MAPPING NEW TECHNOLOGIES FOR SOCIETY

DESIGN IN A POLITICAL ENVIRONMENT

by Niko Vegt

Mapping new technologies for society
Design in a political environment

Master thesis
M2.2 graduation project
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Contents

Abstract

This report describes an exploration on the integration of design for debate and technology assessment. Technology assessment is a research field where the impact of technology on society is studied and communicated in political terms. Design for debate is an approach where design is deployed to ask questions about facts or values. This was explored in the context of the Nano supermarket and at the Rathenau Institute. The Nano supermarket is a design for debate exhibition about nanotechnology with future nanotech products that can be on the market within 10 years. The Rathenau Institute investigates the impact of technology on society and is commissioned by the Dutch government to broaden the debate about new technologies.

For the Nano supermarket the Nano World map was designed as a product that could be sold at the exhibition and communicates that nanotechnology is not just a trend in material science but has a much larger impact. More than hundred speculative, emerging, and established products were mapped in an imaginative world map with markets as countries, issues as mountains, and fundamental concepts as seas.

For the Rathenau Institute a graphic template was designed for the slideshow at the Making Perfect Life conference at the European Parliament in Brussels. The graphics communicate the ‘new technology wave’ which is a title for the current technological developments that are happening. These developments were reviewed through two mega-trends (‘biology becoming technology’ and ‘technology becoming biology’) in the Making Perfect Life project by the Rathenau Institute. The ‘new technology wave’ was further used to design an interactive version of the graphics and develop a design for debate.

These design activities gave insight in the integration of design for debate and technology assessment. The designs were mainly interesting regarding the integration of design in technology assessment practice. To provide a good picture of the integration of technology assessment methodology in design for debate practice a framework was developed. This framework was exemplified by the design of a tool that helps designers to specify the political values of a design for debate.

Preface

Motivation

I use design as a medium to change people's behaviors and attitudes. This includes both informing and empowering people. Design is a rich medium that has the potential to make complex topics understandable on a concrete human level. It's about transforming complexity into a manageable tangible form. This leads to the empowering quality of design that is important to me. I want to enable people to actively deal with complex topics.

I always seek for new contexts where design (or design-thinking) can make a difference. The first clear example in my work of making an impact in new contexts is my Bachelor graduation project: 'the paperless pursuit'. During this project I worked on the visualization of printing behavior (called 'print-o-graphic') in a company (see Figure 1). The goal was to increase the employees' awareness and eventually reduce their paper consumption. Employees could see their daily consumption of paper in real-time and relate this to the corporate consumption. This resulted in a management strategy entitled: "managing change through design" (Vegt, 2008).

My interest for trends, and technology trends in particular, was stimulated by a design project on DNA analysis. I designed a cartographic representation of the state-of-the-art of genetic technology (see Figure 2). A website that is currently online (www.nikovegt.nl/dnaworld) shows a prototype of the interactive map. I mapped ideas, concepts and existing products in general domains and application fields. The intention was to make people explore the technology and see social implications in many different areas. I transformed the map into a board game (variant of Risk) to achieve people's engagement with genomics and raise awareness about its implications. It addressed the way I want to deploy design: making complex subjects understandable, feasible, and workable for everybody.

My graduation project should be seen in the context of the "reflective transformative design process" (Hummels, et al., 2008). This describes the way we're being taught 'design' at the department of Industrial Design at the TU/e and is instrumental to the way I approach my work. It serves a holistic approach where "knowledge, skills and attitudes" are valued equally. I learned to integrate my knowledge and skills into design, led by a vision on transforming the world by new technologies, with a critical and responsible attitude. This transformative impact on society is my main motivation for becoming a designer.

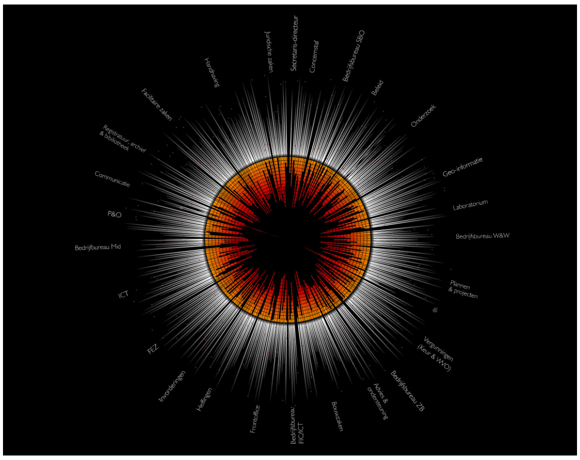

Figure 1: The print-o-graphic. A visualization of every employee's paper consumption

Stakeholders

The before-mentioned design activities (and some smaller projects explained at: www.nikovegt.nl/showcase) served as the backbone for the graduation project that is described in this report. The involved stakeholders were directly or indirectly derived from the above mentioned projects.

The direct connection came from the DNA World. This project was published on the Next Nature blog (“Next nature is the nature caused by human culture” (van Mensvoort, 2005)) as contribution to the Next Nature Lab (van Mensvoort, et al., 2009). The reactions were mainly positive and resulted in two requests for submission in a design contest. I submitted the DNA World to the Nano supermarket contest as an opportunity to provide a broad perspective on nanotechnology. I didn’t win the contest, but did receive the request to design a product for the gift-shop of the Nano supermarket with the same intentions as the DNA World map. The Nano supermarket is a collaborative effort to bring nanotechnology to the general public and show the impact on our daily lives. They offered to support me with the development of the product and financial support for the production. The organizers of this effort are: Next Nature Institute, Eindhoven University of Technology, and Studium Generale.

The Rathenau Institute (RI) as a stakeholder is the result of my personal wish to have a real client for my graduation project. This wish came from my experience during the Paperless Pursuit project where I could situate my design work and make a (although modest) transformative impact. The RI keeps track of the leading technological developments and assesses the impact on society.

To get the best out of the relation with the RI we established an internship contract. My role as an intern at the Technology Assessment department enabled the contribution to several projects that related to my graduation work and resulted in many new learning experiences.

With my personal motivation and these stakeholders a promising frame was created for an interesting graduation project. In this report I briefly describe the process and mainly its outcomes. Enjoy the reading.

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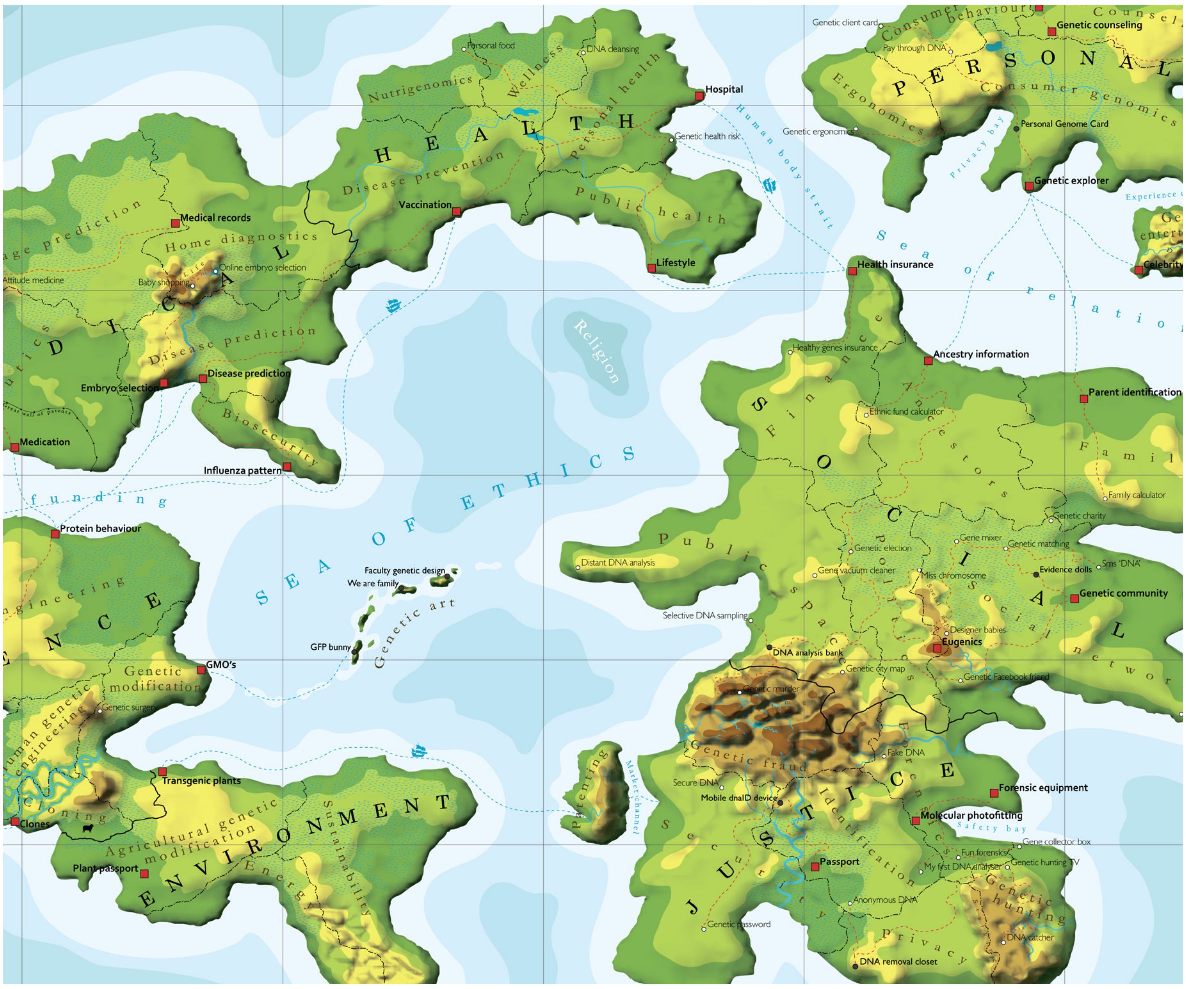

Figure 2: Genomica. An imaginative cartography of the emerging world of genomics

Introduction

1.1 Problem statement

Kevin Warwick is a pioneer in the field of cybernetics (this is about integrating technology with organisms). He gave a keynote presentation at the STRP conference 2010 about his successful endeavors in becoming the first cybernetic human. His story about advancements in implementing technology in the human body was fascinating. Warwick connected electrodes to nerves in his arm and linked them wirelessly with electrodes connected to his wife's nervous system in the arm. This enabled them to communicate through finger movements; being directly experienced in the brain of the other.

Such technological development is astonishing and doesn't seem a large threat, except from the physical risks. But the issues that arise here come from the way Warwick expresses his research activities. A selection of quotes from the presentation: "RFID is implemented in pets, but don't worry, they were first fully tested on humans", "We have a finite number of brain cells, only five senses, and limited calculation power when compared to a computer", and "Aren't you jealous of the television, because he can see infrared light? Human communication is very limited and inefficient". This simplified view on human capabilities raises concern because it shows little respect for the integrity of the human body. So questions have to be asked about the desirability of this kind of research, because it could lead to a shift in our attitude towards human dignity.

1.2 Socio-technological perspective

1.2.1 Trends

To explore the urgency of the issues arising from such pioneering efforts it has to be seen in a broader context. Does it represent a fundamental change in our values towards a disrespectful attitude or is it just a single incident? This question can only be answered by the identification of relations between incidents. When many relations are perceived we can start speaking of a trend. "Trends are developments that have been going on for some time and that are expected to play a role in the coming years" (van Est, et al., 2004). Trends serve as an instrument to assess and communicate the urgency of a technological development and its issues in the long term. The stories (socio-technological scenarios) related to a trend are dynamic; continuously shifting due to new insights from science and society. So continuous monitoring is important.

1.2.2 Technology assessment

But what use does this trend analysis have if we can't control the technological developments? The general public is predominantly ignorant about the current state of science and is badly informed about its implications in their lives. There appears to be a large gap between science and society. Many people believe in autonomous technology development where resistance is senseless. Such a

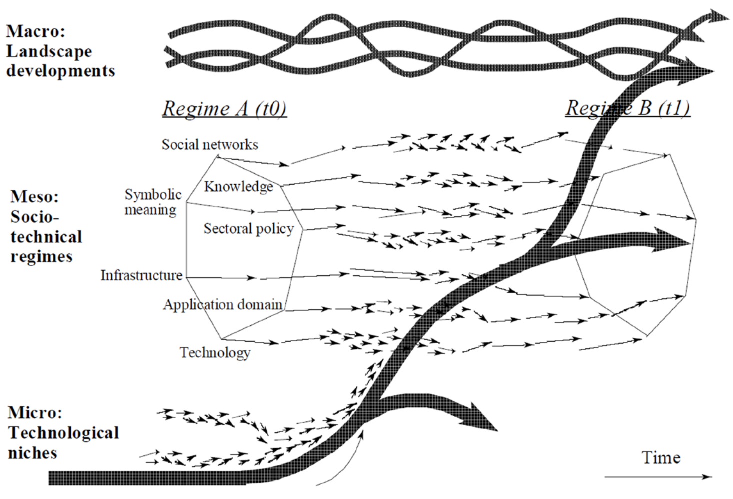

Figure 3: A dynamic multi-level perspective on transitions (Geels, et al., 2000)

fatalistic attitude makes reflection and evaluation useless. A more constructive picture is provided when we look at the interaction between science and society. This shows that technology and society "co-evolve" (Schwarz, et al., 1990). We live in a techno-culture where technology reacts on society and vice versa.

This socio-technological perspective is becoming widely accepted and gives rise to the field of Science and Technology Studies (STS) as well as the raison d'être of the Rathenau Institute. Since the information revolution (that succeeds the industrial revolution) "technology has lost its innocence" due to the negative effects of the industrial revolution and the fact that technology is getting closer to, and actually inside, ourselves. This raised a critical public attitude towards technologies, and STS methods to assess their impact. "Technology and life is no longer solely in the hands of engineers, but will be defined by the quality of the political and public debate around science and technology. [...] To ensure that technology development leads to an increase in the quality of life it is needed therefore to stimulate the public debate about the relationship between science and technology and quality of life" (van Est, 2008). Technology assessment (TA) originates from this goal and is a research field since the 1970's.

Geels and Kemp provide three different levels to look at socio-technological developments (see Figure 3): micro (technological niches), meso (socio-technical regimes), and macro (landscape developments) (Geels, et al., 2000). The micro-level serves as the basis for the discovery of transitions in society and technologies. In TA terms this level relates to technology niches; in design we speak of cutting edge manifestations which relates to culture research. The just mentioned field of cybernetics is such a niche. The macro level is where broad trends are identified in different categories: socio-cultural, economic, political, technological, ecological, and demographical (Römsgens, 2002). The meso-level is about the socio-technological perspective, where different kinds of dimensions influence each other. It is this level that is the main subject of research within TA and design for debate. The micro- and macro-level serve as input.

1.2.3 Technology trends

The work of cybernetics scientist Kevin Warwick, for example, is a technology niche. It relates to the NBIC-convergence that provides a macro perspective on many micro developments. This acronym refers to four key technologies: nanotechnology, biology, information technology, and cognitive sciences. "Convergence points to the belief that progress depends on the mutual interplay between those four key technologies" (van Est, et al., 2010). Warwick's work puts the belief in 'engineering' into practice, which relates to a common trend on the macro perspective. There is a synergy going on between revolutions in the different areas, which results in the emergence of many new research fields and shifting attitudes towards biology and technology. Other macro-trends that play a role in this are digitization and miniaturization. On one hand there is an information revolution going on and on the other hand we can make and control things on an increasingly smaller level, giving rise to nanotechnology.

1.3 Rathenau Institute

The Dutch Rathenau Institute (RI) keeps track of these leading technological developments and assesses the impact on society. “One of the key tasks of the Rathenau Institute is to encourage societal debate and the process of political opinion-forming“. The institute contains two departments, Science System Assessment and Technology Assessment. The latter is “intended to explore the social, political and ethical implications of new technological developments” (van Velzen, 2009). The RI is originally commissioned by the government to advise them on how to deal with upcoming technologies. But their role has become broader, with the department of Science System Assessment as a result.

The RI investigates the interaction between science and society in an intellectual way, i.e. through reading and writing. Their goal is to transform the socio-technological problems that arise into workable publications for politicians and general public. The means that are used for TA research projects are: websites, social online media, contributions to congresses, popularized versions of research outcomes, and meetings with scientists, stakeholders, policymakers and politicians. Different kinds of media are used to communicate the findings. The established intellectual media are: reports, scientific articles, essay bundles and other forms of publication. But they also use media like: festivals, theatre plays, debates, exhibitions, and film.

The RI’s role as a mediator between scientific experts and politicians asks for communication strategies. Specific terms and examples are instrumental to steer and stimulate the debate intellectually. The ‘new technology wave’, for example, is used to describe a specific set of current technological developments that emerge from the NBIC convergence. It is used to broaden current debates about biotechnology and nanotechnology. Text is the main medium to achieve this; sometimes illustrated with drawings or pictures. Descriptions of concrete examples are valuable, because they enable the shift from abstract to concrete.

1.4 Design for debate

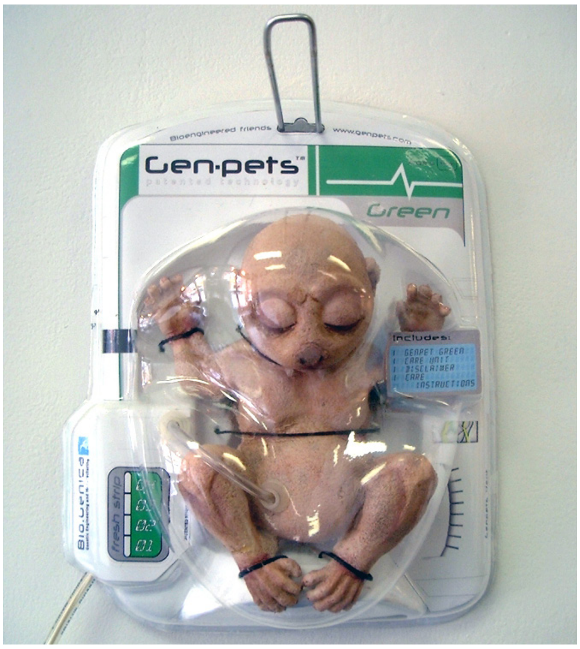

Figure 4: GenPet – a well worked out example of design for debate (source: http://www.genpets.com/media.php)

Design for debate has this role as a mediator as well, but with an emotional value-centered approach and design as the medium. It is therefore suitable for general public and not specifically for politicians. The GenPet (Figure 4) is a good example of a DfD. Not only is genetic technology worked out well in this design, it is also marketed as an exhibition piece without distracting the attention from the debatable topic that it addresses. It clearly shows the strength of DfD as a medium that addresses values rather than facts. The technology to actually make such GenPet is still in development, but this is secondary to the emotional reaction that it generates.

The book ‘Design Noir’ by Dunne & Raby is one of the first that describes design as a medium to explore socio-technological scenarios (Dunne, et al., 2001). They involved common industrial design practices in speculative products to make them fit for use in everyday contexts; resulting in an accessible story for everybody – “both factual and imagined”. This method approaches design as a medium to raise questions about the interaction between science and society. “Design for debate is a way to start discussion in society at large. [It] is focused on the meaning of future scenarios, mostly in relation with emerging technologies, [and] makes use of designers' visualization skills to make abstract concepts tangible. Design for debate is value-centered instead of fact-centered. [So] discussion within design for debate is meant to question values of the future, but doesn't necessarily seek answers" (Reeskamp, et al., 2007).

Design for debate (DfD) is a young field within industrial design. "Since the late 1990s, there has been a proliferation of projects that examine and experiment with the capability and role of design in increasing societal awareness, and motivating and enabling political action" (DiSalvo, 2009). In an early work, Dunne & Raby introduced the term 'value fiction' (as the counterpart of 'science fiction'): "in value fiction, ideas come from imagining possible products, based on existing technologies, and trying to understand why they would not work in our current culture" (Dunne, et al., 1997). In the same publication "research through design" is introduced. It can be said that design for debate is the socio-cultural discourse within that field. Many different terms refer to the approach of "exploring and questioning two-sided stories that come along with the development of a future techno-society" (Reeskamp, et al., 2007). Some related terms are: critical design, design for dilemma, design for thought, conceptual design, placebo objects, and speculative design.

There is no comprehensive knowledge base on methods for design for debate. Two publications are interesting for this project. First DiSalvo provides methodological guidance for DfD in "Design and the construction of publics" (DiSalvo, 2009). In this work he translates a STS publication of John Dewey "The public and its problems" (Dewey, 1927) into concrete design for debate practice. Two design tactics are identified in relation to Dewey's theory: 'projection' and 'tracing'. "The tactic of projection can be defined as the representation of a possible set of future consequences associated with an issue. […] The tactic of tracing is characterized by the use of designerly forms to creatively express the histories, discourses, and techniques that constitute an issue". These design tactics can be used to assess the contribution of a design and also, to some extent, as design methods.

Tobie Kerridge explores methods for speculative design in his PhD work and also makes the relation with STS literature (Kerridge, 2009). He describes "a design-lead public engagement project" with an open collaborative process where "speculative design provides a ground for discussions between researchers and non-experts about incomplete technologies". The access to laboratories for public-groups and the interaction between scientists and designers is one of the key-factors for a speculative design process. Bringing the designs out to the public is briefly described, where exhibitions seem the most appropriate method to do this. "An exhibition cannot do much, but it can explore new possibilities with a much greater degree of freedom because it is so good at thought experiments, or rather Gedankenausstellung. One of those attempts is to design not one assembly but rather an assembly of assemblies, so that, much like a fair, visitors or readers can compare the different types of representation." (Latour, 2005)

An important common denominator of the publications is the relation that they make with STS literature. They both clearly signal the opportunities for combining design practice with STS methodology, where TA is a sub-field. TA methodology seems useful to provide more structure to DfD. The above described publications hint towards DfD methodology, but describe practical translations of STS methods.

Objective

2.1 Merge two worlds for debate

The goal of both DfD and TA is to stimulate and steer the debate. In DfD socio-technological problems are transformed into tangible forms. In technology assessment the problem transformation mainly takes place through text and imagery. The goal of this project was to merge the approaches of TA with DfD practice. This is both valuable for the RI as well as for designers that are involved in DfD. Both parties are interested in enhancing their practices when this leads to improved communication to their target groups: politicians and layman public respectively.

So the merging goes in two directions. Design can be integrated in the practice of the RI, and technology assessment can be used in the design process. The RI has to be differently addressed then designers though. TA practice is rich of methodology and literature, whereas DfD lacks methodology and the available literature only describes practice experiences. So for RI employees a practical experiential implementation of design in their current practice is of most value. Designers are more helped with a methodological approach.

To achieve this mergence of worlds, two cases were explored through the integration of design and technology assessment: the Nano supermarket and the 'new technology wave'. The insight provided by the design activities a framework was developed to integrate technology assessment methodology in the design process.

2.2 Methods

2.2.1 Design as communication tool

Currently one of the main challenges of the RI is to "reach out to the general public". Their website has an important role in this. The chairman of the board states that "our challenge is to make that website interesting and entertaining, without detracting from the depth of the issues under consideration. We must cross a bridge, but it is a narrow bridge" (van Velzen, 2009). In this challenge opportunities arise for design practice at the RI. The bridge that has to be crossed is the one from abstract fact-centered understanding to tangible value-centered communication. This is exactly what design or design thinking is about.

To provide a clearer image about the role of design as a communication tool in TA practice a model about four societal discourses is used (Figure 5): art, political-philosophic, policy, and popular (van Est, 2008). The political-philosophical approach deals with information and reflection. This mainly relates to the socio-technological perspective, where not only economical factors should be seen as driving forces for technological developments. The policy discourse is about decision-making and relates to staging the debate with the right actors to form an opinion. The popular approach is used to engage general public with a socio-technological perspective and make the gap between the debate among experts and the experience of general public smaller. Art is about imagination, which is becoming a more and more important

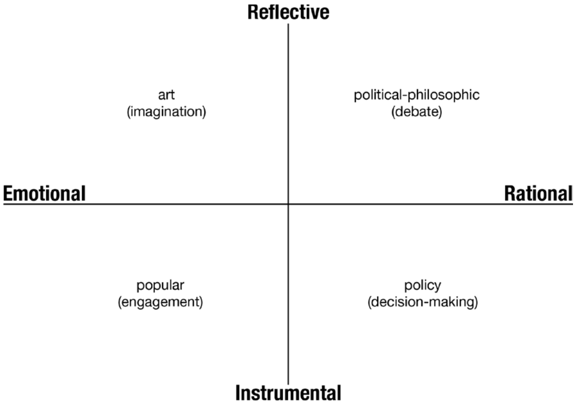

Figure 5: Model of the societal discourse consisting of four discourses showing four potential deficits of the political discourse (van Est, 2008)

factor, because we are increasingly directing developments towards projections of the future, rather than knowledge from the past.

As opposed to text, the value of design in TA practice is its rich communicative property. At the RI it can be implemented to cover the instrumentalization of an emotional attitude towards new technologies. Text is valuable for its precise descriptive property and covers the rational side (see Figure 5). At the RI imagination is highly valued, especially when it comes to reaching general public. But their expertise is on the rational debate where textual description is the main tool. The explorative design activities serve an investigation on combining technology assessment and design practice for improving internal and external communication. For internal communication classical design methods (like drawing, brainstorming, and prototyping) were used within a project at the RI. And graphic design was implemented for communicating a socio-technological perspective to the outside world.

2.2.2 Research through design

But within this project the role of design is broader. Besides serving as a communication tool it was used within a research process. This is commonly referred to as “research through design”, where design activities are used for exploring hypotheses and ideas. The aim is at “eliciting a personal approach to a problem, rather than achieving a supposedly objective truth” (Dunne, et al., 1997). In this project design was deployed to elicit this personal approach to merge TA and design. The explorative design activities were design projects on their own, but also served a higher goal of understanding TA and DfD practices. In the case of the ‘new technology wave’ the design of an interactive graphic (as described in paragraph 3.2.7) had this as its core purpose.

From this ‘research through design’ perspective there were several questions that had to be answered. The main question was: How can TA methods be integrated in a DfD process without losing qualities of design? Sub-questions were: What are the qualities of TA? What are the qualities of DfD? How are the TA approach and DfD approach related? How do TA methods contribute to the DfD process? How can a DfD process contribute to TA practice?

2.3 Approach

The answers to these questions can be found in the paragraphs about the evaluation of the explorative design activities, the description of the framework, and the conclusion chapter. First two cases of explorative design activities will be described where in the context of the Nano supermarket and the ‘new technology wave’ the integration of DfD and TA was explored. After the evaluation of these activities a third design cycle is described about a DfD framework for designers to make their work suitable for politicians. The two cases and the framework provide the input for the conclusion chapter, where general insights are described in relation to the project objectice.

2.3.1 Nano supermarket: explore the role of TA in DfD

The case about the Nano supermarket was used to explore the role of technology assessment in design for debate. Nanotechnology is a core research topic at the RI and one of the main technological developments that the Dutch government is investing in. The Nano Supermarket, a Dutch DfD exhibition about nanotechnology, gave the

Figure 6: Nano supermarket bus (source: http://www.nextnature.net/events/nano-supermarket/)

opportunity to do a real DfD project in cooperation with the RI. The design for such exhibition provided insight in the role of TA and served as an explorative design cycle for the design for debate framework. The goal was to gain experience with the communication of new technological developments in a socio-technological perspective.

2.3.2 New technology wave: explore the role of design in TA

At the RI the role of design was explored through the case of the 'new technology wave'. This term relates to the NBIC-convergence which is another core research topic at the RI. A graphic design contribution to the Making Perfect Life project was performed to become familiar with the practice of TA at the RI and explore the role of design in the process.

Making Perfect Life (MPL) is a project commissioned by the EU with a contribution of several European institutions. The MPL project was halfway in the interim study and just started with the conclusion phase when this design project started. This provided good opportunities for exploring the role of design in the TA process. A design approach was added to the TA process as part of the conclusion phase, where it seemed most useful. The MPL interim study ended with a conference at the European Union. This provided an understanding of the political environment and politicians as a target group for the DfD framework. It also gave insight in the way the RI investigates and communicates the socio-technological perspective.

The case of the 'new technology wave' was also explored through the design of an interactive graphic. This design activity followed upon the explorations on design for debate (through the Nano Supermarket) and technology assessment (through the MPL project). The interactive graphic is a tangible conceptualization of the insights from these two cycles and served as an exploration tool for the framework. The integration of TA and DfD was explored within the case of the 'new technology wave'. One case of DfD was developed to investigate its relation with the trends that are instrumental for the 'new technology wave'.

2.3.3 Develop framework for designers

The insights gained from the above mentioned explorative design activities gave input for a methodological outcome for designers. A framework was developed that provides guidelines for design for debate in a political environment. This framework was translated into a toolset for actual implementation in the design process. One tool was worked out to provide a clear picture of the toolset and how it can be used.

Explorative design activities

3.1 Case: Nano supermarket

3.1.1 Introduction

Nanotechnology is an important topic at the RI. It relates to the technology trend of miniaturization, that can be witnessed in many different application fields. Nanotechnology is an emerging field of science that deals with the manipulation of structures on an atomic and molecular scale – the size of one billionth of a meter. It is often seen as a trend in material science, but has much deeper implications; it may realize the dreams people have and significantly improve our lives, but may also have its downsides.

3.1.2 Goal

The goal of this first design activity was to provide a broad overview of the impact of nanotechnology with a socio-technological perspective. This had to stimulate and steer the public debate. The design had to serve as an accessible personal reference book for people that are interested in the developments of nanotechnology and is a way of bringing the Nano supermarket to people's homes.

3.1.3 Context

The design had to suit the Nano supermarket. The Nano supermarket is a collaborative effort to bring nanotechnology to the general public and show the impact on our daily lives, through a DfD approach. An old grocery truck was transformed into an exhibition of speculative nanotech products that can hit the shelves within the next ten years. The exhibition was open for visitors during the Dutch Design Week (DDW) in Eindhoven, the Netherlands, between 23 and 31 October 2010.

Whereas the other exhibited designs communicated the impact of nanotechnology in a particular context, this design had to communicate nanotechnology's broadness. It had to place the nanotech supermarket products in context. The form had to relate to the supermarket environment as a sellable product and appeal to its visitors. It had to become a relations-gift from the Nano supermarket, and was going to be sold during the DDW. The design of such a broad overview of nanotechnology not only resulted in a product for the Nano supermarket, but also contributed to the structure of the exhibition itself. Being part of the Nano supermarket also served as an exploration on how to communicate new technological developments to the public.

3.1.4 User

The public's interest in nanotechnology can arise from widely differing reasons, so the public was expected to range from nanotechnology experts to mothers that are concerned about the effect of nanotechnology on their children. To get a grip on this broad range of users, three target groups were identified: technology experts, laymen with interest for technology, and shopping- or DDW public.

The technology experts have a professional relation with nanotechnology. They can be scientists that deal with the technology or manufacturers of nanotech products. For them the factual information has to be correct, so solid background research is necessary. For experts the added value of the map is the overview from a consumer perspective, because experts generally lack this overview. They are deeply involved in one particular development and have no time to look at the whole field, especially not on the market implementation (or consumer) perspective. This consumer perspective is in fact what design for debate in general has experts to offer, and what is also appreciated by them. It provides a sense of their work's contribution to society (in the market and research fields). So they have a personal need for an overview of nanotechnology.

All citizens of Eindhoven received a leaflet as advertisement for the Nano supermarket. It was expected that the largest group that would respond to this were laymen that are interested in technology. They don't have a professional relation with nanotechnology, but do have a relation with technology or design. They want to stay up-to-date with the developments and read about it on the internet, in magazines and in newspapers. For them the consumer perspective is not particularly interesting. The current state of technologies is what they want to know. So this state-of-the-art is an important factor in the design.

The shopping- and DDW public that aren't particularly interested in technology had to be addressed as well. They visit the Nano supermarket as part of their shopping activities or as visitors of the Dutch Design Week. This visit is not driven by their interest in the developments in nanotechnology, but they want to know what's new and useful. They had to be able to see what impact nanotechnology has on their daily lives. A consumer perspective is particularly important for them. They're used to browse through a dozen of products and quickly select what they like or find interesting. From the selected application they want to know when it is expected to hit the shelves and how it works.

3.1.5 Design

The term 'landscape' is much used in trend-analysis to communicate broad overviews. This term was the inspiration for the design of a cartographic representation of the current state of nanotechnology. The exploitation of the world map metaphor not only served well as a physical product for the Nano supermarket, but also contained enough information layers to cover a socio-technological story about nanotechnology.

The impact of nanotechnology on our daily lives is highly uncertain these days and huge risks can arise. So the style of the cartography had to communicate a dark and adventurous story. And the cartographic elements on the map had to invite for an explorative journey through this unknown and risky world. Therefore a satellite image of the world by night served as inspiration for the visual detailing (see Figure 7).

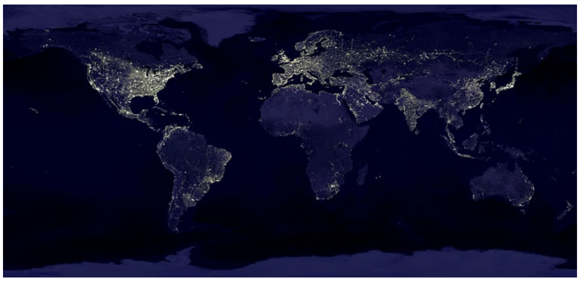

Figure 7: Satellite image of the world by night (source: Google Images)

The selection of colors not only created an adventurous and technological look, but also provided a visual hierarchy. As Tufte describes in “Envisioning information”, color can be used for: labeling, measures, imitating reality, or decoration. And “if one limits strong, heavy, rich and solid colors to the small areas of extremes, then expressive and beautiful patterns occur" (Tufte, 1991). Grayed colors were used for the larger areas, and the white letters stand out as descriptive elements in a nanotech world of 'enabling technologies'. The selection of typeface was used to communicate categories of information.

To give the viewer a better understanding of how to use the map, storylines (or routes) were drawn that dictate a certain perspective. They show how technologies and products can be related. The pictograms that indicate 'points of reflection', 'research opportunities', 'business opportunities', etc. urge for a reflective attitude within such a storyline. There was chosen for a technological and sociological route. The 'super soldier suit' route and 'demilitarization' cruise related to technological trends, whereas the 'nano high society' route is a sociological one (see Figure 9).

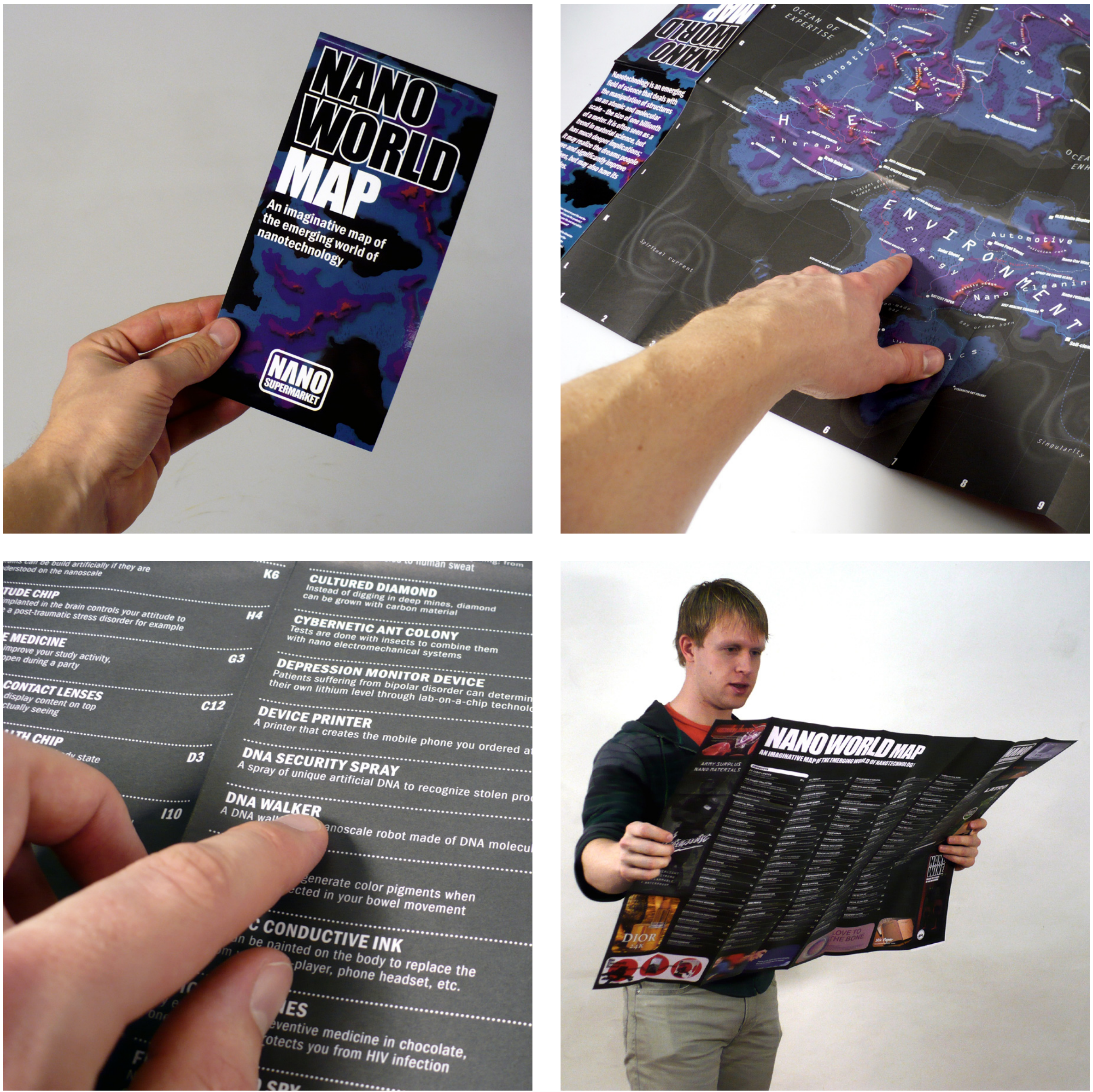

Figure 8: Nano World map in use

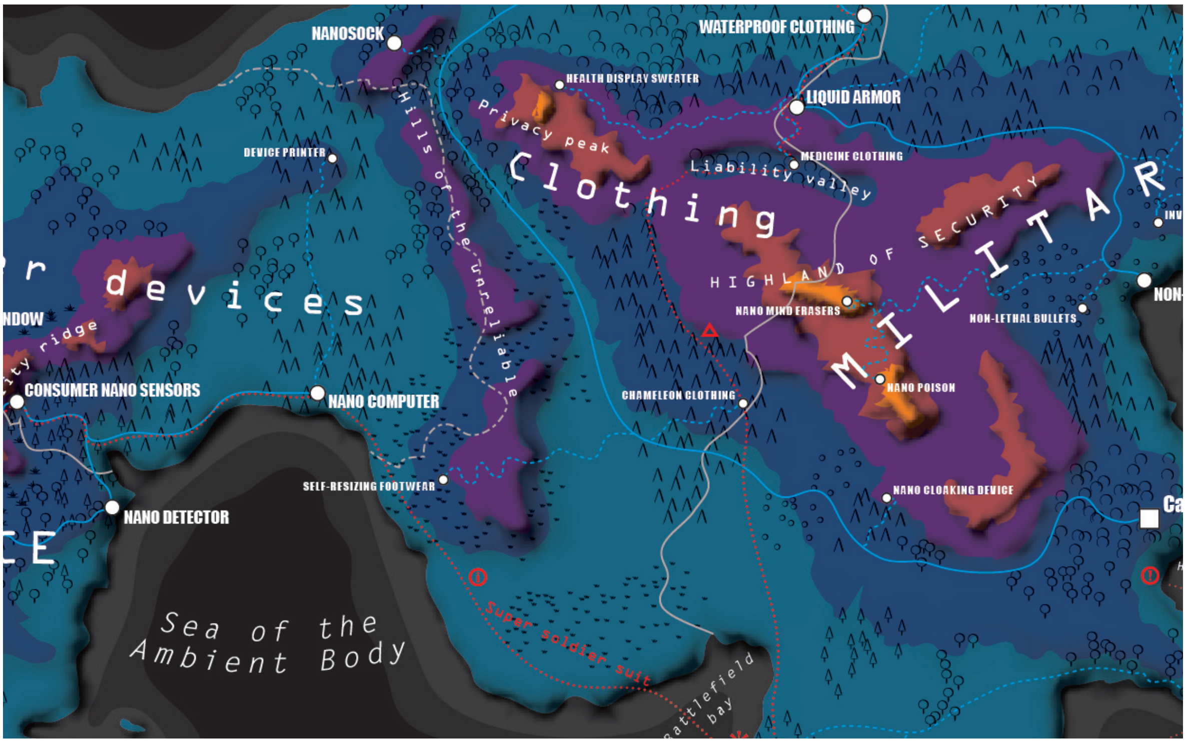

Figure 9: Nano World map detail

3.1.6 Information structure

The cartographic representation of nanotechnology resulted from a short literature study and the collaboration with the Next Nature Institute and the RI. The map has a narrative character with nanotech products as the basic component. Nanotechnology will become tangible as a wide variety and huge amount of products and services. The information structure has evolved around these speculative, emerging and established products (see Figure 10). The products served as the starting point for further investigation. Every nanotech product has its own story and was mapped accordingly.

This can be seen as a bottom-up investigation. Trends within nanotechnology arise from the categorization of nanotech products. This way of looking at current technological developments can be characterized as a consumer or design perspective. For every product it is explained in which application field they will be marketed and which kind of nanotechnology makes the product possible. These factual elements are important to give the public a feeling for the possibilities and opportunities; providing a sense of reality. It relates to the multi-level perspective of Geels and Kemp (see Figure 3). The starting point for investigation is the micro-level (or technology niches). Further research continued on the meso-level (like ‘military’, ’surveillance’, and ‘clothing’). The domains relate to the macro-level.

The problem that arises with a bottom-up approach is that it makes the viewer nearly blind for the bigger societal issues that are at stake. This is where a top-down (in this case mainly ethical) approach comes in, which is common at the RI. In the book “Life as a construction kit” a three-part approach is used to explore new technological developments. This method covers three levels of uncertainty: factual, normative and symbolic. “First there is the uncertainty of facts: what is going to happen? Next there is also an uncertainty of norms: if something becomes feasible, do we find it also desirable? […] The cross-border developments within the new technology wave challenge us to reconsider symbolic categories, that are the

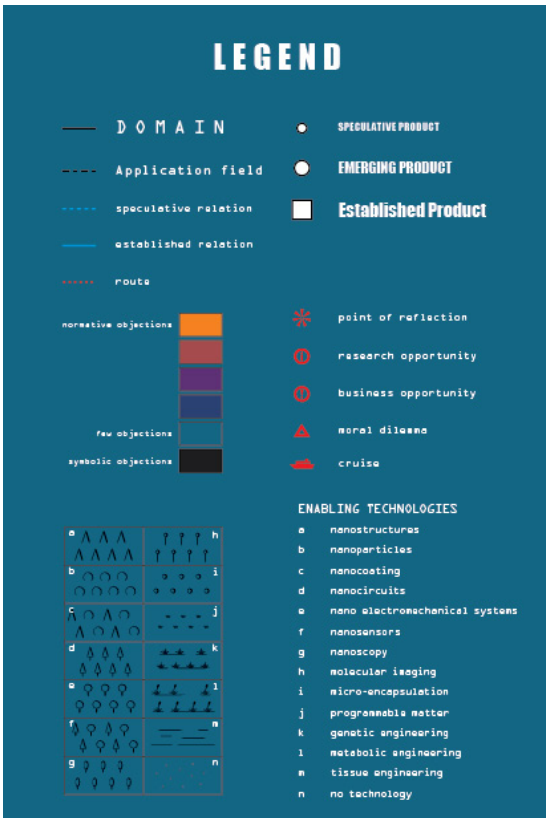

Figure 10: Nano World map legend

foundation for our interpretation of facts and with which we justify our virtues and values. The question is: on which normative criteria can we trust for the evaluation of consequences of the NBIC convergence?” (Swierstra, et al., 2009).

A bottom-up (or design thinking) approach mainly covers the factual uncertainty and leaves the normative and symbolic issues to the imagination of the viewer (or designer). But in order to generate an informed opinion about the technological developments it is important to communicate normative issues (ethical, legal, social). This doesn’t cover all issues that can pop up in a debate though. Therefore the symbolic uncertainty has to be addressed; this involves considerations that mainly occur unconsciously. It’s about topics that are thought to be undisputable (like nature, life, or fait). Fact is that also these symbolic issues change with new technological developments.

The information structure (Appendix I) of the Nano World map was developed according to this treble uncertainty. This resulted in the following elements that were used to map the nanotech products:

- Product title
- One sentence descriptions
- Feasibility
- Enabling technologies
- Application fields
- Domains
- Symbolic concepts
- Ethical, legal, and social issues (ELSI)
- Control vs. autonomy
- Born vs. man-made
- Routes

The term nanotechnology is merely a subset of different technologies that work on the level of molecules. The layer with ‘enabling technologies’ was implemented to provide a differentiated image of nanotechnology. A clear distinction between ‘products’ and ‘enabling technologies’ was important in the mapping to enable the evaluation of implications of a specific technology. It also shows that the term nanotechnology is fragmented.

‘Control vs. autonomy’ and ‘born vs. man-made’ were used as a quadrant to place the nanotech products. These two axes are part of the symbolic uncertainty and are fundamental categories that address almost every nanotech product. Born vs. man-made relates to our notion of biology and technology and shows how the two are merging. The axis scale ranges from ‘not originating from conscious human creation’ (born) to ‘originating from conscious human creation’ (man-made). Nanotechnology will also have a huge impact on the way we have and perceive control. On one hand products will provide total control over things we think now are totally autonomous. The question is: do we find full control desirable? On the other hand we will lose control and give full autonomy to things that we are now in total control of. The question is: do we trust the full autonomy of artifacts? So this axis will range from ‘gaining total control’ to ‘giving all control away’ or ‘allowing full autonomy’.

The back of the map provided the opportunity to give more detailed information about every single element that was depicted on the map. Every product was described through one sentence that communicated the particular nanotechnology behind the product and its purpose.

3.1.7 Evaluation

The initial plan was to publish 1000 copies of the Nano World map for the Nano supermarket, to be sold during the Dutch Design Week. But with the presentation of some early prototypes at the RI, their enthusiasm grew and made them order 4000 pieces (2000 for their magazine Flux, and 2000 as a business gift). The map is also available online at www.rathenau.nl/nanoworld. From a marketing perspective we can call this a success. But to which extend is it a good design for public debate? And does it fit a socio-technological approach?

In this paragraph the Nano World map is evaluated on two levels. The map should be seen as an exhibition in itself and can therefore be compared with the Nano supermarket. The products that were mapped are single designs for debate. These levels seemed equally important for the framework.

Public debate takes place at festivals, exhibitions, and other public events. The Nano World map addresses the public on a personal level. It brings the debate about nanotechnology to people at home. The cooperation with the RI resulted in a valuable contribution. It provided the socio-technological perspective that is important to shape the public debate. The map clearly prepares people for a debate about nanotechnology. The fact that it combines different timeframes and perspectives makes it a valuable product when evaluating it as an exhibition.

The Nano supermarket has the same quality and is a good example of the place where the debate takes place. Design is in this case the facilitator for a debate between experts and general public. An exhibition space is regarded to be the most suitable context for such design for debate (Kerridge, 2009). The use of exhibitions is much addressed within STS work. And the creation of public (Dewey, 1927) provides good guidance. The public of any event arises from the event's content and form of communication. A problem with the Nano supermarket was that the experts were missing, so not all elements were present to facilitate a full public debate. The designs and designers can shape and feed the debate, but aren't the right interlocutor.

The Nano World map clearly relates to TA and the RI. They also have a preparative role, with politicians as their main target group. A socio-technological perspective is advocated. For politicians such a perspective is crucial, but the public debate can't go without it as well, although the level of abstraction is different from a political debate. This is why the addressing of the factual, normative, and symbolic uncertainties is important. In public debate the factual and normative uncertainties are addressed on a superficial everyday level. But symbolic uncertainties play an important unconscious (emotional) role.

For a review on the DfD qualities of the Nano World map Nanometing.nl (Koppeschaar, et al., 2010) serves as a good reference. This was a good inspiration for topics and products on the map, but can also be used as a benchmark. It's a website that hosted a large public questionnaire on the desirability of nanotechnology. It had an interesting setup, with a good approach towards general public. Concrete everyday future scenarios were given that provided a clear image of the current technological developments and issues were addressed on an equal level. A critical perspective was well integrated with a progressive story about opportunities. The form of everyday scenarios clearly facilitated a story about the interaction between science and society. This relates to the design tactic of 'projection' (DiSalvo, 2009). Possible futures were presented in relation to a certain issue. There is no clear role for design; but the socio-technological scenarios do relate to design-thinking.

Nanometing continued with weekly topics after the publication of the Nano World map and only addressed facts that were on the map. This shows a good factual basis, but this factual perfection seems to come with a price. The Nano World map is superficial in comparison with the Nanometing. It is fact-centered and out of balance when it comes to the discussion of values. The story that is told by the Nano World map is too broad to get the right depth that is required for a good design for debate. It successfully serves an informative purpose, but is not strong in provoking a critical attitude and debate.

The Nano World relates to both 'projection' and 'tracing' tactic. The map itself is best related to the tactic of 'tracing', although "the network of histories, discourses, and techniques that shape and frame an issue over time" (DiSalvo, 2009) are only addressed briefly. The speculative nanotech products relate to the tactic of 'projection' and work well as a conversation starter. When questioning visitors of the Nano supermarket about issues, they came with interesting reactions. From the scenarios that the visitors imagined dilemmas emerged, that addressed the right socio-technological level for discussion.

Reactions from the RI were predominantly positive. The people that are related to the RI and received the map as a gift are mainly experts in technology or sociology. So as a design for technology experts the Nano World map is definitely successful. Its impact on laymen with a technology interest and shopping/DDW public is less clear. At the Nano supermarket the map was generally overlooked because it was not exhibited in line with the other products. But it did function as guidance for the Nano supermarket crew to tell the story about nanotechnology, and as a gift-product it worked quite well, because around 70 pieces were sold during the DDW.

3.2 Case: the new technology wave

3.2.1 Introduction

The story about the 'new technology wave' is in development at the RI. It communicates their view on the current technological developments and in which direction they are going (Walhout, et al., 2010). The use of the new technology wave is twofold. It serves as a framework for factual reflection on technology trends and scenarios and it urges for a normative reflective attitude on these developments.

The "new technology wave" (Nordmann, 2004) is a title that relates to the emergence of many new technologies where trends can be witnessed. These developments are mainly seen as a result of the NBIC convergence. The direction of this convergence goes two ways, both representing a macro-trend: "biology becoming technology" and "technology becoming biology" (Arthur, 2009). These engineering trends describe the dynamics of the new technology wave. Research fields and applications can be reviewed within the light of these macro-trends, so they serve as a framework for analysis.

The notion of biology and technology interfering with each other gives light to shifts in fundamental societal values (like living vs. non-living, human vs. machine or natural vs. synthetic). It urges for a reflection on implications for these fundamental concepts. But this type of reflection is generally missing when it comes to technological developments (Smits, 2002). We seem to adjust ourselves to new technologies without critical reflection. This can be seen as the silence before the storm (van Est, 2010). Everything seems totally quiet and peaceful, but the animals around you are acting stressed and start seeking for shelter. There are small subtle clues that hint to a devastating storm that is coming. We can prepare for this storm if we become sensitive for these omens. The new technology wave serves as a framework for such sensibility. Large issues are at stake, but the only way to address them and prepare for them is to look for the small clues.

3.2.2 Goal

The goal of this explorative design activity was to visualize the results of the first (preparatory) phase of the MPL project, which led to the notions of the 'new technology wave' and the megatrends: 'biology becoming technology' and 'technology becoming biology'. The visualizations were used in the slides of the introduction presentation (Appendix II) at the conference and were instrumental as graphical explorations of the 'new technological wave' during the development of the MPL monitoring report. The goal of the presentation was to introduce the RI's vision on the 'new technology wave'. And this vision served as guidance for the conference. It had to guide the conference public towards a socio-technological perspective on the discussed technological developments.

3.2.3 Context

The graphics were presented at the MPL conference at the European Parliament (see Figure 11). Conferences are mainly held for feeding and directing the debate. So the goal of the event was to feed the political debate, rather than facilitating it. The MPL introduction presentation was designed to stage this goal.

MPL is a long-term technology assessment project by the Science and Technology Options Assessment group (STOA) of the European Parliament, and "continues the intellectual search for the social meaning of NBIC convergence". The RI has a leading role in this project and several other European institutes are involved. On November 10 2010 a conference was organized, by the RI and STOA, in the European Parliament, to finalize the second phase of the project: "this phase elaborates on the horizon scan and preliminary research that was done during the first phase". The public of this conference consisted of members of the European parliament, as well as scientists, sociology experts and other policy makers.

Summary of the Making Perfect Life report and conference

Figure 11: Overview of the conference in Brussels (photo by Dann Cortier)

The Making Perfect Life project provides a broad trans-technological overview of the new technology wave and its issues in four bio-engineering fields: engineering the body, engineering the brain, engineering living artifacts and engineering intelligent artifacts. The NBIC convergence is thought to be essential for a successful development of these engineering areas. The fields promise a new technology wave with a large amount of opportunities for new interventions and artifacts. Will this technology wave come true? And what will be its societal impact?

The two mega-trends ('biology becoming technology' and 'technology becoming biology') provide a good way of looking at it. In terms of science dynamics a merging of the physical sciences and life sciences becomes visible. Current engineering activities work on the border between living and nonliving material; natural and superficial artifacts; and humans and machines. These new types of engineering broaden the social debate. The trend of biology becoming technology shows new opportunities for interventions, like electrodes in the brain and continuous monitoring of diseases. Technology becoming biology can result in totally new types of artifacts. It will become possible to create organisms from chemical processes, and products can become intelligent and autonomous. Are these new interventions and artifacts desirable? To which extend does this shift fundamental concepts? And what is the consequence for regulatory practices? (van Est, et al., 2010)

At the conference, the roundtable session about 'biology becoming technology' was of very different character than the roundtable session about 'technology becoming biology'. The latter was much more understandable and the developments that were discussed seemed less threatening. In the 'biology becoming technology' session they spoke of "an extraordinary revolution" as opposed to "good technology education for children" in the 'technology becoming biology' session. This difference was mainly the result of the selection of speakers in these roundtable sessions. But it clearly illustrated a difference between the two mega-trends of revolution versus evolution.

A more threatening story from the 'technology becoming biology' side came from the EU funded projects that were presented. In the project ETHICBOTS the unmanned combat aerial vehicles were ethically assessed. This showed a shift in responsibility from the soldier to a robot, and a lowering threshold to start a war with robots. In the project FACETS about the hardware simulation of the brain a quote was "it runs 10^4 times faster than biology" and a slide title was "Vision – BrainScales and beyond". This relates to the attitude towards biology and technology of Kevin Warwick as described in the introduction.

3.2.4 User

The presentation was targeted towards the experts and politicians that were present at the conference in Brussels. At this conference there were not only technology experts but also sociology experts. The technology experts can be addressed the same way as it was explained for the Nano World map. But the sociology experts are mainly interested in the perspective of symbolic uncertainties. They approach, what can be seen as, the emotional reaction on technological developments in a rational way. As explained for the Nano World map symbolic uncertainty shapes the debate mainly unconsciously, because it addresses fundamental concepts that we assume to be static (like our perception of the human body, animals, machines, and death). But these concepts are pressurized by new technologies, and this is what sociologists are mainly interested in.

Politicians (Appendix VI) are initially interested in the normative uncertainties that arise from technological developments, because these uncertainties are concrete enough for policy-making. Issues like safety and privacy can be directly affected by technologies. And politicians can respond to these effects by the implementation of rules and laws. But this normative perspective is fed and led by the current social- and technological trends, which can be described through factual- and symbolic uncertainties.

With respect to the contribution of design to the MPL project the RI can be reviewed as a client with its employees as users. The RI investigates the symbolic and factual uncertainties and transforms them into normative issues that can be governed. The graphic design process served this goal (and therefore the RI employees) with a visual approach in the investigation- and presentation phase. The graphics worked as an internal and external communication tool besides the textual modality that the RI employees are used to. Its main use was in providing overview and assisting in shaping the introduction and conclusion of the MPL interim report. The graphics served as a framework to interpret and communicate the current technological developments and its accompanying issues (dilemmas). From the RI employee perspective the eventual graphics functioned as a visual presentation template.

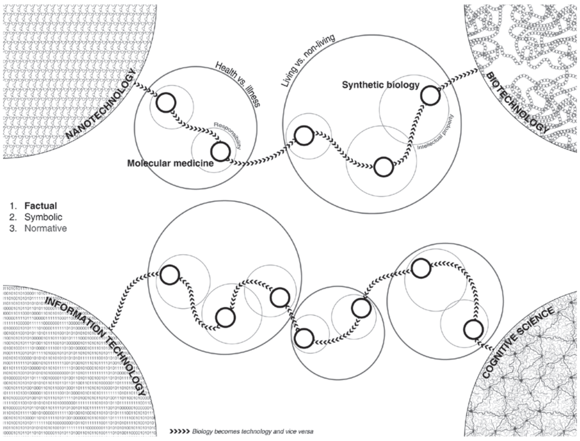

Figure 12: An NBIC playground with the levels of uncertainty

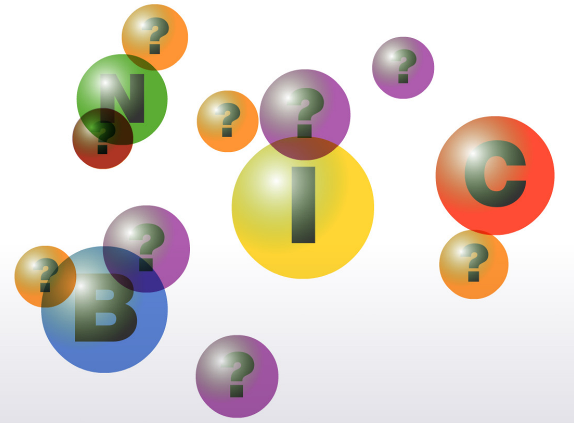

Figure 13: A playful representation of the NBIC convergence

Figure 14: Shifting iconic representations

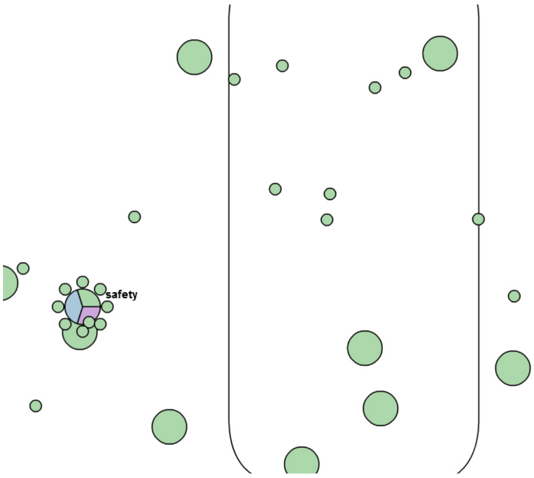

Figure 15: Interactive try-out with research fields and its issues

3.2.5 An information-graphic design process

During the design process it became evident that a clear distinction between technological trends and societal trends was sufficient to set the agenda for the new technology wave. Making use of the dimensions: factual, normative, and symbolic; didn't work because it doubled the complexity. The levels of information that were introduced in the story ranged from macro-trends to concrete applications (the micro level). Making a relation between technology and society (the meso-level) was leading. Furthermore the relations between different levels of information had to be clear.

In the first ideation phase a cartographic representation of the MPL story was explored. It became clear that the distinction between technological and societal developments were problematic for a cartographic implementation due to the increase of dimensions. The story was simply too broad for cartography, so a variety of mappings would have to be implemented to cover the whole story. In the cartographic design for the Nano supermarket the technological and societal developments merged, whereas the MPL visualization couldn't go without a clear distinction.

Ideas for an 'NBIC playground' (see Figure 12) and storylines were explored through interactive try-outs. One of the ideas was to separate NBIC into its four key-technologies and show the synergy by enabling the user to make the key-technologies overlap which resulted in a new research field (see Figure 13). An interactive storyline was explored on the factual level, where specific iconic representations distort into another iconic representation (see Figure 14). This shift from one icon to the other communicated an engineering trend on a concrete level. Using scaling for the communication of information layers was implemented through extreme zooming, where the Eames movie 'Powers of ten' served as inspiration. It became not only clearer which graphics worked best, but also how to structure the story. The implementation of scaling seemed useful for all goals. Using the metaphor of a playground was also interesting, but was not appropriate for the MPL project.

In a second phase of idea generation an interactive graphic was developed where research fields and ethical, legal, and social issues (ELSI) were presented on the same visual level (see Figure 15). This included the implementation of more concrete content to get a better understanding of the different scales and categories that make the eventual information structure. The research fields served as the basis for the story about MPL and the different issues that came with it were dynamic to show that the same issues can be seen in different research areas. This setup didn't suit the bigger picture though. The engineering trends and societal trends were represented statically,

although they are dynamic. So the dynamics of a trend were important to implement.
To achieve this, three directions were explored in a third phase of idea generation: represent the trends as poles (see Figure 16), integrate the factor of time (see Figure 18), and map the research fields in terms of control (see Figure 19). Using the trends as poles didn't work. The poles had to be defined as the trend's source and direction, in this case biology and technology (see Figure 17). By indicating the direction of a particular research field the trend could be communicated. Another observation was that mapping research fields in terms of control urges for a more practical level of description. So 'neuromodulation' had to become 'conscious brains' and 'in-vitro neuroengineering' had to be described as 'cultured neural networks'. In this way the notion of control and autonomy could be understood. Adding time to the visualization gave perspective to the trends themselves. 'Biology becoming technology' had a much earlier origin than 'technology becoming biology' for example. This didn't relate to the story of MPL though and adding this dimension would make the visualization more complex.

In this idea generation cycle two levels of science and society popped-up and interconnections became visible. This suggested opportunities for communicating the dynamics between the technology trends and societal trends. So these dynamics were explored in a following step (see Figure 20). For a more concrete tangible implementation of the story and to create a clearer image icons were used (see Figure 21). But the use of technology and biology as poles was selected for the MPL graphic to represent the new technology wave. It addressed the dynamic of the mega-trends within the NBIC convergence well and provided good opportunities for integrating current research and applications.

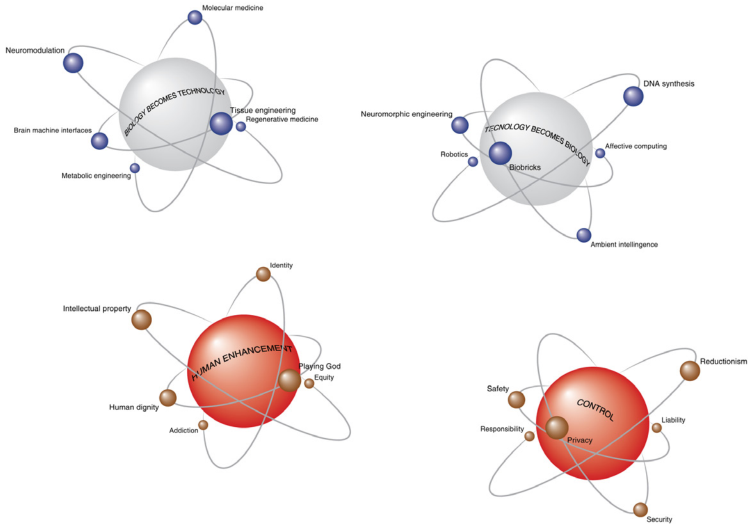

Figure 16: Representing the trends as poles

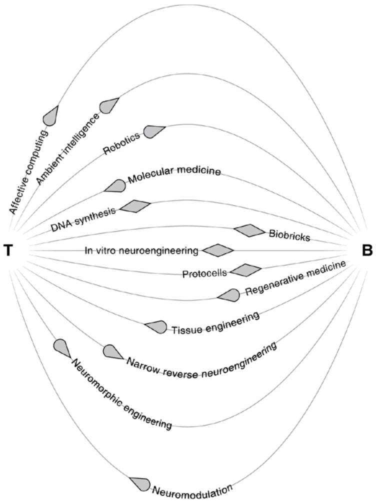

Figure 17: Representing biology and technology as poles

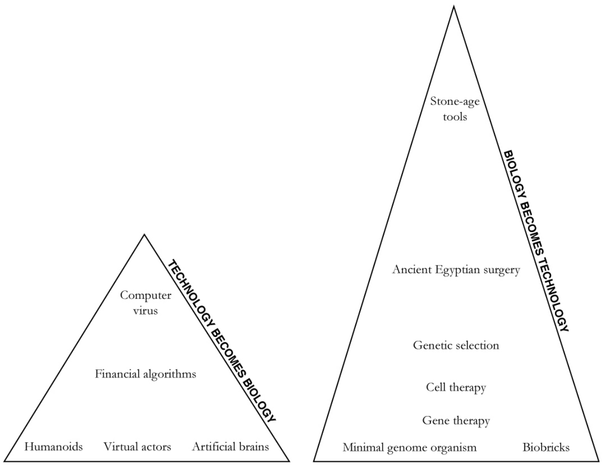

Figure 18: The integration of time as a factor in the representation of trends

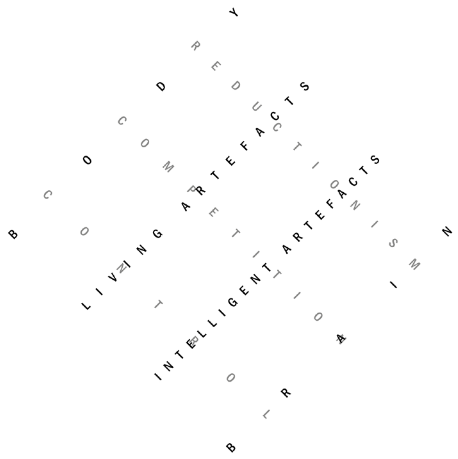

Figure 20: Representing the mutual interplay between technological and societal trends

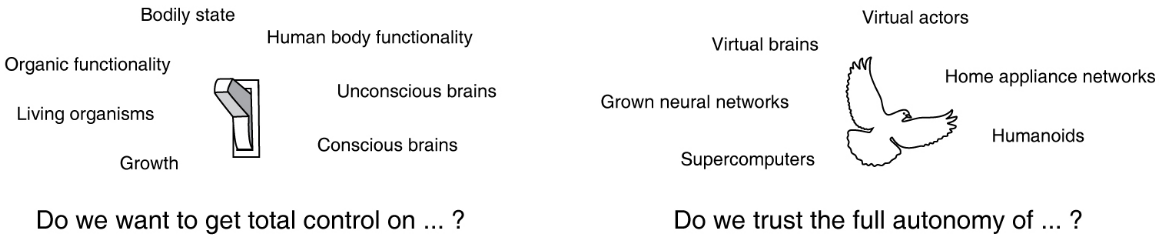

Figure 19: Visualizing the trends in terms of 'control'

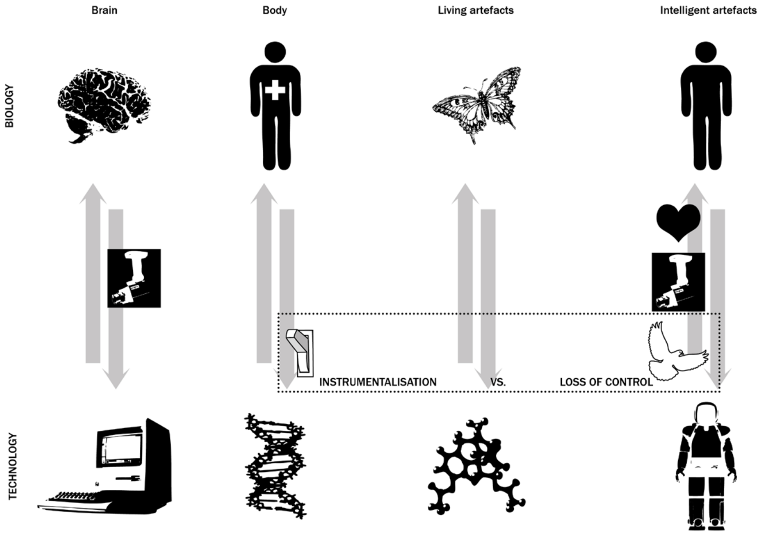

Figure 21: An exploration on an iconic representation of the 'new technology wave'

3.2.6 Design

In dialogue with Rinie van Est (the speaker for the introduction presentation) the graphic presentation template (Appendix II) was detailed. A graphic representation of the NBIC convergence was designed that enabled the separation into the four key-technologies. These key-technologies were depicted by their related fundamental elements: bits, atoms, neurons, and genes (see Figure 22). This NBIC convergence graphic served as the starting point for the story and visually depicted the poles 'technology' and 'biology'. From these poles many technological developments emerge and are drawn towards the opposite pole. These developments formed the evidence for the megatrends, so visually they also form a coherent structure into a particular direction. The coloring was used to communicate the four engineering fields that were explored (see Figure 23).

The social debate part of the story was also visualized with the two poles of 'technology' and 'biology' (see Figure 24). The dynamics in the societal trends are related to the technology trends and originate from the NBIC convergence. So the overall shape of the debated topics was the same as the structure that was formed by the technological developments. The debate is not fragmented; it shows an accumulation of disputed paradigms. For 'biology becoming technology' this was about the new areas where interventions can take place, starting with micro-organisms and broadening towards the human body and the brain. For 'technology becoming biology' the whole debate is new and is about new artifacts, which are bio-, socio-, and cogno-inspired.

An alternative version of the poles-graphic was created to show the final most extreme possible end-result of the engineering trends, where biology has become technology and vice versa. From this extreme situation the implausible and fearful scenarios arise about 'singularity' and extreme 'human enhancement'.

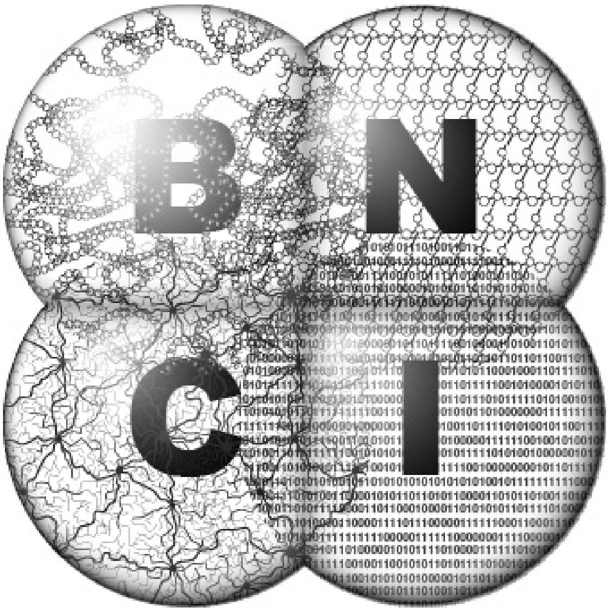

Figure 22: The visual representation of the NBIC-convergence

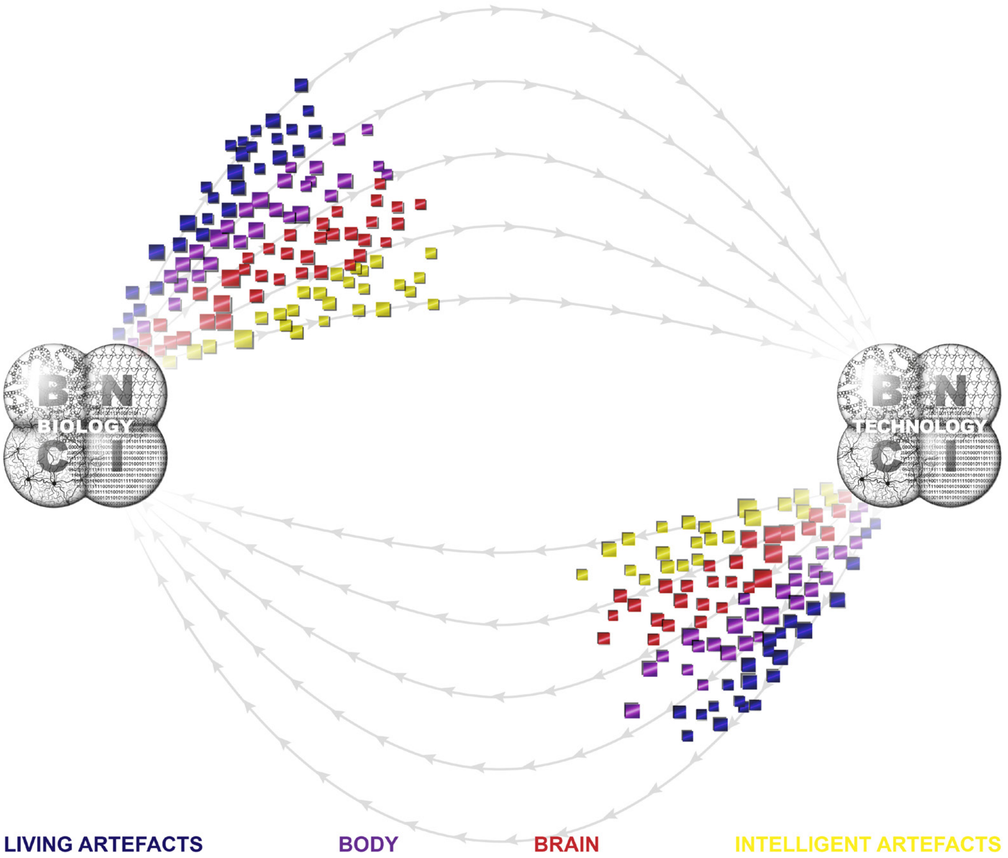

Figure 23: The visual representation of the ‘new technology wave’

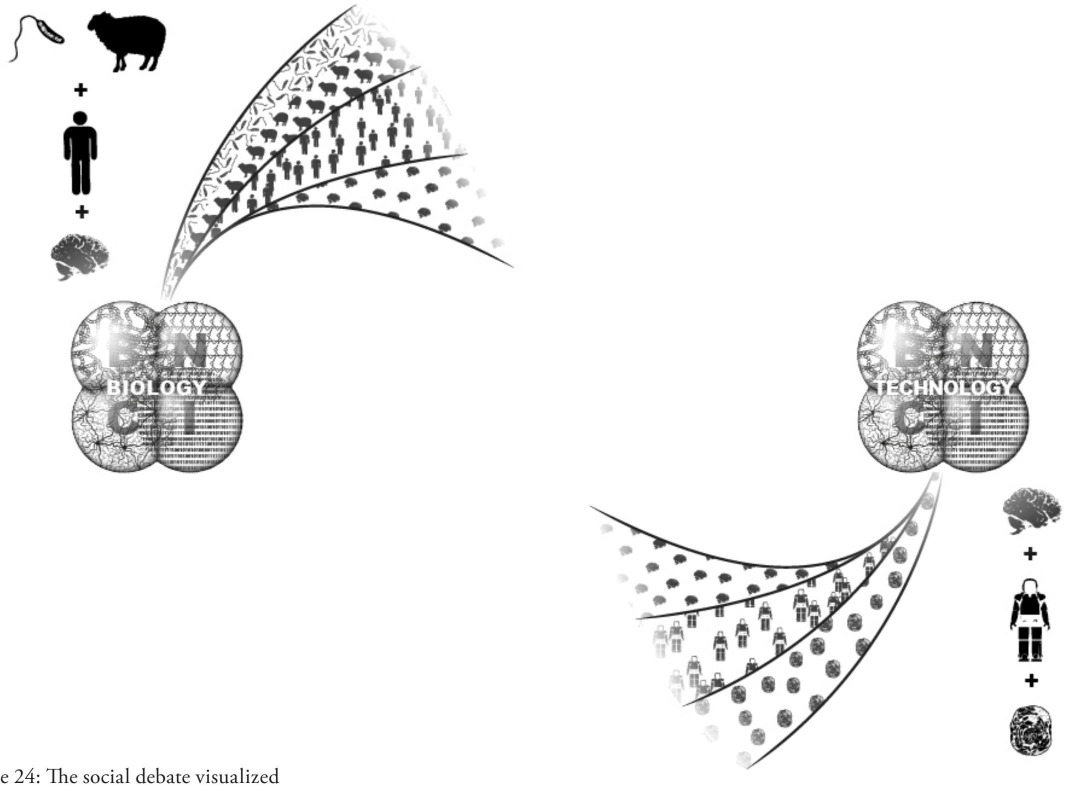

Figure 24: The social debate visualized

Vacuum cleaner cat

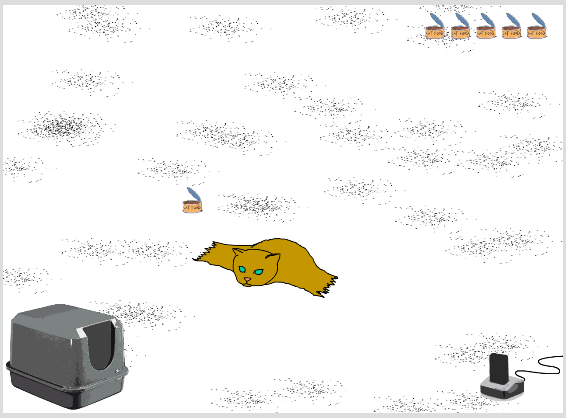
Figure 25: An interactive virtual vacuum cleaner cat suitable for online implementation

Today, autonomous vacuum clean robots are on the market. Healthcare robots are in development for elderly healthcare. Robot pets for elderly are also on the market these days. The combination between emotive and functional properties isn't available yet. But why shouldn't healthcare robots in elderly homes also provide social care through their being?

The vacuum clean cat (VCC) is an animal-machine that is designed and built by bio-engineers. They were inspired by a "natural" cat and rebuilt it with vacuum clean functionality. The VCC walks around through the house and continuously vacuums the floor. The internal biological structure of the VCC enables suction as a result from its movement. The dust capacity is limited, but by making use of a "natural" cat's spewing reflex the VCC can empty itself at a particular place. It has to be trained to spew the dust at the right place.

The VCC's brain is also inspired from a 'natural' cat. But it's modified; resulting in behavior that makes the cat go everywhere in the house to clean all floors. Once in a while an upgrade is available, which improves, for example, the learning curve of the cat or its efficiency in cleaning the total house. The cat can also be trained to clean several places in a house more than others, like for example the hall as opposed to the floor under the couch. The VCC can also be directly controlled by grabbing it at the neck and placing it at a certain area.

The VCC is fueled by regular cat food. It needs food and water on the same regular basis as a "natural" cat, although it is programmed to be much more active. Compared to a "natural" cat (12-15 years) a VCC has a higher life expectancy (20-25 years). This lifespan can only be achieved through significant care by the owner.

3.2.7 Integration with design for debate

The 'new technology wave' is not only an intellectual story for experts and politicians. The sensibility that it urges for is also meant for general public. This sensibility can be created by showing the newest technological developments and placing them in an everyday context to raise questions. Design for debate is instrumental in this. So the goal was to come up with a DfD for the 'new technology wave'. The resulting scenario had to be founded by a good understanding of the current technological developments, as the tactic of 'projection' prescribes, and clearly communicate issues that arise. The applications that were involved in the scenarios had to be particularly designed for debate and provoke discussion.

The graphic from MPL was made interactive to make it suitable for public display. Initially the goal was to do another full design cycle to achieve an interactive graphic for a technology festival, but this wasn't feasible within the timeframe of the project. The concept of an interactive graphic was still used to explore the possibilities of making the graphics from MPL accessible for public, like the visitors of a technology festival. As explained before, such event attracts a specific public. It can be expected that a technology festival that is organized by the RI attracts technology experts, sociology experts, politicians, and other public that is interested in technological developments. These user groups are all described in previous paragraphs. To communicate the story of the 'new technology wave' to them, the trends perspective from the MPL project was combined with a DfD case. With the purpose of making people sensible for the small signs about shifting normative and symbolic values.

The interactive DfD scenario is like a 'serious game'. The user can operate the speculative application and get a feel for issues that arise from this kind of applications through interaction. Both factual and normative/symbolic input was used for brainstorming on provocative DfD ideas. The case that was worked out for this project was a 'vacuum cleaner cat'. This concept originated from the MPL interim report, which provided good technological foundation and insight in new normative and symbolic issues.

The vacuum cleaner cat is the result of advanced bio-engineering, where the biological model of a cat was used to design a vacuum cleaner made of 'natural' cat components. This raises questions on the fundamental concepts 'animal' and 'machine'. It also relates to the issue of emotional bonding, i.e. the fact that people can become emotionally attached to technological applications especially when a living creature is simulated. These issues can be experienced by operating the vacuum cleaner cat by, for example, making the user choose between cat food and a recharger (see Figure 25).

On a factual and symbolic level the uncertainty is high, it's not to be said when such animal machine can hit the market and what an animal machine will do with our perception on the concept of animals and machines. But the normative aspects are familiar, because we're used

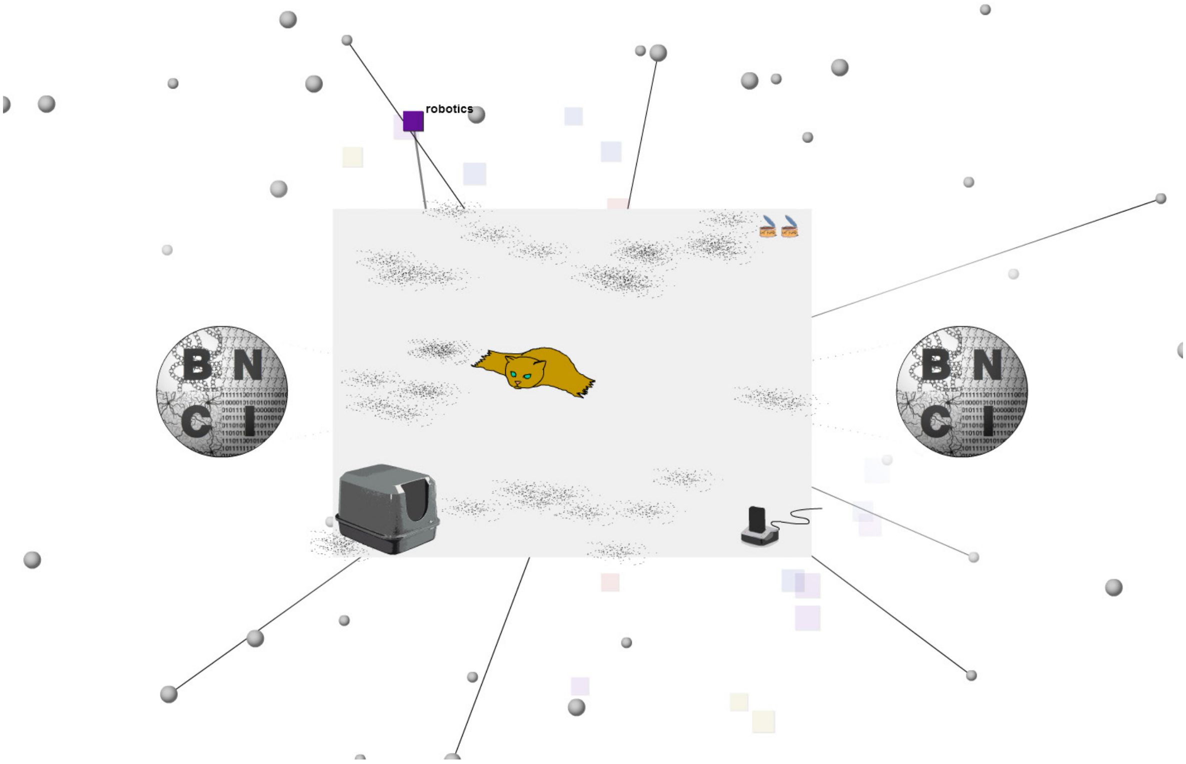

Figure 26: The vacuum cleaner cat embedded in the interactive MPL graphic

to domesticated cats and autonomous vacuum cleaner robots. This normative familiarity is one of the reasons for its urgency, but to make a political impact the factual uncertainty has to be grounded. So it had to be made clear from which current technological developments this kind of application can emerge. In the case of the vacuum cleaner cat the background lies in two technological developments: robotics and standard bio-parts. The field of robotics is most likely the starting-point for the combination of pets and home appliances. The promises from far future projections of biotechnology create the possibility of shifting from non-living material to living material.

With this DfD the challenge was to integrate it in the MPL graphic (see Figure 26). It became clear that the clearest relation between the vacuum cleaner cat and MPL graphic was on the scenario (pet as home appliance) and application field (living artifacts) level (see Figure 27). They are directly founded by technological developments and provide concrete starting-points for the investigation of issues. Although the technological developments are the basis for both TA and DfD it was chosen to make the connection with the MPL graphic explicit through the normative and symbolic issues. This was done to clearly identify the role of DfD as a value-centered approach.

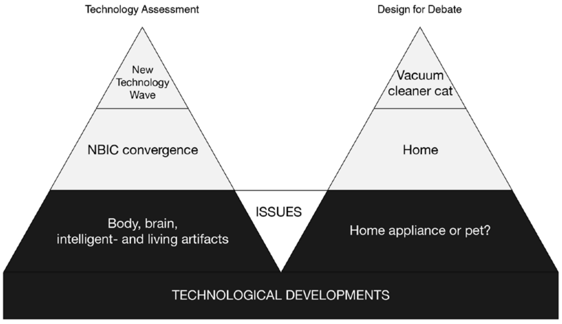

Figure 27: Information levels of Making Perfect Life and the vacuum cleaner cat

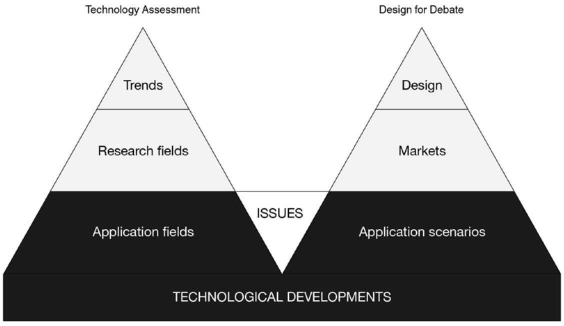

Figure 28: Information levels of TA and DfD in general

3.2.8 Evaluation

The explorative design activities with the ‘new technology wave’ clearly addressed the dynamic multi-level perspective of transitions as described in the introduction of this report. The graphic explorations on MPL were on the macro level and related to the tactic of ‘tracing’, because it provides an image of the history, discourses, and techniques that constitute issues. The trends were a tool for the RI to look at the current developments and were transformed into a graphic design. The added value of design in this case was the transformation of trends to a tangible form without losing its abstract qualities. With a language-based approach this is not possible, because the only way to make trends more concrete is through exemplification which also results in simplification.

The NBIC convergence was not new and graphic models were already available for this phenomenon. But the ‘new technology wave’ was not yet visually addressed. The challenge was to visualize the dynamics (‘biology becoming technology’ and ‘technology becoming biology’) that make an impact on society. The design process assisted in drawing conclusions for the MPL report and resulted in a visual overview of the ‘new technology wave’. The graphic conceptualization of the ‘new technology wave’ is important because it enables a more concrete discussion about the abstract concept.

Rather than reviewing the graphic design process opposed to TA practice, the interest is to find a synergy. There lie great opportunities in integrating the rational and precise character of TA with the emotional and rich character of DfD. Many techniques and methods used in TA can greatly improve the quality of a DfD. TA provides structure to the debate and can therefore be used to actively steer it. A DfD designer is to a certain extend the director of the debate, and TA methods can increase his or her control.

Design approaches on the other hand can improve TA by bringing it to a more practical level. Debates are generally performed on a rational basis, and DfD adds emotions to it. It increases the communication of the emotional relation with technologies and is a good way to address sociocultural values. This can significantly reduce the intellectual distance from the target group, so that less effort has to be put in the transformation process towards presentable content.

During the graphic design process of MPL a synergy between TA and DfD became clearly apparent with the graphic template for the introduction presentation as a result. But with the merging of practices there are also qualities that get lost. There was for example less focus on the public. In design practice user focus is an important quality, but with the conceptualization of the 'new technology wave' there was not much eye for the user. Fact is that this kind of abstraction level doesn't provide a clear intuitive message, so there is also a limit in intuitive communication possibilities. The story about the 'new technology wave' asks for much intellectual interpretation. But this seemed acceptable for the public of the conference.

This explains why besides "your graphics look very nice" there weren't many direct reactions on the use of the information graphics in the presentation. Some speakers referred to the technology trends in terms of the graphics, like: "the bottom trend flowing from technology to biology is new to me" and "is convergence the right term? There is no central point where the sciences are going". But the conference itself provided a lot of insight: in the way the RI approaches technology, the network of people that deals with these topics, and a better understanding of the 'new technology wave' and its purpose in TA.

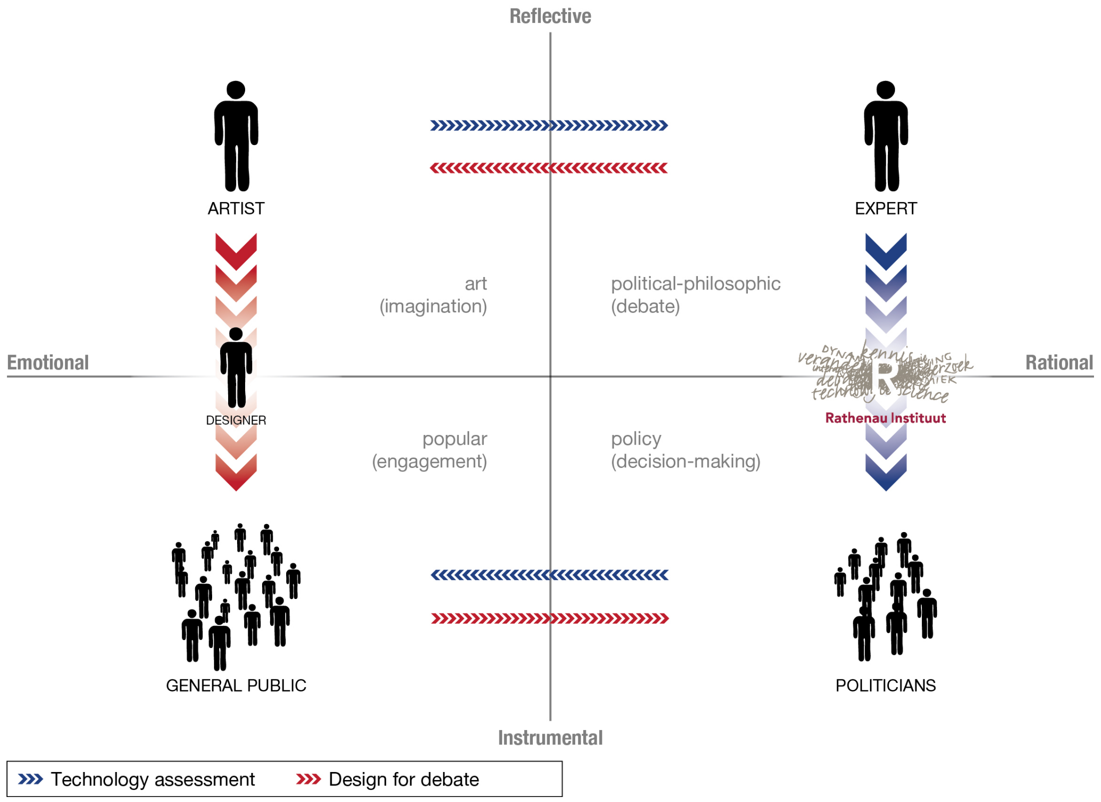

Figure 29: TA, DfD and the stakeholders in the debate mapped in the four societal discourses

3.3 Conclusion

The above described explorative design activities gave much insight in TA, DfD, and how to combine them. It became clear that TA and DfD share the same goal: bringing new socio-technological developments under attention and raising questions about them. But their target groups and methods are clearly different. As explained in paragraph 2.1 TA is rich of methods and DfD rich of practice. The evaluation of the different cases showed a difference in depth. This can be ascribed to the fact that the Nano World map was about the integration of TA in design and the 'new technology wave' graphics was about integrating design in TA. For the Nano World map more depth was added; resulting in a deeper evaluation. The integration of design in the TA process around the 'new technology wave' had a broadening (enriching) effect; resulting in a broad evaluation.

From the Nano World map it became clear that a design for debate should address the factual, normative, and symbolic uncertainty with an everyday life perspective to communicate new technological developments from a socio-technological point of view. The MPL project showed how technological developments can be reviewed from a trends perspective and that both micro- and macro-level serve as input to tell a story about the socio-technological meso-level.

The main value of creating such stories is in stimulating rather than facilitating the debate. The Nano World map (and Nano supermarket) shows that nanotechnology is not just a development in material science, and stimulates people to look at it in a broader perspective. The MPL graphic is a visual conceptualization of the 'new technology wave' that stimulates people to look at the subtle clues of big changes in society. Both Nano World map and MPL graphic provide a way of looking at current technological developments. They're best used for bringing certain issues under attention (creating publics) and structuring a debate. Even the MPL conference (although all necessary actors for a debate were present) had a stimulating purpose rather than a facilitating one. A structure was presented for guidance towards a fruitful debate about mega-trends like: 'biology becoming technology' and 'technology becoming biology'.

The ultimate goal is to convince people of their impact on the developments in technology and become empowered through a socio-technological perspective. It is impossible to fully overcome technological determinism, but informing and empowering public with a critical attitude towards new technologies seems to be a feasible goal. A good example was given by Inez de Beaufort at the MPL conference. She recalled her son asking her to reset his Tamagotchi back to life again, which she refused to safeguard the concept of death.

The belief in a techno-society has not deeply rooted yet, so currently informing public is the main activity. Within this project the role of design towards public is also about conveying a message, but the information is provided within a certain structure that might have a slight empowering effect. The project does clearly empower mediators of the socio-technological message: the RI and designers. The explorative design activities that were described in this chapter are mainly interesting for the RI. The following chapter is targeted towards designers.

Design for debate framework

4.1 Goal

DfD is performed for an impact on the public opinion and on experts. The current practice is not structured enough to effectively communicate to politicians, although politics is an important factor regarding the impact on the social implications of new technologies. This framework provides a toolset that enables designers to enhance the political impact of a DfD. The tools assist in the design process to cover crucial aspects necessary for a political debate.

The political debate is of rational character; intended for decision- and policy-making. Proper argumentation on social and technological level is therefore important. The debate takes place at many different places, so it is not possible to specify one particular context. It takes place where the politicians are, so to stimulate and steer the political debate politicians need to be addressed through invitation, or by organizing events at known political environments like a parliament or a congress.

DfD as we know it has clear communicative qualities and it is important to not undermine them. Its core target group should not shift towards politicians; the user should still be defined through classic design methodology. This works best for addressing values and relating to emotions that people have. Although politicians need a rational approach for decision making, they behave according to their values and emotions.

4.2 User

This framework will be used by designers, but the target group to reach consists of politicians. From literature on DfD and a DfD workshop with design students it became clear that we can divide designers in two groups: fact-centered, and value-centered. In literature Dunne & Raby can be regarded as value-centered designers, whereas Kerridge represents the fact-centered group. In the DfD workshop this distinction became apparent by the different kind of scenarios that every individual student came up with. As a starting point they all received a new technology and an issue (Appendix IV) with the assignment to develop a negative and positive application scenario. Half of the students created a scenario around the opportunities of the technology whereas the other half focused on the issue (Appendix V).

It seems that value-centered designers respond to new technologies from an emotional perspective. They can be described as artist-designers. Fact-centered designers have a rational attitude towards design for debate and can be seen as “classical” industrial designers. In DfD they are more concerned with the communication towards experts. DfD with a political attitude should be value-centered though, so this framework is mainly intended for artist-designers.

Having a good image of politicians is important for the framework. There are different kinds of politicians like: leftwing or rightwing, conservative or progressive, and liberal or social. In TA the parliamentarians with expertise in technology are generally reached. Some TA topics relate more to the societal impact of technology, which appeals most to the leftwing socialist, whereas the legal or economical impact receives more interest from rightwing liberals. In TA the term ELSI (ethical, legal, social issues) relates to both. But the specific user of a DfD should never be a politician. It is the story behind the DfD that can be appealing to them.

4.3 Content

4.3.1 Design for debate guidelines

The previously described explorative design activities and literature provided insight in integrating TA practice in a design for debate process. They gave rise to a set of requirements that are important to suit a political environment, without losing important qualities of DfD:

- Interact with experts
- Define the public
- Address feasibility and desirability equally
- Specify why a politician should care
- Place it in timeframes
- Relate to macro-trends
- Address an everyday topic
- Set a stage
- Never present one

Interact with experts

New technological developments are the most important source of inspiration. When technologies are in development the experts are responsible for the course of developments. It is vital to be aware of the fact that there are people behind these new technologies. Talking to them is most inspiring and provides the best insight in a technology. But to get the best out of experts it is important to exchange information. What DfD can give experts is a tangible tool for reflection on their own work. Debatable scenarios can be used to create internal reflection for the responsible experts or scientists. This relates to the design for debate process described by Kerridge (Kerridge, 2009).

Define the public

"Indirect, extensive, enduring and serious consequences of conjoint and interacting behavior call a public into existence having a common interest in controlling these consequences" (Dewey, 1927). So the public in a public debate emerges from the issues that are addressed. In this sense there are two ways of defining the public for a design or exhibition. This can be done directly by defining a user and addressing the issues that appeal to this specific target group, i.e. a classical design approach. This works best when the feasibility of a technology is high. An indirect approach is to let emerge the issues from the interaction between designers and experts in the ideation process and define afterwards which target group will be interested. This is a good approach if feasible applications of a technology lie in the far future. With such a reversed approach a communication strategy is of increased importance because the public is not yet "called into existence".

Address feasibility and desirability equally

It is not enough to have a proper factual foundation for a DfD. A deep understanding of current technological developments is important, but eventually it is about the critical reflection and raising questions. So when doing research on the facts it is important to keep track of the related virtues and values. This is crucial for addressing politicians, and also useful for shaping the public debate. Dividing the related virtues and values into normative and symbolic ones broadens the debate, and makes sure to address both rational and emotional socio-cultural issues. Only one of these uncertainty levels may be high to keep a convincing story. So if the feasibility is low, the desirability of such a product has to be high.

Design for debate workshop

Figure 30: Image of the design for debate workshop with design students

To get a better understanding of the DfD process two workshops were organized. One workshop was done with design students, the other with employees of the RI. These groups clearly had a different background. The design students were not familiar with the current technological developments and are not trained to review these developments in political terms. The workshop with the Rathenau employees can be seen as an investigation on design for debate within a political environment. They are trained in addressing the new technological developments in ethical and political terms. But the design-perspective was new to them and they are not technology experts.

The structure of the workshop (Appendix III) was inspired by the card-sorting method. This is a generative technique mainly used for information architecture design. It is a content-driven approach. "Card sorting can be used to develop the information and navigational architecture for an application and to examine how different groups view the same subject matter" (Killam, et al., 2009). Two groups of cards were given: state-of-the-art technology descriptions, and issues. The information that was presented on the cards (Appendix IV) was derived from the Making Perfect Life interim report (van Est, et al., 2010). The set of cards that described the technological developments consisted of all enabling technologies that were mentioned in the report. To communicate the current state of a technology a timeframe was given with three elements: now, close future, and distant future. The set of cards with issues covered the most urgent issues. Every issue was communicated through three questions that referred to the impact of a speculative application.

The participants received a technology card and were asked to select a card from the issues set. They had to write down the reason behind their selection. The first brainstorm assignment was to come up with a storyboard with positive implications on the issue of the given technology. It was important to think of a certain user in a specific context. The next assignment was to reverse the positive storyboard and think of negative implications for the same user and context. As a final brainstorm activity the participants now had to come up with an everyday product that was related to the storyboards. This resulted in a dilemma regarding a certain technological development which was directed by the selected issue and embodied by an everyday application. Every participant presented his or her application and storyboards which were subject in a discussion.

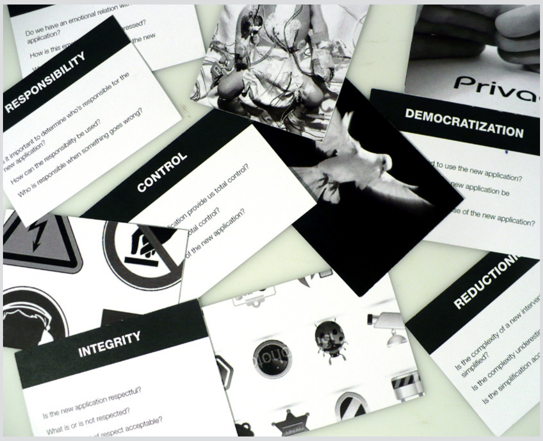

Figure 31: The cards that were used as input for a brainstorm

In TA the feasibility always serves as the basis for research on the impact of technology. But for DfD the starting point can be a technological development (factual) or a certain socio-cultural issue (normative or symbolic). The selection for a factual starting point is most useful for initiating the debate, whereas starting from a normative or symbolic point of view works for guiding the debate.

Specify why a politician should care

DfD is about making uncertain topics tangible. It is important to specify why this effort was made. The first step is to use the terms that are relevant for politicians. What can be governed? The next step is to specify what's urgent. A certain new technology can provide a wide range of uncertainties. To make a design for debate communicate well it is important to select the most urgent issues and dilemmas. This selection depends on the goal of the design. In what stage is the current debate? Where should it be directed to? Finally it is important to explain what's new. Questions to answer are: what is familiar and has been dealt with before? And what is truly new about the technology? This should be clear for the factual, normative, and symbolic level.

Place it in timeframes (now, near future, far future)

A projection in a specific timeframe is useful to communicate what's new. First of all it's important to know the current state of a technological development. This serves as the starting point for investigating the developments. But of main interest are projections on the future, because the current state is a fact and can't be changed anymore. Projections of the near future are of most interest for politicians because they can be directly addressed through regulation. Although projections of the far future carry much more uncertainty, it is useful for DfD in a political environment because it urges for extremes and therefore strong communication of issues and dilemmas.

Relate to macro-trends

The storyline between the different timeframes should be coherent. It is tempting to limit the research only to exciting new technological developments because they provide the most inspiration for provocative DfD concepts. But it is important to be aware of the different abstraction levels that a DfD relates to. A DfD should relate to current macro-, meso-, and micro-trends. These different perspectives assist in making the different timeframes convincingly related.

Address an everyday topic

To appeal to general public a design for debate should address everyday topics that many people can relate to. It is already complex enough to inform people about new technological developments and their social implications. An uncommon scenario distracts from the socio-technological issues.

Set a stage

Politicians are difficult to address in existing political contexts. So the best way to get in touch with them is by setting a political stage. This can be done by inviting them for an exhibition or conference, or by situating the DfD in a known political environment. Both tactics require proper advertisement where the relevancy for a political opinion is expressed through the newness and urgency of the DfD. Be aware of the fact that that the chosen stage appeals to a particular group and that the stage for a debate is mainly created from its present actors. So the availability of all related actors is desirable. Ideally, experts, politicians, public, and artists (or designers) should be present to cover all discourses (see Figure 29).

Never present one

When addressing a new technology that is not on the market yet; one single future projection of a new technology is not interesting for politicians. They have to be able to compare and choose different possible futures. The higher the uncertainty the more options arise. "The assumption that technology development will lead automatically to a better quality of life has been proven to be a naïve one, or maybe phrased in a better way, a one-sided one" (van Est, 2008). So it is important to always communicate positive and negative future applications. Using an exhibition is good for "Gedankenausstellungen" (Latour, 2005) where the same topic is communicated in different ways, enabling the public to choose what appeals to them most.

A design for debate process scenario

Imagine you're an artist-designer (Appendix VI) and contracted to design a critical contribution to a political congress about new applications with stem cell technology. Or a synthetic biology company asks you to design a speculative product that conveys politicians to rise the funding for genetic synthesis research. Or you're just asked to design provocative graphics for a political report about new applications with robotic technology. In all cases this toolbox can help you in developing and communicating your design in a way that appeals to politicians.

You will start with getting a feel for the current state of the technology. You need to know what is currently possible. Are there already applications available on the market? What is the current research about? And what kind of applications can emerge from this research? The most efficient way to get this information is by talking to experts. You want to talk to more than one expert about the new technology, especially regarding future projections, but the current state of a technology is also an important topic.

To get the right political attitude the next step is to explore the issues that come with the new technology. The best way to do this is by imagining applications within a certain context. Where can the new technology make an impact? It is in this phase also important to get a clear picture of your target group. Your ideas should relate to their personal everyday context. From such imaginary implementations issues arise. You can use quick prototypes as communication tool with experts because they are interested in this kind of projections. And such interaction with experts results in a deeper understanding for your project.

For both issues and facts it is important to place them in a timeframe and define how certain they are. You have to look at the desirability of the implementation of the technology but also at the fundamental concepts that underlie these desires. In some cases an idea seems completely desirable, but changes our perception of certain fundamental things like: death, illness, the human body or family. These perceptions are important to address.

The next step is to work towards speculative application concepts. Known brainstorm techniques can be used to generate more ideas. The findings about the new technology and its issues should serve as a guideline. In this way you'll automatically have an argumentation behind the level of certainty of each idea. This will facilitate the reasoning about your motivation for the DfD. For the selection of ideas there are two strategies. You can go for a high uncertainty on the desirability or for a high uncertainty on the feasibility, but never both. It is important to stay away from a science fiction character. Politicians need reasoning for why they should give attention to this particular topic, science fiction holds too much uncertainty to relate it to policy-making.

If you want to start a debate that is currently non-existent, it is best to go for a high uncertainty on the feasibility. Is there already a debate and you want to steer it in a certain direction; then a high uncertainty on the desirability is the best choice. With the selection made, you can start working out the DfD concept. You need to specify how it relates to certain technological and societal trends. Does the concept contribute to the trend or should it work against it? It is also important to clearly relate your DfD concept to other developments, because this is the way to explain why your DfD is worth to be taken seriously.

In the presentation of your DfD concept you need to leave the public to a choice. So you have to think of a positive and negative application scenario. In this way you stimulate your public to think critically about the new technology you want to have discussed and they will have clear tangible topics to talk about. If you want to get the full potential out of your DfD you need to create a context where the debate can take place. This involves arranging a physical room and the invitation of the right actors.

4.3.2 Facilitating the design process

To facilitate the design process the above mentioned framework should be translated into a workable form. This form should suit particular phases in the design process. The described requirements are not all important at the same time, so a set of tools for different moments in the process is most suitable. Within this project one requirement was selected to work out as a tool for the design process to exemplify how the framework can be implemented.

Because this framework is about enhancing DfD to reach politicians, the framework-element that is worked out as a tool is 'specify why a politician should care'. This requirement holds the most significant elements from the framework. It describes three ways of persuading a politician about the political importance of a DfD. The topic that a DfD addresses should be **governable**, **urgent**, and **new**. Therefore the tool is appropriately called 'GUN'.

GUN can be used in several phases of the design process, but is most useful during selection procedures. After a diverging phase of brainstorming the large amount of ideas can be assessed through GUN. The questions that should be asked are: 'Does the idea represent a governable topic?', 'Is this topic urgent?', and 'Is this topic new?'. This not only provides a clue about how well an idea relates to political needs ('is it GUN?'), but also makes the designer to think about the DfD ideas in a political way ('how is it GUN?'). So it will be helpful in presenting the DfD.

GUN is made physical through three axes representing its three dimensions. This results in a three-dimensional matrix where ideas can be placed. To facilitate the attachment of post-it notes the matrix becomes a cube frame with outline bars and middle bars that represent the axes (see Figure 32). The GUN-cube is made available as a do-it-yourself kit. It consists of a sheet of cardboard with printed instructions. The cardboard sheet can be folded into a cube to facilitate the idea selection process.

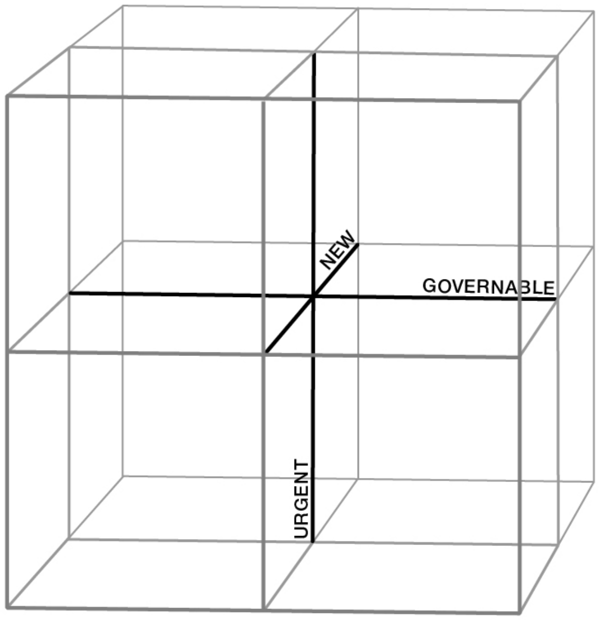

Figure 32: The GUN-cube

Conclusion

All design activities that were done during this project can be related to DfD and TA. Two designs were implemented in the 'real' world and provided much insight in the role of design in a socio-technological context. In the external point of view design can be exploited as a medium for storytelling, which was the case for the Nano World map and the Making Perfect Life graphic. But even as important was the internal role of design (or design-thinking), where it functions as a research medium. Doing design at the RI clearly showed the value of this internal role. This was best seen in the process of the MPL graphic, where the intellectual development of the story co-evolved with the graphical development. The design process contributed in the 'shaping' of the story.

Currently there already is quite some attention to imagination at the RI. But it is always preceded by a textual transformation of a socio-technological problem. So the current non-textual communication methods of the RI have had a double interpretation cycle. If these cycles are done within the organization this is not a problem. But when an assignment for imagination is outsourced the interpretations are performed in different contexts. This is not beneficial for the communicative properties of an image (or design). The best way to improve this is by integrating a design attitude in the TA process. Ideally this would mean that a design process runs along with a classical TA process; using the same sources and exchanging findings through different media. Design should not only be seen as a medium for communication, but also as a research medium.

Eventually it can be said that the role of design at the RI is mainly valuable in the endeavor to come closer to general public. Currently the intellectual approach can place the RI on an ivory tower. This is an ongoing pitfall and reduces their public to science experts and expert politicians. Their work can become more accessible for general public with a design approach and the intellectual depth can be guaranteed. This will not only broaden their public but will also improve the communication towards politicians.

The impact that TA methods can have on a design for debate process was of equal importance in this project. DfD is about storytelling, and TA methods are helpful in structuring the story. It is the rational approach of socio-technological problems that can significantly increase the impact of a DfD. Currently a DfD doesn't have a long lasting effect on debate. It is not taken seriously by many people because it is seen as an art-form. This results in a short temporary impact or a small public. Adding TA methodology can increase the credibility of DfD and maybe even design as a medium in general. The Nano World map already gave a hint of increased credibility because RI relations reacted positively on it.

Both DfD and TA are about creating a stage to empower public for a debate. In DfD a debate can evolve around socio-technological problems that are embodied by design. In TA the stages are more familiar, like in theatre, at conferences or at festivals. This stage is not only physical, it also consists of the structure that is used for giving specific information. TA and DfD both have an empowering and informing purpose. It is important to be aware of this twofold goal for every single TA or DfD project.

Another important fact that seems to be easily overlooked is the fact that a debate doesn't take place without actors. This clearly relates to Dewey's "construction of publics". If there is no shared concern, there is no public and there will be no debate. So for both DfD and TA finding shared concerns is important, followed by proper argumentation why the concerns have to be addressed.

Discussion

With the merging of different worlds the aim is to generate a synergy. But in practice there are always qualities of both fields that get lost. This is also the case with this project. With the increase of an intellectual structure in the design process the user gets easily lost. This was visible in the Nano World map and Making Perfect Life process. The focus on proper argumentation behind the story and the design placed the user on the background. For good communication through design conscious user focus is vital.

But the balance between research and design is fragile. When design predominates the precision of the story gets lost, which will reduce the credibility. But in this project it was mainly in the design approach where sacrifices were made. For the Nano World map a TA attitude was added to the design process, so the precision and credibility was increased at the expense of communicative qualities. Within the Making Perfect Life project design was added as an extra feature, without reducing the man-hours spend on the research. So in that case nothing had to be sacrificed. All in all the credibility of the designs are high, but the communicative qualities could have been better. The start of the design of a DfD toolset for designers is promising in achieving a better balance between research and design.

Another factor that was less present in this project is the empowering quality of design. Classical industrial design is intended to empower people. In this project the informing property prevailed. Within industrial design the informing quality is rather new, but it is growing these days. Nonetheless it is important to keep the tangible empowering quality. Only providing information through design would significantly decrease its value. Although in relation to a debate providing information can be seen as an approach to empower people. It provides terms to talk about and guides the debate through the way it is presented. In this sense information is the basis of empowering people for a debate.

Recommendations

I recommend the integration of a design process with technology assessment processes at the RI. This does not imply a total shift in technology assessment practices but is a matter of integrating more modalities in the process. It is a fact that a multi-modal approach is more effective because we as humans are trained to work with more modalities at a time. In text-based communication we make a projection in our heads of what is communicated. Why not directly communicate this projection? A first step in integrating design with the TA process at the RI would be to use images more often for internal communication. As this involves a rich but ambiguous communication style it should always be accompanied with text though.

The explorative design activities provided interesting starting points for new design projects. The message that the interactive graphic of the 'new technology wave' provides is not a short temporary one. The technique behind the interactive graphic should facilitate an ongoing story. There should be the possibility to update the story. It has to be a mobile setup to place it quickly at several places. For a more continuous presentation it should be translated towards a website that contains the same properties. The website should be updatable in order to keep an up-to-date image of the 'new technology wave' with designs for debate and the newest technological developments. The implementation requires integration with a content-management system and a dynamic graphic that adapts itself to the content.

The cards that are used in the workshop are more directly an interesting medium for the RI. A cardset for children at primary schools was proposed for example. This would be a simple (in terms of design) but interesting project to further integrate design at the RI. A clear user-centered process can be done, which will provide an improved image of the qualities of design and design-thinking.

The framework also provides clear opportunities for further development. The large amount of requirements that are described can be worked out as a full toolset. With the GUN-cube as an interesting starting-point it would be recommendable to start with testing this particular tool. From such test new insights can arise for the development of other tools that relate to the framework. Eventually it would be interesting to test the whole toolset in a one-day DfD workshop, where participants have to start from scratch and finish the day with a DfD that is targeted towards politicians.

Acknowledgements

The exploration and in particular exploitation of design in new contexts wasn't possible without the help of others. First of all I would like to thank Koert van Mensvoort (TU/e) and Bart Walhout (Rathenau Institute) for their enthusiasm and coaching in this design project and giving me the opportunity to contribute to the Nano supermarket and several Rathenau projects. I want to thank Hendrik-Jan Grievink for his advising role in the graphic design and publication of the map; I learned many new practical tips & tricks. I thank Berry Eggen for leading me towards the RI and providing the entrance through Rinie van Est, and Rinie himself for the inspiring collaboration in the development of the Making Perfect Life presentation and his general enthusiasm and interest for my work at the RI. And finally I want to mention Oscar Tomico for his advice on the exploration towards a 'design for debate' framework.

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Appendices

I. NANO World map information table

Product	Application field	Domain	Enabling technology	Research area	Symbolic uncertainty	ELSI1	ELSI2	ELSI3	ELSI4	ELSI5	ELSI6	ELSI7
24-carat lipstick	Cosmetics	Lifestyle	Nano particles	Nano materials			toxicity					
Air energy collector	Energy	Environment	Nano structures	Nano materials		pollution	equity					
Anti-epilepsy electrode	Therapy	Health	Nanocircuits	Neuro-engineering	Human vs. machine							
Anti-Parkinson electrode	Therapy	Health	Nanocircuits	Neuro-engineering	Human vs. machine							
Artificial brain	Robotics	Environment	Nanocircuits	Neuro-engineering	Living vs. non-living		liability					
Attitude chip	Therapy	Health	Nanocircuits	Neuro-engineering	Human vs. machine	security			safety			
Attitude medicine	Therapy	Health	Micro-encapsulation	Neuro-engineering	Human vs. machine, rational vs. irrational							
Augmented contact lenses	Cosmetics	Lifestyle	Nanocircuits	Nano electronics	Human vs. machine	security						
Autonomous health chip	Home diagnostics	Health	Nanocircuits	Molecular medicine	Human vs. machine, healthy vs. ill		liability	reliability	responsibility			
Autonomous nano surveillance	Surveillance	Public	Nanocircuits	Ambient intelligence	Active vs. passive	security		second nature		privacy		
Autonomous war robot	Military	Public	Nanocircuits	Nano electronics	Living vs. non-living	security	liability					
Battery paper	Energy	Environment	Nano structures	Nano materials								
Bio computer	Consumer devices	Lifestyle	Programmable matter	Neuro-engineering	Born vs. made	security	reductionism					
Biojewellery	Decoration	Lifestyle	Tissue engineering	Tissue engineering	Born vs. made	identity	human body integrity					
Blood cells 2.0	Diagnostics	Health	Nano electromechanical systems	Nano robotics	Human vs. machine	security			safety			
Blood cells 2.0	Therapy	Health	Nano electromechanical systems	Nano robotics	Human vs. machine	security			safety			
Bloodbots	Diagnostics	Health	Nano electromechanical systems	Nano robotics	Human vs. machine	security			safety			
Bloodbots	Therapy	Health	Nano electromechanical systems	Nano robotics	Human vs. machine	security			safety			
Body grown medicine	Pharmaceutics	Health	Genetic engineering	Tissue engineering	Human vs. machine							
Brain controlled computer	Home appliances	Lifestyle	Nanosensors	Neuro-engineering	Human vs. machine, active vs. passive	security	reductionism	reliability	safety	body image		quality of li
Brain controlled prosthesis	Therapy	Health	Nanosensors	Neuro-engineering	Human vs. machine, active vs. passive	security	reductionism	reliability	safety	body image	sense of independe	quality of li
Brain relax game	Therapy	Health	Nanosensors	Neuro-engineering	Human vs. machine, active vs. passive	security	reductionism	reliability	safety	body image	quality of life	
Bulletproof t-shirt	Military	Public	Nano structures			security						
Camouflage paint	Military	Public	Nano particles	Nano materials		security	liability					
Cancer nanobomb	Therapy	Health	Nano structures									
Cell therapy	Therapy	Health	Tissue engineering	Regenerative medicine	Born vs. made		safety	reliability				
Chameleon clothing	Clothing	Lifestyle	Nano structures	Nano electronics		security						
Chocolate slim nanoshake	Food	Health	Micro-encapsulation		Active vs. passive		responsibility	commercialization				
Consumer nano sensors	Consumer devices	Lifestyle	Nanocircuits	Ambient intelligence	Active vs. passive	security	liability					
Cultured diamond	Decoration	Lifestyle	Nano structures	Nano materials	Born vs. Made	equity						
Cybernetic ant colony	Robotics	Environment	Nano electromechanical systems	Nano electronics	Born vs. Made	security	liability					
Depression monitor device	Home diagnostics	Health	Nanocircuits									
Device printer	Consumer devices	Lifestyle	Nano structures	Nano electronics	Information vs. thing	security	liability		safety			
DNA security spray	Surveillance	Public	Genetic engineering	Genomics	Organic vs. inorganic	security	liability					
DNA walker	Robotics	Environment	Genetic engineering	Genomics	Organic vs. inorganic							
E.chromi	Home diagnostics	Health	Molecular imaging	Molecular medicine	Human vs. information, healthy vs. ill		safety		responsibility	body image		
Electric conductive ink	Cosmetics	Lifestyle	Nano particles	Nano materials	Human vs. machine		safety					
Epicur pralines	Food	Health	Micro-encapsulation	Molecular medicine	Healthy vs. ill, fait vs. intentional	equity			responsibility			
Epicur pralines	Pharmaceutics	Health	Micro-encapsulation	Molecular medicine	Healthy vs. ill, fait vs. intentional	equity			responsibility			
Federal nano spy	Secret governance											
Fludoc	Home diagnostics	Health	Molecular imaging	Molecular medicine	Healthy vs. ill		liability	reliability	responsibility			
Food conservation foil	Food	Health	Nano coating	Nano materials			reliability					
Food printer	Food	Health	Tissue engineering		Information vs. thing, organic vs. inorganic	security	liability	reductionism	safety			
Freshness sensor	Food	Health	Nanosensors		Organic vs. inorganic		reliability					
Full body health mirror	Home diagnostics	Health	Nanocircuits	Molecular medicine	Human vs. information, healthy vs. ill		liability	reliability	responsibility			
Gene doping	Sports	Lifestyle	Genetic engineering	Genomics	Human vs. machine		safety	commercialization				
Gene therapy	Therapy	Health	Genetic engineering	Genomics			safety	reliability				
Glucose monitor chip	Diagnostics	Health	Nanocircuits									
Golf ball	Sports	Lifestyle	Nano structures	Nano materials								
Grey goo	Robotics	Environment	Programmable matter		Born vs. made, living vs. non-living	security	liability					
Health display sweater	Clothing	Lifestyle	Nanosensors	Nano electronics	Healthy vs. ill, active vs. passive	security		identity	responsibility	privacy		
Home appliance network	Home appliances	Lifestyle	Nanocircuits	Ambient intelligence	Active vs. passive		liability		second nature	privacy		
Human nano experiment	Secret governance											
Inkjet skin printer	Therapy	Health	Tissue engineering	Tissue engineering	Born vs. made		safety		identity			
Invisible warfare	Military	Public	Nano structures	Nano materials		security						
I-pill	Pharmaceutics	Health	Nanocircuits	Molecular medicine			liability					
Latro algae lamp	Energy	Environment	Metabolic engineering	Synthetic biology	Plant vs. machine			reliability				
Liquid armor	Military	Public	Nano structures	Nano materials		security						
Loudspeaker paper	Home appliances	Lifestyle	Nano structures	Ambient intelligence								
Medical nano camera	Diagnostics	Health	Nanocircuits	Nano electronics	Healthy vs. ill		privacy					
Medicine bacteria bots	Pharmaceutics	Health	Micro-encapsulation	Bionics, Molecular medicine	Born vs. made	security			safety			
Medicine clothing	Clothing	Lifestyle	Nano particles	Molecular medicine	Healthy vs. ill		safety	liability	toxicity			
Milk filter	Food	Health	Nano structures				reliability					
Mood responsive make-up	Cosmetics	Lifestyle	Nanosensors	Nano electronics	Rational vs. irrational		reliability	commercialization				
Motor nanocars	Science	Science	Nano structures	Nano materials		security						
Multi-vitamin tablet	Food	Health	Nano particles			reductionism						
Nano bioelectric plants	Energy	Environment	Metabolic engineering	Synthetic biology	Plant vs. machine							
Nano car wax	Automotive	Environment	Nano coating	Nano materials								
Nano cloaking device	Military	Public	Nano structures	Nano materials		security						
Nano computer	Consumer devices	Lifestyle	Nano structures									
Nano detector	Surveillance	Public	Nanosensors		Active vs. passive		liability	safety				
Nano force field	Military	Public	Nano coating	Nano materials		security		commercialization				
Nano forest	Science	Science	Nano structures	Nano materials								
Nano free zone	Nanophobia											
Nano fuel saver	Automotive	Environment	Nano structures	Nano materials								
Nano mind erasers	Military	Public	Micro-encapsulation	Neuro-engineering	Human vs. machine	security		commercialization				
Nano organic food	Food	Health	Nano particles		Organic vs. inorganic		toxicity					
Nano organic skincare	Cosmetics	Lifestyle	Nano particles	Nano materials	Organic vs. inorganic		toxicity					
Nano photograph	Art	Public	Nanoscopy	Nano optics	Natural vs. artificial							
Nano plaster	Pharmaceutics	Health	Nano structures	Molecular medicine	Active vs. passive							
Nano poison	Military	Public	Micro-encapsulation	Molecular medicine	Human vs. machine	security		commercialization				
Nano radio	Home appliances	Lifestyle	Nano structures	Ambient intelligence								
Nano resistance	Nanophobia											
Nano sculpture	Art	Public	Nano structures	Nano materials	Natural vs. artificial							
Nano wine	Food	Health	Micro-encapsulation		Information vs. thing, organic vs. inorganic	security	toxicity					
Nanobomb	Military	Public	Nano structures			security						
Nanochair 2.0	Art	Public	Nano structures	Nano optics / nano materials								
Nanogold eye shadow	Cosmetics	Lifestyle	Nano particles	Nano materials			toxicity					
Nanolift	Cosmetics	Lifestyle	Nano particles	Tissue engineering	Fait vs. intentional	identity	human body integrity					
Nanonaise	Food	Health	Micro-encapsulation		Active vs. passive		responsibility					
Nano remediation	Nano cleaning	Environment	Nano particles	Nano materials		pollution						
Nanosock	Clothing	Lifestyle	Nano electromechanical systems		Living vs. non-living		safety	reliability				
Non-lethal bullets	Military	Public	Micro-encapsulation			security						
Non-lethal weapons	Military	Public	Micro-encapsulation	Nano materials	Human vs. machine	security		commercialization				
OLED radio display	Automotive	Environment	Nano structures	Nano materials								
Perfect sense	Pharmaceutics	Health	Micro-encapsulation	Neuro-engineering	Man vs. woman, born vs. made		safety					
Personalized shop window	Consumer devices	Lifestyle	Nanocircuits	Ambient intelligence	Active vs. passive		privacy					
Pharmaceutical sushi	Food	Health	Metabolic engineering	Synthetic biology	Healthy vs. ill, born vs. made		responsibility	commercialization				
Programmable food	Food	Health	Programmable matter		Information vs. thing, organic vs. inorganic	security	toxicity					
Remote control nano plague	Military	Public										
Robo-fly	Military	Public	Nano electromechanical systems	Nano electronics	Animal vs. machine	security	privacy					
Self-cleaning surfaces	Nano cleaning	Environment	Nano coating	Nano materials								
Self-healing surfaces	Nano cleaning	Environment	Micro-encapsulation	Nano materials	Born vs. made		safety	reliability				
Self-resizing footwear	Clothing	Lifestyle	Programmable matter		Living vs. non-living		safety	reliability				
Skin paper	Decoration	Lifestyle	Tissue engineering	Tissue engineering	Born vs. made	identity	human body integrity					
Smart dust	Surveillance	Public	Programmable matter		Active vs. passive	security						
Smell free socks	Clothing	Lifestyle	Nano particles	Nano materials	Active vs. passive		safety		toxicity			
Solar sheet	Energy	Environment	Nano structures	Nano materials								
Spider silk condom	Cosmetics	Lifestyle	Nano structures	Bionics	Born vs. made							
Sports towel	Sports	Lifestyle	Nano particles	Nano materials		pollution	toxicity					
Spray-on liquid glass	Nano cleaning	Environment	Nano coating	Nano materials	Normal vs. abnormal							
Sunscreen	Cosmetics	Lifestyle	Nano particles	Nano materials			toxicity					
Synthetic biofuel bacteria	Energy	Environment	Genetic engineering	Synthetic biology	Born vs. made		toxicity					
Tennis racket	Sports	Lifestyle	Nano structures	Nano materials								
The necklace	Home diagnostics	Health	Molecular imaging	Molecular medicine	Healthy vs. ill		liability	reliability	responsibility			
Tooth phone	Consumer devices	Lifestyle	Nanocircuits	Nano electronics	Human vs. machine	security	privacy					
Trash eating bacteria	Nano cleaning	Environment	Metabolic engineering	Synthetic biology	Born vs. made		toxicity					
Twitter implant	Home diagnostics	Health	Nanocircuits	Nano electronics	Human vs. machine, healthy vs. ill	identity	privacy	commercialization	responsibility	body image		
Virtual soldier buddy	Military	Public	Nanocircuits	Neuro-engineering	Living vs. non-living		second nature					
Wallsmart	Decoration	Lifestyle	Nano structures	Nano electronics	Active vs. passive	security						
Waterproof clothing	Clothing	Lifestyle	Nano coating	Nano materials								
Genetic engineering		Enabling technology										
Metabolic engineering		Enabling technology										
Micro-encapsulation		Enabling technology										
Molecular imaging		Enabling technology										
Nano electromechanical systems		Enabling technology										
Nanocircuits		Enabling technology										
Nanocoating		Enabling technology										
Nanoparticles		Enabling technology										
Nanoscopy		Enabling technology										
Nanosensors		Enabling technology										
Nanostructures		Enabling technology										
Programmable matter		Enabling technology										
Tissue engineering		Enabling technology										
Demilitarization cruise		Route										
Nano high society route		Route										
Super soldier suit route		Route										

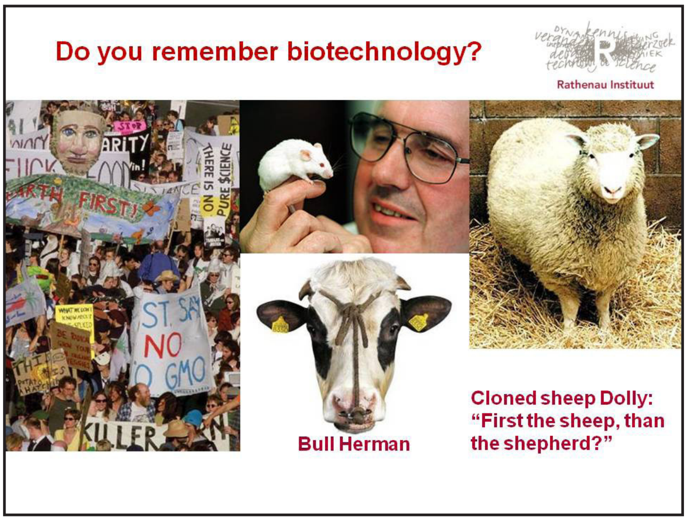
	BANG	Desirability	Feasibility	Control	Born	Terms	Description	Reference	Coordinate
	Atoms	6	7	7	1	Nano particles	Lipstick that is made of gold particles; fabricated into lipstick substance	NANO supermarket	D11
	Atoms	9	6	7	7	hygroelectricity	Like solar energy nanostructures capture energy from humid air; a powerful source, as lightning demonstrates	http://www.nano.org.uk/news/950/	I5
	Neurons	8	6	7	1	Nanocircuits	An electrode in the brains that reduces epilepsy attacks	Making perfect life (Rathenau Institute)	H4
	Neurons	8	6	7	1	Nano electromechanical systems	An electrode in the brains that reduces the effects of Parkinson's disease	Making perfect life (Rathenau Institute)	H4
	Atoms	6	2	2	8	Nanocircuits	Brains can be build artificially if they are understood on the nanoscale	Making perfect life (Rathenau Institute)	K6
	Neurons	1	1	8	1	Nanocircuits	A chip implanted in the brain controls your attitude to eliminate a post-traumatic stress disorder for example		H4
	Neurons	3	2	8	1	Micro-encapsulation	Take a pill to improve your study activity, or to be more open during a party		G3
	Bits	8	2	10	1	Nano electromechanical systems	Contact lenses that display content on top of the things you're actually seeing	http://www.nextnature.net/2009/09/second-	C12
	Atoms	7	6	1	7	Nanocircuits	An implanted chip that measures your body state and improves your health when needed	http://www.nanometing.nl/	D3
	Bits	7	3	1	5	Nano lithography, pattern recognition	Surveillance systems can become intelligent due to increased computational power and nano communication technology	http://www.nanometing.nl/	I10
	Bits/ atoms	5	3	2	3		Robots mimic brain functionality to make their own decisions on a battlefield	http://www.nanometing.nl/nieuws/de-echte-	I14
	Atoms	9	10	10	1	Carbon nanotubes	A carbon nanotube sheet can hold energy; enabling very thin batteries	http://en.wikipedia.org/wiki/Paper_battery	J6
	Neurons	6	4	2	7	Biobricks	A computer that is grown from neurons conducts massive parallel computing	Making perfect life (Rathenau Institute)	G9
	Genes	7	10	6	5	Bioceramics	Rings grown of your partner's bone tissue, the ultimate wedding gift	NANO supermarket	E8
	Atoms	3	3	1	1	Nano electromechanical systems	It might be possible to build blood cells that are better than our natural ones	http://www.nextnature.net/2009/11/blood-c	G3
	Atoms	3	3	1	1	Nano electromechanical systems	It might be possible to build blood cells that are better than our natural ones	http://www.nextnature.net/2009/11/blood-c	G3
	Atoms	6	6	1	1	Nano electromechanical systems	Robots that swim in our blood and kill suspicious bacteria and viruses	http://blogs.discovermagazine.com/discoblog	G2
	Atoms	6	6	1	1	Nano electromechanical systems	Robots that swim in our blood and kill suspicious bacteria and viruses	http://blogs.discovermagazine.com/discoblog	G2
	Genes	1	1	6	8	Modified DNA	Why not grow medication on your own body?	http://www.nextnature.net/2008/10/human-	G4
fe	Neurons	4	4	9	4	Nanosensors	A computer that is directly connected to the brain, no mouse or keyboard needed	Making perfect life (Rathenau Institute)	I12
fe	Neurons	8	7	3	5	Nanosensors	Ways to directly control prosthesis from the brain are in far stages of development	Making perfect life (Rathenau Institute)	I4
	Neurons	6	5	8	3	Nanosensors	A game that uses EEG technology with nanowires to measure the state of your brains, enabling neurofeedback	Making perfect life (Rathenau Institute)	H3
	Atoms						Bulletproof business suits are already on the market, future nanostructures can make a t-shirt stop bullets		E14
	Atoms	8	10	3	1	Nano particles	Paint that makes anything invisible for a radar due to certain nano particles	http://gizmodo.com/388418/camouflage-pair	H14
	Atoms						Single cancer cells can be literally blown up with microscopic explosions of carbon nanotubes	http://www.udel.edu/PR/UDaily/2005/mar/n	I2
	Genes	8	10	7	10	Stem cells / biobricks	Stem cells are used to regenerate damaged parts of your body	Making perfect life (Rathenau Institute)	H2
	Atoms	7	3	7	1	Nanorods	Clothing can adapt its color to the environment with nanorods and nanocameras	NANO supermarket	G13
	Atoms	10	10	3	1	Micro-encapsulation	Encapsulation techniques make chocolate shakes taste the same, but without calories	http://www.nanotechproject.org/inventories/	F5
	Bits	3	9	10	1	Nanocircuits	Tiny sensors which can measure anything; from marihuana particles to human sweat	http://www.nanometing.nl/	G10
	Atoms	8	6	8	4	Chemical Vapor Deposition	Instead of digging in deep mines, diamond can be grown with carbon material	http://www.nanotechproject.org/inventories/	E9
	Atoms	2	2	1	5		Tests are done with insects to combine them with nano electromechanical systems	http://www.mi2g.com/cgi/mi2g/frameset.ph	K7
	Atoms						Patients suffering from bipolar disorder can determine their own lithium level through lab-on-a-chip technology		E2
	Bits / atoms	3	5	10	1	Nano lithography	A printer that creates the mobile phone you ordered at home		F12
	Genes	10	10	7	1	Synthetic DNA	A spray of unique artificial DNA to recognize stolen products	http://www.selectadna.co.uk/selectadna-anti	G10
	Genes	4	6	5	3		A DNA walker is a nanoscale robot made of DNA molecules	http://en.wikipedia.org/wiki/DNA_machine	K6
	Genes	6	8	6	5	Biomarkers, metabolic engineering	E.chromi bacteria generate color pigments when diseases are detected in your bowel movement	NANO supermarket	C1
	Atoms	5	10	10	1	Nano particles	Ink that can be painted on the body to replace the wires from your mp3-player, phone headset, etc.	http://www.nextnature.net/2009/04/conduct	C10
	Atoms	5	6	10	3	Micro-encapsulation	By encapsulating preventive medicine in chocolate, one praline a day protects you from HIV infection	NANO supermarket	F5
	Atoms	5	6	10	3	Micro-encapsulation	By encapsulating preventive medicine in chocolate, one praline a day protects you from HIV infection	NANO supermarket	F5
							Nano devices can be exploited to spy on people without being seen		A3
	Genes	8	8	7	7	Biomarkers, metabolic engineering	Genetically modified luminescent bacteria show if you have the flu	NANO supermarket	C2
	Atoms	8	9	10	1	Nano coating	Packaging food with nano materials can improve conservation significantly	Base camp nano	E6
	Bits / atoms	2	3	10	1	Biobricks	No need to go to the grocery store, you can print any food you like with biobrick technology	http://www.nextnature.net/2010/05/nano-pr	D6
	Atoms	8	9	10	1	Nanosensors	A sensor measuring and displaying your food's freshness	RTL Z, Nano in beeld	E6
	Atoms	5	9	8	4	Nanocircuits	A mirror that shows your full body health state every morning based on implanted lab-on-a-chip information	http://www.nanometing.nl/	D2
	Genes	3	7	9	8	Modified DNA	Doping through genetic modification can improve your sports performance	http://en.wikipedia.org/wiki/Gene_doping	C7
	Genes	8	9	8	8	Modified DNA	Viruses are eliminated by modifying their DNA	http://en.wikipedia.org/wiki/Gene_therapy	H2
	Atoms						Diabetes patients can get a lab-on-a-chip implant that continuously measures the glucose level		F2
	Atoms	8	10	10	1	Carbon nanotubes	The material properties of golf balls are improved for better flying capabilities with carbon nanotubes		C8
	Atoms	1	1	1	10	Programmable matter	Grey goo is the worst nightmare of nano singularity, where self-replicating artificial nanorobots take over the world	http://en.wikipedia.org/wiki/Grey_goo	K9
	Atoms	2	5	1	2	Nanosensors	With nanosensors and nanorods a sweater could display your health status	http://www.nanometing.nl/	F12
	Bits / atoms	4	8	3	1	Nano lithography	Nanocircuits can deliver computational power to every device, they can communicate with each other and make our lives easier	http://www.nanometing.nl/	J13
							Experiments with nanotechnology can be done on people without noticing it		A3
	Genes	10	8	8	7	Buckyballs	A printer that prints skin cells directly on damaged skin tissue	http://www.nextnature.net/2010/04/inkjet-b	H3
	Atoms	3	2	3	1		Weaponry can be miniaturized to invisible proportions, so war won't come on television anymore		G15
	Atoms	7	7	8	1	Micro-encapsulation	A pill that looks for certain diseases in your body and releases medication if needed	http://www.research.philips.com/newscenter	E4
	Genes	6	10	6	10	Metabolic engineering	A lamp with luminous bacteria, only needing your breath to survive for a half year	NANO supermarket	H5
	Atoms	10	8	10	1	Inorganic nanotubes	Armor that is liquid in normal state and solid when hit by a bullet	http://en.wikipedia.org/wiki/Liquid_Armor	F13
	Atoms	6	10	1	1	Carbon nanotubes	Carbon nanotubes enable very thin loudspeakers	http://en.wikipedia.org/wiki/Carbon_nanotut	I12
	Bits	10	7	6	1	Nanocircuits	Tiny cameras that can go in your body for more detailed medical diagnosis	http://www.nanometing.nl/	E3
	Atoms	10	7	8	9	Micro-encapsulation	Bacteria that carry medication and are steered through your blood through magnetism	http://www.technologyreview.com/computin	E3
	Atoms	8	6	3	1	Nano particles	With nanotubes that penetrate your skin, medication could be given through clothing	RTL Z, Nano in beeld	F13
	Atoms	8	10	10	1	Nano filters	Tiny filters are developed that can replace the heating of milk to remove malicious bacteria	RTL Z, Nano in beeld	E6
	Atoms	3	2	3	7	Nanosensors	Make-up that adapts its color to your mood through programmable nanorods	NANO supermarket	B10
	Atoms	5	10	7	1	Buckyballs	A car created from a few molecules, with buckyballs as wheels	http://en.wikipedia.org/wiki/Nanocar	B14
	Atoms	7	10	6	1	Micro-encapsulation	Nanotechnology improves synthetic vitamin properties and its delivery in the body		E4
	Atoms	3	5	3	9	Metabolic engineering	Exploiting energy from the photosynthesis of plants; if you use it too much the plant will die	NANO supermarket	I4
	Atoms	7	10	7	1	Nano coating	Nanoparticles make car wax more scratch resistant	http://www.nextnature.net/2010/01/nano-ca	I8
	Atoms	6	4	3	1		Metamaterials make everything invisible that is behind or under it	http://www.nanometing.nl/nieuws/de-echte-	H14
	Atoms	8	7	8	1	Inorganic nanowires	Tiny computers that can increase the computation power of every imaginable product	http://en.wikipedia.org/wiki/Nanocomputer	G11
	Atoms	10	8	7	1	Nanosensors	A device that helps you detecting nanotechnology	NANO supermarket	H11
	Atoms	6	4	9	1	Nano coating	An invisible sheet that can seal total buildings, so that no one can escape	http://alfin2100.blogspot.com/2008/05/nano	F15
	Atoms	7	10	7	1	Carbon nanotubes	Flower like shapes occur when growing structures with carbon nanotubes	http://www.nextnature.net/2009/03/growing	C13
							If nanotechnology has become omnipresent in our society, nano free zones might arise as a reaction		B5
	Atoms	8	10	6	1		The nano fuel saver is a device with nanostructures that separates fuel in smaller particles for improved combustion	http://www.nanotechproject.org/inventories/	I6
	Neurons	5	5	7	3	Micro-encapsulation	A spray that affects memory; useful to remove confidential information	http://alfin2100.blogspot.com/2008/05/nano	G13
	Atoms	4	9	8	7	Nano particles	Organic nano particles can be used in food to give it more healthy properties		E5
	Atoms	6	10	10	1	Nano particles	Anti aging skincare with organic antioxidant and nutrient particles	http://www.nanoorganicliving.com/	E11
	Atoms	8	10	5	5	Atomic force microscopy, scanning tunneling	Nano photography is an art form that shows the beauty of materials on nanoscale using techniques like atomic force microscopy and scanning tunneling microscopy	http://www.nanoart21.org/	C9
	Atoms	9	6	6	3	Micro-encapsulation	Nanotubes on a plaster can ease inserting medication through the skin	RTL Z, Nano in beeld	F4
	Atoms	3	8	6	1	Micro-encapsulation	Instead of killing, paralyzing has the same effect	http://alfin2100.blogspot.com/2008/05/nano	G14
	Atoms	3	10	4	1	Nano lithography	The electric properties of carbon nanotubes enables the production of tiny radios	http://en.wikipedia.org/wiki/Carbon_nanotut	J13
							As the opposition of nuclear weapons, nanotechnology can get this kind of public resistance too		B6
	Atoms	3	10	10	1	Laser	The nano sculpture is a remake of Rodin's thinker 93.000 times smaller than the original	http://www.livescience.com/technology/0701	B10
	Atoms	2	2	10	3	Micro-encapsulation	Wine that can be changed into any type, depending on the occasion	NANO supermarket	D5
	Atoms						Bombs that are too small to see won't do much damage, but billions of them will		F15
	Atoms	2	10	8	2	Focused electron beam, atomic force microsc	With focused electron beams a chair was created of 3 micron (the smallest chair in the world)	http://lucasmaassen.com/Lucas_Maassen/_/	B9
	Atoms	6	10	7	1	Nano particles	Eye shadow with artificial gold particles to create a shiny look	http://www.temptalia.com/looks-n-inspired-	D11
	Genes	8	1	7	5	Modified DNA	With an implant of magnetic particles in the skin you can change the shape of your face every day (only one cosmetic surgery needed)	NANO supermarket	C10
	Atoms	10	10	3	1	Micro-encapsulation	Nanonaise tastes like regular mayonnaise, but contains 70% less fat	Base camp nano	D4
	Atoms	8	9	7	1		Nanomaterials clean up pollutants in contaminated areas, like oil fields	http://www.nanotechproject.org/inventories/	I8
	Atoms	10	3	3	1	Nano electromechanical systems	The nanosock helps elderly by putting itself on autonomously	NANO supermarket	F12
	Atoms						Bullets that don't kill but paralyze		G14
	Atoms	10	8	3	1	Micro-encapsulation	Nanotechnology is used on the development of weapons with specific goals other than killing	http://alfin2100.blogspot.com/2008/05/nano	G14
	Atoms	7	10	7	2		OLED (Organic Light Emitting Diode) displays are used for car radios because they can be viewed on a wide angle and in bright sunlight	http://www.nanotechproject.org/inventories/	H7
	Neurons	6	3	8	1	Micro-encapsulation	With precise drug delivery perfect sense changes the attitude of women to improve their chances in a career	NANO supermarket	G3
	Bits	6	9	3	1	Nanocircuits	A shopping window that recognizes you and adapts its presentation to your preferences	http://www.nanometing.nl/	G10
	Atoms	5	3	10	8	Metabolic engineering	Fishes are genetically modified to produce medicine, when eating the fish the medicine is taken	http://www.nextnature.net/2010/02/nano-pr	F4
	Atoms	2	1	10	3	Programmable matter	Food ingredients that can be programmed into different taste and texture		C6
	Atoms						With cybernetic insects a plague could be initiated and controlled		I14
	Atoms	7	10	7	1	Nano electromechanical systems	A fly sized robot that is used for spy purposes	http://www.technologyreview.com/Infotech/	H15
	Atoms	10	10	4	1	Nano coating	Nano structured surfaces where dirt can not hold	RTL Z, Nano in beeld	J8
	Atoms	10	7	3	1	Micro-encapsulation	If a surface fractures tiny capsules break open and fill the gap	http://www.nextnature.net/2010/05/self-hea	J8
	Atoms	6	3	3	1	Programmable matter	Footwear that recognizes pressure points adapts its size to your feet	NANO supermarket	G12
	Genes	3	10	6	5	Biobricks	Create a personal diary with paper that is grown from your own skin cells on a layer of nanomaterial	NANO supermarket	E8
	Bits / atoms	5	1	8	5	Programmable matter	Dust that can sense and communicate behavior of people	http://www.nanometing.nl/	I9
	Atoms	6	10	10	2	Nano particles	Socks that are impregnated with silver particles that eliminates stinky bacteria	Hema	E12
	Atoms	10	10	10	1	Carbon nanotubes	The properties of solar panels are improved by nanotechnology; making them more efficient and applicable everywhere	RTL Z, Nano in beeld	I6
	Genes	10	6	10	5	Organic nanowires	Condoms made of material inspired by spider silk; improving the feeling properties significantly	http://www.nextnature.net/2010/04/spider-s	D10
	Atoms	6	10	7	1		Sports towels stay fresh when impregnated with silver particles which kill stinky bacteria	http://www.nanotechproject.org/inventories/	A8
	Atoms	8	8	7	1	Nano coating	To make every surface easy to clean you can spray them with tiny glass particles	http://www.nextnature.net/2010/02/spray-o	I7
	Atoms	8	10	9	1	Nano particles	Nano particles are used to improve sunscreen properties; making it invisible and improve protection	RTL Z, Nano in beeld	D12
	Genes	7	4	1	6	Minimal genomes	With minimal genome organisms bacteria can be created that generate biofuel from any kind of waste material	Craig Venter institute	J5
	Atoms	8	10	10	1	Carbon nanotubes	Tennis rackets are made stronger and stiffer with carbon nanotubes		C8
	Atoms	8	7	8	5	Biomarkers	Personal biomarker technology enables to share the state of cancer in an unobtrusive way	NANO supermarket	D3
	Bits	1	7	10	1	Nanocircuits	An artificial tooth with phone functionality	http://www.nextnature.net/2006/06/excuse-	F9
	Genes	10	7	2	7	Metabolic engineering	Bacteria that are modified to turn trash into a useful material		J7
	Bits	6	5	1	4	Nanocircuits	A tooth implant checks your body continuously and sends a message to the doctor if something's wrong	NANO supermarket	E3
	Bits	10	4	1	1	Nanocircuits	An artificial extension of a soldier's mind and perception		H13
	Bits	6	8	6	1	Nanorods	Programmable wallpaper; making it very easy to change the color of your room	NANO supermarket	E10
	Atoms	10	10	10	2	Nano coating	Clothing that has a water resistant nano coating, not affecting the properties of the garment	RTL Z, Nano in beeld	F13
							With DNA analysis and synthesis biological elements can be modified and created		
							By rearranging and changing cells biological functions can be altered		
							Single molecules can be encapsulated to control the properties of substances		
							The goal of molecular imaging is to detect the existence of single molecules		
							Electromechanical systems are miniaturized, this enables new functionality of material and makes combination with biological systems possible		
							Electronic circuits can be created on nanoscale, through nanolithography for example		
							The development of coatings on the nanoscale enables new properties of material surfaces		
							Nanoparticles are single elements between 1 - 100 nm; this size enables new properties		
							Atomic force microscopy and scanning tunneling microscopy are used to visualize structures that light can't make visible to the human eye		
							Sensors of nanometer size are realized through controlling chemical processes by nanocircuits		
							Nanostructures are between 1 - 100 nm, examples are: nanotubes, nanowires, nanorods and buckyballs		
							Matter can be programmed chemically or with nanoelectronics		
							By growing artificial biological structures functions can be replaced or improved		
							Many technological developments in the military field will come to the consumer market one day		
							Many nano products are likely to be only available for rich parts of society		
							A super soldier suit combines features of many products in the nano world	http://www.nanometing.nl/themas/militaire-toepassinge	

II. M.P.L. introduction presentation slides

Also available at www.slideshare.net/Rathenau/making-perfect-life10112010

Making *Perfect* Life

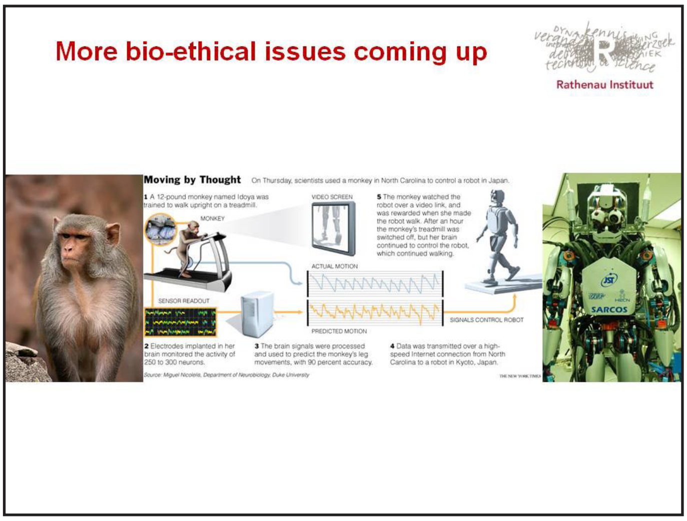
Bio-engineering (in) the 21st Century



Do you remember biotechnology?

Bull Herman

Cloned sheep Dolly: “First the sheep, than the shepherd?”



More bio-ethical issues coming up

Moving by Thought On Thursday, scientists used a monkey in North Carolina to control a robot in Japan.

1 A 12-pound monkey named Idoya was trained to walk upright on a treadmill.

2 Electrodes implanted in her brain monitored the activity of 250 to 300 neurons.

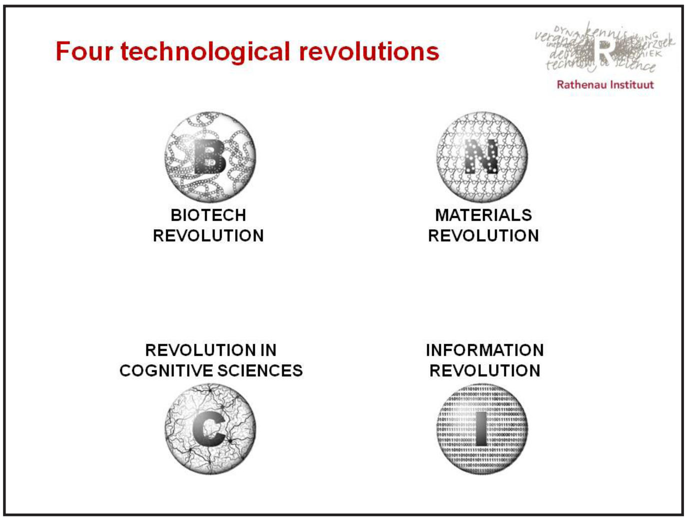
3 The brain signals were processed and used to predict the monkey's leg movements, with 90 percent accuracy.

4 Data was transmitted over a high-speed Internet connection from North Carolina to a robot in Kyoto, Japan.

5 The monkey watched the robot over a video link, and was rewarded when she made the robot walk. After an hour the monkey's treadmill was switched off, but her brain continued to control the robot, which continued walking.

Source: Miguel Nicolelis, Department of Neurobiology, Duke University

THE NEW YORK TIMES



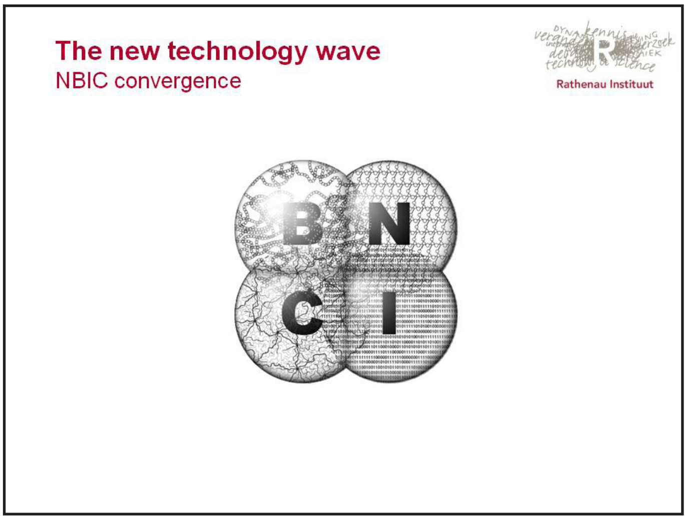
Four technological revolutions

BIOTECH REVOLUTION

MATERIALS REVOLUTION

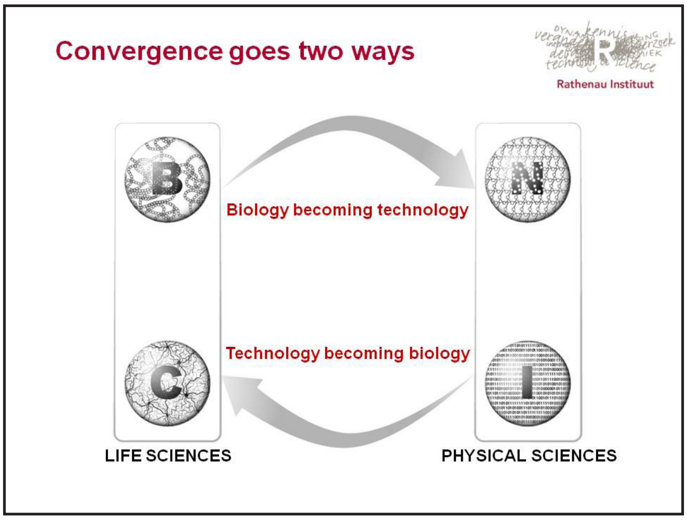
REVOLUTION IN COGNITIVE SCIENCES

INFORMATION REVOLUTION



The new technology wave

NBIC convergence



Convergence goes two ways

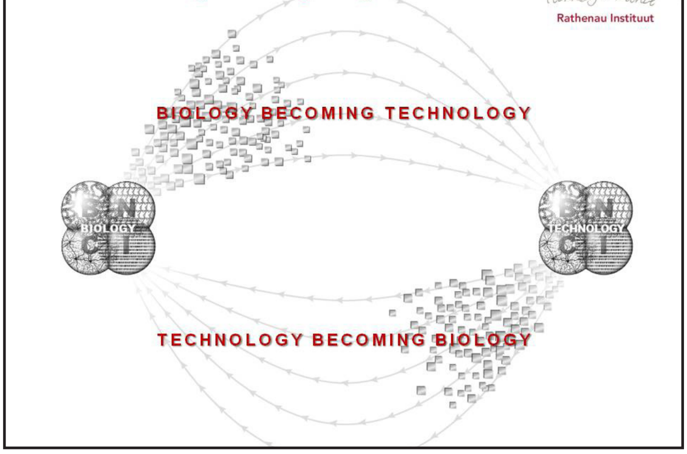
Biology becoming technology

Technology becoming biology

LIFE SCIENCES

PHYSICAL SCIENCES

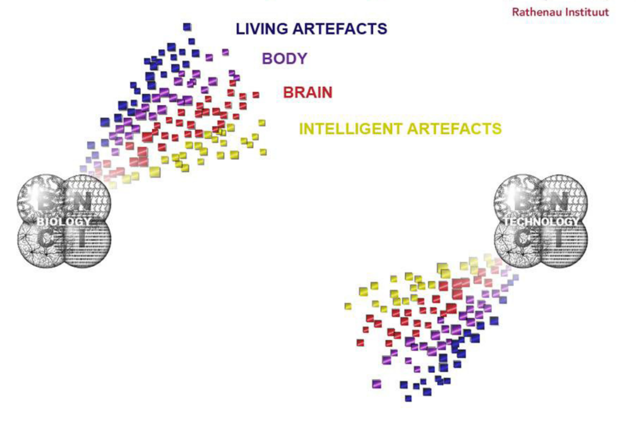
Two bio-engineering megatrends



BIOLOGY BECOMING TECHNOLOGY

TECHNOLOGY BECOMING BIOLOGY

Four fields of bio-engineering



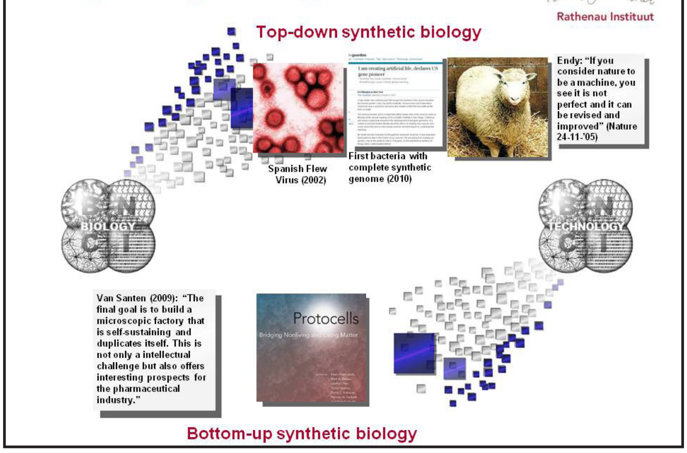
LIVING ARTEFACTS

BODY

BRAIN

INTELLIGENT ARTEFACTS

Engineering of living artefacts



Top-down synthetic biology

Spanish Flew Virus (2002)

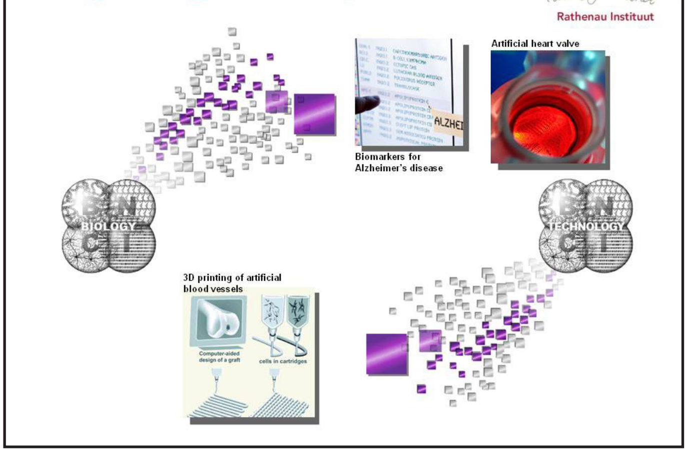
First bacteria with complete synthetic genome (2010)

Endy: "If you consider nature to be a machine, you see it is not perfect and it can be revised and improved" (Nature 24-11-'05)

Van Santen (2009): "The final goal is to build a microscopic factory that is self-sustaining and duplicates itself. This is not only a intellectual challenge but also offers interesting prospects for the pharmaceutical industry."

Bottom-up synthetic biology

Engineering of the body

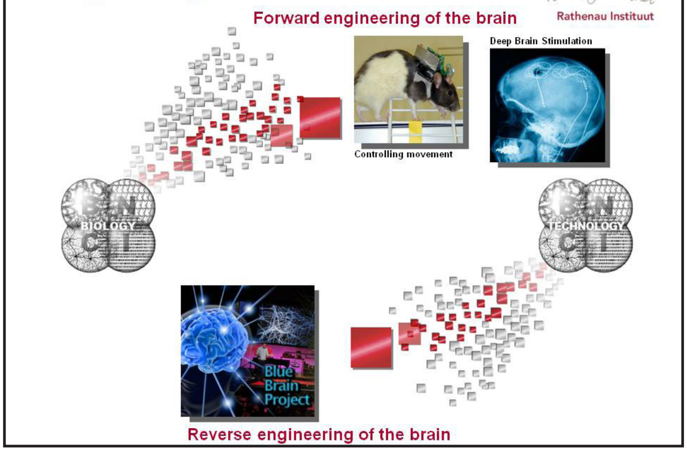


Biomarkers for Alzheimer's disease

Artificial heart valve

3D printing of artificial blood vessels

Engineering of the brain



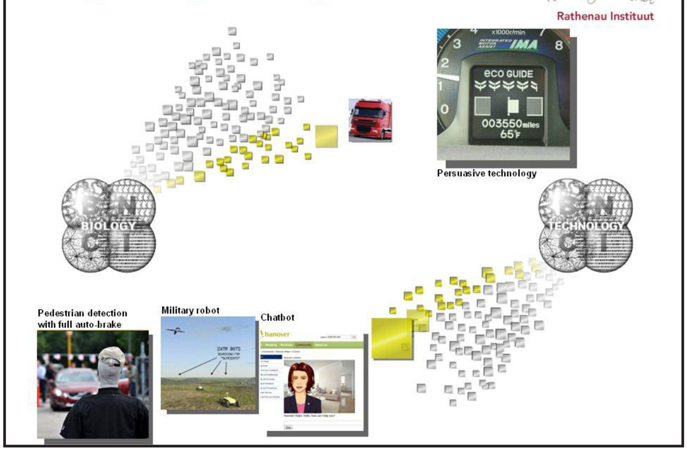
Forward engineering of the brain

Controlling movement

Deep Brain Stimulation

Reverse engineering of the brain

Engineering of intelligent artefacts



Persuasive technology

Pedestrian detection with full auto-brake

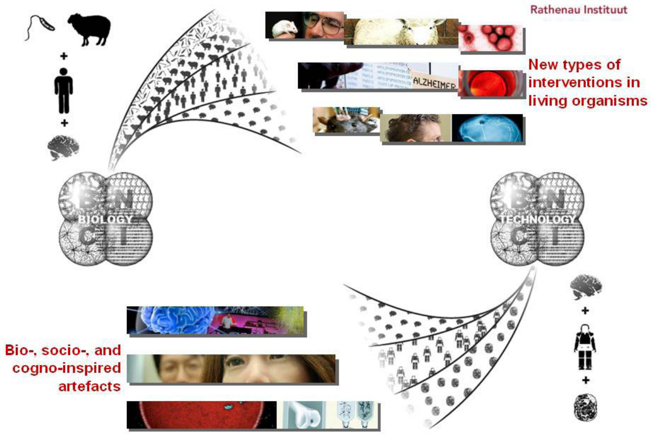
Military robot

Chatbot

Familiar interventions in living organisms

Genetic modification of living organisms

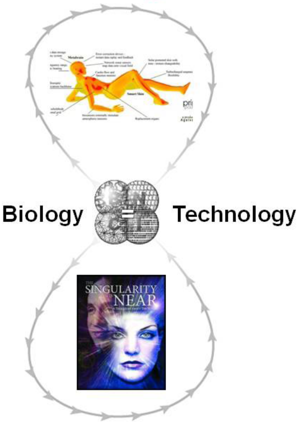
New interventions and artefacts



New types of interventions in living organisms?

Bio-, socio-, and cogno-inspired artefacts

How to safeguard human dignity?



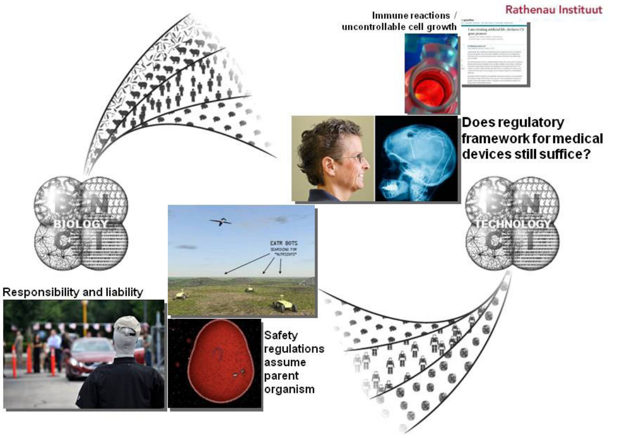
Challenges regulatory practices

- Safety
- Privacy
- Bodily integrity
- Informed consent
- …

Challenging fundamental concepts

- Living and non-living
- Health and sickness
- Brain and machine
- Human and machine agency
- …

New safety issues



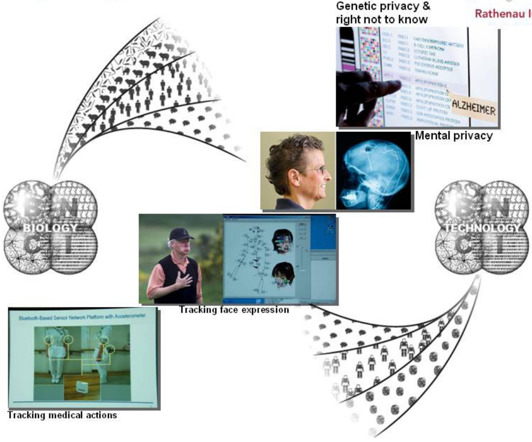
Immune reactions / uncontrollable cell growth

Does regulatory framework for medical devices still suffice?

Responsibility and liability

Safety regulations assume parent organism

New privacy issues



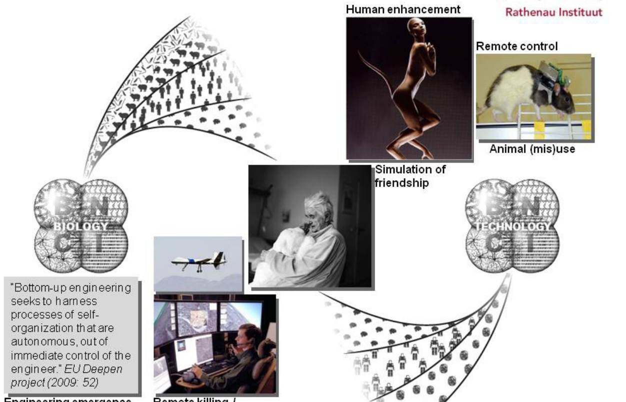
Genetic privacy & right not to know

Mental privacy

Tracking face expression

Tracking medical actions

New moral issues



Human enhancement

Remote control

Animal (mis)use

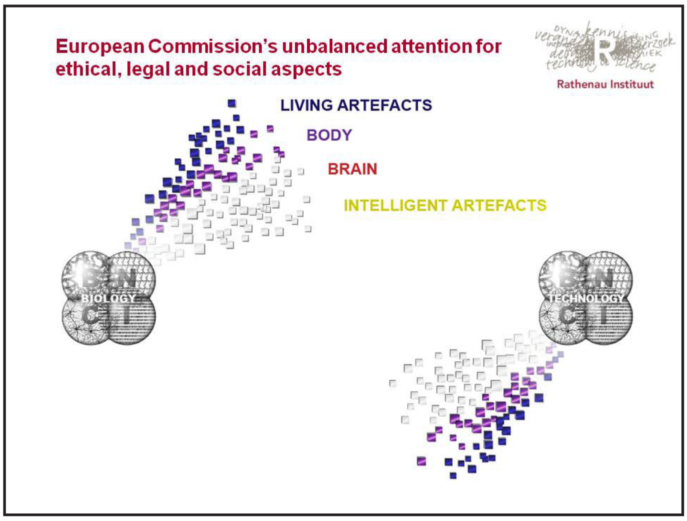
Simulation of friendship

"Bottom-up engineering seeks to harness processes of self-organization that are autonomous, out of immediate control of the engineer." *EU Deepen project (2009: 52)*

Engineering emergence

Remote killing / Dehumanisation of the enemy

European Commission’s unbalanced attention for ethical, legal and social aspects



Conclusions

- From biotechnology to NBIC convergence
  - Promises new types of interventions into living organisms (“*biology becoming technology*”) and bio-, cogno-, and socio-inspired artefacts (“*technology becoming biology*”)
  - Radically broadens the bio-debate
  - Challenges human diginity & regulatory practices
- European Commission’s challenge to safeguard human dignity
  - Attention for ELSA of engineering body & living artefacts
  - Little attention for ELSA of engineering brain & intelligent artefacts
  - Needs a more integral approach to the anticipatory governance of NBIC convergence

Credits

MEPs
Malcolm Harbour
Vittorio Prodi

STOA
Vittorio De Crescenzo

Fraunhofer
Bärbel Hüsling

ITA
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Karen Kastenhofer
Markus Schmidt

KIT
Knud Böhle
Christopher Coenen
Michael Decker
Michael Rader
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Rathenau Institute
Ira van Keulen
Ingrid Geesink
Mirjam Schuijff
Dirk Stemerding

Presentation / project leader
Rinie van Est

Presentation graphics
Niko Vegt

III. Workshop protocol

WORKSHOP DESIGN FOR DEBATE
Het doel van deze sessie is om speculatieve applicaties voor nieuwe technologische ontwikkelingen te bedenken en d.m.v. scenario's (positief en negatief) een dilemma te verbeelden. De eerste opdracht is individueel en bevat het bedenken van een positief en negatief verhaal, waarbij twee kaartensets als inspiratie dienen. Hierbij is het de bedoeling dat de context en gebruiker in beide verhalen hetzelfde zijn. Vervolgens is de opdracht om een applicatie te bedenken die een rol kan spelen in beide verhalen. Je mag op ieder moment vragen stellen.

Na de individuele activiteiten presenteert iedereen zijn/haar scenario's kort. Welk dilemma communiceert de applicatie? Vervolgens is er mogelijkheid tot discussie, met als doel het rangschikken van de gebruikte issuekaartjes in volgorde van urgentie. Tot slot evalueren we de sessie.

1. Uitleg.

2. Technologie kaart. Iedereen krijgt een kaart die een nieuwe technologische ontwikkeling omschrijft (afkomstig van Making Perfect Life). Lees de omschrijving zorgvuldig. Graag aangeven als er iets onduidelijk is.

3. Issue kaart kiezen. Iedereen selecteert vervolgens een kaart uit de set van issues. Schrijf de titel van de twee kaartjes op en omschrijf de redenering achter de keuze voor een bepaald issue.

4. Positief verhaal. Nu is de opdracht om individueel een verhaal te bedenken waarbij de nieuwe technologie ingezet wordt voor een positieve uitwerking van de gestelde vragen op het issuekaartje. Bepaal hiervoor een bepaalde gebruiker (of groep gebruikers) in een bepaalde context.

5. Negatief verhaal. Bedenk vervolgens een verhaal voor dezelfde gebruiker (of gebruikersgroep) in dezelfde context waarbij de nieuwe technologie negatief effect heeft op de issue op het kaartje.

6. Product. In de laatste brainstorm stap maken we de verhalen concreet door een product of service te bedenken die in beide verhalen toepasbaar is en nu zouden kunnen bestaan. Dit product moet in de huidige status van de technologie passen.

7. Presenteren. Iedereen presenteert zijn/haar concrete product of service en de positieve en negatieve verhalen. Wat voor dilemma ontstaat er?

8. Discussie. De dilemma's nodigen uit to discussie. Het doel van de discussie is om tot een volgorde van de urgentie van issues te komen. Hoe is die volgorde gerelateerd aan de toepassingen van een technologie?

9. Evaluatie. Vragen over de invulling van deze sessie:
   a. Had je het idee dat je goed geïnformeerd was om de opdrachten uit te voeren?
   b. Welke elementen inspireerden het meest?
   c. Wat zou je nog meer willen weten om een beter speculatief product te kunnen bedenken?
   d. Hoe zou een speculatief product ingezet kunnen worden?

IV. Workshop card content

BIOMARKERS

now
Disease-associated information at molecular level

near future
Clinical relevance and interventions based on evidence

distant future
More specific diagnostics, new drugs aimed at unknown targets, targeted therapies, personalized therapies, intelligent control of medical implants

GENE THERAPY

now
Clinical trials of gene therapy on somatic cells (not inheritable)

near future
Repair mutated or non-functional genes

distant future
Modification of the human genes

STEM CELL THERAPY

now
Treatments for blood-, and immune system, and cancer

near future
Treatments to regenerate any kind of human cell

distant future
Human cloning for therapies and repoduction

TISSUE ENGINEERING

now
Clinical use for skin and bone replacement, cell-coated devices

near future
Replacing any kind of human tissue

distant future
Prostheses from biomaterial with natural functioning

BRAIN-COMPUTER INTERFACES

now
Research with monkeys, useful for few small patient groups, some simple computer games

near future
Drive a wheelchair, play a computer game, control prostheses through brain activity

distant future
BCI machines and monitoring applications

NEUROMODULATION

now
Treatments for depression, auditory hallucination, ADHD, and Parkinson’s disease (with side-effects)

near future
Treatments for pain, epilepsy, anxiety, empathy, migraine, obesity, Tourette’s syndrome, and Alzheimer’s

distant future
Cognitive enhancement: boosting learning and memory consolidation

IN VITRO ENGINEERING

now
Research on grown brain structures, can serve as a sensitive bio-sensor

near future
Use living neurons as computing elements in tasks commonly solved by computers of non-living material

distant future
Decode information from brain activity, improve or substitute damaged brain function, connect grown brain structure to a body

NARROW REVERSE ENGINEERING

now
Simulate elements of the brain through software

near future
Software model that mimics a brain

distant future
Connect brain model to a robotic body

NEUROMORPHIC ENGINEERING

now
Neuro-inspired computer chips, for investigating of how the brain works

near future
A physical simulation of the brain

distant future
An artificial brain on portable power

HUMANOIDS

now
Simulate the visual appearance of a human being

near future
Simulate the behaviour of a human being

distant future
Simulate a human being, functioning flawlessly in a world designed for humans

ROBOTICS

now
Industrial robots, household robots, robot pets for therapeutic purposes

near future
Multi-disciplinary assistive robots in everyday life

distant future
Robots as ideal social companions with a (simulated) consciousness

SOFTWARE AGENTS

now
At the interface of online services and computer games

near future
Assess emotional states, cool down a debate

distant future
Self-managed computing systems without human interference

AFFECTIVE COMPUTING

now
Adapt a computer application and its interface to the user's affective state

near future
Software reacting on emotions, affect human behaviour

distant future
Adapt a computer application and its interface to the user's emotion and attention

AVATARS

now
In computer games or virtual reality

near future
Mimicking user expressions

distant future
Merge with intelligent software agents

PHYSIOLOGICAL COMPUTING

now
Adapt a computer application and its interface to the unconscious processes of the human body

near future
Use unconscious body input as source of real-time adaptability for computer games

distant future
Intimate computing, using physiological input for improved interaction

PROTOCELLS

now
Attempts to create an active cell from non-living chemical components

near future
Create artificial cell-like devices

distant future
Creating life in a chemical process, not rely on pre-existing cells

STANDARD BIO-PARTS

now
Simple applications with micro-organisms

near future
Increase in available biological building blocks

distant future
Open wetware: DIY engineering of biological systems

XENO-ORGANISMS

now
Altered or non-naturally occurring components within DNA

near future
Unnatural biological building blocks

distant future
Life forms entirely different from ‘life as we know it’

GENOME SYNTHESIS

now
Constructing bacteria (600.000 base pairs)

near future
Constructing more complex organisms (20.000.000 base pairs or more)

distant future
Construct a human genome (3.000.000.000 base pairs)

METABOLIC ENGINEERING

now
Produce an anti-malaria substance by micro-organisms

near future
Redesign the internal structure of micro-organisms to produce raw material

distant future
Redesign the internal structure of any living organism for useful purposes

MINIMAL GENOME

now
Eliminating ‘unnecessary’ genes from natural genomes

near future
A cell as platform for engineered biological systems

distant future
Digital biology, designing new micro-organisms through genome programming

SAFETY

What kind of risks can arise?

Could there be unforeseen side-effects?

Who is affected by these side-effects?

SECURITY

Can the new application become dangerous?

How can new applications be used for negative purposes?

Who benefits from negative purposes?

REDUCTIONISM

Is the complexity of a new intervention or artefact simplified?

Is the complexity underestimated?

Is the simplification acceptable?

PRIVACY

What kinds of information can be retrieved?

How can this information be used?

Who can use this information?

INTEGRITY

Is the new application respectful?

What is or is not respected?

Is the amount of respect acceptable?

DEMOCRATIZATION

Is everyone allowed to use the new application?

Can the availability of the new application be confined?

Who is excluded from the use of the new application?

AUTONOMY

Is the new application totally autonomous?

Why is the new application autonomous?

Do we trust full autonomy of the new application?

RESPONSIBILITY

Is it important to determine who's responsible for the new application?

How can the responsibility be used?

Who is responsible when something goes wrong?

EMOTIONAL BONDING

Do we have an emotional relation with the new application?

How is this emotional relation expressed?

Who has an emotional relation with the new application?

CONTROL

Does the new application provide us total control?

How can we use this total control?

Who is in control of the new application?

SECOND NATURE

Will we become dependent on the new application?

How will we become dependent on the new application?

Who will become dependent on the new application?

V. Workshop results

From the first brainstorm (with design students)

Biomarkers and privacy

The privacy of the information on the patients is important. The information of patients can be used against them by e.g. insurance companies.

The daughter of a serial killer has lived an anonymous life, away from media. Now she has to register her genes to check for which diseases she is susceptible for. The problem she is dealing with is that she is afraid that the test will show that she has the genes of a serial killer, leading to medical & psychological examination. These examination will ruine her life, because the results are shown with all health instances including the one of her neighbor.

Eddie the orphan has lived his cozy life with his foster parents. In his happy adult life he has always wondered whether he has inherited diseases from his biological parents. The new technology of biomarkers has presented him with the possibility to test his genes from illnesses, and know the preventive medical causes, so that he can live his happy life into eternity.

Xeno-organisms and emotional bonding

I chose for this issues because I think it's interesting whether new organisms can reach humans emotionally and if this has to be done thru this particular technology.

In a time far far away, new life forms are created to stimulate an extreme consumption world. The new ones are highly empathic and integrate in the close friendship bond to convince, no to guide people, to buy a certain consumer life style pack. But Simon was talking to his buddy and noticed that there was something up. And he noticed that Carl (xeno-organism) always says the same sentence except this day. Nike came up with a new slogan and so did Carl. Strange…

Creating more empathic and helpful pets for blind elderly. The pet not only helps elderly to dress and wash, but also serves as an awareness display for their own status. When they need to wash themselves, when the pasta is ready, or when it is time to put on warmer clothes. Don't rain dogs, program them with your phone!

Protocells and autonomy

Autonomy is an important point in how 'self-sufficient' we let protocells evolve.

Scientists need medical solutions to fight diseases they don't know.
Protocells are used to create new 'living' antidote.
Once antidote is inserted, we 'trust' in its autonomy.
Kills the disease… but moves on to next cells.
Host dies.

The road is full of snow and there is no end in sight (2036). It's a nuclear winter.
Scientists use the snow itself as free 'catalyst' to cool a chemical environment.
In the chemical environment; snow 'killing' cells evolve (exothermic reaction, excretes water and oxygen)
As long as there is snow, chemical process remains and snow is gotten rid of.
When the snow is gone, the catalyst is gone, so the chemical process stops and the protocells will die.

Stem cell therapy and responsibility

Are you still responsible for your life when you have clones?

People hang out with their own clones.
"What do you want to do tonight Pain?"
"Same thing we do every night"
They want to take over the world with violence.
But the clone gets caught by the sheriff.
It is an unregistered clone though, so Pain is not persecuted.

What happens if you always have an inverted clone with you?
When I'm travelling with my inverted clone and have a car accident there's not a big problem.
I broke my lungs and heart, but my inverted clone just broke his brain.
So after a short transplantation operation I'm fully healthy again.

I just need a new inverted clone.

Neuromorphic engineering and control

Do we have / keep control over artificial brains?
How do we use them?
How do we keep them (just) stupid enough? Or smart in specified subjects?

A brain accelerator card for €50.000,-
You can place this accelerator in your brain and become much better at university.
This is only accessible for those who can afford it, so a strong division will arise between people in society.

People invest in an artificial brain, and use I to make a living.
Artificial brains are used to do 90% of the work we do now, reducing a regular working week to 0,1 fte.
Work, earn money for artificial brain. Then retire at the age of 40.

In vitro engineering and democratization

If everybody gets access to improvements and recovery of brain functions the difference between poor and rich will grow.

People with money buy brain enhancements.
Poor people can't afford this.
Knowledge becomes more important then money and leads to unethicalities.
Poor people die as they are of no use.

"Hello, I'm John"
"I'm Harry"
"Hello, I'm John"
"Ehh, Harry"
"Hello, I'm John"
"Right…"
A robot with brains gives John new brains.
The robot says: "Hi John, you'll get fired"
John: "I remember everything!"
Robot: "That's great John"
John: "But I'm afraid"
Robot: "Don't worry John"

From the second brainstorm (with RI emplyees)

Avatars and emotional bonding

Emotional bonding is important to identify yourself (=actual form of emotional bonding) with it.

My daughter is searching for a suitable study.
Her avatar takes her to different studies and the environments that are connected to it: working in lab, designing, making decisions, and providing descriptions. In this way she can identify herself more (or less) with different study activities and professional activities. She can ask the avatar questions and make it do things and discover different dimensions.

My daughter can become deeply engaged with the game and discover so many possibilities that she can't see the wood for the trees. The feeling that she was searching for – who am I? what am I capable of? what do I want? – seems further away than ever, because her avatar could adopt an endless amount of roles. If there are so many identities that I like, what is my own identity? This is what my daughter can ask herself.

A kind of SIMS where you can walk around in a university and experience study activities as well as a kind of 'internships' showing the relation with a profession. Such a program could also be used in an educative environment, with interviews of students (from the 'real' world), and different professionals.

Minimal genome and democratization

'Public' image. We all own science (culture related). But does that also count for applications?

Bacteria-kit for food: like the fungi on hay, now also bacteria cultures. Back to nature, grow your own food. User = consumer. Use them for mood-enhancers, happy people, flower power.

Quality is not guaranteed. Mood enhancer prohibition, but huge illegal circuit. It's a new kind of soft drug. Because it's an elite drug, it generates organized crime.

A bacteria-kit for fuel or other raw material (pads, Senso Origins: Sensation)

Affective computing and autonomy

If computers can use or react on emotions of people (which they are or are not conscious of) the computer-human relation will shift. It is not a human that steers the computer, the computer will become ‘autonomous’.

A computer could help people that are for example paralyzed to perform certain tasks. A simple example is closing the curtains when the sun is shining in the person’s eye. This creates more autonomy for the patient. The computer could also change the environment as reacting on a certain mood.

Because the computer can pick up emotions it can react at moments that you don’t want it. This would result in restricting your own behavior / autonomy. The computer has too much autonomy in this case, there is no off-button. It could give impulses to calm you if you’re angry, although fights are not necessarily a bad thing. Or your anger could grow and shift towards the computer.

Such a computer could be integrated in a wheelchair. Sensors can be implemented in this wheelchair to enable good monitoring of the users state. This could be useful for people that can’t adjust their environment according to their mood by themselves.

Neuromodulation and control

The availability of neuromodulation treatments ask for doing something about your condition, regardless of what you want. Can we really decide for a treatment or not? This technology will increase the control over certain illnesses.

A person suffering from obesity could get a neuromodulating treatment to reduce hunger. This increases the control over your body, with help of a doctor, and therefore make you feel better. This improves the quality of your life.

The control on your illness has increased, but that doesn’t say that the control over your body has increased. A treatment could have side-effects. The social pressure can make you use the treatment, although you’re actually afraid of the side-effects. Where is the quality of life than? Do you have a choice? You gain control on the illness, but is this control really your own? Who’s actually in control?

Treatments for depression are possible through neuromodulation. The doctor decides what is good for the patient, but the patient has to say yes or no. You can do more or less treatments, this reduces the pressure. But depression is less visible than obesity (the social pressure for obese people is larger).

Narrow reverse engineering (of the brain) and reductionism

It’s assumed that we can simulate brain processes/ to reduce them to information models.

Reductionism is the basis for science. Simplification is used to make things step by step understandable. There is always something like “de lof der zotheid” going on. Complexity is always underestimated. But this underestimation does have a function. Simplification by science is therefore acceptable.

A side-effect of this research field could be that we place the working of the brain on the same level as the model that we make of it. In such a case a new deterministic vision arises on human activities: “it’s my brain model’s fault!”.

A decision maker. A model that is based on the brain that can be used for simple decision making. Like ‘which dress should I wear this evening?’. People can use this ‘decider’ instead of making the decision themselves, like a divining rod.

Stem cell therapy and safety

What happens with unwanted effects? Is stem cell therapy reversible?

If the therapy can be reversed, it will become possible to experiment with it. Like for example athletes that do extreme sports. They can go further because they know they can easily regenerate themselves.

This can result in competition fraud. A kind of doping, with lock-in effect and shifting the boundaries of the human body.

This could result in an Xtreme sports shot, an injection at sore places. A reverse set has to be bought when the injection has negative side-effects.

VI. Personas

Politician

Michelle is a liberal socialist, 43 year old. She comes from a family that has been in politics for centuries. Her father is member of the same national party and her mother is active in regional committees. Michelle was raised with a social liberalism background. The healthcare for elderly and good education is important to her. Currently she's employed as parliamentarian at the European Union. She has studied politics and started her career as sidekick of her father, who has always been a member of the national parliament. At the European Union she's mainly engaged in improving healthcare systems. Her opinion is that the European Union should demand high standards in every EU country because currently some EU countries have "dehumanizing" healthcare facilities. Michelle spends most of her time speaking to other EU parliamentarians to discover what the overall opinion is on this matter. If she has found enough support she will start writing a statement for the European Committee.

Artist-designer

Pete is 31 and works independently. He calls himself an "artist-designer". After his graduation at the design academy, where he created a new kind of furniture that merges with the garden, he started taking all kinds of small assignments from different parties. Since then he could build up a steady stream of incoming assignments, also through friends that are in the same business. So he can rent a little studio apart from the apartment where he lives. What he values most in his work is creation. The subject that he works on is of less importance, as long as it can result in physical objects. The creative process is very visible in his studio. It seems a big mess of all kinds of old try-outs from different projects. But for Pete this mess works inspiring and sometimes he can reuse something that he has done in a previous project. He doesn't work alone most of the time. There are generally always friends around that cooperate in projects.