Responsible Innovation in Practice

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Abstract

Responsible Innovation extends the scope of Corporate Social Responsibility to the development of new technologies and products. In the upcoming EU HORIZON 2020 programme, Responsible Research & Innovation is expected to be an integral requirement for all EU funded projects. However, there are as yet few working instruments available for putting Responsible Innovation into practice. The article will review recent projects where the concept Responsible Innovation and tools for its implementation have been developed. In particular, results of Dutch projects on dual use biosecurity and EU funded projects ObservatoryNano, NanoCode and EthicSchool will be discussed.

1. Introduction

Responsible Innovation is the talk of the town, but there is no consensus on what it means and how to implement it in practice. (Hellström, 2003, van den Hove et al, 2012, Owen et al, forthcoming) Arguably, it extends the scope of Corporate Social Responsibility to the development of new technologies and products. In that sense, experience with instruments for responsible care including accountability for the value chain, occupational health & safety, sustainability and stakeholder dialogue could be useful for responsible innovation as well. In the upcoming EU HORIZON 2020 programme, Responsible Research & Innovation is expected to be an integral requirement for all EU funded projects.[1] In the past decade, the European Commission has gained experience with responsible research in Science and Society and Nanotechnology research programmes. How this experience will be taken into account in the new programme is still a matter of discussion in the EU and its Member States.[2] In any case, there are as yet few tried and tested instruments available for putting Responsible Innovation into practice.

The central research question in this article is: "What is responsible innovation and how can it be put into practice?" This question is specified as follows:

1. Which concept of responsibility is most appropriate for responsible innovation as distinct from related activities such as corporate social responsibility for the life cycle of goods and services?

[1] European Commission, 2011, HORIZON 2020 programme http://ec.europa.eu/research/horizon2020/index_en.cfm?pg=home&video=none (last accessed 27-07-2012)
[2] Mr Philippe Galiay reviewed this experience during the ObservatoryNano workshop on Responsible Research and Innovation, 1-2 February 2012, Brussels. See report at http://www.observatorynano.eu/project/document/3733/ See also the EU nanotechnology strategy http://ec.europa.eu/nanotechnology

2. What are suitable dimensions for an analytical framework for evaluating instruments used for putting responsible innovation in practice?
3. What can be learned from experience with some of these instruments?

In order to answer the first question, the article will start with a brief theoretical discussion of different types of responsibility. This discussion provides arguments for selecting suitable dimensions of an adequate analytical framework in response to question two. Then, the article will review some recent projects where the concept Responsible Innovation and tools for its implementation have been developed. The Dutch programme Responsible Innovation of the funding council NWO[3] has focused mainly on academic research developing the concept "Responsible Innovation". An example is the project biosecurity and dual use research. In the EU funded project ObservatoryNano[4], two tools for responsible innovation have been developed: the Nanometer self-assessment tool and the Ethics Toolkit. In the NanoCode[5] project, a Nanocode meter has been developed. And the EU project EthicSchool[6] has delivered an e-learning DVD on ethics of nanotechnology and converging technologies. These examples will be compared by means of the analytical framework in response to the third question. Learning from experience with these tools, elements of a strategy for practical training in responsible innovation can be proposed, that will be tried out in the follow-up project EthicSchool.

2. Defining responsibility

This section examines which concept of responsibility is most appropriate for responsible innovation as distinct from other activities.

Responsibility is a concept that has been discussed and developed among philosophers as well as policy makers at international level. In the 20th century, the political philosophical discussion about an ethic of responsibility has been tabled by Max Weber (1919). He made a distinction between an ethic of conviction and an ethic of responsibility. The first calls upon a professional politician to carefully choose the right ends for his or her actions and is a form of deontological ethics. The second evaluates the means chosen to achieve those ends, and is a form of consequentialist ethics. (Kim, 2012)

Hans Jonas (1979, 1980) has further developed this ethic of responsibility in relation to progress in science and technology. He analysed the dynamics in technological progress and stressed the fact that this development was human made at a collective rather than individual level. Technology development was not considered to be an autonomous process beyond human control. The technological progress had for the first time in history become so powerful that it was able to cause uncertain future impacts on humankind and the global ecosystem. Whereas such uncertain impacts could turn out to be benefits as well as threats, Jonas called for assuming and acting upon pessimistic future scenarios of technology development endangering the survival of humankind and seriously damaging the global ecosystem. He took the position that people should not be allowed to kill themselves or

[3] NWO website Responsible Innovation theme
http://www.nwo.nl/nwohome.nsf/pages/NWOA_73HBPY_Eng (last accessed 27-07-2012)
[4] www.observatorynano.org
[5] www.nanocode.eu
[6] www.ethicschool.nl/english

others, and certainly not put the survival of the human race at stake. Later scholars have built upon Jonas' work, recognising his valuable contribution to raising awareness of technological risks, but warning that it brought about a "heuristic of fear" that made it difficult to take effective actions to govern emerging technologies. (Grunwald, 2008)

Responsibility for science and technology is not only a concern for philosophers, but also for policy makers at international level. This concern has been expressed in a number of international declarations formulated in the last half century. Prior to any concern with potential negative consequences, academic freedom is granted at an international political level under article 15 of the International Covenant of Economic, Social and Cultural Rights (1966):

"1. The States Parties to the present Covenant recognize the right of everyone:

… (b) To enjoy the benefits of scientific progress and its applications;

(c) To benefit from the protection of the moral and material interests resulting from any scientific … production of which he is the author.

2. The steps to be taken by the States Parties to the present Covenant to achieve the full realization of this right shall include those necessary for the conservation, the development and the diffusion of science …

3. The States Parties to the present Covenant undertake to respect the freedom indispensable for scientific research …

4. The States Parties to the present Covenant recognize the benefits to be derived from the encouragement and development of international contacts and co-operation in the scientific … fields."

Subsequent international declarations concerned with implications of science and technology for the environment, society or the human body since 1972 have placed human beings at the centre of concern for sustainable development. This implies two things: the ecosystem should be able to support human life also in the future, and impacts on society as a whole should be balanced to protect particularly vulnerable people and allow for equal access to the benefits of present and future generations.

In later declarations on implications of science and technology for individuals, society and the environment most responsibility was still granted to States who were called upon to translate the common principles into national legislation. However, the international community, groups and individuals were also given explicit responsibilities. The UN Conference on the Human Environment (1972) considered potential benefits as well as harms of scientific and technological developments to the human environment and set environmental goals. " … To achieve this environmental goal will demand the acceptance of responsibility by citizens and communities and by enterprises and institutions at every level, all sharing equitably in common efforts…" Most responsibility was allocated to local and national governments, but international cooperation was also deemed necessary. Governments and peoples were called upon "to exert common efforts for the preservation and improvement of the human environment, for the benefit of all the people and for their posterity." States were granted the sovereign right to exploit their own resources but also the responsibility to avoid damage to other countries and areas beyond national jurisdiction.[7]

[7] http://www.unep.org/Documents.Multilingual/Default.asp?documentid=97

Twenty years later, the Rio Declaration on Environment and Development (1992) extended the scope of this 1972 declaration to include development of present and future generations of humans, aiming to establish a new and equitable global partnership among States, key sectors of societies and people. Human beings were explicitly placed at the centre of concerns for sustainable development. Whereas most responsibilities for legislation, international cooperation and policy measures including awareness raising and precaution were attributed to States, other groups were also mentioned. All concerned citizens including women, youth and indigenous people and local communities should participate in decision making on environmental issues and cooperate with States.[8]

UNESCO (1997) adopted the Universal Declaration on the Human Genome and Human Rights, granting most responsibilities for creating the right conditions for the exercise of related scientific activity to States, but not exclusively. In general, researchers have responsibilities "including meticulousness, caution, intellectual honesty and integrity in carrying out their research as well as in the presentation and utilization of their findings." Public and private science policy makers and society and all its members were also deemed to have particular responsibilities for research on the human genome. States should raise awareness of these responsibilities and facilitate open international discussion on the subject.[9]

The UNESCO Universal Declaration on Bioethics and Human Rights (2005) broadened the scope of their 1997 declaration to "…ethical issues related to medicine, life sciences and associated technologies as applied to human beings, taking into account their social, legal and environmental dimensions…" "…considering the desirability of developing new approaches to social responsibility to ensure that progress in science and technology contributes to justice, equity and to the interest of humanity…" Whereas the declaration is addressed to States who are given most responsibilities, "…it also provides guidance to decisions or practices of individuals, groups, communities, institutions and corporations, public and private." Decision making should be characterised by professionalism, honesty, integrity and transparency, and regular dialogue and public debate should engage persons, professionals and society as a whole. States should install bioethics committees with particular expert responsibilities.[10]

European policy maker cum philosopher von Schomberg (2007) has made an attempt to develop an ethics of technology into an ethics of knowledge policy and knowledge assessment. He pleads for a collective, process oriented, forward looking concept of co-responsibility involving the whole society to cater for the unintended consequences of progress in science and technology and the implications of collective actions. His new ethic of responsibility has four dimensions: public debate, technology assessment, constitutional change, and foresight and knowledge assessment. (von Schomberg, 2007) Such collective co-responsibility should be organised. However, because the effects of technological progress are uncertain, such a division of labour may result in "organised irresponsibility" as Arie Rip calls it. If every group restricts its own share in the responsibility to the tasks assigned to it,

[8] http://www.unep.org/Documents.Multilingual/Default.asp?documentid=78
[9] http://portal.unesco.org/en/ev.php-URL_ID=13177&URL_DO=DO_TOPIC&URL_SECTION=201.html
[10] http://portal.unesco.org/en/ev.php-URL_ID=31058&URL_DO=DO_TOPIC&URL_SECTION=201.html

nobody is responsible for the common good or for the accumulative or non-linear effects of the collective effort into technological development. (Rip, 2008, see also Malsch & Hvidtfelt-Nielsen, 2009)

In the Netherlands, the NWO programme Responsible Innovation was launched in 2008 and funds "ethical and societal exploration of science and technology". It focuses on new technologies and technological systems in transition that are expected to have a dramatic – positive or negative – impact on society. The aim of the programme is to generate new and more extensive understanding of these issues. Valorisation of results is an important deliverable of the funded projects, not just publications in academic literature. During the first MVI congress 18-19 April 2011, Armin Grunwald (ITAS/TAB) remarked that this innovative MVI programme posed challenges for the field of Technology Assessment and could mark the birth of a new field of Responsible Innovation, and René von Schomberg (European Commission) discussed the European policy-relevance of this programme (von Schomberg, 2012). (MVI website, 2012)

To conclude, the concept of responsibility that is most appropriate for responsible innovation as distinct from other activities takes a consequentialist ethical approach, emphasises ethical more than legal responsibility, at a collective rather than individual level, is prospective rather than retrospective and attributes responsibilities to a heterogeneous group of actors including states, the scientific community, industry and civil society.

3 The analytical framework

The brief overview above of the discussion on responsibility in relation to science and technology suggests some relevant dimensions for an analytical framework for assessing instruments for putting responsible innovation in practice:

- Ethical traditions: deontological, virtue and consequentialist ethics
- Legal versus moral responsibility
- Retrospective versus prospective
- Individual versus collective
- Actor type

3.1 Ethical traditions: deontological, virtue and consequentialist ethics

As noticed above, Weber's ethic of responsibility is a consequentialist form of ethics, distinct from deontological, but also virtue ethics. Deontological ethics evaluates actions based on the right behaviour, irrespective of the consequences. An example of deontological ethics is Kant's categorical imperative: "Act anytime in such a way, that you treat humankind in your own person as well as in any other person simultaneously as a goal in itself, never merely as a means to an end." (Kant: Grundl. Zur Met. der Sitten, cited in Ritter & Gründer, 1989) Legal responsibility is related to deontological ethics in that it is also normative: primarily prescribing the right behaviour. It is different because these legal norms are posited in formal legislation imposed and enforced by the government of a sovereign state. Virtue ethics focuses on individual responsibility for a person's own actions. In relation to nanotechnology, Tsjalling Swierstra and Arie Rip have proposed that virtue ethics would be appropriate to deal with potential societal implications of new and emerging science and technology. (Swierstra & Rip, 2007)

3.2 Legal versus moral responsibility

The relation between legal and moral responsibility is a fundamental philosophical ethical question in its own right that will not be explored in depth in this article. (Hart, 1968, Williams, 2009) In the context of this article, legal responsibility will be interpreted as liability under pre-existing formal legislation posited and enforced by an internationally recognised sovereign state. It is a passive form of responsibility, attributed to any natural or legal person under the jurisdiction of the state in question, whether or not this person takes the responsibility. Responsibilities attributed in international declarations like the ones presented in section 2 have to be posited in formal legislation by states in order to become legally binding. Legal responsibility covers emerging science and technology only to the extent that their properties and effects on humans, society and the environment are predictable and attributable to a particular actor. The discussion in section 2 demonstrates that this is not always the case. Moral responsibility is not limited to formal juridical norms and can in general not be enforced by a state. Moral responsibility can be passive, attributed as well as active, voluntary. Someone can attribute moral responsibility to another person, organisation or group based on ethical principles that are deemed to be commonly shared in a particular area and in a particular period. On the other hand, a person can voluntarily take responsibility for something based on ethical principles he or she adheres to. Attributed and voluntary responsibilities don't always coincide, as there are several different ethical traditions including deontological, consequentialist and virtue ethics. Even if both the person who attributes and the person who is attributed the responsibility subscribe to the same principles, they may draw different conclusions on how to interpret these in practice.

3.3 Retrospective versus prospective

Responsibility can be attributed retrospectively, judging whether or not a past action by a particular natural or legal person violates a pre-existing norm. These norms can be legal (e.g. a nano-enabled novel food product must be tested pre-marketing under EC regulation xxx) as well as moral ("no [Environment, Health, Safety Test] data, no market" for nanomaterials). Responsibility can also be attributed or voluntarily taken for uncertain but foreseeable future consequences of present actions. Prospective responsibility can be attributed to specific actors, but also to more diffuse, heterogeneous groups. E.g. the international declarations presented in section 2 call upon states, the scientific community, industry and civil society to share in a common prospective responsibility.

3.4 Individual versus collective

Responsibilities can be addressed at an individual or collective level. Virtue ethics typically addressed the individual and calls upon him or her to practice virtues deemed valuable by the person in question on a voluntary basis, whether or not others do the same. Other ethical traditions including deontological and consequentialist ethics are relevant to individuals as well as collective actors. As noted in section 2, responsibility for science and technology has to be taken at a collective level. This suggests that virtue ethics is less suitable than other ethical traditions.

3.5 Actor type

The international declarations discussed in section 2 and others attribute responsibilities to different types of actors including states, the scientific community, industry and civil society. For each of these actors to take its particular responsibility for innovation, tools should be available that cater for its needs.

4. Experience with practical tools

Several recent projects have developed and tested practical tools for responsible innovation. What can be learned from experience with some of these tools? Five of them will be reviewed in this section: dual use tools, an Ethics Toolkit, a Nanometer self-assessment tool, a NanoCode Meter, and an EthicSchool e-learning DVD. These tools were selected, because they have been developed fairly recently as instruments in the ongoing discussion on responsible development of emerging (nano)technologies. The tools represent different approaches, which makes it possible to compare and evaluate them. Furthermore, the author has first-hand experience with the tools.

4.1. Dual use tools

In subsequent projects in the Netherlands, a set of tools for governing dual use biosecurity have been developed. A working group of the Royal Dutch Academy of Sciences (KNAW) has developed a biosecurity code of conduct[11] and raised awareness of it among life science professionals. In a later project on Biosecurity and Dual Use Research, funded under the Responsible Innovation (MVI) programme[12], a definition of "dual use" for researchers, universities, companies and policy makers and policy guidelines for science and government have been developed. (Miller et al, 2011)
Interim results were discussed with a valorisation panel during the project, consisting of representatives of research organisations, industry, government, and policy analysts. Due to the active involvement of representatives of key stakeholders in the valorisation panel, these persons were aware of the main issues and recommendation. There is no information on whether or not the results were taken up by the represented organisations. There is some evidence of follow-up activities, including the workshop on "Dual Use Research and Biosecurity: Implications for Science, Governance and the Law", 12 March 2012.[13] This resulted in an international feasibility study on the governance of infectious disease. The target groups are mainly public research organisations and government organisations.

4.2 The Ethics Toolkit

According to its co-developer Alexei Grinbaum, the ObservatoryNano Ethics Toolkit is an attempt to inspire and provide a language for non-ethicists working with technology that

[11] http://www.knaw.nl/Pages/DEF/28/449.bGFuZz1FTkc.html
[12] http://www.nwo.nl/nwohome.nsf/pages/NWOP_8FDG75 / http://www.ethicsandtechnology.eu/research/projects/biosecurity_and_dual_use_research/
[13] http://www.thehagueinstituteforglobaljustice.org/cp/uploads/agenda/120323%20FINAL%20Workshop%20Summary%20Report%20_1332495029.pdf

may cause ethical concern or ethical dilemmas at any level: research, technology development or in practice. The toolkit points to relevant concepts in order to facilitate a reflection of the practitioner with new insight, new language and new inspiration. It is an example of the approach of ongoing normative assessment. (Dupuy & Grinbaum, 2005) It is primarily intended for and has been tested on a scientific audience. The toolkit consists of an introduction, a glossary and four parts with different ethical tools scientists may use in dialogue with stakeholders. These include a classification of the issues, ethical concepts, responsible communication and narratives. The issues classification was deemed the most operational part of the toolkit. The ethical concepts-part was either considered too superficial by scientists wanting to learn more about ethics, or uninteresting by people who preferred to stay at an operational level. The part on responsible communication was considered insufficiently focused. The narratives proved useful to open the discussion, but their relationship with actual research was unclear, and they were culture dependent. Their emotional character was controversial: some appreciated it, others preferred rational argumentation. (Pavlopoulos et al, 2010, Grinbaum & Bontems, 2012) The toolkit is apparently still a work in progress, and the present form of a 75 page report may not be the most accessible form for an ethics toolkit for non-ethicists as a stand alone tool. The toolkit has been tested in workshops and conferences with 10-100 participants, where scientists were after an introduction able to use it as a resource in discussions. It could therefore be a useful document in interactive dialogues and education. The results of the tests have been reported by Grinbaum & Bontems (2012).

4.3 The Nanometer

The Nanometer is an online self-assessment tool for responsible nano-enabled product development. It was first developed in the EU funded Nanologue project as an instrument for assessing opportunities and risks of nanotechnology applications,[14] and further developed as one of the business tools in the EU funded ObservatoryNano project.[15] It helps users map their best estimates of a wide range of environmental, health, safety as well as ethical and societal aspects of a concrete nano-enabled product they want to introduce in comparison with existing alternative products. In addition, the Nanometer gives access to sources of information about specific issues, summarised in reports and briefings on the ObservatoryNano website. The Nanometer was deemed useful as an instrument in standardisation and communication of companies with their shareholders about potential risks and benefits of their products and for demonstrating progress towards risk governance. Expanding the scope to a more general Innovationmeter was recommended.[16] One of the first EthicSchool workshops will raise awareness of the Nanometer to entrepreneurs and professionals in nano-innovation and stimulate them to use it for their strategy development.

[14] http://www.nanologue.net/

[15] http://www.observatorynano.eu/project/questionnaire/nanometer

[16] Discussed during the ObservatoryNano workshop on Responsible Research and Innovation, 1-2 February 2012, Brussels. See report at http://www.observatorynano.eu/project/document/3733/

4.4 The NanoCode Meter

In 2008, the European Commission recommended a code of conduct for nanoresearch, consisting of seven ethical principles: meaning, accountability, excellence, precaution, sustainability and innovation. This code of conduct should be implemented by the EU Member States. (EC, 2008) After two years, the NanoCode project evaluated its implementation and proposed a practical NanoCode Meter as a self-assessment tool for research performers engaging with the tool on a voluntary basis. It takes the form of a structured questionnaire embedded in an excel document that can be downloaded from the nanocode website. The NanoCode Meter has been tested during the project. It was found to be most applicable to decision makers in public research organisations. Recommendations were made to extend its scope including lower ranking researchers and private companies, by building in flexibility. In its present form the NanoCode Meter is particularly suitable as a self-assessment tool, but adaptation as an instrument for assessing applications for EU funding could be envisaged. This would require measures to protect the privacy of users.[17]

4.5 The EthicSchool e-learning DVD

Another EU funded project, EthicSchool, produced 500 copies of a set of e-learning DVDs on Ethics of Nano- and Converging Technologies (nano- bio-, information technologies and cognitive sciences). These DVDs included presentations and background materials of two summerschools on these topics for PhD-students and young researchers held in 2008. The contents review current scholarly debates on ethics of emerging technologies. Topics of the first DVD on nanoethics are:

- Practical exercises stimulating debate on ethical dilemma's
- Presentations and background information
- Introduction in the main ethical theories
- Ethics of nanomedicine
- Nanoelectronics
- Military and Dual Use Nanotechnology
- Governance of nanotechnology

The second DVD on ethics of converging technologies covers more philosophical discussion of these topics:

- Framing the debate about Converging Technologies
- Blurring the Boundaries: Organism and Artefact in the Age of Technoscience
- Enabled through Technology: Human Beings in the Convergence
- In*corp*orating the Mind: The Place of the "C" in NBIC
- Excess and Control: Global Abundance in a Limited World?
- Good Housekeeping: The Political Economy of Information and Control in Smart Environments

The DVDs can be used as a resource in academic curricula or for individual training. The 500 copies have been distributed to users inside and outside Europe since 2009, but the impact of the project in terms of actual use has not been measured. The DVDs are only intended for offline use. The follow-up project EthicSchool builds upon the experience in the EU funded project, integrating elements in workshops and training on responsible innovation. In September 2012, 23 out of 162 people who had been sent the DVD and whose e-mail

[17] http://www.nanocode.eu/

address had been retained responded to a survey of their experience with it. This is a response rate of around 14%.

Received DVD		How did you use it		What did you use	
In 2009	10	Individual self-study	14	All materials	9
Later	3	Group	3	Most parts	1
Don't know	4	No answer	2	Some parts	6
Not	4	Not	4	Unspecified	3

It appears that about half of the respondents received the DVD when it was ready by the end of the project. Unfortunately several people had not received the DVD, which was sent out all over the world. Most respondents used it for self-study. One of the respondents who used the DVD in groups did this in lectures for students, one to prepare a status report on NBIC, and one did not specify the group. About half used all and about half part of the materials.

The contents of the DVD were evaluated differently. Two people just said the DVDs were good without further explanation. On the other hand, one person did not find the DVDs "too useful at all". Most respondents mentioned one or more specific strengths or weaknesses, suggested improvements or other comments. Strengths included strategic impacts of the DVDs, representation of scholarly debate, technical aspects and individual usefulness. Suggestions for improvements were to add contents (basic information, index of literature and interactive sessions), technical (sound quality), and to adapt the contents to the needs of developing countries. Weaknesses were the Euro-US-centric focus of the contents, language barriers, cost-benefit balance, presentation (long talks) and technical (installation). Other comments were about the future of EthicSchool, language problems in teaching nanoethics and respondents' own research and teaching. All in all there were more positive than negative comments.

5 Comparing the tools

The tools can be compared in five dimensions of the analytical framework related to the concept of responsibility (see table 1 below).

- Ethical traditions: deontological, virtue and consequentialist ethics
- Legal versus moral responsibility
- Retrospective versus prospective
- Individual versus collective
- Actor type

Tool	**Dual use tools**	**Ethics Toolkit**	**Nanometer**	**NanoCode Meter**	**E-learning DVD**
Types of ethics	Deontological	Virtue, deontological, consequentialist	Consequentialist	Deontological	Virtue
Legal-ethical	Mix ethical and legal	Ethical	Ethical	Mix ethical and legal	Ethical

Prospective-retrospective	Prospective and Retrospective	Prospective	Prospective	Prospective	Prospective
Individual-collective	Collective (organisation)	Individual & collective	Collective (organisation)	Collective (organisation)	Individual
Actor type	Government	Academic	Industry	Academic	Student

Table 1: Comparing the tools for putting responsible innovation in practice in five dimensions.

The dual use tools and NanoCode Meter can be characterised as predominantly deontological. They are positioned in a legal framework and proposed by advisors reasoning from a governmental perspective. The tools can be interpreted as attempts at finding viable solutions to expand these legal rules to areas of research and innovation suspected to be potentially contributing to future violations of these rules. The DVD primarily furthers virtue ethics – while also explaining other ethical traditions - due to its focus on individual users. The Ethics Toolkit presents arguments from all three ethical traditions. Only the Nanometer can be considered primarily consequentialist, as it aims at guiding innovative companies searching for potential future consequences of their nanoproduct in development. However, its scope is limited in time and impact.

Three tools are mainly aimed at supporting moral responsibility, by non-state actors involved in activities with uncertain future consequences. However, the dual use tools were developed in a context where legal and moral instruments for governing biosecurity are mixed. On the one hand, misuse of life sciences for hostile purposes is legally forbidden in States Parties to the BTWC convention. This convention obliges these States to implement its regulations in national law and to prosecute perpetrators under their jurisdiction. On the other hand, many of these States Parties have resorted to convincing the scientific community in their country to adopt voluntary biosecurity codes of conduct for dual use research, education and related activities rather than formal legislation. The boundary between accountability under the law and voluntary moral responsibility is not always clear to the scientists concerned. The recent public debate about the freedom of publication and research surrounding results of studies of transfer mechanisms of H5N1 virus are a case in point.[18] Similarly, the NanoCode Meter is developed as an instrument for measuring compliance with a form of soft law, the European Commission's code of conduct for nanoresearch. (EC, 2008) This again mixes compulsory legal and voluntary ethical aspects – though less prominently than in the case of the biosecurity code.

Four tools are prospective in the sense that they assist decision making on actions with to some extent uncertain future consequences. The dual use tools are distinct, because they address the needs of both regulators and research practitioners and hence intend to improve both retrospective legislation and prospective research strategies.

The DVD is mainly intended for individual users, informing them so as to be able to make better personal decisions. The approach in these is predominantly virtue ethics, even though

[18] http://www.sciencemag.org/site/feature/data/hottopics/biosecurity/

deontological and consequentialist traditions are also explained. The other three target the needs of organisations involved in innovation, and therefore presuppose a collective concept of responsibility. The Ethics Toolkit is intended for use in groups, but can also be used by individuals. Collective and individual responsibilities are addressed.

The tools are primarily intended for different user groups. The dual use tools are mainly addressed to government policy makers. The Ethics Toolkit and NanoCode Meter are most adapted to the needs of academic researchers – whereby the Nanocode Meter is even more focused to those in decision making positions. The Nanometer is intended as a tool for industry and the E-learning DVD for students – both participating in formal education and for self-study.

Taken together, the tools form a broad and varied set of instruments that can support different stakeholders engaged in responsible research and innovation. As yet, it is not a comprehensive set. For example, none of these tools explicitly caters for the needs of civil society actors who are increasingly involved in dialogue and in some cases also in decision making on innovation. (c.f. Malsch et al, 2012) Even though the tools are suitable for individual use without prior training, they may only contribute in a substantial way to responsible innovation by employment in a societal context. This could be a workshop, an education curriculum or a project where the tools can be developed further and tested.

6. Conclusions

This article is an attempt at answering the question: "What is responsible innovation and how can it be put into practice?"
Following Weber and Jonas, responsible innovation calls for a consequentialist ethical approach because it evaluates the means that are chosen to further progress in science and technology, goals that are in general not restricted a priori on ethical grounds. This consequentialist ethics is required for those aspects of innovation that are different from other related activities such as manufacturing of products and individual voluntary moral choices. The difference can be that the possible implications of the innovation are uncertain or that effects can not be attributed to a single actor. To the extent that innovation is similar to these other activities, the same approach to responsibility can be taken. E.g. methods and tools for implementing Corporate Social Responsibility should also be used for incremental innovation, where the possible effects can be estimated with a reasonable amount of certainty. And a virtuous individual researcher can voluntarily choose to work on topics with a particular societal relevance such as a therapy for an incurable disease, or water purification for developing countries.
A brief overview of the discussion of responsibility in relation to science and technology suggests an analytical framework for evaluating instruments for putting responsible innovation in practice that includes five dimensions:

- Ethical traditions: deontological, virtue and consequentialist ethics
- Legal versus moral responsibility
- Retrospective versus prospective
- Individual versus collective
- Actor type

These dimensions are not independent, but emphasize different aspects that are important for better understanding responsible innovation.
In this article, five recent tools for putting responsible innovation into practice were compared. Not all tools take a consequentialist ethical approach stimulating collective prospective responsibility for new and emerging technologies. Several tools extend tried and tested methods for putting responsibility into practice including legislation, individual virtues, corporate social responsibility etc towards innovation. As has been argued in this article, this may not be adequate for new and emerging technologies that are very different from existing systems and products. The uncertain effects that are not attributable to individual actors call for new consequentialist ethical methods for putting collective, prospective moral responsibility into practice – in addition to the existing instruments. The Ethics Toolkit and Nanometer self-assessment tools are interesting first steps in this direction, but should be developed further.

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References

Alexander, Larry and Moore, Michael, "Deontological Ethics", *The Stanford Encyclopedia of Philosophy (Fall 2008 Edition)*, Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/fall2008/entries/ethics-deontological/>. (last accessed 2-8-2012)

Bonazzi, Matteo, "Communicating Nanotechnology; Why, to whom, saying what and how?" European Commission, Brussels, 2010, http://cordis.europa.eu/nanotechnology/src/publication_events.htm

Dupuy, Jean-Pierre & Alexei Grinbaum (2005) Living with Uncertainty: Toward the Ongoing Normative Assessment of Nanotechnology, in *Techné: Research in Philosophy and Technology* Vol 8, Nr. 2, Spring 2005,

http://scholar.lib.vt.edu/ejournals/SPT/v8n2/grinbaum.html (last accessed 2-8-2012)

EC, "Commission Recommendation of 07/02/2008 on a code of conduct for responsible nanosciences and nanotechnologies research" European Commission, 2008, Brussels, C(2008) 424 final http://ec.europa.eu/nanotechnology/pdf/nanocode-rec_pe0894c_en.pdf (last accessed 27-07-2012)

Free dictionary, the, http://www.thefreedictionary.com/subsidiarity (accessed 2010)

Grinbaum, Alexei & Vincent Bontems, The Ethics Toolkit, chapter 2 in Malsch, Ineke, Alexei Grinbaum, Vincent Bontems and Anne-Mette Fruelund Andersen (2012) Communicating Nanoethics, ObservatoryNano, March 2012, http://www.observatorynano.eu/project/document/3755/ (last accessed 30-07-2012)

Grunwald, A. (2008). Nanoparticles: Risk Management and the Precautionary Principle. In F. Jotterand (Ed.), *Emerging Conceptual, Ethical and Policy Issues in Bionanotechnology* (pp. 85-102). Berlin: Springer Science + Business Media.
Hart, H.L.A. (1968), "Punishment and responsibility" Oxford University Press, Oxford
Hellström, Tomas (2003), Systemic innovation and risk: technology assessment and the challenge of responsible innovation, in *Technology in Society* Vol 25, Iss. 3, August 2003, pp 369-384 http://www.sciencedirect.com/science/article/pii/S0160791X03000411 (last accessed 2-8-2012)
Jonas, Hans, "Das Prinzip Verantwortung. Versuch einer Ethik für die technologische Zivilisation" Frankfurt/M, 1979
Jonas, H. (1980). The Heuristics of Fear. In M. Kranzberg (Ed.), *Ethics in an Age of Pervasive Technology*. Boulder, Colo.: Westview Press.
Kim, Sung Ho, "Max Weber", *The Stanford Encyclopedia of Philosophy* (Fall 2012 Edition), Edward N. Zalta (ed.), forthcoming URL = http://plato.stanford.edu/archives/fall2012/entries/weber/ (last accessed 10-09-2012)
Malsch, Ineke & Kristian Hvidtfelt-Nielsen (2009) Individual and Collective Responsibility for Nanotechnology, ObservatoryNano, 30 March 2009, http://www.observatorynano.eu/project/catalogue/4RC/
Malsch, Ineke, Alexei Grinbaum, Vincent Bontems and Anne-Mette Fruelund Andersen (2012) Communicating Nanoethics, ObservatoryNano, March 2012, http://www.observatorynano.eu/project/document/3755/ (last accessed 30-07-2012)
Miller, Seumas, Michael J. Selgelid and Koos van der Bruggen (2011), Report on Biosecurity and Dual Use Research; a report for the Dutch research council, 3TU Centre for Ethics and Technology, Delft, January 2011, http://www.unog.ch/80256EDD006B8954/(httpAssets)/1390D426940BD24EC125785B004D3E96/$file/Miller+et+al+-+Report+on+Biosecurity+and+Dual+Use+Research.pdf (last accessed 30-07-2012)
MVI website, 2012, http://www.nwo.nl/nwohome.nsf/pages/NWOA_73HBPY_Eng (last accessed 30-07-2012)
Owen, Richard, John Bessant & Maggy Heintz (eds) (forthcoming) Responsible Innovation, John Wiley and Sons
Pavlopoulos, Marc, Alexei Grinbaum and Vincent Bontems (2010) Toolkit for Ethical Reflection and Communication, ObservatoryNano, June 2010, http://www.observatorynano.eu/project/catalogue/4ET/ (last accessed 30-07-2012)
Rip, Arie, „A conversation on Governance of Nanotechnology", Interviews with opinion leaders on individual and collective responsibility for nanotechnology, Observatorynano, 16 October 2008, http://www.observatorynano.eu/project/document/2179/ (last accessed 15-10-2010)

Risser, David T, Collective Moral Responsibility, in Internet Encyclopedia of Philosophy, Last updated December 14, 2009, Originally published: July 6, 2004, http://www.iep.utm.edu/collecti/ (last accessed 15-10-2010)

Ritter, Joachim & Gründer, Karlfried, "Historisches Wörterbuch der Philosophie," Schwabe & Co Ag, Basel, 1989

Sinnott-Armstrong, Walter, "Consequentialism", *The Stanford Encyclopedia of Philosophy (Winter 2011 Edition)*, Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2011/entries/consequentialism/>.

Swierstra, Tsjalling, Rip, Arie: “Nano-ethics as NEST-ethics: patterns of moral argumentation about new and emerging science and technology,” *NanoEthics* 1 (2007) 3-20

van den Hove, Sybille, Jacqueline McGlade, Pierre Mottet, Michael H. Depledge (2012) The Innovation Union: a perfect means to confused ends? in *Environmental Science & Policy,* Vol 16, February 2012, pp 73-80
http://www.sciencedirect.com/science/article/pii/S1462901111001778 (last accessed 2-8-2012)
van der Bruggen, Koos, Possibilities, intentions and threats: dual use in the life sciences reconsidered, in *Science and Engineering Ethics* online first, 17 February 2011,
http://www.springerlink.com/content/27481463g7w32528/ (last accessed 2-8-2012)
von Schomberg, René, “From the ethics of technology towards an ethics of knowledge policy and knowledge assessment,” European Commission Working Document EUR 22429, Brussels, 2007,
http://ec.europa.eu/research/sciencesociety/pdf/ethicsofknowledgepolicy_en.pdf
von Schomberg, René (2012) Prospects for Technology Assessment in a framework of responsible research and innovation, in *Technikfolgen abschätzen lehren,* Teil 1, pp 39-61
http://www.springerlink.com/content/h7480gj77j862qj0/ (last accessed 2-8-2012)

Weber, Max, 1919/1994. “The Profession and Vocation of Politics” in *Max Weber: Political Writing*.

Williams, Garrath, “Responsibility”, in Internet Encyclopedia of Philosophy, Last updated March 9, 2009, Originally published, July 19, 2006, http://www.iep.utm.edu/responsi/ (last accessed 15-10-2010)