# Chapter 3
# Constructive Technology Assessment and the Methodology of Insertion

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**Abstract** Constructive Technology Assessment (CTA) started out (in the Netherlands in the late 1980s) as an attempt to broaden technology developments by including more aspects and more actors, and has been further positioned as a way to overcome the institutionalised division of labour between promotion and control of technology. For newly emerging technologies like nanotechnology, which live on promises, CTA has to address uncertain futures. It does so by analysing dynamics and emerging irreversibilities in a technology domain, identifying "endogenous futures" and creating socio-technical scenarios exploring what could happen. Such scenarios are a platform for interaction between stakeholders in strategy-articulation workshops. Organizing such workshops by CTA agents constitutes a soft intervention in ongoing developments, and contributes to make ongoing co-evolution of science, technology and society more reflexive. The CTA analyst inserts herself in ongoing developments in the domain that is being addressed, to identify what is at stake. This is not just data collection, but already interaction, as a knowledgeable visitor. Such a role has to be earned, for example by offering useful (but also critical) insights based on circulation in the domain and social-science analysis. This constitutes a methodology of inquiry-in-interaction, which increases reflexivity of the developments. It is an essential part of the CTA enterprise.

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N. Doorn et al. (eds.), *Early Engagement and New Technologies: Opening Up the Laboratory*, Philosophy of Engineering and Technology 16, DOI 10.1007/978-94-007-7844-3_3,

## 3.1 Introduction

The two key elements of Constructive Technology Assessment (CTA), broadening technology development by including more aspects and involving more actors, and doing so on the basis of an understanding of the dynamics of technology development and its embedding in society, were identified in the mid/late 1980s in the Netherlands (Schot and Rip 1997). It was part of a larger perspective, laid down in the government's Policy Memorandum on Integration of Science and Technology in Society (Ministerie van Onderwijs en Wetenschappen 1984). On the basis of the Policy Memorandum, a Netherlands Organization for Technology Assessment (now Rathenau Institute) was established in 1986. One of its projects was to develop the approach of Constructive Technology Assessment (Daey Ouwens et al. 1987). In the Ministry of Education and Sciences and in the Netherlands Organization for Technology Assessment, perspectives and expertise from Science, Technology and Society studies played an important role. The further development of CTA occurred in STS studies, linked to evolutionary economics of technological change (Rip et al. 1995), and in the evaluation of attempts to broaden technology development, as in social experiments with electric vehicles (Hoogma 2000; Hoogma et al. 2002). The CTA approach was taken up in studies in Canada, the UK, Australia, Denmark and Sweden. And it was positioned as part of an overall move towards more reflexive co-evolution of science, technology and society (Rip 2002).

Newly emerging technologies like nanotechnology, with their promises but also raising concerns about possible negative impacts, are a challenge for the CTA approach because the envisioned broadening of technology development must now be about possible future developments rather than current practices. Such a challenge had been recognized before, and could then be addressed systematically from the early 2000s onwards when the Dutch national R&D program NanoNed, on nanoscience and nanotechnology, wanted to have a Technology Assessment (TA) component, and made funding available for PhD students and postdocs. The findings of this TA NanoNed program are the basis for this chapter, located in the larger picture of reflexive co-evolution of science, technology and society.

CTA is a "soft" intervention, and studies and reports are an input, not the main result. For emerging technologies, two key components of a CTA activity are (1) the building of sociotechnical scenarios of possible technological developments and the vicissitudes of their embedding in society (based on extensive document study and field work) and (2) the organizing and orchestration of workshops with a broad variety of stakeholders. The scenarios help to structure the discussion in the workshops (Robinson 2010) and stimulate learning about possible strategies (Parandian 2012). Therefore it is important to have scenarios of high quality and relevance, and which can be seen as legitimate by workshop participants.

Compared with other approaches as discussed in this volume, CTA activities take into account what happens on a variety of "work floors": research laboratories, conferences, workshops, agenda setting and planning meetings, roadmapping events, public debates anticipating on issues related to technology developments. A corollary

is that the CTA actor has to move about, observe and actively circulate in locations where actors are shaping the emerging paths of nanotechnology and how it will become embedded in society. We will call this 'insertion' by the CTA actor, to emphasize it is not just a practical matter of collecting data, but also part of the methodology of CTA, combining diagnosis of dynamics and some soft intervention.

## 3.2 The Enterprise of CTA: Goals and Practices

While explicit goals for CTA were specified already in the 1980s, the actual approaches were also shaped by opportunities and circumstances that arose following its inception. Based on the experiences, there was further articulation of goals. This section is an attempt to take stock, by looking at overall goals, how these are linked to more concrete objectives, particularly for the case of emerging technologies, and what sort of concrete activities and methodologies are now in place.

CTA sees itself as part of the overall undertaking of TA, starting in the late 1960s. The background of this undertaking can be formulated, in retrospect, as a 'philosophy' of TA (cf. Rip 2001a):

> Reduce the (human) costs of learning by trial-and-error -- which characterized much of our handling of technology in society –, and do so by anticipating future developments and their impacts, and by accommodating these insights in decision making and implementation.

This is not easy because early signalling may not get a hearing – particularly if it is early warning (cf. Harremoës 2001). And it is not limited to commissioned TA studies. It is a societal learning process, in which many actors participate. Actually, over the years, TA has moved in the direction of societal debate and agenda-building, at least with Rathenau Institute and some other European TA offices (Delvenne 2011).

Within TA, some of the specifics of CTA derive from a diagnosis of how the handling of technology in society has evolved: the separation of "promotion" and "control" of technology in our societies, which emerged in the nineteenth century and are still with us (Rip et al. 1995). It is a heritage of the industrial revolution of the eighteenth and nineteenth centuries, where technology development became a separate activity, carried by engineers and located in firms and public or semi-public research institutes. Culturally, a mandate to do so emerged: new technologies could then be developed as such, because they could be positioned as contributing to progress of society, and therefore to be accepted, almost by definition. Institutionally, an indication of the separation between "promotion" and "control" is the division of labour between government ministries, some promoting the development of new technologies and innovation, while other ministries consider impacts and regulation. TA emerged within this regime of handling technology in society, and was institutionalized at the "control" side of the division of labour. An important argument was (and is) the asymmetry between technology development actors and society at large, with the latter coming in at a late stage, and little information about the

technology. The asymmetry is structural, but TA would offer information and considerations to the "control" side, and reduce the asymmetry.[1] CTA wants to compensate for the asymmetry in TA approaches, by focusing on technology development.[2]

Building on this diagnosis, CTA aims to bridge the gap between innovation and the consideration of social aspects which inform attempts at "control", and in doing so, broaden technology development and its embedding in society. It is "constructive" TA because it aims to be part of the construction of new technologies and their embedding in society. This was the starting point of the enterprise of Constructive TA (Daey Ouwens et al. 1987). These aims can then be taken as objectives for the design and execution of CTA activities. They require analysis of dynamics of technology development and its embedding in society, and the ways it is influenced/shaped – insights which can be translated into leverage for change. They are input into the preparation for concrete CTA activities like "bridging" workshops with stakeholders in a technology domain. They are also building blocks for a theory of CTA (Rip 1992).

The rationale for pursuing these objectives stems from larger goals and perspectives, as was clear in how we developed a diagnosis of what is the case now in handling technology in society, with the implication that it should be improved. By now, a number of overlapping goals have been put forward. Taking an evolutionary perspective, the division of labour between "promotion" and "control" of technology in society is part of how technology and society co-evolved. One can then take a step back, and consider ongoing co-evolution of science, technology and society, and in particular, how it is becoming more reflexive, for example through technology policy, technology foresight and technology assessment (Rip 2002). Thus, one can work towards improving reflexivity of the co-evolution, in various ways – this implies some modulation of the co-evolution. This qualifies as a background goal for CTA and is linked to learning (cf. also Grin and Van de Graaf 1996). It has been emphasized in the studies in the TA NanoNed program (e.g. Robinson 2010; Parandian 2012). Then, constructive in CTA refers to its being part of the construction of increased reflexivity in science, technology and society.[3]

Broadening technology development and increasing reflexivity serve a purpose. To be explicit about this, Schot and Rip (1997) emphasized an overall goal served by CTA, of a better technology in a better society. It is important to keep such a substantive goal visible, in general but also because the CTA objective of including more actors is often taken as advocating more participation, and thus refer to a goal

[1] This then led technology developers to see TA as "technology harassment".

[2] We note that there is another tradition of TA, in firms and research institutes, where technological options are assessed as to eventual performance and production possibilities and costs. This can be called "technical" TA, to distinguish it from the "public" TA that we discussed here (Rip 2001a). When broader considerations would be taken into account, "technical" TA would become "sociotechnical" TA, and the tools of CTA (see below) could be used by the firms and research institutes, or by consultancies that are commissioned to do "sociotechnical" TA.

[3] Note that 'reflexivity' here refers to institutions and approaches in society and sectors in society, not to individuals becoming more reflective – even while that is part of overall reflexivity.

of democratization of technological development (Genus 2006; cf. also Callon et al. 2001 for an intermediate position). Of course, no one has a monopoly on goals for CTA. The point is that recognition of a goal has implications for what are appropriate CTA activities. The activities we describe in this chapter are appropriate to the overlapping goals we have outlined, so it is inappropriate to criticize them as being insufficiently democratic.

### *3.2.1 Signs of Change*

An increase in reflexivity of co-evolution of science, technology and society is visible in the recent policy discourse about responsible development of new technology, and responsible innovation. There are now some attempts to implement this, especially in the domain of nanotechnologies. One example is the Code of Conduct for Responsible Nanosciences and Nanotechnologies Research (European Commission 2008), which can now be referred to in the Member States of the European Union. There is overlap with CTA objectives, in the sense that responsible development is a way to bridge promotion and control, by internalizing control at the side of technology development. This can still keep a focus on promotion, when 'responsible' is only modifying 'development'. When 'responsible' is emphasized the development itself might be queried, up to the possibility of stopping it.[4]

Thus, there are signs that the institutional separation of technology development and attempts at control (because of projected societal impact), is being bridged. At least, there are pressures to bridge and various attempts at handling these pressures. Of course, there were such pressures before, as when TA was proposed and started to become institutionalized in the 1970s. What is new is that anticipation on societal impacts is now seen as being also a responsibility of technology developers (see also Gustin and Sarewitz 2002).

While the dichotomies (innovation vs. responsible, technology developers vs. users) remain visible, there are interactions and mixed approaches, and the situation evolves further. The domain of nanoscience and nanotechnologies turns out to be a site for experimentation and learning – including controversy. There is widespread uncertainty about impacts and risks, while there are also proposals for regulation, and NGOs which advocate a precautionary approach. There is additional uncertainty about consumer and citizen reactions to new nanotechnology-enabled products and processes, and innovators can fear for barriers to public acceptance and possibly a public backlash if something would go wrong. All this is to be expected.

[4] A well-known precedent is the temporary moratorium on recombinant DNA research, after the 1974 Asilomar meeting. The present call for a moratorium on nano-particle development comes from critical outsiders, not from nanoscientists. A mixed case (early 2012) is the voluntary stop (for 60 days) of bird flu virus research, after the US National Science Advisory Board on Biosecurity had required a virology research group in Erasmus University Rotterdam to take out details in their pending publication in *Science*, because of the risk of misuse.

What is new is that innovation actors are asked by societal actors to account for what they do. This will set articulation processes in motion.[5] When some stabilization occurs, there will be *de facto* governance, i.e. steering and shaping of action that has some legitimity, even if there is no formal authoritative basis as in law and regulation (Rip 2010b). Up to a modification of the division of labour, with responsible innovation becoming the responsibility of innovation actors, in interaction with various societal actors.

The experimentation and mutual learning that occurs in and around nanotechnology is now taken up for other emerging technologies like synthetic biology and ambitious technological ventures like geo-engineering. Thus, one can take learning in sectors and in society as a further overall goal, and formulate stimulation of such learning as a broad objective for CTA.[6] For new technologies, the point has been made that responsibilities are distributed, just like technological development itself (Von Schomberg 2007). The simple contrast between technology developers and users is inapplicable then. Interaction and mutual learning become important to overcome mismatches and fragmentation, in innovation as well as in 'distributed responsible development'. New 'divisions of moral labour' have to be invented, and one can see various actors exploring (even if reluctantly) possibilities (Rip and Shelley-Egan 2010).

### *3.2.2 Transforming Objectives into Activities*

In the move from objectives to concrete activities, particularly for doing CTA about new technologies, some further conceptualizations are introduced – in effect, more building blocks for a theory of CTA.

Our diagnosis of a gap between promotion and control of technology at the societal level, and as we phrased it in the TA NanoNed program, the gap between innovation and ELSA in a sociotechnical domain or sector,[7] can be detailed further, to the level of interactions, using Garud and Ahlstrom (1997). They distinguish "insiders" (i.e. developers/promoters) and "outsiders" (i.e. users/regulators) and show that their evaluations of technology are structurally different because of this difference in position. They also consider situations where insiders and outsiders interact, to some extent, calling these situations 'bridging events'. One of the

[5] Perspectives, expectations, preferences and positions of various actors/stakeholders will be articulated, i.e. become more explicit, further specified and linked to arguments, findings and values, in interaction and this may lead to scrutiny and assessment.

[6] This is particularly important when the focus is on embedding of technology in society (including further sociotechnical development). This is how Hoogma and Schot evaluated social experiments with electric vehicles (Hoogma 2000; Hoogma et al. 2002, see also Schot and Rip 1997).

[7] Ethical, Legal and Societal Aspects, the "Aspects" are sometimes referred to as Issues (then the acronym becomes ELSI).

examples they study are hearings conducted by a regulatory agency like the US Food and Drug Administration.

Their terminology of insiders and outsiders captures one aspect of the positions with respect to technology development, but assumes these positions are given. However, a firm developing technology for new products or processes of its own, may also be a user of products supplied by another firm and then position itself as an outsider, e.g. requiring quality assurance. When Garud and Ahlstrom (1997) discuss the difference in perspective between insiders and outsiders, they speak of "enactment" and "selection" cycles, respectively, in which the two function. "Enactment", a term from symbolic interactionism, here refers to technology developers and promoters working to realize their goal and vision, "enacting" their project. Thus, a functional terminology is possible, of "enactors" who realize the technology and identify with the project of doing so, and "comparative selectors" who can consider different options to select from and do formal or informal versions of cost-risk-benefit assessment (Rip 2006).[8] Garud and Ahlstrom show how enactors focus on their projections (i.e. informal scenarios) for further development of the technology and its embedding in society, and thus see society as a constellation of possible barriers which have to be overcome. If questions are raised about the technology, such an enactor perspective will immediately see them as indications of potential barriers, even when the questions are mainly inquiry rather than criticism. The response of the enactor then is to emphasize the promise of the new technology – with the corollary that the commentators, if still reluctant, are positioned as being against progress. If this happens in the public domain, it will incite further, and possibly more critical, responses (Swierstra and Rip 2007).

One concrete implication of this diagnosis of the two positions and related perspectives is that CTA workshops must have 'enactors' as well as 'comparative selectors' as participants, so as to function as bridging events, where participants can (in Garud and Ahlstrom's felicitous phrase) probe each other's realities. With the right mix of participants, what happens in these CTA workshops will reflect dynamics in the wider world, so they will be like a micro-cosmos. The workshop is also a protected space, where participants have the opportunity to consider alternatives and the possibility of modifying their strategies and eventual interactions in the real world without there being immediate repercussions.[9] Still, the wider world has

[8] The term "enactor" can be used for all cases where a project is pursued, and identification occurs so that the world is seen in terms of whether it helps or hinders the project. An actor can be enactor in one case, and comparative selector in another case. An interesting example is the NGO Greenpeace, almost by definition an outsider/comparative selector. But Greenpeace Germany, at one moment, pushed for an environmentally-friendly fridge, and collaborated with scientists and a firm to realize it (Van de Poel 1998: 84–97). So it became an enactor, for the time being.

[9] This is often a novel possibility for participants. Moving beyond their own interests and perspectives comes easier to some than others, but it is recognized as a possibility in post-workshop interviews with participants (Parandian 2012). The set-up of a CTA workshop has to facilitate and stimulate this, by making sure various actor perspectives are visible, and possible developments in the real world are considered, for example with the help of sociotechnical scenarios.

its own dynamics, and these are important for eventual uptake and effect of the CTA exercise.[10]

There is a further implication, given that we decided to develop sociotechnical scenarios as an input into the CTA workshops. Scenarios speak to an enactor perspective, in their projection of further development of a new technology. But we introduce twists, showing unexpected shifts (for enactors) and repercussions. Stakeholders representing comparative selectors, from potential users to regulators and NGOs, will be present in the workshops. Thus, in the interactions, different perspectives as visible in the scenarios will come alive because their protagonists are present. This will work out well only if the scenarios reflect what is at stake in the worlds of the participants, otherwise they will be disregarded as irrelevant. At the same time, the scenarios must offer challenges to participants' understanding of the situation. This is where social-science insights (from innovation studies, from STS, and more generally) will have to come in, to improve the quality of mutual probing in the workshops.[11]

In general, analysis and diagnosis of developments are necessary steps to prepare a CTA exercise and orchestrate it productively. One has to know about the forces at play in the technology domain and the evolving relationships (or lack of relationships) between stakeholders. A key point for understanding what happens as well as the eventual construction of scenarios is that "entanglements" occur, existing and emerging mutual dependencies which guide and thus limit interactions and strategic choices (Rip 2010c). This shapes the way new technologies (in our cases, nanotechnologies) will materialize. In other words, the future is predicated on these patterns and dynamics: an "endogenous future" (Rip and Te Kulve 2008; Robinson 2009). The scenarios develop the endogenous future into a number of possible futures, each starting with certain interventions and interactions and then exploring responses, repercussions, and eventual outcomes.

For example, in the case of possible nanotechnology applications in food packaging, studied by Te Kulve (2011), there is reluctance with the producers and retailers to invest in it because of uncertainty about consumer acceptance, combined with uncertainty about eventual regulation of the products. The mutual dependencies have the form of a waiting game (Parandian et al. 2012), and if nothing happens, the waiting game will continue (thus, an endogenous future). Given this diagnosis, one can imagine that interventions occur attempting to break through the waiting game.

[10] Marris et al. (2008) have shown this for an Interactive TA exercise about field tests of genetically modified vines in France. Their point is reinforced by what happened subsequently: productive co-construction of the design of the field tests between local stakeholders and researchers, and 5 years later, August 2010, the destruction of the test fields by critics of GMO. In LMC et al. (2010), the story is told from the perspective of the actors involved in the co-construction.

[11] Scenarios add substance to the interactions, which is necessary because they are not just about participation and empowerment (which are sometimes taken as goals for CTA, cf. earlier comments on democracy). To serve the change aim of CTA, they must be seen as relevant as well as challenging to the participants. Quite some effort has to be put into the creation of robust sociotechnical scenarios. Thus, they become a product in their own right, which can be put to further use, also by participants.

This was the starting point for the construction of three scenarios. In scenario 1, "Only a little nano", collaborations between academic and industrial researchers are sought and supported, but that leads to niche applications only. The big promise of nanotechnology is backgrounded. In scenario 2, "Regulation helps", the concerns about health and safety aspects cast a shadow over the developments, and small companies move away from working on nano-applications, also because regulation might be strict (and thus make product development expensive). The big incumbents welcome regulation because it reduces the uncertainties, and they proceed – cautiously. In scenario 3, "Thresholds are passed", some institutional entrepreneurs recognizing the barriers set up a consortium for product development and persuade consumer organizations and risk research institutes to participate, arguing that this is a way for them to have some influence on the shape of future technology. This creates legitimacy and further support becomes available for strategic research topics like nano-enabled improvement of barrier properties of paper and plastic packaging. Pharmaceutical companies then become interested as well.

### *3.2.3 Choices to Be Made*

As is clear from this example, in constructing scenarios choices must be made about what to focus on, and what not. These choices can be discussed in the workshop, and alternatives may be considered. In general, the need to make choices in setting up the CTA activity is a challenge (and a task) for the CTA analyst, especially for emerging technologies like nanotechnology which live on promises: Which expectations are to be taken into account as more realistic and/or more important? What is seen as important also depends, of course, on the position from which such expectations are voiced, e.g. by an enactor or a comparative selector. The CTA analyst can build on her knowledge of the domain and its dynamics, including expectations and investments in the different worlds in which a new technology option is being developed and will be embedded. But the challenge remains.

The challenge can be brought out (even if in a somewhat simplified manner) by considering the hype-disappointment cycle, as introduced by Gartner Inc. Figure 3.1 shows the cycle, as well as different options for projecting a future state of the world. The realistic option (the eventual "plateau of productivity") is also the most uncertain one, while relying on present promises may risk becoming victim of inflated expectations.

The risk is real, and not only in funding applications and other resource mobilisation activities, where exaggerated promises are expected, and discounted. In discussions and activities exploring potential futures of a technology and its ethical and societal impacts, there is a tendency to go for the big impacts, so as to justify the effort to anticipate. It is all too easy then to extrapolate from current promises and end up in brave new worlds where human enhancement or interventionist ambient intelligence creates interesting ethical dilemmas. Nordmann and Rip (2009) have criticized such "speculative" ethics of new technologies as disconnected from

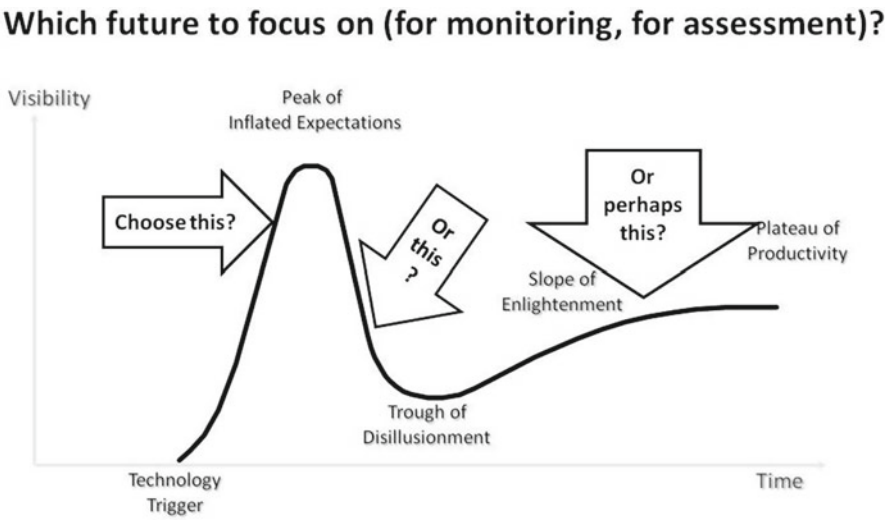


**Fig. 3.1** Gartner Group's hype-disappointment cycle (Versions of the hype-cycle were presented by Gartner Group since at least 1999, see Fenn 1999)

ongoing activities and the choices, ethical and otherwise, that have to be made there. Our sociotechnical scenarios, building on endogenous futures, start from the other side. There is still speculation and imagination, of course, but it is not free-floating.[12]

For actors articulating their strategies the question of hype is a recurrent concern. Interaction with other relevant actors is important to reduce uncertainty, and in fact, the CTA workshops offer an opportunity to do so, and are appreciated for it. This was clear in the domain of Organic Large Area Electronics, studied by Parandian (2012). In one of his scenarios, he actually used the phenomenon of hype and disappointment, for nano-enabled RFID applications for security. This induced extended consideration of the value of government measures to realize the promises of a new technology.

So far, we have presented the CTA activities as doing a good job. And indeed they do, but some reflection is in order. CTA for new technologies aims to broaden design and development, at an early stage. Thus, it has an upstream bias: better outcomes result from doing better at an earlier stage. It is a bias, because it is the overall co-production process that leads to eventual outcomes, there is no determinism. But it

[12] The emphasis on choices in ongoing developments is also important to counter the opposite position, that there is no way to predict future impacts of a technology, so better give up on technology assessment and other attempts at anticipation and feedback. This "hard truth" was pushed by Nathan Rosenberg in an OECD workshop on Social Sciences and Innovation (Tokyo, 2000), but it overlooks how present dynamics shape opportunities and constraints for future developments, and are thus a basis for anticipation and feedback (Rip 2001b). The further point is that anticipations need not be correct to be useful in guiding action – think of self-negating prophecies.

is an unavoidable bias if one wants to address new technologies – which are by definition still at an early stage.

Upstream public engagement (in the UK and elsewhere) has the same bias, but in contrast with CTA it focuses on actors with little or no agency. They may well remain empty exercises, even if the views and discussions reported might be taken up by policy makers when they see fit. CTA addresses stakeholders, and does more than just soliciting views from stakeholders. There are orchestrated bridging events, and there must be something at stake, for the participants and developments in the domain or sector. Looking back at the almost twenty CTA workshops we organized in the TA NanoNed program, we see that the less successful ones indeed suffered from there being little at stake (Robinson 2010).

## 3.3 A Methodology of Insertion

The aims of CTA to broaden technological design and development and make it more reflexive, imply an action-orientation of CTA. CTA agents are change agents, but softly, through support and attempts at opening up, rather than pushing. If there is pushing, it is a push for more reflexivity (cf. Schot and Rip 1997). Theoretically and practically, this relates to the rationale of making the co-evolution of science, technology and society more reflexive (so there will be some modulation of the co-evolution).

What happens in practice is that a CTA exercise, like the strategy-articulation workshops we discussed, is inserted in ongoing developments and interactions, often with support of one or more of the actors involved, for example the EU Network of Excellence Frontiers,[13] which is important to create some legitimacy for the exercise. In preparing the exercise, the organizer (CTA analyst/agent) moves about in the relevant worlds, finding out about "entanglements", forces at play, and stakes, and using those insights to prepare for the workshop and orchestrate it. When moving about, it is the CTA analyst (as a social scientist) who inserts herself in these worlds. But in doing so, she leaves traces and thus creates small changes: the CTA analyst is already a CTA agent.

Becoming an agent in this way is not just a circumstance that requires some methodological reflection. It is actually a methodology in its own right, a methodology of insertion. Our recognizing it as a methodology emerged gradually over time. It started with the notion that the analyst moving about makes patterns in the co-evolution of technology and society visible, and thus creates some reflexivity. We learned by doing, also building on some general insights. Robinson (2010) devoted a chapter in his PhD thesis to describe his "insertions" and their outcomes, from the perspective of a methodology in the making.

[13] This network of nanotechnology research institutions focused on the development of nanotechnology instrumentation and approaches for the life sciences (see Robinson 2010).

**Table 3.1** Multi-layered landscape of insertion

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|---|
| The **top layer has** broad activities related to public policy, regulation and societal debate. This includes overall institutions, arrangements and authorities in our society. |
| The **middle layer** is located in collectives of actors, relevant institutions and networks that are directly involved in nanotechnology development through coordination and agenda setting. |
| The **bottom layer** represents ongoing practices and projects (often shaped by enactment cycles). For nanotechnology these may occur in publicly funded research laboratories, universities, and large or small firms. |

The recent interest in "integration" or "immersion" of social scientists and humanities scholars in the work on the lab floor can be seen as having a similar thrust, and has sometimes been developed as a methodology.[14] The important difference is that "insertion", as we use the term here, happens at a variety of "work floors", it happens in a multi-layered landscape and addresses the layers explicitly. Table 3.1 indicates the layers.

In the lab floor studies, the bottom layer is what is focused on, but the other layers are still there, and shape what happens on the lab floor.

What does the methodology of insertion consist of? We will indicate steps, but what we mostly do is report on our learning by doing, offering some evaluations and further perspectives. The first step is 'moving about' in the world of nanotechnology. In particular, visiting locations of nanotechnology R&D, conferences and other meetings, and tracing anticipatory coordinating activities like roadmaps and European Technology Platform meetings where nanotechnology developments are being shaped. Interactions occur, and the CTA analyst & agent-to-be should be willing to enter into the substance of the developments and concerns so as to be a legitimate partner.[15] The CTA analyst must be recognized as a knowledgeable visitor, and this constitutes the second step of the methodology, the actual 'insertion' in the world of nanotechnology. Insertion is the process of becoming a temporary member of the field, a legitimate visitor. But the inserted CTA analyst should not go native, and make sure she is recognized as a visitor and not a full member.

Moving about helps to capture what is going on, and thus to target, tailor and embed CTA exercises. CTA exercises must embed themselves, and thus fit to evolving circumstances in order to be accepted as legitimate/plausible. But there must also be some stretching of these circumstances so as to broaden enactment processes and stimulate reflexive learning. In other words, the visitor moving about is doing more than sightseeing. Fitting and stretching requires deep knowledge of dynamics and contexts. Along with the rapidly evolving developments in and around nanotechnology such knowledge can only be garnered by insertion. This is more than an anthropologist, also a visitor by definition, would do. The CTA analyst

[14] In particular in the Socio-Technical Integration Research (STIR) project, funded by the US National Science Foundation and led by Erik Fisher (Arizona State University). See Schuurbiers and Fisher (2009).

[15] So this is more than participant observation, or anthropologists alternating between insider and outsider positions.

moving about in the nano-world is also formulating diagnoses about what is happening and could happen.

Insertion into the world of nanotechnology development requires the active circulation of the analyst in locations were actors are shaping the emerging paths of nanotechnology R&D. This includes research laboratories, conferences, workshops, agenda setting meetings, roadmapping events, and public debates anticipating on issues related to technology developments. As a knowledgeable visitor, and based on her diagnoses of the situation, the CTA analyst can actively probe views and interactions, so as to find out about the forces at play. This will be done in preparation for a CTA exercise, but the insertion can continue over the course of a few years, so that changes over time can be traced. This is what Robinson did, within the European Network of Excellence Frontiers, and more broadly. His role evolved from 'foreigner' to 'regular': his activities became gradually accepted, visible, and in some circles, legitimate.

Important in these activities were aggregation of what was happening in the nanoworld, and analyzing it, creating an overall picture, and presenting it if only in conversation with members of the nanoworld. This functions as an entry ticket ("see, I am inserted and knowledgeable") and a way of getting feedback. But there will be the danger of being positioned as part of the nanoworld, so being pressed to go native, or positioned in a service role to the nanoworld which limits the freedom of movement of the analyst. Thus, there is further requirement: play a distinct role in the nanoworld and make sure it is seen as distinct. This role of a (welcome) visitor can be highlighted by moving in and moving out of the nanoworld. The possibility to refer to own social-science publications which could be helpful to nanoscientists and nanotechnologists, (for example, Robinson and Propp 2008) turned out to be a good way to create legitimity. Given the vicissitudes of insertion, including working under time pressure, there will be lots of contingencies. So there will be no simple recipes.

As to overall changes, there is a clear difference between 2004 when the CTA projects started and nano-scientists looked dubiously at the intruders, and the present situation in which social scientists and other non-technical actors are welcome in the nano-world. In the particular case of Robinson, his pro-active service role was recognized, i.e. that such non-technical actors could be of some help (in indicating innovation dynamics and contributing to roadmapping, for example). The main drivers of acceptance were the pressures on the nano-world, as visible in the concerns about risk and in the call for responsible development. Listening to the knowledgeable visitor, and accepting CTA exercises, were ways to address these pressures.

Are outcomes in terms of CTA goals visible? Of course, it is too early to see better technology in a better society (and if so, it would not be attributable to CTA exercises). But one may see increased reflexivity in co-evolution. This relates to anticipatory coordination. In the world of nanotechnology, there is an interest in anticipation and coordination so as to choose right directions. Actual and potential stakeholders are attempting to shape emerging nanotechnology developments, in different fora and with a variety of strategies. CTA exercises are part of this move, and they create further openings. As they do this, they become recognized and

accepted. There is some institutionalization of scenario/strategy workshops (Robinson 2010; Parandian 2012).

Insertion is an integral part of the CTA activities, and necessary to make them effective. It is not a means to achieve CTA goals directly, even it does contribute.[16] It is reconnoitering the lay of the land and probing the dynamics. On that basis, circumstances (like CTA workshops) can be created that stimulate actors to reflect, act and interact in ways that might achieve the CTA agent's objectives.

A key element in achieving these objectives is making visible what was invisible to actors,[17] not by explaining (although that might occur), but in interaction with actors (that's also where the scenarios come in). As it is experimenting in real-world interactions, there is an interesting link with Lindblom's (1990) plea for inquiry rather than a search for truth as such, in relation to change. People probe the world (probe into situations, into other actor's perspectives, into problems and possible solutions) in order to change it, and this constitutes inquiry. The resulting insights can be formulated as such, somewhat independent of proposed actions. Social scientists also probe the world, whether they have a change perspective or not. Lindblom emphasizes that there is no epistemological difference between probing by citizens, by government functionaries and by social scientists. However, as he notes, the latter may well have more honed and articulated probing skills. When one scales down the scope of Lindblom's argument from society in general to the world of nanotechnology development, it constitutes a justification of the 'insertion' approach. It is probing by the social scientist, but also stimulates probing by the actors themselves.[18]

## 3.4 Concluding Thoughts

For new technologies, most concrete activities are at the R&D stage, rather than product development and uptake in society. Firms and research institutes are important locations, but given the open-ended promises for new technologies like nanotechnology, academic research institutions are important as well. This introduces additional dynamics, related to "opening up the laboratory", as the title of this volume phrases it.

In a sense, scientists (even the technoscientists that abound in nanotechnology) are outsiders to society, because they live in protected places (Rip 2010a). They are insiders in their own world of science, and strongly feel like insiders, up to

[16] Social scientists moving about in the world of a scientific specialty or domain will set the members of that world thinking about what is happening, and about patterns that enable or constrain. This is relevant for the overall CTA goal of increasing reflexivity of co-evolution of technology and society. Moving about in the nano-worlds may have such an effect, but it was not an explicit aim that structured the moving about.

[17] A sort of sociological enlightenment in the small, cf. Rip and Groen (2001).

[18] Phrased in this way, there is overlap with participatory research approaches (cf. Bergold and Thomas 2012). There, the social scientists have the higher status, while in our case, nano-scientists and policy makers tend to relegate the social scientists to a service role. Thus, building trust will have a different complexion.

patrolling and protecting the boundaries of their world.[19] Bridging the gap between the inside world of science and the outside world now occurs in various ways, proactively or because of outside pressures.

Social scientists and humanities scholars are outsiders to that world of science, in particular to the protected place of the lab where the work of science is done. They can visit, even become accommodated to some extent – perhaps as "social scientist in residence". Social scientists visiting a lab, occasionally staying there for some time, shift out of their own world. Anthropologists and ethnographers (of science) have been doing that all along, but with another purpose, to gather data rather than changing the world they study. Their presence would increase reflexivity of the actors, however, whether they wanted that or not. Our methodology of insertion is explicit about this.[20]

CTA has a larger scope, and addresses embedding in society, if only through anticipation. The dynamics will be more complex: there are now different overlapping worlds, different perspectives, and actors at the collective level (ranging from branch organizations to government agencies), with some collective responsibility. And there larger and long-term developments, in particular the traditional division of labour between promotion and control, which is now questioned, as in the discourse of responsible research and innovation.

Concretely, in the world of nanotechnology, CTA exercises are welcomed (and funded) by the technology developers and technology promoters, who see them as necessary to anticipate on societal embedding, and meeting possible reactions from various societal actors. Co-evolution of technology and society goes on anyway, but anticipations are becoming more important, so that the co-evolution will be more reflexive – even if enactors will work from their concentric perspective.

If co-evolution becomes reflexive, and actors absorb CTA activities in their practices, will CTA agents become superfluous? Not yet, and probably never. One reason is that CTA agents can circulate across locations, and observe and analyse what happens at the collective level, which will be more difficult for regular actors. Another reason is that these visiting "knowledgeable" strangers irritate existing ways of working and thus create openings for learning and further evolution of how we handle new technologies in our society.

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[19] There is a functional argument: scientists should live in protected spaces, at least to some extent, in order to be productive (Rip 2010a).

[20] There are normative issues involved, which can refer to the background goals of CTA, but have also an experimental component, finding out about the issues by doing and learning (cf. also Laurent and Van Oudheusden 2013).

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