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Towards New Forms of Participatory Technology Development

JOHAN SCHOT

ABSTRACT *Technical change is crucial for sustainable development. Yet, it is unclear what kind of technology policy would suit such development. In this article constructive technology assessment (CTA) is offered as a model. CTA proposes broadening design by bringing together all interested parties early on and throughout the design process. CTA activities are not automatically directed at substantive goals such as those incorporated in the notion of sustainable development. The purpose of CTA is to shape technology development processes in such a way that social aspects are symmetrically considered in the process itself. To evaluate and shape CTA processes three criteria are offered: anticipation, reflexivity and social learning. These criteria are applied to three case-studies to illustrate their usefulness.*

Introduction[1]

Technology poses a perplexing dilemma in the sustainable development debate: it seems to promise both limitless potential for benefit and it has already demonstrated almost limitless ability to produce harm. The quantity of scientific and technological knowledge amassed and translated into practical applications during World War II fostered a global optimism about the great benefits of technology. However, many of those once promising technologies have negative side-effects, many of them appearing long after the first application of the technology, as they have with nuclear energy, radiation effects, industrial by-products and environmental pollution. Technological solutions to those technological problems have frequently proven insufficient, just as chimney filters and catalytic converters have barely made a dent in environmental pollution problems.

During the last 20 years, technology assessment (TA) has been widely adopted for mapping the probable consequences of various technological options.[2] Yet, TA conducted by technical experts has proven ineffective at predicting social responses or unexpected consequences associated with many technologies. Participatory technology assessment is a more recent response to that challenge, bringing public values and opinions into the assessment of technologies. Both conventional TA and participatory TA assess the impact of specific technology options that have already been designed and thus their primary focus is on shaping public policy and not on changing the technology itself. Implicit in this approach to technology is the assumption that the creation or design of technology is an insular and self-generating activity; the public's role is in shaping, through policy and regulation, how that technology will be applied.

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Constructive technology assessment (CTA) is based on different assumptions about the nature of technology development, social values and subsequent outcomes.[3] Proponents of CTA assume that the design process itself is influenced by the interests and values of all individuals, whether technical experts or not, who participate in designing and developing a technology. They also contend that end users (as well as other interested parties) make valuable contributions to the design process, even opening up new areas of innovation. CTA proposes bringing together all interested parties early in the design process, far earlier than other types of participatory TA do. Thus, in CTA, technology is assessed from many points of view throughout the entire process of design and redesign, and the interests of all parties can be incorporated in the design from the beginning.

It is by integrating the perspectives of many interest groups throughout the development process that CTA may be of greatest utility in sustainable development efforts. The current debate on sustainable development castes technology in two roles, either as culprit, consuming resources faster than they can be replenished or producing adverse side effects, or as a saviour, multiplying productivity far in excess of growing demand or producing 'miracle cures'.[4] Those who see technology as the problem argue that a 'social fix' or value change that reins in consumption to a sustainable level is the solution.[5] Yet, raising social and cultural issues in relation to technology is extremely difficult. As Alan Irwin has argued, the emphasis on social equity and citizen participation is generally swept away whenever firms and governments begin to tackle issues of sustainable development. There is little room in existing procedures and institutions for building upon the knowledge and values of the general public and specific users.[6] The CTA approach creates opportunities for a broader set of actors to embed new needs and values in material (technology) realities and vice versa. This could be a major contribution itself to sustainable development.

In the first section, this paper presents the general concepts of CTA that differ most strikingly from other forms of TA, and then discusses three features that proponents of CTA consider to be essential to the process: anticipation of potential technological interactions and adverse side-effects; reflexivity; and the process of social learning. The second section briefly discusses three occasions in the Netherlands when CTA played a role. In the first, a Dutch technology assessment institution introduced the idea of CTA and then eventually withdrew from a prominent public role in fostering it. In the second, a sustainable technology development programme planned CTA as an integral part of their programme but used it in very limited areas. In the third case, a redesign of the infrastructure for the Rotterdam harbour included many CTA principles without invoking them explicitly. The concluding section examines the degree to which anticipation, reflexivity and social learning played an effective role in these instances, and discusses how we might improve future CTA endeavours by identifying and fostering these aspects of the CTA process.

Features of CTA

CTA was developed in the Netherlands in response to a diagnosis that current methods of technology management, especially TA methods, had failed (see section on Dutch TA below). These methods did not improve the integration of technology and society. It was concluded that such an integration cannot be achieved through TA alone. Rather, the fundamental character of the design process needs to change, broadening to encompass social aspects and actors. Ultimately, such a broadening could lead to a change in the current pattern of technology management (which is to sponsor development and regulate application).[7] The initiators of CTA based their ideas on analysis of historical cases of broadening design (or lack of broadening) and theories of technical change drawn from evolutionary economics and the history and sociology of technology. This has not only resulted in the development of the CTA perspective, but also in the development of a new theory combining economic and sociological insights into a quasi-evolutionary and multi-level model of technical change.[8]

A basic tenet of CTA is that the design of technological development should be a broader, interactive process including a variety of societal actors in addition to technical experts. The effect of broadening the design process is that the designers', users', citizens' and policy makers' ideas and values are articulated quite early, and are negotiated and renegotiated throughout the course of the technology development process (which is itself a process of constant design and redesign). This will counteract the prevalent tendency to organize technology development in a basically linear fashion (from development, to market introduction, to regulation) and will allow for more continuous evaluation and modification of new technologies in the making.

The actors involved in CTA fall roughly into three or four categories. First, technology actors are those who invest in and maintain technology development programs. Secondly, societal actors are those who experience the impact of technologies new and old, such as users, citizens and workers. Thirdly, regulating actors are those who develop rules and represent some kind of general interest. In CTA processes, we often see a fourth type of meta-actor, who is responsible for facilitating and modulating interactions among the other type of actors. These categories are useful for analytical purposes only; in practice, actors may fit in more than one category. For example, various government agencies may be located in any category.

The creation of interaction among various kinds of actors in technology development is the first and most important step in any CTA process. This interaction can be quite diffuse, and does not need to involve bringing specific actors together in one room. A recent overview of CTA defined technology forcing as a generic CTA strategy because it can, if designed and implemented in an appropriate way, stimulate diffuse interaction and co-production of new technologies, implicated user needs, and societal impacts among technology developers, societal actors and regulators.[9]

The idea of CTA can be taken up and implemented by many actors, although not necessarily in the same way. Producers of a new technology, consumer organizations, and specific government agencies, such as ministries or technology assessment agencies, face very different opportunities and constraints.[10] Given the lack of institutional room for integrating design and societal impacts and the difficulty actors have in appreciating a broad range of perspectives and technical criticism, further development of CTA usually depends upon the support of meta-actors interested in its implementation. Effective proponents of CTA include those in companies with a mission to do boundary spanning work with users and societal groups, government agencies developing technology policies and technology assessment, and consumer platforms committed to discuss technology impacts.

We can ask the question: What kind of value profile will these catalysts for CTA develop? Broadening of design can become an empty phrase if one does not specify goals or measures that would guide designers of CTA activities and their evaluators. CTA activities are not automatically directed at such substantive goals as sustainable development, the reduction of environmental pollution, or creation of more privacy. Thus, for instance, the development of wind energy or a security system to guard against bank fraud cannot be automatically labelled as CTA.

The purpose of CTA is to shape technological development *processes* in such a way that social aspects—in the long run—are symmetrically considered. By broadening design, technology development becomes more transparent and more compliant to the wishes of various social actors. Actors will address the social effects that are relevant to them. In a society where CTA processes have become the norm and are institutionalized, technology developers and those likely to be affected by the technology will be in a position to negotiate about the technology. An ability to formulate sociotechnical critique and contribute to design will become widespread. Resistance to specific social aspects will not be viewed as technophobia, but as a signal that further work is needed to optimize a design or achieve a better fit in society.

CTA embraces broadening as an end in itself and it accepts uncertainty about substantive outcomes. However, it is based on the assumption that CTA practices will eventually lead to better outcomes, in the sense that new technological practices, including hardware, knowledge and user behaviour, etc., will produce outcomes more widely acceptable, with fewer adverse effects than previously. What is desirable and what is not, is defined as part of the process of CTA and is not a fixed objective dictated in advance of the CTA.

Many technology assessment activities and discussions on public participation in technological development are guided by a wish to enhance democracy. However, these calls for more democracy are often not guided by a clear definition of the concept and seem to assume that any form of public participation will lead to a more democratic procedure. In the last few decades several attempts have been made to develop criteria for assessing the democratic content of various participatory practices and to connect those criteria and practices to political theories on democracy.

For example, Laird has discussed two sets of normative criteria for two different views on democracy.[11] A pluralistic view of the actions of interest groups assumes that citizens join and support groups to further the interest of the group, and democratic governance is the free interaction among these groups. A pluralistic view assumes that interest groups are the most effective political force. Citizens further their own interests best by joining an interest group and striving for fair distribution of benefits and burdens through the power of the citizen's groups. A direct participation view, in contrast, assumes that democratic governance relies heavily on full participation by individuals. The emphasis is on the educational and psychological effects that the participatory activity has on the participants. Truly democratic participation enables individuals to become fully developed citizens instead of members of an interest group.

Accordingly, pluralism predicts that democracy will be increasingly successful as more groups enter the policy process and as these groups participate in a meaningful way and learn from the process. The direct participation view predicts that democracy will be increasingly successful as increasing numbers of individuals enter the process as lay people (non-experts), their understanding improves, all participants gain equal access to resources, and individuals develop influence on final decisions. Although CTA proponents seek to expand participation of interest groups in the design process, they have not placed democratic criteria as a prominent goal in the development of the CTA perspective. Yet, it is clear that the implementation of CTA practices will enhance the democratic nature of the design process for both individuals and groups.

Criteria for Measuring the Quality of CTA

Three criteria are proposed for qualitatively monitoring CTA practices as they are implemented in actual design situations: (1) anticipation, (2) reflexivity and (3) social learning. These criteria refer to crucial mechanisms that create opportunities for actors (governments, firms, societal groups) to relate technical and social issues. These criteria differ clearly from quality measures used in the literature on democratic technological design and participatory TA literature. The criteria used for evaluating the CTA process are intended to monitor whether the design process itself is changing, or whether a modulation of the network and actual content of the interaction is required.[12] By contrast, criteria for evaluating the democratic process tend to emphasise the mechanisms for inclusion of actors in the public policy process. I see both sets of criteria as complementary rather than mutually exclusive.

Anticipation

In the prevalent method of consumer research, manufacturers design new products and then ask potential consumers to respond to prototypes or product ideas. Users are not offered any space in which to come up with their own ideas. Car users, for example, are invited to car 'clinics' to try out the latest model and fill in structured questionnaires. They are not asked to define the problems themselves or encouraged to experiment with various creative modes of mobility. Consequently, when questionnaires ask only about comfort, speed and acceleration, consumers seem to want only more comfort, speed and acceleration capacity in new cars. As a broad generalization, those who design technologies focus first on the hardware and then react to market signals and social effects as they occur, thus leading to *ad hoc* problem solving.[13] Conversely, when users, social groups and citizens participate in the design process, they are more likely to anticipate the potential social issues in a design project at a much earlier stage and to bring it up for discussion.

In 1995, in a reversal of the typical scenario, residents of Groningen in the Netherlands, organised four *workateliers* (workshop with intensive interaction) to help design solutions to the city's persistent problems with traffic congestion. The *workateliers* developed projections for making Groningen an accessible city in the future, as well as a number of innovative and feasible traffic systems.[14] However, the traffic system designers were not present at the discussions, so there was no opportunity for the lay participants and the traffic engineers to interact. A basic premise in CTA is that all design contributors, users and designers are stimulated to consider possible synergies between design, market conditions and social effects. Without that interaction, the essential purpose of CTA is eliminated.

Despite the emphasis in CTA on the value of anticipating future consequences, there is no presumption that all social effects are predictable. On the contrary, we must assume that technological development is non-linear and unpredictable. During development, all kinds of unexpected side roads and branchings emerge. Path dependencies will appear; certain solutions chosen to fit local requirements will continue to drive technological development. Nevertheless, this unpredictability does not mean that anticipation is impossible or is senseless. New analytical methods can address the non-linear and capricious character of technological development and build upon the notion of path dependencies.[15]

The unpredictability of technological development has two implications for CTA. First, project managers will need to organize anticipation as a regular activity during both design and implementation, as unforeseen effects emerge and unanticipated interactions take place. Jelsma and Rip advise firms to organize trajectories for anticipating social effects as early as possible and coping with important consequences, alongside product development trajectories.[16] Secondly, the technology development process should be structured flexibly so that choices can be deferred or altered. If flexibility and alternation are built into the standard design process, effectively the 'things' themselves will take on the form of an experiment that is more open to input from social actors. Herbold has shown how the design of a disposal site allowed subsequent changes to reduce risk in later stages. This gave designers and social groups the time to negotiate a definition of a safe site.[17]

Reflexivity

When the design process includes many interested parties in addition to technical design experts, the potential social effects associated with specific technical options emerge far earlier and more clearly than they do under current practices. This occurs because actors inevitably make explicit their own perspectives, while negotiating design concepts within a diverse design team. The effects that emerge depend not only on the technical designers' ideas and values, but also on the interactions among the various social actors and the context within which these actors operate. The purpose of CTA is to encourage actors to recognize their own and others' perspectives and to understand that every design option simultaneously creates potential social effects, desirable and undesirable, as it develops a technological option. Reflexivity, as it is used in this paper and elsewhere in the literature on CTA, refers to the ability of actors to consider technology design and social design as one integrated process and to act upon that premise.

Although CTA may ease the path to consensus by bringing interest groups together early in design phases, it makes no claim to eliminating controversy. In fact, CTA may provoke controversy earlier than expected as implicit scripts are made explicit and compared early in the design process. In societies where controversies are a normal part of the process of technology assessment and mechanisms exist for conflict resolution, that is not necessarily a problem.[18] However, efforts to resolve controversies in a project can easily divert the project from CTA principles. In analyses of controversies and methods of conflict resolution, Jelsma and Wynne found that attempts are often made to suppress reflexivity.[19] Conflict resolution tactics often separate technical facts from assumptions about the social reality in which the technologies will function and severely restrict discussion of alternative solutions that would not involve the technology in question. The controversies are defused and the separate parts, technology design and social impact, can be relegated to the appropriate sectors of society: technology development and regulation of technology application.

Societal Learning Processes

New technologies evolve in a mutual learning process: technological options, user preferences and necessary institutional changes are not given *ex-ante*, but are created and modified along the way. Many historical case studies have shown how user demands and regulatory requirements are articulated and expressed during the development process itself, in interaction with the technological options available. Producers gain new perspectives on their technologies from their customers and design modifications in response. For example, at the beginning of this century, automobile producers found no articulated demand for automobiles, so they gradually learned to distinguish which product attributes were most relevant to their customers.[20] During this ongoing exchange, professional users, user firms and end-users all played an active role.[21] As another example, early telephone customers used the telephone for chatting and other social purposes, while the telephone companies tried to reduce what they viewed as unnecessary and frivolous use. Telephone companies marketed the telephone service as a practical business and household tool, and it took some time before they realized the market potential of social talk, a use found and propelled by consumers.[22]

In current design processes, options for mutual learning processes are often not fully captured because of a prevailing tendency to optimize technology first, then check for user acceptance and finally for regulatory fit. Of course, no design process is strictly linear and it does include planned feedback mechanisms. Feedback also arrives unexpectedly, as problems during application force redesign.[23] However, such adjustments rarely change the pervasive assumption that design and development have to focus first on optimizing technology before specifying and detailing markets and social effects.

We can think of learning as occurring on two levels. First order learning refers to the ability to articulate existing market demands (user preferences) and regulatory requirements and to connect conclusions to design features. Second-order learning involves questioning existing preferences and requirements in order to accommodate development of more radical sustainable technology development.[24] High quality CTA engages actors in both forms of learning.

Development of CTA by a Dutch TA Institution

In a policy memorandum issued in 1984, the Dutch government called for an innovative approach to TA that would differ from the conventional expert analysis of potential impacts, often based on complex models. The new role for TA was to stimulate awareness of how applications of new technologies might meet individual users' or societal needs, to assist in articulating those needs and to provide input in strategic decision-making along the way. This new form of TA would be organized as a continuous resource integrated in decision-making processes.[25]

The 1984 policy memorandum led to the establishment of the Netherlands Organisation Technology Assessment (NOTA) in 1986. The installation decree described TA as:

> 'The entirety of activities and methods applied to that end to study as early as possible the various aspects and consequences of a technological or scientific development for (various groups in) society, preferably coherently, with the purpose to embed technology or a discipline involved in society.'

NOTA ended up using this shorter working definition of TA: 'TA is the systematic identification, analysis and evaluation, directed at decision-making, of the consequences of the introduction and use of science and technology.'[26]

These initial, broad definitions embraced many types of activities as part of new TA and allowed much of NOTA's early work to be an exploration of its mission and clients. The development of the CTA perspective was part of this search. In the early phases it was not clear how the NOTA should assign priority to all the clients they were asked to serve. Which decision-making process deserved the NOTA's greatest attention and devotion of resources? Some stressed that the government ministries or Parliament should have first claim to the NOTA's resources and loyalties, while others pressured the NOTA to organize public debates addressing a wider public. Still others wanted to focus the NOTA's efforts on directly influencing the development of technology through CTA.

In this early period, the NOTA developed and articulated several new approaches to TA simultaneously, with its contributions to CTA serving as an important catalyst in the field. NOTA commissioned research, supported conceptual work among academics, sponsored workshops and published a number of studies. In one study, the NOTA recommended that every technology subsidy programme devote at least 1% of all funding to incorporating TA impact studies into decision making from the start.[27] In another study, the NOTA concluded:

> This programme illustrated that it is quite feasible, and indeed pertinent, that developers of technology enter discussions with other concerned parties in society during the actual designing process and by doing so contribute toward the further development and introduction of the new technology.[28]

This conclusion encouraged the NOTA to start a major project, designated PRISMA, to stimulate the introduction of environment-friendly technologies in firms.

This project appeared to have substantial impact. A number of firms made allowances for environmental aspects in their design processes. PRISMA also influenced the ministries responsible for clean technology programmes to shift their emphasis from end-of-pipe solutions to preventive technologies instead. Some firms began to proactively integrate environmental issues. This was a learning process and it led to more measurement (and anticipation) of environmental impacts on a continuing basis. Business organizations began to recognize the incorporation of environmental issues as a business opportunity and as a necessary step for remaining competitive in future markets. The development of more radical designs that would entail discussion with environmental groups and interaction with users did not occur. PRISMA increasingly focussed on numerous small-scale and easily-adopted solutions.[29] This might relate to the fact that PRISMA did not substantially broaden the design processes, or develop reflexivity among its participants: technical aspects remained separated from social aspects in a checklist developed to enumerate individual barriers for change.

A 1992 evaluation of NOTA concluded that NOTA should have a stronger orientation toward serving Parliament and public debate. This evaluation was a pivot point for NOTA, in practice as well as in conceptual identity. In the organization, newly renamed the Rathenau Institute, CTA received less attention, although Rathenau staff continued to conduct infrequent though important work in this area. Rathenau focussed instead on developing forms of participatory technology assessment, organizing consensus conferences and public debates, identifying various policy options and producing reports for Parliament, newly defined as its primary client.

The Rathenau Institute demonstrated expertise in its new role with the successful organization of a public debate in 1993 on transgenic animals, modelled after Danish consensus conferences on biotechnology. In this three-day consensus conference, a well-prepared panel of 15 lay people posed questions to experts whom they had invited. The conclusions of the debate were laid down in a closing statement. Rathenau clearly had a new mission and a newly defined client, and development of CTA could no longer serve as a primary pursuit. Recent work at Rathenau has mainly focussed on participatory TA and not CTA.

Explicit CTA: The Dutch Sustainable Technology Programme

The Dutch Sustainable Technology Programme[30] began in 1993 when it became clear that incremental development of technologies would never lead to sustainable development. To fulfil consumer demand in the coming 50 years, eco-efficiency of production and consumption would have to increase by a factor of between 10 and 50. Although huge technological transformations take decades, the Dutch government wanted to start working on the problem through the Sustainable Technology Programme (DTO). This programme was explicitly conceived as a CTA process, at least by one of the main initiators.[31] The Dutch government proposed to move towards sustainable technology through a communicative and productive interaction between technology developers, governmental agencies, future users and others directly and indirectly affected by the application of these technologies.

The programme was intended to produce only a written plan that could be adopted by firms and other technology developers during a follow-up process. Theoretically, the definition of needs, directions and possible solutions would co-evolve from beginning to end in what was labelled 'illustration processes', a sequence of steps with workshops and studies. In practice, however, most illustration processes were geared to technology developers, and users and citizens did not participate at all. In part, this was because programme managers felt pressured to come up with promising, concrete technological options to attract businesses, when businesses provided the only access to sustained funding. In addition, the individuals managing illustration projects were not trained in CTA and did not share the same perspectives on the social dimensions of technical change. On the contrary, they believed in technology fixes for what they perceived as strictly technical problems.

Social and cultural aspects of sustainable development were studied in a small, separate programme, isolated from the illustration processes. Despite the isolation, the programme was very successful in creating a new vision of the need to go beyond small and incremental steps, and in conveying to various ministries and industrial firms the imperative need at times for revolutionary technological change (and fixes.)

One of the illustration processes consciously involved users and environmental groups in an explicit adoption of CTA principles. Various government ministries, as well as Gist Brocades and Unilever, supported this illustration process. The central question was whether it was possible to create appealing, novel protein foods that could displace meat and relieve pressure on the environment. Representatives of universities, marketing organizations, supermarkets, firms, consumers, environmental organizations and ministries met three times to discuss such a replacement. They did produce a document stipulating minimum standards for new meat substitutes, describing what market prospects existed for such novel foods and suggesting further steps representatives could take. Subsequently, several of the participating firms and universities did create new R&D programmes to further develop some of the proposed technological options. In this sense, the programme was highly successful. How would we judge this process from a CTA perspective?[32]

The novel protein illustration process was implemented according to a method based on the CTA perspective, called *Toekomstbeelden voor Consumenten* (TvC, Future Images for Consumers) developed by SWOKA (Institute for Strategic Consumer Research).[33] In a series of meetings, representative organizations spoke as advocates for the future needs of consumers and the environment, while representatives of the groups involved in the novel protein design project tried to reach consensus about what should characterize optimal solutions for perceived problems. These solutions had to be acceptable solutions to the problems that the *users* perceived, not just that the producers and others perceived. All parties involved made explicit their images of future use and negotiated about various aspects (attitude, taste, values, expected first responses of consumers).

The TvC evaluation helped redirect R&D efforts on novel protein foods when it became apparent that technology developers had not paid enough attention to the issue of taste and texture of the projected product. The evaluation study concluded that the participants in the novel protein illustration project had developed a deeper understanding of the various issues at stake, a better appreciation of the opportunities and constraints presented by other parties and a longer term planning horizon. Intensive interactions during the process led participants to reconsider their own assumptions, and members of environmental and consumer organizations felt they had built their levels of competence and would be better equipped to deal with biotechnological issues adequately in the future. The design options chosen for further development were credible options and suitable for the next steps in implementation.

In the Dutch Sustainable Development Project, which mandated CTA as a crucial element of the development process, CTA practices appeared erratically. Some design processes did broaden, albeit only on an *ad-hoc* basis. The broadening did lead to anticipation of social effects and first order learning about a number of relevant aspects. Second order learning never surfaced, however. Food values were never discussed and the entire process was aimed at reaching a consensus. Reflexivity did emerge because different types of actors related specific design options to social aspects and they discussed various alternatives. Yet, food use was only considered in a static way. The possibility of a co-evolution of technology and user needs and values was never really incorporated.

Implicit CTA: Expansion of a Dutch Harbour[34]

In April, 1996 the Dutch cabinet announced that it would experiment with a new, open planning process in dealing with the major ecological consequences of a proposed new Rotterdam harbour (Tweede Maasvlakte). One year would be reserved for debate on so-called 'problem recognition'. A separate organization (VERM), in collaboration with the public, would determine whether a new infrastructure was truly necessary. In a routine planning procedure, the government would develop a plan that would go through a process of public hearings.

The government had recently been accused of being out of touch with the views of the public, when it had pushed through construction of the Betuwelijn, an unpopular new main freight line from Rotterdam to Germany, despite public opposition. In recognition of this legitimacy crisis, the government invited advice on how to increase positive public awareness and political legitimacy for future infrastuctural works. They decided to use the Rotterdam harbour case for experimenting with a problem recognition discussion.

Together with the relevant ministries, interest groups and other public (lay) participants were called upon in initial consultation rounds consisting of public discussions, *werkateliers*, telephone interviews, expert meetings, questionnaires and roundtable discussions, to take stock of 'the nature, extent and urgency' of the space and congestion problem and the expected effects of various solutions. The results were used in the final project decision before it was sent through a normal planning procedure. The participants in the open planning process were not directly involved in the final project decision. This decision was, however, presented in a meeting and discussed. This dialogue was the last phase in an intensive process of iterative discussions with many participants.

How can we evaluate this process from a CTA perspective? Although the process was not designed as a CTA process, it can be seen as *de facto* CTA. The explicit aim was to broaden the design of a large infrastructure project. Many different sorts of actors were involved. However, many high ranking governmental and industry representatives did not participate in the open discussion, reserving their commentary until after the open discussions were finished. This lessened the legitimacy of the procedure in the eyes of the public; 71% of the participants surveyed reported that citizens had little influence on the outcomes.

During the planning process dissension emerged about the amount of new space needed for the harbour redesign. The proposed area ranged from 2000 ha to zero. After consultation, VERM concluded that there was general agreement on a space shortage of approximately 1000 ha by the year 2018. Non-government organizations involved did not agree, however. In their opinion, the harbour companies were not using their land as efficiently as possible, for it is currently more economical to expand than to clean up and re-use polluted terrain.

In the final report, VERM specifically mentioned design ideas that emerged from participatory sessions. The proposed solutions were designed to ease road congestion, reduce emissions and create sustainable mobility plans, and included ones for new water ferries and passenger travel on the Betuwelijn, bicycle buses bound for new nature areas (young dynamic dunes), and goods transport over water and by underground pipelines. The final project decision was to build a new harbour. This decision entailed a number of measures and studies to see if some polluting activities could be moved out of the harbour. It also stipulated that some of the consequences of the harbour redesign would be studied in more detail. This would never have happened without the open planning process.

This case demonstrates anticipation, not only on an *ad-hoc* basis, but as an on-going process with further articulation while the plans unfold. It also included social learning as participants developed a better understanding of all the issues at stake and learned about how to organize an open planning procedure. Second order learning did happen, as controversy forced participants to review their own values and assumptions about the need for expansion. The level of reflexivity among actors was apparent, as they developed alternatives and gained understanding of the relationship between specific design choices and their associated impacts.

Final Remarks

In the sustainable development debate, quick implementation of new technologies is a political priority. Convincing people to accept such new technologies as biotechnology, that hold promises (but also threats) for sustainable development, is high on the agenda of many governments. To overcome the problem of resistance to new technologies, firms are increasingly anticipating the prospective social effects, especially when developing 'sensitive' technologies. They enter into discussions with social groups at an early stage. At times, environmental groups also seek contact with the firms and some governments and agencies attempt to support this kind of co-operation.[35] Researchers and practitioners attempting to develop the CTA perspective are following this trend and trying to modulate it. The development of the CTA perspective is to be understood as an attempt to articulate what is going on and which steps could be taken to improve the integration of technology and society. Such an integration cannot be achieved through research alone, or simply through technology assessment. Rather, the character of the design process is in need of change. It must be broadened to encompass social aspects and actors. The goal is to embed anticipation as a regular, frequent activity beginning early in technology design processes and to encourage reflexive and learning processes to emerge.

Cases discussed in this article show the difficulties and promises of this approach. The harbour case shows that in broadening the design phase the plans finally chosen integrated various aspects (harbour expansion, and social and environmental impacts) and included new kinds of solutions. The challenge was to establish a broadly accepted legitimacy for the design process and its outcomes. The novel protein food case shows that a CTA process could lead to the development of a new R&D priority. It also shows, however, that CTA efforts are fragile and can easily be abandoned as CTA practices will not accompany further R&D activities on novel protein foods. In this case, institutionalization of CTA was lacking. The Rathenau case was a special case, because the history of the Rathenau Institute is so closely connected to the development of the CTA perspective. Yet, Rathenau has not been involved in implementing CTA because the definition of its mission has shifted to keeping the Dutch Parliament and public policy makers well informed about technology development.

In the long-run, proliferation of CTA practices could lead to a change in the current pattern of technology management (which separates design of technology and management of its impacts). New institutions that will become platforms for the constructive integration of technology and society will emerge.[36] It is labelled constructive because all those affected share responsibility for the design, construction, application and effects of the technology from the outset. In the existing situation no one claims responsibility for the effects. To technology developers, the public sphere must deal with negative effects because, in their view, the effects usually derive from the manner in which individuals use the technology, not from the hardware itself. The users and others do not feel responsible for the negative effects because they assume that producers should not be allowed to produce technologies that cause adverse reactions; they subsequently call for protection from the government. If CTA practices are incorporated into the design process, proponents and opponents will both become responsible for giving meaning to technology and its effects. This will not only change the public policy process (both technology development and technology assessment policy) but also effect a new technology politics.

Notes and References

1. This article draws on research done and many discussions held in the context of the EC/DG XII funded TSER project 'Public Engagement and Science and Technology Policy Options' (PESTO). See A. Jamison (Ed.), *Technology Meets the Public*, Vols. I and II (Aalborg, Aalborg University Press, 1997, 1998). I would like to thank José Andringa, Adrew Jamison, Markus Popkema and all other PESTO participants for their contribution to this process of idea sharing. I also would like to thank Arie Rip for continuous discussions and exchanges on the CTA perspective and its implications. In the process of editing this article, Ellen Koch made various valuable suggestions about how to introduce and position CTA and about the definition of three CTA criteria discussed in this article.
2. For a recent overview of TA practice, see N.J. Vig & H. Paschen, *Parliaments and Technology. The Development of Technology Assessment in Europe* (State University of New York Press, 2000). On participatory TA see S. Joss (Ed.), 'Public Participation in Science and Technology Policy- and Decision-Making: Ephemeral Phenomenon or Lasting Change?' Special Issue, *Science and Public Policy*, *26*, 5, 1999, pp. 290–373; G. Rower & L.J. Frewer, 'Public Participation Methods: A Framework for Evalution', *Science, Technology and Human Values*, *25*, 1, 2000, pp. 3–29. Finally, see L. Klüwer *et al.*, 'European Participatory Technology Assessment', Draft Report of project supported by the EC/DG XII TSER programme.
3. For an overview of CTA see A. Rip, T.J. Misa & J. Schot (Eds), *Managing Technology in Society. The Approach of Constructive Technology Assessment* (London, Pinter, 1995); and J. Schot & A. Rip. 'The Past and Future of Constructive Technology Assessment', *Technological Forecasting and Social Change*, *54*, 1998, pp. 251–268. CTA also has been taken up in discussion on the future of technology policy, see for example, C. Freemand & L. Soete, *The Economics of Industrial Innovation*, 3rd edn (London, Pinter, 1997), esp. pp. 430–432.
4. See for example, A. Lovins & E. von Weizsacker, *Factor 4. Doubling Wealth—Halving Resource Use* (London, Earthscan 1998).
5. See for example, R. Welford, *Environmental Strategy and Sustainable Development* (London, Routledge, 1995).
6. A. Irwin, *Citizen Science, A Study of People, Expertise, and Sustainable Development* (London, Routledge, 1995) pp. 135–136.

7. For a discussion on this pattern, refer to the introduction in Rip *et al.*, *op. cit.*, Ref. 3.
8. For some early publications see C. Daey Ouwens, P. van Hoogstraten, J. Jelsma & A. Rip, *Constructief Technologisch Aspectenonderzoek. Een verkenning* (Den Haag, NOTA, 1987); M. Schwarz & M. Thompson, *Divided We Stand. Redefining Politics and Social Choice* (New York, Wheatsheaf, 1990) and J. Schot, 'Constructive Technology Assessment and Technology Dynamics: The Case of Cleaner Technologies', *Science, Technology and Human Values*, *17*, 1, 1992, pp. 36–56.
9. Technology forcing is a strategy to stipulate desired impacts, and challenge firms to come up with technologies that fulfil these requirements. See Schot & Rip, *op. cit.*, Ref. 3.
10. Specific forms of CTA have been developed for consumers and producers. On consumer CTA see, G. Fonk, 'Een constructieve rol van de consument in technologie-ontwikkeling Constructief Technologisch Aspectenonderzoek vanuit consumentenoptiek', PhD thesis, University of Twente, 1994; on producer CTA, see J. Jelsma & A. Rip, *Biotechnologie in bedrijf. Een bijdrage van constructief technoloy assessment aan biotechologisch innoveren* (Den Haag, Rathenau Instituut, 1995).
11. F. N. Laird, 'Participatory Analysis, Democracy and Technological Decision-making', *Science, Technology and Human Values*, *18*, 3, 1993, pp. 341–361. See also R.E. Sclove, *Democracy and Technology* (New York, Guilford Press, 1995).
12. This difference related to content of interaction was suggested to me by Markus Popkema.
13. Jelsma & Rip, *op. cit.*, Ref. 10.
14. *NRC-Handelsblad*, 18 June 1996.
15. A. Rip, 'Introduction of New Technology: Making Use of Recent Insights from Sociology and Economics of Technology', *Technology Analysis & Strategic Management*, *17*, 4, 1995, pp. 417–431.
16. Jelsma & Rip, *op. cit.*, Ref. 10.
17. R. Herbold, 'Technologies as Social Experiments. The Construction and Implementation of a High-Tech Waste Disposal Site', in: Rip *et al.*, *op. cit.*, Ref. 3, pp. 185–198.
18. A. Cambrosio & C. Limoges, 'Controversies as Governing Processes in Technology Assessment', *Technology Analysis & Strategic Management*, *3*, 4, 1991, pp. 377–396.
19. J. Jelsma, 'Learning About Learning in the Development of Biotechnology', in: Rip *et al.*, *op. cit.*, Ref. 3, pp. 141–166; and B. Wynne, 'Technology Assessment and Reflexive Social Learning: Observations from the Risk Field, in: Rip *et al.*, *op. cit.*, Ref. 3, pp. 19–36.
20. W.J. Abernathy, K.B. Clark & A.M. Kantrow, *Industrial Renaissance. Producing a Competitive Future for America* (New York, Basic Books, 1983), p. 25–26. See also K. Green, 'Creating Demand for Biotechnology: Shaping Technologies and Markets', in: R. Coombs, P. Saviotti & V. Walsh, *Technological Change and Company Strategies* (London, Harcourt Brace Jovanovich, 1992), pp. 164–184.
21. For the innovative role of user firms, see E. von Hippel, 'The Dominant Role of Users in the Scientific Instruments Industry', *Research Policy*, 5, 1976, pp. 212–239; see also E. von Hippel, *The Sources of Innovation* (Oxford, Oxford University Press, 1988), and D. Leonard, *Wellsprings of Knowledge. Building and Sustaining the Sources of Innovation* (Boston, Harvard Business School Press, 1998).
22. C.S. Fischer, *America Calling. A Social History of the Telephone to 1940* (Berkeley, University of California Press, 1992), esp. ch. 3.
23. Jelsma & Rip, *op. cit.*, Ref. 10.
24. For the notion of second-order learning see J. Grin & H. van der Graaf, 'Technology Assessment as Learning', *Science, Technology and Human Values*, *21*, 1996, pp. 72–99.
25. The drafting of this memorandum was influenced by the work on CTA published in Daey Ouwens *et al.*, *op. cit.*, Ref. 8, and by R. Smits & J. Leyten, who later synthesized their work in a book, *Technology Assessment. Waakhond of speurhond* (Kerckebosch, Zeist 1991). See also by same authors 'Key Issues in the Institutionalisation of Technology Assessment', *Futures*, *20*, 1988, pp. 19–36.
26. For a history of Rathenau see J. van Eijndhoven, 'The Netherlands. Technology Assessment from Academically Oriented Analyses to Support of Public Debate, in: Vig & Paschen, *op cit.*, Ref. 2, pp. 147–172. See also, Schot & Rip, *op cit.*, Ref. 3.
27. C. Daey Ouwens *et al.*, *op. cit.*, Ref. 8.
28. NOTA, *Technology Assessment: To Adjust or to Channel* (The Hague, NOTA 1994), p. 4.
29. H. Dieleman & S. de Hoo, 'Toward a Tailor-made Process of Pollution Prevention and Cleaner Production: Results and Implications of the PRISMA Project', in: K. Fischer & J. Schot (Eds), *Environmental Strategies for Industry* (Washington DC, Island Press, 1993), pp. 245–276.
30. I am drawing on my own experience. I have been involved, at a distance (as an *ad-hoc* advisor) in the

development of this programme, and in addition, in co-operation with José Andringa, who studied the programme in the context of the PESTO project (see Ref. 1). See also P. Weaver, L. Jansen, G. van Grootveld, E. van Spiegel & P. Vergragt, *Sustainable Technology Development* (Sheffield, Greenleaf, 2000).

31. This is Philip Vergragt, see P. Vergragt & D. van Noort, 'Sustainable Technology Development: The Hydrogen Fuel Cell', *Business Strategy and the Environment, 5*, 1996, pp. 168–177. See also E. Schramm & P. Wehling, *Forschungspolitik für eine nachhalitige Entwicklung: Das niederländische DTO-Programm und seine Bedeuting für die Bundesrepublik Deutschland* (Frankfurt am Main, 1997). This study was commissioned by the german TA buro, and defined DTO as a CTA initiative.
32. A. Hamstra, 'The Role of the Public in Instruments of Constructive Technology Assessment', in: S. Joss & J. Durant (Eds), *Public Participation in Science. The Role of Consensus Conferences in Europe* (London, Science Museum) pp. 53–66. See also A. Loeber, 'Illustratieproces Novel Protein Foods. Slotevaluatie. Samenvattend Rapport', Working Document of DTO program, 1997.
33. See Fonk, *op cit.*, Ref. 10.
34. Based on research done by Markus Popkema, in the context of the PESTO project (see Ref. 1). It draws on discussions with him and with Richard Rogers on the application of CTA criteria to this case. See also VERM, *Verslag Verkenning Ruimtekort Mainport Rotterdam*, deel A, B and C (Den Haag, SDU, 1997).
35. For some trends see, J. Bendell (Ed.), *Terms for Endearment. Business, NGOs and Sustainable Development* (Sheffield, Greenleaf, 2000).
36. Such a new institution can be defined as a technology nexus, that is, a place and space for working on design and societal needs simultaneously. See Short, *op. cit.*, Ref. 8.