FORESIGHT IN RTD PROJECTS

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Abstract: A foresight or future thinking process inside a technology research project provides an interactive process between stakeholders including the project partners aiming at optimum impact of the research results. Foresight processes cover several dimensions such as technological impact assessment, social developments, economic aspects, and future of education, or policy aspects. Hence, a foresight process supplies information about social, economic, ecological, political, cultural, and technological notions of the future and possibilities for robust scenarios in these areas.

Science and technology research projects often focus only on specific science and technology challenges and problems. Considering the adjacent disciplines and fields and the view on the impact on possible market, on the ecology (e.g. life cycle assessment), on society with education aspects can also open the science and research work to new dimensions during the project.

The objective of this paper is the presentation of a concept for future thinking processes, so called foresight in RTD projects. This foresight has the purpose to describe and estimate the impact on and from adjacent fields. It also tries to strengthen the impact of the science and technology results of the RTD work on economy, society, ecology, and also on policy. The paper works out methodologies for such a foresight process during an RTD project.

The applied methodology is based on the experience of the authors in foresight processes on the one hand and on experiences in science and technology development processes on the other hand.

We give an overview of applicable foresight methodologies, such as drivers identification and scenarios development, etc. Additionally, the paper works out specifics requirements for RTD projects. The presented concept includes possible process steps, process description, benefits, and discussion points.

Keywords: foresight, RDT projects, future thinking in RTD projects

Introduction and Objective

The broad aim of technology foresight is to identify emerging generic technologies likely to yield the **greatest economic and social benefits** with the **optimal impact on ecology.**

Foresight is a structured futures' dialogue involving thinking the future, debating the future, shaping the future in order to underpin future oriented decision making and enhance dynamic capability.

Foresight can be characterised as **systematic** with deploying formal methods for generating and collective intelligence out of a diversity of perspectives and anticipatory intelligence beyond linear extrapolation of today, **participatory** which means involving key stakeholders, **non-deterministic** such as forecasting a given future but exploring the potential of the present to evolve into different futures, and **holistic** with exploring the complex interplay of social, political and technological change.

A foresight approach addresses

- Diagnosis: Understanding the current dynamics of change
- Exploration: Challenging underlying assumptions, exploring different futures
- Visioning: Debating values and exploring desirable futures
- Prescription: Exploring strategic options

The term "Technology Foresight" took off in the 1990s, as European and then other countries sought new policy tools to deal with problems in their science, technology and innovation systems. Large-scale exercises drew in numerous stakeholders as sources of knowledge and influence, and the prominence of these exercises led to "foresight" being used much more widely to describe future activities of many kinds. While few new tools and techniques have been developed in these exercises, they represent an unprecedented diffusion of forecasting, planning and participatory approaches to long-term issues. Future approaches are, in consequence, far more officially acceptable and legitimate than in the past[1].

'Technology Foresight' is a term now widely used by academic researchers, policy-makers, industrialists, consultants and others around the world[2]. The term is now often used to respond to

1 Miles I. The development of technology foresight: A review, Technological Forecasting and Social Change, Volume 77, Issue 9, November 2010, Pages 1448–1456

2 Martin B.R. The origins of the concept of 'foresight' in science and technology: An insider's perspective, Technological Forecasting & Social Change 77 (2010) 1438–1447

the emerging needs of private and public sector organizations in the highly competitive global environment. The history of the subject and its variant forms, including impact assessment, national foresight studies, road-mapping and competitive technological intelligence shows how it has responded to changing institutional motivations.[3]

In the last decades "Technology foresight has emerged as a prominent instrument of technology policy" at national or regional level and it has also become relevant for private companies. Literature on "Technology foresight" therefore now mainly addresses strategic regional, national processes which aim at the development of innovative futures or the strategic enhancement of innovativeness or the selection of future technology fields.[4]

As foresight has become very fashionable in the last decades some authors (e.g. Havas et al.) describe impacts of foresight on innovation policy-making. They point out that foresight should not be conducted for its own sake or just because it is currently 'fashionable' throughout the world and being promoted by international organisations and describe within the context of policy-making four future directions of foresight: Foresight as

- a sophisticated policy informing tool;
- an integral part of policy processes;
- a pacemaker for building up reflexivity;
- a tool for impact assessment.

Foresight has evolved as a distinct prospective analytical tool: it considers alternative futures of various science and technology fields or socio-economic systems by bringing together the perspectives of various stakeholder groups, and thus assists the decision-making processes at different levels. Havas et al. delivered a framework to classify the impacts of foresight activities (see table in Figure 1)[5].

3 Coates V. et al. On the Future of Technological Forecasting, Technological Forecasting and Social Change, Volume 67, Issue 1, May 2001, Pages 1–17

4 See for example:

Georghiou L. The UK technology foresight programme, Futures, 1996 – Elsevier;

Martin BR., Johnston R. Technology foresight for wiring up the national innovation system: experiences in Britain, Australia, and New Zealand;

Grupp H., Linstone HA. National technology foresight activities around the globe: resurrection and new paradigms, Technological Forecasting and Social Change, 1999 – Elsevier;

Georghiou L. The handbook of technology foresight: concepts and practice 2008

5 Havas A., Schartinger D. and Weber M. The impact of foresight on innovation policy-making: recent experiences and future perspectives, Research Evaluation, 19(2), June 2010, pages 91–104

Literature also provides several examples for useful support of strategic processes and technology developments within companies through foresight elements.[6] Rohrbeck and Gemünden aim to explore the ability of corporate foresight to increase the innovation capacity of a firm. They differentiate into the capacity to innovate incrementally, i.e. enhanced or new products and services within a current business field and the capacity to innovate radically, i.e. creating products and services in new business fields often using new technologies. Ruff F. focuses on the practice of corporate foresight within a multinational automotive company. He portrays how the early detection of medium- to long-term developments in the broader business environment, including social and market developments, is integrated into innovation and strategy processes.

Furthermore various companies have implemented a foresight process into their strategy development. A pioneer of corporate foresight processes is Shell[7]. Royal Dutch Shell (commonly known as Shell), a well-known oil and gas industry company, started foresight processes after the oil crises in the 1970th. They call this process "Shell Scenarios". They argue:

"Our scenarios ask "what if?" questions, helping us explore alternative views of the future. They consider long-term trends in economics, energy supply and demand, geopolitical shifts and social change. They also help governments, academia, and other businesses understand the possibilities and uncertainties ahead."

Over time, Shell Scenarios have gained a global following among governments, academia, and business. The scenarios provide a clearer view and new lenses on the future.[8] (see footnote 7 and footnote 8).

Eriksson A. and Weber K.M. consider adaptive foresight as a foresight process in the context of strategic planning. They argue that foresight is increasingly required to deliver coherent and co-ordinated support to the formulation of strategic agendas for action, both in the public and the private sector. Innovation is seen as increasingly complex, interdependent and uncertain and

6 See for example:

Rohrbeck R., Gemünden H.G. (2011) Corporate foresight: Its three roles in enhancing the innovation capacity of a firm, Technological Forecasting and Social Change, 78(2), 231-243.;

Vecchiato R. and Roveda C. (2010)Strategic foresight in corporate organizations: Handling the effect and response uncertainty of technology and social drivers of change, Technological Forecasting and Social Change, Volume 77, Issue 9, November 2010, Pages 1527–1539

Ruff F. (2006)Corporate foresight: integrating the future business environment into innovation and strategy, Journal International Journal of Technology Management, Issue Volume 34, Number 3-4/2006, P. 278-295

7 Paul J.H. Schoemaker, Cornelius A.J.M. van der Heijden. (1992). Integrating scenarios into strategic planning at Royal Dutch/Shell. IN: Planning Review 1992 20:3 , 41-46. http://dx.doi.org/10.1108/eb054360

8 http://www.shell.com/energy-and-innovation/the-energy-future/shell-scenarios.html

therefore in need of broad and multi- disciplinary exploration and participation. The authors indicate that to be perceived as useful and effective, forward-looking exercises must enable decision-makers to better understand and cope with this interactive, complex and inherently uncertain character of innovation. This requires first of all that these approaches are based on and reflect an appropriate understanding of the changing characteristics of innovation and decision-making. Secondly, they should contribute to the mobilisation and coordination of the decision-making by different actors. Thirdly, they must be able to deliver insights on possible strategies and options for individual actors on how to "change course" and direction, or at least enable to think "out of the box" about qualitatively different approaches and strategies.9

However, when regarding foresight as a strategic supportive element on a project level, e.g. within large-scale European RTD (Research Technology Development) projects very little literature can be found. Silva M. recently reviewed leading literature on project management concerning foresight elements. Based on the results of the review she finds evidence that there is value in adopting foresight within project management (with certain limitations). [10]

The European project 3D-LightTrans used experiences gained within the project for the **development of a concept using specific** future thinking techniques for large RTD projects. In order to ensure the industrial relevance of the research of the project, the cost effectiveness and commercial potential of the innovative technologies compared to state-of-the-art solutions on the market it was required to do a quantitatively monitoring of the RTD project. During the project it became clear that a foresight process covering the aspects of several dimensions regarding society, economy, ecology, and industry together might serve this demand. [11]

9 Eriksson E.A. and Weber M. (2008). Adaptive foresight: navigating the complex landscape of policy strategies. Technol. Forecast. Soc. Chang. 75 (4), 462–482 (May).

10 Silva M. (2015) A systematic review of Foresight in Project Management literature, Procedia Computer Science 64 (2015) 792 - 799

11 Almansa M.A., Kny E., Wepner B., Kasztler A., and Hörlesberger M. (2015) 3D Light Trans, Deliverable 5.14, Market Analysis, Part 4 RTD Project Foresight

Function	Time lag	Targeted and/or unintended impact
Informing	Immediate	• Increased recognition of a topic area • Individual learning: awareness of science, technology and innovation options among players, fostering debate • Context and views of other stakeholders become clearer • Foresight skills are developed in a wider circle • New network options through dialogues in new combinations of experts and stakeholders, shared understanding (knowledge network)
	Intermediate	• Realisation and continuation of established common understanding
	Ultimate	• Integrating able new actors and their views and inputs into the community that is shaping an area of concern
Advisory	Immediate	• Making hidden agendas and objectives explicit • Effective actions taken
	Intermediate	• Devising recommendations and identifying options for action • Activating and supporting fast policy-learning and policy-unlearning processes • Identify hidden obstacles to the introduction of more informed, transparent, open participatory processes to governance
	Ultimate	• Influence on (research/ policy) agendas of actors, both public and private (as revealed, for instance, in strategies and policy programmes) • Formulation and implementation of new policies • Incorporating forward-looking elements in organisations' internal procedures
Facilitating	Immediate	• Initiating collective learning processes • Articulation of common visions of the future, establishing longer-term perspectives • Awareness of systemic character of change process
	Intermediate	• Formation of action networks • Creation of follow-up activities • Development of new projects
	Ultimate	• Adoption of foresight results in the research and teaching agenda of organisations as well as in various disciplinary matters • Increasing the coherence of policies • Cultural changes towards longer-term and systemic thinking

Source: AIT, building on Cassingena Harper and Georghiou (2005); ForSociety (2007); and PREST (2006)

Figure 1. Table from Havas A., Schartinger D., and Weber M. (2010). The impact of foresight on innovation policy- making: recent experiences and future perspectives, Research Evaluation, 19(2), pages 91–104.

In this paper we refer to and further develop this concept based on empirical data and on literature by addressing the research question, how can foresight elements support RTD processes within large-scale European RTD projects.

Hence, the objective of this paper is the presentation of a concept for future thinking processes, so called foresight in RTD projects. This foresight has the purpose to strengthen the impact of the science and technology results of the RTD work on economy, society, ecology, and also on policy. The paper works out methodologies for foresight processes in RTD projects with various organisations (with those a project work requires).

Why is it important to do future studies also for RTD projects with various organisations on a

public research level? Andersen and Andersen[12] worked out the different generations of innovation systems and the development of the complexity in of the innovation process. The rising complexity of technology and innovation limits the value of an organisation internal knowledge. They present the link between innovation systems and foresight. The growing importance of external linkages suggests a systems approach to understanding innovation that focuses not only on the performance of individual organisation but also on how they are embedded into complex social and economic relationships in their environments. Martin describes the main drivers of change in the global economy over coming decades can be in the 'four Cs': increasing ***C***ompetition, increasing ***C***onstraints on public expenditure, increasing ***C***omplexity, increasing importance of scientific and technological ***C***ompetencies. [13] Therefore the scope of actions for individual actors regarding the achieved results of an RTD project on a public research level is limited and therefore requires coordinated actions.

- There is an increase of independence and international networking so that the classical planning cannot manage the complexity of affected fields in RTD projects with various organisations on a public research level.
- The change in science and society is accelerating so that scenarios beyond short-term planning are necessary also for achievements and the affected group of RTD project.
- EU calls more and more requires foresight processes in RTD projects.
- The implementation of concrete decisions needs mobilization through participation.

In addition Europe research projects lags for commercialisation of the developed technology and innovation (the so-called 'Valley of Death'). The implementation of foresight processes in research projects is able to underpin the commercialisation process.

12 Andersen A. D. and Andersen P. D. (2014). Innovation system foresight. Technological Forecasting and Social Change, 88(0), 276-286. doi: http://dx.doi.org/10.1016/j.techfore.2014.06.016.

13 see

Martin, B.R. (2001). Technology foresight in a rapidly globalizing economy.

and also

Cuhls, K. (2012). Zukunftsforschung und Vorausschau. In: FOCUS-Jahrbuch 2012.

Approach

A foresight process supports the success of an RTD project because it draws attention more consciously to the impact on science and technology, the environment, the stakeholders, the possible impact on economy, society, and even policy. Such a process sharpens the problem and research questions on the one hand and opens the possibilities for further applications on the other hand. The advantage of such a process is that the involved experts from different disciplines and areas get excellent insight into all other involved fields, because features, properties, characteristics, and "skills" of the technology (or even technologies) developed during the RTD project are discussed in details and the assets for adjacent fields get uncovered. This technological and scientific output and the created knowledge are high potentials for building new bridges for future innovations and creating new values. The experiences and results of the authors are various projects on the national and European level revealed these perceptions.[14] Though there is a big demand on an excellent project management especially regarding the foresight part. A smooth communication flow and knowledge exchange is crucial for the success of the foresight. But if this succeeds the project gains important values and results. A foresight process for that would also create resilience for the developed technology.

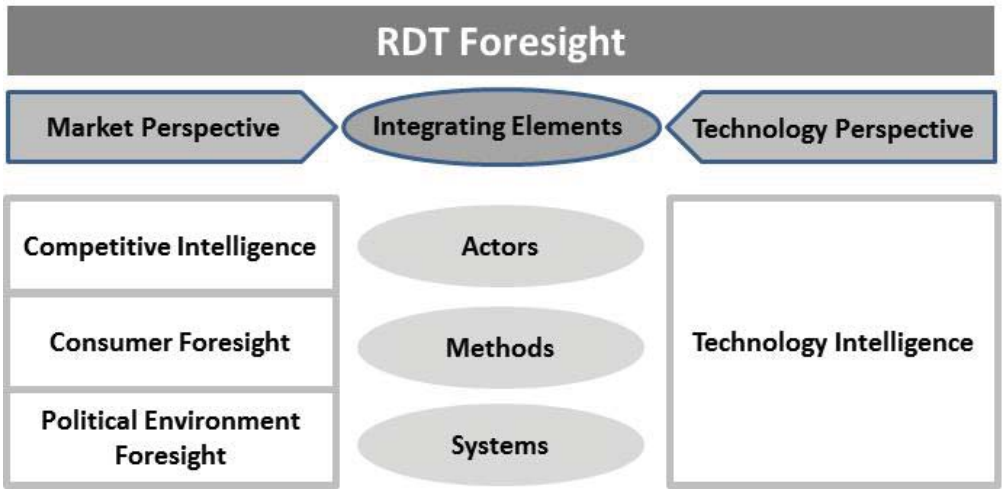

Figure 2. Integration of strategic foresight from two perspectives. (Source: Own figure inspired by Rohrbeck and Gemünden (2006)).

Result - Concept for Foresight in RTD Projects

14 For examples "3D-LightTrans" (http://www.3d-lighttrans.com/) and also the "Austrian Materials Foresight" (http://asmet.org/wp-content/uploads/2015/05/Studie-zur-Austrian-Materials-Foresight-_Endfassung.pdf) , also presented in "Foresight for the Enabling Technologies Materials" (Hörlesberger, M., Kriszt, B., Hribernik, B. (2015).. IN: Proceedings of the 24th International Association for Management of Technology Conference, 08th - 11th June, Kapstadt, 449-464.)

We consider RTD projects where various organisations on the international level such as EU projects (universities, research institutes, companies) work together. The authors propose the implementation of a work package dealing with the foresight process (future thinking process) in each (international) research project. Figure 2 shows a project structure with an RTD Foresight process. There are of course the core technology processes in this structure such as basic research and engineering, the necessary tests and modelling and simulation.

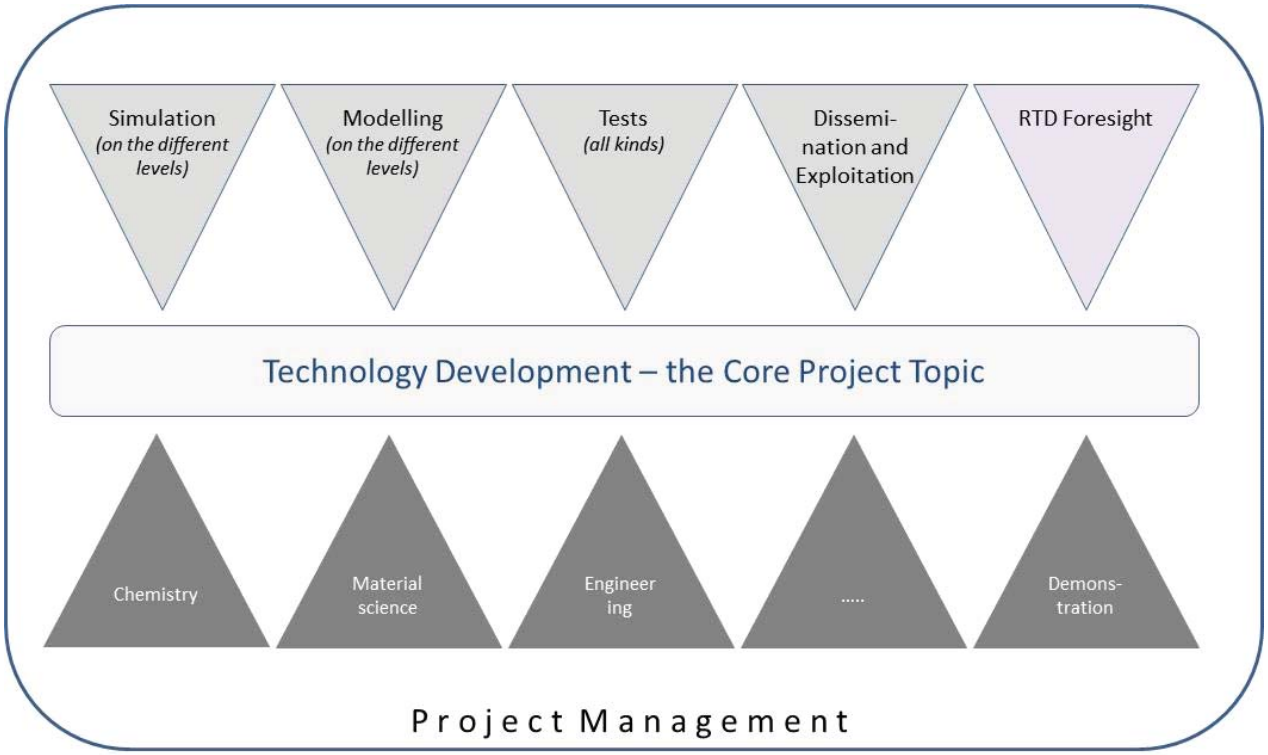

Figure 3. **A structure for a RTD (international) project with an RTD Foresight process.** (Source: Own figure inspired by project management experiences).

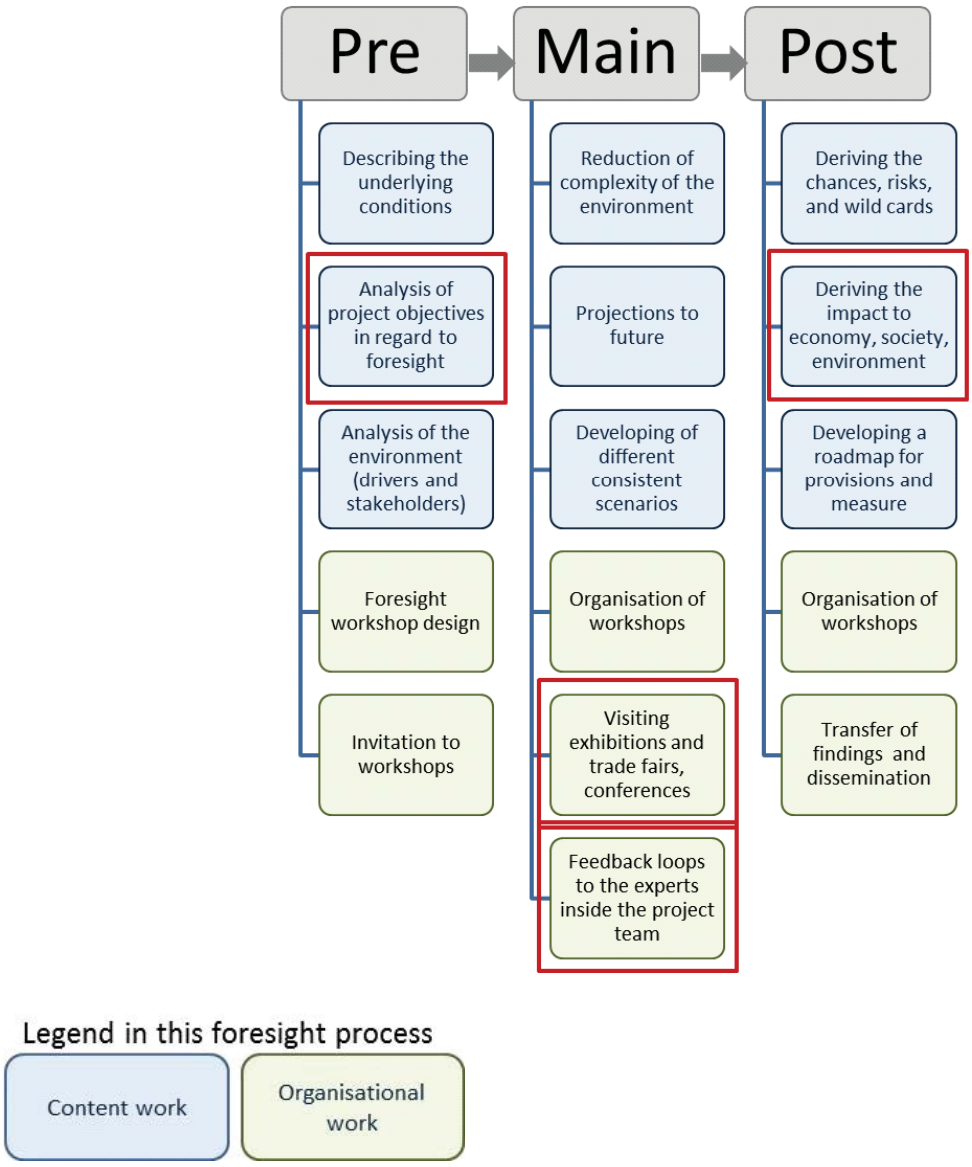

Figure 4. **The foresight process in an (international) RTD project**. (Source: Own figure inspired by project management experiences).

The process in an (international) RTD project could be as presented in Figure 3. The differences to a foresight process such as in "technology foresight" lays in the specific project objectives in the 'pre-foresight' phase, in better possibility for 'visiting exhibitions, fair trades, and conferences' (in the 'main-foresight') as research projects includes presenting the research results in such events. Then RDT projects offer the advantage that feedback loops for discussion the

outcome of the foresight process can inspire directly the progress of the research inside the project and vice versa. The impact of the research and technological results are often required. An RTD foresight includes and covers this analysis and assessment within the foresight process (part in the post-foresight). Generally speaking, multiple techniques can be useful for each impact study activity, while there is no single method which is capable of meeting all needs. The literature describes different alternative methodologies, such as indices or indicators, monitoring (baseline), qualitative and quantitative models, laboratory testing and scale models, scenario building (which is covered inside an RTD foresight), literature review, expert opinions. A fact-based foundation is seen as crucial for the credibility of foresight as a critical assessment of the sources of knowledge. Therefore, a consolidated integration of analytical and exploratory scientific methods (e.g. system analysis and modelling) on the one hand and of participatory processes and interactions with experts and stakeholders on the other would help enhance the scientific credibility of foresight results.15 These specific steps of a foresight in an RTD project are framed in red in Figure 4.

The other process steps in this proposed RTD foresight are supported by the availability of the experts and knowledge in the project team. For thinking "out of the box" few further people can be invited to workshops such as young people, artists, historians, or philosophers. Though these problem/question has to be solved also in traditional (technology or corporate) foresight processes.

	1st third of project duration	**2nd third of project duration**	**3rd third of project duration**
Pre foresight			
Main foresight			
Post foresight			

Figure 5. Gantt chart for an RDT project foresight. (Source: Own figure inspired by project management experiences).

An RTD foresight can assess the projections and extraordinary scenarios directly with the experts in the project team. These feedback loops gain new knowledge for the further development of the core technology and even for all other process steps inside the project. Such feedback loops are

15 Eriksson E.A. and Weber M. (2008). Adaptive foresight: navigating the complex landscape of policy strategies. Technol. Forecast. Soc. Chang. 75 (4), 462–482 (May).

not possible in ‘Technology Foresight’ or “Corporate Foresight’ processes in this detail because the last foresight types are discussed on a different technological level. ‘Technology Foresight’ works on a meta level compared to this RTD foresight because the RTD foresight takes into account the specific technological developments inside the project. ‘Corporate Foresight’ focusses on the company and its direct adjacent areas.

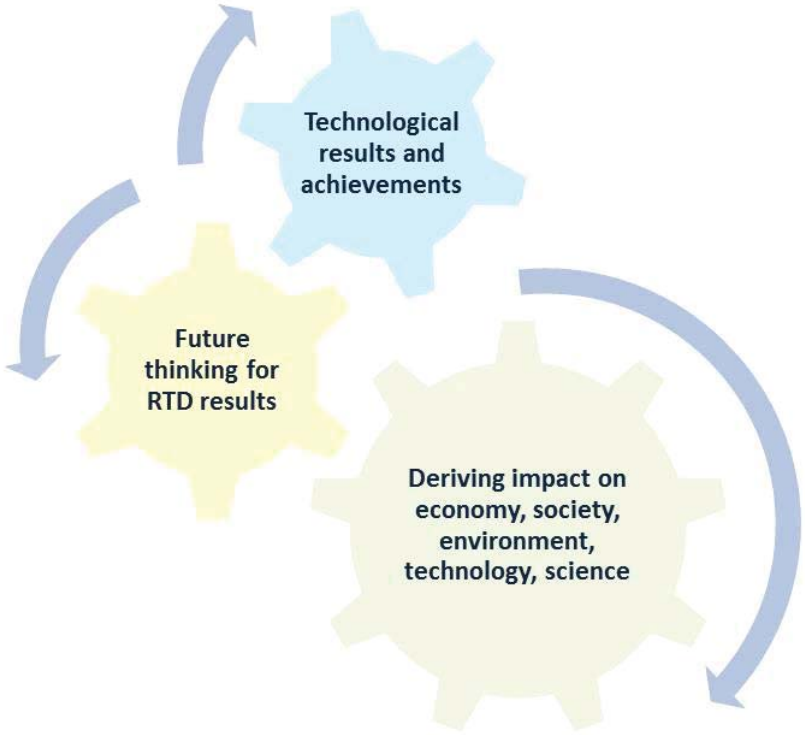

Figure 6. Interaction of technological results and future thinking processes in RTD projects. **(Source: Own figure).**

Conclusion and Outlook

An RTD foresight process in research projects addresses directly the involved organisations in the research project and demonstrates the impact on economy, environment, society, technology, and science. But there is nobody who takes the responsibility for the transfer and implementation of the outcome for the whole developed foresight. The reason is that the involved organisations and experts are connected in a loose network. This is the big difference to a ‘Technology Foresight’ and to ‘Corporate Foresight’.

The big advantage of such an RTD foresight is that the diverse experts from different field (required in the RTD project such as physicists, chemistries, engineers, experts for modelling and simulation, etc.) are together in project meetings (mainly twice a year and often big research projects last four years). Therefore feedback loops for the foresight part can easily be organised.

New knowledge and improved technology is gained continuously during the project frame. Therefore feedback loops are necessary because of the progress of the developed technology inside the project frame.

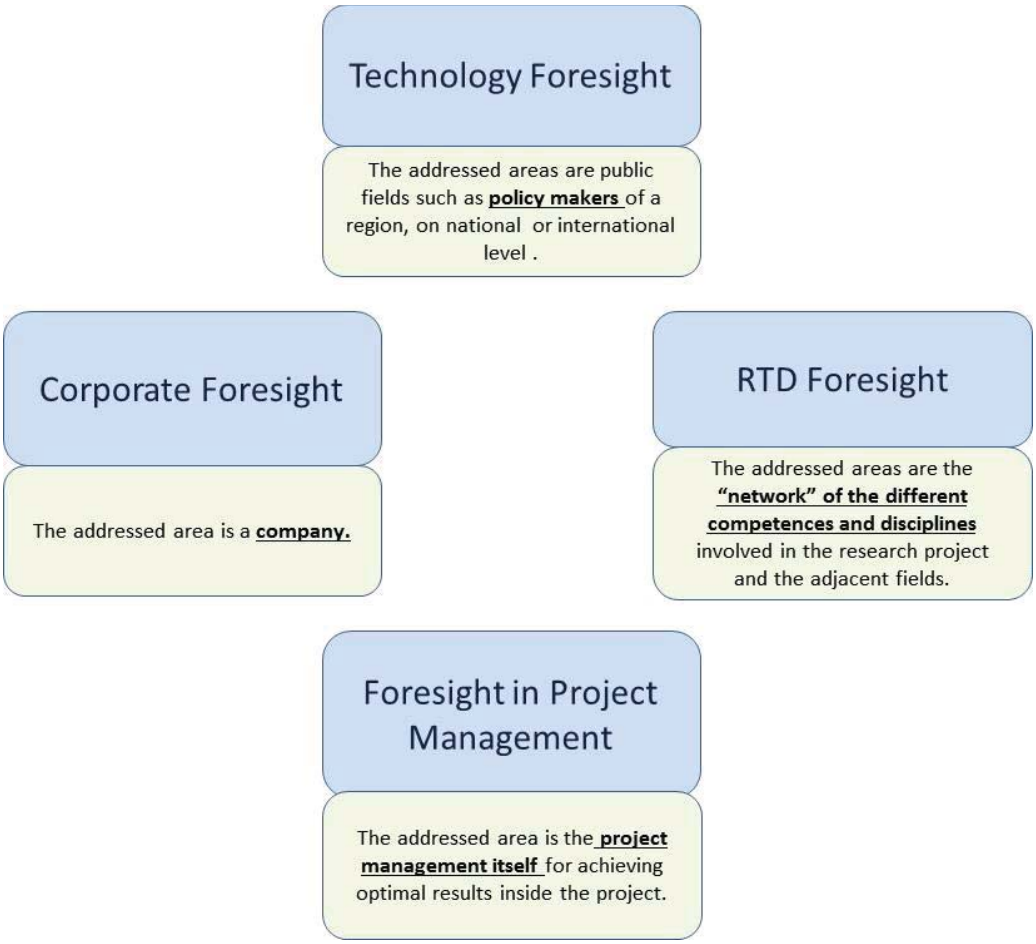

Figure 7. Four different foresights and their core specification. (Source: Own figure).

We have shown that applying foresight methods within large collaborative RTD projects could potentially bring diverse advantages for the project output and impact. Traditional foresights in a technology policy context and also in an organisational context (corporate foresight) were taken as a reference and selected foresight elements and specific methods were transferred to the

context of a collaborative RTD project. The selection and adaption of the chosen elements was based on empirical findings within past European Projects.

RTD foresight has the advantage to be able to assess scenarios directly with the experts in the project team. These feedback loops gain new knowledge for the further development of the core technology and even for all other process steps inside the project. Such feedback loops are not possible in 'Technology Foresight' or "Corporate Foresight' processes in this detail because they are discussed on a different technological level. 'Technology Foresight' works on a meta level compared to this RTD foresight because the RTD foresight takes into account the specific technological developments inside the project. 'Corporate Foresight' focusses on the company and its direct adjacent areas.

However, when transferring foresight elements to the context of RTD projects it will have to be proved that the expected benefits will definitely occur. For example, there is one big difference between foresight in a policy or in an organisational context and between a RTD foresight process. The latter addresses directly the involved organisations in the research project and demonstrates the impact on economy, environment, society, technology, and science. But there is nobody who takes the responsibility for the transfer and implementation of the outcome for the whole developed foresight. The reason is that the involved organisations and experts are connected in a loose network.

Also, it was pointed out by other authors[16] that although there is at least qualitative evidence for foresight exercises to actually shape innovation processes, there are also serious doubts about whether this influence really goes in the right direction. Consequently, further research on the described subject will be necessary in the future.

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