from which further derived results can be developed.

The countries of the world have invested considerable resources in the CTBTO monitoring regime and annually invest more in its upkeep. They also invest in their national data centres, which includes both a monetary aspect and the dedication of personnel who might otherwise provide some other service to the country. We all hope this international and national investment is never needed for its intended purpose—that is we hope there is never another nuclear test. How do we maintain Member State and public interest and investment in a system we hope will never be used as intended? How do we maintain proficiency in this system if the signal it is designed to detect is never observed? One answer to these questions is to promote civil and scientific use of the system.

Civil and scientific applications of IMS data is not just altruism—it is a means to achieve several important benefits for the nuclear test monitoring community. Particularly, civil and scientific applications provides

- a tangible return to Member States who can better justify continued investment in their NDC if those staff provide some other societal benefit such as seismic hazards analysis, tsunami warning, radiation health warnings, civil aviation safety notices, etc.…
- improved analysis methods to the nuclear test monitoring community when scientists working on a civil application develop new tools to discriminate signals of interest to them within the IMS data stream (one person's noise is another's signal)
- increased quality control on IMS data ("well exercised data is healthy data"—Paul Richards)
- an increased pool of experts familiar with IMS data who could be potential recruits into the nuclear test monitoring community
- operational tests of the monitoring network to ensure it remains functional (for example bolides test the infrasound component of the IMS)
- public exposure that reinforces awareness of the regime

In conclusion I'd like to re-emphasize several points:

The purpose of the verification regime is to promote trust and understanding. It gives confidence that parties to the Treaty are abiding by the Treaty's provisions.

The CTBT is particular in that the regime provides trusted data to the Member States that reach their own conclusions. In this, it is a democratic, non-discriminatory regime—and this has implications on technology related to the regime.

It's crucial to refresh the technology of the CTBT verification regime, and this is being done.

Both "Capacity Building" and "Civil and Scientific Applications" provide value to Member States and increase the future pool of practitioners who can be recruited to carry on the mission of the CTBTO.

The CTBTO verification regime is effective and working today.

Thank you for your attention and I welcome any questions.

Chapter 26
Science Beyond Boundaries: SESAME and the International Cooperation

Chris Llewellyn Smith

SESAME is a 2.5 GeV third-generation light source, which is coming into operation in Jordan. It will foster science and technology in the Middle East and neighbouring countries (from biology and medical sciences through materials science, chemistry, and physics to archaeology), as well as cooperation among the scientists from diverse countries across the region who will visit SESAME periodically to carry out experiments.

SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East) is a large scientific facility, just coming into operation in Jordan, which will enable research in many fields, and foster cooperation across political, religious and cultural divides. There is nothing remarkable about SESAME as a scientific facility, except that of over 50 synchrotron light sources in the world, it is the only one in the Middle East. The list of Members that belong to SESAME, which is an intergovernmental organisation, is however very remarkable. They are Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey. The list of SESAME Observers (Brazil, Canada, China, EU, France, Germany, Greece, Italy, Japan, Kuwait, Portugal, Russian Federation, Spain, Sweden, Switzerland, the UK, and the USA), whose role will be explained later, is a manifestation of world-wide support for SESAME.

SESAME has faced many difficulties, almost all financial, but it is now starting to work, and the experimental programme is about to begin, albeit on a limited scale, with minimal supporting infrastructure. For over a decade, SESAME's vigorous training programme has been building scientific capacity in the region and nurturing a community of scientists who will visit the facility in order to carry out research.

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I will begin this talk by saying something about CERN, on which SESAME is modelled conceptually, although the scale and scientific aims of the two organisations are completely different. I will then go on to introduce SESAME and synchrotron radiation, describe the origins of the project and how it is funded and how it was built, outline some of the science that will be enabled by SESAME, discuss SESAME's training programme, and finally describe some of the challenges the project has faced and its future prospects.

CERN and SESAME were both created under the umbrella of UNESCO, which uses the strapline 'science for peace'. CERN was conceived in the late 1940s, with two aims: to enable the construction of expensive facilities beyond the means of any individual European country, and to foster collaboration between countries that had very recently been in conflict. European physicists (of whom Edoardo Amaldi was one) realised that the large, expensive accelerators being built in the USA would soon take over from cosmic rays as a source of high-energy particles whose collisions they wished to study, and that they could only afford to build competitive facilities by collaborating. They joined forces with some far-sighted science administrators and diplomats who were developing the idea of establishing a collaborative project to help rebuild collaboration and trust in Europe following the war.

SESAME was conceived in the late 1990s with the same aims, the major differences being that some of the Members are currently in conflict, and the scientific goals of SESAME and CERN are very different. CERN has built bridges between peoples in many ways. For example:

- It was the first intergovernmental organisation that Germany joined after the war.
- The first post-war meetings between German and Israeli scientists took place at CERN.
- Collaboration between CERN and Russia continued through the Cold War, and was a model for later USA-Russia collaboration.
- In the late 1970s, when China was closed, scientific contacts between Europe and China were pioneered in work at DESY (in Hamburg) and later at CERN, in collaborations led by Nobel Laureate Sam Ting from MIT with the backing of Deng Xiaoping.
- In 1985, when USSR-USA arms negotiations in Geneva were stalled, the US delegation asked the Director General of CERN to arrange a dinner at CERN for Russian and American scientific advisors—which facilitated a subsequent breakthrough.
- CERN had an open-door policy for scientists from East European countries during the cold war, which allowed them quickly to join CERN (as an expression of their European identity) following the fall of the Berlin wall.

CERN has found that, although they are often initially mutually suspicious, scientists and engineers with very different political and religious views and cultures who work together develop technical respect. This then leads to greater understanding and tolerance of their respective views. Today over 12,000 scientists carry out research at CERN (some 7,300 from the 21 Member States, the rest from 81 other countries, among which the largest contingents come from the Observers —India, Japan, Russia and the USA). The collaborative work these (mainly young) scientists carry out at CERN undoubtedly creates better understanding. This is also happening at SESAME.

SESAME is a third-generation light source, a device which (pending an explanation below) can be thought of as an extremely bright flashlight which illuminates samples of materials that scientists study using very powerful microscopes. SESAME will foster science and technology in the Middle East and neighbouring countries (from biology and medical sciences through materials science, chemistry, and physics to archaeology), as well as cooperation across political, religious and cultural divides.

International collaboration is the obvious way for countries with relatively small scientific communities and/or limited science budgets to build synchrotron light sources. The breadth of the scientific programme they can support makes them ideal facilities for building scientific capacity, which is SESAME's primary goal. SESAME will be a user facility: scientists will typically go to the Centre two or three times a year for a few days to carry out experiments, often in collaboration with scientists from other institutions/countries, with the support of SESAME's small permanent staff.

Synchrotron light sources accelerate bunches of electrons that then circulate for many hours in an evacuated beam-pipe with a diameter of a few centimetres which forms a (almost) circular ring (with a circumference of 133 m in the case of SESAME). The electromagnetic field surrounding the electrons is unable to respond instantaneously when the electrons are steered around the ring by the magnets that surround the beam pipe. Some of the energy in the field keeps going, producing a tangential cone of synchrotron radiation. As the electrons' energy increases, the cone of radiation narrows, and the radiated power goes up dramatically. In third-generation sources such as SESAME, devices inserted in straight sections of the accelerator (called wigglers or undulators) put magnetic 'bumps in the road'—radiation shaken off as the electrons traverse successive bumps adds up to make a much more intense beam of synchrotron light.

Devices called beamlines, positioned at various points around the accelerator, select synchrotron light with particular wavelengths and focus it on samples of materials that scientists wish to study, which are surrounded by sophisticated detectors that are used to analyse what happens.

Eminent scientists such as the Pakistani Nobel Laureate Abdus Salam recognised the need for an international synchrotron light source in the Middle East some 35 years ago. The CERN and Middle-East based Middle East Scientific Cooperation (MESC) group, headed by Sergio Fubini, also felt this need. MESC's efforts to promote regional cooperation in science, and also solidarity and peace, started in 1995 with the organisation in Dahab (Egypt) of a meeting at which the then Minister of Higher Education of Egypt, Venice Gouda, and Eliezer Rabinovici

(MESC and Hebrew University, Israel) took an official stand in support of Arab-Israeli cooperation.

In 1997, Herman Winick (SLAC National Accelerator Laboratory, USA) and the Gustav-Adolf Voss (Deutsches Elektronen Synchrotron, Germany) suggested building a light source in the Middle East using components of the soon to be decommissioned BESSY I facility in Berlin. This brilliant proposal fell on fertile ground when it was presented and pursued during workshops in Italy and Sweden organised by MESC (which adopted the proposal) and others. Fubini and Herwig Schopper (a former Director-General of CERN) persuaded the German Government to donate the components of BESSY 1 to SESAME, provided funding to transport the equipment (which was eventually mainly provided by UNESCO) could be found.

Schopper brought this plan to the attention of Federico Mayor, then Director-General of UNESCO, who convened a meeting of delegates from the Middle East and other regions at the Organization's Headquarters in Paris in June 1999. The meeting resulted in the launching of the project and establishment of an international Interim Council with Schopper as Chair. Jordan was subsequently selected to host SESAME in a competition with five other countries from the region. The Government of Jordan provided the land, as well as funds for the construction of the building. In May 2002, the Executive Board of UNESCO unanimously approved the establishment of the Centre under the auspices of UNESCO, which is the depository of SESAME's Statutes. The Centre formally came into existence in April 2004 when the required number of Members had informed the Director-General of UNESCO of their decision to join.

Meanwhile, in 2002 questions were raised about the wisdom of re-building and upgrading BESSY 1. It was formally abandoned in 2004 in favour of building a completely new 2.5 GeV main storage ring, with straight sections that can accommodate insertion devices (wigglers and undulators), thereby making SESAME a competitive third-generation light source, while retaining the BESSY 1 microtron and booster synchrotron, which provide the first two stages of acceleration. A ground-breaking ceremony was held in January 2003 in the presence of HM King Abdullah II of Jordan and Koïchiro Matsuura, then Director-General of UNESCO. The SESAME building was formally opened on 3 November 2008 in a ceremony held under the auspices of HM King Abdullah II, with the participation of HRH Prince Ghazi Ben Mohammed of Jordan and Koïchiro Matsuura, then Director General of UNESCO, representatives of the SESAME Members and other distinguished guests.

Following the opening of the building in November 2008, I took over from Herwig Schopper as President of the Council. Before agreeing to this, I visited SESAME where I was impressed by the commitment of Khaled Toukan, the Director of SESAME (who was then also Jordan's Minister of Education; he is now the Chairman of the Jordan Atomic Energy Commission, having meanwhile been the Energy Minister). I was also deeply impressed by the enthusiasm of the young people who, having been trained as accelerator specialists in Europe, with Fellowships arranged by SESAME, had returned to the Middle East to build

SESAME (the training programme is described in Sect. 7). I was further impressed by a remark made by Eliezer Rabinovici, when he visited the UK to persuade me to take on the role of President, that "As a string theorist, I work on parallel universes. I was always curious about what a parallel universe was like, and now I know. I'm living in one when I go to SESAME meetings working hand in hand with our neighbours on a common goal, bringing advanced knowledge to our region."

When I took over as President, SESAME had a large empty building and a design for the accelerator, but there was no plan for building the facility as there were no funds to do so. I decided that anyway SESAME needed a Strategic Plan, which of necessity would be based on the obviously false assumption that the necessary funding would become available when needed, and that there was a need to review earlier costings. This plan (which the SESAME Council endorsed in November 2009) has been followed subsequently, albeit nothing like as rapidly as hoped, and with numerous items postponed, because the necessary capital funding was not available.

The Members of SESAME make annual contributions, which cover operational costs (manpower, consumables, electricity,…). However, when SESAME was set up, no provision was made for the Members to cover the initial capital costs since the plan then was simply to upgrade and rebuild the old Berlin Synchrotron, while Jordan had agreed to provide the land and fund the building. When the decision to build a completely new (2.5 GeV) main storage ring was taken, it was hoped that the European Union, which the SESAME Council had hoped would fund the upgrade, would provide the much larger capital funding that was needed to build and equip the new main ring. However, the 2009 Strategic Plan revealed that (as I had suspected) construction would cost much more than previously assumed, and it became clear that it would not be possible to obtain all the funding from outside without first obtaining a substantial part from the Members.

A breakthrough came in early 2012 when Israel volunteered to contribute $5 million provided four other Members did the same. I convened a meeting of Members who were willing to consider contributing, which was attended by representatives of Iran, Israel, Jordan and Turkey. Until shortly before the meeting, it was hoped Egypt would send a representative but the country was then in a state of turmoil and a change in the government intervened. The four countries that did attend agreed to contribute $5 million each, while hoping that Egypt or others would join them later (meanwhile the Royal Court of Jordan had made a significant cash contribution, and Jordan's Scientific Research Support Fund is currently supporting construction of a beamline as described in Sect. 6). In the event, Iran has not yet been able to pay its voluntary capital contribution, or since 2011 its annual contributions, due to sanctions. Unfortunately, partly because of frequent changes of government, Egypt has so far not fulfilled its expressed wish to make a capital contribution (this is the only example of a direct effect on SESAME of the Arab Spring).

Following this breakthrough, the European Commission (which had already provided funds to SESAME though its collaboration agreement with Jordan) agreed to provide CERN with €5 million to lead the procurement of the magnet system for the main ring, in collaboration with SESAME. CERN's contribution was hugely beneficial, and working with CERN's experts provided wonderful training experience for SESAME staff. The voluntary support from the Members also encouraged Italy to provide €1 million in 2014, which was used to procure accelerating cavities; this was followed by further Italian contributions, so far amounting to a total of €3.35 million of which the most recent part is being used to build a hostel for SESAME users.

This funding, together with the Members' annual contributions to the operational budget and donations of equipment that had become surplus to requirements by a number of synchrotron laboratories,[1] were sufficient to bring SESAME into operation. I hope that the additional capital funding that will be needed in the future, for purposes indicated in Sect. 9, will come from the annual contributions as well as from external supporters. This should be made possible by the construction of a solar power plant (see Sect. 8) which will reduce the enormous burden of paying for power that would otherwise have fallen on the Members. Many have tiny science budgets and have sometimes struggled to pay their annual contributions, although I hope that they will find it easier once SESAME is producing results.

Construction began with the installation of the massive concrete shielding walls that surround SESAME's accelerators, and fill much of the experimental hall, using funds from the Royal Court of Jordan. By November 2013, the ex-BESY 1 mictrotron, a relatively small device that provides the first stage of acceleration (through 22 meV), had been refurbished, brought into operation, and installed in its final position. Installation of the refurbished BESSY 1 booster synchrotron, which accelerates the electron bunches up to 800 meV, was well underway, but in December 2013 disaster struck when an unprecedented snowstorm (it even snowed in Cairo for the first time in 112 years) produced an accumulation of slush on the roof, which collapsed.

While time was spent debating who was responsible, and who would pay for a replacement roof, the SESAME staff—working under open skies—valiantly got on with the job, and in September 2014 a beam was stored in the booster and accelerated to 800 meV, making the booster the then highest energy accelerator in the Middle East. By the time the new roof was fully in place, in March 2015, the first of 16 'cells' of the magnet system which is at the heart of SESAME's main ring had been built, using EU funding, and assembled for testing at CERN.

Thereafter installation of the components of the main ring and associated systems proceeded relatively smoothly, and was essentially complete by late 2016. On 11 January 2017, a beam was transferred from the booster and circulated in the main storage ring for the first time. By late April, the accelerating system was fully installed and a beam (albeit with a very modest current) was accelerated to the design energy of 2.5 GeV.

[1]For a list of external contributors to SESAME see www.sesame.org.jo/sesame/images/News/SESAME-Opening/Souvenir_Booklet.pdf.

During 2016 we planned a major opening ceremony for May 2017, on the assumption that the machine would be working by then. On 16 May, His Majesty King Abdullah II of Jordan duly declared SESAME open, in the presence of the Directors General of CERN, IAEA and UNESCO, the European Commissioner for Research, Science and Innovation, senior representatives of the SESAME Members and Observers, visitors from round the world, and of course the SESAME staff and their spouses. Following a meeting of the Council the next day, I handed over as President to Rolf Heuer, another former Director General of CERN.

I had hoped that by the time of the opening, the first experiments would have begun, but installation of the initial beamlines (which are described in the next section) took longer than anticipated, although the scientific programme is now about to start. Since the full energy was reached in April, there have been some problems with the reliability of the machine. Just before this conference, however, a 40 mA beam was accelerated to 2.5 GeV (much less than the ultimate/design current of 400 mA, but enough to allow experiments to begin) and stored for three hours (the current then fell to 20 mA, which was stored for another three hours). Light was sent down the first beamline for the first time shortly after the Amaldi Conference.

Synchrotron light sources are equipped with ‘beamlines’ which focus the light on samples that scientists wish to study. Each beamline can support several experiments in series and in parallel. Initially, SESAME will have just two beamlines, which are described below: an X-Ray Absorption Fine Structure/X-Ray Fluorescence (XAFS/XRF) spectroscopy beamline, which is currently being commissioned, and an Infrared (IR) spectroscopy beamline, which is expected to come into operation around the end of this year. A Materials Science (MS) beamline (for studying disordered/amorphous material on the atomic scale and the evolution of nano-scale structures and materials in extreme conditions of pressure and temperature) is expected to come into operation in 2018. It is based on high quality components that were donated by the Swiss Light Source, which also donated a wiggler which will be associated with this beamline. A Macromolecular Crystallography (MX) beamline (which, combined with a protein expression/crystallization facility for structural molecular biology, will be used to elucidating the mechanisms of proteins at the atomic level and providing guidelines for developing new drugs) should become operational in 2019. The MX beamline is a new beamline constructed in part with funds provided by Jordan’s Scientific Research Support Fund. In Phase 1, three more beamlines will be built once funding is available: it currently seems likely that the European Union will fund one of them.

The XAFS/XRF beamline, which is based on components of a beamline previously in use at the European Synchrotron Radiation Facility, will be equipped with an advanced detector, generously contributed by Italy, that will have a sensitivity at least 50 times higher than existing detectors and an unprecedented dynamic range. This beamline will have applications in basic materials science, life sciences, and environmental science on the nano-and micro-metre scale. Some research undertaken by scientists from the region at synchrotrons in Europe is expected to continue at SESAME. Examples with regional relevance include a study of absorption and mobility of heavy metals in soils in the vicinity of the Jordan and Yarmouk rivers, tracking air and soil pollution in some Arab regions, and studies of metal storage and balance in wheat (which uncovered the origin of the efficacy of zinc-based fertilisers, and of the deleterious effects of cadmium in the soil).

Topics that can be studied at the IR beamline, which is a new beamline constructed in collaboration with the Soleil Synchrotron, include surface and materials science, biochemistry, microanalysis, archaeology, geology, cell biology, biomedical diagnostics, and environmental science. In 2014, SESAME purchased a Fourier Transform Infrared microscope which (pending the availability of a very much more intense beam generated by SESAME) has been used with a thermal source of infrared radiation. The first experiments included a study of breast cancer by Fatemeh Elmi (from the University of Mazandaran in Iran), and a study of the effect of a medicinal oil (now published, with Randa Mansour, a PhD student in the Faculty of Pharmacy, University of Jordan, as first author). Further medical work at SESAME is expected to include investigation of a hepatitis C genotype that is prevalent in the Middle East.

SESAME put out a call for proposals to carry out experiments at the XAFS/XRF and IR beamlines in early 2017. Fifty-five were received, demonstrating a clear need for SESAME.

The process of training scientists and engineers from the region in the use of synchrotron radiation and relevant accelerator technology began soon after SESAME came into existence. Support for training has been received from Brazil, Canada, China, France, Germany, Italy, Japan, Portugal, Spain, Sweden, Switzerland, UK, USA, EU, IAEA, ICTP, and UNESCO (see the link in footnote 1 for a list of the organisations that have helped SESAME). To date, SESAME has organised some 30 workshops and schools in the Middle East and elsewhere. These meetings, which have attracted some 750 scientists and engineers, have focussed on applications of synchrotron radiation in biology, materials science and other fields, as well as on informatics (in six meetings organised with the Cyprus Institute in the framework of the EU-funded LinkSCEEM project) and accelerator technology.

In addition, the training programme has allowed approximately 105 young men and women to spend periods of up to two years working at synchrotron radiation facilities and other centres (mostly in Observer countries) in Europe, the USA, Asia and Latin America. This has provided them with first-hand experience and further swollen the ranks of Middle Eastern scientists with experience in using synchrotron radiation sources. In addition to offering training opportunities, scientists from the world's synchrotron laboratories have generously provided invaluable advice as visitors and as members of SESAME's Advisory Committees, while representatives of the Observers have shared their wisdom with the Council.

On-going support for training, from the IAEA and others, will be further strengthened by the OPEN SESAME project, funded by the European Union. Its three key objectives are to: train SESAME staff in storage ring and beamline instrumentation technology, research techniques and administration for optimal use of a modern light source facility; build-up human capacity in the Middle East and neighbouring regions to make optimal use of SESAME's infrastructure; train SESAME staff and its user community in public outreach and corporate communications; and to support SESAME and its stakeholders in building awareness and demonstrating its socio-economic impact to assure longer-term success.

When fully operational (5000 h/year) SESAME will consume 10 GWh/year of electrical power, which (at the price of $375/MWh which the laboratory is currently paying) would lead to an annual bill of $3.75 million. This would roughly double the annual budget, which many of the Members are already struggling to pay. Contemplating this prospect, it became clear that construction of a Solar Power Plant (SPP) would be necessary to ensure the sustainability of the project. The conditions near Amman are favourable, a suitable site was made available by the Jordan Atomic Energy Commission, and agreement was reached with the grid to provide SESAME (when needed) with the same amount of power that SESAME's SPP will feed into the grid.

SESAME was thinking of a build, operate, transfer contract for the SPP, when the Government of Jordan generously agreed to transfer to SESAME part of funds provided by the EU (for carbon emissions reduction in neighbourhood countries) for the construction of the SPP. Consequently, power will be almost free when the SPP comes into operation in mid-2018. This will not only put SESAME on a sustainable basis, but will make it the world's first accelerator powered entirely by renewable energy.

SESAME has overcome many challenges. Most were financial, although some (such as the perennial question of the name under which Palestinians participate) were political, and one (the collapse of the roof) was natural. Construction has taken longer than hoped because of lack of funding (the Strategic Plan adopted in 2009 asserted that SESAME could be in operation in 2014 with three beamlines if sufficient funds became available when needed). However, the design energy has now been reached, experiments are about to begin at the first two beamlines, and—in parallel with construction—the training programme has strengthened scientific and technical capacity in the region. Meanwhile construction of the Solar Power Plant will prevent the budget rising to an unaffordable level, thereby putting SESAME on a sustainable basis, and provide an example for accelerators elsewhere.

In addition to dealing with on-going problems generated by the political situation in the region, such as travel restrictions which have made it impossible for most of the Members to host Council meetings, SESAME faces three immediate challenges. The first is to find the funding needed to complete the proposed suite of seven 'Phase 1' beamlines (as stated in Sect. 6, it currently looks as if the EU may fund one of them), and (perhaps more urgently) provide additional supporting infrastructure, including laboratories and properly equipped workshops. The second is to find a means for Iran to pay, which has been impossible since sanctions began.

The third is to attract new Members, which SESAME has always sought in order to spread the benefits more widely. The political complexion of SESAME, coupled with scepticism that SESAME would ever work, has made it difficult to attract new Members, but with SESAME in operation, and potentially large rises in annual contributions now capped by the construction of the SPP, the situation has changed, and the time has come for vigorous efforts to increase the number of Members.

In the not too distant future, SESAME will have to be equipped with a 2.5 GeV injector in order to remain competitive with other light sources, where full energy injection is becoming increasingly common. Such injectors allow the beam current, which would otherwise decay with time, to be topped up so that the intensity of the synchrotron light remains constant in time, allowing experiments to be performed more rapidly (and making the whole system easier to operate as the conditions remain constant). This will be an expensive undertaking, for which (as agreed at the last Council meeting that I chaired) SESAME needs to begin planning now.

SESAME also needs to find funds to build a conference centre. When SESAME is not in operation, and the conference centre and guest house (which is now being built, funded by Italy; there is already a small temporary guest house which will be able to accommodate the relatively small number of initial SESAME users meanwhile) are not in use, they can be used to house international meetings on other topics of regional interest (related to agriculture, water, archaeology, etc.) in secure easily accessible surroundings, in a country that is open to visitors from across the region. It is my dream that this will lead to the creation of other regional collaborations and facilities, just as CERN led to the creation of other joint European scientific centres.

Meanwhile SESAME is building scientific and technical capacity in the region, and will soon be producing results, some of immediate regional impact for the environment and health. It is already a working example of Arab-Israeli-Iranian-Turkish-Cypriot-Pakistani collaboration. Senior scientists and administrators from the region are working together to govern SESAME through the Council, with input from scientists from around the world through its Advisory Committees. Young and senior scientists from the region who have been collaborating in preparing the scientific programme (at Users' Meetings and Workshops) will soon be collaborating in experiments at SESAME.

On several occasions since I became involved, the future of the project was in doubt, but we soldiered on and the construction of SESAME has been a victory of optimism over scepticism and realism. I would like to leave the last word to some scientists who will use SESAME, which they expressed in a short 2012 BBC film that can be seen at http://www.bbc.co.uk/news/science-environment-20447422, and in contributions to a (now in other ways out-of-date) brochure http://mag.digitalpc.co.uk/fvx/iop/esrf/sesamepeople (further information about SESAME can be found at www.sesame.org.jo). Their enthusiasm makes me confident that the future of SESAME is secure.

Chapter 27
SESAME Synchrotron Light Source, Why in the Middle East?

Gihan Kamel

> *Take care of small things if you want to obtain the greatest results*
> Federico Cesi (Founder of the Accademia dei Lincei in 1603)

I am here to deliver a message about SESAME where I currently work in Jordan, why do we need it in our region and how it is succeeding so far, based on a personal, as well as, a professional experience. I don't intend to deliver a completely positive or pink picture because we still have difficulties and challenges those we face every day, nevertheless, some wonderful things are earnest to be declared.

I got my Master Degree in Physics in Egypt, then I moved afterwards to Italy where I obtained a Ph.D. in Biophysics from the University of Rome, La Sapienza. After returning back to Egypt, I worked at my university as a Physics Lecturer for 2 years before realizing that I need to go back to Europe to pursue an advanced scientific career in a synchrotron facility as I was dreaming. After a few trials, I was selected for a researcher position at the *Laboratori Nazionale di Frascati*, LNF-INFN, Italy. When SESAME opened an Infrared Beamline Scientist position, I applied—thanks to the experience I gained at the LNF-INFN. I was selected for the position. With this, SESAME brought me back close to my home country, Egypt. It brought me back to the region I belong to: the Middle East. The region that is painted with blood and tears.

Speaking about the Middle East, no one is certain of what is going on there. As an Egyptian, I am expected to know a lot about the region. Sometimes I get my friends and colleagues asking me if it is safe to visit Egypt, and the question became "is it safe to visit Jordan?" Well, I also do ask the same questions now "is it safe to visit Italy or France or Germany, or any place in the world?" The recent events of terrorism and violence leave so many people in doubt and fear of what could

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happen if they are planning a visit to the region. But for us living in the Middle East, the situation is so much different. We are *always* in doubt, fear, and bitterness.

If anyone tries to understand what's going on there, one may get an image of a huge number of complicated and conflicted geo-political networks—which is just one of so many. Through various channels, I noticed that nearly everyone wants to know what is going *wrong* with the Middle East, but very few want to know what is going *right*. I am here to say that SESAME is our brilliant model of those things going right. It opens many doors wide, not only doors for science, not only for reversing the brain-drain dispute where so many Mediterranean scientists keep searching for a better future—exactly as I did some years ago- flowing to the west, but also for the mutual and human understanding and unity among very different nations.

My journey with SESAME dates back to 2005. I witnessed that place when it was merely a desert. Now after 12 years, I see an oasis. An oasis of advanced science and technology, of understanding, neutrality, and fairness. An oasis of peace; a certain kind of peace that calls no diplomatic deals. Just science. The very pure logic of science. I don't think that the governments of SESAME Members or Observers are wasting their time or money for nothing. There are politicians, policymakers, diplomats, administrators, but the key players are scientists, engineers, and technicians. The end product is scientific results, not agreements, regulations or measures. The end product of SESAME is scientific publications, and this is the only feedback that our council relies on. It is we are working on and it is our "*safety measure*" that we are keen to follow.

With even our similarities and common standards, we are still different. Globally, it is difficult to see that. One needs to focus on the right tool to create a status of peace and harmony, one needs to speak the right language that *must* be neutral and the *must* be well understood and accepted by *all*. This is why the SESAME people chose to speak "Science".

Compared to other regions and similar facilities all over the world, things at our side are developing slowly, and the reasons are quite clear, but as long as they do develop in the right direction, we'll not stop. We can't deny or ignore what is happening around us every day, we can't ignore the destruction and the threats, but somehow we decided to be the "Love in the Time of Cholera", instead of leaving or dying, at least we are trying. A nice proverb that I got to know more than a year ago says "If you want to walk fast, walk alone. If you want to walk far, walk together" And this is exactly how I see us: the SESAME people. As individuals, we represent different motives, perspectives, and intentions, but at the end of the day we create our own future in this age of devastation and sadness.

Since you are discussing the safety issue in this conference, I want to share with you the same concern and to tell you that similar to you and as all the people on this planet, we also strive to feel safe and to live in peace. I want to take this opportunity to deeply thank you all for your hard efforts towards a safer world and harmless undertakings. As I did learn in these few days of this accomplished conference that you certainly pay attention to the very small details, I want to convey to you my message that is we, at SESAME are also doing the same. Together, step by step, with our growing community, are proud of what we did so far, and definitely we'll be pushing for more.

I believe that changing the negative perspectives is a success, finding the middle ground between the traditional restrictions of different societies with the ambitions and motivations of the young generations is a success, and I believe that converting hate to trust and despair to hope is a *huge* success.

Lastly, as you cannot fully guarantee safety and security, nevertheless, you are still hoping for and toughly, as well as, progressively working on with patience and persistence, we also are doing our best with you. And as long as others insist to fight for war, we will also insist to fight for peace.

Part VIII
The Future of Nuclear Disarmament and Non-proliferation

Luciano Maiani, Micah Lowenthal, Alexander Savelyev and Xiangli Sun

Chapter 28
Introduction

Luciano Maiani

The two years that have passed since the last Edoardo Amaldi Conference have registered a sudden change of climate in Nuclear Disarmament and Non-proliferation.

In 2015 one could quote opinions expressed by well know personalities in the international arena, among them one President of the United States, pointing to a nuclear weapon free world. Discussions between Iran and representatives of the P5 group on the Iran nuclear weapon program were heading towards a successful conclusion.

Soon thereafter, US and Russia have manifested the intention to upgrade their military strength, the US President has put in doubt the validity of the agreement reached by Iran and P5 in Vienna and North Korea has given a serious blow to Non-Proliferation, with a string of nuclear and missile tests.

In January 2017, the Science and Security Board of the Bulletin of the Atomic Scientist has advanced by 30 s the Doomsday Clock, bringing it to 2½ min from midnight.

The preoccupations of the technical and scientific community working in the Nuclear Disarmament and Non-Proliferation have clearly emerged in this Conference, in particular in the opinions expressed by the experts participating in this Panel, from China, Russia and US, and in the subsequent interventions from the floor.

Some light seems to come from the fact that inspections under New START have continued to proceed smoothly in both Russia and the United States and by the hope that a new START bilateral agreement can be renovated at the expiration of the present one, in 2021.

In this connection, the scientific community is called to an increased effort to inform Governments and public opinion of the risks implied by changes in the

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policy of armaments and to increase the opportunities of dialog and exchange of information among its members.

Following the examples of Panofsky, Amaldi and others, we have to use our "pessimistic minds and optimistic hearts" (as proposed to us by Lowenthal) to counter the raise of national and regional confrontations we are assisting in these days.

Chapter 29
Nuclear Disarmament and Non-proliferation Today and in the Near Future

Micah Lowenthal

The prospects for nuclear disarmament, arms control, and nonproliferation today and in the near future are bleak. Multiple factors have made the United States and the Russian Federation increasingly unlikely over the last several years to seek and agree on new measures, and some existing agreements are in peril. North Korea has violated norms, defied the world powers including its few allies, and threatened its neighbors and the United States with nuclear war. Iran abides by the Joint Comprehensive Plan of Action, but the United States seeks to reopen the deal to tighten restrictions. In the face of these circumstances, the nuclear technical policy community can continue to engage and explore opportunities for promoting peace, stability, and security; provide relevant and timely advice inside governments and to the larger public; improve the ability to prevent clandestine proliferation programs and continue to stigmatize overt proliferation; and address systematically the reasons leading specific nations to pursue nuclear weapons.

After many years of enjoying relatively stable relations among nuclear armed states, during which time many of us who work on nuclear security issues focused primarily on countering nuclear terrorism, we find ourselves in a time of heightened and increasing state-level nuclear threats. Without setting aside the concerns about nuclear terrorism, we must devote more attention to arms control, disarmament, and nonproliferation. To that end, I begin with my understanding of current bilateral relations between the United States and Russia with respect to arms control and disarmament. Second, I address international arms control and nonproliferation. And third, I touch briefly on the prohibition treaty and discuss what we in the technical policy community can do in this context.

Eight years after President Barack Obama's Prague speech expressing America's commitment to seek the peace and security of a world without nuclear weapons, we

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are collectively in a difficult time for arms control and disarmament. This is a result of both philosophical and real-world developments.

In the United States, policy reviews are conducted by each new presidential administration. The current reviews promise more fundamental examinations of goals, methods, and means, and they are expected to reflect President Trump's perspective. Trump says that the United States military has endured years of decline and depletion and is backed by an outdated nuclear arsenal. He presents this as a dangerous situation that emboldens enemies of the United States and its allies and weakens the United States' negotiating position inside and outside of crises. The Nuclear Posture Review and Ballistic Missile Defense Review led by the Department of Defense along with policy reviews by the National Security Council are being held close, with few or no public disclosures, but we can speculate that the internal discussions reflect the external debates on several points.

First, with the accusations that Russia has violated the Intermediate Nuclear Forces Treaty, policy analysts in Washington argue forcefully both for and against withdrawal from the treaty. Some say plainly that we cannot be party to a treaty if our counterpart does not abide by the terms of the treaty. Others say that, at least for now, the treaty places some constraints on Russia's deployment of intermediate-range nuclear missiles, and withdrawing from the treaty would free Russia to deploy a menagerie of intermediate forces that threaten U.S. allies. Such deployments could trigger another arms race. The United States has sought discussions with Russia to address and resolve the violations, but Russia has made counter-accusations and has declined talks pending U.S. disclosure of additional information on the basis for U.S. accusations. The United States says that it has provided sufficient information and there are no signs of progress. Experts in the United States and Russia are privately sharing worries that the INF Treaty might dissolve in months.

The pessimism about U.S.-Russia relations is reinforced by reactions to President Putin's approach to foreign policy, which is seen in the United States as driven by domestic politics but nonetheless returning us to an adversarial world. Putin has built his popularity on the image of a resurgent Russia that is a counterweight to the United States, which he characterizes as having hegemonic aspirations, and to NATO countries, which are characterized as the United States' European client or puppet states. Russia's increasing use of military might and unconventional engagements to intimidate and destabilize its neighbors and potential adversaries are coupled with bellicose talk and reported aggressive war planning strategies that utilize escalation and brinksmanship for advantage.

Despite bad and worsening bilateral relations, inspections under New START have continued to proceed smoothly in both Russia and the United States. This is good news, but the agreement expires on Feb. 5, 2021. It has a provision for extension for up to 5-years without returning to the Russian Duma and U.S. Senate for approval if both presidents agree. In July 2017, U.S. Under Secretary Shannon and Russian Deputy Foreign Minister Ryabkov committed to convening the New START Bilateral Consultative Commission and they have quietly begun holding strategic stability talks. One can hope that such meetings will lay the foundation for a 5-year extension of NewSTART.

The overall bleak picture for U.S.-Russian arms control did not emerge suddenly or even quickly. In general, a contentious international security environment con-tracepts new initiatives and makes the parties question existing commitments. The worsening security environment became increasingly apparent as Russia reacted to increased U.S. influence in former Soviet States, and as the United States and its allies supported (morally and, in some cases, militarily) overthrows of authoritarian governments in the Middle East and North Africa. Russia perceived both of these types of U.S. actions as profoundly threatening.

Russia's assertion of influence or control in Ukraine, to the point of annexing Crimea and providing manpower and materiel in support of breakaway groups in the Donbas, triggered a more severe and sustained U.S. response than the response to Russo-Georgian war in 2008. The White House was determined to make clear that Russian-sponsored actions in Ukrainian sovereign territory violated international law, international norms, and the trust of the international community, including an explicit treaty obligation in the Budapest Memorandum on Security Assurances. Therefor a "no business as usual" policy was imposed. As a result, military-to-military contacts were halted and a long list of U.S.-Russian cooperative efforts was suspended, including types of cooperation that proceeded even during tense times in the Cold War. The U.S. allowed exceptions for cooperation on security and other essential matters (space launch, for example), but the Russian government partly responded to U.S. restrictions by saying that Russia would engage in cooperative efforts only if the full portfolio of cooperation was resumed, not just the topics that were U.S. priorities.

Obama's strategy of deemphasizing the role of nuclear weapons in U.S. security also seems to have exacerbated rather than alleviated Russian concerns about U.S. intentions. Although the United States maintains a nuclear deterrent against strategic threats, it has elevated other military capabilities, such as conventional long-range precision weapons, against the other threats that tend to dominate U.S. security planning. Some in Russia entertain the idea that the United States is strengthening its cruise missile strike and European ballistic missile defense capabilities to enable a U.S. bolt-from-the-blue thrust and parry against Russian strategic forces. The Russian scenario has a U.S. attack with precision conventional weapons disabling a large fraction of Russia's nuclear forces (silo-based and mobile ICBMs, and submarines) and U.S. and NATO missile defense systems blocking Russia's counterstrike with its surviving nuclear forces. This fear is totally unfounded in the view of the U.S., but—warranted or not—that fear has become a reality both constraining and aggravating relations between our two countries.

We are told that the same Russian voices speculate that the United States might think that Russia would not respond to a conventional attack on its nuclear forces with a nuclear counterattack. I know of no American who agrees with these claims.

Others in Russia see U.S. policies as steps toward delegitimizing nuclear weapons, and shifting to a new potential battlefield in which the United States has an established technological advantage. Russia has, so far, rejected such a shift, and undertaken efforts that underscore the centrality of nuclear forces in Russia's security plans. Russia is said to be developing and deploying new delivery vehicles, including the 100-ton RS-28 Sarmat, a 10-warhead MIRVed missile.

Turning to nonproliferation, North Korea is regarded by many in the United States as the greatest threat today to international peace and security. In an aggressive test program surpassing all except the U.S. and Soviet programs at the height of Cold War, North Korea has launched missiles with ever greater range, and detonated nuclear explosives of significant yields. Observations indicate that North Korea has tested a missile with intercontinental range, although it is less clear that their missiles can strike their intended targets reliably. The most recent nuclear explosive test appears to have had a yield of hundreds of kilotons. A nuclear arsenal is of grave concern even with lower ranges and yields.

It is reported that North Korean officials say that their leader, Kim Jong Un, learned the lessons of Iraq and Libya. The argument goes that Kim sees nuclear weapons as a guarantee that preserves his regime, unlike Saddam Hussein and Muammar Qadaffi, who gave up their WMD. Looking at the timeline and the actual circumstances, however, one could equally argue that giving up WMD bought Saddam Hussein about 10 more years in power (and might have had more if he had clarified that he did not possess WMD prior to the second conflict) and Muammar Qaddafi got about 7 more years in power and ultimately was toppled by a civil war, not an invasion.[1]

To be clear, the United States seems to have little insight into actual North Korean thinking and reasoning, which itself increases the risk of miscalculation and accidental conflict. Still, we can hope that official DPRK statements do not reflect genuine belief that the United States seeks to invade and overthrow North Korea. It is true that there is no peace treaty formally ending the Korean War, but it is also true that the United States did not pursue military options when the DPRK was at its weakest in the 1990s and early 2000s. The United States has placed preconditions on negotiations for a peace deal to include the affected people in the negotiation (South Korea) and to reduce the potential for catastrophic conflict. Rather than guaranteeing the continuation of his regime, North Korea's development of nuclear weapons has only increased the risk of conflict.

The other major nuclear nonproliferation priority for the United States is Iran. Iran secretly developed enrichment capacity in violation of its commitments under the NPT. It has since reached an agreement, the Joint Comprehensive Plan of Action (JCPOA) with China, France, Germany, Russia, United Kingdom, United States, and the European Union. IAEA inspectors and the parties to the JCPOA have determined in each report that Iran has abided by the explicit, narrow

[1]Saddam Hussein's programs were dismantled in the early 1990s. He stayed in power until the completion of the invasion of Iraq in 2003, an invasion predicated on a claim (later shown to be incorrect) that he had reconstituted his WMD programs. Qaddafi gave up his weapons program in 2003–2004 under a threat of serious consequences. He stayed in power until 2011 when civil war broke out in Libya as part of the Arab Spring, against which a nuclear weapon would have been beside the point.

requirements of the agreement, including granting access to sites where inspections have been requested.

As of the finalization of this paper, there are reports that Trump will decertify Iran's compliance with the JCPOA and that the agreement is in the United States' national-security interests, and that he will seek to renegotiate the agreement.[2] If this is correct then it not only has a difficult path to achieving its goals. It creates a difficult situation with the U.S. Congress with little room for alternatives, except reimposing sanctions or succeeding in renegotiation. Opening a renegotiation would require convincing all of the other parties to participate when they disagree with the U.S. position. Reimposing sanctions under present circumstances may set a more dangerous precedent and do more damage to nonproliferation than anything in the JCPOA does.

Both Iran and North Korea make statements and take actions that threaten their neighbors and peace and stability, but Iran has entered into an agreement to assuage concerns about its nuclear programs. North Korea, on the other hand, has taken provocative acts at every opportunity and actually developed and tested nuclear explosives. Which alternative do we wish to encourage? Sanctions are only effective if there is a realistic prospect of alternative actions leading to relief from those sanctions, so one threatens the sanctions regime if the agreement is not followed. What would be the lesson of Iran?

In this context, it is difficult for the United States and the other members of the P5 to make progress on arms control and disarmament. The governments also say that they cannot engage the ban movement because however well-intentioned the movement may be, the Treaty on the Prohibition of Nuclear Weapons ignores the realities of the international security environment, it does not provide a path to its goal, and therefor they argue it is counterproductive. While agreeing with many of those points, I argue that there are reasons to pursue both progress on arms control and engagement with those who support the ban treaty.

Congratulations are due to those promoting the Ban treaty both on their accomplishment in getting sufficient support to open the treaty for signature and for receiving recognition from the Nobel committee. These successes express many people's deeply held feelings against nuclear weapons and dissatisfaction with progress on disarmament.

The prohibition seeks to delegitimize nuclear weapons, but it does not address the conditions that lead nations to seek or depend on nuclear weapons. It does not say how to proceed with reductions or elimination. It also has minimal verification provisions (it does not even require parties to the treaty to sign on to the Additional

[2]The decision and the reasoning will be known by the time of publication. We can note now that some who are opposed to the deal argue that we should never have established, and cannot establish, the precedent of allowing Iran to keep an enrichment capability, diminished though it is for the next eight years, because during that period Iran will gain more expertise and after the sunset of those provisions, Iran will be unconstrained. Critics also note developments outside of the agreement, such as Iran's ballistic missile advances and its sponsorship of non-state actors that attack civilians of Iran's neighbors. These are matters that do need to be addressed.

Protocol) and has only weak enforcement provisions. The Nuclear Weapon States already have commitment under Article VI the Nuclear Non-Proliferation Treaty to pursue negotiations for disarmament. Many of the Non-Nuclear-Weapon States are dissatisfied with the lack of progress on the commitment, as are many people in the nuclear weapons states and so-called nuclear umbrella states. But the Prohibition Treaty does not focus on the obstacles (the actors and situations) that make it challenging to fulfill (not only pursue, but act on) the Article VI commitments. For example, it does little to pressure Russia, which has more nuclear weapons than any other country and which has been the greatest obstacle to further reductions. As noted above, North Korea offers a parallel logic, that they need nuclear weapons more than ever at the present time.

Many of the people who support the treaty believe that terrible as nuclear weapons are, we need a nuclear deterrent against North Korea. In every nation, nearly any organization, and even in governments that seem monolithic, there are multiple perspectives. It makes sense to strengthen the hand of those inside who share your feelings and goals. This is true for the P5 governments and it is true for those who support the ban movement, and that is reason enough for those who support the Prohibition Treaty and their P5 counterparts to engage in dialogue. Perhaps the movement can use the enthusiasm and support for prohibition not only to pressure the governments (particularly Russia) on nuclear weapons but also to work on the real factors that motivate nations to have nuclear weapons and serve as major obstacles to arms control and disarmament, beyond just the inability to conceive of a world without nuclear weapons.

The nuclear policy community, including the subset with technical training, is accustomed to operating with a pessimistic mind and an optimistic heart. We can see the realities of the challenges that we face, but because of the importance of success we continue to devote ourselves to efforts whose rewards and progress are measured in the terrible things that have not happened. Taking this commitment as a given, the question is What can we and should we do? I offer here four suggestions actions.

I. We should work with other sectors and with counterparts in other countries to promote better understanding and to identify opportunities and options for cooperation, collaboration, and coordination.

This suggestion should not be mistaken for a superficial gesture and a naïve hope that we will all just get along if we better understand each other. Many of our disagreements are rooted in genuine differences in goals and perspectives. But the National Academy of Sciences Committee on International Security and Arms Control (CISAC) has found that technically based engagements have led to successes in part because of the common language and agreed forms of reasoning and evidence. Engagement among academic, scientific, military, and diplomatic sectors in different countries involves hard work to learn about the technologies and the situation, do analyses, share them, understand the perspectives and analyses of others, and develop new ideas. Because of the unique challenges and the possible benefits, CISAC is always looking for additional opportunities to do this work.

II. We should ensure that our input is relevant and timely inside governments and to the larger public.

We need to address questions that decision makers and even those who advise them are not permitted to consider (by time or mandate) or are not equipped to consider. This includes addressing both nuclear challenges (such as monitoring, dismantlement, disposition, and verification) and the broader security concerns, which I return to in a moment.

III. We should improve our ability to prevent clandestine proliferation programs and continue to stigmatize overt proliferation. This is in the mutual interest of nations around the world.
IV. We should address, systematically, the reasons leading specific nations to pursue nuclear weapons.

The reasons may have little to do with nuclear weapons, per se. In some cases, they are to address regional issues, which the world at large could alleviate or exacerbate, depending on their actions. More dialogue and joint efforts leading to increased entanglement may offer opportunities.

Our overarching goal must be international peace, stability, and prosperity to enable people to live healthy, fulfilling, and meaningful lives. This implies, among other things, respect for international law and for everyone's security. As we act on Article VI obligations, our treaty obligation to "pursue negotiations in good faith on effective measures relating to… nuclear disarmament," I know that some of the parties to the NPT with and without nuclear weapons will continue to examine their own and their allies' comprehensive security picture, and evaluate whether nuclear reductions and disarmament improve or worsen that security. If they conclude that they are less secure pursuing nuclear reductions and disarmament, then leaders may see it as their responsibility to avoid that path until the security picture changes.

So, to make progress, we need to address broader security concerns even as we deal with the unique challenges of nuclear weapons.

Chapter 30
The Future of Nuclear Disarmament

Alexander Savelyev

In this presentation, I would like to focus exclusively on the issue of the prospects for nuclear disarmament. This question seems to require separate consideration, because the current situation in this area not only has all the signs of stagnation, but so far does not give rise to manifestations of even moderate optimism.

So, after the signing in 2010 and entry into force in February 2011 the Treaty between the Russian Federation and the United States of America on further reduction and limitation of strategic offensive arms, the questions of a progress towards nuclear disarmament went out from the agenda of Russian-American relations. In contrast to previous periods, the current situation in this area can hardly be described as "pause".

In the past, such pauses were filled by active consultations of the Parties on the questions of future agreements on nuclear arms control. They were also used for a rethinking of their policies in this area, for a comprehensive evaluation of the positions the opposite side. Even since the autumn of 1983 (when the Soviet Union withdrew from all the negotiations with the United States on nuclear weapons) till the spring of 1985 (resume of the talks) "was not vain". The preparatory work continued, and contacts with the United States at an informal level (primarily through scientific communities) significantly increased. Now, at least for the fourth year in a row, we witness a decrease (rather, even lack of) activity in Russia and the United States in the field of nuclear arms control, which is very noticeable not only at the official level, but also at the expert level.

Politicians and experts referred to a number of reasons that underlie the gap in the relations between Russia and the United States in the field of nuclear arms control. One of them is the worsening of relations between Russia and the West as a result of the Ukrainian crisis. But the evidence suggests that the problem originated much earlier. We need only to recall that in March 2013 (i.e., one year before the

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events in Ukraine), the former head of the presidential administration of the Russian Federation S. Ivanov stated openly that Russia was not interested in further arms reductions. He stated that the reason for the absence of such an interest was the completion of the modernization of Russia's strategic nuclear forces and reluctance to reduce the number of the recently deployed modern systems of strategic weapons.

Another argument made by Russian President Vladimir Putin in February 2012 was the need to connect the process of nuclear disarmament with the third level nuclear powers during the following of the 2010 Treaty stages. Further clarification of this position by a number of officials, including the Minister for Foreign Affairs of the Russian Federation S. Lavrov, were that deeper cuts (then the 2010 Treaty provides) may lead to a situation where Russian and American strategic forces "become comparable with third level" nuclear powers.

One of the most serious obstacles to the achievement of new agreements with the United States in the field of nuclear arms control, according to the Russian leadership, is ballistic missile defense. This problem has arisen periodically in the relevant negotiations in the days of the Soviet Union. It spiked in 1983 after the US President R. Reagan declared the "Strategic Defense Initiative" (SDI), which slowed down the process of negotiations on START-1 and nearly blocked the conclusion of this and other agreements in the field of nuclear disarmament. The withdrawal of the United States from the ABM Treaty and subsequent US actions aimed at the development and deployment of the defense of the territory of the country and some of its allies, negatively affected the situation even more. Alongside with this all attempts to agree on the implementation of the joint (Russia-United States) programs in the field of defense also failed.

Russian leadership also explains the difficulties in reaching new agreements in the field of further reductions of strategic nuclear weapons, by the existence of nuclear weapons in the inventory of the US NATO allies that "cannot be ignored". In particular, this has been stated by the Deputy Minister of defense of the Russian Federation A. Antonov (at present—Russian Ambassador in the United States). Along with this, Russia is going to "take into account" the concept of the "Prompt Global Strike", the deployment of strategic non-nuclear precision weapons systems, the prospects of the placement of weapons in outer space, the presence of non-strategic nuclear weapons of the United States in Europe and a number of other imbalances of military confrontation. Many of these provisions are reflected in the current National Security Strategy of the Russian Federation, approved by V. Putin at the end of 2015.

Generally speaking, the position of Russia regarding the prospects of further steps in nuclear disarmament, is reminiscent of the one followed by the USSR in the late 1960s. In concentrated form, it is expressed in the principle of "equal security". This principle required to take into consideration all the factors determining the balance with the opposing forces. This meant that during the process of negotiations of an agreement with the United States in the field of strategic nuclear weapons, the Soviet Union felt justified to claim compensation for imbalances in other categories of weapons.

Of course, 50 years ago, these categories of "compensation", were somewhat different than today. So, they completely ignored non-nuclear weapons. The Soviet Union expressed concern on British and French nuclear weapons as well as on the US forward-based nuclear weapons in Europe. Now Russia raises the question of imbalances more widely, focusing mainly on non-nuclear, than nuclear weapons. And this creates additional difficulties in finding an understanding with the United States, and also raises serious doubts on the possibility of concluding new agreements in the field of strategic nuclear weapons.

From the American side there is not a "visible" and serious desire to continue the dialogue on nuclear disarmament. Moreover, the United States raises questions about "violations" of the existing agreements on nuclear disarmament from the part of Russia. In particular, serious complaints are made against certain provisions of the Treaty on the Elimination of Intermediate-range and Shorter-range missiles (INF Treaty). There are also doubts about the ability of Russia to implement all the provisions of the New START Treaty in terms of reducing its strategic weapons by the agreed levels by February 2018. Overall, it appears that the President of the United States D. Trump is very skeptical of the existing arms control agreements, particularly those that have been concluded by the previous democratic administration. He repeated it in his speeches.

Thus, from the point of view of the prospects for continuing the dialogue on further reductions of nuclear weapons, the situation does not look very promising. In such circumstances, the best option for developments in the near future (5–7 years) should be regarded as a preservation of the agreements already reached in this area. In other words, it is necessary to resolve the conflict regarding the INF Treaty and to extend the New Start Treaty to the year 2026, as contemplated by this agreement.

In opposite case one cannot exclude the option of further aggravation of the relations, not only between Russia and the United States, but also between Russia and NATO in general. If the existing treaties will no longer work, the nuclear arms race will continue, with further accusations of the Parties and the complete lack of control of the development and the deployment of nuclear forces. It will be quite possible that Russia and United States in such a case will deploy nuclear strategic weapons in excess of the limits of the New START Treaty (700 delivery vehicles and 1550 warheads), as well as will deploy the prohibited by the INF Treaty nuclear weapons in Europe.

One can clearly conclude that the progress in the area of strengthening the control of nuclear weapons and the new steps in the field of nuclear disarmament, with the existing Russian and United States administrations can be considered improbable. However, there is still a small hope that the Parties nevertheless can agree on new measures to limit the nuclear arms race.

It is obvious that both in Russian-American relations and in Russia-West relations on the whole, a lot of political obstacles to the beginning of new negotiations have been accumulated. It is extremely difficult to overcome them, and it will take most likely significant efforts of the parties and an extended period of time. There is a point of view that the move towards the negotiations on deeper cuts of strategic nuclear forces of the Parties is possible only after their relationships become more or less stable or, in any case, they indicate a clear trend towards improvement.

But one can approach this problem in a different way. Namely, to put at the forefront the achievement of a new agreement on deeper reductions of strategic offensive arms of the United States and Russia up to 1000 strategic warheads for each side. In case of a success, the new agreement could become a positive example of cooperation, which will give a serious chance to achieve mutual understanding in other areas. This will be facilitated by the beginning of extensive consultations on the whole range of security issues, including those of concern to the Russian side.

With regard to the problems of the military-technical nature, it is obvious that there are no serious obstacles to continue the dialogue on Russian and the US strategic nuclear arms reductions. The role and influence of "precision weapons" and "space weapons" on the strategic balance of the Parties was clearly exaggerated. In the foreseeable future, such influence will also be minimal if not absent at all.

U.S. programs in the sphere of missile defense are quite limited in terms of their impact on the ability of Russia to a crushing retaliation even by using weakened as a result of the "first attack" strategic forces. And this "attack" is extremely questionable strategic "first strike" concept, which, however, underlies many speculations about the ways to strengthen security and so-called "strategic stability". The reliance on highly unreliable missile defense system, many exercises of which ended unsuccessfully, is quite unrealistic. This system can easily be "bypassed" in terms of the direction of the strike. The decision to deliver a first strike cannot be taken by any reasonably thinking leader under any circumstances.

Relative to more distant prospects—after the year 2024, one can build pessimistic and optimistic scenarios as well. Many will depend of whether the Parties will be able to preserve the existing treaties on disarmament and thus to prevent uncontrolled arms race. In the meantime, one can only talk about the high degree of uncertainty in this area. This uncertainty is compounded by the fact that the question of the continuity of Putin's policies after his resignation from the post of the President of the Russian Federation in 2024 is still open.

Among other factors that may have a significant impact on prospects for nuclear disarmament not the last role will play American policy regarding the settlement of the North Korean crisis. Russian attitude to the continuation of the dialogue on disarmament, including the signing of new arms control agreements will depend (alongside with the other factors) on how consistently and firmly will the United States act in this regard.

In conclusion, the most optimistic (but, unfortunately, the least likely) version of the further steps on nuclear disarmament can be described as a shift from a quantitative to a qualitative solution. This approach, can open up the possibility to conclude a multilateral agreement in this area. The idea is to negotiate by the five major nuclear powers a total ban on ground-based ballistic missiles with a range more than 500 km (as provided by the INF Treaty). In this case, the Parties will talk about the complete elimination, first of all, of the most dangerous category of the first strike strategic nuclear weapons.

In the future, such a qualitative approach can be extended to other nuclear systems. This question, at least, could be discussed in the international format, first at the level of experts and then involving governmental representatives and authorities. Unfortunately, as already stated, such an option can be considered the least likely of wider set of scenarios of the development of the strategic situation in the future. But it seems that nothing prevents the scientific community consider and fully discuss even such seemingly fantastic, approaches to strengthening international security and nuclear disarmament. This will allow the leadership of many states to take informed decisions on the measures aimed at strengthening international security and may open up new perspectives on the road to complete nuclear disarmament.

Chapter 31
Promoting Nuclear Disarmament and Non-proliferation in Parallel

Xiangli Sun

Nuclear disarmament and non-proliferation are two major missions of the global efforts in reducing nuclear dangers, and the international community has obtained significant achievements in these two areas in the past decades.

In the non-proliferation area, a global non-proliferation regime, in which the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is a cornerstone, has established. With the comprehensive safeguards of International Atomic Energy Agency (IAEA) and the cooperation between the nuclear member states and non-nuclear member states of the NPT, this global non-proliferation regime has succeeded in slowing nuclear proliferation in this world.

With regard to nuclear disarmament, the United States and Russia have reduced a notable part of their huge nuclear arsenals through bilateral nuclear reduction mechanism. And multilateral co-operations have also made remarkable progress in promoting nuclear disarmament process, in which the conclusion of the Comprehensive Nuclear-Test-Ban Treaty in 1996 marked an important milestone.

Unfortunately, in recent years, we have been encountering pressing challenges and difficulties in nuclear disarmament and non-proliferation. The rapid progress in North Korea's nuclear capability prompted serious tension between this country and the United States. In the meantime, the Iran nuclear deal is facing to be abandoned by the Trump administration. Both cases pose acute challenges to the international non-proliferation regime. With the strained US-Russian relations, there is little prospect for continued bilateral nuclear reductions in the near future.

Another big challenge is related to the Treaty on Prohibition of Nuclear Weapons which was concluded months ago. This treaty, supported by over one hundred of countries, reveals the long concerns about nuclear dangers, representing a wish of eliminating nuclear dangers through a rapid disarmament approach. This treaty is also a reflection of severe division between nuclear-weapon states (NWSs)

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and non-nuclear-weapon states (NNWSs) on the issues of nuclear disarmament and non-proliferation. The increasing tension between these two groups has cast a shadow over the future of nuclear disarmament and non-proliferation.

Facing these challenges, what should we do? Here I would emphasize two suggestions.

Firstly, in the non-proliferation field, we should improve and expand existing global non-proliferation regime, and design a more comprehensive initiative in preventing nuclear proliferation. A comprehensive initiative in non-proliferation would include measures not only strengthening the non-proliferation norms, enhancing IAEA safeguards and export control, imposing economic sanctions on proliferation activities, but also promoting diplomatic dialogues, providing economic aids, building security co-operation regimes and so on. Among these efforts, security co-operation arrangements are particularly important, and more attention and efforts are needed.

Decades of history of nuclear proliferation has demonstrated that countries pursue nuclear weapons for security or/and national prestige. Security concern is the primary reason for a country to pursue nuclear weapons. Without addressing security concerns, it's hard to remove the main motivation of developing nuclear capabilities.

Security assurances and regional security cooperation arrangements are desirable and necessary measures in easing security concerns of NNWSs. Unfortunately, the existing international non-proliferation regime lacks of security arrangements. Under the NPT framework, the NNWSs have been pursuing legally binding security assurances from the NWSs for decades, but the NWSs failed to meet these requests. For addressing regional proliferation, some kinds of regional security co-operation arrangements are crucial. But so far there have been no any security arrangements in the concerned regions such as Middle East and Northeast Asia. Undoubtedly, security assurances and regional security arrangements are the most fundamental measures for preventing proliferation. So we need more active efforts in this regard.

Secondly, in the disarmament field, we should further nuclear reductions and multilateral arms control, and develop a step-by-step disarmament road map.

The balance in nuclear deterrence between major powers serves an important role in maintaining international strategic stability, and no other alternative is available currently. Therefore in the foreseeable future, the world still needs nuclear deterrence to maintain international strategic stability.

Actually, the maintenance of strategic stability is not directly related to the amount of nuclear weapons. Strategic stability can be maintained either at a high level of amount of nuclear weapons or low level of amount, with either symmetric nuclear capability or asymmetric nuclear capability. The key is to maintain mutual retaliation capabilities. So, maintaining strategic stability does not necessarily require nuclear reductions. However, the higher level of nuclear arsenal a country has, the higher cost and the more difficulties it will face in maintaining the arsenal. Therefore, it's relatively ideal for nuclear powers to maintain a balance of nuclear deterrence with small scale arsenals, which means continued nuclear reductions in the world nuclear stockpile are meaningful for the nuclear powers.

In addition, given the serious situation of nuclear proliferation and nuclear terrorism, and considering the NNWS's dissatisfaction with the slow progress made by NWSs in disarmament, it's necessary for NWSs to continue to make commitments and take actions in disarmament to convince and mobilize more NWWSs to join the global efforts against non-proliferation and anti-terrorism. So we should promote nuclear disarmament process even for non-proliferation purpose.

Of course, nuclear disarmament can't be achieved overnight; step-by-step approach is the only sustainable solution.

A step-by-step approach could include reducing the nuclear weapons that exceed the basic need for minimum deterrence, reducing reliance on nuclear weapons in national security policy, addressing the issues related to missile defense and overcoming other obstacles impeding further reductions.

Because 90% of global nuclear stockpile are possessed by the United States and Russia, these two nuclear powers have the responsibility to lead in the nuclear reductions. It is hoped that the United States and Russia could overcome related obstacles to start negotiations for further reductions beyond the New START.[1]

As for the United Kingdom, France and China, as their nuclear arsenals are at level of several hundreds of nuclear weapons respectively, only meeting the need for a minimum deterrence, there is less room for these three countries to reduce arsenals. Nevertheless, they should also join the multilateral arms control and disarmament process. As long as they stick to the minimum deterrence policy, observe moratorium on nuclear testing, and would join the negotiation for a Fissile Material Cutoff Treaty (FMCT), they can also make contributions to the nuclear disarmament process.

More than that, the United States, Russia, the United Kingdom, France and China, as the five permanent members of the United Nations Security Council (also known as the P5), have responsibility to double their efforts in leading the global nuclear disarmament process in a more concrete and practical way. I would suggest that the P5 make co-operation in this regard by discussing issues related to deep disarmament, such as the approach to maintain strategic stability with low numbers of nuclear weapons, the verification for deep disarmament, and so on. I hope they can design a road map for the step-by-step approach to deep nuclear disarmament.

To summarize, nuclear dangers and threats can't be eliminated in the near future, but can be managed well through global joint efforts. As two major missions in reducing nuclear dangers, nuclear disarmament and non-proliferation are inter-linked, mutually complementary and mutually promoted, and should be advanced in parallel. Nuclear dangers and risks could be minimized through maximizing global joint efforts in nuclear disarmament and non-proliferation.

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[1]New START refers to the Strategic Arms Reduction Treaty which is a nuclear arms reduction treaty between the United States and the Russian Federation with the formal name of Measures for the Further Reduction and Limitation of Strategic Offensive Arms. It was signed on 8 April 2010, and entered into force on 5 February 2011.

XX Edoardo Amaldi Conference

International Cooperation for Enhancing
Nuclear Safety, Security, Safeguards and Non-Proliferation

60 Years
IAEA Atoms for Peace and Development
EURATOM Treaty

Accademia Nazionale dei Lincei
Rome, 9–10 October 2017
Italy

IAEA 60 Years Atoms for Peace and Development
Accademia Nazionale dei Lincei
European Commission

Patronage

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Götz Neuneck, Carlo Schaerf, and Edoardo Vesentini

Program

Monday, 9 October

9.30–10.00 Opening addresses
Alberto Quadrio Curzio–President of the Accademia Nazionale dei Lincei, Italy
Luca Giansanti–Director General for Political Affairs and Security at the Ministry of Foreign Affairs and International Cooperation, Italy
Vladimír Šucha–Director General of the Joint Research Centre, European Commission
Luciano Maiani–Chair of the XX Edoardo Amaldi Conference, Italy

Keynote Lectures
Chairs
Alberto Quadrio Curzio–President of the Accademia Nazionale dei Lincei, Italy
Vladimír Šucha–Director General of the Joint Research Centre, European Commission

10.00–10.30 60 Years of IAEA: Atoms for Peace and Development
Lecturer **H.E. Yukiya Amano**–*IAEA Director General*

10.30–11.00 60 Years of EURATOM Treaty: Disarmament and Non-Proliferation, New Challenges And Opportunities
Lecturer **H.E. Federica Mogherini**–*High Representative of the Union for Foreign Affairs and Security Policy–Vice-President of the European Commission*

11.00–11.30 Coffee break

Session 1–Part I

Nuclear Safety and Security

Chair: **Jacek Bylica**–EEAS, European Union

11.30–12.00 IAEA's Central Role in International Cooperation for Strengthening Nuclear Safety and Nuclear Security Worldwide
Speaker **Gustavo Caruso**–*IAEA*

12.00–12.30 Nuclear Security Summits and Legacy
Speaker **Alexandre Bilodeau**–*IGN, Canada*

12.30–13.00 The GICNT Contribution to Nuclear Security
Speaker **Jari Luoto**–*GICNT IAG*

13.00–14.15 Lunch break

Session 1–Part II

Nuclear Safety and Security

Chair: **Umberto Vattani**–President of the Italy-Japan Foundation, Italy

14.15–14.45 EURATOM Nuclear Safety Framework
Speaker **Massimo Garribba**–*DG ENER, European Commission*

14.45–15.15 Updating from Lessons Learnt from Fukushima
Speaker **Tatsujiro Suzuki**–*RECNA, Japan*

15.15–15.45 Cyber Security and Nuclear Security: How Are They Related–an Overview
Speaker **Götz Neuneck**–*IFSH, Germany*

15.45–16.00 Coffee break

Session 2

Nuclear Safeguards

Chair: **Maria Betti**–DG JRC, European Commission

16.00–16.30 Sixty Years of Nuclear Verification
Speaker **Frederic Claude**–*IAEA*

16.30–17.00 EURATOM Safeguards System
Speaker **Stephan Lechner**–*DG ENER, European Commission*

17.00–17.30 Technical Synergies between Safeguards and Security
Speaker **Elina Martikka**–*STUK, Finland*

17.30–19.00 Panel
Nuclear Safeguards Challenges
Chair: **Said Abousahl**–DG JRC, European Commission

17.30–18.00 **Anne Harrington**–USA
Willem Janssens–DG JRC European Commission
Yosuke Naoi–Japan
18.00–19.00 General Discussion
20.00 Welcome Reception at the Accademia Nazionale dei Lincei

Tuesday, 10 October

Session 3–Part I

Topics of Nuclear Non-Proliferation: Present and Future Challenges
Chair: **Gianfranco Incarnato**–Ministry of Foreign Affairs and International Cooperation, Italy

9.45–10.15 Status of Nuclear Non-Proliferation
Speaker **Paolo Cotta Ramusino**–*PUGWASH*
10.15–10.45 The French National Perspective on Nuclear Non-Proliferation
Speaker **Remo Chiappini**–*CEA, France*
10.45–11.15 The Israeli National Perspective on Nuclear Non-Proliferation
Speaker **Merav Zafary-Odiz**–*IAEC, Israel*
11.15–11.30 Coffee break

Session 3–Part II

Topics of Nuclear Non-Proliferation: Present and Future Challenges
Chair: **Francesco Calogero**–Sapienza University of Rome, Italy

11.30–12.00 The Iranian National Perspective on Nuclear Non-Proliferation
Speaker **Ali Akbar Salehi**–*AEOI, Iran*
12.00–12.30 The Pakistani National Perspective on Nuclear Non-Proliferation
Speaker **Khalid Ahmed Kidwai**–*NCA, Pakistan*
12.30–13.00 Future of the Non-Proliferation Treaty
Speaker **Harald Müller**–*PRIF, Germany*
13.00–14.15 Lunch break

Session 4

Role of Science in Technical and International Cooperation
Chair: **Zehra Sayers**–Sabanci University, Turkey

14.15–14.45 IAEA's Technical Cooperation Programme-Nuclear Technology Contributing to Development
Speaker **Ana Raffo-Caiado**–*IAEA*
14.45–15.15 CTBTO Science and Technology for a Safer World

	Speaker **Randy Bell**–*CTBTO*
15.15–15.45	Science beyond Boundaries: SESAME and the International Cooperation
	Speaker **Chris Llewellyn Smith**–*Oxford University, United Kingdom*
	testimonial **Gihan Kamel**–*SESAME, Egypt*
16.00–16.15	Coffee break
16.15–17.45	Panel
	The Future of Nuclear Disarmament and Non-Proliferation
	Chair: **Luciano Maiani**–Accademia Nazionale dei Lincei, Italy
16.15–16.45	**Micah Lowenthal**–USA
	Alexander Savelyev–Russia
	Xiangli Sun–China
16.45–17.45	General Discussion
17.45–18.15	Closing of the Conference
18.15–20.00	Guided tour of Villa Farnesina and Biblioteca Corsiniana

Venue of the Conference
Accademia Nazionale dei Lincei
Palazzo Corsini–Via della Lungara 10
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