Lappeenranta
University of Technology

Kalle A. Piirainen

IDEAS for Strategic Technology Management: Design of an electronically mediated scenario method

Thesis for the degree of Doctor of Science (Technology) to be presented with due permission for public examination and criticism in the Auditorium 1383 at Lappeenranta University of Technology, Lappeenranta, Finland on the 3rd of December, 2010, at noon.

Acta Universitatis
Lappeenrantaensis 406

Supervisor Professor Markku Tuominen
Faculty of Technology Management
Department of Industrial Management
Lappeenranta University of Technology
Finland

Reviewers Professor Fran Ackermann
Department of Management Science
School of Business
University of Strathclyde
United Kingdom

Professor Robert O. Briggs
Center for Collaboration Science
College of Business Administration
University of Nebraska at Omaha
United States of America

Opponent Professor Robert O. Briggs
Center for Collaboration Science
College of Business Administration
University of Nebraska at Omaha
United States of America

ISBN 978-952-214-997-8 (Paperback)
ISBN 978-952-214-998-5 (PDF)
ISSN 1456-4491

Lappeenranta University of Technology
Digipaino 2010

ABSTRACT

Kalle A. Piirainen

IDEAS for Strategic Technology Management: Design of an electronically mediated scenario method

Lappeenranta 2010
104 p., 2 Appendixes

Acta Universitatis Lappeenrantaensis 406
Diss. Lappeenranta University of Technology

ISBN 978-952-214-997-8, ISBN 978-952-214-998-5 (PDF), ISSN 1456-4491

The age-old adage goes that nothing in this world lasts but change, and this generation has indeed seen changes that are unprecedented. Business managers do not have the luxury of going with the flow: they have to plan ahead, to think strategies that will meet the changing conditions, however stormy the weather seems to be. This demand raises the question of whether there is something a manager or planner can do to circumvent the eye of the storm in the future? Intuitively, one can either run on the risk of something happening without preparing, or one can try to prepare oneself. Preparing by planning for each eventuality and contingency would be impractical and prohibitively expensive, so one needs to develop foreknowledge, or foresight past the horizon of the present and the immediate future.

The research mission in this study is to support strategic technology management by designing an effective and efficient scenario method to induce foresight to practicing managers. The design science framework guides this study in developing and evaluating the IDEAS method. The IDEAS method is an electronically mediated scenario method that is specifically designed to be an effective and accessible. The design is based on the state-of-the-art in scenario planning, and the product is a technology-based artifact to solve the foresight problem. This study demonstrates the utility, quality and efficacy of the artifact through a multi-method empirical evaluation study, first by experimental testing and secondly through two case studies. The construction of the artifact is rigorously documented as justification knowledge as well as the principles of form and function on the general level, and later through the description and evaluation of instantiations.

This design contributes both to practice and foundation of the design. The IDEAS method contributes to the state-of-the-art in scenario planning by offering a light-weight and intuitive scenario method for resource constrained applications. Additionally, the study contributes to the foundations and methods of design by forging a clear design science framework which is followed rigorously.

To summarize, the IDEAS method is offered for strategic technology management, with a confident belief that it will enable gaining foresight and aid the users to choose trajectories past the gales of creative destruction and off to a brighter future.

Keywords: Scenario planning, scenario method, design science, design theory, strategic planning, strategic management, management of technology

UDC: 65.012.2 : 62

ACKNOWLEDGEMENTS

I thank my advisor, Professor Markku Tuominen for giving me the opportunity to take on this fascinating subject and work on it. I would like to extend my thanks to my nearest colleagues Kalle Elfvengren and Samuli Kortelainen, whose support and mentorship has been most invaluable, especially during the first steps of my research career. Besides my closest influences, I would like give my thanks also to the Management of Technology research group in general for these past years. A very special sentiment goes also to Sectie Systeemkunde in Faculteit Techniek, Bestuur ein Management at TUDelft, especially to my nearest colleagues there, Gwendolyn Kolfschoten, Rafael Gonzalez and Stephan Lukosch, for welcoming me to a visit and offering various stimuli and a friendly atmosphere to work in.

Concerning this thesis in particular, I owe thanks to my co-authors who have offered their insights and support to writing the publications enclosed in this thesis, Hannu Kivijärvi of Aalto University, Antti Lindqvist of Stora-Enso, and Tuomo Kässi and Kirsi Kokkonen of LUT. Anne Jalkala and Marko Torkkeli were kind enough to help me with their insightful comments in finalizing this thesis and Sinikka Talonpoika helped me in putting the finishing touches to the language. Special thanks are due to my examiners who honored my work by devoting their dear time to examining it and offering constructive feedback to improve it. Besides the people I have already mentioned, there is a long list of collaborators and people who have otherwise inspired or influenced my work one way or another, and whose names I dare not list due to my poor memory for names. You know who you are anyway.

Even though the professional influences come first in the protocol, my personal influences have been of none the less importance for me and my work with this thesis. Starting from my wife, who has endured the strains of living apart, and my parents who have supported my long and sometimes arduous journey from the cradle to the lectern, I thank you most wholeheartedly. I doubt that this project would have concluded at all, or in this very form without you. To my dear friends I extend many thanks as well. I thank you for the friendship and peer support during the hurdles of school, studies and everyday life. I think you might know who you are as well. However, among my peers one stands taller than others; Juha Panula-Ontto has been the voice of my reason since the tender years of High School, and I do not hesitate to say that he has influenced my thinking significantly during the countless hours of ponderings, conjectures and refutations over the years.

Lastly, I would like to acknowledge my financial influences. The generosity of the following institutions has made this work possible: Kauhajoki Cultural Fund (Inkeri Kantele Fund), Lappeenranta University of Technology Support Foundation (Lauri and Lahja Hotinen Fund), the Society for Viipuri School of Economics (Tuomo Rönkkö Fund), and the Academy of Finland.

Thus spake Zarathustra about the future:

> “The present and bygone upon earth – ah! My friends – that is my most unbearable trouble; and I should not know how to live, if I were not a seer of what is to come.”
>
> - Friedrich Nietzsche, “Thus Spake Zarathustra”, 1999 (orig. transl. 1911, Thomas Common), p. 95, Dover Thrift Editions, Dover Publications.

TABLE OF CONTENTS

PUBLICATIONS

This thesis consists of two main parts, the overview (Part I) and the publications (Part II). The publications comprising the second part are listed below, summarizing the contribution of the author of this thesis and the acceptance procedure for each paper.

Paper 1

Piirainen K., Kortelainen S., Elfvengren K., Tuominen M. 2006. A Framework for Utilizing Group Support System in Scenario Process, in Maula, M., Hannula, M., Seppä, M., Tommila, J. (eds.) Frontiers of e-Business Research (FeBR), Proceedings of eBRF+ICEB Conference, Tampere University of Technology and University of Tampere, Finland.

The author was responsible for the literature review and the design of the scenario method, as well as the experimental design in collaboration with the other authors. The paper was accepted based on a double blind review of an extended abstract.

Paper 2

Kivijärvi, H. Piirainen, K. Tuominen, M. Kortelainen, S. Elfvengren, K. 2008. A Support System for the Strategic Scenario Process in Adam, F., Humphreys, P. (eds.) Encyclopedia of Decision Making and Decision Support Technologies, IGI Global, Hershey, PA, USA, pp. 822-836.

The author was responsible for designing the scenario method and authoring the scenarios used as illustration. The paper was invited, and the full paper was reviewed by the editors of the encyclopedia.

Paper 3

Piirainen K., Kortelainen S., Elfvengren K., Tuominen M. 2010. A scenario approach for assessing new business concepts, Management Research Review, Vol. 33, No. 6, pp.635-655.

The author was responsible for the literature review and the design of the scenario method, as well as for the experimental design in collaboration with the other authors. The paper was accepted to a conference based on a double blind review of an extended abstract and invited to the journal, where the full paper was double blind reviewed.

Paper 4

Kokkonen, K, Piirainen, K., Kässi, T. 2008. E-business opportunities in the Finnish forest sector – a multi-method scenario study, in the Proceedings of XVIII International Conference of International Society for Professional Innovation Management (ISPIM), Tours, France.

The author was in charge of the literature review and the research design, comparison of the methods, and authoring the scenarios in collaboration with the other authors. The paper was accepted based on a double blind review of an extended abstract.

Paper 5

Lindqvist, A. Piirainen, K., Tuominen, M. 2008. Utilising group innovation to enhance business foresight for capital-intensive manufacturing industries, in the Proceedings of the 1st ISPIM Innovation Symposium, Singapore.

The author was jointly in charge of the literature review, discussion and conclusions. The paper was accepted based on a double blind review of and extended abstract.

Paper 6

Piirainen, K., Lindqvist, A. 2010. Enhancing business and technology foresight with electronically mediated scenario process, Foresight, Vol. 12, No. 2, pp. 16-37.

The author was jointly in charge of writing the paper, as well as the conclusions. The paper was accepted to a conference based on a double blind review of the full paper, and invited to the journal, where it was double blind reviewed.

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CSR	Case Study Research
DS	Design Science
DSR	Design Science Research
DSS	Decision Support System
DT	Design Theory
EMS	Electronic Meeting System
FAR	Field Anomaly Relaxation
FS	Futures Studies
GDSS	Group Decision Support System
GSS	Group Support System
IE	Industrial Economics
IS	Information Systems
MoT	Management of Technology
OE	Organizational Economics
RBV	The Resource Based View

PART I: Overview of the Thesis

1 INTRODUCTION

This overview of the research that has led to this thesis starts with introduction summarizing the background and motivation, research design and structure of the thesis. As a note on matters of style, I, the author, have striven to write in an accessible and engaging manner to encourage all audiences to read this study. This stylistic line includes the choice to write in active voice, and occasionally even to use of the first person voice. While this is perhaps still an unconventional choice, I am aiming for accessible and effective results and I want to engage the reader, not hide behind the pomp of academic language. Despite using the first person voice, I do want to recognize the influences and hard work several people have put into the research that has become this thesis. My appreciation for their effort is spelled out in the acknowledgements.

1.1 Background and Motivation

In modern day business, managing and adapting to changes in the operational environment has become a vital part of building success. Already Herakleitos (2010) (c. 535-475BCE) uttered the often repeated words “Nothing endures but change.” The increasing speed of changes in the field of business and shortening product lifecycles are discussed almost *ad nauseam*. Among others, the yearly “Strategy Barometer” of The Strategic Management Society of Finland (Skurnik et al., 2009) indicates that the industry sees stormy weather ahead; the top themes of importance in strategic management for the year 2009 were changes in customer behavior, changes in competitive environment, and strategic perspective in organization development; and sudden changes in the business environment were perceived as one of the most dreaded obstacles for implementing strategy across industries. Against this backdrop it seems that turbulent winds are here to stay and to rattle the foundations of many business ventures.

From the perspective of strategic technology management, the problem of uncertain operating conditions boils down to the question of how a business can develop reasonable strategies for steering the company in the long run (Mintzberg, 1994), how to utilize and adapt the capabilities of the firm (Teece et al., 1997; Teece, 2007), or alternatively how to build strategic agility and responsiveness toward changes in the environment (Doz and Kosonen, 2008). While strategic planning in some form is seen as an important part of modern corporate management despite Mintzberg's (1994) critique, traditional techniques and tools have been criticized for being too rigid in the perspective of managing change in the environment (e.g. Miller and Waller, 2003; Schoemaker, 1995). In the field of strategic decision making, technology management is a representative example of risky business, where large investments to research and technologies have to be made years ahead of payback, with quite uncertain information. Without a proper understanding about the future uncertainties, a company can miss many opportunities and grant its competitors the front-row seat for benefiting from e.g. new technologies, innovations and business concepts.

The above points of criticism raise the question of what a manager or planner can do to circumnavigate the eye of the storm in the future. Intuitively, one can either run the risk of something happening without preparing, or one can try to get prepared. However, planning for each eventuality and contingency would be impractical and prohibitively expensive, so one needs to develop foreknowledge or foresight past the horizon of the present and the immediate future to steer one’s trajectory toward clear skies. The management and business administration literature has proposed many solutions, different models of beamers, for looking past the horizon, scenario planning being one of the best known and used of this gamut of foresight and forecasting techniques (e.g. Glenn, 2009; Coyle, 2004).

The utilization of scenarios for business purposes started in the 1970s when Royal Dutch/Shell successfully managed to anticipate several political and economic uncertainties. Since those early experiences, corporate foresight practices have been built into the fabric of the energy conglomerate, and the showcase scenario reports are widely read by researchers, practitioners and policy makers. In general, scenarios have been often offered as an effective way to manage uncertainty and to envision plausible future paths. Following the rise of uncertainty in recent years, scenario planning has regained its position as one of the key support tools for strategic and technology management (e.g. Rigby and Bilodeau, 2007; Stenfors and Tanner; 2006).

1.2 The Research Gap and Mission

The example of Shell illustrates how foresight can support competitive advantage despite the turbulence that shakes the flight every now and then. However, at the same time there has been criticism regarding both the process and contents of scenario planning. The literature has presented findings that suggest that scenario planning is in fact often not well integrated to the management system of organizations (Millet, 2003), and that scenario planning is a time consuming and resources intensive activity where the benefits are not often apparent (Raspin and Terjesen, 2007). Particularly the effectiveness of the process, attention to organizational learning aspects, commitment, and the qualitative, in some cases superficial, nature of the results have been questioned (Lindqvist et al., 2008). Although, there have recently been efforts to make scenario planning more accessible to practitioners (Bradfield et al., 2005; Bishop et al., 2007), the field of scenario methods resembles a "methodological jungle" with little guidance which method to choose for a given foresight need and context (Bradfield et al., 2005; Chermack, et al., 2001) and with multiple overlapping methods (Bishop et al., 2007) that have been described as a "coveted art with only a selected few understanding the application methodologies" (Chermack et al., 2001, p. 9). This discussion points out a clear gap for this research to fill; an effective, transparently documented and easy-to-use scenario method.

Following this discussion, the purpose on this study is to design a scenario method for strategic technology management addressing the critique toward the existing methods, and to execute the design and evaluation in a transparent and explicit manner to make the method more accessible and to enable critical appraisal of the results. The broader objective is to introduce a tool to interface strategic management and management of technology (MoT) to the development of the business environment. The resulting basic research questions are:

- What are the business needs and challenges for scenario planning in strategic technology management?
- How improve can the effectiveness of scenario planning process be improved?
- How are these methods implemented to improve the state-of-the-art of scenario methods?

To fulfill this research mission the study searches for tools that can aid scenario planning, alleviate the known challenges, and make the process more practical and transparent. The contribution is a novel artifact which enables effective scenario planning in the context of strategic management of technology, and thus potentially raises the competitiveness of industrial companies.

1.3 Scope, Design and Limitations

The research mission sets this piece of research squarely into the intersection of the literary bodies of strategic and technology management, futures studies, more specifically scenario planning, and information systems research, as illustrated below. The broad field of strategic management, and as a part of that field, technology management sets the context, motivation and business problem for this study. As the conceptualized business problem is that strategic technology management can benefit from increased foresight, the study explores the field of futures studies and foresight, and in particular scenario planning, to guide the design of the scenario method. Lastly, the study looks for support for the scenario method from the field of information systems research, particularly management information or decision support systems. The contribution is a method for conducting scenario planning exercises to raise the level or organizational foresight. This thesis contributes directly to the literary bodies of foresight and scenario planning, as well as to information systems and management information systems, while the results will be of use to audiences in strategic management of technology.

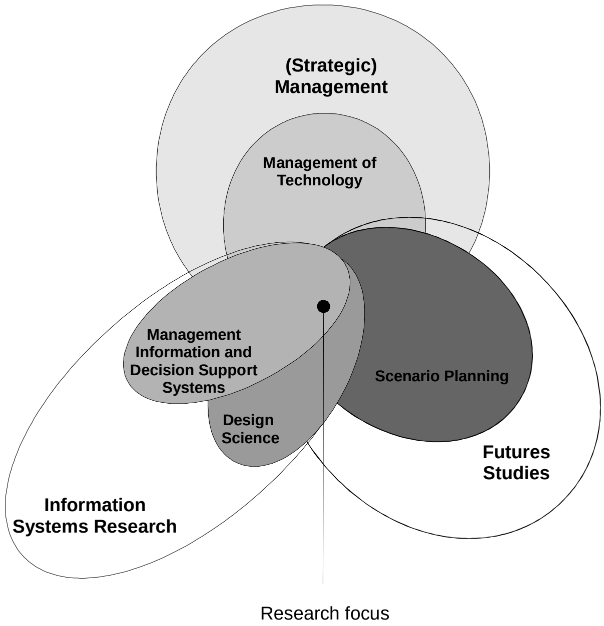

Figure 1. Scope and position of the thesis

As the mission is fulfilled by artificing a new thing, a method for scenario planning, a methodological framework is needed to support the design of the method. Design science as a scientific methodology has been bubbling under, so to speak, especially in the information systems discipline, since Herbert Simon's seminal volume "The Sciences of the Artificial" (1996, 1st edition 1969). The mission in design science is to plan, make, artifice, in a word to design, solutions, including artifacts or more generally design theories for classes or artifacts, to solve relevant business problems in a novel manner and to evaluate their utility, quality and efficacy rigorously (Hevner et al., 2004; Venable, 2006; Gregor and Jones, 2007). While much of the literature has been published in the field of information systems research (Piirainen et al., 2010a), the management literature has a significant tradition in design-oriented research under various labels (e.g. van Aken, 2005; 2004; Kasanen et al., 1993; Lukka, 2003). Taking up on this stream, Hodkinson and Healey (2008), for example, discuss design science in management research at length and come to the suggestion that insofar as management research is supposed to produce useful results for practitioners, design-oriented research is an appropriate approach for management research. To rephrase accordingly, the application area, or the environment (Hevner et al., 2004) we work in, is strategic management of technology, while the construction of the design theory (DT) for the scenario method draws its justification knowledge (Gregor and Jones, 2007) from the knowledge base of the areas of foresight and futures studies, as well as from information systems research. In terms of the design science process, this study designs a scenario method to the stage of a DT, demonstrated it, and evaluates it through several expository instantiations.

While I discussed the shortcomings of present scenario practice superficially above, and conceded that linking scenario planning to the management system is one major challenge, I have decided not to include it in this study. Even though, or rather because, it is an important pitfall in the process, I feel that integrating scenario planning to the management system and thus maximizing the learning potential from scenarios is a topic that deserves more attention I could have given it during the course of this study. Thus this study focuses specifically only on designing and evaluating a scenario method for strategic technology management. Another important limitation is that while I discuss strategic theory and competitive advantage, I do not aim to evaluate how scenario planning affects the competitiveness of a firm. The discussion is conceptual in nature and is aimed to set the stage for the design by outlining the business challenges for scenarios and underlining why these kinds of methods are potentially important for strategic management of technology. Additionally, as software, local work practices and preferences differ, I will not delve very deeply into the issues of facilitation, as the research process establishes an extended proof-of-concept for the DT, rather than finalizing and it fully.

1.4 Overview and Organization of the Thesis

The thesis is divided to two main parts; the first part is an introduction and overview of the research, and the second part comprises the publications. In the first part I start by delineating the assumptions and research design which structure and guide the rest of the research process. Following the design, I set the stage for the "IDEAS" scenario method by discussing the business case and needs for foresight from the perspective of strategic technology management. Then I proceed to discuss the literature and practice of foresight and scenario planning or analysis, to compose adequate justification knowledge to design the principles of form and function for the design theory and the ensuing artifact. After the design, I present a summary of the evaluation of the design theory through a multi-method empirical study, as presented in the publications of the second part of this thesis. The evaluation is followed by communicating and positioning the contribution and a critical appraisal of the research and findings. Lastly, the concluding section summarizes the main findings and outlines some directions for further study. Figure 2 summarizes the structure of the first part and illustrates how the sections contribute to the design. The contribution of the publications in the second part of this thesis is discussed in depth in the evaluation chapter (chapter 4). To compare the structure to the research questions, the first three are answered in the third chapter, where I discuss the scope and context of scenario planning and review the relevant literature. The last question is answered fully only in the fourth chapter where the previously formulated recommendations are evaluated.

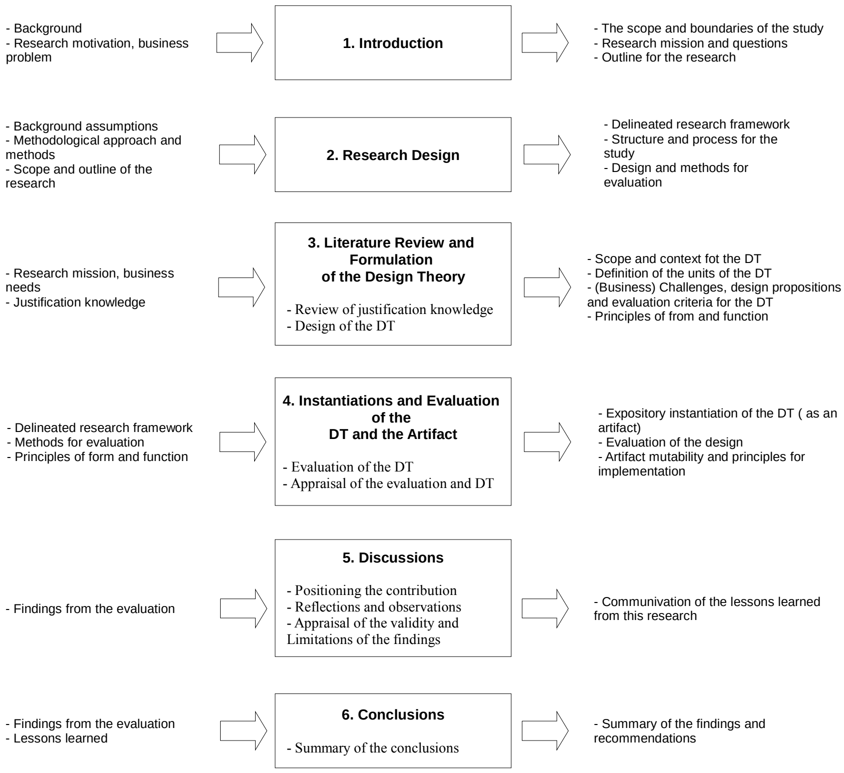

Figure 2. Structure of the first part of the thesis and contributions of the individual chapters

2 RESEARCH DESIGN

This chapter presents the research design which sets the framework and structure for the rest of the thesis. The chapter starts by introducing design science, its aims and the underlying philosophy. It continues by discussing the methodology of design science research, how research can be executed within the framework. Finally, the chapter describes the empirical methods and instruments which I use within the course of this study.

2.1 Introduction to and Foundations of Design Science

Herbert Simon (1996, p. 111) writes in his influential book ‘The Science of the Artificial’ that "Design … is the core of all professional training; it is the principal mark that distinguishes the professions from sciences", or in this context applied sciences from (pure) sciences. It has been written that whereas (natural) science seeks to describe and explain phenomena, design science seeks to apply that accumulated knowledge to solve problems encountered in professions (March and Smith, 1995; Hevner et al., 2004). Accordingly, I will approach the research problem through the design science framework.

Beside the distinction between natural and design science (DS), there is a difference between routine design and design science research (DSR). To condense the position presented in the core DS literature, Hevner et al. (2004) address the difference between routine design and DSR by defining design as application of knowledge to solve a previously examined problem while DS contributes to existing knowledge by seeking solution to a (previously unsolved) non-trivial problems in novel and innovative ways. Thus, in short, the difference between design and design science (in the information systems [IS] context) is that DS aims to add to the existing body of (scientific) knowledge by examining uncharted problems and solving them in novel ways in a rigorous fashion. To be more specific, design science as an activity can be characterized as formulating design theories (Walls et al., 1992; Markus et al., 2002; Gregor and Jones, 2007), that is, valid prescriptions on how to develop classes of artifacts (constructs, models, methods, or instantiations) (March and Smith, 1995) to fill a certain kind of problem space (Markus et al., 2002). According to Hevner et al., to be successful, DSR should (paraphrased from Hevner et al., 2004):

1. produce a viable artifact (construct, model, method or instantiation)
2. develop (technology-based) solutions to important and relevant business problems
3. demonstrate utility, quality and efficacy of the design rigorously
4. provide a contribution
    a. in the form of an artifact and/or instantiation
    b. to the foundations of the design [kernel theories/justification knowledge] or design methodologies
5. apply rigorous methodology to construction and evaluation of the artifact
6. search for available means to attain the ends under the constrains of the problem environment
7. present the results to both technology and management-oriented audiences.

While much of the DSR literature is positioned in the IS field, Winter (2008), as well as Gregor and Jones (2007) point out that there has been a tradition of design-oriented research, especially in Europe. There are similar strands of research in management science as well, though sometimes under different labels (e.g. Gregor and Jones, 2007), including design science (most notably van Aken, 2004; 2007; van Aken and Romme, 2009), the constructive research approach to management research (Kasanen et al., 1993; Lukka, 2003), and action research (Susman and Evered, 1978; Baskerville and Wood-Harper, 1998; Davison et al., 2004), the latter identified as a parallel approach by Lukka (2003) and Jönsson and Lukka (2007). Despite the differences between the approaches, the research mission and basic guidelines between the DSR framework and for example the constructive approach (Kasanen et al., 1993; Lukka, 2003) are compatible, even to the extent that the constructive approach can be viewed as a subset of DSR (Piirainen and Gonzalez, 2010). Action research is, as proposed by Lukka (2006), more action or intervention-oriented than either DSR or the constructive approach. I have chosen DSR as it is consistent with my philosophical views, as I will discuss below, and approaches the research topic from a more theory-driven perspective than action research and the constructive approach, while retaining practical relevance of the results.

Before going to the practical research design, there is a need to address the underlying research philosophy, specifically ontology and epistemology that guide the research process. After all, all the claims and careful arguments offered to the scientific community lay on these two blocks, the cornerstones of research, and are evaluated within the framework they set. Accordingly, transparency about the assumptions is a key in ensuring understanding of the research and evaluating its rigor. The philosophical foundations of DSR are a subject for discussion (Piirainen et al., 2010a; Venable, 2006; 2010). Hevner et al. (2004) are perhaps the most important source on DSR and they do not explicitly address research philosophy while otherwise laying out a framework for DSR. According to them, truth informs design and design informs truth. While subscribing to this view, I discuss the issues a little further.

The first cornerstone of research and research philosophy is the ontology, the statement of the structure of reality, what is and can be. There are a multitude of ontologies, the most common being the idealist and the realist (Gonzalez and Dahanayake, 2007). The great divide is whether there is an immutable world or truth which does not depend on someone observing or constructing it. My point of view to science is what might be characterized as a common-sense realist after Moore (1960) and Russel (1969). In terms of ontology I subscribe to the 3-world ontology as put forward by Popper (e.g. 1978), which is quite consistent with the often implicit or sometimes explicit view of DSR literature (Gregor, 2006; Gregor and Jones, 2007).

The second cornerstone is epistemology, which gives us guidelines on how to gain knowledge of the world defined by our ontology. Epistemology, in short, studies what can be known of the world and how we can gain and verify that knowledge. When it comes to epistemology of DSR, the matter is more complex. As mentioned above, Hevner et al. (2004) do not prescribe any particular epistemology or ontology. Vaishnavi and Kuechler (2004) state that instrumentalism or pragmatism is built in DSR, that is, the utility received from the efforts expended to design a solution to the given problem validates the artifact, and the theory or previous knowledge is instrumental in achieving the goals rather than seeking truth *per se* (Kleindorfer et al., 1998). March and Smith (1995) even go as far as proposing that an artifact does not have a truth value but only utility, i.e. it may be useful in solving the problem, but it is not true or false in any meaningful sense as long as it exists. Iivari (2007) has continued from this thought and concedes that while an artifact does not have truth value, the theory or the foundations on which the design is built have, and insofar as DSR aims to contribute to the theoretical knowledge, truthfulness is an issue.

Kasanen et al. (1991; 1993) have been perhaps the most vocal within the design-oriented research field about the epistemology of DSR. They cite Peirce's pragmaticism and conclude that the "validity of [an artifact] in the field of business administration has to be approached by practical functionality" (Kasanen et al., 1991, p. 322). To be explicit, following Lukka and Kasanen (1995, p. 83) I assume "the pragmatist notion of truth" in matters of truth or truthfulness after William James (e.g. 1955). Goodman (2008) discusses James' view of truth and states that it is a variety or perspective of goodness: truth is good because it is useful and provides a basis upon which we can build our actions and predict the results. James himself (1995, p. 77) writes about Pragmatism's Conception of Truth that "The truth of an idea is not a stagnant property inherent in it. Truth happens to an idea. It becomes true, is made true by events. Its verity is in fact an event, a process: the process namely of its verifying itself, its verification. Its validity is the process of its validation." He then follows by arguing that verification and validation "signify certain practical consequences of the verified and validated idea". According to James (1995, p. 78) validation follows "the ordinary agreement formula" in that a statement is true or in agreement with reality if acting upon the statement has the consequences anticipated in the statement and they indice a feeling on the actor that the original idea is in agreement with reality. I interpret that a logical sentence or proposition is truthful if 1) acting upon it has the consequence which can be reasonably extrapolated from the logical sentence, and 2) that the consequences prove to be useful (James, 1995, p. 79).

In essence, we gain knowledge of the world, arrive to justified true beliefs, by formulating propositions or prescriptions for action and by examining whether the propositions lead to the intended conclusion and whether the conclusion is useful. That is not to say that just any artifact that is perceived to be useful would be a contribution to scientific knowledge, but the usefulness of a purposefully built artifact that works as intended validates the underlying proposition. In the case of DSR, we can contribute by designing artifacts and testing whether they work as proposed, and whether they are useful.

2.2 Design Science Research Framework and Methodology

To complete the mission given above in practical terms, the thesis builds on the DSR framework presented by Hevner et al. (2004). They describe a basic framework by explaining that IS research in general, and DSR in particular, should be linked to both the surrounding (business) environment and the knowledge base built by previous research. They suggest that DSR builds and evaluates artifacts and theories, using applicable knowledge from the knowledge base and business needs from the environment as input for the design. Hevner (2007) adds that DSR is built from three related cycles of activities as illustrated in Figure 3. Firstly there is the relevance cycle which interfaces with the environment to gather the (functional) requirements and constraints for the artifact. Secondly, the rigor cycle accesses the knowledge base for theories and practical knowledge for the kernel of the artifact. And thirdly, the central design cycle builds and evaluates plausible artifacts based on the kernel theories which fulfill the requirements. Ideally, through these three cycles, DSR will produce artifacts which solve business problems. While solving practical problems, DSR creates new knowledge and insights which can be then added to the knowledge base as a feedback of the rigor cycle, and the artifacts can be implemented in the environment through the relevance cycle (Hevner, 2007).

As Venable (2006) notes, there are two gaps in the DSR framework from the practical point of view, as Hevner et al. (2004) do not discuss the process of DSR, how DSR should be organized, and what exactly is the role of theory in the DSR process, as it grounds itself to the knowledge base and contributes back to it. To address the latter issues first, let us discuss the interface between the knowledge base and design. Gregor and Jones (2007) add to the discussion by stating that while it seems to be quite commonly accepted that if an artifact is novel and innovative it makes a contribution in its own right, and formalization of the design knowledge to a design theory (DT) not only helps communicating the results more transparently, it also codifies design knowledge to easily transferrable form so that redundant work is reduced. Accordingly, I use the concept of DT as a frame around which to structure the design of the artifact and through which to communicate its foundations and evaluation during the course of this study.

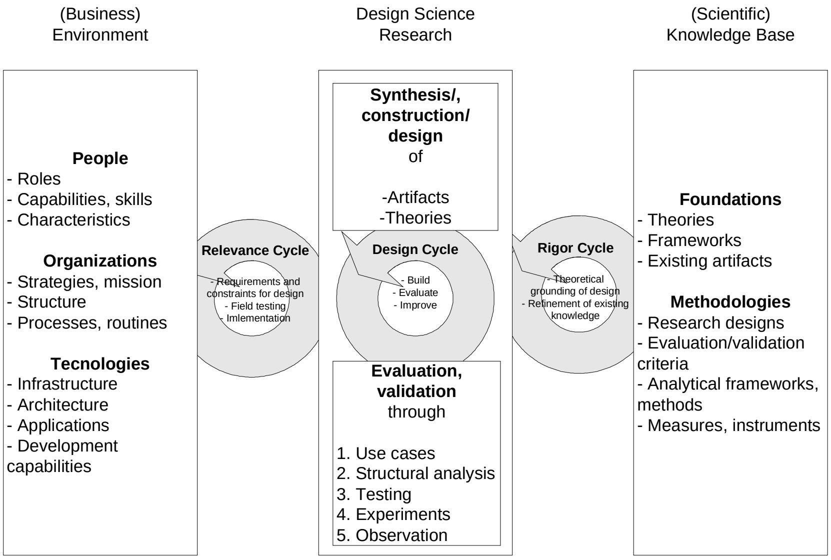

Figure 3. The framework and the three cycles of DSR (Hevner et al., 2004; Hevner, 2007)

Walls et al. (1992, p. 37) define a DT in short as " … a prescriptive theory based on theoretical underpinnings which says how a design process can be carried out in a way which is both effective and feasible." However, DTs differ from most social science theories which explain the relation between phenomena and units, or predict what will happen given a set of circumstances. In short, DTs will tell how to build artifacts based on a given kernel theory to achieve certain goals. Walls et al. (1992) explain that DTs are composites of existing theories, foundations in Hevner's framework (Figure 3), which act as 'kernels' to the DT and prescriptions of how to use the (kernel) theories to achieve the practical goals. Instead of explaining observed phenomena or predicting what will follow from certain events or conditions, DTs will explain how to build an artifact to solve a problem based on an existing theory and predict how it will behave in an organization. From these characteristics, it follows that DTs are theories of procedural rationality, to use Simon's (1996) term, in the sense that DTs should describe the artifact and its properties, and prescribe a process to build it.

Gregor and Jones (2007) have revised the rendition of design theory of Walls et al. (1992) and simplify the structure by proposing that the design process and product need not be separated and that further the same kernel theories often apply to both the process and the artifact. They (Gregor and Jones, 2007) also introduce three new facets to the theory based on Dubin (1978). Firstly, the units or constructs that the theory deals with; secondly, artifact mutability, i.e. to what extent the theory predicts changes in the artifact when implemented or how the artifact could or should be changed from the initial rendition or instantiation; and thirdly, expository instantiation, a real-life proof-of-concept as an auxiliary component. Even though constructs are not explicitly addressed in Walls' writings, we can assume that the meta-requirements or -design have to deal with constructs at least implicitly, so we can connect them. In a similar fashion, we can map mutability to meta-design as a researcher will, again at least implicitly, consider points for further research or how the artifact will fare after implementation. Otherwise the components map quite nicely together, as illustrated in Figure 4 with black arrows. The comparison leaves one item, the proof-of-concept instantiation that is completely new and perhaps a nod toward Hevner et al. (2004), who propose that DSR should produce an instantiation of the artifact, as opposed to e.g. March and Storey (2008), who argue that the artifacts themselves are often sufficient contributions.

	Component (Walls et al., 1992)	Guiding question	Example: Joes' Garage
Design Product	Meta-requirements	Which class of goals or problems does DT apply to?	Cost accounting in service enterprises needs to be more informative and accurate
	Kernel theories	Which theory helps me solve the problem?	Activity Based Costing (ABC)
	Meta-design	Which (class of) artifacts meet the meta-requirements?	Computerized accounting system
	Testable product hypotheses	Does the meta-design fulfill the requirements?	H1: The costing is based on the principles of ABC H2: ABC represents the costs of the operations in the context more accurately …
Design Process	Design method	How to build an artifact based on the meta-design?	Design process specification: take the RUP process…
	Kernel theories	Which theory helps me to build the artifact successfully?	Software engineering theory and practice
	Testable process hypotheses	Is the artifact consistent with the meta-design?	H1: The system works, it is usable and reliable H2: Is based on ABC …

Components (Gregor and Jones, 2007)	
Purpose and scope	Core components
Constructs	
Justification knowledge	
Principle of form and function	
Artifact mutability	
Testable propositions	
Principles of implementation	Additional/ auxiliary components
Expository instantiation	

Figure 4. Components of a DT (adapted from Walls et al., 1992; 2004; Gregor and Jones, 2007; Venable 2006)

While the concept of DT is quite clear as a result of the discussion, we need to relate the artifact to the DT to reconcile the DSR framework and DT. Walls et al. (1992) propose that a design (theory) can be ultimately proven only through an artifact that can be observed and measured. They go further by writing that a DT should prescribe what properties ad artifact should have and how it should be built to solve the research problem (Walls et al., 1992; 2004). Gregor and Jones (2007, p. 327) propose that "[t]esting theoretical design propositions is demonstrated through an instantiation by constructing … [an artifact]…". This can be interpreted that an artifact is an instantiation of a DT, which in turn can be instantiated in an organization. We can also interpret that the artifact should embody or operationalize the theory to the extent that we can validate the theory by observing the artifact. This discussion also brings us back to the epistemology. As discussed above, a proposition is true if it works and is useful, so in extension, a design theory is true and valid, if acting upon it will produce an artifact that embodies or represents the justification knowledge and is useful in solving the original problem. So we should arrive at justified true beliefs if we follow Gregor and Jones' (2007) prescription of DT and if we can show that it solves the research problem in a useful way.

As for the other practical gap, Vaishnavi and Kuechler (2004) were the first to introduce a concrete process description to operationalize the DSR framework. Later, Offerman et al. (2009) as well as Peffers et al. (2008) have modeled a DS process and a methodological framework respectively based on existing research and literature. Both of these more recent processes are quite consistent with Vaishnavi and Kuechler's (2004) description, even though the process outline is different. I have chosen to use the process of Peffers et al. (2008) (Figure 5) to structure this thesis, as the process is quite complete and well demonstrated.

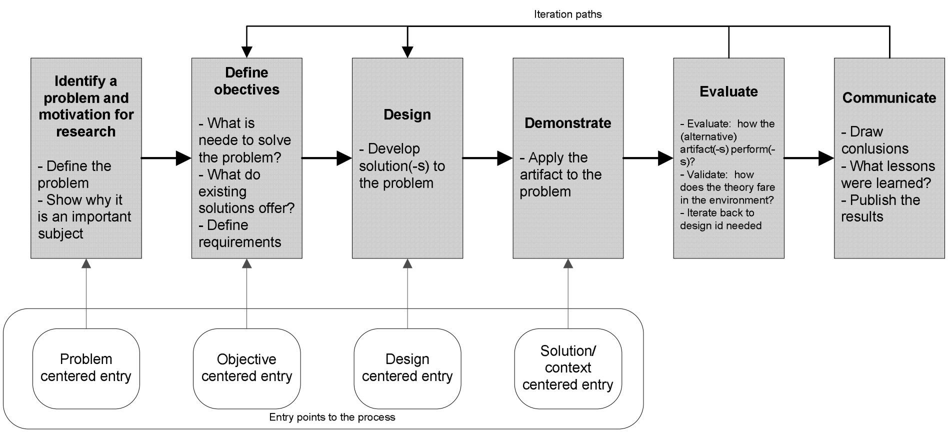

Figure 5. Outline of the DSR process (adapted from Peffers et al., 2008)

The initial phase of the DSR process is outlining the problem, which results in a research proposal. The second phase then concentrates on suggesting solutions to the problem defined in the proposal, where the knowledge base is accessed to find feasible solutions. The third phase is effectively the design phase. Here the researchers use the suggested solutions to develop or construct the artifact. At this point, Peffers at al. (2008) add demonstration of the artifact, a sort of proof-of-concept testing or evaluation, as a separate stage, compared to Vaishnavi and Kuechler (2004). After design and/or demonstration, the artifact moves into evaluation. The process has plausible parallels in the proposed structure of DT as discussed above. The definition of the research mission will firstly draw the outline for design context and meta-requirements. The objective definition can be a backdrop to define the constructs and scope of the theory. The design is based on the justification knowledge and addresses the principles of form, implementation and testable propositions. The demonstration can act as an expository instantiation. The evaluation will finally validate the DT.

Together with the components and structure of DT, the DSR process or methodology will guide and structure the rest of this thesis. The relationship between the DSR framework, process and DT is that the DSR framework dictates the broad guidelines for DSR, legitimizes the general research mission, and gives a philosophical backdrop for the research. The components of DT will then structure the conceptual effort, guide the search within the knowledge base to ground the research, and later give a structure for communicating the products of the research. In plain language, the conception of DT in the context of this study is that it gives form to the rigor cycle and the design product, the artifact, by articulating the foundations of design, the reasoning behind it and the general form of it, the meta-artifact so to speak, from which the artifact is built following deductive logic (Vaishnavi and Kuechler, 2004). In my conception of the DSR framework, the process of DS is the practical guideline which will structure the efforts to complete the design theory and to evaluate it.

2.3 Evaluation Methods

Hevner et al. (2004) argue that the "utility quality and efficacy of the artifact has to be rigorously evaluated" as a part of the DSR framework. The interface of the DT and the world is the artifact, and the validation of the DT can be accomplished by extension through evaluation of the artifact, as proposed by our epistemology. On the practical level, we can draw both from the epistemology and the discussion of the structure of DTs to set the tasks for evaluation. The first purpose of evaluation is to examine the validity of the DT by verifying that the DT will produce an artifact that represents or embodies the justification knowledge or kernel theories, and secondly to evaluate whether it proves to be useful, just as discussed by James (1995). Hevner et al. (2004) propose that the completion of this mission can use multiple empirical methodologies as well as logical proof that the artifact solves the problem, as illustrated in Table 1, from the most empirical and "realistical" to the most abstract.

Table 1. Evaluation of a DSR artifact (adapted from Hevner et al., 2004)

Class	Evaluation approaches
Observational: field study of instantiations	Case study of the (instantiation of) the artifact in the business environment
	Field study/Multiple case study of multiple instantiations
Experimental: controlled or simulation experiments	Controlled experiment to test certain qualities of the artifact
	Simulation to try the artifact with real data
Testing: functional or structural	Functional(black box) testing of the overall functionality to indentify defects in behavior
	Structural(white box) testing of the instantiation to test particular properties/functionalities
Analytical: structural and performance analysis	Static analysis of the artifact structure
	Architecture analysis of the fit of the artifact to IT the infrastructure
	Optimization the behavior of the artifact and demonstration of the operational bounds
	Dynamic analysis of the performance and the stability/reliability of the artifact
Descriptive: plausibility of the artifact in use cases	Informed argument for the plausibility of the designed artifact based on the knowledge base, i.e. previous experience and research
	Scenarios to demonstrate the utility of the intended artifact in use

The evaluation practices, save for the descriptive and to some extent analytical evaluation, require an instantiation of the DT as an artifact, which can be somehow observed and measured to gather data based on which conclusions about DT can be presented. It is worth noting that if the design is based on a DT as discussed above, the descriptive validation is at least partly built in the design process. Further, not all the practices require an instantiation of the artifact to an actual environment; descriptive, analytical and to some extent experimental evaluation can be done by examination of the artifact or through a simulation, without a physical instantiation of the artifact.

What is more, an instantiation of an artifact alone is not sufficient to validate the design propositions or a DT. As stated above in multiple occasions, the DT has to guide the building of an artifact that embodies the essence of the DT, and it has to be useful in solving the research problem; to test this usefulness the simple fact that we have an instantiation does not give us information about its usefulness. This duality of evaluation and validation is referred to as 'verification and validation' in simulation modeling (e.g. Sargent, 2005; Kleijnen, 1995; Balci, 2009), where verification corresponds roughly to the act of ascertaining that the model artifact represents the phenomenon it models sufficiently, and validation to the act of determining whether the model works as intended and has realistic outputs. In the software context, the matter is a bit different and it is often understood that verification answers the question "have we built the software right?" in terms of structural and architectural features, and validation the question of "have we built the right software?" in terms of user requirements. As discussed above, evaluation has a further implicit meaning for determining the worth of something, in a similar sense as Hevner et al. (2004) use the word. To summarize, in the context of DT the task of verification would correspond to ascertaining that the (instantiated) artifact represents or embodies aspects of the DT, validation then corresponds to determining whether the artifact works as proposed and by extension whether the DT is valid, and lastly, evaluation measures its quality, efficacy and utility. In practice, however, validation is intertwined with the evaluation and verification activities in terms of methods and instruments.

To return briefly to the philosophical basis of the presented framework; the other dimension in choosing evaluation methods and instruments is that, as our ontology describes, there are three worlds where science operates. For validation, this means that we need to use methods measures that can give us the information we need. I discussed above that the two main interests we have is ascertaining that our propositions are true and useful. Our artifact is naturally in the third world, the world of artificial, and truthfulness is a question for both the world of facts and the world of perceptions. Usefulness is then more strongly associated with the second world, the world of perceptions, as (perceived) usefulness is associated with user expectations and their fulfillment, even though the behavior of the artifact that evokes a satisfaction response is associated with the world of facts.

McGrath (1981) illustrates the need for triangulation with arguing that the choice of a research design or strategy is a "three-horned dilemma", where the researcher has to compromise between representativeness in a population, describing behavior accurately, and taking the context into account, often by choosing to optimize one dimension and "sitting uncomfortably" on one or two of the horns. Essentially this means that triangulation of multiple strategies/methods enables better compromises if we choose methods that complement each other. I have chosen a three-fold evaluation design following Hevner et al. (2004). On the whole, the evaluation procedure follows roughly the guideline set by Iivari (2007) and backed by Hevner (2007), stating that the artifact should be tried in controlled conditions first before moving to implementation. Kitchenham et al. (1995) discuss the difference between case studies and experimentation in software evaluation, and argue that by nature experiments are more rigorous, and when properly designed offer highly valid and generalizable results, where cases can be more illustrative of complex cause-effect relations, especially over time. Further, by nature experiments tend to be scaled down and simplified in order to exert better control over the phenomenon under study. The aim of my design is to choose methods that support each other, as experimental research in general aims to control for interference in order to examine the phenomenon of interest in its most bare form, whereas case study research (CSR) results in rich descriptions of phenomena in their surroundings and promote deep understanding of the subject. In other words, my first compromise is controlling the situation to be able to evaluate the treatment better, at the expense of a realistic context. The case study strategy illuminates the effect of the context, with the expense of generalizability and control over the situation, balancing the overall design.

Accordingly, the artifact is first tested in experimental conditions to examine its functionality and to demonstrate the principle, in short to produce a general proof of concept. This stage of evaluation roughly corresponds to the verification of the DT. The tested artifact is then tried in a "production" condition in two cases, which are oriented toward evaluation and validation. In terms of the research process, the testing is on the border between building and demonstration, as it carries elements from the build-evaluate cycle as well as demonstration. The cases build a bridge from demonstration to evaluation. So, where the tests focus on trying whether the DT will produce an artifact, the cases are more revealing in terms of utility.

2.3.1 Experimental Testing

Experimental testing is based on creating a controlled situation, where a 'treatment' is administered to a group of test subjects to determine what the effect is. To the end of finding out what the net effect of the treatment is, the design needs to determine what the relevant situational factors that can affect the effect of the treatment are, and control or at least keep them constant between the experiments. This design allows for two things, rigorous evaluation of the effect of the treatment and assessment of the scope of applicability through replicating the treatment to any number of cases inside the populations the researchers wish to generalize to.

While the basic design remains the same, Zelkowitz et al. (2003) recognize four types of experimentation approaches found in the literature, 1) the scientific method, 2) the engineering method, 3) the empirical method, and 4) the analytical method. Of these four approaches, the engineering method seems closest to the epistemology and research mission of the study, as Zelkowitz et al. (2003) describe it as development of a solution to a hypothesis, which is then tried and developed further until further improvement is not necessary. This is roughly consistent with the develop-test cycle (Simon, 1996) or build-evaluate activity within the DSR framework (Hevner et al., 2004; Hevner, 2007)

As Campbell and Stanley (1966) and Shadish et al. (2001) describe, there is any number of experimental designs devised to measure different kinds of treatments and ensure the reliability and validity of the results. In the course of the present research, the question I am most interested in answering through experimental testing is "does the artifact work as intended?" To this end, the most basic of designs, called *XO*, or in plain language treatment and post test (Campbell and Stanley, 1966) can be used.

To measure the test, our research group devised multi-item instruments to measure the most important constructs, the success of the treatment in its broadcast objectives, the perceived validity of the results from the treatment, and the satisfaction and willingness to use the treatment again. The test subjects filled in a questionnaire after a treatment session as a standard measure. The main instruments in the questionnaire beside the success measure of the treatment were satisfaction with the process, the tools, and the results (the instruments are presented in Table 13 and Table 15). As discussed in the literature, satisfaction is an important predictor of future use, and thus and important instrument in the validation of the artifact (Briggs et al., 2003a, Reinig, 2003). In the absence of satisfaction, it is unlikely that the users will adopt the artifact, regardless of any productivity gains that might be realized (Reinig, 2003).

2.3.2 Case Study Research

Case study research (CSR) has a relatively long tradition in IS (Benbasat et al., 1987; Lee 1989) as a strategy for descriptive research. Fundamentally, the CSR strategy has been developed for a descriptive research strategy in social sciences (Yin, 1994) and popularized for theory development in management research (Eisenhardt, 1989). CSR is generally most applicable to explorative-descriptive situations, where the aim is to explore previously uncharted phenomena and to develop qualitative, in-depth, causal explanations (Eisenhardt, 1989; Yin, 1994; Gerring, 2004). Gerring (2004) further proposes that CSR has a methodological high ground when the strategy is exploratory rather than confirmative, insight to causal mechanisms is more important than insight to effects, and internal validity is prized over external.

In a manner these characteristics can be seen as points against using the CSR approach. Yin (1994) discusses that Campbell and Stanley (1966) equate the case study method to the experimental design *XO*, post test only, only now the treatment is administered to an at least to some extent uncontrolled environment. It follows from the inherent uncontrollability that where multiple experiments can be regarded as sub samples of the same population, different cases are regarded as instances of different populations (Lee and Baskerville, 2003; Johnston et al., 1999). On the other hand, case-based testing is a common practice in IS and management literature, as illustrated by e.g. Kitchenham et al. (1995), as well as Bragge and Merisalo-Rantanen (2008), and in the management side Elfvengren et al. (2004) and Lindholm (2008). Johnston et al. (1999) also argue that given certain conditions, CSR can be used in confirming theories and by extension also in DT evaluation. CSR is also a method often associated with design-oriented research within the constructive approach, where the dominant evaluation design is to create an instantiation of the artifact and study it by following the CSR strategy (Lukka, 2003; Lindholm, 2008). The strong points of CSR in this context are that CSR can illustrate the artifact in its realistic surroundings and offer a rich view to the artifact under study. In our particular application, the effect of the phenomenon, that is, the output of the artifact is further studied through a comparison between rivaling artifacts.

As for guidance on how to conduct CSR, I rely primarily on Yin (1994) and Eisenhardt (1989), whose CSR process is illustrated in Table 2. The process is a synthesis of the two frameworks, but follows Yin (Ibid.) in the wider perspective more closely and Eisenhardt (Ibid.) contributes to the more practical aspects. In additions to the process outline, Yin (1994) sets five basics for CSR which need to be taken into account: 1) the research question, 2) propositions, 3) the unit of analysis, 4) the basic link between the data and propositions, and 5) the interpretation framework for the data. Lee (1989) discusses CSR and similarly proposes that CSR can refute or falsify a theory, given that the stated theory is falsifiable, logically consistent, more predictive than rival theories that explain the same pattern and outcome of the unit, and not falsified by the experience. To this end, the researcher clearly defines propositions and patterns of data that either support or falsify the theory and contrast them to the gathered data. In this context, these aspects are linked with the DT and DSR process: the basic problem is to evaluate the artifact in relation to the DT and its objectives, thus the unit is the artifact, and the proposition is that it either represents the DT and is useful or it does not and is not. Now the link between data and propositions is more a case dependent issue and will be discussed below, as well as the framework for analysis. The basic pattern, however, is that one needs to think beforehand what would be the criteria to deem the artifact unsuccessful, and unrepresentative of the DT, and what data would be needed to test this (Kitchenham et al., 1995; Johnston et al., 1999).

A further issue is the choice of cases, as Yin (1994) reminds, the cases should be representative and interesting, and a single case study is strong mainly if the case is critical, i.e.

somehow extreme or very illustrative and can confirm, challenge or extend the theory behind the study. From a purely Popperian perspective, all test cases are critical for an artifact, for if the artifact does not work, it needs to be redesigned and tried again. However, even if it works, it is possible that the situation can change in different instantiations. Multiple cases, in turn, should be chosen so that the circumstances imply that the case either supports the propositions, or refutes them for predictable reasons. Lee and Baskerville (2003) have explored generalizability further, and they conclude that research results are generalizable to units similar to the units studied, in other words within a population, so the choice of the case affects the boundaries of applicability for the results significantly. In this sense the main criteria for case choice would be to choose cases that exhibit the problem to be solved by the DT exceptionally well, or are very representative of the population one strives to generalize to.

Table 2. The CSR process (adapted from Eisenhardt, 1989; Yin, 1994)

Phase (Yin, 1994)	**Step (Eisenhardt, 1989)**	**Activity (Eisenhardt, 1989; Yin, 1994)**
Designing the study	Getting started	- Definition of research question - Developing a priori constructs/propositions
	Case selection	- Specifying population - Theoretical, purposeful case selection/sampling
Preparing for data collection	Crafting instruments and protocols	- Selection of data collection methods - Determining relevant data - Determining field procedures - Briefing investigators - Pilot case
Collecting the evidence	Entering the field	(- Pilot case) - Data collection and retrieval - Documentation of the case and field notes - Flexible collection, iteration between research agenda and data - Establish a case study database
Analyzing the evidence	Analyzing data	- Within-case analysis - Cross-case comparisons
	Shaping hypotheses/propositions	- Looking for evidence for each construct/proposition - Looking for replication of results across cases - Explanation building
	Enfolding literature	- Comparison with existing, conflicting and confirming literature
	Reaching conclusions/closure	- Theoretical saturation is reached

3 LITERATURE REVIEW AND FORMULATION OF THE DESIGN THEORY

This chapter is structured around the main components of a DT (Gregor and Jones, 2007) and encompasses all the three bodies of literature relevant to this thesis. Figure 6 illustrates how this chapter is structured in terms of content and how the different bodies of justification knowledge relate and contribute to the DT. I will start putting the DT together by discussing the scope and context of the DT in the field of strategic technology management and the challenges this area of application presents to the DT. After that I will move to the field of futures studies and discuss the constructs and principles of form and function, and underline the challenges faced in fulfilling the research mission of making scenario planning more accessible. As these subchapters chart the environment I work in, as well as the design problem, I will delve into the knowledge base to find foundations for the DT and seek justification knowledge for supporting the design. Lastly, the final subchapter will summarize the principles of form and function for the DT.

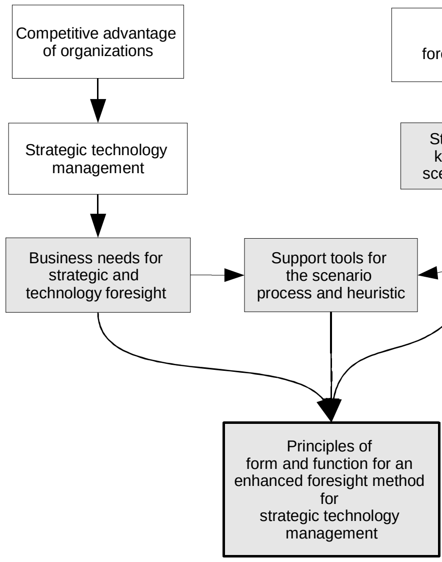

Figure 6. Structure of the literature review

3.1 Foresight and Strategic and Technology Management – Purpose and Scope

3.1.1 Strategic Management and Competitive Advantage

Strategic management is ubiquitous for modern organizations. In common language the word strategy means “a careful plan or method; a clever stratagem” or “the art of devising or employing plans or stratagems toward a goal” and further “an adaptation or complex of adaptations (as of behavior, metabolism, or structure) that serves or appears to serve an important function in achieving evolutionary success” (strategy, 2010). These definitions let us summarize that strategy is a plan, or in biology adaptive behavior, to achieve set goals. Mintzberg (et al., 1998; 1987) has defined strategy through five Ps: Plan, Ploy, Pattern, Position, and Perspective, which each represent a slightly different perspective to strategy and strategic planning or management.

The field of organizational strategy has been divided by the strategic paradigm, the source of competitive advantage, and the process of strategy creation e.g. (Foss 2005; Coyle, 2004; Johnson and Scholes, 2002). The leading paradigms in strategic theory are considered to be the view of Organizational Economics (OE), the Resource Based View (RBV). These theories or views try to explain the source of sustained competitive advantage, and offer a framework for a manager to achieve such advantage. Sustained advantage is defined as an ability to earn rent over comparable or substitute products/services for extended periods of time (Foss, 2005; Porter, 1985, p. 3), that is, making more money than firms with comparable offerings, which is in fact the underlying reason and objective for strategic considerations.

Nikolai Foss (2005) considers Ronald Coase's paper "The Nature of the Firm" of 1937 (Coase, 1937) as a starting shot for the development of organizational strategy in the business field. In chronological order the first view was OE (later also IE) in Coase's footsteps, trying to explain the existence of firms. OE has been mostly concerned with economies of scale and economies of scope, and transactional costs in operations as the basis for competitive advantage. OE deals mostly with optimizing transactional costs and contracting. Perhaps the key issue in OE, with respect to strategy, is the economics of transactional costs. Some consider Edith Penrose's "Theory of the Growth of the Firm" (Penrose, 1959) as an overture for strategic theory, as it describes the mechanisms and premises for growth.

To some extent, the RBV could be characterized as a logical continuum from OE. The main proposition in RBV is that firms are basically heterogeneous in terms of internal structure, they have different resources, which explains the difference in performance (Barney, 1991; Peteraf, 1993). This proposition is quite opposite to the popular framework of strategic positioning and choice of generic strategies (Porter, 1985), which implies that firms are more or less homogenous in the long term, which allows for forging generic stratagems that can be played when appropriate. More specifically, Barney (1991) has posited that resources that are Valuable, Rare, Imperfectly /Inimitable and Non-transferrable/-substitutable, VRIN for short, are the main source of competitive advantage, as their uniqueness allows the firm to do different things or things differently compared to its competitors. Sustained competitive advantage follows from managerial decisions to deploy and develop these resources to create and leverage subtle market failures (Amit and Schoemaker, 1993).

RBV has been made popular through ideas like Prahalad and Hamel's (1990) idea of core competence and the dynamic capabilities by Teece et al. (1997). Core competences can be seen as an extension to the concept of resources as they are defined by Prahalad and Hamel (op.cit.) as the set competences, accumulation of skills and expert knowledge and people possessing these assets, which allow a firm to enter new markets and quickly differentiate their product or service offering based on operational conditions. The next evolution of competences is the framework of dynamic capabilities (Teece et al.,1997), similar to Jules Goddard's (1997) meta-competence. Goddard explains meta-competence as being an ability to renew and develop a company's core competences on the macro level, in much a similar fashion as competences are enabling on the micro level. The key term in managing with RBV is according to Johnson and Scholes (2002, p. 7) strategic fit, or managing and organizing the portfolio of resources, material and intangible, for an optimal fit to current conditions.

However, it is not in the scope of this study to go into too much detail on the sources of competitive advantage, but to discuss how technology management contributes to sustained competitive advantage of the firm, and how we can support strategic technology management through scenario planning. For short, the literature summarized above suggests that sustainable competitive advantage is a function of its resources, how these resources are activated to operations and how they are replenished and replaced by acquiring new resources. Teece et al. (1997) propose a framework of dynamic capabilities for strategy creation. The message is that an organization’s competitive advantage is a function of its managerial action, processes, resource positioning and paths to and from the current position. The difference to for example Porter (1985) is the acknowledgement of path dependency created by the finite rationality of members of the organization (Cohen and Levinthal, 1990), and the knowledge assets and the processes and structures that contain them as resources. A dynamic strategy is formed through a learning process, revolves around the recognized competences and capabilities of the firm, directing the path of the organization.

This brings us to the relationship between strategic planning, competitive advantage and RBV. When we accept the RBV as a valid framework to explain differences in competitive advantage between firms, we can see that technology management has strategic significance, as in general the products and services any given firm offers is its main revenue source, and its main competitive advantage, so we can propose that MoT has an important function in applying the resources of the company to realize the potential competitive advantage. As Arend (2003) points out, the study of competitive advantage is irrelevant without the means to realize the advantage, as theoretical competitive advantage, say a wealth of VRIN resources, does not by itself result in sustained superior performance without action.

3.1.2 Strategic Technology Management and Competitive Advantage

As conceded, technology and innovation management have strategic significance, and I will now discuss the challenges this strategic technology management has that can be alleviated with the scenario method. So, based on the RBV, I argue that the resources are tied to technology management and innovation through capabilities, or as Wernerfeld (1984) proposes, products are the logical extension of organizational resources and capabilities. The (dynamic) capabilities, coined by Teece et al. (1997) are defined as a capability to use and develop new competencies for sustained competitive advantage over rivaling firms, or in other terms “a learned pattern of collective activity [routines] through which the organization generates and modifies its operational routines [here also formal processes] in pursuit of improved effectiveness” (Teece et al., 1997; Zollo and Winter, 1999; Eisenhardt and Martin, 2000). Competencies, on the other hand, as Prahalad and Hamel (1990) describe them, are distinct, hard-to-imitate skills, processes, structures or pools of knowledge, which are manifested in an ability to create advantage through for example rapid product changes and give opportunity to invest in new markets flexibly (Javidan 1998).

Dierickx and Cool (1989) propose that in normal circumstances the resources or assets of a firm are like stocks, whose levels are moderated by flows, and they can not be readily bought and sold, only the flows can be adjusted. This metaphor illustrates the path dependent nature of strategic management, illustrated among others as a river, which is guided by the direction, mass and velocity of the current and constrained by the surrounding environment of competitors and stakeholders (Lamberg and Parvinen, 2003). Cohen and Levinthal (1990) introduce absorptive capacity as an explanation to path dependency by arguing that present knowledge (resources) directs our perception of what is potentially important and valuable, and thus creates path dependency. This implies that the choices made today will affect the possibilities or at least the perception of decision options tomorrow and long after that.

A firm has a certain set of capabilities and a portfolio of technology at a given time. Technology development is generally cumulative, based on previous projects and ideas, following path dependence. In a similar fashion, capabilities are also considered to be path-dependent, as they are based on a body of knowledge and they evolve through learning and reflection of new information against the existing body of knowledge (Cohen and Levinthal, 1990; Kogut and Zander, 1992). In plain terms: the firm evolves based on previous experience and generally does not do sudden turns. More recent literature (e.g. Cepeda and Vera, 2007; Danneels 2008; Ellonen et al., 2009) goes further to distinguish between first and second order capabilities. The first order capabilities are the operative capabilities and routines, and the second order capabilities are capabilities that enable acquisition and combination of new and old knowledge and adaptation of the first order capabilities to match the evolving competition better, or according to Teece (2007), they can be classified as sensing, seizing and reconfiguration capabilities.

Figure 7 illustrates the layered nature of innovation in relation to the innovator, and the linkage of technological innovation to the resources and capabilities of the firm. The vertical axis represents the target of innovation. Following RBV, the capabilities and competence of the firm are the base of the competitive advantage pyramid that supports successful products and services. On top of these tacit routines are the formal processes. The routines and processes are separated in this classification, as routine is seen as a more informal and intuitive structure, the *gist* or 'the way we do things in this organization' and the formal processes are formal statements that are descriptions of these structures, or aim to reform them. These two levels form the backend structure normally invisible to outsiders, whereas the services and products, which build on these preceding levels, form the tip of the proverbial iceberg and large parts of the company's façade. The relevance of these considerations of capabilities and levels of innovation are better understood in the realm of 4^{th} generation R&D (Miller and Morris, 1999). Miller and Morris (ibid.) propose that the aim of technology management is to recognize the latent customer need, which, when identified, guides the acquisition and building of capabilities to cater these needs, and these capabilities in turn manifest themselves in the operations, as illustrated in Figure 7.

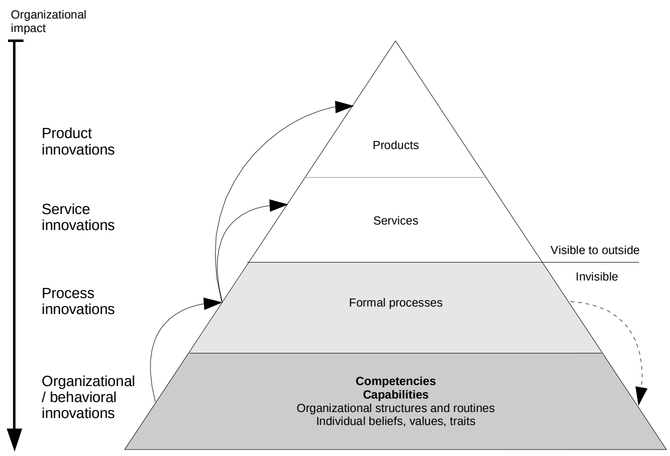

Figure 7. Innovations by target and the level of organizational impact

What this means for strategic technology management, are fundamental challenges. If the dynamic capabilities are path dependent as Cohen and Levinthal (1990) suggest, they form a path of possibilities, which technological progress is built on. The challenge is that an organization is tied to certain technologies by its present resources and knowledge, and can not easily take a side step even if the market does, which brings a fundamental risk in investments to resources. On the technological level, the discrepancy between the views in the organization and the potential customer come into play. Customers have needs that can be satisfied with certain technologies, which may or may not be attainable by the means available to the organization. Similarly, there is the actual customer need, as the customer conceives it, and the image the organization has of the actual need. The discrepancy between the need and identifying it may come from a lacking market analysis, misconception of the customers' statements, or the customers' inability to formulate the present needs in an explicit manner. Also the customers' perceptions of the offering may differ from the intended use or the value proposition put forward by the developer. These sources of uncertainty and thus risk create a need to anticipate the development of the competitive landscape, as I will elaborate below.

3.1.1 Business Needs for Strategic and Technology Foresight

While it can be argued convincingly that possession of VRIN resources leads to competitive advantage, the other side of the coin is that the resources do not necessarily stay VRIN indefinitely. The competitors develop new resources, the resources may be depleted or become obsolete, or their nature may leak to competitors. Amit and Schoemaker (1993) discuss the decision making associated with 'strategic assets' i.e. adapting and activating the resources of the firm to suit the structure of competition. They (Ibid.) propose that management decisions are easily biased by present and recent events, especially when the form has been successful recently. However, as natural it is to continue behavior that has been rewarded in the past, they (Amit and Schoemaker, 1993) go on to argue that remaining open and looking past the present, and especially the recent past, is crucial. The key issue to sustained competitive advantage is developing a program to acquire new resources progressively, to replenish the stocks that determine the potential for competitive advantage.

As discussed above, path dependency and limited resources raise the question of "if these are the resources active now, are they still important to us in two, five, or even ten years' time?" and "if not, what are the resources that grant us competitive advantage then?". Overall, Amit and Schoemaker (1993) remind that strategic management is not a closed form, rational, game, as the rules, the players, and even the board, tend to change over time and it is difficult to understand how the moves will affect the status quo. This uncertainty is the reason I argue that industrial companies can benefit from foresight, as the use of foresight methods will give insights about possible future developments and enable testing present choices against the possible contingencies that lay ahead.

However, to remain critical, we should stop for a moment to consider the ramifications of assuming RBV as the framework to work with. The Porterian school (e.g. Porter, 1985) to strategy, also referred to as the positioning school (Mintzberg et al., 1998), can benefit from foresight just as well. Porter (Ibid.) proposes using scenario planning to support strategy making. The positioning school offers a relatively simple and closed form framework for strategic management, where gaining sustained competitive advantage is based on choosing a lucrative market, managing the five forces that set the competitive environment, and choosing the correct strategy according to the properties of the environment. Inside this framework, the uncertainty comes from possible changes in the five forces, which could render the chosen strategy inappropriate. We see that the need for foresight is not limited inside the RBV framework, although the reasons for favoring scenario planning in Porterian strategy making might be different from the ones proposed above. On these bases, the proposition that foresight is beneficial to strategic technology management seems robust.

Let us use the river metaphor (Lamberg and Parvinen, 2003) further to wrap up the challenges of strategic technology management, which can benefit from foresight. The metaphor pictures an industrial company as a river, a moving body of water that has speed and thus inertia. Because of the inertia, the body has to move forward and the decision can not be taken back once done. As Keen and Sol (2008) add, decision making can not be avoided, or the river spreads out to tiny streams and withers away. When the water flows, it is at the same time constrained by the environment, while it also carves its marks in the landscape. Due to the time pressure created by inertia and factors like bounded rationality (Simon, 1996; Keen and Sol, 2008), incomplete information (Keen and Sol, 2008), complexity and uncertainty (Amit and Schoemaker, 1993), many important strategic decisions, “decisions that matter”, are by nature “wicked”, as there is no one single optimal or right solution, only a set of compromises, some of which are more satisficing than other (Rittel and Webber, 1973; Simon, 1996; Keen and Sol, 2008).

Table 3. Strategic management according to the river metaphor (adapted from Lamberg and Parvinen, 2003; Amit and Schoemaker, 1993)

Aspects of strategic management	Details of the river metaphor
Role of evolution and dynamics in decision making	Decision making is bound by past decisions and present resources; Once made, decisions can not be reversed
Time and timing	Time moves constantly, and (some) decisions have an appropriate time window; Cycles and phases in the industry are relevant to decision making
Industry co-evolution	Strategy making is a process of co-evolution; Strategic decisions are based on the environment, While strategies shape the environment
Momentum	The mass and velocity of the organization are in correlation with the amount of strategic inertia
Systemic nature of decision making	Decisions are complex and involve unpredictable contingencies; Actors, organizations and their environments are interlinked on different levels

While the original river metaphor is placed in a strategic context, we can recognize the same challenges in technology management. The market response of a product is often quite uncertain, and new products or other news can launch an unexpected competitive reaction in the market; the choices made concerning technology in relatively insignificant projects can have a long-term impact on organizational capabilities and absorptive capacity, and so on. As conceded, technology management is an important part of strategic management of firms. In this context developing foresight, some sort of chart for navigating the landscape ahead can help to alleviate some of this risk and uncertainty. To illustrate the challenge by paraphrasing the introduction to futures research methodology by the United Nations Millennium Project: when navigating in dark on a river lousy with rocks and mudflats, the faster we move on and the harder it is for us to turn, the better headlights we need to avoid accidents (Glenn 2009, p. 3). This is the main point of the purpose and scope I will discuss next when we move from the context and meta requirements toward justification knowledge and design.

3.2 Scenario Planning – Constructs and Principles of Form and Function

3.2.1 Foresight and Scenarios – An Introduction

Figure 8 illustrates different commonly used methods to manage and mitigate uncertainty in strategic management according to Coyle (2004, p. 49). If we proceed from the bottom, the most basic choice is between a passive and an active approach or outlook to uncertainty. A passive strategist either relies on the plans and hopes for the best, or ignores the possibility of changes and consequences, or copes with them. The second crossroad is between sharing the risk and anticipating the consequence. Insuring or shifting the risk works for situations where the risks are more of the everyday variety, while the fundamental business risks that concern the future of the business are not insurable may have even more impact on the organization’s ability to operate in the future deserve more attention. The final choice up the tree is between quantitative and qualitative methods. Quantitative methods include classical forecasting activities, trend analysis, game simulations, system dynamics modeling, real options, *et cetera*. The cognitive (qualitative) methods include a variety of methods commonly known as foresight of futures study methods, example include narrative studies and systematic assessment methods or the scenario approach.

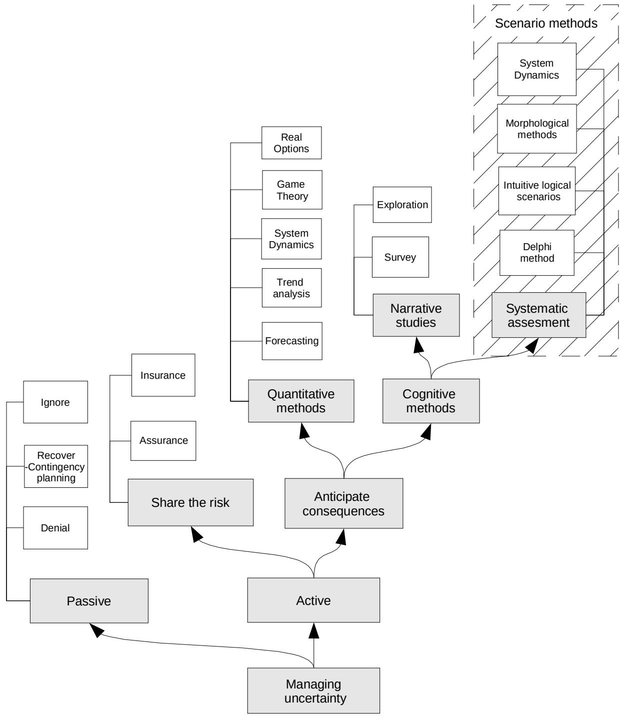

Figure 8. Methods for coping with uncertainty and risk (adapted from Coyle, 1997; Coyle, 2004, p. 49; Bradfield et al., 2005)

While there are persuasive arguments for each approach and method, this study will focus on the scenario approach. Between scenario practitioners and scholars, there is an unsurprising consensus that scenarios are a versatile way to manage uncertainty (Stauffer, 2002), but Schoemaker (1993) stresses that scenarios gain appeal as complexity and uncertainty of a situation rise. Thus in the literature scenarios are often proposed as a tool for strategic management or strategic foresight, even as an integrated part of the strategy making process (Coyle, 2004; Walsh, 2005), or as a backdrop for the strategy process (Godet and Roubelat, 1996; Godet, 2000). Besides Coyle, Mintzberg et al. (1998) seem cautiously positive toward scenario planning, specifically referring to Porter's (1985, p. 445) thoughts on the subject. Porter (Ibid.) criticizes strategy formulation for being based on conventional wisdom, as well as forecasting activities, which in his view tend to smoothen the expectations unnecessarily.

On the surface, the more obvious benefits of scenario planning are a wide and robust view to the future of the business and technology, increased foresight and sensitivity to possible changes, while the more recent literature has raised process-related aspects such as increased organizational learning, more flexible and robust mental models, heightened awareness of the environment, and the dialogue that creates shared understanding and consensus about the future and actions for the future in the organization, as equally important benefits from engagement in scenario planning. (see e.g. the review by Varum and Melo, 2010)

Depending on the author, scenarios or scenario planning can be seen as rooting from very different sources. One proposition comes all the way from ancient Greece, as the word scenario can be seen as the etymologic parent of the word "scene" in theatrical terminology (Ogilvy, 2002). The field of futures studies (FS) that can be characterized as scientific activity has been incepted in the nineteen fifties e.g. during the Manhattan Project simulations in the 1940s to find out if 'The Bomb' would literally light up the skies, or while building the Strategic Missile Command early warning system (Bradfield et al., 2005; van der Heijden et al., 2002; Schoemaker, 1993), and futures studies as a scientific field followed during the sixties and seventies.

The scenario approach is rooted in relatively straightforward techniques and has evolved to a variety of more or less intricate views, with a trend of applying more "scientific" modeling and analysis techniques. In its infancy, scenario planning was mostly used for military purposes in the new world and for governmental planning purposes in Europe. The dawn of scenario planning, as it is known today, dates back to the 1960s. The credit of being the *primus motor* has been given to Herman Kahn, who at the time worked with the RAND Corporation, although Gaston Berger worked on the same lines at the same time when pondering the future of France (Bradfield et al., 2005; Schwartz, 1996, p. 7; Chermack et al., 2001). Since the inception, the variety of scenario techniques and applications has broadened substantially (Chermack et al., 2001; Bradfield et al., 2005). The breakthrough in business was in the early 1970s when Pierre Wack, being familiar with Kahn's work, started to experiment with scenario planning in Royal Dutch/Shell. The landmark of scenario planning, also widely popularized, is Wack's first scenario set which supposedly predicted the oil crisis in the seventies, but at the time Shell failed to act according to what the scenarios commended.

Table 4. Types and uses of scenarios

	Kahn and Wiener (1967)	**Ogilvy (2002)**	**Schwartz (1996)**	**Schoemaker (1991)**	**Coyle (2004)**	**Porter (1985) Walsh (2005)**
Form	Story, descriptive	Story, descriptive	Story, (normative)	Story, descriptive	Story, descriptive	Story, normative
Use, perspective	Macro level, global and state level developments	Macro level, Changes in society, values	Macro level, Organizational strategy	Macro level, Organizational strategy	Industry level	Industry level, organizations, positions
Emphasis	Detailed, elaborate, broad sight	Values, social structures	Learning as a result of the process	Relations in the operational field	Directing actions, shaping paradigms	Environment analysis, positioning
Time horizon (approx)	<40	<20	<15	<10	<10	<10

Today the field of scenario planning is rather scattered, and Bradfield et al. (2005) go as far as describing the situation as a methodological chaos. A probable reason for this apparent chaos is that practitioners tend to have different emphasis and views. The two main schools are Kahn's American school and the French or *La Prospective* –school. Inside these camps, the variety of methodologies can be further divided to Intuitive-logical, *La Prospective*, and Probability – models. In the beginning of scenarios the scope was usually at the state or global level, and the time horizon spanned up to forty years forward, but the modern uses include innovation management and technology selection, organizational strategy formulation, operational strategizing and military applications, and the time lines can be as short as a few years (Table 4). (e.g. Ralston and Wilson, 2006; Kokkonen et al., 2005; Naumanen, 2006; van der Heijden et al., 2002)

3.2.2 Definitions – Constructs and Units of the DT

Starting from the definition of scenarios, Kahn and Wiener (1967, p. 33) define scenarios as "Hypothetical sequences of events constructed for the purpose of focusing attention to causal processes and decision points" with the addition that each situation's development is mapped step by step and each actor's decision options are considered along the way. The aim is to answer the questions "What kind of chain of events leads to a certain event or state?" and "How can each actor influence the chain of events at each time?"

Coyle (2004, p.57) defines scenarios as justifiable and traceable chains of events, which can be reasonably expected to happen in the future. Coyle's point is that scenarios are stories of the future rather than descriptions of conditions at a defined time, and that the key is not accurate prediction but the process, which is supposed to lead the decision makers to ponder boundaries of the future outside their usual frame of mind. Schoemaker (1991; 1993; 1995) writes that scenarios simplify the infinitely complex reality to a finite number of logical states, by telling how the elements of a scenario relate to each other in a defined situation. In Schoemaker's view, scenarios as realistic stories might focus the attention to perspectives which might otherwise be overlooked.

Ogilvy (2002, p. 176) expresses this more poetically; his view is that, like in a proper tragedy, a scenario should have a beginning, a middle, and an end. Ogilvy's (Ibid.) spin is that creative and attractive stories arouse the readers' imagination, thus helping in adopting the ideas of change and facilitating action. Also Schwartz (1996) describes scenarios with theatrical terms, as plots that tie together the driving forces and key actors of the environment. In Schwartz' (Ibid.) view the story gives a meaning to the events, and helps the strategists in seeing the trend behind seemingly unconnected events or developments.

From these definitions, we can derive that scenarios are a set of separate, logical paths of development, which lead from the present to a defined state in the future. Further, scenarios are not descriptions of a certain situation sometime in the future, nor are they a simple extrapolation of past and present trends. Figure 9 provides further illustration of scenarios, for the purpose of clarifying the concepts. As of this point, a single scenario is referred to as a scenario and multiple scenarios developed as a set are referred to as scenarios. The other dimension in scenarios is the relationship of entities in a scenario set.

Some writers (e.g. Schwartz, 1996) use the concept of "drivers of change" to describe the forces, such as influential interest groups, nations, large organizations and trends, which shape the operational environment of organizations. Especially the methods derived from the so called Shell/Global Business Network method seem to stress finding the drivers and the processes that shape the future (e.g. Wright and Goodwin, 2009). I interpret that these drivers create movement in the operational field, which can be reduced to a chain of related events. These chains of events are in turn labeled as scenarios, leading from the present *status quo* to the defined end state during the time span of the respective scenarios. It may have to be noted that it is not assumed that a driver has one defined state, but multiple possible states. Thus, a driver can influence multiple events, which may or may not be inconsistent in a given set of scenarios, but of course, according to the definition of a scenario, not in a single scenario.

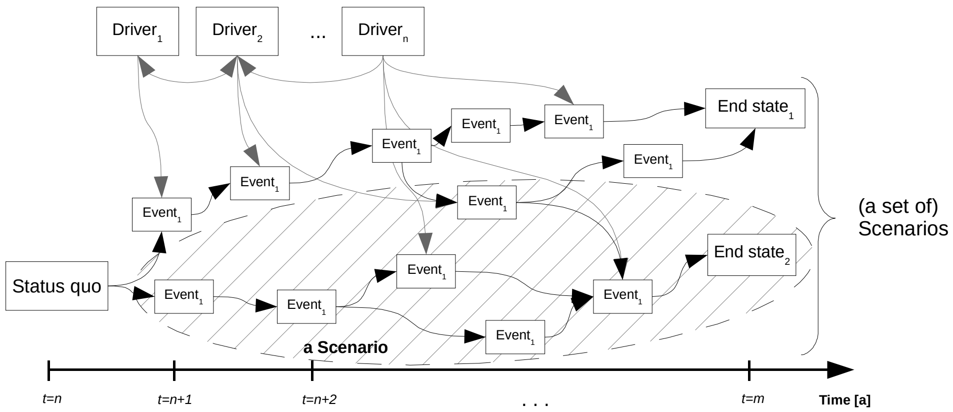

Figure 9. The relationship of drivers, events and scenarios (a single scenario highlighted, driver relations depicted with the gray arrows)

In scenario planning, another key construct beside the definition of scenarios is the method through which the scenarios are composed. The method in fact prescribes the principles of form and function for scenario planning. While, again, in common language a method is “a procedure or process for attaining an object”, “a systematic procedure, technique, or mode of inquiry employed by or proper to a particular discipline or art” or “a way, technique, or process of or for doing something” (method., 2010), I propose that besides the description of a process, a successful description of a method should also describe success criteria for the outputs or products of the process. To underline the difference, the method generally describes the ‘principles of form and function’ for the process of attaining the objectives, while the success criteria will prescribe the form of the output.

Further, I would like to highlight the scenario heuristic as a significant part of the method. By heuristic I mean the sub-method or ‘algorithm’ of making the scenarios out of the data collected in the process. However, I do not associate the terms scenario heuristic specifically with the so called heuristic school of scenario planning, but I propose that inside the scenario process, there is a phase where the scenarios are composed according to a logic with certain means and methods, ‘heuristics’, prescribed by that given school and method description. In *La Prospective*, for instance, the heuristic includes structural analysis with the MIC MAC (sub-)method and envisioning actor strategies with the MACTOR (sub-)method (Godet 1993; 2000; Arcade et al., 2009), where the Field Anomaly Relaxation (FAR) method is based on using morphological analysis (Ritchey, 2008) to forge coherent, consistent and logical scenarios (Rhyne, 1981; 1995; Coyle, 2009), and in the intuitive-logical method the common heuristic is choosing the most crucial trends or drivers as “axes of uncertainty” and building the scenario around them (Schwartz, 1996; van t’Klooster and van Asselt, 2006).

3.2.3 Scenario Process and Heuristics – Principles of Form and Function

As discussed above, the literature describes a wealth of scenario methods (e.g. Bradfield et al., 2005; Bishop et al., 2007). Table 5 describes some of the more often cited and popular methods according to Bergman (2005) in more detail to illustrate the main phases of the process, and it also gives a superficial view to the heuristics. The table acts as an illustration of actual scenario processes in different methods, and as a reference point to the generic process used in the course of this study from this point forward, but as can be seen, the description at this level is not complete.

Table 5. Different scenario processes (adapted from Bergman, 2005)

Key elements	Intuitive approach	Heuristic approaches		Statistical approach
	Schwartz (1996)	van der Heijden et al. (2002)	Schoemaker (1995; 1991)	Godet (1993)
Defining the problem and scope	1. Exploration of a strategic issue	1. Structuring of the scenario process	1. Framing the scope 2. Identification of actors and stakeholders	1. Delimitation of the context 2. Identification of the key variables
Analyzing the key elements of scenarios	2. Identification of key external forces 3. Exploring past trends 4. Evaluation of the environmental forces	2. Exploring the context of the issue	3. Exploring the predetermined elements 4. Identification of uncertainties	3. Analysis of past trends and actors 4. Analysis of the interaction of actors and the environment
Constructing the scenarios	5. Creation of the logic of initial scenarios 6. Creation of final scenarios	3. Developing the scenarios 4. Stakeholder analysis 5. System check, evaluation	5. Construction of initial scenarios 6. Assessment of initial scenarios 7. Creation of the final learning scenarios 8. Evaluation of stakeholders	5. Creation of the environmental scenarios 6. Building the final scenarios
Implications	7. Implications for decision-making 8. Follow-up research	6. Action planning	9. Action planning 10. Reassessment of the scenarios and decision-making	7. Identification of strategic options 8. Action planning

Starting from the first column on the left, Schwartz exemplifies the intuitive approach, which largely relies on logical thinking in constructing scenarios. In the middle are two examples of heuristic methods that are more structured than the intuitive, but less than the statistic ones. In the far right Godet, represents the statistical or model-driven approach, which is built on modeling the environment and estimating the development based on more mathematical heuristics.

When we examine the description of the processes, despite obvious differences in the approaches, there are common elements across the field of scenario planning. These characteristic elements are: 1) definition of the problem 2) analyzing the key elements, i.e. the drivers of change and uncertainties, 3) developing (preliminary) scenarios, 4) evaluation of results and revision, 5) creating final scenarios, and 6) implementing the scenarios to decision making. These elements also correspond largely to the phases of the generic foresight process presented by Voros (2003). Figure 10 below illustrates the generic scenario process, based on the synthesis of these existing approaches, I adopt for this study. The size and background color of the phases illustrate the scope of this study; as discussed in the introduction, I will be focusing on designing the method, and will leave the implementation for further study.

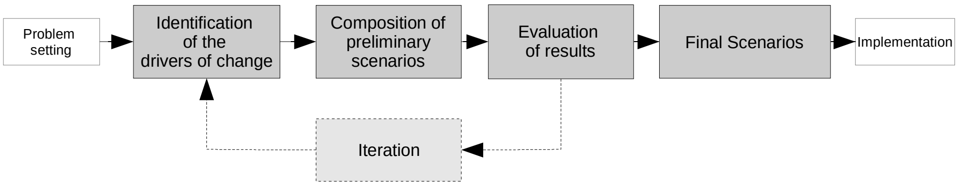

Figure 10. A generic scenario process

The problem setting is defined by the foresight problem the organization wants to know more about. Scoping includes deciding on the resources for the project, deciding on a schedule, choosing the method, choosing the context and level of analysis, as well as the time span, and the topic. For example in technology foresight, the problem might be "how do the core technologies develop during the time period of seven years, and what are the possible substitutes?", to be answered through heuristic scenarios, in a half-year project, with 2 person years of labor, etc.

The first step of the actual scenario process is identification of the drivers of change, as the scenarios were defined in Figure 9; the drivers do indeed drive the other uncertainties and processes (e.g. Schwartz, 1996), so the scenarios should be based on identifying the source or cause of the uncertainty. Depending on the actual method, the uncertainties can be identified through e.g. trend exploration, brainstorming, interviews, or identifying weak signals, and evaluated with different heuristics like morphological analysis (e.g. Coyle, 2004; Arcade et al., 2009; Wright and Goodwin, 2009).

The second step is the composition of (preliminary) scenarios. These scenarios should be again derived from the drivers, and they should be fairly consistent and independent, even though the next step is evaluation of the results. Schoemaker (1995) proposes developing an excess number of scenarios and then choosing or combining the required set from them. In the same way, Schwartz (1996) proposes that the initial scenarios should be evaluated, and if the results are satisfactory and seem trustworthy, then the process can move to the next stage, or if the results seem lacking, a revision is in order. Even though these two practitioners come from the intuitive and heuristic field, the process applies to the more mechanical approaches in the same way, for example the heavily heuristic FAR method is described as a cycle of analysis and scenario development until the scenarios reach certain saturation (Rhyne 1981; 1995). Also in the quantitative field, self-respecting modelers simulate the results with time series data to verify that the model correlates with the reality, and statisticians test alternative models and choose the best-fitting ones.

The third step is then forming the final scenarios. In this phase the scenarios are, at the latest, forged from events and drivers to the logical paths of development based on the previously developed preliminary scenarios. Whereas the first steps of the process can be more of a group action, the actual scenario writing can be done by a smaller group or an individual writer. Again, depending on the method, the writing may be a fairly simple write-up of the event sequences, or the scenarios may need some additional data.

Lastly, there is the implementation of the scenarios, which often may be the weakest link in the chain of scenario planning (Millet, 2003). At the very least, the implementation should be an overview presentation of the final results and handing of the scenario reports to the decision makers. The purpose of such an occasion would be giving an idea of the scenarios and the process to the decision makers, who (should) use the scenarios, and to clear any misconceptions and doubts, so that the scenarios would actually be used in the organization. Many writers propose that scenarios can have a cultural impact, open the thinking of the organization to consider uncertainties better, or perhaps help to avert decision failures etc (Chermack, 2004;

O'Brien, 2004; Schwartz, 1996). However, it can be assumed that there is hardly any effect outside the people participating in the sessions, if the reports lay on the shelves gathering dust. In other contexts, the implementation may not be a separate occasion, but handing the results over for organizational strategy formulation.

3.2.4 Evaluation Criteria for Scenarios

Now that the definition of scenarios is established, the next step is to discuss what qualities should be achieved in the scenario process. Dressed in a cliché: it is not enough to do things 'the right way' i.e. efficiently, one should be as concerned about whether one is doing the right things. Starting from the obvious, one should choose a suitable method according to the foresight need, the level of analysis, and the available resources (for discussion, Börjeson et al., 2006; Piirainen and Lindqvist, 2010). Rigorous use of methodology, documentation, and transparent use of data are good practice and common sense. Another normal due diligence measure is critical evaluation of the project and acknowledging the limitations that come from the method, data and the main assumptions. O'Brien (2004) specifically points out that a common deficiency in scenario planning is to make hidden assumptions; most common of which is to imagine that the present way of life is unchanging. Fulfilling these basic criteria raise confidence to the results and they enable savvy readers to evaluate the results for themselves.

According to the definition, scenarios are sequences of events. Many writers also stress that this chain must be detailed enough, in order to give ground for interpreting which scenario(s) is about to materialize (Ogilvy, 2002; Schoemaker, 1991; 1995; Kahn and Wiener, 1967). The justification of the scenario approach is that in an uncertain situation, the path of development can be recognized at an early stage in order to influence the chain of events or to start damage control measures in time. Kahn and Wiener (1967) for example propose that scenarios should map the decision options for different actors and draw milestones that flag the start of important developments that may lead to future altering consequences. Otherwise the scenarios remain too abstract and distant so as to be actionable to operational management, as discussed by Millet (2003). In contrast, even if good scenarios are detailed, they have to be comprehensible and manageable. Looking at Kahn and Wiener's (1967) scenarios "The Year 2000" in all their 300 page glory; they have foreseen many developments with surprising accuracy and presented a wealth of useful information, but they can also overload an unwary reader fairly easily. The optimum of depth and breadth depends on the audience, use or purpose and the severity of the situation, being a compromise of manageability and detail.

The third point is relevance to the decision makers (Millet, 2003), which is also related to the level of analysis. Relevance starts from the corner stones of actors and drivers; it can be argued that, at least in an infinite span, everything is connected in some way or another, but a reasonable cropping of the picture is necessary to keep the scenarios within some reasonable boundaries. Then again the scenario stories should not be too trimmed, so that important features are not left out and the individual scenarios remain identifiable. The other dimension of relevance is that other things aside, all relevant drivers and events should be included in the scenarios. At the first look, this point might strike as the most obvious, but this is also the pitfall of relevance. The reason of scenarios is to break free from the safety of convention and the obvious, at least for a moment, and to explore the possible instead of the probable (Schoemaker, 1998). Sometimes fairly insignificant innovations or events may have surprising repercussions. For instance, in the 1990s the media and music industry did not take on-line sales seriously as a distribution channel, and recoiled even further away from the on-line world after Napster became wildly popular, but now, as of year 2010, online sales of music, through for example the Ovi Store or iTunes music shop and various streaming services like Spotify, are a growing commercial success.

Other very basic criteria are that the scenarios should be plausible, logical and internally consistent, and coherent and compatible with the drivers and the set time frame (Schoemaker, 1995; McKay and McKiernan, 2010). The definition of a scenario adopted above was a logical and consistent chain of events from status quo to a defined end state. Schoemaker (1995, p. 29) defines three basic tests for consistence: 1) are the trends compatible with the chosen timeframe, 2) do the scenarios combine the effects of compatible drivers, and 3) are the major stakeholders positioned in places that are realistic? As an example from IT industry: 1) can open source software movement disrupt the earning logic of the software industry, and can it happen in five years or in ten?; 2) does the trend of tightening legal governance for intellectual property rights and possible software patents allow open source software to develop to its full potential?; and 3) are the incumbent software vendors joining the bandwagon, or do they try to raise entry barriers?

A smaller qualitative factor is the number of scenarios. Walsh (2005, p. 117) suggests that 2-4 would be optimal, although Schwartz (1996) is certain that more than three would be waste. The general opinion is that more than four scenarios would be too much and would serve only to confuse, especially if a separate strategy is formulated for each eventuality, and two is the obvious minimum, if the objective is to develop scenarios instead of a narrative study. However, Ralston and Wilson (2006, p. 120) remind that when two scenarios are presented, decision makers tend to interpret them as a positive and a negative scenario, which is necessarily not the case, and when three scenarios are presented, the risk is that one will be taken as the most probable, resulting in a tunnel vision toward the selected direction. Schoemaker (1995) has proposed a compromise by suggesting developing 7-9 preliminary scenarios, and then choosing or combining the necessary number of final scenarios out of them.

Another qualitative concern is preserving the nuances of expert opinions and innovativeness in the final scenarios, which is also related to the transparency of the process and handling the data. An innovative atmosphere in the process helps thinking outside the box and nuances give depth to the story, which may help in reflecting which of the scenarios is about to unravel in the near future. Scenarios do not help much if they only encompass the convenient and obvious ‘truth’ or the writer is the only one who bothers to read the whole set.

Lastly, there is the issue of trust. As a quality attribute trust refers to subjective trust. As noted above the, validity and reliability of scenarios can be hard to assess and the aim is not always in the most accurate projection. In fact, Selin (2006) reminds that the subjective trust of the intended audience is what makes or breaks the final results. Selin (Ibid.) lists five conditions for trustworthy scenarios, which apply to the substance of the scenarios, the scenario process and the use of scenarios: 1) the members of the group must trust each other enough to share their expert knowledge, to create reliable data for the scenarios, 2) the process must meet the methodological requirements of the participants for the results to be trusted, 3) the scenario stories must be written in a trust inspiring manner, 4) the substance of the scenarios must be trustworthy, and 5) the scenarios must be presented in a trustworthy manner.

Table 6 summarizes the challenges for successful scenarios which can be used to evaluate the output of a scenario process/method and the success of a scenario planning exercise. The three main challenges specifically for scenarios are sufficient detail, relevance to the user, and length. A good scenario is detailed and informative and gives a vivid image of the future, and the volume of information should be kept at a manageable level. A related point is keeping the scenarios relevant to decision making, as there is little use for totally unrelated information and, which frustrate the reader. While these challenges are important, we can also see that they concern the scenarios themselves more than the process, for which reason I will next review the process and organizational challenges insofar as they concern scenario methods.

Table 6. Levels of successful scenarios

Levels	Success criteria
1. Substance	Consistency and coherence of the individual scenarios
	Right level of analysis and compatibility with the time frame and drivers
	Relevance to the organization and decision makers
2. Form	Sufficiently detailed scenarios, manageable breadth and depth
	Right number of scenarios
	Preserving the undertones and nuances in the final scenarios
3. Methodological integrity	Choice of proper method and rigorous execution
	Transparent documentation of the whole project and evaluation of the results
	Trust building in the process and in communication of the scenarios

3.2.5 Challenges for the Scenario Method – Design Propositions

The criteria for a successful scenario process were discussed above. These criteria translate quite straightforwardly to challenges for the process and the method. However, much of the challenge pertains to choosing and following a method diligently and documenting the work. While this is not necessarily a small obstacle, there are additional considerations from viewpoint of the process and organization. Schoemaker (1998) lists common pitfalls that pertain to the process and content of scenario planning; process-related pitfalls are mostly finding and committing a diverse group of people from inside and outside the organization to the process, and securing management approval and support for the process. Also the interface between the organization's processes and day-to-day management and the scenario process can often be quite loose (Schoemaker, 1998; Millet, 2003). Taking the perspective to scenarios as a management tool, one recurring challenge for scenario planning has been seemingly excessive resource consumption, long projects and thus relatively low return on investment for scenario planning, in addition to the sometimes low impact on decision making (Raspin and Terjesen, 2007).

One angle to the success or failure of the process is, as discussed in the previous sub-chapter, enabling the participants to immerse in the strategic questions and articulate their views (Godet, 2000). Hodgkinson and Healey (2008) also propose that elaboration of one's views is an important mechanism and will help challenge the participants' worldviews, in addition to creating shared understanding between the participant panel and trust to the final scenarios. Postma and Liebl (2005) propose that one of the main challenges in scenarios, as well as in other foresight, is to judge which trends or elements of the future are known or predetermined, which are plain uncertain, and which are not known and thus complete wild cards.

Creativity and innovativeness are often regarded an important part in successful scenario exercise, as the participants are supposed to specifically consider the boundaries of their knowledge and chart the unknown and unexpected (e.g. Postma and Liebl, 2005; Schoemaker, 1995; Schwartz, 1996), but innovativeness can also have adverse effects on the organization, ranging from stress, anxiety and loss of sense of security to idea theft, sabotaging the process and the organization, and destructive conflicts (McKay and McKiernan, 2010). McKay and McKiernan (Ibid.) highlight three challenges to be avoided, including 1) creativity turned to fantasy, 2) confusion about the process and heightened expectations and 3) territorial behavior and sticking to old mental models.

Hodgkinson and Healey (2008) discuss design propositions for scenario planning at length and propose that the design problem associated with achieving the proposed benefits of scenario planning, from the organizational learning perspective, is threefold. First, the team should be configured to include diverse background knowledge and perspective. Secondly, the team should have a blend of people who are able to work together without unnecessary conflict, anxiety and stress, which could inhibit information processing and co-operation to achieve the goals. The third challenge is to design the facilitation process to maximize the likelihood of achieving the goal and minimizing the potential problems. Hodgkinson and Healey go on to write that "Designing an appropriate facilitation process is particularly important, since it may be politically and/or logistically difficult to configure scenario teams to possess ideal informational and personality profiles [at the same time]" (Ibid., p. 439).

Raspin and Terjesen (2007), for example, claim that in the present form scenario planning is not likely going to be an ubiquitous management tool, despite the promises it makes. I propose that one the major obstacles is that the process is at least perceived to be too time consuming and heavy, especially when trying to engage a varied group of people across the organization. Additionally, I assume Hodgkinson and Healey's (2008) proposition that the present practice does not enable discussion and exchanging controversial views in the process, which may inhibit commitment and also possibly increase the risk of 'future myopia' (O'Brien, 2004) or tunnel vision. In the following chapter I will discuss how these challenges can be address with different means to make scenario planning more reachable, efficient and effective.

To condense the challenges (Table 7) to meta-requirements or design propositions, the overall goal is to create a process where a diverse group of people can engage, structure the process to enhance creativity and innovation while avoiding the risks, and use transparent, rigorous heuristics to compose scenarios that summarize the process. At the process level an important overarching challenge is to create a democratic process that engages the participants to a free exchange of ideas and encourages them to examine their mental models critically in a safe environment. This leads to the following design propositions for the scenario method (artifact) which completes the research mission:

P1: The artifact is feasible and usable

P2: The artifact produces scenarios reliably

P3: The artifact enables effective production of scenarios

P4: The process is structured yet innovative

P5: The people are engaged and feel free to contribute

P6: The process compares favorably to existing scenario practices

Table 7. Challenges for a scenario method (adapted from Courtney, 2003; Postma and Liebl, 2005; Kivijärvi et al., 2008; McKay and Mc Kiernan, 2010; Wright and Goodwin, 2009)

Level\Phase	Problem setting	Drivers	Preliminary scenarios	Evaluation	Final scenarios	Implementation
Content	Reasonable and clear objectives and scope	Cropping the relevant drivers	Recognizing relevant and significant events, "milestones", caused by the drivers	Ensuring that the scenario are compatible with the objective and the timeframe	Preserving the underlying logic of the group	
	Choosing the participating group	Covering all aspects in the scope of the scenarios	Interfacing the events with the drivers	Ensuring that the scenarios are logical, consistent and coherent	Compromising between level of detail, length and style	
		Charting the borders of known, uncertain and completely unknown	Elucidation of events and underlying logic prior to vote	Checking for cognitive or framing biases		
Process	Choosing the (right) methods and means	Including multiple worldviews to challenge the 'convenient truth'	Getting the causalities and time line right	Trust building and assurance to the preliminary scenarios		
	Gaining the trust of the participants	Fusing the collective knowledge of the participants	Interfacing the events logically to the drivers	Getting the attention of the group to actually validate the results	Making the scenarios realistic and interesting, without alienating the readers	Instituting the scenarios in strategizing and/or daily management
Organization	Budgeting for resources for the project	Getting the organization involved, getting multiple perspectives to the process				Reinforcing the learning potential from the scenarios

3.3 Tools for and Design of the Artifact – Justification Knowledge and Design

3.3.1 Group Support Systems – Tools for the Scenario Process

Electronic Meeting Systems (EMS) or Group (Decision) Support Systems (GSS/GDSS) emerged in the late 1980s or early 1990s (e.g. Dennis et al., 1988; Nunamaker et al., 1991). The purpose of these systems is to facilitate group work and decision making through enabling fluent anonymous electronic communication and tools, such as voting and structured ideation. In the general hierarchy of decision support systems (DSS), GSS is placed in the branch of communication-driven DSS (Power, 2002). Without going into too much detail, GSS implementations generally feature tools for idea generation, prioritization, commenting and discussion, packaged into a software suite (Turban et al., 2005). As an observation, groupware can be positioned either as a more abstract class than GSS, but in many sources groupware is seen as a parallel construct (Benbunan-Fich et al., 2002; Turban et al., 2005) as both groupware and GSS are computerized systems designed for facilitating group work, and in many cases they use similar tools, but in practice the uses differ. In a similar manner, GSS and EMS can be used interchangeably, or EMS can be seen as an evolution of GSS technology, depending on the author and application (see e.g. Dennis et al., 1988; for practical usage e.g. Nunamaker et al., 1991; Weatherall, 1997; Blanning and Reinig, 1998). I adopt here a narrow definition of GSS as a system that is used to aid decision making in a defined situation, between certain individuals assembled for this particular task, during a specified time, and groupware as a system that is used to mediate and facilitate the workflow of a wider audience in an undisclosed timeframe.

Since its inception in the 1980s, GSS graduated quite quickly from general group support in tactical and operational management to the board room and strategic analysis and planning (Nunamaker et al., 1989). The idea of using GSS in the scenario process is not a new one; GSS has been used on strategic management and planning in various applications since the late 1980s (Nunamaker et al., 1989; Weatherall, 1997; Shortt, 1997; Adkins et al., 2002), including scenario planning (Blanning and Reinig, 1998; 2002; Eden and Ackermann, 1999).

Nunamaker et al. (1991) and Dennis et al. (1997) propose that GSS supports group work and strategic planning on four levels by offering support and input to the group process (Table 8). Dennis et al. (Ibid.) found that the use of process support, as well as process and task structure were the most beneficial features of GSS in the strategic planning context. Most of the benefits listed in the table are efficiency-oriented and aim at a manageable and effective process, which is one of the goals of the present study, as discussed above. Generally, GSS tools are perceived as an effective way to mediate meetings, share information and achieve consensus on decisions concerning un- or semi structured problems (Aiken et al., 1994; Power, 2002; Turban et al., 2005). The main benefits are increased creativity and effective idea generation or gathering through electronic brainstorming, less time spent waiting for others and 'production blocking' through parallel input in the system, and convenient and easy analysis with voting and categorizing tools (e.g. Nunamaker et al., 1991; 1997; Dennis and Williams, 2003). It has been found that the managers participating in strategic planning with GSS were more satisfied with the plans they made, thought that they were more effective and used less time than without support (Adkins et al., 2002; Dennis et al., 1997). Adkins et al. (Ibid.) further note that GSS-supported workshops can act as an effective medium to broadcast the goals of the organization and build commitment and shared understanding over the goals.

Table 8. Dimensions of GSS support (adapted from Nunamaker et al., 1991; Dennis et al., 1997)

Support dimension	Characteristics
Process support	Enhanced capabilities over traditional meetings and pen-and-paper group work, including simultaneous/parallel and anonymous working, group memory and log, as well as other tools
Process structure	Enhanced structure and focus through explicit agenda and facilitation
Task support	Use of additional information, databases and other resources to support the completion of the task
Task structure	Structuring and facilitation of the goals and work process to manageable chunks through facilitation techniques and structuring the workflow

Much less has been written directly on the subject of mediating the scenario process with electronic means. Perhaps the best known example is Blanning and Reinig's method, which has been described in multiple instances, e.g. (Blanning and Reinig, 2005). Another one of the better known methods was perhaps first introduced by Eden and Ackermann (1999), when they discussed the use of a GSS in brainstorming the scenario elements. Blanning and Reinig (2002) brought forward a further contribution by describing a framework for conducting 'political event analysis', including (multi-period) scenario construction, basic cross-impact analysis and political actor analysis with the support of a GSS.

Group work has been offered as a solution to improve the scenario process. Improvements in many pitfall areas of conventional scenario planning, e.g. decreasing the resource-intensity and committing more internal resources, could be achieved by combining group support to scenario planning methodologies, since many studies concerning GSS and electronic brainstorming in general strategic planning have substantiated notable enhancement in information production and communication (e.g. Dennis and Valacich, 1993; Dennis et al., 1997) participant motivation and activity (e.g. Gessner et al., 1994; Dennis and Garfield, 2003) and time efficiency, resulting in better user satisfaction (e.g. Adkins et al., 2002).

However, while we want to have an effective method which does not consume resources excessively and has a relatively short turn-around time, the discussion points out that especially in terms of the learning potential and buy-in, ability to communicate freely and conveniently is quite important. In many instances, GSS has been deemed effective in facilitating communication, and to some extent improving group cohesion and idea generation (e.g. Benbunan-Fich et al., 2002; Huang et al., 2002). It has also been proposed that GSS would particularly enhance "exchange of unshared information" (Garavelli et al., 2002), which may suggest that the users may be more prone to share private thoughts through GSS than in conventional meetings. Of course, vested interests are not unavoidable when dealing with humans, but in an anonymous system, power distance and relations will presumably not have as great an effect as in unmediated face-to-face communication (e.g. Blanning and Reinig, 1998). While electronic communication can be rightly criticized for losing information and nuances compared to face-to-face communication, in effective information sharing and consensus creation, the use of a GSS could in fact be beneficial to learning or knowledge creation in a group (Garavelli et al., 2002; Kwok and Khalifa, 1998). Although one could criticize written communication compared to oral, the original input is retrievable unaltered from the GSS system as opposed to traditional meetings. Other benefits might be commitment and consensus creation through anonymity and information sharing. When the participants' roles outside the session are not present with the input seen by the group, the focus would turn to the substance more than in a traditional face-to-face situation (Nunamaker et al., 1991).

From the early pilots onward, the results for using GSS to support group work have been impressive (Nunamaker et al., 1989). However, in a wider view it seems that achieving success is not automatic, as the comprehensive survey by Fjermestad and Hiltz (1999; 2000) illustrates. Despite the positive overtone in most studies, Fjermestad and Hiltz (1999) conclude that actually studies concerning GSS efficiency as a whole would indicate that the difference compared to unsupported face-to-face meetings is insignificant or inconclusive. Nunamaker et al. (1997) discuss their experiences in working with GSS and write that while a GSS can make a well planned meeting better, it can make a poorly planned and badly conducted meeting much worse. Fjermestad and Hiltz (2000) summarize the results of literally hundreds of papers on GSS effectiveness to the following recommendations, which on average have had a positive effect on the results:

1) Use a “level 2” system with sophisticated analysis tools built in.
2) Use subjects who are likely to be knowledgeable and motivated about the task
3) Aggregate the subjects in medium to large sized groups—at least 6, 10 or more is even better.
4) Give the groups a facilitator and plenty of time.
5) Use a task type that is most likely to benefit from GSS and is matched to the communication medium.
6) A planning task is especially likely to benefit from GSS.
7) If you have a decision (preference) task, use [computer mediated collaboration/groupware], and if an intellective task, use decision room GSS.

While the preceding list of factors plays directly toward using a GSS to facilitate the scenario process, we may want to recap what the previous literature has written on the subject. The benefits of using a GSS specifically in the scenario process have been discussed on a general level by Eden and Ackermann (1999), Blanning and Reinig (2002), and Kivijärvi et al. (2008; 2010a). The suggested benefits include more efficient brainstorming and thus data collection from the participants, better handling of the data through automatic recording and export, and especially anonymous discussion, which is supposed to unlock the participants to think and speak freely. Among others, Kwok and Khalifa (1998) claim that the GSS enhances group learning through active participation and cooperative working. In the scenario literature, it is sometimes claimed that the major benefit of scenario process is the process itself, in the sense that it directs the decision makers to consider the effects of change, also in ways that are not written down in the actual scenarios (Bergman, 2005; Chermack, 2004; Schoemaker, 1995). In this perspective, it would be feasible that the GSS could add value to both the process and the final scenarios. Based on the literature on GSSs, especially in strategic planning and analysis contexts, it seems that the value proposition is that the use of the GSS will potentially enable a more fluent and structured group work session, it will enable integration of a previously unfamiliar and non-cohesive team to complete the task, and result in better satisfaction to the group work results, i.e. the scenarios in our case, which roughly corresponds to the ‘meta-requirements’ discussed above.

3.3.2 Mapping and Clustering - Tools for Scenario Heuristics

As discussed above, scenarios are chains of events which are triggered by drivers. Thus, by definition, causality between the events, as well as between the drivers and events is important information to be preserved in the scenarios. However, we need not look very far for a suitable tool for illustrating the logic of scenarios, as causal mapping is quite established in scenario practice. For example Eden and Ackermann (1999) as well as Goodier et al. (2010) rely heavily on building causal maps in their scenario method. Causal maps are used in management and IS research on multiple levels (e.g. Narayanan, 2005). Causal mapping is quite strongly associated with representing cognition, as well as with building knowledge and simulation models (Armstrong, 2005; Fiol and Huff, 1992; Laukkanen, 1994; Spector et al., 2001), especially systems dynamic models (Sterman, 2000), and combining scenario analysis and modeling (Howick et al., 2006).

Fiol and Huff (1992) define a map as a graphical representation that provides a frame of reference. Figure 11 illustrates some well known and general map types. Perhaps the most widely featured type of maps is the Mind Map, which is even registered as a trademark. The others are the concept map and the related cognitive and causal maps. A cognitive map consists of *concepts*, or more technically *nodes*, which can be related to each other, but they do not have to be. The relations are illustrated with *connectors* or *arcs*, which are assigned with polarity to depict the relationship. Causal maps in turn include elements called *nodes*, which are allowed to have causal relationships of different strengths of positive or negative loading depicted with a number, usually in the range of from 1 (weak) to 3 (strong). The (believed) relationships of the nodes are depicted with *arcs* or *links* labeled with the assumed polarity and loading factor or *strength* of causality. Links with positive polarity refer to dependency (when A increases B increases proportionally to the loading factor) and negative to inverse dependency (when A increases, B decreases). A cognitive map consists of nodes similar to causal map, but the relationships do not have specified strength, just the polarity is included (Perusich and McNeese, 1997). The resemblance in cognitive and causal maps is striking apart from the numbers associated with the connectors of a causal map, and in fact the names are often used interchangeably, even though the maps can and often do illustrate different lines of reasoning (Howick et al., 2006). I have adopted a naming convention consistent with the system dynamics tradition where 'causal loop diagrams' or causal maps (e.g. Sterman, 2000, p. 135) are used for identifying the basic elements and relations of a system. The difference between these two types and a concept map is that in the platter type the connectors have written descriptions, *linking phrases*, instead of numerical strengths, but otherwise the map or the logic are not very different.

As mentioned above, maps have been used to model peoples' knowledge and perceptions, and to support learning through better understanding of one's own and others' mental models and surfacing hidden assumptions (Tegarden and Sheetz, 2003). Fiol and Huff (1992) propose that maps can among other things focus the readers' attention, highlight priorities and supply missing information, or highlight gaps in current knowledge. These properties are related to Schoemaker's (1995) three missions for scenarios, which are to map what is known, what is unknown and what is not known that needs to be known. The advantage of concepts formed in maps is their relatively easy and quick understandability, courtesy of the graphical representation and immediately observable relations between the elements (Perusich and MacNeese, 1997). Novak and Cañas (2006) present about the same claims about concept maps than were presented above of the other options; concept maps promote meaningful learning as they clarify conceptual structures and relations in them, and concept maps suit also aggregation and preserving knowledge.

As for the question of which mapping technique to use, Siua and Tan (2005) conclude that causal mapping is suited for describing complex network structures and causal relations between constructs, whereas concept mapping is suited for describing complex networks as well, with semantically rich descriptions of relations. In a similar manner, Kivijärvi et al. (2008) suggest that causal maps offer a chance to use correlation coefficients and such qualitative techniques as reinforcement, cognitive maps suit the illustration on systems thinking and a way to identify feedback loops and such from the data, and concept maps offer a touch of qualitative spice with free use of verbal descriptions in the linking phrases. As for mind maps, they perhaps suit best the purpose of data abstraction or summarizing. An example of mind maps in the scenario process is given by Coyle (2004, p.67), as he proposes writing essays or drawing mind maps as the first step in picturing the plausible futures. In the same line, it could be suggested that a mind map would suit the initial stages or the conclusions of the scenario process. However, as a mind map does not describe interrelationships in the map any other way than from the center to a branch, the use might be limited to summarizing information related to the scenarios.

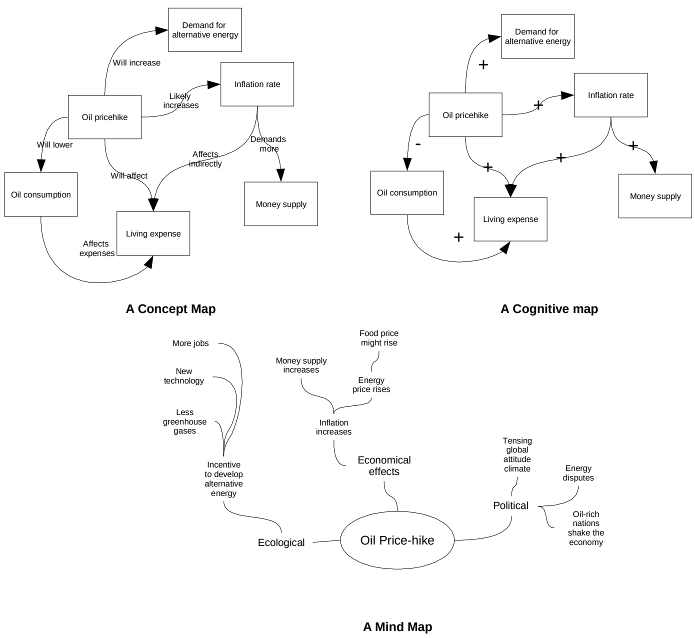

Figure 11. Illustration of different maps (Kivijärvi et al., 2008)

Based on the above discussion, I propose that maps in general support presentation of relatively large volumes of complex data; including constructs of different kinds and levels of analysis (see e.g. Goodier et al., 2010), in an illustrative manner. Thinking of say a table of correlation coefficients, the content is not very informative, but if it were formed as a map, especially the relations of the elements would be more visual than in the raw data. Thus I propose to use a causal or a concept map to surface the relation between the drivers and to recognize the potentially unintuitive behavior and effects that arise from the feedback relation between the drivers. In a similar manner, scenarios as chains of event can be illustrated as a map to make the logic more explicit and to raise legibility, to form context maps to support strategic thinking (Fiol and Huff, 1992).

Another possible tool to support the analysis of scenario data is cluster analysis. Cluster analysis is analysis and classification of things based on their attributes or proximity variables (Everitt et al., 2001). The umbrella of cluster analysis includes a wide array of mathematical methods and algorithms for grouping similar items in a sample to create classifications and hierarchies (Everitt et al. 2001; Witten and Frank, 2005). Cluster analysis can be used to classify datasets to internally homogenous group of similar cases according to different categorical variables (Everitt et al., 2001; Ketchen and Shook, 1996; Witten and Frank, 2005). The advantage of statistical cluster analysis over intuitive classification is that it allows the use of multiple categorical variables, i.e. dimensions, and the process is convenient to execute for large volumes of data.

Given that group brainstorming can produce large amounts of data, I propose that cluster analysis can support the analysis and classification of those volumes. Then again, this approach could be criticized for the fact that although statistical clustering is a methodically sound choice on the surface, using clustering would not bring anything to the scenarios *per se*. Using one method or another in grouping the events does not actually give more consistency in the substance level unless the method scans the events based on logical cohesion of the events themselves, not just the impact vectors. Also technically reliable cluster analysis would require quite a large panel data. Either way, the use of clustering may very well be justified by matching the participants' methodological criteria, and the grouping of events has to be done in some reasonable way, but the actual gains from using these more sophisticated methods are not axiomatic. In any case, the possibility of clustering error often demands some form of manual elicitation for meaningful results.

3.4 Recapitulation of the Principles of Form and Function

I have discussed the nature and challenges of strategic technology management and proposed that the major challenges are that managers have to make decisions based on incomplete information, and remain uncertain of the consequences. A lot of this uncertainty concerns also the environment and other players who also try to act in their best interest. From these aspects of context and scope, I proceeded to the literature of scenario planning to define the units or constructs of the DT and to outline the principles of form and function. Thirdly, I discussed justification knowledge for the tools I intend to use to support the scenario method.

The aim of this study is to create an accessible and effective scenario method, which points more to the intuitive-logical end of the method spectrum, and leading to illustrative and relatively easy-to-use tools at the expense of certain scientific rigor. Thus I propose to use an EMS or a GSS to support the process of scenario method and help gather data and include the relevant people to articulate their views. Further tools scenario heuristic are cognitive and causal mapping to illustrate and organize data, and cluster analysis to support the scenario heuristic.

After this lengthy discussion, it is time to integrate the principles derived from the separate bodies of justification knowledge; the literature on scenario methods and the literature on the tools to support scenario planning. To set a structure for the discussion, Figure 12 summarizes the principles of form and function for the scenario method I have dubbed the IDEAS method, as the scenario process should give IDEAS for technology management. On a different level, IDEAS can be seen as an acronym where the I stands for objectIve definition, D for Drivers of change, E for identification of plausible future Events, A for Assessment of the scenario components, and S for formulating the Scenarios.

As discussed above in section 3.2.5, there are two overarching challenges the method aims to alleviate, one is time and resource consumption, and the other is complexity of the method and legibility of the scenarios. When we look at the challenges for scenario planning, much of it boils down to facilitation of group work, as Hodginson and Healey (2008) also suggest in their design propositions. Facilitation of group work is the bread and butter of GSS (research). I discussed GSS in general above, and I propose that while the use of a GSS generally improves effectiveness of group work (e.g. Fjermestad and Hiltz, 2000), potentially features such as anonymity and facilitation can also help the participants discuss potentially sensitive issues freely and thus create high quality scenarios. The mapping tools and cluster analysis are then aimed at raising the impact of the scenarios, to make the intuitive heuristic more transparent and to improve the legibility of the results. As Figure 12 suggests, I propose that the main tasks of the process are carried out in GSS sessions. The third and fourth phases are combined in the figure, as the grouping of the events to preliminary scenarios and evaluation are closely related activities. Following the general guidelines set by Fjermestad and Hiltz (2000), I have chosen a facilitated decision room setting. For the mapping phase, I use general purpose tools, but as illustrated by Ackermann and Eden (2005), there are tools that can enable group mapping. These principles or the meta-design of the artifact are discussed in closed detail below.

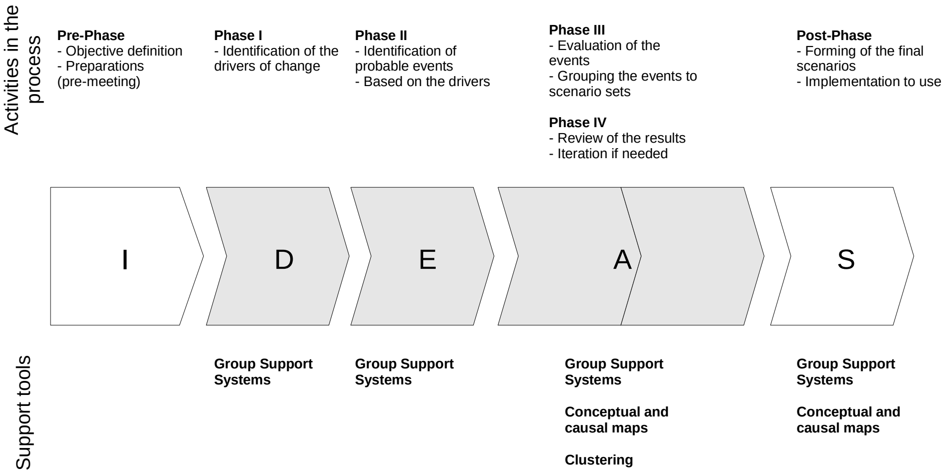

Figure 12. Summary of the principles of form and function and support tools for the scenario method (adapted from Kivijärvi et al., 2010a)

Starting from the beginning, the scoping of the process is an important step that determines much of the latter result directly through method selection and setting the frame of reference to the whole project, as well as indirectly through resourcing and commitment or lack thereof from the organization's side. Ralston and Wilson (2006, p. 51.) even go as far as writing that it is difficult to overemphasize the definition of scope and objectives. Some questions that need answering before starting the process in general are: what is the goal of the process, what information and data are needed, who will (need to) participate in the process to which phases and for how many work hours, what methods are to be used, what is the schedule for the process, what questions the scenarios aim to answer, what is the time span, who will participate, in short, who will do what in which time and through which method or process?

As for participant selection, the group composition should depend on the objectives, but foresight literature reminds that the participants need to be open to think about the future and committed to the results. As a general guideline, there are three cornerstones for the selection: first the senior managers of the organization in question, staff from planning, middle management and technological/R&D functions, and outside experts as needed (Ralston and Wilson, 2006, p. 48; van der Heijden et al., 2002). As in any major project involving resources and possible changes in organizational structure and direction, the senior management carries the authority to make the process work. Furthermore, if a desired outcome is to shape the mental models of the organization to be more open, senior management with the executive power to shape the organization is not a bad place to start. Accordingly, for example Schoemaker (1998) mentions the failure to secure top management support as one the main pitfalls in scenario planning. Including the other layers of organization would in turn be likely to alleviate resistance to change, and especially in intra-organizational scenarios, workers from specific functions are likely to possess information not held by the senior management. Related advices include introducing 'remarkable persons', that is, strong personalities who are innovative and outward looking and carry certain authority, to bring fresh perspectives and new ideas to the process or act as a 'Devil's Advocate' to purposefully challenge the people involved, and to surface hidden assumptions and contradict easy answers.

On the tool side, Grohowski et al. (1990) conclude that the planning of meetings, including selection of participants and tools, is of great importance to success. Sawyer et al. (2001) remind that after all is said and done, the GSS is a software that offers a set of tools, the use of which needs planning and facilitation to be effective in achieving the goals. This translates to a need to first plan the meetings carefully in advance so as not waste the participants' time, and second, while planning, to consider the participants' ability to use the tools, and offer facilitation and training as needed, or to adapt the tools.

The scenario work starts with identifying the drivers of change. I propose that electronic brainstorming or simple ideation with a GSS can be used to gather ideas from a previously selected expert panel. However, O'Brien (2004) noticed that on average the participants in the scenario process often fail to consider the gamut of factors, i.e. drivers that may have an impact on the future. One way of giving structure and stimulating idea generation at this stage could be using the PESTEL framework as categories for the drivers (O'Brien, 2004; Wright et al., 2009). PESTEL presents a framework for analyzing an organization's macro environment, or acts as a checklist where different driving forces are considered. (Coyle, 2004, p. 60) In PESTEL/R, in fact originally just PEST, the acronym stands for the Political, Economical, Social, Environmental and Legislative or Regulatory factors in the sense how they affect the organizations concerned (Burt et al., 2006; Wright et al., 2009). The proposed procedure is a defined period of time for idea generation with a categorizer or a similar tool, for example a category at a time. As per advice from Burt et al. (2006), it is important to discuss how the drivers relate to the organization, and in general what are the interpretations of drivers. Thus I propose a period for writing comments on the ideas and clarification of the proposed drivers through a discussion, to reduce the ambiguity of the drivers in the group in lieu of the next phases. The phase can be finished with prioritizing the drivers in order of importance or impact, to focus the attention on the most important drivers.

Table 9. An exemplary driver set to illustrate the modified 'axes of uncertainty' heuristic

	Drivers	**State**			
Lead drivers - 'Axes of Uncertainty'	Driver A	Realized	Not realized	Realized	Not realized
	Driver B	Realized	Realized	Not	Not
Ordinary drivers	Driver C	Not	Realized	Not	…
	Driver D	Realized	Realized	Not	
	Driver E	Realized	Not	Realized	
	…	…	…	…	

After working out the relevant drivers and, if need be, selecting the most significant ones, there is a variety of possibilities to work out the preliminary scenarios. I propose here two possible heuristics, tested empirically in the following section. The first approach is an adaptation of the 'axes of uncertainty', familiar from the Shell/Global Business Network method (Schwatz, 1996; van t'Klooster and van Asselt, 2006), which I call here driver array heuristic. The idea is to take the two most significant drivers as the axes, or lead drivers, but instead of losing the information about the other drivers, attaching the others to the main axes by figuring which drivers fall to which quadrant. Table 9 illustrates the principle. The drivers are tabulated to a matrix, where A an B are the 'axes', or let us call them the lead drivers. This matrix forms naturally four scenarios, when each column is examined and each driver is assigned a state by answering question, for example in the first column "if A and B are both realized, will this happen?" When the basic frames for the scenarios are set in this fashion, the participants are given the task of generating events that would arise in each scenario, which is the world driven by a specific column. This principle is implemented in the SAGES method (Lindqvist, 2009), and the result is a set of scenarios consisting of events directly related to certain drivers and their alignment.

The second heuristic we can consider is what I call the impact-based heuristic presented by Blanning and Reinig (1998; 2002; 2005), who propose either pre-selecting a set of plausible events or brainstorming a sufficient number of them, say 50-100 altogether. The point of this exercise is to have a large set of events which are derived from the drivers. The actual scenario heuristic is based on voting (or otherwise assigning) a subjective probability and impact factor for each event and clustering the events to scenarios, most basically to a pessimistic, optimistic and realistic scenario based on the probability and impact (positive/negative vote). In this stage, Blanning and Reinig (2005) propose that the events are projected to a scatter plot where probability 1-100% forms the x-axis and impact from very negative to very positive forms the y-axis. The scenarios are then grouped by selecting three groups of 10-20 events, so that the most probable events form a realistic scenario, medium to high probability events with a positive impact form the positive scenario group, and events with medium to high probability and a negative impact form a negative scenario, respectively. Figure 13 illustrates the intuitive clustering based on the simple heuristics and Figure 14 illustrates statistical clustering with Weka 3 Machine Learning Workbench. As a minor design point, the events should be discussed and commented on to clarify them before the impact vote. To augment the brainstorming there could be categories for the events like in the driver phase and for mostly the same reasons, categories such as internal, stakeholders, micro-environment, and macro-environment.

Working through these heuristics constitute the phase of forming initial scenario sets. The next phase in the process is the evaluation of the results, and if the data prove to be satisficing, forming the final scenarios. The objective in the evaluation is to judge whether the preliminary scenarios fulfill the criteria summarized in Table 6; whether the sets are consistent internally and within the timeframe, whether they are relevant, and whether the participants are satisfied with the process, method and results.

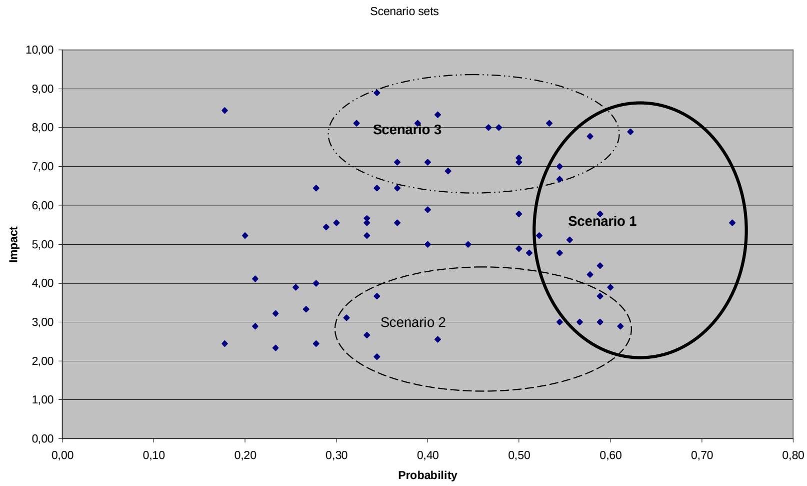

Figure 13. Illustration of qualitative clustering with heuristic rules (Piirainen et al., 2007)

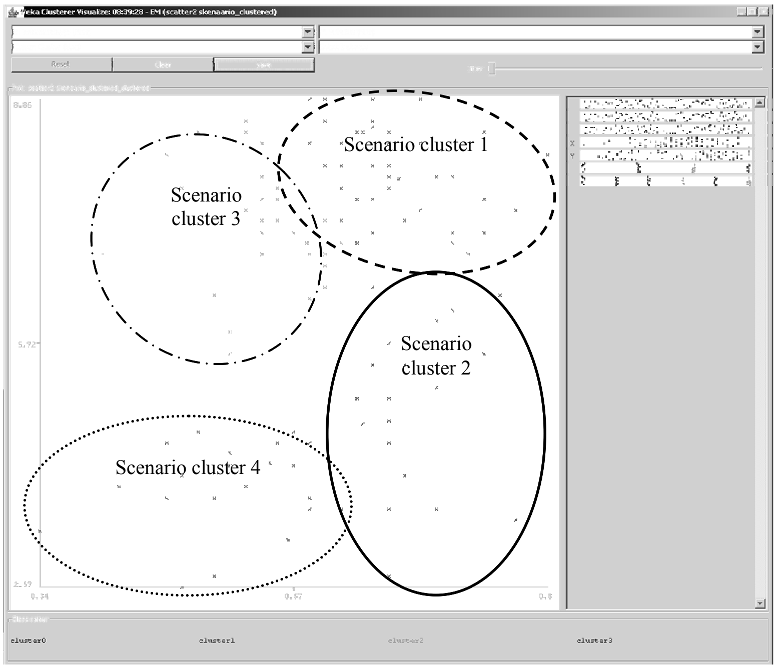

Figure 14. Illustration of the results of quantitative cluster analysis (Piirainen et al., 2007)

In practice, regardless of the chosen heuristic, what arrives to the evaluation in this GSS driven scenario method, is a bunch of drivers and events and voting results printed from the GSS. As an initial clean up of the data, I suggest finding irregularities in the voting results, outliers, or for example large deviation of the votes. One basic case is where a participant tends to be an outlier all the time, which may be an indication of malicious intent, but it may also indicate special insight or information not familiar to others. Although the reason for this kind of pattern is not always easy to find out, especially in an anonymous GSS session, it is worth finding out which is the case before excluding the case as an outlier. Another interesting pattern to watch for is large deviation in the voting result, especially if the distribution is two-pointed, which tells that the issue is controversial and deserves special attention, or in the latter case that the group is divided by the issue and consensus is not strong. The next task after the clean-up of the data, is to inspect the sets of events to ensure that they are reasonably logically grouped around a theme, especially with statistical clustering, and to possibly adjust the grouping carefully.

Here I suggest that the mapping tools discussed above can be valuable in enabling illustration and evaluation of the results. The mapping and evaluation of the results is an iterative process where the theme of the scenarios evolves when events are added, and it depends also on the drivers. Accordingly, Wright et al. (2009) propose mapping the drivers to illustrate how they interact and develop certain themes. In the lead driver array heuristic, the drivers govern the scenarios more closely, so the evaluation is more straightforward consistency check between the drivers and events, where the latter impact-based heuristic is more dependent on the author developing the themes of the scenarios. In the mapping phase it is also easy to include the observations from the data analysis by color-coding the events based on for example standard deviation of the votes.

When the maps or preliminary scenarios are ready, if they are authored by a process facilitator or a small sub group of the scenario team, they should be evaluated one more time by the original group. There is always the possibility that the initial scenario maps do not satisfy the audience, and in such a case there can be multiple reasons and possible actions, depending on the response. If the reason is lack of logicality and consistency on the content level, a revision might do, but if the deficiency is severe, there is a need to revert to the previous phases and make revisions or organize new sessions. If the reason is the method, there is little choice but to change the method and call forth another session. The lack of subjective trust in the results or overcoming the vested interests of the participants might well be the hardest obstacle to overcome, and can be seen as a failure in organizing the process.

Although not exactly the last phase in the scenario process, writing the final scenarios concludes the description of the method. To start with, van der Heijden et al. (2002) propose that the writers should think of the roles and the actions of the key actors and other driving forces, and illustrate how their actions may lead to the supposed events in a scenario. This advice echoes the definitions of scenarios, which are supposed to be stories that map the decision options of actors along the way and give some milestones that indicate which scenario is unraveling. Ralston and Wilson (2006, p. 125) underline the need to weave the drivers and events together to form a bigger picture of the development. The stories should describe how the drivers affect the events; to describe the relationships, temporal and causal, between the events leading to a described end state. To summarize, the stories should (Ralston and Wilson, 2006; Flowers, 2003; van der Heijden et al. 2002):

- explain the core logic and central theme of each scenario

- describe the cause and effect relations between the elements, drivers and actors

- describe the end state of the scenario and how thing have developed to that point

- highlight critical events that signify the scenario and strategic decision points for actors

- include an introduction, the main narrative, preferably with illustrations, and summaries for comparison between the scenarios.

Flowers (2003), who has also been a part of the Shell team, phrases this more poetically. In her view, the scenarios should be written so that they resemble the stage of a theater, and the managers who read the stories would then act on the stage. The objective in proposing this, perhaps unorthodox, angle is to make the scenarios more memorable, as volumes of facts and figures rarely stick in one's memory as well as a concise and anecdotal little story. Similarly, Neilson and Stouffer (2005) suggest using colorful and popular language in the scenarios and embed the hard facts in the stories. On a more serious note, Flowers (2003) adheres to a method where she tries to pick a central theme or a definitive aspect in a scenario, name the story after the fact and build the rest of the story around it. This kind of iterative development of the storyline is something that possibly happens already in the phase of shaping the initial scenarios when using the impact-based heuristic. One reasonable question is how long the stories should be. At least two sources propose that around ten pages (per scenario) should be adequate (Flowers, 2003; Schnaars and Ziamou, 2001). Similarly, for example the Shell scenario team publishes two sets; one of ten pages a piece as a sort of quick reference and the other set with much broader set of research material and analysis spanning across tens or even hundreds of pages (Flowers, 2003). In this case, the evaluated drivers and scenario maps can act as the core logic, based on which the stories are built. The different important or controversial events highlighted by the data should be underlined.

In short, the objective is to use the preliminary scenarios, and to write up credible stories of how the identified events form a causal and temporal chain from the present to the end state, including the driving forces and how they act in the chains. Comparing the amount of literature on scenario methods and heuristics, there is a relative shortage of advice in authoring scenarios, even though the final scenarios are quite important in the implementation, as they are the only thing that is available to people who are not involved in the process, and they affect the overall perceptions of the audience about the whole method and process a great deal.

4 INSTANTIATIONS AND EVALUATION OF THE DT AND THE ARTIFACT

The second chapter presented the general DSR framework employed in this study. The previous chapter discussed the justification knowledge and the principles of form and function for the DT. This chapter will continue toward the end of the DSR process and presents the DT and its instantiations, and the empirical evaluation of it. I will start with an overview of the publications and presenting the DT to be evaluated, with its three instantiations. Then I will present the evaluation results phase by phase.

4.1 Overview of the Publications and the DSR Process

The artifact was designed based on literature or justification knowledge, to use the DSR term. Besides this overview of the thesis, the design and evaluation of the artifact has been reported on in several publications summarized in this chapter. The design has followed the process discussed in the second chapter, and during the course of the research process, each publication has contributed to the design and evaluation, and thus toward answering the research questions, as summarized in Table 10. After the design, the artifact was first instantiated, tried, and refined in experimental conditions, as presented in the first paper (paper 1 in Table 10). The main attention of the experimental testing was in the GSS workshop, which is a part of the whole artifact. The experiments were organized as a part of a graduate course, and the test subjects were graduate students, and thus the results can be generalized foremost to students and young professionals. The second paper (2) is an overview of the first case, and demonstrates the whole of the instantiated artifact together with the evaluation of the workshop presented in the first paper. The second case is presented in papers three (3) and four (4), where the first of the two illustrates the case application and the workshop, and the second the scenarios. The second case includes an additional measure of benchmarking the artifact with another artifact. The fifth (5) and sixth (6) papers mostly contribute to communicating and positioning the contribution, but they have elements of evaluation, as they compare the artifact to its sibling developed in a research co-operation to different applications. This benchmarking is a part of the communication of the artifact, as it helps outlining the contribution of this study and positioning it to prior literature in the field.

The reader will notice that the evaluation is focused on the first phases of the scenario process, especially on the phases where the data, the drivers and the preliminary scenarios are gathered. The evaluation of the design is focused more closely on the expert panel sessions for various reasons. First, the scenarios are as good as the data that is gathered, which makes the expert panel an important bottleneck in the process. Second, scenarios are used as far as the participants trust them, and as discussed above, the workshop is an important venue to create that trust. For the rest of the process, the evaluation relies more on the pragmatist logic of “what works is true” in the sense that as far as the IDEAS method, that is the artifact, works and creates plausible scenarios comparable to competing artifacts, it satisfices the conditions for a pragmatic truth. As discussed in the introduction, the implementation of the scenarios is not discussed in this thesis, as it deserves more attention than was plausible during the course of this study.

Table 10. Overview of the contribution of the publications

	Paper 1	**Paper 2**	**Paper 3**	**Paper 4**	**Paper 5**	**Paper 6**
Citation	Piirainen K., Kortelainen S., Elfvengren K., Tuominen M. 2006. A Framework for Utilizing Group Support System in Scenario Process, in Maula, M., Hannula, M., Seppä, M., Tommila, J. (eds.) Frontiers of e-Business Research (FeBR), Proceedings of eBRF+ICEB Conference, Tampere University of Technology and University of Tampere, Finland.	Kivijärvi, H. Piirainen, K. Tuominen, M. Kortelainen, S. Elfvengren, K. 2008. A Support System for the Strategic Scenario Process, in Adam, F., Humphreys, P. (eds.) Encyclopedia of Decision Making and Decision Support Technologies, IGI Global, Hershey, PA, USA, pp. 822-836.	Piirainen K., Kortelainen S., Elfvengren K., Tuominen M. 2010. A scenario approach for assessing new business concepts, Management Research Review, Vol. 33, No. 6, pp.635-655.	Kokkonen, K, Piirainen, K., Kässi, T. 2008. E-business opportunities in the Finnish forest sector – a multi-method scenario study, in the Proceedings of XVIII International Conference of International Society for Professional Innovation Management (ISPIM), Tours, France.	Lindqvist, A. Piirainen, K., Tuominen, M. 2008. Utilising group innovation to enhance business foresight for capital-intensive manufacturing industries, in the Proceedings of the 1st ISPIM Innovation Symposium, Singapore.	Piirainen, K., Lindqvist, A. 2010. Enhancing business and technology foresight with electronically mediated scenario process, Foresight, Vol. 12, No. 2, pp. 16-37.
Research mission	To test whether a GSS can be used to facilitate the scenario process and whether there are gains to be achieved	To describe the electronically mediated scenario process	To discuss and test how scenario planning could be used in the innovation process to interface new product development with the environment	To use two different scenario methods to answer the same research question and to compare the methods and results	To describe the two electronically mediated scenario methods developed at LUT in relation to prior work	To position the electronically mediated scenario methods to prior literature and to communicate the finding to the scientific community
Methods, measures	Experimental testing, satisfaction questionnaire, interviews	Description of the artifact, overview of the scenarios	Case workshop, satisfaction questionnaire, observations	Description of the scenarios, comparison between methods, reflections	Comparison of methods to previous practice, reflections	Outlining the contribution through description and reflection
Contribution to the design and evaluation of the DT	Evaluation of the basic framework for and the design of the electronically mediated scenario process	Overview of the DT and the second instantiated artifact	Evaluation of the artifact in the MoT context	Comparison of the artifact and (meta-) design to an established scenario method	Further evaluation, positioning and communication of the results	Drawing conclusions and observations together, communicating the results

The main phases of the empirical evaluation of the artifact as described in the overview are: 1) experimental evaluation of the meta-design with student groups, which resulted in minor changes to the artifact, 2) case evaluation of the artifact in two scenario processes, and 3) benchmarking with an established state-of-the-art scenario method and a similar electronically mediated process. For clarity, I will summarize the results and discuss them in relation to the evaluation framework of Hevner et al. (2004) discussed above.

The first level of evaluation was a test of the meta-design, or principles of form and function, with student groups (Paper 1, Case 1). The test were run in a laboratory setting and graded with a questionnaire. The tests also concerned only the part of the scenario process where an expert panel was used to gather the drivers and events.

The test results and feedback from the test subjects were used to improve the artifact, especially the scenario heuristic, following the generate-test cycle (e.g. Simon, 1996). The improvements led to further testing, this time a case within a public organization (Paper 1 Case 2; Paper 2), where the process ran its course all the way from two expert panel workshops to finished scenarios. The test subjects were administrative and operational staff of the organization, and as such the case can be characterized as a production run more than as a simple laboratory experiment.

The second case was adaptation of the artifact to MoT context in the industry intersection case (Paper 3; Paper 4), where the process was run in a workshop with industry experts and independent researchers, and the scenarios were developed in association with a research project. The case evaluation continued to a benchmarking study (Paper 4) between the artifact and another scenario method.

4.2 Overview of the DT and the Instantiations

The artifact is based on the principles of form and function of the generic scenario process, as described in the previous chapter. The meta-requirements for the DT or the artifact were that the scenario method and process should be more accessible and effective while fulfilling the criteria for a successful scenario process. The design is an electronically mediated intuitive-logical scenario method, as summarized in Table 11. The main components of the artifact are the process, an electronically mediated expert panel workshop, and the intuitive impact-based scenario heuristic. The scenario creation is supported further with mapping and clustering where appropriate.

Table 11. Components of the DT for the IDEAS method

	General components	Guiding question	Components of the DT
Core components	Purpose and scope	Which class of goals or problems does the DT apply to?	- Class of problems: organizational (technology) foresight with emphasis on resource use and efficiency of the foresight Goals: - The scenario process and method should be easily available, documented, and executable - Scenarios should be reliable, consistent and convincing
	Constructs	What are the key units and constructs governed by the theory?	- Events, drivers and scenarios - (The generic) Scenario process - Scenario heuristics - Support tools, GSS and mapping

	General components	Guiding question	Components of the DT
	Justification knowledge	Which literature helps me to solve the problem by building an artifact?	- Theory-in-use from FS and scenario planning - IS research and GSS - Local and global best practices for facilitation
	Principle of form and function	Which (class of) artifacts meet the meta-requirements?	An artifact combining: - The generic scenario process, with - The intuitive impact-based scenario heuristics, and - Mapping tools and clustering
	Artifact mutability	How does the artifact behave when implemented?	- The contents of the workshop depend on the context (see papers 2 and 4) - The content of the scenarios will affect the illustrations and tools used in the process - The scenario heuristics can be adapted to suit the case - The workshop does not have to be a facilitated face-to-face session - The use of the scenarios e.g. to MoT or strategy depend on the research mission and organization
	Testable propositions	Does the meta-design fulfill the requirements?	P1: The artifact is feasible and usable P2: The artifact produces scenarios reliably P3: The artifact enables effective production of scenarios P4: The process is structured yet innovative P5: The people are engaged and feel free to contribute P6: The process compares favorably to existing scenario practices
Additional/ auxiliary components	Principles of implementation	How to build an artifact based on the meta-design?	Use the description of the meta-design with established practices to build and execute the scenario process
	Expository instantiation	Is the artifact consistent with the meta-design?	Cases 1 and 2 (papers 1-4, particularly paper 2) instantiated artifact following the DT/meta-design

The main design propositions correspond to the objective of creating an effective scenario process with electronic mediation. During the development of DT, the instantiated artifact underwent two revisions, which in their part demonstrated the mutability of the artifact. Before going on to the evaluation, I will discuss the instantiations in the following sub-chapters, which will also illustrate the extent to which the instantiation follows the DT, preparing the ground for the evaluation of the DT through the artifact.

4.2.1 Instantiation 1: Demonstration of Principle

The first instantiation was a process where the method used the driver array heuristic described above, where the drivers were tabulated and two of the most influential ones were used to frame how the others would develop. The session followed a modification of the generic process described in Table 12. The bulk of the tasks in the process were completed in a face-to-face GSS session. The facilitation of the session was based on local best practices and on a free-form verbally sketched script. The first step, definition of the problem was made by the facilitator, who presented the group with a summary of the exercise and a paper version of PESTEL analysis considering the target organization. The purpose of preliminary PESTEL was to introduce the issue and the environment to the test subjects.

The work progressed to the next phase where the group brainstormed the key drivers of change and uncertainties. The PESTEL framework was used also here as preset categories for idea generation, and the facilitator went through the categories one at a time with the group. Brainstorming was followed by a discussion where ambiguous items were clarified between the participants, by verbal explanations and additions to the system. Unclear items were rephrased or explained by comments, and overlapping items were removed or merged. After the discussion, the drivers were prioritized by voting. A ten-point scale was used in all the voting, as it allows accurate weighing and does not have a neutral point, so the participants are forced to take either a negative or a positive posture.

Table 12. Process outline in the first two instantiations, GroupSystems tools used for facilitation in italic style

<table>
<tr><th>First instantiation
Session time 1h 45min</th><th>Second instantiation
Session time 3h 45min</th></tr>
<tr><td>Problem setting (15min)</td><td>Problem setting (15min)</td></tr>
<tr><td rowspan="2">Key drivers of change (30min)
Categorizer</td><td>Key drivers of change (30min)
Categorizer</td></tr>
<tr><td>Identifying future events (45min)
Categorizer</td></tr>
<tr><td rowspan="2">Preliminary scenarios (30min)
Voter</td><td>Priorization of events (45min)
Categorizer</td></tr>
<tr><td>Creating scenarios (45min)
Alternative Analysis</td></tr>
<tr><td>Evaluation and final scenarios (30min)
Categorizer</td><td>Evaluation (45min)
Categorizer</td></tr>
</table>

The first tests instantiated the driver array heuristic described above. The first ten of the most important prioritized drivers were chosen. The drivers were positioned in a matrix so that two of the most important independent drivers were first given the four possible combinations of realization/not realization. These four combinations also formed the four scenarios created in the session. The rest of the chosen drivers were placed in the matrix below the first drivers, and the state of realization was logically derived from the previous by the group. The formed scenarios or scenario logics were evaluated by reasoning after Schoemaker's (1995) criteria, and if there were perceived inconsistencies, the driver states were adjusted.

The last step of the session was event generation. The scenario logics were printed to the participants, and they generated events according to the formed driver framework, one scenario at a time. The purpose was to use these event sets as a basis for the actual scenarios. Again, after the event generation, the results were inspected by the group for illogicalities and adjusted. The actual scenarios were written around the events as home assignments and returned later to be inspected.

The weak point in this instantiation was that, depending on the drivers, the distinctions between the scenarios could be very small, thus bringing the borders of possibility narrower than might be sought after. In addition, when the drivers were voted with question setting "When A happens and B does not, would C materialize, or not?" the frequencies of Yes and No –answers were in many occasions almost equal, which of course undermines the usefulness of the vote results, as the decision could go either way. Of course, in a situation where the group is unanimous in deciding about the driver states, the problem goes away. On the content level, the pre-filled PESTEL analysis quite plausibly steered the panel's thinking, which is not an issue in a test setting, but considering actual scenarios, the possible tunnel vision this creates is not a feature sought for.

4.2.2 *Instantiation 2: Production Method for Strategic Positioning*

The second instantiation was the first case process (papers 1-2) with modifications to the process and scenario heuristics. The case consisted of processes which followed the right column of Table 12 with minor differences, as recounted below.

The session started with definition of the problem and proceeded to defining the major drivers of change. The drivers were brainstormed to PESTEL categories in a similar fashion as in the first instantiation. The difference was the scenario heuristic, as this case instantiated the impact-based heuristic described above. Following the logic of the impact-based heuristic, instead of sorting the drivers in the array, the participants were presented with the prioritized list of drivers and were asked to identify concrete events that are triggered by the identified drivers. In the first of the sessions, the subjects started with a blank screen and a printed list of the identified drivers, and in the second session there were three base categories, internal, interest groups, and micro- and macro environment. The resulting event sets were once again discussed and commented, and overlapping events were merged or removed. These events were then subjected to voting in two dimensions with an alternative analysis tool; first the impact of the event and then the probability, following Blanning and Reinig (2005). The ten-point scale was interpreted here so that in probability vote 10 was read as 100% and 1 as 10%, with impact 10 set to being an extremely positive incident and 1 a highly negative one. Then the scenarios were formed on grounds of the voting, so that events that had high probability were grouped in a "realistic" scenario, and events with average to high probability and the most negative or positive impact were grouped in a "negative" and "positive" scenarios, respectively.

In the final stage, the events forming each scenario were subjected to discussion about whether the set was logical and coherent, and the events were also grouped in an approximately chronological order. In the latter of the two instantiations, the scenario heuristic was enhanced with two-dimensional cluster analysis to group the events to scenarios. The scenarios were developed by one author through intuitive-logical reasoning based on the panel data by mapping the driver interactions and then reflecting between the drivers, previous literature and events, which gave rise to chains of events, first evaluated and discussed with colleagues, and then the final stories around the events.

Compared to the first generation, the scenario-heuristic was equally intuitive. In this version the inconsistency issue in the driver logic was averted by moving some of the work to the author of the final scenarios. The weakness in this version was that the test subjects felt that the events were not connected to the drivers as well as they hoped, which also made them a bit skeptical toward the final scenarios.

4.2.3 *Instantiation 3: Production Method for Technology Foresight*

The last tested instantiation was the revision of the second generation, adapted for technology foresight. The problem for the group was to identify and assess new business concepts in the intersection of two manufacturing industries. The study started with a presentation of the aims of the research project and scenarios in general, followed by the outline and objectives of the study (held in a workshop setting).

As previously, the workshop started with a presentation of the objectives and the method, and the first actual phase was the identification of the drivers. After idea generation, the drivers were discussed by category, removing duplicates and editing ambiguous wording. After the discussion, the drivers were prioritized by voting on one category at a time.

When the drivers had been sorted, the work proceeded to identifying the events, or in this case, business opportunities. The identification was completed in two phases to interface the idea generation better with the drivers. The basic questions to aid the event recognition were “What kind of business opportunities can the identified trends open in ten years’ time?” and “What events will these opportunities create?” After idea generation, the events were discussed and clarified in the group.

Differing from the previous setups, the events were evaluated in three dimensions instead of two. The first dimension was the probability of occurrence for the event, but the impact was split to two dimensions, which differed from the original set-up. The second dimension was the impact each event would have in the business and earning logic of the industry implementing the product, and the third dimension was the impact an event would have on the earning logic of the supplying industry and technology. This dual dimension was selected firstly to separate the consideration of impact and usability clearly to one industry perspective at a time, and secondly to serve the interest groups equally in terms of the results.

The workshop concluded after the evaluation and presentation of the intermediate results. The events were presented in a scatter plot, the grouping was discussed preliminarily, and the voting results were examined. The final grouping of the scenario sets was left to be done with cluster analysis, but the possible themes were discussed freely and the scenario writers took notes of the comments. The final task in the workshop was to fill in a questionnaire to evaluate the workshop and the methods.

The major practical differences to the previous instantiation were that there was an auxiliary presentation was on a smart board alongside the common video screen, where each phase was briefly outlined. A major revision that was not context-dependent was using a nominal group technique -like ideation for the events. The test subjects were asked first to ideate for business concepts on a piece of paper, and after a short period of individual work they started to use the system. The reason for the two-part event identification was participant input from previous sessions, which stated that the events were not necessarily well connected with the drivers. Another revision was of course the separation of the impact vote to two perspectives, which basically enabled creating two separate sets of scenarios from the same panel data.

4.3 Summary of the Evaluation

4.3.1 Test Results

Starting from the first paper, the primary mission of the tests was to examine whether a GSS can be used to facilitate the scenario process. The paper starts with discussing the scenario process and quality criteria for the process and scenarios, to compose what would be called meta-requirements and a meta-design for an electronically mediated scenario process. The formulated DT was operationalized as an instantiation of the artifact in a laboratory setting and tried with student groups to test the proposition of using a GSS in the scenario process. The first paper reports two ‘cases’, first of which corresponds to the first instantiation and the second to the second one. To focus on the first instantiation, the setting was that the test subjects took part in the ‘treatment’ as a course assignment. The process was executed as described in the first instantiation, and the treatment was rated with a questionnaire. To keep the conditions constant, the experiments were facilitated by the same, relatively experienced person who took care of the course assignments. The facilitator gave each group the same introduction, and the objective and assignment were the same for each group. The objective was to create scenarios for the university the students studied at. The objective was chosen on the basis that it carried some significance to the students, was to some extent interesting, and the subjects were familiar with the organization. Due to the limitations of the sample, the data were analyzed using basic, mostly descriptive, statistical measures.

Table 13 below summarizes the questions in the survey form, and gives an overview of the results. The test data include three sub samples from separate sessions, with $n_{tot}=29$. Kruskal-Wallis 2-tailed variance analysis with the margin of error $p=0.05$ showed that the data can be handled as a unified sample of the population. The confidence intervals are also calculated with the standard margin of error $p=0.05$. If we wish to be critical, the sample size for this experiment was quite small, in fact just large enough to use basic statistical tests. This is precisely the reason we have a research design with multiple methods and measures of evaluation.

As can be seen in the table, the overall scores are high, especially considering that the common verbal key the students are used to, which is used to rate their work, is 1 'tolerable', 3 'good' and 5 'excellent'. Notable figures are the confidence interval and standard error, as the deviation in the group is within half a point. While conceding that the sample was small, the group was quite unanimous, which can be interpret either as a sign of consensual agreement on the results or a positive response bias. I would like to propose the first, as the critical comments on the open-ended items in the questionnaire indicated that the participants were able to evaluate the artifact critically. On average the scores are good or even very good, but trustworthiness is lacking. Judging by the feedback through the open-ended items, the reason for low trust for the results is that the sessions were carried out as assignments, participated solely by students, which actually speaks highly of the test subjects' ability to evaluate their experience critically. Nevertheless, the treatment received some critique of its own. The main point was the actual creation of scenarios, where the drivers of change were positioned in a matrix and given yes/no-states, which the test subjects experienced as a confusing and incoherent practice.

Besides interpretation of the satisfaction measures, Spearman's Correlation factors were calculated for the items to analyze the dependencies between the items and to get a picture of the factors of success, still with $p=0.05$ (Appendix 1). The most significant correlations were the following; 1) *GSS helps observing different perspectives* correlates positively with *usefulness and coherence of the results and commitment to the process,* 2) *GSS helps in committing to the process correlates positively* with *identifying most important drivers of change and observing different perspectives,* and 3) *the goals of the session were met* correlates positively with *the objectives being clear and trustworthiness of the results*. Interestingly enough, there was no statistically significant correlation between the level of prior knowledge about scenario process and other answers. I interpret the correlations so that the main benefits or added value from GSS is that it improves commitment and thus may lead the participants to exert more effort to the process, resulting in better substance, and diffuses information within the group, which helps the participants in identifying important pieces of information regarding the goals of the session. To interpret the results further, I propose that there is a dependency between commitment and information diffusion inside the group. The basic case is that when the objectives are explicit in the group, they are easier to accomplish, and the results are more trustworthy. These correlations are consistent with the justification knowledge, which can be seen as support to the propositions.

Table 13. Questionnaire results from the experiments and the first case

Question	Test sessions								Case 1							
	Results			Std.Error		Confidence interval			Results			Std.Error		Confidence interval		
	Avg	Std. Dev.	Md	D(x)	D (Md)	+/-x¯	LL	UL	Avg	Std. Dev.	Md	D(x)	D (Md)	+/-x¯	LL	UL
1. Do you have previous experience with scenario planning?																
a) I am familiar with scenario planning	2,64	1.10	2.00	0.20	0.26	0.42	2.23	3.06	3.11	1.54	3.00	0.44	0.56	0.91	2.20	4.02
2. Scenario process																
a) The objectives of the session were clear	3.86	0.92	4.00	0.17	0.21	0.35	3.51	4.21	4.00	0.71	4.00	0.20	0.26	0.42	3.58	4.42
b) The objectives were reached	3.31	0.85	4.00	0.16	0.20	0.32	2.99	3.63	3.89	0.78	4.00	0.23	0.28	0.46	3.43	4.35
c) Do you feel that the process produced useful results?	3.62	0.78	4.00	0.14	0.18	0.29	3.33	3.92	4.11	0.33	4.00	0.10	0.12	0.20	3.91	4.31
d)Do you feel that the key drivers of change were identified?	3.31	1.07	3.00	0.20	0.25	0.41	2.90	3.72	3.72	0.57	4.00	0.16	0.20	0.33	3.39	4.06
e) Do you see think the results are relevant to the operation of [your university]?	2.62	0.68	3.00	0.13	0.16	0.26	2.36	2.88	4.06	0.17	4.00	0.05	0.06	0.10	3.96	4.15
f) Do you feel that the results were trustworthy?	2.31	0.60	2.00	0.11	0.14	0.23	2.08	2.54	4.00	0.71	4.00	0.20	0.26	0.42	3.58	4.42
g) Were the results logical and coherent	2.97	0.68	3.00	0.13	0.16	0.26	2.71	3.22	3.22	0.67	3.00	0.19	0.24	0.39	2.83	3.62
h) How much of the trust depends on the process itself (1 smallest -5 greatest)	2.86	1.06	3.00	0.20	0.25	0.40	2.46	3.27	3.11	0.60	3.00	0.17	0.22	0.36	2.76	3.47
3. GSS in the scenario process																
a) GSS fitted naturally with the scenario process	4.14	0.69	4.00	0.13	0.16	0.26	3.87	4.40	4.00	0.87	4.00	0.25	0.31	0.51	3.49	4.51
b) GSS systematized the process	4.28	0.59	4.00	0.11	0.14	0.22	4.05	4.50	4.56	0.53	5.00	0.15	0.19	0.31	4.24	4.87
c) GSS helped in observing different perspectives	3.76	0.74	4.00	0.14	0.17	0.28	3.48	4.04	3.89	0.60	4.00	0.17	0.22	0.36	3.53	4.24
d) GSS helped committing to the process	3.52	0.99	4.00	0.18	0.23	0.38	3.14	3.89	4.22	0.83	4.00	0.24	0.30	0.49	3.73	4.71
e) GSS helped in creating trustworthy results	2.97	0.78	3.00	0.14	0.18	0.30	2.67	3.26	3.67	0.71	4.00	0.20	0.26	0.42	3.25	4.08

Summing up the test results, it can be said that they support the design proposition that GSS supports the scenario process. As observed, the test subjects were fairly unanimous in their answers, so even though the sample was small, the validity of the results can be seen as better than the sample size alone would suggest. The correlation test suggested that GSS adds value to the process by focusing the group's attention to the task at hand and through supporting commitment to the process. Further, it seems that the main benefit from using a GSS in the process is its ability to diffuse the information the participants put into the system, and thus facilitate discussion and improve commitment.

4.3.2 Case 1

The test results (as discussed above) gave quite strong support to parts of the DT, particularly for the use of GSS as a tool for gathering expert input to scenarios. Encouraged by these results, the DT was revised as indicated by the description of the second instantiation, and evaluated in a test case. The case outline was a public organization, a university. At the time of the case study, the university was just planning a move from an organization of independent departments under central administration to a two-tiered administration of two to four faculties which were to administer the departments. The 'client' for the scenarios was one relatively large and influential department inside the university. The research mission for the scenario process was to map the position of the university in its competitive environment during the next ten years. The case consisted of two workshops, one inside the department, and one with representatives from university administration and different departments, and writing of the final scenarios. The objective was to find out whether the artifact works in its entirety beside the expert panel workshops, whether it instantiates the DT for its entirety beside the workshop, and whether it is useful. The unit is the artifact, and the propositions are the design propositions as stated in the DT. To fulfill the mission and examine the propositions, the same questionnaire was used at the end of the workshops to evaluate the test and was complemented with interviews.

In terms of evaluation the second paper (Paper 2) starts where the first left, by discussing the justification knowledge and meta-requirements for the electronically mediated scenario process and how the DT corresponds to them. The paper goes on to describe the instantiated artifact in case 1 from the problem setting to the final scenarios. The main contribution of the paper is the description of the meta-design and the artifact. In terms of conclusions, it can be said that the paper demonstrates in a concise package that the artifact worked in creating scenarios. Besides that observation, we have to turn to the other data to evaluate the unit further.

The first source is the same questionnaire as the one that was used to evaluate the first instantiation in the experiments (Table 13). This time the number of returned questionnaires was quite a bit lower than in the tests, so the results are more indicative. Nevertheless, the results are quite positive, even more so than the test result. The most notable differences are in the items considering usefulness, coherence and trustworthiness of the results, which improved considerably from the experimental phase. This can be an effect of two different things separately or together: either the revision to scenario heuristic was well received and thus successful, or the participants trusted each others' professionalism and expertise more than the students did.

Table 14. Coded statements from the interviews by theme

Theme	Themes and sub themes	Positive comments (number of similar)	Negative comments (number of similar)
1.	How deep was your previous knowledge of scenario planning and how does that compare to the session - Was there something missing? - Should there have been more structure or intuition? - Was the essence of the scenario process captured in the session in your view?	- Efficient process - The process was generally successful	- Might be too structured to capture most 'far-out' possibilities - Loosening the schedule might improve the substance - Tight schedule leaves little time for critical assessment
2.	In the survey there were implications that the goals were not clear enough: was the process enough goal-oriented and if not, how would you improve it? - Were the goals communicated clearly? - Should the goals have been emphasized more during the action?		- The group should be reminded of the objectives (4) - The time span tends to slip out of mind (2) - Difficult to juggle the process and objectives at the same time - More exhaustive introduction to the framework would help
3.	There were also implications that the results lacked logic, what induced these problems in your view? - Was the reason the process, the facilitation or the subject? - How would you improve the logic?		- Identification of drivers did not meet with the generation of events (4) - People are reluctant to give good grading without seeing the final results (2) - Grouping of the scenarios (event sets) was equivocal - Different contextual meaning of input, because of differences in mental models
4.	Did the final result meet the spirit of the session? - If not, where did the process go wrong? - Did you feel that the positive-negative-realistic heuristic would have affected the results? - Were the ideas and tacit knowledge transferred efficiently?	- Generally yes (2) - Heuristic did not bother (5)	- Some negative or improbable contributions were not taken seriously - Hard to detach from one's own point of view

Theme	Themes and sub themes	Positive comments (number of similar)	Negative comments (number of similar)
5.	Did you feel that GSS enhanced communication? - Was the communication better or worse than verbally? - Do you feel that the meaning of the ideas and comments was understood in the group? - Was there something important missing in the written communication? - Was there enough clarifying verbal communication?	- GSS promoted democracy in the group - Idea generation was effective (2) - Generally the input was understood well in the group (2) - Enhances commitment (in a tech-savvy group) - Ability to see the session logs reduces ambiguity - Ability to see intermediate results gives some sense of accomplishment	- More time would have waken perhaps more resonance in the group
6.	Do you feel that knowledge was diffused and/or transcended in the session? - What helped or hindered the communication? - Do you feel that you have got something from the session?	- Information diffusion and extraction was efficient (3) - Promotes considering new perspectives (2) - Possible to ride on the wave of others' ideas	- Maybe too much information in a short time
7.	Do you feel that using the results of this process in actual situation would be feasible? - If not, why? - Is the trust in the process, participants, GSS or in all of them?	- Yes, promotes open-mindedness toward decision options (3) - Especially in complex and uncertain decision conditions - Possibility for consensus creation in a larger perspective as a byproduct of the process	- Risk of the stories being too populist to gain trust

The participants of the first workshops of the case were interviewed to gain perspective to the questionnaire. The interviews were carried out as semi-structured with predetermined themes, but without pre-chosen answer options or precisely formulated questions. The themes were based on the justification knowledge, design propositions and the critique found in the after-session survey results. The objective was to gain insights about the reasons for the critique, and how the DT could be developed. The main themes were the perceived usefulness of the scenarios, trust in the results, the fit of GSS as a tool, and the possible shortcomings of the artifact. The interviews were carried out by one person on face-to-face basis, recorded and transcribed. The interviews were conducted some time after the session to lower the possible effect of the novelty of GSS and other situational factors. The transcripts were analyzed and coded following the content analysis logic and classified to Table 14.

While the interviewees still rated the artifact positively, clear points of critique arose. On the negative side, the goals of the process or the process itself were somewhat unclear to the participants or were forgotten during the process. The identification of drivers of change was not integrated to the process well enough, or the identified drivers did not connect to the future events properly. Even though the subjects were presented with a list of the prioritized drivers to look at while generating the events, they felt that the events did not connect to the drivers, which is somewhat puzzling as the group was specifically asked to think of events those drivers would cause. One topic of critique was also poor catering to relationships in the elements of the scenarios. There are two main reasons for the poor logicality or credibility of the scenarios beside the shortcomings of the artifact. Some subjects were downright suspicious of the validity of the scenario sets. The other reason for average rating in the survey appeared to be that the subjects did not want to rate the results too high, when they had seen only a handful of probable events instead of ready scenario stories.

On the other hand, the scenario heuristics of splitting the event to positive, negative and probable scenarios did not seem to bother the subjects despite the fact that the literature has argued that it may oversimplify the view to the future. Then again, one point is how the final scenarios might act in decision making, as the most probable scenario is likely to attract most attention, whether it is a negative matter is another story. The subjects also rated the GSS as a good tool for the task because they felt that the information sharing was effective, and that it promoted open-minded considerations, as seeing others' contribution can awake different connotations and mind sets.

In the concluding question, the subjects generally saw the scenario method as a viable tool for large and important decisions, even with its flaws. When asked, the basis of trust was the whole process, the GSS, and the whole situation, rather than one separate factor. In addition to the concrete scenarios, some interviewees also saw the process as a kind of learning experience, promoting open-minded consideration of different options and ideas, and as a possibility to create consensus on large issues and goals in a large heterogeneous organization.

To sum up, the quantitative results are positive regarding the feasibility of using a GSS in supporting the scenario process. The results duplicate many of the reported results of the benefits of a GSS, so it can be cautiously suggested that the theory supports the usability of a GSS in a scenario process and *vice versa*. At the same time, it needs to be noted that this testing did not evaluate other parts of the artifact, than the creation of (preliminary) scenarios with the support of a GSS. In addition, the qualitative analysis revealed that there were some setbacks in the actual scenario method, so there is still work to be done on before deeming the framework ready.

What the above means for the DT, is that first of all, the artifact instantiates the DT quite well, as illustrated, which gives way to evaluating the DT and the design propositions. The first conclusion we can draw is that the electronically mediated expert panel is a tool that enables synthesizing the views of the experts to data for the scenarios quite well, as indicated by the questionnaire. However, what we cannot tell based on the data, is how well the artifact works in creating scenarios, even though we can tell that the artifact was successful in creating a set of event to base scenarios on. Even though the questionnaire indicated that the panel discussion was relevant, and the interviews indicated that the group in general was quite content with the artifact despite some problems, the group has not evaluated the actual scenarios, which leaves questions about the quality of output unanswered for now.

4.3.3 Case 2

The second case complements the experiments and the first case by repeating the instantiation of the artifact in a different setting. The case (Papers 3 and 4) continues down along the DSR process. The artifact was previously demonstrated, and this case takes it to the context of strategic management of technology. The objective for the scenario process was to identify new business opportunities in the intersection of a manufacturing and a service industry. The 'client' for the case was a research project that was focused on the convergence of industries and finding new businesses. To recap the basics for successful case studies (discussed in the research design section), the research question and propositions were again linked to the DT. The question was whether following the DT would produce a feasible and useful instantiation of the artifact, and whether it would be useful. The unit was naturally the artifact, the scenario method and its products. To evaluate the propositions, we collected data that would measure the usefulness of the artifact in its designed task. In practice the artifact followed the same DT as before but the instantiation had some context-dependent modifications, as well as improvements as described above.

Beside the change of context, the research design in this case was different. The data for evaluation was gathered in a one-day session where industrial managers, industry experts and researchers acted as test subjects and created scenarios for an intersection of two industries. The instruments were again a post-test survey, supplemented with open-ended items and participant observations. In addition to the evaluation of the session, this time the artifact and the resulting scenarios were evaluated against another scenario method, which enabled evaluation of the final phases of the process and the other tools in addition to the already evaluated first phases of the method. In practice, the third paper is essentially a replication of the first and second. In the fourth, however, the DT and the artifact are compared to the FAR method. The paper describes the scenario methods, our artifact and the parallel FAR method used as a benchmark, and compares them on the meta-design level, as well as on the level of instantiation.

Starting chronologically from the scenario workshop, the session was organized as a part of a research project in a LUT-affiliated research center. The participants were not affiliated with the university and were chosen primarily for their substance expertise on the topic of the scenarios and interest in participating. However, the search for willing participants was initiated through personal networks, so the sampling was not random, but quite representative. The DT was instantiated as described in instantiation 2 above. The case session was evaluated with a questionnaire as described above. Table 15 presents the questionnaire items. The questionnaire was a rephrased version of the one used in the test sessions and the first case. All the items were evaluated with a Likert-type 10-step scale, and each category held at least one negatively phrased item to test for a positive response bias in the group. Excluding the researchers, the number of respondents was $n=7$, which is very low and defeats the use of many statistical tests, or affects their reliability significantly.

Table 15. Evaluation of the instantiated artifact in the second case

	Questionnaire items	Avg.	Md	St.Dev.	Conf.
1.	Have you used or tried GSS tools previously?				
1.1	I have worked with a GSS previously (1 never - 10 regularly)	5.71	8.00	3.09	2.29
1.2	How do you think the environment affected the results? (1 extremely negatively, 10 extremely positively)	7.86	8.00	0.90	0.67
1.3	I have not used a GSS environment but I have otherwise participated in similar sessions (1 never – 10 regularly)	5.00	6.00	2.83	2.10
1.4	I believe that unsupported idea generation creates better results	5.29	5.00	1.60	1.19
2.	The brainstorming process (1 completely disagree - completely agree 10)				
2.1	The goals of the session were clear	8.57	9.00	1.40	1.04
2.2	The goals were reached	8.14	8.00	1.21	0.90
2.3	Do you feel that the process provided useful results?	8.50	9.00	1.22	0.91
2.4	Do you feel that the process included the most important factors?	8.00	8.00	1.00	0.74
2.5	Do you consider the results as realistic and relevant to your company?	7.86	8.00	1.35	1.00
2.6	Are the results trust-inspiring to you?	8.00	8.00	0.82	0.60
2.7	The session was confusing and relevant steps were skipped	2.43	3.00	0.79	0.58
2.8	The results are not realistic or relevant to our company	2.14	2.00	1.07	0.79
2.9	The results are trustworthy because of the process	4.71	5.00	2.29	1.70
2.10	The results are trustworthy because of the used work methods	7.29	8.00	1.38	1.02
3.	Work methods (1 completely disagree - completely agree 10)				
3.1	The process helped in getting and outline ideas	7.71	8.00	1.25	0.93
3.2	The ideas were clear and understood	7.43	8.00	1.13	0.84
3.3	Everyone’s input had equal treatment	7.86	9.00	2.41	1.79
3.4	Evaluation was a useful and relevant phase	8.43	9.00	1.51	1.12
3.5	The process was logical and proceeded fluently	8.29	8.00	1.50	1.11
3.6	The evaluation did not clarify the ideas	2.57	2.00	1.27	0.94
3.7	The available time was too short	5.36	5.00	2.43	1.80
3.8	I had time to concentrate on the evaluation and the results were reliable	6.86	8.00	2.48	1.84
4.	GSS-environment in the process (1 completely disagree - completely agree 10)				
4.1	GSS fitted naturally with the scenario process	8.86	9.00	1.21	0.90
4.2	GSS systematized the process	8.86	9.00	1.21	0.90
4.3	GSS did not have added value in this task	2.36	2.50	0.75	0.55
4.4	GSS helped in observing different perspectives	7.57	8.00	2.64	1.95
4.5	Using the GSS made the working more difficult	2.29	2.00	1.11	0.82
4.6	GSS helped in getting committed to the process	7.29	8.00	1.60	1.19
4.7	GSS helped in creating trustworthy results	7.43	7.00	1.27	0.94
4.8	The GSS was a confusing experience and made working more difficult	2.00	2.00	1.00	0.74

When examining the basic statistics, the participants were generally somewhat familiar with the GSS environment and were more skeptical about the effect of the support methods compared to the previous studies, and even slightly agreed that an unsupported session would give better results. On average, the basic premises seemed to be in order, as the session goals seemed to be clear to the participants, the goals were apparently reached, and the most important factors were also included in the scenarios. What can be seen as a negative point was that the group only slightly disagreed that the time was too short, even though they mostly agreed that there was enough time for the evaluation of the events. Again, on average, the results were seen as trustworthy, but the participants only slightly agreed that it was because of the process, but then again agreed strongly that the work methods brought trustworthiness to the results. Judging by the answers, the GSS seems to have had a positive impact on the results, as it seems to have fitted effortlessly to the process as a support tool and have helped in systemizing the process and creating trustworthy results.

While the sample size for the questionnaire was extremely small, we took a risk and calculated the correlations between the items as we did with the test session data. We computed 2-tailed Spearman's Rho tests with a significance level $p=0.05$ where applicable. It needs to be noted that the small sample will degrade the validity and reliability of the correlation coefficients, and should be considered only as suggestive evidence. The correlation table (Appendix 2) can be interpreted concisely as follows. Firstly, trust in the results and the amount of experience in working with a GSS were positively associated, which could suggest some bias in the answers. While it is possible that the people who have used the technology before see the benefits more readily, it might just as well be that they are less objective to see the shortcomings or have developed more rosy goggles. Secondly, the most important factors in reaching the goals of a session would be equal treatment of each participant's contribution, democratic treatment of participants, commitment to the process, and systematic working. Concerning the practical aspects, the more systematic the process was seen to be, and the more time the participants felt they had at their disposal to complete the phases, the better the trustworthiness of the results. These factors lead to a conclusion that the GSS had a positive impact through systemizing the process and granting anonymity, which helped in democratizing the process and supported the evaluation of the events.

In addition to the questionnaire, the participating researchers, two of whom participated in the session as a participant and as the technical facilitator, gathered observations during and reflections after the session (presented in Paper 3). The aim was to enrich the case description and to confirm or dispute the questionnaire data in the spirit on triangulation (Jack and Raturi, 2006). The observations and reflections were divided to four identifiable levels affecting the success of the session, including meeting satisfaction as specified above. The first level was the technical implementation of the process, including the physical environment and the technical aspects of the GSS system. The second was the process level, the outline of the workshop, proper task definition, support in completing the tasks, and facilitation. The third level was the participant experience, satisfaction with the previous two facets in the workshop and the level of satisfaction with the process. The fourth level was the participant experience and satisfaction with the results of the session. Together these levels contributed to the overall satisfaction and willingness to adopt the artifact.

As a finding worth noting, the introduction and session time interventions are of great importance to the process and the content, as also recorded in the participant feedback. Especially the introduction has surprising power to steer the group and to introduce ideas. This function can be seen as an opportunity to create an innovative and forward looking attitude in the group, but the power also brings responsibility to the facilitator not to exploit the leverage to get convenient results from the group. When looking at the open-ended items in the questionnaire, the input concentrated on the process level, although some of the comments were hard to isolate. It is probably safe to assume that most of the input covered the participant experience, as well as the process and technical levels. The open-ended answers were in line with the questionnaire results, and satisfaction with the process and the arrangements was high. On the other hand, the results may also indicate a slight positive response bias, as negative comments were absent and critique or suggestions for improvement scarce. Concerning the recorded critique, it would seem that the relatively strict timetable was one of the main causes.

Comparing the questionnaire, the open-ended answers and the observations, the effect of the GSS dominates in the questionnaire, but the rest of the data point out that the technical level of the session is just one aspect. Overall, the results correlate reasonably between the data sources and the researchers. Based on the feedback, it can be summarized that the GSS enabled efficient working and offered usable tools, but the real value came from the process used together with the GSS. An additional twist in the case was the inclusion of representatives of three different industries and multiple organizations. In fact, most of the participants were from different organizations or at least departments, except for the authors who were present. Based on the feedback and observations, the instantiated artifact worked in a satisfying manner as proposed by the DT. All in all, the participants seemed to be well motivated, open toward the group and constructive, and all the participants contributed significantly to the session. Part of this 'effect' is of course due to the personal motivation of the participants, and also facilitation had an effect, but on the other hand, the artifact did not hinder the group, either.

The evaluation of the DT has so far concerned the first phases of the second case and the third instantiation, up until the preliminary scenarios, where the data was transferred to writing the final scenarios. The final scenarios, and especially the rather strong convergence between the two industry scenarios gave the push to compare the output of the artifact, the scenarios, with another method. The starting point for the evaluation was the scenarios composed with the artifact as a result of the workshop described in paper 3. The same expert panel data was used as the basis for the FAR process to ensure comparability of the results. The FAR process was conducted mainly by the authors of Paper 4, but the crucial steps involving decisions that are important to the substance were validated within the research project by other researchers, who had expertise in the field and the industry.

Starting the comparison from the method description, or should we say meta-design, the presented scenario methods seem to be quite different, right from the constructs and terms. Overlooking the terminology, there is also some common ground. Both processes start with defining the scope and objectives and a broad consensus on the broad terms of the future. The second phase is similar in both methods, the general scenario literature calls it finding the drivers of change, whereas FAR writers talk about forming a language. The objective is to find the most influential forces shaping the future during the time span of the scenarios. The processes diverge in the third step, as the intuitive process goes on to identify the events triggered by the drivers, and FAR concentrates on the morphological table. The main difference comes from the difference in scenario heuristics, i.e. the ways to synthesize the final scenarios from the data. The final phase of formulating the scenarios is not very different; where the intuitive process organizes the event to consistent chains, the FAR method takes a sort of bird's eye view and organizes whole-field configurations, or descriptions of the world to chains. Although the concept of "event" as discussed in the context of the DT is not very discriminatory, the "events" range from a simple discrete events to names for complex field conditions with their own implicit assumptions, just the same as the factors in FAR. Based on this comparison, it seems that beneath the surface the meta-design of the methods is quite similar, save for the scenario heuristics; where FAR utilizes morphological analysis and the DT resorts to intuitive reasoning. The essence and the tasks are still quite the same, and it can be cautiously suggested that on the whole both methods follow the generic scenario process, but the scenario heuristics are quite different between them. The similarity of the methods does not tell much beside the fact that the DT including the generic process is comparable to existing practice, and the feasibility argument gains weight through analogy.

Going deeper to the scenarios, the first great difference was the overall theme in the scenarios. The intuitive scenarios, which were guided by the panel data, were more technology and operations-oriented by nature. The second set developed with the FAR method was considerably more policy-driven. The difference was quite surprising at first, but then an explanation started to emerge. In FAR the drivers, which are often more general trends and phenomena, guide the scenario composition more closely than in the impact-based heuristic. Another factor is that if the scenario language or elements were chosen directly by the expert panel, they could have been on a more operative level, where now the driver-factor –array was composed based on the drivers and to some extent the events by the authors of paper 4 and inspected mainly by other researchers. The scenario artists were not familiar enough with the operational reality of the industry to be able to paint a vivid picture of the future on the shop floor level.

Beside the plausible author biases, the second finding was that the difference in scenarios was the level of analysis. As discussed above, the factors represent more general developments than the events specified in the IDEAS process. The participants in an IDEAS workshop are more or less tied to their level of operation when they picture the future. They see general drivers, but the events are for most parts on the operational level, where the FAR scenarios concentrate on general lines of development. As a result, the DT tends to result in scenarios that are more tied to the panel data and views of the experts than FAR scenarios, for example.

Thirdly, as mentioned, the instantiated artifact (instantiation 3) produced a set of scenarios with relatively little variation between scenario stories, whereas the FAR scenarios were quite distinctive from each other. Plausible reasons for this fact are the positive expectations in the expert panel, which may guide the scenarios to one direction if the scenario composition follows the plausibility/impact-heuristic as described above. Another reason for the observed difference can be the freedom of choice for the final storylines in the FAR method. An essential factor which also affected the scenarios is the fact that the scenarios were developed at different times and by slightly different people. While the impact-based heuristic may steer the results in special cases or in very cohesive groups, the FAR process does not speak out the probabilities of the future events, and the assessment is entrusted to the scenario writer and user, unless there is a possibility to use an expert opinion on the morphological table or the sequences.

The next question is how these findings relate to the plausibility of the scenarios, and by extension to the feasibility of the DT we are evaluating. The DT and the instantiation consist of the workshop and the ensuing scenario heuristics based on either intuitive graphical clustering of the events or using clustering tools, as discussed above. In this case, both were tried and mathematical clustering was chosen. While the resulting scenarios are close to each other, they are based on data that were deemed satisfying by the experts and they are quite plausible, given the perspective the test subjects have on the issue. In this sense there is no reason to regard the scenarios or the method as a failure. However, what this finding shows is that the scenarios are always to some extent an embodiment of the creators' worldview, and in this case quite strongly the one of the test subjects. While we could enter into the 'bug or a feature' –debate, I would like to conclude on this issue that within the discussed limits or properties, the instantiated artifact is useful in creating plausible, consistent and reliable scenarios, and by extension the DT results in an artifact which embodies the DT.

To summarize the main findings f the second case: for the workshop, the test subjects rated the session as successful in terms of reaching the set goals and using GSS as a tool for the process. The questionnaire indicated that the subjects thought that the GSS helped to systemize and structure the process, and enabled democratic participation. However, the response to the use of GSS was more muted compared to the other cases, and some of the subjects were skeptical about GSS providing value over an unsupported workshop. The data were consistent over the instruments, and the open-ended items as well as the observations supported the findings that the electronically mediated scenario process worked as intended.

As for the scenarios, the main findings were that the results differed significantly between the DT and the benchmark method, despite the fact that the methods were used on the same basic input data. The main difference was the level of analysis. While the test subjects using the artifact identified drivers that encapsulate the whole industry they operated in, the events and ensuing scenarios had a perspective that corresponded to the level of analysis or operation the test subject operated on in their daily routines. The benchmark method steered the attention to a more general level of analysis through greater attention to the drivers. Nevertheless, the comparison did not suggest that either of the methods or would produce more valid scenarios, and thus the findings support the proposition that the artifact is a feasible solution. To conclude this evaluation, I summarize the findings as they are related to the actual scenarios in Table 16. As a conclusion, I propose that the instantiated DT is able to produce adequate scenarios, which are intuitive yet tied to the participants' expertise and views. The contribution to the evaluation is that the findings give further support to the proposition that the artifact enables creation of feasible scenarios.

Table 16. Evaluation of the instantiation against the success criteria for scenarios

Levels	Success criteria	Evaluation
1. Substance	Consistency and coherence of the individual scenarios	- The scenarios were coherent and consistent with the drivers and time frame, - The scenarios were quite convergent, they offered only limited 'peripheral vision' to the future
	Right level of analysis and compatibility with the time frame and drivers	- The level of analysis was tied to the group - The scenarios were compatible with the chosen scope
	Relevance to the organization and decision makers	- The scenarios were presumably relevant as they are tied to the participants' views - Accordingly, the panel should be chosen carefully
2. Form	Sufficiently detailed scenarios, manageable breadth and depth	- The underlying logic of the scenarios were well illustrated by the maps, and can be developed as far and wide as needed
	Right number of scenarios	- The number of scenarios can be chosen as needed, usually three or four - The basic 'optimistic', 'pessimistic' 'realistic/most plausible' setting can be a shortcoming if the aim is to explore the bounds of the possible
	Preserving the undertones and nuances in the final scenarios	- The nuances of the discussion are reasonably conveyed by the GSS logs, and the session notes to scenario writing
3. Methodological integrity	Choice of proper method and rigorous execution	- The method (DT) has its limitations in terms of level of analysis
	Transparent documentation of the whole project and evaluation of the results	- The GSS log and session notes assure transparency and allow for going back to the data to review the scenarios
	Trust building in the process and in communication of the scenarios	- Facilitation is in a key position to build trust in the scenarios

5 DISCUSSIONS

This chapter represents the final phase of the DSR process. In this chapter I will interpret and discuss the findings and the research process, inspecting them critically. I continue directly from the previous chapter by summarizing the last two publications (Papers 5 and 6), as they are mostly focused on communication of the results. As the papers in general are mainly focused on the evaluation of the DT, I will additionally discuss how the findings relate to strategic technology management. In addition to communication and positioning, I will discuss the limitations and validity of this research critically and summarize the lessons I have learned during the process.

5.1 Summary of the Findings

The communication mission set in the DSR process is fulfilled in papers five (5) and six (6). Paper five discusses the need for scenario planning in the industry and the prior work on electronically mediated scenario methods. The paper continues to describe the artifact and the SAGES method, which is derived from similar roots as the artifact, in fact close enough, to that it is possibly justified to call the methods siblings. The paper closes with a discussion on the properties of the methods and their relation to prior work. The design of the paper is conceptual discussion and reflection. The sixth and final paper continues the discussion started in the fifth paper, but the focus is broader this time, and the artifact is positioned in relation to the long line of research and practice on scenario planning. The paper discusses the roots of scenario planning and develops a classification for scenario methods to illustrate the properties of the artifact.

Table 17 summarizes the findings in a side-by-side comparison of the DT with the SAGES and FAR methods. The table summarizes the main features of the methods, as well as the evaluation discussed in the previous chapter. On the method level the main differences between the DT and SAGES are the scenario heuristics. While the development of the DT abandoned the driver array for the benefit of the impact-based heuristic, SAGES has taken the driver array further. Piirainen and Lindqvist (Paper 6) propose that, besides the heuristic, the fundamental difference between the methods or instantiations is the scale: the DT and the IDEAS method can be characterized as a 'quick-and-dirty' approach, whereas the SAGES method is a more complete heuristic scenario method.

Together, the papers (5 and 6) suggest that the IDEAS and SAGES methods are suited to applications where time and resources are precious, but there is a need to involve the key decision maker in the process, either to increase acceptance and buy-in of the scenarios or to gather expert insights. The main feature in both methods is a strong interface of the results to the contribution of the expert panel. This feature can be also seen as the main pitfall, but it does not have to be the case, as long as the feature and its effects are recognized when selecting the method. It is also a fact that this feature forces the practitioner to take care in selecting the expert panel. Since both the IDEAS and SAGES methods were perceived to result in high participant satisfaction and motivation to support the use of internal group expertise, these elements are expected to contribute further to achieving positive organizational learning advantages in scenario planning.

To take the FAR method as the point of comparison, it is quite structured and offers rigorous scenario heuristic. However, the FAR method is considered quite heavy and takes well up to half a year to complete (Coyle, 2009), while the results of the IDEAS/DT process can be completed within the same or shorter time frame and the expert panel is needed only in the workshop and evaluation of the scenario stories later. As an example, the completion of the process in the first case took half a year from one person beside the two workshops, and during that time the person was developing the method and worked with other research as well (see Piirainen et al., 2007). Besides the issue of resource use, FAR is not considerably more rigorous in scenario creation. In the early phases the FAR method relies on the heuristic to create possible worldviews while the DT relies on the expert panel, but intuitive logical reasoning is still needed to complete the scenarios, so I judge that the rigor is roughly on par. However, as observed, the FAR heuristic might help the scenario author to detach him- or herself from the subject, which may be an advantage in some applications.

Table 17. Comparison of the discussed scenario methods (adapted from Kokkonen et al., 2008; Piirainen and Lindqvist, 2010)

Methods		IDEAS	SAGES	FAR
Features	School of thought	Intuitive logical	Intuitive logical/ Heuristic	Heuristic
	Committed resources	Scenario team, expert group	Scenario team, expert group, internal steering group, interviewed experts	Scenario team and experts as needed
	Data gathering	Group innovation, literature	Group innovation, literature, interviews	Open to possibilities, can use data from IDEAS for example, as well as literature, interviews etc.
	Scenario heuristic	Impact-based heuristic and clustering, intuitive scenario composition based on systems thinking for driver relations and the events	Axes of uncertainty/driver array heuristic for drivers, intuitive scenario composition based on the events	Morphological analysis based on the driver/factor-array, exclusion of impossible futures and intuitive scenario composition based on the world views
	Grouping of drivers and events	Causal mapping, cluster analysis	Driver array/scenario matrix, causal mapping	n/a
	Creation of initial scenario themes	Scenario team and possibly expert panel, based on the drivers and events	Scenario team, internal steering group, expert group, based on the collected data and the megatrends and drivers	Scenario team based on the drivers and worldviews
	Scenario narratives	Single author	Single author	Single or multiple authors
Findings	Strengths	- Effective process, fast results - Does not consume expert time excessively	- Effective and fast process - Structured and logical facilitation for creating qualitative and partly quantitative data for initial scenarios - Taking both expert panel participants' views and the latest public views into account	- Rigorous heuristic to find plausible futures based on drivers - Transparent and auditable logic to find the worldviews - Enforces rigorous thinking and exploration of the limits of possibility
	Weaknesses	- Participant-perspective bias - Intuitive structure eludes analytical scenario composition - Results are hard to quantify and present as "hard facts"	- Partial participant-perspective bias - Small sample sizes reduce the trust on generated quantitative data	- Choice of the sectors/drivers and factors steer the results, should be well validated - The final scenarios are as intuitive as in the comparison methods, can be misleading
	Possible applications	- Roadmapping - Technology scenarios inside an R&D group, department or similar sub-entity	- Business strategy scenarios (both industry and company levels) - Suitable also for policy scenarios and partly for technology scenarios	- Policy and other high-level scenarios

5.2 Positioning and Communication of the Contribution

Besides discussing how the DT and SAGES compare with each other, another relevant question is how the methods contribute to the existing wide variety of scenario methods (Bishop et al., 2007; Bradfield et al, 2005). All in all, this discussion and the accumulated research on using GSS to facilitate group work in general, and the scenario process in particular, seems to confirm that using a GSS in the scenario process is viable, and that the group innovation-based methods are able to offer light-weight and effective ways to compose scenarios. The strong point of the electronically mediated scenario methods is the ability to create personalized scenarios with a strong qualitative spice for the target organization. The traditional methods have been criticized for resource intensiveness and excessive workload presented to the process participants (e.g. Courtney, 2003; Millet, 2003; Raspin and Terjesen, 2007).

The broader finding that is based on comparison between the methods themselves and prior work is that indeed the main contribution of the methods to the state-of-the art is that they enable extremely fluid engagement of an expert panel to the process and overall quite a short runtime compared to existing practice. Further, the practical properties enable scenario creation in a relatively short time even with quite few resources. Thus the most obvious contribution of this research the tradition of scenario planning, is reducing resource consumption with to the use of GSS and possibly reducing the cycle time of the process. Paper 6 concludes that these properties make the IDEAS/DT well suited for e.g. roadmapping and similar smaller scale foresight applications. The question of whether the methods improve the content is another matter. Lindqvist et al. (Paper 5) are confident that the use of a GSS does not in itself affect the results, but only enables efficient input from the expert panel.

As for the foundations of design, the study contributes to the literature on scenario planning by tidying up the methodological jungle (Bradfield et al., 2005) and making the use of scenarios less of a coveted art (Chermack et al., 2001). The contribution here is the explicit design and positioning of the method, which should enable practitioners to employ the method more readily. The main findings concerning the DT and the SAGES method are that in the spectrum of scenario methods, the artifact is in the intuitive-logical end of the spectrum. The properties of the DT make it exceptionally suited for applications where the source of uncertainty is within the unit of analysis or on the same level than the participants. Generally, I would suggest that by using GSS-based scenario methods, one gains speed and effectiveness, and trades in some of the impartiality of the more rigorous and analytical models. This trade-off effectively offers a chance to use scenarios more often, without straining the organization and the resources.

While much attention in this thesis has been paid to the evaluation of the efficacy and utility of the artifact, the meta-design, the principles of form and function have received less attention. A more abstract contribution to the knowledge base is the generic scenario process, which is a conceptually important pivot in the meta-design of the artifact. The benchmarking studies with FAR and SAGES support the idea that the process can be used as a template to codify and develop scenario methods in a more general sense. This may not be a spectacular finding, but together with the classification built for describing the IDEAS methods, the generic process is a stepping stone toward a more transparent scenario practice and a more analytical choice of method to a given foresight problem.

Additionally, the study contributes to the foundations of design, as well as to design methodology. Starting from the methodology, the study presents a novel synthesis between the concept of DT (orig. Walls et al., 1992, later Gregor and Jones, 2007), the DSR framework (Hevner et al., 2004), and the process of DSR (Peffers et al., 2008). The novel contribution here is the use of the DT to codify the products of the design cycle (Hevner, 2007) explicitly, thus increasing transparency and enabling better evaluation and transfer of the design. I expect this same schema can be used in subsequent DSR to make the link between design artifacts and the knowledge base more transparent, and the principles of form and function more explicit and easy to replicate.

Going back to the area of strategic technology management, the research is positioned to this stream, with the aim of supporting foresight of strategic technology issues. Returning to the river metaphor, an organization is like a river, or a motorless boat navigating a river, in the sense that it cannot turn back but has to move ahead constantly with the flow and adapt itself to the environment (Lamberg and Parvinen, 2003). Foresight is the bright headlight (Glenn, 2009) for the boat, which enables the captain to at least steer clear of the worst caveats ahead. In this sense, the contribution of this study to this area is mostly practical, as the DT can be used to instantiate foresight exercises to raise awareness of plausible futures in technology management. If we look at what the evaluation tells about strategic technology management, we need to go back to papers three and four which apply the DT in the MoT context. While we have no data on the long-term impact of the scenarios, we can at least see that the instantiation enabled creation of viable scenarios and was rated useful by the practitioners. This tells us to some extent that they found the headlight useful for their line of work, and that the DT could plausibly provide them with that headlight.

Looking at the previous contributions to supporting scenario methods electronically, perhaps the most prolifically discussed methods are presented by Eden and Ackermann (1999) and Blanning and Reinig (2002; 2005). Eden and Ackermann (1999) describe an iterative method of reasoning and imagination, which converges to a handful of possible futures. The core of their process is an exercise to develop causal maps in the group and to develop stories around the maps. While the DT relies on the impact-based heuristic for scenario creation, there are common elements, as both of the cases exhibit similar systems thinking –type causal reasoning. The difference between the methods may also stem from the tools; Eden and Ackermann (Ibid.) have used Group Explorer and Decision Explorer, which are tailored for causal mapping, where the IDEAS and SAGES use a general purpose GSS, and the causal mapping is done outside the workshop.

The DT is more indebted to Blanning and Reinig (2005), as the basis for the impact-based heuristic is on their proposed method for voting on the impact and probability of the events, and using these votes to group the events. The main differences are that Blanning and Reinig (2002) propose either using less events, which are picked from literature before the scenario workshop, or brainstorming the events on the spot and straight to categories, such as ‘pessimistic’, ‘optimistic’ and ‘realistic’. They also propose a multi-period approach, where the vote on importance and impact is repeated for different time periods at different times (Blanning and Reinig, 2002; 2005). The IDEAS/DT adopts a more intuitive approach to scenario building, which is similar to the static multi-dimensional case of Blanning and Reinig (2005). As described above, the scenarios are built by forming causal chains from the grouped events following the drivers. This reliance on the drivers in the building of the scenarios is the main difference between the IDEAS method and Blanning and Reinig’s (Ibid.) method. While the difference may seem to be a superficial one, the identification of the drivers of change is used to persuade the expert panel to think above and beyond their daily routines, “outside the box” so to speak. The events picked after pondering about the drivers of change should be more connected and relevant to future change than events brainstormed straight up, but of course without direct benchmarking it is hard to evaluate the actual impact of the process variation.

5.3 Reflections and Observations

While I have evaluated the instantiated artifact, the main objective has been to evaluate the DT. In this sense it is important to remember the design propositions, which in fact are the link between the DT and the data. As it seems, the evaluation has given us insight on all the propositions. Proposition 1 (P1) was that the DT can be instantiated as a useful artifact, and the DT was instantiated in three different settings where the artifact was able to produce scenarios reliably in each context with different people and different substances (P2). The support tools enabled effective work and were rated as usable (P3). Using these tools, the participants felt that while the sessions were structured, they were innovative and that they could contribute in a good spirit (P4-5). Finally, the DT compares to existing practice quite favorably, given its limitations and thus certain domain considerations (P6). Data-wise these propositions were verified mainly by questionnaires and observations. The empirical evaluation of the artifact has raised several observations and resulted in reflection, reported particularly in the latter publications (Papers 4-6). I will gather these discussions here, to synthesize the lessons learned from this research.

To start with the big picture, so to speak, the results as whole can and also should be examined critically. Initially (Paper 1), the outlook to the usefulness of the method and the benefits of GSS was optimistic. The proposition was that the use of electronic mediation could benefit both the process and the resulting scenarios, but later evidence did not provide strong support to this. The proposition was based on the supposition that effective communication through the system would enable the participants to contribute more and to have more time to absorb others' input and evaluate it. However, without a direct pen-and-paper benchmark it is hard to support the proposition, and comparison between IDEAS and FAR in this respect is a case of 'apples versus apples', when we should be comparing apples and oranges. Accordingly, the conclusion in the latter publications was that the electronic mediation does not necessarily improve the results, nor does it hurt them, but it enables receiving the same results more efficiently. There are, however, some data that suggest that the anonymous communication through the system can enable more freedom of thought for the participants, and the voting feature can support getting new insights, especially when the group discusses the results, they may see the ideas from a new angle based on the impact and importance votes.

Another content-related aspect is trust to the method. The test data exhibit interesting patterns, as the subjects' answers indicate that trust in the method and in the results correlate. This raises a concern whether trust in the method hinders evaluation of the scenarios. Especially when it was noted that the scenarios were quite well grounded on the data collected from the panel, and to the views expressed in the sessions, the implication is that the test subjects' expertise is as great a concern as the quality of the method, as the method is a subject to the old 'garbage in – garbage out' –adage. An issue raised at this point is the composition of the scenario team. One observation that rises from the empirical research in IDEAS that the most the method can do is to synthesize the participants' information and knowledge to a set of plausible scenarios, which is not necessarily a small feat as such. However, in this sense the composition of the team has great impact on the results, greater than in some other methods, such as FAR or the similar MIC-MAC (Arcade et al., 2009). Thus there are three considerations in choosing the expert panel, the information the experts carry, the perspective they have on the issue, and the personality, as discussed by Hodgkinson and Healey (2008), and although the use of GSS can somewhat alleviate the personality issue, the information and perspective issues are unilateral in scenario practice.

While we are discussing the scenario heuristic, I would like to add a warning about a potential pitfall in the impact-based heuristic. Namely, both cases ended up using statistical cluster analysis to group the event to scenarios, mostly because it was perceived as a more 'scientific' and thus automatically a better method. However, Ketchen and Shook (1996) criticize management research for misusing cluster analysis, one point being that cluster analysis involves more use of judgment than other statistical tests or methods, and is thus more prone to bias, and the other that cluster analysis can be conducted in a brute-force manner to impose groups where no meaningful clusters exist, or even to override what might be called natural cluster borders. In the present case, it is easy to interpret the results of cluster analysis so that the events somehow belong to the same scenario and are automatically consistent with the drivers and general theme of the scenario, while the fact of the matter is almost completely different. Roughly described, cluster analysis only analyzes the variance of the data in the given classifying dimension and minimizes the total variance in each cluster. As none of the categorical variables available for clustering contain any information about the causal relationship of the events, this method does not as such add anything other to the result than a little polish of 'scientificity'. Nevertheless, it needs to be noted as well that statistical clustering is not any worse than the intuitive grouping we used in the first instantiation, as long as one does not try to read anything more to the method or the results than there actually is.

A recurring theme or observation in the papers is that the artifact seems to work in a satisfying manner even with people who are not familiar with each other, or have not worked with each other previously. However, it is hard to distinguish whether the positive outlook to the artifact is due to the specified principles of form and function, i.e. the process, the facilitation of the process, or the tools and information systems. A careful assessment suggests that the whole of the thing may be the answer. There are also downsides to collaboration and group work (e.g. Nunamaker et al., 1991), but during the limited experience with the artifact there were none to speak of. It is a fact, however, that the participants were generally invited and agreed to come, instead of being ordered by a superior. Also the kind of special setting and facilitation probably put everyone on their best behavior.

The observation (Papers 4-6) that the intuitive-logical IDEAS process is tied to the participants' views is hardly a revelation when one thinks critically about the properties and processes of the methods. However, it is the kind of note that seems to be rarely written down. As noted in the later publications (paper 6), it seems that the foresight methods, whatever they may be, are often rather indiscriminately offered as a kind of panaceas for foresight, or it is implicitly assumed that the users can judge the suitability of a method to a given situation by the description. However, it is the author's belief that more explicit discussion on this vein would improve the transparency of foresight and thus would lend more scientific credential and credibility to foresight studies, and foremost help the lay person and practitioners starting off in the field. The situation is analogous to for example the (engineering) design field, where it is commonly thought that explicit design methodologies are less needed by experts than lay persons and beginners in the craft (Piirainen et al., 2010b).

The timeline for the scenario process is another matter, the test sessions were one workday or less each, and the phases that were accomplished were mainly identification of the drivers of change, composition of preliminary scenarios, and evaluation to some extent, but that can be considered as the absolute minimum time and tasks to gather data for meaningful scenarios. Also the feedback for the test sessions and cases indicated that the participants felt rushed and would have liked to spend more time with the issues. Thinking of the process phases, a natural division would be three sessions, firstly identifying the drivers and constructing a driver map, secondly ideating the events based on the drivers and creating basic scenario logics, and thirdly reviewing and evaluating the results when the scenario maps are ready. In this enhanced process it would be potentially beneficial to devote some time to discussing the main assumptions on which the then current lifestyle or business builds on. Ketonen (2009) reminds that these most crucial assumptions are often not necessarily recognized, or people do not want to challenge them seriously, while foresight, such as scenarios, are prone to fail if they do not specifically address the issues that have the most impact on the *status quo*.

It has also been written that the need for foresight is underlined in capital-intensive industries because the planning horizons are long and thus forecasting is hard. The logic is sound, but the argument may seem to be that foresight is needed only in slow moving industries. Glenn (2009), however, remarks quite insightfully that the faster you drive, the better headlights you need. Following this line of reasoning, foresight is equally important in fast moving industries, although for different reasons. Namely when the competitive landscape moves fast, foresight can ‘buy some time’ to react by enabling mental rehearsal for different contingencies. Scenarios can also act together with other tools, like following weak signals or business intelligence to make a vivid picture of plausible futures, and help choosing a path to follow into the future.

5.4 Limitations, Validity and Reliability

There are three main limitations to this work. First, when we position the research design to McGrath’s (1981) three-horned dilemma, we see that the research design of the study has optimized the precision of measurement in the experimental setting on one hand, and realistic context in CSR on the other, which leaves us “impaled” by the third horn of generalizability. As discussed by Lee and Baskerville (2003), generalizability is determined by how representative a sampling or cases within a population one can gather. While the study has not tapped into any particular industry or organization very deeply, the DT has worked quite well and consistently in a variety of situations with people with various experiences. The test subjects in the first trials were students of industrial management, the first case was a public educational organization, and the last one was a pure MoT case with representatives from the concerned industries and industry experts from educational organizations. However, I have discussed the justification knowledge and principles of form and function at a rather general level within organizational strategy and technology management fields, so conceptually the results are not especially limited. Now, while the design in the traditional sense is on the weak side, it may prove to be a strength, as the evaluation has given some ground to suggest that the DT can be successfully instantiated in a variety of organizations and contexts, as the findings are quite consistent and thus reliable between the instantiation and with the justification knowledge. What is common between most of the cases and test subjects is an academic background and in the case tests various industry and administrative experience.

The second limitation is associated with the previous ones, as the evaluation of the artifact and DT in this study is mostly associated with its usability and utility in terms of its effectiveness in composing scenarios, its user experience, and ability to produce results. However, the output of the artifact, the scenarios, is not validated in depth. Only in the second case and in the positioning of the contribution, I have self-evaluated the scenarios superficially, and, while attached to empirics especially in paper 4, the comparison is self-evaluated and self-reported, which sheds a shadow of doubt over the results in the eyes of a critical reader. This leaves trust to and validity of the scenarios from the participants’ point of view open. Another related point is that he sustained performance of the DT or the scenarios has not been measured, as there are no longitudinal data.

From a more technical viewpoint, to return to the ontology, the study has mostly evaluated the artifact in terms of how it is reflected in the inner world of the users, that is, the data on the process and on the results are mostly perceptional. While I argued that satisfaction and acceptance are important for adoption, the performance of the instantiated artifact in the real world is important for the utility of the design. To use different wording, the instruments measure the inner worlds of the participants, i.e. they are perceptional, and thus they do not accurately tell about the actual performance in the immutable world. This is a common positivist criticism against pragmatist or instrumentalist science, and cannot be resolved on the spot, but would require further research into the validity of the scenarios and their impact on the organization. Nevertheless, in terms of the epistemology, the study has succeeded, as I have created a proposition, the DT, acting on which creates an artifact that is useful in creating scenarios. In these terms and by the criteria set by the pragmatist conception of truth I discussed in the research design, the study contributes to scientific knowledge.

The third limitation is evaluation or validation in terms of levels of analysis. The guiding question of the study has been that can the scenario method and process produce scenarios effective and efficiently, which has ruled out considerations of what happens to the scenarios after they are ready. The literature proposes that the scenario process in the wide meaning can be a beneficial venue for learning, and it can support strategic flexibility in the organization, and so on. While some of the results of the study lend some support to the propositions that the participants learn in the process, we can not make definitive conclusions on that aspect of the DT.

With these limitations outspoken, I have discussed that in the adopted philosophical framework, a proposition is true if acting upon it reliably produces the proposed result and it is useful. Despite the shortcomings of the design and data, I argue that the DT has reliably instantiated the artifact which follows the principles of form and function with reasonable fidelity, and the instantiated artifact has been proven useful in creating scenarios that fulfill the basic quality criteria. Validity is raised by the observation that the findings are largely consistent with the existing literature, e.g. Hodgkinson and Healey (2008).

5.5 Further Research

The limitations of this research give ample ground for further empirical research in scenario planning with and without electronic mediation. We can start the propositions for further research by recapitulating the limitations of the current study, by proposing more rigorous evaluation in different contexts. I propose that beside this extended proof of concept or demonstration, the DT could be soundly tested by gathering a sample of experts and practitioners and splitting the group to three to four samples, and treating one group to a GSS-supported instantiation of the DT, another to a manual pen-and-paper instantiation, one to a different scenario method, and leaving the fourth group as an untreated control group. The design could be further enhanced by using the control group or a separate fifth group of the sample to blindly evaluate the scenarios from each session. This design would enable testing whether the DT creates scenarios that appear valid for experts, whether it is comparable to an equivalent state-of-the-art treatment, and whether the GSS gives an additional advantage.

However, refining the experimental design can give us more information about the treatment, but not necessarily about how it generally works in the wider population, and very little about how it would work in a real environment. Thus, what really deserves further attention are the questions of what happens to the scenarios when they are ready, and how the learning potential from the scenario process can be maximized not only to create scenarios as a forecast, but to have a tangible impact to the mental models of the managers. It is easy to lose sight of the fact that no matter how good the method is in a controlled trial, it is effectively useless if the practitioners do not want to use the method or the results it offers.

This discussion winds to the strand of literature that has proposed that a scenario process is a process of learning in some way or the other, proposed by practitioners and authors, such as Day and Schoemaker (2006), Chermack (2004) and Wright et al. (2009). The learning perspective has followed the discussion around the IDEAS method since the first publication (Paper 1). The idea of creating or combining and disseminating knowledge in a scenario process has been following the IDEAS method during the arc of the development. Kivijärvi et al. (2010b) have examined the proposition and suggest that scenarios in the broad sense can be a process of learning, and following from that, scenarios are also knowledge artifacts as products of a learning process, and they are further representations of the current knowledge, assumptions and attitudes of the participants of the process. This opens new directions for research, as the examination of scenarios made by someone provides a window to the inner world of that someone. As such, scenarios could be used in new and unorthodox ways, for example as a source for examining customer needs and attitudes, given a method that is fast and easy to operate.

Another interesting and important perspective to the scenario method is to look at the scenarios as forecasts. At best, using a GSS should raise not only the participants' satisfaction to the scenarios, but the plausibility of the scenarios. A conceivable mechanism, suggested by the data from the second case (Paper 3), would be that the fluent and innovative process would enable all participants to contribute their best knowledge and dispassionately and objectively evaluate the others' input, which would result in a better assessment of the situation and thus better foresight. Whether this is true, we do not know as yet, but we could get some indication through assessment of the scenario quality and longitudinal study.

The data from the present study quite consistently show that while the satisfaction to the method and results was generally good, the participants would have wanted more control over the scenario logic. While the data was collected by and from a group of professionals and experts, the final themes of the scenarios and the interface with the drivers was largely dependent on the author(-s) of the scenarios. While this feature is quite common in the main stream of scenario planning (see e.g. Bishop et al., 2007; Schwartz, 1996), and it can not necessarily be counted as a fault as such, neither does it take the full advantage of the expert panel. At some point I regarded it as a flaw in the scenario heuristic, but it might just as well be a flaw of the tools, which do not enable gathering causal data in an effective enough manner. Based on the literature I have discussed, and our own observations, the buy-in to the scenarios would be higher and the learning potential greater if it was possible to engage the group to form and evaluate the scenario logics, say, through collaborative mapping, either with proprietary software tools such as Banxia Decision Explorer (Eden and Ackerman, 1999; Ackerman and Eden, 2005), or just a general purpose GSS. Basically causal maps can be formed to an $n \times n$ – matrix where column and row headings are the constructs of the map, and each element represents the strength of relation between the constructs (Markóczy and Goldberg, 1995). Using a general GSS one could place the events or drivers in a voting tool and ask the participants to evaluate "will A affect B" or "will A lead to B" for each of the pairs. The results could be placed to a matrix where each element of the matrix tells whether there is causal link and, depending on the voting scale, possibly the strength for the causality. In an $n \times n$ matrix non-zero entries below the main diagonal would then give links from A to B, and the entries above main diagonal *vice versa*, and zero entries could be interpreted as no relation. Another, less technical, way could be using the technique Hannola et al. (2009) used while studying cognitive maps. They used simple office software to successfully synthesize multiple cognitive maps, and the same technique could be just as well implemented to gather driver and scenario maps from the participants either during or after the session.

Speaking of the other tools, an issue that was scarcely discussed is facilitation and its effect on the results. The evaluation of the DT was based on sessions facilitated according to local best practices with quite intuitive planning. While the instantiations worked well, the importance of consistent and well planned facilitation is well known in GSS research, ant the effects of small changes to facilitation scripts are well recognized (e.g. Grohowski et al., 1990; Anson et al., 1995; Griffith et al., 1998). To enable getting consistently good results in the future, developing and refining a working and transferable facilitation script is imperative. Here I would like to point toward the collaboration engineering literature (e.g. Briggs et al., 2003b; Kolfschoten and de Vreede, 2007). The mission of collaboration engineering is to provide tools for making transferable and consistent facilitation interventions, which enable transferring practices and group processes and getting consistent results. The main tool of collaboration engineering is the ThinkLet-pattern language (e.g. Briggs and de Vreede, 2009) that enables codification and transfer of collaborative work practices. Collaboration engineering could potentially lend a hand in making operationalization of the DT in different contexts easier, or at least facilitate transferring the instantiations between cases.

Related to facilitation, the papers circled around the issue of using a GSS to support scenarios over geographical or time distance. The issue is also related to the discussion about splitting the process over a number of workshops, when using distributed and/or asynchronous GSS to support the session could make the process easier to organize for all. These settings are harder to test and possibly more challenging to facilitate, because the facilitator has significantly less control over the group process and the discussion, but the promise of added value to the scenario process is that sedimenting the GSS or EMS to the everyday workflow would first of all bring the scenario process to the workflow as well. The discussion presented by Tung and Turban (1998) suggests that stretching the process over time might enable more profound discussion over the items and give the participants time to think about the issues, while it also could dilute the process and lower the motivation to participate. The dispersed and asynchronous option is a double-edged sword; it may prove to be effective, but to also do more harm that help. This is probably an issue of trust and motivation, and incentives. The advantages of asynchronous and/or decentralized sessions are not indisputable, but there are propositions that with asynchronous setting the substance of interaction gains depth, as people are more able to reflect on the theme and the input of others, resulting in better decisions (Benbunan-Fich et al., 2002). Similarly, the question of decentralized participation arises with the above discussed demand for including external interest groups and experts in the scenario process; it would seem feasible to have an efficient virtual or decentralized session with GSS mediation, the main concern being motivation and team cohesion of the participants (Huang et al., 2002). In addition, on the basis of the above, a hypothesis could be set that GSS would lower the transaction costs in acquiring knowledge, i.e. in the form of lessened time consumption and travel expenses.

Taking the point about virtual participation and the relationship with the GSS and scenario quality together, they relate easily with the idea of ‘Wisdom of Crowds’ (Surowiecki, 2005). This opens up a new direction for research on the substance level as well. The proposition is that aggregation of opinions or judgment gathered from large samples of people ($n > \sim 200$ or in the neighborhood) who are independent, with diverse backgrounds and decentralized are as apt in estimating or forecasting things as the best experts, because the randomization of the sample together with large number of cases will average the error out of the estimate. The potential added value is that that engaging a large number of people through virtual participation would enable getting estimates as good as the best experts could give, while reducing the risk of sampling bias and error, not to mention the less tangible benefit of giving the participants the empowering experience of being able to participate in a large scale foresight project.

6 CONCLUSIONS

The speed of technological development and the ensuing uncertainty hardly needs repeating at this point and after the preceding discussion. Scenario planning, among other methods, can address this issue by building foresight to the possible developments of the future and by developing awareness of the key uncertainties that lay ahead in the path of the organization. The research mission in this thesis was to support strategic technology management by designing an effective and efficient scenario method. The specific purpose in this thesis was to design a scenario method for strategic technology management, addressing the critique toward existing methods, and to execute the design and evaluation in a transparent and explicit manner to make the method more accessible and enable critical appraisal of the results.

I assumed the design science framework to structure the effort to design and evaluate the design theory for the IDEAS method. After reviewing existing literature for justification knowledge, I forged the principles of form and function for the specified scenario method. The design follows a generic scenario process, with proven impact-based scenario heuristic originally designed by Blanning and Reinig (1998; 2002; 2005), and includes elements from the tradition that leans on causal mapping (Ward and Schriefer, 1998; Eden and Ackerman, 1999) when it comes to forming the final scenarios. This DT as a whole was evaluated through laboratory tests and case studies. The response of the test subjects to the method was generally good, and the method was useful in creating scenarios. Thus I propose that the "quality, utility and efficacy" (Hevner et al., 2004) of the design, the IDEAS method, was reasonably demonstrated. Further, I propose that the DT was demonstrated to be valid as it instantiated reliably, and the instantiated artifacts proved to be useful and viable way to produce plausible scenarios in various organizational contexts. The method I propose falls into the intuitive logical variety and has been purposefully designed to be easy enough to be followed by a layperson given the tools.

Through this process, the study has answered the research questions gradually by first discussing the business needs for and challenges of scenario planning, and developing a DT that contributes to the state-or-the-art of scenario planning. The business needs and challenges were in short that the scenario method needs to be accessible and people should be able to contribute to the process easily (RQ1). To respond to these challenges, a scenario method that uses GSS, mapping tools and clustering was designed to enhance the effectiveness process and make the scenarios more approachable (RQ2). The transparent reporting of the design gives the necessary guidelines to implement the design and the discussions underlines the contribution to the state of the art (RQ3).

While considering the contribution of the study, we can revisit the criteria for DSR as discussed in the second section (p. 22). Hevner et al. (2004) propose in short that good DSR contributes to practice and existing knowledge by designing solutions to novel problems and evaluating them rigorously. In this thesis I have additionally leaned on the DT framework (Gregor and Jones, 2007; Walls et al., 1992) to outline how the artifact is built and how it possibly contributes. To start with the criteria, the study has produced a technology-based artifact to solve a business problem, which was proven viable by the expository instantiation in the two cases. The relevance of the artifact to a business problem was argued through literature in the third chapter. The utility, quality and efficacy of the artifact were demonstrated through testing and later case studies. The construction of the artifact was rigorously documented first as justification knowledge, as well as principles of form and function on the general level, and later through the description and evaluation of the instantiations. Thus I propose that the thesis contributes both to practice and foundation of the design. Here the DT bridges the contribution as it describes the general class of problems and the theoretical proposition of how to solve the problems, while it enables the creation of a practical artifact. Finally I have presented the results to a wide audience through this thesis and the enclosed publications.

The main contribution of this research is in fact threefold. The first and most obvious is the DT, the IDEAS scenario method, which contributes to the state-of-the-art in scenario planning by offering an effective and accessible method for resource-constrained applications. While the main contribution, the IDEAS method, is mostly practical, the study contributes to the knowledge base, so to speak, in two ways. Firstly the meta-design, the generic scenario process is a contribution to the literature and practice of scenario planning, and can be used as a template to design scenario methods with different heuristics and tools. Secondly, I expect to have contributed to the discussion on scenario planning by raising the bar for more evidence-based and transparent practice, as proposed by e.g. Hodgkinson and Healey (2008). The discussion on the justification knowledge and principles of form and function aimed at enabling replication of the instantiation and results, and positioning of the artifact to existing literature. Thirdly, I present a novel synthesis of DSR literature, explicitly positioning the DT in the DSR framework.

While I confidently proposed that the evaluation supports the validity of the DT as the data clearly supported its feasibility, I recognize that due to the limitations in the research design, full validation would require more testing. Besides that, this research has highlighted a few areas of further research I would like to mention. The main dimensions are refining the method and tools, and concentrating on the effect of the scenario process on the organization, as also suggested in prior literature (e.g. Chermack, 2004). Regarding the first dimension, the method could benefit from more discussion time, and thus the process could be split to multiple workshops instead of the one used for evaluation. Another issue would be finding tools to support the process over time and possibly over different places to enable participation as fluently as possible. The discussion about the benefits and success criteria for the scenario process highlighted the question of what happens to the scenarios when they are ready; how to maximize the benefit of the scenario (reports)-s and the process in an organization.

To summarize, my intention from the start was to offer IDEAS for strategic technology management. Reviewing this research, I am confident that the IDEAS method proves to be useful for practicing managers. I also hope I can encourage further research in scenario planning in the same vein, to improve the applicability and transparency of futures study methods to managerial problems.

REFERENCES

Ackermann, F., Eden, C. 2005. Using Causal Mapping with Group Support Systems to Elicit an Understanding of Failure in Complex Projects: Some Implications for Organizational Research, *Group Decision and Negotiation*, Vol. 14, pp. 355-376.

Adkins, M., Burgoon, M., Nunamaker, J. F. Jr. 2002. Using group support systems for strategic planning with the United States Air Force, *Decision Support Systems*, Vol. 34, pp. 315-337.

Aiken, M., Hawley, D., Zhang, W. 1994. Increasing Meeting Efficiency with a GDSS, *Industrial Management & Data Systems*, Vol. 94, pp. 13-16.

Amit, R., Schoemaker, P.J.H. 1993. Strategic Assets and Organizational Rent, *Strategic Management Journal*, Vol. 14, No. 1, pp. 33-46.

Anson, R., Bostrom, R., Wynne, B. 1995. An Experiment Assessing Group Support System and Facilitator Effects on Meeting Outcomes, *Management Science*, Vol. 41, No. 2, pp. 189-208.

Arcade, J., Godet, M., Meunier, F., Roubelat F. 2009. *Structural Analysis with the MICMAC method and Actors' Strategies with the MACTOR method* [CD-ROM], in Glenn, J.C., Gordon T.J. (eds.) The Millennium Project Futures Research Methodology Version 3.0, AC/UNU Millennium Project.

Arend, R.J. 2003. Revisiting the Logical and Research Considerations of Competitive Advantage, *Strategic Management Journal*, Vol. 24, pp. 279-284.

Armstrong, D.J. 2005. *Causal Mapping: A Discussion and Demonstration*, in Narayan, V.K., Armstrong, D.J. (eds.) Causal Mapping for Research in Information Technology, pp. 20-45, IGI Global, Hershey, PA.

Balci, O. 2009. A Life Cycle for Modeling and Simulation, in the Proceedings of the International Workshop on Enterprise & Organizational Modeling and Simulation EOMAS 2009, Amsterdam, NL.

Barney, J.B., 1991. Firm Resources and Sustained Competitive Advantage, *Journal of Management*, Vol. 17, No. 1, pp. 99-120.

Baskerville, R. Wood-Harper, A.T. 1998. Diversity in information systems action research methods, *European Journal of Information Systems*, Vol. 7, No. 2, pp. 90-107.

Benbasat, I., Goldstein, D.K., Mead, M. 1987. The Case Research Strategy in Studies of Information Systems, *MIS Quarterly*, Vol. 11, No. 3, pp. 369-386.

Benbunan-Fich, R., Hiltz S.R., Turoff, M. 2002. A comparative content analysis of face to face vs. asynchronous group decision making, *Decision Support Systems*, Vol. 38, pp. 457-469

Bergman, J.-P. 2005. *Supporting Knowledge Creation and Sharing in the Early Phases of the Strategic Innovation Process*, Acta Universitatis Lappeenrantaesis 212, Lappeenranta University of Technology, Lappeenranta.

Bishop, P., Hines, A., Collins, T. 2007. The current state of scenario development: an overview of techniques, *foresight*, Vol. 9, No. 1, pp. 5-25.

Blanning, R.W., Reinig, B.A. 1998. Building Scenarios for Honk Kong Using EMS, *Long Range Planning*, Vol. 31, No. 6, pp. 900-910.

Blanning, R.W., Reinig, B.A. 2002. Political Event Analysis Using Group Support Systems, *Technological Forecasting & Social Change*, Vol. 69, pp. 153-172.

Blanning R.W., Reinig, B.A. 2005. A Framework for Conducting Political Event Analysis Using Group Support Systems, *Decision Support Systems*, Vol. 38, pp. 511-527.

Bradfield, R., Wright, G., Burt, G., Cairns, G., van der Heijden, K. 2005. The origins and evolution of scenario techniques in long range business planning, *Futures*, Vol. 37, pp. 795-812.

Bragge, J., Merisalo-Rantanen, H. 2008. Engineering E-Collaboration Processes to Obtain Innovative End-User Feedback on Advanced Web-Based Information Systems, *Journal of the Association for Information Systems*, Vol. 19, pp. 196-220.

Briggs, R.O., de Vreede G.-J., Reinig, B.A. 2003a. A Theory and Measurement of Meeting Satisfaction, in the Proceedings of 36th Hawaii International Conference on System Sciences, Waikoloa HI.

Briggs, R. O., de Vreede, G.-J., Nunamaker, J. F. Jr., 2003b. Collaboration Engineering with ThinkLets to Pursue Sustained Success with Group support systems, *Journal of Management Information Systems*, Vol. 19, No. 4, pp. 31-64.

Briggs, R.O., de Vreede, G.-J. 2009. *ThinkLets: Building Blocks for Concerted Collaboration*, Briggs and de Vreede, Omaha NE, through Lulu.com, Morrisville NC.

Burt, G., Wright, G., Bradfield, R., Cairns, G., van der Heijden, K. 2006. The Role of Scenario Planning in Exploring the Environment in View of the Limitations of PEST and Its Derivatives, *International Studies of Management & Organization*, Vol 36, No. 3, pp. 50-76.

Börjeson, L., Höjer, M., Dreborg, K.-H., Ekvall, T., Finnveden, G. 2006. Scenario Types and Techniques: Towards a User's Guide, *Futures*, Vol. 38, pp. 723-739.

Campbell, D.T., Stanley, J.C. 1966. *Experimental and Quasi-experimental Designs for Research*, Houhgton Mifflin, Boston MA.

Cepeda, G., Vera, D. 2007. Dynamic capabilities and operational capabilities: a knowledge management perspective, *Journal of Business Research*, Vol. 60, Issue 5, pp. 426–437.

Chermack, T.J. 2004. Improving decision-making with scenario planning, *Futures*, Vol. 36, pp. 295-309.

Chermack, T.J., Lynham, S.A., Ruona, W.E. 2001. A Review of Scenario Planning Literature, *Futures Research Quarterly*, Summer 2001, pp. 7-32.

Coase, R. 1937. The Nature of the Firm, *Economica*, Vol. 4, pp. 386-405.

Cohen, W.M., Levinthal, D.A. 1990. Absorptive Capacity: A new Perspective on Learning and Innovation, *Administrative Science Quarterly*, Vol. 35, pp. 128-152.

Courtney, H. 2003. Decision-driven scenarios to assess four levels of uncertainty, *Strategy & Leadership*, Vol. 31, No. 1, pp. 14-22.

Coyle, G. 1997. The nature and value of futures studies or do futures have a future?, *Futures*, Vol. 29, No. 1, pp. 77-93.

Coyle, G. 2004. *Practical Strategy: Structured Tools and Techniques*, Pearson Education Ltd., Glasgow.

Coyle, G. 2009. *Field Anomaly Relaxation (FAR)* [CD-ROM], in Glenn, J.C., Gordon, T.J. (eds.) The Millennium Project Futures Research Methodology Version 3.0, AC/UNU Millennium Project.

Danneels, E. 2008. Organizational antecedents of second-order competences, *Strategic Management Journal*, Vol. 29, Issue 5, pp. 519–543.

Davison, R.M., Martinsons, M.G., Kock, N. 2004. Principles of Canonical Action Research, *Info Systems Journal*, Vol. 14, pp. 65-86.

Day, G.S., Schoemaker, P.J.H. 2006. *Peripheral Vision: Detecting the Weak Signals That Will Make or Break Your Company*, Harvard Business School Press, Boston MA.

Dennis, A.R., Garfield, M.J. 2003. The Adoption and Use of GSS in Project Teams: Toward More Participative Processes and Outcomes, *MIS Quarterly*, Vol. 27, No. 2, pp. 289-323.

Dennis, A.R., George, J.F., Jessup, L.M., Nunamaker, J.F. Jr., Vogel, D.R. 1989. Information Technology to Support Electronic Meetings, *MIS Quarterly*, Dec 1988, pp. 591-624.

Dennis, A. R., Tyran, C.K., Vogel, D.R., Nunamaker, J.F. Jr. 1997. Group Support Systems for Strategic Planning, *Journal of Management Information Systems*, Vol. 14, No. 1, pp. 155-184.

Dennis, A.R., Valacich, J.S. 1993. Computer Brainstorms: More heads are better than one, *Journal of Applied Psychology*, Vol. 78, No. 4, pp. 531-537.

Dennis, A.R., Williams, M.L. 2003. *Electronic Brainstorming: Theory, Research and Future Directions*, in Paulus, P.B., Nijstrand, B.A. (eds.) Group Creativity: Innovation Through Collaboration, pp. 160-176, Oxford University Press, New York NY.

Dierickx, I., Cool, K. 1989. Asset Stock Accumulation and Sustainability of Competitive Advantage, *Management Science*, Vol. 35, No. 12, pp. 1504-1511.

Doz, Y., Kosonen, M. 2008. *Fast Strategy: How Strategic Agility Will Help You Stay Ahead of the Game*, Wharton School Publishing imprint, Pearson Education Ltd., Harlow.

Dubin, R. 1978. *Theory development*, The Free Press, New York NY.

Eden, C., Ackermann, F. 1999. *The Role of GDSS in Scenario Development and Strategy Making*, in the Proceedings of String Processing and Information Retrieval Symposium and International Workshop on Groupware, pp. 234-242.

Eisenhardt, K.M. 1989. Building Theories from Case Study Research, *The Academy of Management Review*, Vol. 14, No. 4, pp. 532-550.

Eisenhardt, K.M., Martin, J. A. 2000. Dynamic Capabilities: What are they?, *Strategic Management Journal*, Vol. 21, pp. 1105-1121.

Elfvengren, K., Kärkkäinen, H., Torkkeli, M., Tuominen, M. 2004. A GDSS based approach for the assessment of customer needs in industrial markets, *International Journal of Production Economics*, Vol. 89, pp. 275-292.

Ellonen, H.-K., Wikström, P., Jantunen, A. 2009. Linking dynamic-capability portfolios and innovation outcomes, *Technovation*, Vol. 29, No. 11, pp. 753-762.

Everitt, B. S., Landau, S., Leese, M. 2001. *Cluster Analysis*, 4th ed., Hodder-Arnold, London.

Fiol, C.M., Huff, A.S. 1992. Maps for Managers: Where Are We? Where Do We Go from Here?, *Journal of Management Studies*, Vol. 29, No. 3, pp. 267-285.

Fjermestad, J., Hiltz, S. R. 1999. An Assessment of Group Support Systems Research: Results, in the Proceedings of the 32nd Hawaii International Conference on System Sciences, Maui HI.

Fjermestad, J., Hiltz, S.R. 2000. Group support systems: A descriptive evaluation of group support systems case and field studies. *Journal of Management Information Systems*, Vol. 17, No. 3, pp. 115–159.

Flowers, B. S. 2003. The art and strategy of scenario writing, *Strategy & Leadership*, Vol. 31, Issue 2, pp. 29-33.

Foss, N. J. 2005. *Strategy, Economic Organization, and the Knowledge Economy: The coordination of Firms and Resources*, Oxford University Press, Oxford.

Garavelli, A.C., Gorgoglione, M., Scozzi, B. 2002. Managing knowledge transfer by knowledge technologies, *Technovation*, Vol. 22, No. 5, pp. 269-279.

Gerring, J. 2004. What Is a Case Study and What Is It Good for?, *The American Political Review*, Vol. 98, No. 2, pp. 341-354.

Gessner, S., McNeilly, M., Leskee, B. 1994. Using Electronic Meeting Systems for Collaborative Planning at IBM Rochester, *Planning Review*, Vol. 22, No. 1, pp. 34-39.

Glenn J.C. 2009. *Introduction to Futures Research* [CD-ROM], in Glenn J.C., Gordon T.J. (eds.) The Millennium Project Futures Research Methodology Version 3.0, AC/UNU Millennium Project.

Goddard, J. 1997. The Architecture of Core Competence, *Business Strategy Review*, Vol. 8, No. 1, pp. 43-52.

Godet, M. 1993. *From anticipation to action: a handbook of strategic prospective*, UNESCO Publishing, Paris.

Godet, M. 2000. The Art of Scenarios and Strategic Planning: Tools and Pitfalls, *Technological Forecasting and Social Change*, Vol. 65, pp. 3-22.

Godet M., Roubelat, F. 1996. Creating the Future: The Use and Misuse of Scenarios, *Long Range Planning*, Vol. 29, No. 2, pp. 164-171.

Gonzalez, R., Dahanayake, A. 2007. A Concept Map of Information Systems Research Approaches, in the Proceedings of the 2007 IRMA International Conference, Vancouver.

Goodier, C., Austin, S., Soetano, R., Dainty, A. 2010. Causal mapping and scenario building with multiple organizations, *Futures*, Vol. 42, pp. 219-229.

Goodman, R., 2008. *William James* [www-document], in Zalta, E.N. (ed.) The Stanford Encyclopedia of Philosophy (Fall 2008 Edition), [Accessed 14.7.2009]. Available from: <http://plato.stanford.edu/archives/fall2008/entries/james/>.

Gregor, S. 2006. The Nature of Theory in Information Systems, *MIS Quarterly*, Vol. 30, No. 3, pp. 611-642.

Gregor, S., Jones, D. 2007. The Anatomy of Design Theory, *Journal of the Association for Information Systems*, Vol. 8, No. 5, pp. 312-335.

Griffith, T.L., Fuller, M.A., Northtcraft, G.B. 1998. Facilitator Influence in Group Support Systems: Intended and Unintended Effects, *Information Systems Research*, Vol. 9, No. 1, pp. 20-36.

Grohowski, R., McGoff, C., Vogel, D., Martz, B., Nunamaker, J. 1990. Implementing Electronic Meeting Systems at IBM: Lessons Learned and Success Factors, *MIS Quarterly*, Dec. 1990, pp. 369-383.

Hannola, L., Kortelainen, S., Kärkkäinen, H., Tuominen, M. 2009. Utilizing front-end-of-innovation concepts in software development, *Industrial Management & Data Systems*, Vol. 109, No. 7, pp. 898-915.

Herakleitos. 2010. quote [www-document], Wikiquotes [Accessed 14.3.2010]. Available from: <http://en.wikiquote.org/w/index.php?title=Heraclitus&oldid=1078379>.

Hevner, A.R. 2007. A Three Cycle View of Design Science Research, *Scandinavian Journal of Information Systems*, Vol. 19, No. 2, pp. 39-64.

Hevner, A.R., Ram, S., March, S.T., Park, J. 2004. Design Science in Information Systems Research, *MIS Quarterly*, Vol. 28, No. 1, pp. 75-105.

Hodgkinson, G.P., Healey, M.P. 2008. Toward a (Pragmatic) Science of Strategic Intervention: Design Propositions for Scenario Planning, Organization Studies, Vol. 29, No. 3, pp. 437-457.

Howick, S., Ackermann, F., Andersen, D. 2006. Linking event thinking with structural thinking: methods to improve client value in projects, *Systems Dynamics Review*, Vol. 22, No. 2, pp. 113-140.

Huang, W.W., Wei, K.-K., Watson, R.T., Tan, B.C.Y. 2002. Supporting virtual team-building with a GSS: an empirical investigation, *Decision Support Systems*, Vol. 34, pp. 359-367.

Iivari, J. 2007. A Paradigmatic Analysis of Information Systems as a Design Science, *Scandinavian Journal of Information Systems*, Vol. 19, No. 2, pp. 39-64.

Jack, E. P., Raturi, A. S. 2006. Lessons learned from methodological triangulation in management research, *Management Research News*, Vol. 29, No. 6, pp. 345-357.

James, W. 1955. *Pragmatism and Four Essays from the Meaning of Truth*, New American Library, New York NY.

James, W. 1995. *Pragmatism*, Dover Thrift Editions, Dover Publications, New York NY.

Javidan, M. 1998. Core Competence: What Does it Mean in Practice?, *Long Range Planning*, Vol. 31, No. 1, pp. 60-71.

Johnson G., Scholes, K. 2002. *Exploring Corporate Strategy*, Pearson Education Ltd., Glasgow.

Johnston, W.J., Leach, M.P., Liu, A.H. 1999. Theory Testing Using Case Studies in Business-to-Business Research, *Industrial Marketing Management*, Vol. 28, pp. 201-213.

Jönsson, S., Lukka, K. 2007. *There and Back Again: Doing Interventionist Research in Management Accounting*, in Chapman, C.S., Hopwood, A.G., Shields, H.G. (eds.) Handbook of Management Accounting Research, Elsevier, Kidlington, pp. 373-397.

Kahn H., Wiener, A. J. 1967. *The Year 2000: A Framework for Speculation on the Next Thirty-Three Years*, Collier-Macmillan Limited, New York NY.

Kasanen, E., Lukka, K., Siitonen, A. 1991. Konstruktiivinen tutkimusote liiketaloustieteessä (The Constructive Research Approach in Business Administration) (in Finnish), *Liiketaloudellinen Aikakauskirja - The Finnish Journal of Business Economics*, No. 3, pp. 301-329.

Kasanen, E.O., Lukka, K. Siitonen, A. 1993. The Constructive Approach in Management Accounting Research, *Journal of Management Accounting Research*, Vol. 5, pp. 243-264.

Keen, P.G.W., Sol, H.G. 2008. *Decision Enhancement Services: Rehearsing the Future for Decisions That Matter*, Delft University Press imprint, IOS Press, Amsterdam.

Ketchen, D.J., Shook, C.L. 1996. The Application of Cluster Analysis in Strategic Management Research: An Analysis and Critique, *Strategic Management Journal*, Vol. 17, pp. 441-458.

Ketonen, O. 2009. Knowing about the Future, *Futura*, 1/2009, pp. 28-35.

Kitchenham, B., Pickard, L., Pfleeger, S.L., 1995. Case Studies for Method and Tool Evaluation, *IEEE Software*, July 1995, pp. 52-62.

Kivijärvi, H., Piirainen, K., Tuominen M. 2010a. Sustaining organizational innovativeness: Advancing knowledge sharing during the scenario process, *International Journal of Knowledge Management*, Vol. 6, No. 2, pp. 22-39.

Kivijärvi, H., Piirainen, K., Tuominen M. 2010b. Scenario Process as a Community for Organizational Knowledge Creation and Sharing, Communications in Computer and Information Science (CCIS), Springer Verlag, Heidelberg. –in press

Kivijärvi, H., Piirainen, K., Tuominen, M., Kortelainen, S., Elfvengren, K. 2008. *A Support System for the Strategic Scenario Process*, in Adam, F., Humphreys P. (eds.) Encyclopedia of Decision Making and Decision Support Technologies, IGI Global, Hershey PA, pp. 822-836.

Kleijnen, J.P.C. 1995. Verification and Validation of Simulation Models, *European Journal of Operational Research*, Vol. 82, pp. 145-162.

Kleindorfer, G.B., O'Neill, L., Gnaeshan, R. 1998. Validation in Simulation: Various Positions in the Philosophy of Science, *Management Science*, Vol. 44, No. 8, pp.1087-1100.

Kogut, B., Zander, U. 1992. Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology, *Organization Science*, Vol. 3, No. 5, pp. 383-397.

Kokkonen, V. Kuuva, M. Leppimäki, S. Lähteinen, V. Meristö, T. Piira, S., Sääskilahti, M. 2005. *Visioiva tuotekonseptointi: Työkalu tutkimus- ja kehitystoiminnan ohjaamiseen, (Vision-driven product concept development)*, Teknologiateollisuuden julkaisuja 4/2005, Teknologiateollisuus ry., Helsinki. (in Finnish)

Kokkonen, K, Piirainen, K., Kässi, T. 2008. E-business opportunities in the Finnish forest sector – a multi-method scenario study, in the Proceedings of XVIII International Conference of International Society for Professional Innovation Management (ISPIM), Tours.

Kolfschoten, G. L., de Vreede, G.-J. 2007. *The Collaboration Engineering Approach for Designing Collaboration Processes*, in Haake, J.M., Ochoa, S.F., Cechich A. (Eds.) the Proceeding of the 13th International Workshop in Groupware: Design, Implementation and Use: CRIWG 2007, Springer Verlag, Heidelberg, pp. 95–110.

Kwok R.C.W., Khalifa, M. 1998. Effect of GSS on Knowledge Acquisition, *Information & Management*, Vol. 34, pp. 307-315.

Lamberg, J.-A., Parvinen, P. 2003. The River Metaphor for Strategic Management, *European Management Journal*, Vo. 21, No. 5, pp. 549-557.

Laukkanen, M. 1994. Comparative Cause Mapping of Organizational Cognitions, *Organization Science*, Vol. 5, No. 3, pp. 322-343.

Lee, A.S. 1989. A Scientific Methodology for MIS Case Studies, *MIS Quarterly*, Vol. 13, No. 1, pp. 33-50.

Lee, A.S., Baskerville, R.L. 2003. Generalizing Generalizability in Information Systems Research, *Information Systems Research*, Vol. 14, No. 3, pp. 221-243.

Lindholm, A.L. 2008. A constructive study on creating core business relevant CREM strategy and performance measure, *Facilities*, Vol. 20, No. 7/8, pp. 343-358.

Lindqvist, A.L. 2009. *Engendering Group Support Based Foresight for Capital Intensive Industries – Case Paper and Steel Industry Scenarios by 2018*, Acta Universitatis Lappeenrantaesis 364, Lappeenranta University of Technology, Lappeenranta.

Lindqvist, A. Piirainen, K., Tuominen, M. 2008. Utilising group innovation to enhance business foresight for capital-intensive manufacturing industries, in the Proceedings of the 1st ISPIM Innovation Symposium, Singapore.

Lukka, K., Kasanen, E. 1995. The problem of generalizability: anecdotes and evidence in accounting research, *Accounting, Auditing & Accountability Journal*, Vol. 8, Issue 5. pp. 71-90.

Lukka, K. 2003. *The Constructive Research Approach*, in Ojala, L., Hilmola, O.-P. (eds.) Case Study Research in Logistics, Publications of Turku School of Economics and Business Administration, Series B, B1:2003, Turku School of Economics, Turku, pp. 83-120.

March, S. T., Smith, G., 1995. Design and Natural Science Research on Information Technology, *Decision Support Systems*, Vol. 15, No. 4, pp. 251-266.

March, S. T., Storey, V. C. 2008. Design Science in the Information Systems Discipline: An Introduction to the Special Issue on Design Science Research. *MIS Quarterly*, Vol. 32, No. 4, 725-730.

Markóczy, L., Goldberg, J. 1995. A Method for Eliciting and Comparing Causal Maps, *Journal of Management*, Vol. 21, Issue 2, pp. 305-333.

Markus, M. L., Majchrzak, A., Gasser, L. 2002. A Design Theory for Systems That Support Emergent Knowledge Processes, *MIS Quarterly*, Vol. 26, No. 3, pp. 179-212.

McGrath, J.E. 1981. Dilemmatics: The Study of Research Choices and Dilemmas, *American Behavioral Scientist*, Vol. 25, No. 2, pp. 179-210.

McKay, B., McKiernan, P. 2010. Creativity and dysfunction on strategic processes: The case of scenario planning, *Futures*, Vol. 42, pp. 271-281.

method. 2010. definition of "method" [www-document], Merriam-Webster Online Dictionary [Accessed: 3.5.2010]. Available from: <http://www.merriam-webster.com/dictionary/method>.

Miller K.D., Waller, H.G. 2003. Scenarios, Real Options and Integrated Risk management, *Long Range Planning*, Vol. 36, pp. 93-107.

Miller, W.L., Morris, L. 1999. *Fourth Generation R&D: Managing Knowledge, Technology and Innovation*, John Wiley, New York NY.

Millet, S.M. 2003. The future of scenarios: challenges and opportunities, *Strategy & Leadership*, Vol. 31, Issue 2, pp. 16-24.

Mintzberg, H. 1987. The Strategy Concept I: Five Ps for Strategy, *California Management Review*, Vol. 30, Issue 1, pp. 11-14.

Mintzberg, H. 1994. *The rise and fall of strategic planning: reconceiving roles for planning, plans, planners*, The Free Press, New York NY.

Mintzberg, H., Ahlstrand, B., Lampel, J. 1998. *Strategy Safari: A Guided Tour Through the Wilds of Strategic Management*, The Free Press, New York NY.

Moore, G.E. 1960. *A Defence of Common Sense*, in Chrisholm, R.M. (ed.) Realism and Background of Phenomenology, Free Press, Glencoe IL, pp. 255-282.

Narayanan V.K. 2005. *Causal Mapping: An Historical Overview*, in Narayanan V.K., Armstrong, D.J. (eds.) Causal Mapping for Research in Information Technology, IGI Global, Hershey PA, pp. 1-19.

Neilson, R.E., Stouffer, D. 2005. Narrating the Vision: Scenarios in Action, *Futurist*, Vol. 39 Issue 3, pp. 26-30.

Novak, J.D., Cañas, A.J. 2006. *The Theory Underlying Concept Maps and How to Construct Them* [e-document], Technical Report, IHMC CmapTools 2006-01, Florida Institute for Human and Machine Cognition, Pensacola FL [Accessed 16.10.2006]. Available from: <http://cmap.ihmc.us/Publications/ResearchPapers/TheoryUnderlyingConceptMaps.pdf>.

Nunamaker, J. Vogel, D. Heminger, A. Martz, B. Grohowski, R., McGoff, C. 1989. Group Support Systems in Practice: Experience at IBM, in the Proceedings of the 22nd Hawaii International Conference on Systems Sciences, Kailua-Kona HI.

Nunamaker, J.F. Jr., Briggs, R.O., Mittleman, D.D., Vogel, D.G., Balthasard, P.A. 1997. Lessons from a Dozen Years of Group Support Systems Research: A Discussion of Lab and Field Findings, *Journal of Management Information Systems*, Vol. 13, No. 3, pp. 163-207.

Nunamaker, J.F., Dennis, A.R., Valacich, J.S., Vogel, D.G., George, J.F. 1991. Electronic Meeting Systems to Support Group Work, *Communications of the ACM*, Vol. 34, No. 7, pp. 40-61.

O'Brien, F.A. 2004. Scenario Planning – Lessons for Practice from Teaching and Learning, *European Journal of Operational Research*, Vol. 152, pp. 709-722.

Offerman, P., Levina, O., Schönherr, M., Bub, U. 2009. Outline of a Design Research Process, in the Proceedings of Design Research in Information Systems and Technology DESRIST'09, Malvern PA.

Ogilvy, J.A. 2002. *Creating Better Futures: Scenario Planning as a Tool for a Better Tomorrow*, Oxford University Press, New York NY.

Peffers, K., Tuunanen, T., Rothenbergerm M.A., Chatterjee, S. 2008. A Design Science Research Methodology for Information Systems Research, *Journal of Management Information Systems*, Vol. 24, No. 3, pp. 45-77.

Penrose, E.T. 1959. *The Theory of the Growth of the Firm*, Basil Blackwell & Mott Ltd., Oxford.

Perusich, K., McNeese, M. D. 1997. Using fuzzy cognitive maps for data abstraction, in the Proceedings of the Annual Meeting of the North America Information Processing Society.

Peteraf, M.A. 1993 The Cornerstones of Competitive Advantage: A Resource Based View, *Strategic Management Journal*, Vol. 14, pp. 179-191.

Piirainen, K., Gonzalez, R.A. 2010. Seeking constructive synergy: Design Science and the Constructive Research Approach, unpublished, available from authors.

Piirainen, K., Gonzalez, R.A., Kolfschoten, G. 2010a. *Quo Vadis, Design Science? – A Survey of Literature*, in Winter, R., Zhao, J.L., Aier, S. (eds.) DESRIST 2010, Lecture Notes in Computer Science (LNCS) 6105, Springer Verlag, Berlin-Heidelberg, pp. 93-108.

Piirainen, K., Kolfschoten G., Lukosch, S. 2010b. In Search for the Right Tools to fix the Right Problem: Challenges of Collaborative Design, in the Proceedings of the 43th Hawaii International Conference on Systems Sciences, Poi'pu HI

Piirainen, K., Lindqvist, A. 2010. Enhancing business and technology foresight with electronically mediated scenario process, *foresight*, Vol. 12, No. 2, pp. 16-37.

Piirainen K., Tuominen M., Elfvengren K., Kortelainen S., Niemistö V.-P. 2007. *Developing Support for Scenario Process: A Scenario Study on Lappeenranta University of Technology from 2006 to 2016*, LUT, Faculty of Technology Management, Department of Industrial Management, Research Report 182, Lappeenranta University of Technology, Lappeenranta.

Popper, K. 1978. *Three Worlds* [e-document], The Tanner Lectures on Human Values, April 7, 1978, University of Utah [Accessed 25.5.2010]. Available from: <http://www.tannerlectures.utah.edu/lectures/documents/popper80.pdf>.

Porter, M. E. 1985. *Competitive Advantage: Creating and Sustaining Superior Performance*, The Free Press, New York NY.

Postma, T.J.B.M., Liebl, F. 2005. How to improve scenario analysis as a strategic management tool?, *Technological Forecasting and Social Change*, Vol. 72, pp. 161-173.

Power, D.J. 2002. *Decision Support Systems, Concepts and Resources for Managers*, Quorum Books, Westport CT.

Prahalad C. K., Hamel, G. 1990. The Core Competence of the Corporation, *Harvard Business Review*, May-June, pp. 79-91.

Ralston, B., Wilson, I. 2006. *The Scenario-Planning Handbook: A Practitioner's Guide to Developing and Using Scenarios to Direct Strategy in Today's Uncertain Times*, Thomson/South-Western, Crawfordsville IN.

Raspin, P., Terjesen, S. 2007. Strategy making: what have we learned about forecasting the future?, *Business Strategy Series*, Vol. 8, No. 2, pp. 116-121.

Reinig, B.A. 2003. Toward an Understanding of Satisfaction with the Process and Outcomes of Teamwork, *Journal of Management Information Systems*, Vol. 19, No. 4, pp. 65-83.

Rhyne, R. 1981. Whole-Pattern futures Projection Using Field Anomaly Relaxation, *Technological Forecasting and Social Change*, Vol. 19, pp. 331-360.

Rhyne, R. 1995. Field Anomaly Relaxation: The arts of usage, *Futures*, Vol. 27, No. 6, pp. 657-674.

Rigby, D. Bilodeau, B. 2007. Bain's Global 2007 Management Tools and Trends Survey, *Strategy & Leadership*, Vol. 35, No. 5, pp. 9-16.

Ritchey, T. 2008. *Futures Studies using Morphological Analysis* [e-document], Adapted from AC/UNU Millennium Project, Futures Research Methodology Series [Accessed: 13.3.2008]. Available from: <http://www.swemorph.com/pdf/futures.pdf>.

Rittel, H.W.J., Webber, M.M. 1973. Dilemmas in a General Theory of Planning, *Policy Sciences*, Vol. 4, pp. 155-169.

Russel, B.A.W. 1969. *Filosofian ongelmat (The Problems of Philosophy)*, Otava, Helsinki. (in Finnish)

Sargent, R.G. 2005. Verification and Validation of Simulation Models, in the Proceeding of the 37th Winter Simulation Conference (WinterSim), Orlando FL, pp. 130-143.

Sawyer, J.E., Ferry, D.L., Kydd, C. 2001. Learning about and from Group Support Systems, *Journal of Management Education*, Vol. 25, No. 3, pp. 352-371.

Schnaars, S., Ziamou, P. S. 2001. The Essential of Scenario Writing, *Business Horizons*, Vol. 44, Issue 4, pp. 25-31.

Schoemaker, P.J.H. 1991.When and How to Use Scenario Planning: A Heuristic Approach with Illustration, *Journal of Forecasting*, Vol. 10, Issue 6, pp. 549-564.

Schoemaker, P.J.H. 1993. Multiple Scenario Development: Its Conceptual and Behavioral Foundation, *Strategic Management Journal*, Vol. 14, Issue 3, pp.193-213.

Schoemaker, P.J.H. 1995. Scenario Planning: A Tool for Strategic Thinking, *Sloan Management Review*, Vol 36, Iss. 2, pp. 25-40.

Schoemaker, P.J.H. 1998. *Twenty Common Pitfalls in Scenario Planning*, in: Fahey, L., Randall, R.M. (eds.) Learning from the Future: Competitive Foresight Scenarios, John Wiley & Sons, New York NY, pp. 422-431.

Schwartz, P. 1996. *The Art of the Long View: Planning for the Future in an Uncertain World*, Doubleday Dell Publishing Inc., New York NY.

Selin, C. 2006. Trust and Illusive Forces of Scenarios, *Futures*, Vol. 38, pp. 1-14.

Shadish, W.R., Cook, T.D., Campbell, D.T. 2001. *Experimental and Quasi-experimental Designs for Generalised Causal Inference*, 2nd ed., Houhgton-Miffin, Atlanta, GA.

Shortt, D.G. 1997. A Case Study: Using Groupware to Build the Air Force Information Resource Management (IRM) Strategic Plan, in the Proceeding of the 30th Hawaii International Conference for Systems Sciences, Wailea HI.

Siau, K., Tan, X. 2005. Improving the quality of conceptual modeling using cognitive mapping techniques, *Data & Knowledge Engineering*, Vol. 55, pp. 343-365.

Simon, H. A. 1996. *The Sciences of the Artificial*, 3rd ed., The MIT Press, Cambridge MA.

Skurnik, S., Laamanen, T., Ylisirniö, P. 2009. *SSJS Strategiabarometri 2009 tulosraportti (The Finnish Strategic Management Society Strategy Barometer Report 2009)* [e-document], The Strategic Management Society of Finland, Helsinki [Accessed 13.3.2010]. Available from: <http://www.ssjs.fi/getfile.ashx?cid=97268>.

Spector, J.M., Christensen, D.L., Sioutine, A.V., McCormack, D. 2001. Models and simulations for learning in complex domains: using causal loop diagrams for assessment and evaluation, *Computers in Human Behavior*, Vol. 17, pp. 517-545.

Stauffer, D. 2002. Five Reasons Why You Still Need Scenario Planning, *Harvard Management Update*, reprint no. U0206A.

Stenfors, S. and Tanner, L. 2006. *High-level Decision Support in Companies: Where Is the Support for Creativity and Innovation?*, in Adam, F., Brezillon, P., Carlsson, S., Humphreys, P. Ludic, (Eds.) Creativity and Innovation in Decision Making and Decision Support, IGI Global, Hershey PA, pp. 215-235.

Sterman, J.D. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*, McGraw-Hill Irwin, New York NY.

strategy. 2010. definition of "strategy" [www-document], Merriam-Webster Online Dictionary [Accessed 26.4.2010]. Available from: <http://www.merriam-webster.com/dictionary/strategy>.

Surowiecki, J. 2005 *The Wisdom of Crowds: Why the Many Are Smarter Than the Few*, Anchor Books, Garden City NY.

Susman, G.I., Evered, R.D. 1978. An Assessment of the Scientific Merits of Action Research, *Administrative Science Quarterly*, Vol. 23, No. 4, pp. 582-603.

Teece, D.J. 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance, *Strategic Management Journal*, Vol. 28, No.13, pp. 1319–1350.

Teece, D., Pisano, G., Shuen, A. 1997. Dynamic Capabilities and Strategic Management, *Strategic Management Journal*, Vol. 18, No. 7, pp. 509-533

Tegarden, D.P., Sheetz, S.D. 2003. Group cognitive mapping: a methodology and system for capturing and evaluating managerial and organizational cognition, *Omega: The International Journal of Management Science*, Vol. 31, pp. 113-125.

Tung, L.-L., Turban, E. 1998 A proposed research framework for distributed group support systems, *Decision Support Systems*, Vol. 23, pp. 175-188.

Turban, E., Aronson, J.A., Liang T.P. 2005. *Decision Support Systems and Intelligent Systems*, 7th ed., Prentice Hall, Upper Saddle River, NJ.

Vaishnavi, V., Kuechler, W. 2004. Design Research in Information Systems [www-document], IS WorldNet, Atlanta GA [Accessed 14.7.2009]. Available from: <http://ais.affiniscape.com/displaycommon.cfm?an=1&subarticlenbr=279>.

van Aken, J.E. 2004. Management Research Based on the Paradigm of the Design Sciences: The Quest for Field-tested and Grounded Technological Rules, *Journal of Management Studies*, Vol. 41, No. 2, pp. 219-246.

van Aken, J.E. 2005. Management Research as a Design Science: Articulating the Research Products of Mode 2 Knowledge Production in Management, *British Journal of Management*, Vol. 16, pp. 19–36.

van Aken, J.E. 2007. Design Science and Organization Development Interventions: Aligning Business and Humanistic Values, *The Journal of Applied Behavioral Science*, Vol. 43, No. 1, pp. 67-88.

van Aken, J.E., Romme, G. 2009. Reinventing the future: adding design science to the repertoire of organization and management studies, *Organization Management Journal*, Vol. 6, No. 5, pp. 5-12.

van der Heijden, K., Bradfield, R., George, B., Cairns G., Wright, G. 2002. *The Sixth Sense – Accelerating Organizational Learning with Scenarios*, John Wiley & Sons, Chichester.

van t'Klooster, S.A., van Asselt, M.B.A. 2006. Practicing the scenario-axes technique, *Futures*, Vol. 38, pp. 15-30.

Varum, C.A., Melo, C. 2010. Directions in scenario planning literature – A review of the past decades, *Futures*, Vol. 42, pp. 355-369.

Venable, J.R. 2006. The Role of Theory and Theorising in Design Science Research, in the Proceedings of Design Research in Information Systems and Technology Conference DESRIST'06, Claremont CA.

Venable, J.R. 2010. *Design Science Research Post Hevner et al.: Criteria, Standards, Guidelines and Expectations*, in Winter, R., Zhao, J.L., Aier, S. (eds.) DESRIST 2010, Lecture Notes in Computer Science (LNCS) 6105, Springer Verlag, Berlin-Heidelberg, pp. 109-123.

Voros, J. 2003. A generic foresight process framework, *foresight*, Vol. 5, No. 3, pp. 10-21.

Walls, J. G., Widmeyer, G. R., El Sawy, O.A. 1992. Building an Information Systems Design Theory for Vigilant EIS, *Information Systems Research*, Vol. 3, No. 1, pp. 36-59.

Walls, J.G., Widmeyer, G.R., El Sawy, O.A. 2004. Assessing Information System Design Theory in Perspective: How Useful Was Our Initial Rendition?, *JITTA: Journal of Information Technology Theory and Application*, Vol. 6, No. 2, pp. 43-58.

Walsh, P. R. 2005. Dealing with the uncertainties of environmental change by adding scenario planning to the strategy reformulation equation, *Management Decision*, Vol. 43, No. 1, pp. 113-122.

Ward, E., Schriefer, A.E. 1998. *Dynamic Scenarios: Systems Thinking Meets Scenario Planning*, in: Fahey, L., Randall, R.M. (eds.) Learning from the Future: Competitive Foresight Scenarios, John Wiley & Sons, New York NY, pp.140-156.

Weatherall, A. 1997. GroupSystems Electronic Meetings across the Enterprise – and across the World, in the Proceedings of the 30th Hawaii International Conference on Systems Sciences, Wailea HI.

Wernerfelt, B. 1984. A Resource Based View of the Firm, *Strategic Management Journal*, Vol. 5, No. 2, pp. 171-180.

Winter, R. 2008. Design science research in Europe, *European Journal of Information Systems*, Vol. 17, No. 5, pp. 470-475.

Witten, I.H., Frank, E. 2005. *Data Mining: Practical machine learning tools and techniques*, 2nd Edition, Morgan Kaufmann, San Francisco CA.

Wright, G., Cairns, G., Goodwin, P. 2009. Teaching scenario planning: Lessons from practice in academe and business, *European Journal of Operational Research*, pp. 323-335.

Wright, G., Goodwin, P. 2009. Decision making and planning under low levels of predictability: Enhancing the scenario method, *International Journal of Forecasting*, Vol. 25, pp. 813-825.

Yin, R.K. 1994. *Case Study Research: Design and Methods*, 2nd Edition, Sage Publishing, Thousand Oaks CA.

Zelkowitz, M.V., Wallace, D.R., Binkley, D.W. 2003. *Experimental validation of new software technology*, Juristo, N., Moreno, A.M. (eds.) Lecture notes on empirical software engineering, World Scientific Publishing, River Edge NJ, pp. 229-263.

Zollo, M., Winter, S. 1999. *From Organizational Routines to Dynamic Capabilities*, A Working Paper of the Reginald H. Jones Center WP99-07, The Wharton School of University of Pennsylvania, Philadelphia PA.

APPENDIX 1: Correlation Table for the Test Data

The verbal key for the row and column titles is consistent with the questions in Table 13.

		1 a)	2 a)	2 b)	2 c)	2 d)	2 e)	2 f)	2 g)	2 h)	3 a)	3 b)	3 c)	3 d)	3 e)
1a	Correlation Coefficient	1	-0.283	-0.188	-0.049	0.22	0.099	-0.171	0.108	0.181	-0.239	-0.145	0.055	0.136	0.026
	Sig. (2-tailed)	.	0.145	0.339	0.805	0.26	0.616	0.384	0.585	0.356	0.221	0.463	0.78	0.49	0.894
2a	Correlation Coefficient	-0.283	1	.450	0.083	0.017	0.005	0.175	0.028	0.226	.382	-0.041	-0.17	0.053	0.113
	Sig. (2-tailed)	0.145	.	0.016	0.676	0.931	0.979	0.373	0.888	0.248	0.045	0.834	0.386	0.791	0.567
2b	Correlation Coefficient	-0.188	.450	1	0.196	-0.085	-0.027	.498	0.318	0.168	0.203	-0.149	0.22	-0.039	0.154
	Sig. (2-tailed)	0.339	0.016	.	0.317	0.667	0.893	0.007	0.099	0.393	0.301	0.451	0.261	0.843	0.433
2c	Correlation Coefficient	-0.049	0.083	0.196	1	.453	-0.079	0.218	0.254	0.058	0.204	-0.13	.550	0.315	0.246
	Sig. (2-tailed)	0.805	0.676	0.317	.	0.015	0.689	0.266	0.193	0.771	0.298	0.509	0.002	0.103	0.206
2d	Correlation Coefficient	0.22	0.017	-0.085	.453	1	0.111	0.095	0.044	-0.076	-0.15	0.062	.402	.395	0.373
	Sig. (2-tailed)	0.26	0.931	0.667	0.015	.	0.575	0.629	0.823	0.702	0.447	0.753	0.034	0.037	0.051
2e	Correlation Coefficient	0.099	0.005	-0.027	-0.079	0.111	1	.411	0.366	0.326	-0.153	-0.355	-0.053	-0.004	0.295
	Sig. (2-tailed)	0.616	0.979	0.893	0.689	0.575	.	0.03	0.055	0.09	0.436	0.064	0.79	0.982	0.128
2f	Correlation Coefficient	-0.171	0.175	.498	0.218	0.095	.411	1	0.146	0.008	-0.135	-0.355	0.264	-0.085	0.291
	Sig. (2-tailed)	0.384	0.373	0.007	0.266	0.629	0.03	.	0.459	0.968	0.494	0.064	0.175	0.669	0.133
2g	Correlation Coefficient	0.108	0.028	0.318	0.254	0.044	0.366	0.146	1	0.145	0.094	-0.22	.404	0.261	0.262
	Sig. (2-tailed)	0.585	0.888	0.099	0.193	0.823	0.055	0.459	.	0.462	0.636	0.26	0.033	0.179	0.178
2h	Correlation Coefficient	0.181	0.226	0.168	0.058	-0.076	0.326	0.008	0.145	1	0.23	0.068	-0.112	0.23	0.052
	Sig. (2-tailed)	0.356	0.248	0.393	0.771	0.702	0.09	0.968	0.462	.	0.239	0.732	0.57	0.239	0.791
3a	Correlation Coefficient	-0.239	.382	0.203	0.204	-0.15	-0.153	-0.135	0.094	0.23	1	-0.015	0.055	0.093	0.223
	Sig. (2-tailed)	0.221	0.045	0.301	0.298	0.447	0.436	0.494	0.636	0.239	.	0.938	0.782	0.637	0.255
3b	Correlation Coefficient	-0.145	-0.041	-0.149	-0.13	0.062	-0.355	-0.355	-0.22	0.068	-0.015	1	0.009	0.3	0.131
	Sig. (2-tailed)	0.463	0.834	0.451	0.509	0.753	0.064	0.064	0.26	0.732	0.938	.	0.963	0.121	0.505
3c	Correlation Coefficient	0.055	-0.17	0.22	.550	.402	-0.053	0.264	.404	-0.112	0.055	0.009	1	.449	.427
	Sig. (2-tailed)	0.78	0.386	0.261	0.002	0.034	0.79	0.175	0.033	0.57	0.782	0.963	.	0.017	0.024
3d	Correlation Coefficient	0.136	0.053	-0.039	0.315	.395	-0.004	-0.085	0.261	0.23	0.093	0.3	.449	1	.421
	Sig. (2-tailed)	0.49	0.791	0.843	0.103	0.037	0.982	0.669	0.179	0.239	0.637	0.121	0.017	.	0.026
3e	Correlation Coefficient	0.026	0.113	0.154	0.246	0.373	0.295	0.291	0.262	0.052	0.223	0.131	.427	.421	1
	Sig. (2-tailed)	0.894	0.567	0.433	0.206	0.051	0.128	0.133	0.178	0.791	0.255	0.505	0.024	0.026	.

APPENDIX 2: Correlation Table for the Second Case

The verbal key for the row and column titles is consistent with the items in Table 15

		1.1	1.2	1.4	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.10	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	4.1	4.2	4.3	4.4	4.6	4.7	4.8
1.2	Correlation Coefficient	0,52	1,00	0,82	0,55	0,70	0,14	-0,37	-0,20	0,00	-0,45	-0,28	0,55	0,21	0,21	0,61	0,34	0,20	0,21	0,55	-0,52	0,70	0,70	-0,49	-0,14	**0,76**	-0,27	-0,29
	Sig. (2-tailed)	0,24	.	0,03	0,20	0,08	0,79	0,41	0,66	1,00	0,31	0,54	0,20	0,65	0,65	0,14	0,46	0,66	0,65	0,20	0,24	0,08	0,08	0,26	0,77	**0,05**	0,55	0,53
1.4	Correlation Coefficient	0,36	0,82	1,00	0,25	0,20	-0,64	-0,61	-0,44	-0,24	-0,03	0,04	0,17	-0,01	0,09	0,19	-0,07	-0,33	0,35	0,55	**-0,77**	0,32	0,32	-0,35	-0,21	0,24	-0,64	-0,08
	Sig. (2-tailed)	0,43	0,03	.	0,59	0,67	0,17	0,15	0,33	0,60	0,95	0,94	0,72	0,98	0,85	0,69	0,87	0,47	0,44	0,20	**0,04**	0,48	0,48	0,44	0,65	0,60	0,12	0,87
2.1	Correlation Coefficient	0,06	0,55	0,25	1,00	**0,77**	0,40	0,11	-0,10	-0,19	**-0,83**	-0,15	0,42	0,13	0,25	0,62	0,38	0,60	0,10	-0,21	0,00	0,59	0,65	-0,38	-0,27	0,61	-0,20	-0,20
	Sig. (2-tailed)	0,90	0,20	0,59	.	**0,04**	0,44	0,81	0,83	0,68	**0,02**	0,74	0,35	0,77	0,59	0,14	0,40	0,16	0,84	0,65	1,00	0,17	0,11	0,39	0,56	0,14	0,67	0,67
2.2	Correlation Coefficient	0,22	0,70	0,20	**0,77**	1,00	0,76	0,06	-0,01	0,05	**-0,85**	-0,54	0,54	0,33	0,16	**0,91**	0,69	**0,82**	-0,04	0,19	-0,07	**0,82**	**0,82**	-0,55	-0,21	***0,92***	0,18	-0,40
	Sig. (2-tailed)	0,64	0,08	0,67	**0,04**	.	0,08	0,89	0,98	0,92	**0,02**	0,21	0,21	0,47	0,74	**0,00**	0,09	**0,02**	0,93	0,68	0,88	**0,02**	**0,02**	0,20	0,65	***0,00***	0,69	0,37
2.3	Correlation Coefficient	0,24	0,14	-0,64	0,40	0,76	1,00	0,43	0,42	0,43	-0,63	-0,43	0,66	0,32	0,16	0,64	0,65	**0,88**	-0,23	-0,05	0,49	0,60	0,62	-0,14	0,13	**0,90**	0,65	-0,28
	Sig. (2-tailed)	0,65	0,79	0,17	0,44	0,08	.	0,39	0,40	0,39	0,18	0,39	0,16	0,54	0,76	0,17	0,16	**0,02**	0,66	0,93	0,32	0,21	0,19	0,79	0,81	**0,01**	0,16	0,59
2.4	Correlation Coefficient	-0,36	-0,37	-0,61	0,11	0,06	0,43	1,00	0,61	0,58	-0,43	-0,31	0,14	0,66	0,61	0,11	0,56	0,51	**-0,81**	**-0,81**	**0,79**	0,04	0,29	0,03	0,43	0,11	0,69	-0,52
	Sig. (2-tailed)	0,42	0,41	0,15	0,81	0,89	0,39	.	0,15	0,17	0,33	0,49	0,76	0,11	0,15	0,81	0,19	0,25	**0,03**	**0,03**	**0,03**	0,93	0,52	0,95	0,34	0,81	0,09	0,24
2.5	Correlation Coefficient	0,27	-0,20	-0,44	-0,10	-0,01	0,42	0,61	1,00	***0,91***	0,03	-0,39	0,51	0,50	0,18	-0,03	0,09	0,15	-0,59	-0,26	**0,77**	0,27	-0,07	0,02	***0,94***	0,20	**0,78**	0,08
	Sig. (2-tailed)	0,56	0,66	0,33	0,83	0,98	0,40	0,15	.	***0,00***	0,95	0,39	0,24	0,25	0,70	0,95	0,84	0,75	0,16	0,57	**0,04**	0,56	0,89	0,97	***0,00***	0,67	**0,04**	0,87
2.6	Correlation Coefficient	0,36	0,00	-0,24	-0,19	0,05	0,43	0,58	***0,91***	1,00	0,00	-0,45	0,59	0,64	0,40	0,05	0,29	0,14	-0,64	-0,10	0,63	0,30	0,15	0,00	***0,91***	0,34	**0,78**	-0,20
	Sig. (2-tailed)	0,42	1,00	0,60	0,68	0,92	0,39	0,17	***0,00***	.	1,00	0,32	0,16	0,12	0,38	0,92	0,53	0,76	0,12	0,83	0,13	0,52	0,75	1,00	***0,00***	0,46	**0,04**	0,66
2.7	Correlation Coefficient	0,20	-0,45	-0,03	**-0,83**	**-0,85**	-0,63	-0,43	0,03	0,00	1,00	0,47	-0,31	-0,50	-0,44	**-0,82**	**-0,82**	***-0,88***	0,31	0,31	-0,10	-0,63	***-0,88***	0,50	0,27	-0,71	-0,18	0,65
	Sig. (2-tailed)	0,67	0,31	0,95	**0,02**	**0,02**	0,18	0,33	0,95	1,00	.	0,29	0,50	0,25	0,33	**0,02**	**0,02**	***0,01***	0,49	0,50	0,83	0,13	***0,01***	0,25	0,55	0,08	0,69	0,12
2.8	Correlation Coefficient	0,18	-0,28	0,04	-0,15	-0,54	-0,43	-0,31	-0,39	-0,45	0,47	1,00	-0,12	**-0,80**	0,07	**-0,78**	-0,64	-0,57	0,69	-0,10	0,00	**-0,80**	-0,46	**0,83**	-0,22	-0,50	-0,66	0,40
	Sig. (2-tailed)	0,71	0,54	0,94	0,74	0,21	0,39	0,49	0,39	0,32	0,29	.	0,80	**0,03**	0,88	**0,04**	0,12	0,18	0,09	0,84	1,00	**0,03**	0,30	**0,02**	0,64	0,25	0,10	0,37
2.9	Correlation Coefficient	***0,91***	0,47	0,25	0,17	0,28	0,39	-0,15	0,19	0,33	0,00	0,30	0,86	-0,21	0,38	-0,06	-0,01	0,00	0,41	0,37	0,19	0,08	0,25	0,44	0,30	0,56	-0,06	0,04
	Sig. (2-tailed)	***0,00***	0,28	0,59	0,72	0,54	0,44	0,75	0,68	0,46	1,00	0,51	0,01	0,65	0,40	0,89	0,98	1,00	0,37	0,41	0,69	0,86	0,58	0,32	0,51	0,20	0,91	0,93
2.10	Correlation Coefficient	**0,82**	0,55	0,17	0,42	0,54	0,66	0,14	0,51	0,59	-0,31	-0,12	1,00	0,19	0,43	0,26	0,25	0,30	0,04	0,19	0,37	0,49	0,47	0,08	0,51	**0,78**	0,25	-0,08
	Sig. (2-tailed)	**0,02**	0,20	0,72	0,35	0,21	0,16	0,76	0,24	0,16	0,50	0,80	.	0,68	0,34	0,57	0,60	0,51	0,93	0,68	0,42	0,27	0,29	0,87	0,24	**0,04**	0,59	0,86
3.1	Correlation Coefficient	-0,23	0,21	-0,01	0,13	0,33	0,32	0,66	0,50	0,64	-0,50	**-0,80**	0,19	1,00	0,47	0,54	0,73	0,46	***-0,91***	-0,27	0,22	0,58	0,58	-0,60	0,41	0,40	0,63	-0,69

		1.1	1.2	1.4	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.10	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	4.1	4.2	4.3	4.4	4.6	4.7	4.8
	Sig. (2-tailed)	0,62	0,65	0,98	0,77	0,47	0,54	0,11	0,25	0,12	0,25	**0,03**	0,68	.	0,29	0,21	0,06	0,30	***0,00***	0,56	0,64	0,17	0,17	0,16	0,36	0,37	0,13	0,09
3.3	Correlation Coefficient	-0,07	0,61	0,19	0,62	***0,91***	0,64	0,11	-0,03	0,05	**-0,82**	**-0,78**	0,26	0,54	0,05	1,00	**0,77**	**0,81**	-0,29	0,17	-0,20	***##***	**0,79**	**-0,80**	-0,24	**0,79**	0,29	-0,51
	Sig. (2-tailed)	0,88	0,14	0,69	0,14	***0,00***	0,17	0,81	0,95	0,92	**0,02**	**0,04**	0,57	0,21	0,92	.	**0,04**	**0,03**	0,53	0,72	0,67	***0,01***	**0,03**	**0,03**	0,60	**0,04**	0,53	0,24
3.4	Correlation Coefficient	-0,22	0,34	-0,07	0,38	0,69	0,65	0,56	0,09	0,29	**-0,82**	-0,64	0,25	0,73	0,55	**0,77**	1,00	**0,83**	-0,59	-0,19	0,13	0,52	***0,88***	-0,45	-0,10	0,67	0,50	***-0,90***
	Sig. (2-tailed)	0,63	0,46	0,87	0,40	0,09	0,16	0,19	0,84	0,53	**0,02**	0,12	0,60	0,06	0,20	**0,04**	.	**0,02**	0,16	0,69	0,78	0,23	***0,01***	0,31	0,83	0,10	0,26	***0,01***
3.5	Correlation Coefficient	-0,18	0,20	-0,33	0,60	**0,82**	**0,88**	0,51	0,15	0,14	***-0,88***	-0,57	0,30	0,46	0,25	0,81	**0,83**	1,00	-0,37	-0,25	0,31	0,57	0,71	-0,39	-0,17	0,70	0,51	-0,55
	Sig. (2-tailed)	0,70	0,66	0,47	0,16	**0,02**	**0,02**	0,25	0,75	0,76	***0,01***	0,18	0,51	0,30	0,59	0,03	**0,02**	.	0,41	0,60	0,50	0,18	0,07	0,39	0,72	0,08	0,24	0,20
3.6	Correlation Coefficient	0,44	0,21	0,35	0,10	-0,04	-0,23	**-0,81**	-0,59	-0,64	0,31	0,69	0,04	***-0,91***	-0,38	-0,29	-0,59	-0,37	1,00	0,50	-0,43	-0,28	-0,28	0,39	-0,47	-0,09	-0,75	0,57
	Sig. (2-tailed)	0,32	0,65	0,44	0,84	0,93	0,66	**0,03**	0,16	0,12	0,49	0,09	0,93	***0,00***	0,40	0,53	0,16	0,41	.	0,25	0,33	0,54	0,54	0,38	0,29	0,85	0,05	0,19
3.7	Correlation Coefficient	0,59	0,55	0,55	-0,21	0,19	-0,05	**-0,81**	-0,26	-0,10	0,31	-0,10	0,19	-0,27	-0,45	0,17	-0,19	-0,25	0,50	1,00	-0,63	0,27	-0,02	-0,17	-0,11	0,29	-0,21	0,24
	Sig. (2-tailed)	0,16	0,20	0,20	0,65	0,68	0,93	**0,03**	0,57	0,83	0,50	0,84	0,68	0,56	0,32	0,72	0,69	0,60	0,25	.	0,13	0,56	0,97	0,71	0,81	0,53	0,65	0,60
3.8	Correlation Coefficient	0,04	-0,52	**-0,77**	0,00	-0,07	0,49	**0,79**	**0,77**	0,63	-0,10	0,00	0,37	0,22	0,35	-0,20	0,13	0,31	-0,43	-0,63	1,00	-0,13	-0,08	0,42	0,62	0,05	0,66	0,00
	Sig. (2-tailed)	0,93	0,24	**0,04**	1,00	0,88	0,32	**0,03**	**0,04**	0,13	0,83	1,00	0,42	0,64	0,44	0,67	0,78	0,50	0,33	0,13	.	0,77	0,86	0,34	0,14	0,91	0,11	1,00
4.1	Correlation Coefficient	0,22	0,70	0,32	0,59	**0,82**	0,60	0,04	0,27	0,30	-0,63	**-0,80**	0,49	0,58	-0,02	***0,88***	0,52	0,57	-0,28	0,27	-0,13	1,00	0,64	**-0,82**	0,13	**0,79**	0,31	-0,24
	Sig. (2-tailed)	0,64	0,08	0,48	0,17	**0,02**	0,21	0,93	0,56	0,52	0,13	**0,03**	0,27	0,17	0,97	***0,01***	0,23	0,18	0,54	0,56	0,77	.	0,12	**0,02**	0,78	**0,04**	0,50	0,60
4.2	Correlation Coefficient	0,06	0,70	0,32	0,65	**0,82**	0,62	0,29	-0,07	0,15	***-0,88***	-0,46	0,47	0,58	0,62	**0,79**	***0,88***	0,71	-0,28	-0,02	-0,08	0,64	1,00	-0,46	-0,18	**0,83**	0,13	**-0,81**
	Sig. (2-tailed)	0,90	0,08	0,48	0,11	**0,02**	0,19	0,52	0,89	0,75	***0,01***	0,30	0,29	0,17	0,14	**0,03**	***0,01***	0,07	0,54	0,97	0,86	0,12	.	0,30	0,70	**0,02**	0,77	**0,03**
4.3	Correlation Coefficient	0,27	-0,49	-0,35	-0,38	-0,55	-0,14	0,03	0,02	0,00	0,50	**0,83**	0,08	-0,60	0,21	-0,80	-0,45	-0,39	0,39	-0,17	0,42	**-0,82**	-0,46	1,00	0,13	-0,38	-0,15	0,28
	Sig. (2-tailed)	0,56	0,26	0,44	0,39	0,20	0,79	0,95	0,97	1,00	0,25	**0,02**	0,87	0,16	0,66	0,03	0,31	0,39	0,38	0,71	0,34	**0,02**	0,30	.	0,78	0,39	0,74	0,54
4.4	Correlation Coefficient	0,42	-0,14	-0,21	-0,27	-0,21	0,13	0,43	***0,94***	***0,91***	0,27	-0,22	0,51	0,41	0,21	-0,24	-0,10	-0,17	-0,47	-0,11	0,62	0,13	-0,18	0,13	1,00	0,07	0,59	0,16
	Sig. (2-tailed)	0,35	0,77	0,65	0,56	0,65	0,81	0,34	***0,00***	***0,00***	0,55	0,64	0,24	0,36	0,65	0,60	0,83	0,72	0,29	0,81	0,14	0,78	0,70	0,78	.	0,87	0,16	0,74
4.5	Correlation Coefficient	0,29	-0,55	-0,36	-0,65	-0,65	-0,24	-0,11	0,50	0,34	**0,83**	0,24	-0,02	-0,33	-0,45	-0,68	-0,73	-0,59	0,10	0,11	0,35	-0,38	**-0,86**	0,45	0,62	-0,50	0,22	0,75
	Sig. (2-tailed)	0,52	0,20	0,42	0,11	0,11	0,65	0,81	0,25	0,46	**0,02**	0,60	0,97	0,47	0,31	0,09	0,06	0,16	0,84	0,81	0,44	0,39	**0,01**	0,31	0,14	0,25	0,64	0,05
4.6	Correlation Coefficient	0,49	**0,76**	0,24	0,61	***0,92***	**0,90**	0,11	0,20	0,34	-0,71	-0,50	**0,78**	0,40	0,34	**0,79**	0,67	0,70	-0,09	0,29	0,05	**0,79**	**0,83**	-0,38	0,07	1,00	0,29	-0,44
	Sig. (2-tailed)	0,27	**0,05**	0,60	0,14	***0,00***	**0,01**	0,81	0,67	0,46	0,08	0,25	**0,04**	0,37	0,46	**0,04**	0,10	0,08	0,85	0,53	0,91	**0,04**	**0,02**	0,39	0,87	.	0,52	0,33
4.7	Correlation Coefficient	-0,06	-0,27	-0,64	-0,20	0,18	0,65	0,69	**0,78**	**0,78**	-0,18	-0,66	0,25	0,63	0,12	0,29	0,50	0,51	-0,75	-0,21	0,66	0,31	0,13	-0,15	0,59	0,29	1,00	-0,28
	Sig. (2-tailed)	0,90	0,55	0,12	0,67	0,69	0,16	0,09	**0,04**	**0,04**	0,69	0,10	0,59	0,13	0,81	0,53	0,26	0,24	0,05	0,65	0,11	0,50	0,77	0,74	0,16	0,52	.	0,55
4.8	Correlation Coefficient	0,30	-0,29	-0,08	-0,20	-0,40	-0,28	-0,52	0,08	-0,20	0,65	0,40	-0,08	-0,69	-0,73	-0,51	***-0,90***	-0,55	0,57	0,24	0,00	-0,24	**-0,81**	0,28	0,16	-0,44	-0,28	1,00
	Sig. (2-tailed)	0,52	0,53	0,87	0,67	0,37	0,59	0,24	0,87	0,66	0,12	0,37	0,86	0,09	0,06	0,24	***0,01***	0,20	0,19	0,60	1,00	0,60	**0,03**	0,54	0,74	0,33	0,55	.

ACTA UNIVERSITATIS LAPPEENRANTAENSIS

362. SALKINOJA, HEIKKI. Optimizing of intelligence level in welding. 2009. Diss.

363. RÖNKKÖNEN, JANI. Continuous multimodal global optimization with differential evolution-based methods. 2009. Diss.

364. LINDQVIST, ANTTI. Engendering group support based foresight for capital intensive manufacturing industries – Case paper and steel industry scenarios by 2018. 2009. Diss.

365. POLESE, GIOVANNI. The detector control systems for the CMS resistive plate chamber at LHC. 2009. Diss.

366. KALENOVA, DIANA. Color and spectral image assessment using novel quality and fidelity techniques. 2009. Diss.

367. JALKALA, ANNE. Customer reference marketing in a business-to-business context. 2009. Diss.

368. HANNOLA, LEA. Challenges and means for the front end activities of software development. 2009. Diss.

369. PÄTÄRI, SATU. On value creation at an industrial intersection – Bioenergy in the forest and energy sectors. 2009. Diss.

370. HENTTONEN, KAISA. The effects of social networks on work-team effectiveness. 2009. Diss.

371. LASSILA, JUKKA. Strategic development of electricity distribution networks – Concept and methods. 2009. Diss.

372. PAAKKUNAINEN, MAARET. Sampling in chemical analysis. 2009. Diss.

373. LISUNOV, KONSTANTIN. Magnetic and transport properties of II-V diluted magnetic semiconductors doped with manganese and nickel. 2009. Diss.

374. JUSSILA, HANNE. Concentrated winding multiphase permanent magnet machine design and electromagnetic properties – Case axial flux machine. 2009. Diss.

375. AUVINEN, HARRI. Inversion and assimilation methods with applications in geophysical remote sensing. 2009. Diss.

376. KINDSIGO, MERIT. Wet oxidation of recalcitrant lignin waters: Experimental and kinetic studies. 2009. Diss.

377. PESSI, PEKKA. Novel robot solutions for carrying out field joint welding and machining in the assembly of the vacuum vessel of ITER. 2009. Diss.

378. STRÖM, JUHA-PEKKA. Active*du*/d*t* filtering for variable-speed AC drives. 2009. Diss.

379. NURMI, SIMO A. Computational and experimental investigation of the grooved roll in paper machine environment. 2009. Diss.

380. HÄKKINEN, ANTTI. The influence of crystallization conditions on the filtration characteristics of sulphathiazole suspensions. 2009. Diss.

381. SYRJÄ, PASI. Pienten osakeyhtiöiden verosuunnittelu – empiirinen tutkimus. 2010. Diss.

382. KERKKÄNEN, ANNASTIINA. Improving demand forecasting practices in the industrial context. 2010. Diss.

383. TAHVANAINEN, KAISA. Managing regulatory risks when outsourcing network-related services in the electricity distribution sector. 2010. Diss.

384. RITALA, PAAVO. Coopetitive advantage – How firms create and appropriate value by collaborating with their competitors. 2010. Diss.

385. RAUVANTO, IRINA. The intrinsic mechanisms of softwood fiber damage in brown stock fiber line unit operations. 2010. Diss.

386. NAUMANEN, VILLE. Multilevel converter modulation: implementation and analysis. 2010. Diss.

387. IKÄVALKO, MARKKU. Contextuality in SME ownership – Studies on owner-managers´ ownership behavior. 2010. Diss.

388. SALOJÄRVI, HANNA. Customer knowledge processing in key account management. 2010. Diss.

389. ITKONEN, TONI. Parallel-operating three-phase voltage source inverters – Circulating current modeling, analysis and mitigation. 2010. Diss.

390. EEROLA, TUOMAS. Computational visual quality of digitally printed images. 2010. Diss.

391. TIAINEN, RISTO. Utilization of a time domain simulator in the technical and economic analysis of a wind turbine electric drive train. 2010. Diss.

392. GRÖNMAN AKI. Numerical modelling of small supersonic axial flow turbines. 2010. Diss.

393. KÄHKÖNEN, ANNI-KAISA. The role of power relations in strategic supply management – A value net approach. 2010. Diss.

394. VIROLAINEN, ILKKA. Johdon coaching: Rajanvetoja, taustateorioita ja prosesseja. 2010. Diss.

395. HONG, JIANZHONG. Cultural aspects of university-industry knowledge interaction. 2010. Diss.

396. AARNIOVUORI, LASSI. Induction motor drive energy efficiency – Simulation and analysis. 2010. Diss.

397. SALMINEN, KRISTIAN. The effects of some furnish and paper structure related factors on wet web tensile and relaxation characteristics. 2010. Diss.

398. WANDERA, CATHERINE. Performance of high power fiber laser cutting of thick-section steel and medium-section aluminium. 2010. Diss.

399. ALATALO, HANNU. Supersaturation-controlled crystallization. 2010. Diss.

400. RUNGI, MAIT. Management of interdependency in project portfolio management. 2010. Diss.

401. PITKÄNEN, HEIKKI. First principles modeling of metallic alloys and alloy surfaces. 2010. Diss.

402. VAHTERISTO, KARI. Kinetic modeling of mechanisms of industrially important organic reactions in gas and liquid phase. 2010. Diss.

403. LAAKKONEN, TOMMI. Distributed control architecture of power electronics building-block-based frequency converters. 2010. Diss.

404. PELTONIEMI, PASI. Phase voltage control and filtering in a converter-fed single-phase customer-end system of the LVDC distribution network. 2010. Diss.

405. TANSKANEN, ANNA. Analysis of electricity distribution network operation business models and capitalization of control room functions with DMS. 2010. Diss.