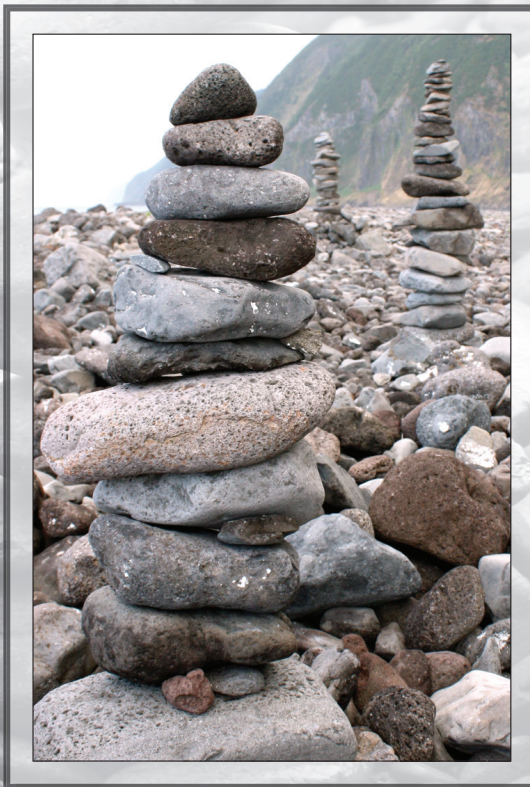# MANAGING UNCERTAINTY IN PROJECTS

Olga Perminova

Olga Perminova (born 1980) has a degree in International Economic Relations from St. Petersburg State University, Russia (2002). She is currently a researcher at the Laboratory of Industrial Management, Department of Chemical Engineering, Åbo Akademi University and PBI Research Institute.

Olga PERMINOVA

International Project Management Association (IPMA) recognized Olga's research in uncertainty management by awarding her with IPMA Young Researcher Honour 2009. Her works on the subject of risk and uncertainty management in projects has been published in books and international journals.

MANAGING UNCERTAINTY IN PROJECTS

Managing Uncertainty in Projects

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This work is a result of an amazing journey in all the senses of this word: scientifically, geographically, emotionally... At times, it felt like a movie full of joyful discovery moments. But there was the suspense — uncertainty, too, at least as a research subject. I would like to express my sincerest gratitude to many kind individuals with whom I had the pleasure to work.

Every movie starts with someone of special importance entering the life of the main character. It all began with the phone call I received some years ago in my native St. Petersburg from Dr. Christian Junnelius. Dr. Junnelius can be truly named the godfather of this research project. I owe a lot to his support, not least in practical matters of settling down in Åbo. He was the person who made it possible for me to start the work that I wholeheartedly pursued — a doctoral thesis — by introducing me into the unique research setting of Åbo Akademi University and PBI Research Institute where high class academic research meets practice. This is probably the best research environment a doctoral student can wish for.

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that knowledge and education are the best treasures one can possess. You have always supported me in all of my studying projects: from the violin lessons to martial arts, and you never doubted me. This is a true blessing.

All the good movies end up in award ceremonies. However, it is uncertain until the end whether you get the coveted prize or not. One prize I have already received: the ability to have all of you along in this journey. I look forward to new projects with you!

Åbo, 22 February 2011

Olga Perminova

SAMMANFATTNING

Målsättningen med denna avhandling är att undersöka osäkerhet inom projekt samt att uppnå en bättre förståelse för ledningsprocessen för att hantera osäkerhet. Undersökningen utördes genom att studera ett antal projekt där oförutsedda händelser påträffas, samt att studera hur projektledarna handlar i dessa fall. Teoretiskt ger avhandlingen en djupare förståelse för fenomenet osäkerhet i projekt, den förklarar förhållandet mellan närliggande variabler, såsom risker och möjligheter, samt förklarar ledningsprocessen av osäkerhet och dess olika element. Sett ur både en teoretisk och praktisk synvinkel bidrar avhandlingen med att förklara vilka ledningsmetoder och -principer som kan användas då traditionell riskhantering inte är tillräcklig för att lösa problem. Studier som nyligen gjorts gällande riskhantering påvisar att projektledare uppfattar tillämpningen av etablerade riskhanteringsmetoder som ineffektiva. När något oförutsett sker är tillvägagångssättet sällan tillräcklig för att ledaren skall erhålla riktlinjer för rätt agerande. I dylika situationer utsätts projektledaren för osäkerhet som berör projektets angelägenheter, hur händelsen påverkar projektet och dess resultat, samt hur hans agerande påverkar dessa tidigare nämnda aspekter. Denna avhandling ger en konceptuell modell och empiriska bevis på hur osäkerhet kan ledas. Särskilt betonas betydelsen av att erkänna osäkerhet som en väsentlig del av projektverksamhet, samt behovet av professionella projektledare för att säkerställa att målen för projekten uppnås. Kunskapen och förtydligandet av osäkerhetsfenomenet samt beskrivningen av förfaringssätt om hur osäkerhet kan hanteras i samband med projekt är alla viktiga förutsättningar för prestationsorienterad projektledning. Hanteringen av osäkerheterskall betraktas som ett tanke- och förfaringssätt som beaktar attityder, beteenden, system och processer relevanta för att leda projekt och projektorganisationer. För forskare inom detta område erbjuder avhandlingens resultat möjligheter att utveckla, testa och upptäcka nya mekanismer för hantering av osäkerhet i projekt.

Denna avhandling bidrar på flera sätt till ämnet projekledning. Först och främst bidrar den med en definition på begreppet osäkerhet i förhållande till risker och möjligheter genom att

kombinera befintliga definitioner med förståelsen för osäkerhet från organisationsteori och strategisk ledning. För det andra bidrar avhandlingen med empiriskt bevis och motivering för ledning av osäkerhet, samt beskriver metoderna som projektbaserade företag tillämpar för att adressera osäkerhet. Bidraget till litteraturen inom projektledning innefattar beskrivningen av de reflektiva mekanismer som bidrar till transformering av osäkerhet till säkerhet, till utökad flexibilitet och stärkt robusthet inom projektgenomföring. För det tredje förklarar avhandlingen relevansen och nyttan av ett reflekterande tillvägagångssätt gällande risk- och osäkerhetshantering inom projektledning. För det fjärde uppmärksammas garantistadiet som en viktig fas för reflektion i projektets livscykel. Avhandlingen bidrar till ett empiriskt bevis på att garantistadiet är en fas där man antingen bemöter risker eller drar nytta av uppstående möjligheter. Mina forskningsresultat indikerar att garantistadiet måste beaktas som lika betydelsefullt som den övriga projektgenomföringen i relation till övergripande prestationsförmåga och ledningsprocesser.

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I INTRODUCTION

In one of the interviews a project manager told a story of power plant turnkey delivery project to Philippines. He was quite confident in the endeavor right from the start. After all, the Finnish-based supplier company, which he represented, specialized on these kinds of turnkey projects. The manager had assistance of his experienced colleagues, knowledge of the previous cases and the customer in question as well as the possible issues that could happen if not taken care of. In other words, he was well prepared and knew his routines. No wonder that the project execution went just fine: the plant started working according to the agreed specifications and on time. However, just one detail was missing. As it appeared later, the customer company in Philippines, although strongly advised by the project manager and his senior top management colleagues, did not consider well who would be supervising and operating the plant on everyday basis. It must have been the beauty of the outcome: the complex systems of the power plant seemed to be doing their job effortlessly without much of a human invasion. Besides, the local staff hired to supervise the equipment did receive training needed to familiarize with the new equipment and the everyday plant procedures. The printed user manual of the plant was not as heavy as one could imagine, and just like any other ordinary appliance, it had a warranty of two years. The customer company was satisfied with the final outcome. So, the plant was successfully commissioned, and the energy production started. At this point many industrial supplier firms would consider their job to be done. The project manager would focus more on the other work, and the warranty supervision would become a task of the other project team member — the warranty manager. The project team would have a small celebration with a glass of champagne and a cake. It was so in this case, too. But the project was not yet over as it entered the post delivery phase — warranty — for two subsequent years. Not over were the responsibilities of the project manager as the leading member of the project team who was in charge of the project overall.

In the first year after the power plant started the operations, a large amount of claims were

received by the supplier firm. According to the project manager, the hired personnel did not have enough of skills to manage the operations and especially the regular maintenance processes at the plant. The situation was somewhat unexpected considering that the customer was instructed to hire people with the technical background. As a rule, the supplier company gives basic training for the operators and plant management, which is included in the contract of the turnkey project. Additionally, the customer is offered to buy the supplier's services in operating and maintaining the power plant. But it is up to the project customer to decide how to proceed after the plant is commissioned. In this case, the successful project execution ended up in costly post delivery stage for the supplier. As a result, the project was prospected to become after warranty less profitable than anticipated at the kick-off. And it is the overall result of the project that counts. The project manager was wondering how to manage unexpected situations and the issues that appeared completely unforeseeable during the project course. He considered several examples from the other familiar projects. A similar project in Cambodia when a critically important road connection used for transporting the equipment to the construction site had been completely blocked overnight by the locals in opposition of the power plant construction. Climatic issues influenced power plant project execution in Siberian extreme cold weathers. The technical solution was expected to perform according to the tests, but it did not. Industrial projects with the aim to deliver large capital goods are complex by definition. The execution of these projects when the unforeseen issues take place becomes even more challenging, thus increasing complexity dramatically. A risk management plan cannot accommodate all the imaginable issues as it is neither possible nor reasonable to foresee all the events which might happen along the project journey. If the project-based supplier firm questions its own products, services and project management expertise, it will not be possible to convince the customer to invest into them. In fact, some of the events might even have a positive outcome in the longer run. The aforementioned situations and issues are unexpected, not known, or even doubtful. They are not yet risk, but they create uncertainty. And it needs to be managed.

From a broader philosophical perspective, uncertainty is one of the fundamental features of the world, which assumes it is impossible for us to fully assess or predict the future. According to

Watts (1951), human belief grounded on the assumption that the world is certain and predictable is an illusion inspired by the desire to control nature. The philosophical approaches to understanding uncertainty are delimited by two perspectives: Zenian and Faustian (Bradac, 2001). The first perspective is based on Zen Buddhist philosophy, which sees uncertainty as inevitable, thus making our contemplations about what is certain and what is not quite futile. The second perspective obtained its name from the fictional character Faustus, and reflects the attempts by human beings to know and, thus, control their fate by every means available. At the same time, the name is also associated with our desire to explain this universe we inhabit.

The concept of uncertainty is employed by many branches of science: psychology, philosophy, physics, economics and finance, statistics and information technology, sociology and so forth. It is the cornerstone of modern physics (Hawking, 1988/2005), economics (Knight, 1921), statistics (Savage, 1954), psychology (James and Jones, 1974), etc. All these sciences have their own interpretation of the concept; however they share an understanding of certain traits of uncertainty. The topic of uncertainty has gained plenty of attention in management research recently. The term as such is one of the most widely used in management in general. What is more, it is a very popular word used in everyday life; something, that all of us can relate to. As noted by Downey and Slocum (1975), the concept is so widely used that it is only natural *"to assume that one knows what he or she is talking about"* (p.562). Hence, the result: there are almost as many interpretations of uncertainty as there are discussions about it. Referring to the use of the term by organization theorists, Milliken (1987) concludes: *"Researchers who assume agreement may interpret literature as though there was agreement when, in fact, there is tremendous inconsistency and confusion about how a construct is defined and used"* (p. 134). A similar situation can be witnessed in the field of project management, partly because the researchers in the field gain insights in different organization theories and strategic management literature with regard to explaining uncertainty-related issues. A significant amount of work has been done to conceptualize and measure uncertainty by the adepts of the administrative science (e.g. March and Simon, 1958; Lawrence and Lorsch, 1967; Duncan, 1972; Child, 1972). They recognize uncertainty as an important factor influencing managerial decision-making, as well as actions and their outcomes (e.g. Knight, 1921; Head, 1967; Lorenzi et al., 1981; March and Simon, 1958; Weick, 1983;

Sommer and Loch, 2004; Loch et al., 2008). Some streams in management literature go even further in their attempts to explain the influence of uncertainty on organizations (firms), their processes, and individuals. Thus, the concept of *uncertainty management* was established, which studies the interdependence between uncertainty and other elements of managerial processes with the purpose of finding ways to cope with uncertainty and even benefit from it. For example, *uncertainty management theory* is a cluster of ideas under the umbrella of communication theory exploring the effects of uncertainty on complex communication systems — or organizations/firms and their processes (Babrow, 1992; Brashers and Babrow, 1996; McPhee and Zaug, 2001). It can be argued that project management can benefit from the application of some of the achievements of the above-mentioned fields, provided that the use of terms and their application to project management realities are carefully considered.

Therefore, the important question is: why managing uncertainty is important from a practical point of view and how does it relate to potential theoretical advances? The aim of this thesis is to explore the issue of uncertainty in projects and gain a better understanding of the uncertainty management process and its elements by studying multiple project cases involving unforeseen events and the actions of managers upon them. Theoretically, the thesis will provide a more profound understanding of the phenomenon of uncertainty in projects, explain the relationship between the variables related to it, such as risk and opportunity, as well as explain the uncertainty management process and its elements. From both theoretical and practical point of view, the contribution is in explaining what kind of management methods and principles can be used when risk management practices are not sufficient in addressing the issue. Recent studies of risk management practices show that project managers perceive the application of well-established risk management practices as ineffective (e.g. Kutsch and Hall, 2005). When an unexpected event takes place, the risk management plan is rarely enough to provide a guideline as to how the manager needs to act. In such a situation, project manager faces uncertainty about the new state of affairs in the project (*state uncertainty* in Milliken's (1987) terms), the effects of the event on the project and its outcomes (*effect uncertainty*, ibid.) as well as about his or her actions and their respective effect (*response uncertainty*). Common scenarios include avoidance, ignorance, delay or denial of the possible consequences of the event, which is associated with

the adverse outcomes on the project success (Kutsch and Hall, 2005). Ignorance strategy may lead to the use of risk reservations in the budget to cover for the costs that an unforeseen event imposes. The failure to address the issue on time can cause project customer or other stakeholders' dissatisfaction with the project, which again, has an effect on project success. Atkinson and his colleagues (2006) provide a good summary of the current view on uncertainty within traditional project management research and practice:

> *"Conventional (common practice) project management processes are concerned with legitimising the project plan, and uncertainty (particularly from fundamental sources) is played down. The project manager is regarded as a convenient recipient of project risk, providing psychological relief to the project owner (if not actual physical relief) from the burden of uncertainty and risk bearing, and someone who subsequently unwillingly serves as scape-goat if things fail to turn out as desired by the project owner."(p.691)*

The current trend in the project management literature is to discuss different approaches to uncertainty management while stating that the issue needs to receive more attention and, using the expression of the aforementioned authors, *"be rather more sophisticated than the current common practice"* (ibid, p. 696). As noted by the researchers in the field, the empirical research on uncertainty and the management practices related to it is scarce (Jaafari, 2001; Chapman and Ward, 2002; 2003).

This thesis provides empirical evidence for uncertainty management and emphasizes the importance of recognizing uncertainty as an essential part of projects which needs to be managed by project management professionals (project managers) to ensure that projects meet their goals. In this perspective, defining and explaining the phenomenon of uncertainty and the way it can be managed in projects is an important element of performance-oriented project management. In this work uncertainty management for projects and project-based companies will be approached as a mindset, or a set of practices, which includes attitudes, behaviors, systems and processes of the project-management organizations and their members. In order to do this, there is a need to gain better understanding of what uncertainty in projects is and how it relates in project management to the well-established concept of risk and the concept of opportunities.

1.1   Trends in project management field

Project management as a scientific discipline emerged at the beginning of the 1950s. During that time, network analysis and different planning techniques (PERT, CPM) captured the attention of researchers in this field. The focus remained on these issues until the 1980s, spreading to different industries, e. g. defense, construction, aerospace. However, the last twenty years of the 20th century are characterized by a focus on project organization, external influences on project performance, development of project management standards, and project risk management. Needless to say, the discipline of project management is highly influenced by trends which take place in general management.

Currently, increased customer orientation is one of the significant trends in general management as well as management of projects on the whole. Many companies, especially those specializing in large, engineering intensive capital goods, concentrate their operations on the provision of high-value *integrated solutions* instead of stand-alone products and services (Hobday et al., 2005; Hellström and Wikström, 2005; Davies et al., 2006). This concept sees the nature of projects as a "mixture" of goods and services, but it is more than just that. The goal is to create value for the customer: to provide a solution-package that is aimed at fulfilling the customer's specific preferences and wishes, which potentially includes a wide range of financing, consulting, and, operation and maintenance services. It is argued that these innovative combinations of products and services constitute the project-based firm's competitive advantage (e.g. Foote et al., 2001; Galbraith, 2002; Davies, 2004; Hamel and Prahalad, 1994). Delivering integrated solutions is associated with high complexity (or *structural complexity*, in Williams' (2005) terms) as the size, number and interdependence between the project elements are extensive. According to the literature review performed by Williams (2005), there is another inseparable element that is inherent in projects which affects complexity positively: uncertainty, specifically uncertainty in project goals and means to achieve those goals.

Although industrial projects are often described as complex and even unique undertakings with

restrictions on time, costs, scope and quality, in a multi-project context these undertakings often have a more repetitive nature. This provides the ground to argue for the need to keep a balance between standardization and customization in order to achieve the benefits that are usually associated with both these issues (Davies and Hobday, 2005). Such a balance in project business can be referred to as *modularity* (Hellström, 2005; Melkin et al., 1999). Furthermore, these trends became the basis for new value logic, where a cost-effective well structured offering can be upgraded with additional modules on demand; thus endeavoring to create repeatable solutions (Davies and Brady, 2000). This logic assumes that cooperation with project customers is crucial in order to be able to configure the solutions-packages. In sum, modularity can be seen as means to control complexity and uncertainty in projects.

Increasing customer orientation and focus on core competences have been one of the key tendencies of project business, followed by the trend towards turn-key contracting. The word *project* itself has become popularly used among practitioners to stress customer focus, and the temporary nature and certain uniqueness of the undertaking. The researchers in the field have followed suit by stating that any endeavor that is considered important from the customer's perspective deserves to be named a project (Artto et al., 1998), and have labeled the phenomenon in question *projectification* (Midler, 1995). A more recent trend is to recognize uncertainty as a distinctive characteristic of projects in line with the other above-mentioned traits (P2M, 2005; Kutsch and Hall, 2005; Atkinson et al., 2006; Maytorena et al., 2007; Zayed et al., 2008). Uncertainty is seen as a factor that affects complexity positively: high uncertainty increases project complexity (Williams, 2005). However, the difficulty lies in the fact that the researchers in the field lack common understanding as to what uncertainty and uncertainty management means for project professionals and project-based firms. Some researchers include it in the project complexity construct (e.g. Floricel and Miller, 2001; Williams, 2005), the others treat it as a part of risk construct (e.g. Kutsch and Hall, 2005; Zayed et al., 2008). Project risk management normative literature (PMBOK, 2000; 2004; Chapman, 2006 referring to PRAM 2004 and RAMP 2005) has a rather strong influence into how uncertainty is interpreted. Generally speaking, it does not recognize uncertainty as an issue that is separate from risk. As Chapman (2006) summarizes:

"At present users can be badly served by guides and a broader literature which is confusing because it uses very basic words like 'risk' in very different ways, and it assumes very different objectives are at stake, with very little discussion in the literature about the implications of these differences" (p.313).

Although some researchers recognize uncertainty as a stand-alone issue (Atkinson et al., 2006; Pich, Loch and De Meyer, 2002; Loch, Solt and Bailey, 2008), there has been little empirical research conducted to confirm how uncertainty, risk and opportunity are related, and should be regarded as independent issues that require different management methods. The aim of this work is to cover this gap by exploring the issue of uncertainty and the uncertainty management process. This assumes an inquiry into how project management professionals treat as uncertainty in projects and how they act upon it — in other words, how they manage it. In addition, the thesis also seeks to examine how the uncertainty management methods that are applied relate to the success of a single project, as well as a series of continuously on-going projects, which could be interpreted as a project-based company.

1.2   Projects and project-based firms

The theoretical base for project management has been developed to a large extent by the Nordic researchers (e.g. Lundin and Söderholm, 1995; Lundin and Hartman, 2000; Lundin and Midler, 1998; Artto and Wikström, 2005). In this work, I operate mostly with the concepts of projects and project-based company, which are both related to that of project business. I use the following terminology that has been established in the project management field:

- Project-based firm (Wikström et al., 2009; Lindkvist, 2008; Keegan and Turner, 2002),
- Project-based company (Lindkvist, 2001),
- Project-based organization (Lindkvist, 2008; Davies and Hobday, 2005),
- Project business (Artto and Wikström 2005; Hellström, 2005).

Researchers understand project business as the business of delivering large scale capital products and services with all its elements (Hellström, 2005). For example, Artto et al. (1998) define project business as all the activities of the company — a project company — that executes and delivers projects for its customers. Wikström (2005) argues that various situations in projects demand for adaption and flexibility, and this requires structures in the products and processes that are instable and thereby adaptive to various, often changing needs. According to Lindkvist (2008), firms investing in a project organization are motivated by the need to achieve flexibility, adaptability and support customer-orientation in their operations. This is motivated by the fact that projects are executed in the continuously changing, if not turbulent, business environment of today. As stated by Floricel and Miller (2001), the causes of the turbulence are the increasing complexity and the *relevant uncertainty* of the environment produced by technological change and competition. As a result, the consequences of strategic managerial actions become unpredictable. Firms need to adapt to change by establishing, developing, and reshaping their core competences as well as by increasing flexibility and robustness (Teece et al., 1997; Floricel and Miller, 2001). Project organization appears to be the most suitable platform to promote such processes within a firm. Furthermore, projects can be regarded as a way of testing the newly built processes — a part of a trial-and-error based strategic learning (Lindkvist, 2008). This is indeed an evolutionary process, which is driven not only by the environment, but also by the members of the (project) organization with their aims and understandings (Levitt and March, 1988; Weick, 1989). As to project-based firms, the day-to-day work of which, according to Keegan and Turner (2002), is delivering products and services for bespoke designs for customers, the increasing complexity of their business environment implies that there is a need to innovate in order to stay competitive in the market and expand the business. The uniqueness of the solution — a bespoke package of products and services for a customer needs — suggests that, in a way, innovation (either incremental or radical) is an inevitable part of any project. Consequently, so is uncertainty and complexity which are associated with the non-routine tasks (Shenhar et al., 1995). As argued by Jauch and Kraft (1986) and Meijer, Hekkert and Koppenjan (2007) among others, uncertainty is a precondition for innovation.

There exist a considerable number of definitions as to what a project means in the extant project

literature (Midler, 1995; Lundin and Söderholm, 1995; Artto et al., 1998; Turner and Müller, 2003; ICB IPMA Competence Baseline, 1999). For example, Turner and Müller (2003) conclude that:

> *"A project is a temporary organization to which resources are assigned to undertake a unique, novel and transient endeavor managing the inherent uncertainty and need for integration in order to deliver beneficial objectives of change"(p.7).*

The descriptions to be found of projects all adhere to the following attributes or characteristics of these undertakings:

1. Temporary nature of projects, which have a strict timeframe.
2. Uniqueness in terms of mission: scope of work, specification, outset, tools and processes to be utilized and/or other.
3. Orientation towards achievement of the objectives, which are well specified a priori.

A project is indeed a value creation undertaking with a fundamental purpose for which the project is created and the project is expected to achieve. Such a fundamental purpose — or mission — is often seen as oriented towards customer preferences, or even more apparently, dictated by the customer. It is especially true if the outcome of the project is not a stand-alone service or product, but a complete solution consisting of products and services specifically tailored to customer needs (Davies and Hobday, 2005; Davies et al., 2006; Hobday et al., 2005). The latter, solution-oriented logic, is gaining dominance today. For instance, Hellström (2005) denotes that companies tend to label their activities projects in order to stress customer orientation. The set of tasks and requirements, definitions of objectives, guidelines, policies, strategy and essential action plans is the practical application of the mission with the aim to satisfy customer needs. It is the task of a project team and its leader is to find out how to run these activities in order to fulfill the objectives.

Each of the involved project stakeholders has their own perception of objectives, goals, resources and uncertainties. Therefore, the strategies that actors consider beneficial to deal with them are also different (Meijer, Hekkert and Koppenjan, 2007). A mutual attempt to reach project goals benefiting of all the members of the undertaking is reflected in a term *project's mental space* (P2M, 2005)*:*

"The project's mental space refers to a space where stakeholders recognize the value of a project mission and carry out work; it is the virtual, motivational space where stakeholders commit themselves to the project from a variety of geographical, cultural, specialized and organizational spheres, and help to build interaction and collaboration through mutual exchanges based on monitoring and communications as well as information exchanges"(p.20).

This concept, which with no doubt is of a reflective nature (at least as opposed to rigidity in Gustafsson and Wikström's (2004) terms), is highly related to that of project performance. The latter is assumed to be greatly influenced by whether or not the project can create an active project mental space. As noted by Atkinson et al. (2006), key performance issues (such as quality, duration or costs of the project) are often less related to technology, but rather are related to uncertainty introduced by the existence of multiple parties and the associated project management infrastructure. Similarly to Meijer, Hekkert and Koppenjan (2007), they conclude that project actors contribute to uncertainty, and the effect of this uncertainty on project performance can be substantial. They list the following project actors-related factors (Atkinson et al., 2006, p. 688):

- uncertainty about the level of performance that will be achieved;
- the objectives and motivation of each party;
- the quality and reliability of work undertaken;
- the extent to which each party's objectives are aligned;
- with the project owner's objectives, and the scope for moral hazard where one party is motivated to do things which are not in the best interests of the project owner;
- the actual abilities of the party;
- availability of the party.

It also relates to the way the project is organized and the risks such organization potentially entails. Here is the quote from the P2M (2005) guide illustrating the issue:

"Where a project is executed through international consortium, the project would encounter misunderstanding and confrontation if attention is not paid to cultural diversity, resulting in higher risk of project failure" (ibid, p.20).

The uniqueness of a project might differ from case to case even in an industrial context, and

some repetitiveness might be feasible (Davies, Brady and Hobday, 2006). However, industrial projects are usually associated with the creation of engineering — and investment, as well as intensive goods and services. Speaking in terms of delivering integrated solutions in typical industrial contexts such as shipbuilding or oil and gas, there is a certain high level of complexity involved. Indeed, the outcomes of the project-based industries are so called *complex products and services* (Hobday, 1998), which imply a high level of uncertainty related to their delivery. The rising complexity and innovativeness require making uncertainty an essential part of the description of a project, without which the project cannot be defined as such (Shenhar et al., 1995).

Due to specific conditions and situation, in which projects are executed, the achievement of the project mission is affected by uncertainty. The most common interpretation of uncertainty in the extant literature on projects is the risk and/or uncertainty caused by unreliable information or lack thereof (Pich, Loch and De Meyer, 2002; Chapman, 2006; Kutsch and Hall, 2005); novel, immature or unproven technology (Meijer, Hekkert and Koppenjan, 2007), project complexity (Williams, 2005; Floricel and Miller, 2001; Sommer and Loch, 2003, 2004) and other unpredictable factors. In projects, these risks are overcome by proactively employing project manager's and team members' combined knowledge, judgment based on experience and creativity (e. g. Maytorena et al., 2007; Gustafsson and Wikström, 2004; Perminova et al., 2008 (a)). The last point causes researchers to consider project (team) members representing different functional specialties, who are forced to coordinate their activities and exchange task-relevant knowledge, as yet another distinctive characteristic of projects and project-based organizations.

1.3   Project management professionals and the management approaches

The contemporary phenomena in project business requires a new body of professional human resources that are able to deal and solve complex problems and issues that encompass different fields

of knowledge: technology, law, finance, management, etc. The creation of new business models, governing processes, applied tools require a broad spectrum of skills, expertise and experience to be applied. The project management guidelines and competence frameworks of today consider project manager as a broad-spectrum professional. IPMA requires 46 elements to describe the competence of PM as the professional specialist who plans and controls the project from three ranges of the project management competences: the technical range, the behavioral range and the contextual range (ICB, 1999)[1]. In line with this thinking, the researchers in the field of project management come to the conclusion that ensuring flexibility and robustness of a project-based firm is the task of the project management professionals (Floricel and Miller, 2001; Gustafsson and Wikström, 2004).

This thesis adopts the following definition of a project management professional: a Project Manager is described as an individual who acts in a transparent manner for the sake of the whole project, program or portfolio to satisfy the expectations of the customers, the partners delivering goods and services for the project, and the other interested parties (ICB, 1999). Same definition apples to a warranty manager, who is a part of the project team and supervises the early post delivery (warranty) phase of the project[2]. Project manager is seen as one of the four most important stakeholders deciding on the criteria for project success in post delivery stage in

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[1] The ICB contains basic terms, task, practices, skills, functions, management practices, methods, techniques and tools that are commonly used in project management (PM).

[2] It must be noted that the project managers' roles discussed in this thesis assume the overall responsibility for the project including the warranty phase. This means that even if the warranty manager is supervising early post delivery and acts as a customer interface during this phase, the project manager is held responsible and reports the project status, profits and results to the top management. While the functions of both of these project management professionals are nearly similar, the responsibilities of the project manager are wider than of the warranty manager. Warranty manager's project management responsibilities are limited to the early post delivery stage. In this thesis the term *project management professionals* will cover both project and warranty managers.

line with the firm's top management, project customer and other team members (Atkinson, 1999). Furthermore, the researchers argue that the project outcomes are influenced by the power of the project manager (power-distance in Hofstede's (2001) terms), and by individuality/collaboration (Williams, 2005). Among the tasks of these project professionals is the involvement and motivation of other specialists to use their knowledge and experience for the benefit of the project. Another project management handbook aimed at practitioners, *Project and Program Management for Enterprise Innovation Guidebook* (P2M, 2005) labels project managers as mission-achievement-type professionals. However, the Guidebook also notes that there have been almost no experts who have covered such broad fields as the modern projects might wish for.

In general, both normative project management literature and especially the research in the field point out that the need has arisen for project management experts who are able to grasp the overall picture of complex issues, which are usually only comprehensible to separate experts, or turn issues into highly feasible scenarios as well as create value by utilizing the different mechanisms and processes. This is especially true in case of dealing with complex large-scale projects and the situations of uncertainty. In the empirical study, Shenhar (2001) concludes that the management styles and approaches depend on the level of (technological) uncertainty of the project: the higher the uncertainty, the more flexibility is required from the managers. Olsson (2007) discusses the need to address uncertainty and opportunity management in projects as opposed to rigid project management thinking. He presents three major factors needed for managing opportunities: the ability of the project manager to develop a holistic view within the project, the organizational support and interest, and the ability to understand how other organizations affect the project objectives. Håkonsson (2006) explores the relationship between managerial cognitive orientations and situational uncertainty to organizational performance. The author concludes that a match between managerial cognitive orientation and situational uncertainty has positive performance consequences.

While the normative literature is mostly focused on planning and thus stresses the role of the project manager as the creator and the executor of the Project Plan (PMBOK 2000, 2004), the researchers emphasize the fact that the project mangers (and warranty managers, for that matter) need to consider a wider array of functions (e.g. a review in Williams, 2005).

Andersen (1996) criticized excessive focus on activity planning, and proposed an alternative concept of goal-based milestone planning which stresses project responsibilities as a central element of successful project execution. According to it, the role of the project management professional helming the project is to manage and control the project together with the project team in such a way that the goals are achieved. Loch, Solt and Bailey (2008) extend the discussion by introducing the management approaches based on learning and experimentation (in this case, trial-and-error learning and selectionism) as opposed to management with deadlines and targets. It is argued that these kinds of approaches are better targeting unforeseen influences and, thus, uncertainty (Pich, Loch and De Meyer, 2002; Atkinson et al., 2006). Project-based organizations require professionals that are capable of bringing in different perspectives to problem solving tasks based on their experience and expertise in practical business. Openness to new knowledge and the ability to obtain knowledge both on the individual level of a project manager and as a member of a project firm are equally stressed in the context of organizational learning, innovation and management (Atkinson et al., 2006; Olsson, 2007; Sommer and Loch, 2003; Chapman, 2006).

In this light, the practices of project management need to be extended along with other topics and compared to standard PM as a process for rational execution of the planning of the undertaking. An important task of the undertaking is to conform to what has been planned, yet this task should not be overemphasized. In other words, the need for performance is stressed. P2M (2005) proposes the creation of a mechanism of innovation stating that partial optimization of innovation is not enough in modern society. The mechanism is created by attaching importance to ideas that create value, and is aimed at developing manufacturing into a new business model by combining non-technological elements with manufacturing. Solution-oriented ways of thinking assumes that there is a shift from traditional control-type project managers to project-setting personnel (ibid.). The latter category is assumed to be able to manage issues on a higher strategic level, dealing not only with individual project tasks, but also considering his/hers tasks and roles from a company perspective. However, the normative literature does not give an answer as to how to achieve these high-level goals.

Pich, Loch and De Meyer (2002) summarize the limitations both the normative literature and the research in the field of project management have:

> *"The existing project management approaches advocate partially conflicting approaches to the project team, such as the need to execute planned tasks, trigger preplanned contingencies based on unfolding events, experiment and learn, or try out multiple solutions simultaneously. While all of these approaches encompass the idea of uncertainty, no conceptual model currently exists that enables project managers to understand why different approaches exist, which one to choose, and when. As a consequence, project failures are numerous in practice; for example, budget and schedule overruns, compromised performance, and missed opportunities, (see, e.g., Morris and Hugh, 1987...)" (p.1008)*

This summary outlines the limitations of the current project management research which are the motivation for this thesis. In this work, I will focus on exploring the uncertainty in projects from the point of view of the project management professionals using the multiple case study approach. The thesis aims at gaining a better understanding of what kind of methods project managers use to address uncertainty, why and when they are applied. At the same time, I attempt to show that the managerial ability to cope with uncertainty is one of the tasks that precisely fit into the strategic mission-achievement category, and thus has an impact on the project-based company's overall performance.

1.4   Aim of the thesis and research questions

The complexity, innovativeness and certain, although limited, uniqueness of projects, all presume a degree of uncertainty associated with them. Being bounded by budget, scope, time and quality, projects strive for the ultimate goal of performing to satisfy the customer needs. In order to avoid unforeseen situations and risks that can challenge this goal, traditional Project Risk Management (e.g. PMBOK, 2000; 2004) particularly emphasizes careful and explicit planning that "*enhances the possibility of success of the risk management processes*" (ibid., p.242). The practical evidence suggests that project managers tend to rely heavily on planning as a means of defining pathways through different stages of a project life cycle. Such an approach seems understandable at a first glance. However, there is another side to the coin: conforming to the plan is potentially harmful to customer satisfaction and other project performance

indicators (e.g. Andersen, 1996). Moreover, it can delimit one's abilities to pursue opportunities, which appear during the course of the project.

This contradiction between planning and performance led the researchers, in the field of strategy, to critically question the overemphasis on planning (Mintzberg, 1994; Andersen, 1996; Dvir and Lechler, 2004). The recent project management literature is oriented towards this trend. Coordination-oriented project management is increasingly criticized for being too rigid, stressing conformity to the plan rather than performance (Gustafsson and Wikström, 2004; Perminova, Hellström and Wikström, 2007; Perminova et al., 2008 (b)). The role of a project manager within this approach becomes quite mechanistic in the strict following of the plan, whereas the constantly changing project environment — and the uncertainty associated with it — demands flexibility from project organization and its decision-makers (Youker, 1992).

These tendencies bring to light the problem of how uncertainty is treated by the established project risk management field. In traditional project management, the term *uncertainty* is often used as a synonym for project risks. In sum, risk is seen as an uncertain event and its consequences as being potentially both negative and positive as to the project's outcomes. Thus, the issues of project uncertainty, risks and opportunities are encompassed by one definition, which leads to the situation, where the same managerial means are prescribed to cope with them. If we consider PMBOK (2004) as one of the most respected and popular guidelines to practitioners in project management field, we will find that it discusses risk management as a supportive function, however, opportunity management and uncertainty management are not recognized as separate management processes. Rather, they seem to be included into risk management processes in a similar vein as the definition of risk is embedded into uncertainty and opportunity. Rather many researchers operate with the similar definition of uncertainty as the aforementioned guidelines and/or do not make a clear distinction between the constructs of risk and uncertainty (Zayed et al., 2008; Kutsch and Hall, 2005; Floricel and Miller, 2001).

However, the idea of recognizing project uncertainty as a separate issue, which needs to be addressed with different managerial approaches than risks or even opportunities, has slowly, but steadily gained commitment among the researchers of project management. The studies

performed during the last decade reveal that project risk management practices tend to fail when it comes to managing uncertainty (e.g. Jaafari, 2001; Chapman and Ward, 2002, 2003; Chapman, 2006; Kutsch and Hall, 2005). The researchers specifically note that the concept of uncertainty management is strongly related to opportunity management (Olsson, 2007; Atkinson et al., 2006). They show the need to move from conformance-based measures to strengthening real performance (Andersen, 1996; Maylor, 2001). The latter has a strong influence on how uncertainty and opportunities are managed in complex projects (Pich, Loch and De Meyer, 2002). Although the researchers in the emerging field of project uncertainty management suggest that uncertainty requires different approaches in management as compared to risk, the empirical support of their ideas is to a large extent missing. There is a significant number of works theorizing uncertainty in strategic management (e.g. Porter, 1980; Child, 1972) and organization theory literature (Milliken, 1987; Downey and Slocum, 1975; Huber, O'Connell and Cummings, 1975; Weick, 1995; Sutcliffe and Zaheer, 1998) which can provide significant input into project management field. But there is a general lack of agreement among scholars as to what uncertainty is in the abovementioned research fields. Thus, the views on uncertainty and uncertainty management practices derived from strategy and organization theory fields need to be systematized and adopted to the realities of project management.

In the light of the outlined limitations of the project management research, there is a need to address the issue of uncertainty and the management practices related to it in greater detail. The aim of this thesis is to explore the issue of uncertainty in projects and gain a better understanding of the uncertainty management process and its elements. Therefore, the following questions are relevant:

- What constitutes uncertainty for project management professionals (project managers and warranty managers)?
- How does uncertainty relate to risks and opportunities?
- What kind of methods or actions project managers and, subsequently, project-based companies employ to deal with uncertainty?
- How does uncertainty management, according to project professionals, affect performance of a single project and a project-based firm in a whole?

To be able to consider the abovementioned issues, the following research questions are raised:

Qa.   How do project management professionals manage uncertainty?

Qb.   How does uncertainty in projects relate to risk and opportunity?

Qc.   What kind of methods do project management professionals use in projects in order to lessen the possible negative impact of uncertainty and take advantage of it?

These questions entail gaining understanding of what project managers treat as uncertainty and how they act upon it. In other words, what kind of methods they apply to manage uncertainty and how they relate the results of these activities to project performance from the supplier company's perspective. The nature of uncertainty in projects, its relation to risk and opportunity, is described as viewed by the project managers and the warranty managers as professionals leading the projects.

The unit of analysis lies on two interdependent levels: at the project level and the project manager (project management professional) level. To some extent, the research questions encompass the project-based supplier firm. In such a case, the project-based firm is seen as a set of more or less repetitive projects — a multi-project context — governed by project professionals. In other words, by looking at projects of a supplier firm, what can be said about the way uncertainty is managed? It must be noted that I limit my research to considering the matter only from the project-based supplier firm perspective.

1.5   Intended contribution

The research questions address the way project management professionals manage uncertainty in individual projects, i.e. the issues of project management. It is an inquiry into how project management functions are applied in practice. In a way, this entails the interest into the impact uncertainty and uncertainty management practices have on the overall performance of a

project-based firm. At the same time, it also entails certain interest in how project-based companies are organized by looking at the processes and competences that are being utilized and developed over time. This research shares the point of view that a project-based company can be treated as an organization formed and determined by project management professionals, a consideration, which allows the extending of their expertise and opinions into the project-organization context. Such a desire is justified by the recent trends in project management and organization research as well as studies of professional experts (Olsson, 2007; Miller, 1993; Fuglseth and Grønhaug, 2000).

Theoretically, this work contributes first and foremost to the field of project management by providing a missing conceptual and empirical basis for uncertainty management. It provides a synthesis of the theories of project management, strategic management and organization theories to explain the relevance of the concept of uncertainty and its implications for management practices. Furthermore, it partially contributes to strategic management literature and organization literature by clarifying the relevance of reflective management practices for uncertainty management. This work provides empirical evidence testifying as to the relevance of several elements of managerial processes (communication and commitment, among other) in uncertainty management.

This thesis touches upon the questions raised in literature on judgment and decision-making and on cognitive science. Task handling under uncertainty has been among the most popular topics in this area. Reflective processes and their constituting elements, such as experience (or expertise), information, interpretation and so forth, and they way they impact uncertainty and thus performance, has drawn a lot of attention from researchers in these fields. Different methodological approaches were employed to reach the results that proved to be contradictory. Although this thesis does not consider behavioral theories and the process of decision-making as such, it addresses similar questions in terms of actions and factors that these theories predict to have an impact on uncertainty. One of the questions raised in the literature in the field of cognitive sciences is reflected in the research question of this work (e.g. Miller, 1993; Fuglseth and Grønhaug, 2000): what kind of (uncertainty-related) issues there are and how they affect the performance of experts (managers). The question can also be looked at from a different

angle i.e. the means by which experts- managers utilize and transfer their experience within organization and with other project stakeholders and the effects this has on the outcomes (risk or opportunity). These two bodies of science regard expert performance as related to the handling of a task, which is uncertainty management in this case. Since the performance of a project-based organization is constituted of the multiple performances of its members on individual project levels, these questions to some extent are addressed in this work.

The practical contribution of this thesis is expected to emerge through the fieldwork that the author undertook to collect and analyze the empirical data (especially considering Company B cases). The empirical data emphasizes the importance of adopting lifecycle perspective in projects, specifically drawing more attention to warranty. In general, the relevance of this study is foremost in explaining the new management concept (uncertainty management) for project-based firms.

1.5.1   Early post delivery stage of projects as a reflection point

In contrast to the operational research and production economics literature, the research in the project management field pays little attention to the early post delivery stage of projects[3]. This is due to the fact that the project management research field is, to a large extent, focused on the actual process of delivery, in other words, the project execution phase. The moment, when the endeavor enters the warranty phase (sometimes called the hand-over from project execution to warranty), is seen as the end of the project. At the same time, some studies in the field suggest that the post delivery stage is an important reflection point to determine the success of the project (Atkinson, 1999; Deane et al., 1997) or project efficiency (Shenhar et al, 1997). For example, Shenhar and his colleagues (1997) proposed

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[3] In this thesis, it will be referred to as warranty stage of the project.

on the basis of the results from 127 projects a multidimensional framework for measuring project success. Three of the four criteria chosen for the measurement belong to the post delivery phase, and one in particular, referring to the customer satisfaction, is attributed to the early post delivery within couple of weeks after implementation. The latter clearly belongs to the phase that later in the text will be referred to as project warranty phase or the beginning of operations.

One reason which explains this situation that the post delivery stage, and especially warranty, lacks attention both in project management research and practice lies in the fact that warranty is perceived as merely a legal obligation, the responsibility of the manufacturer in the event of early product failure (Chattopadhyay and Rahman, 2008) rather than a management process. Another, perhaps, more important reason for the practitioners is that when the project is at the warranty stage, its outcomes are already in use by the customer. Indeed, the beginning of the warranty phase implies the start of the operations — the process, where the supplier is not in charge any more. From this perspective, the main role of the warranty is in stating higher reliability of the end product and giving peace of mind to the customer. This is why the role of the warranty managers is seen as rather reactive in responding to claims. However, recent trends in many industries, especially the automobile industry, indicate that the warranty is important to the company's performance not only in terms of showing commitment to the customer and providing better offerings (Kim and Park, 2008). For the large-scale solution providers, the warranty period appears to have a significant impact on the performance on both a single project level and a company level.

Project life-cycle approach

SALES   PROJECT   WARRANTY

Traditional project
management focus
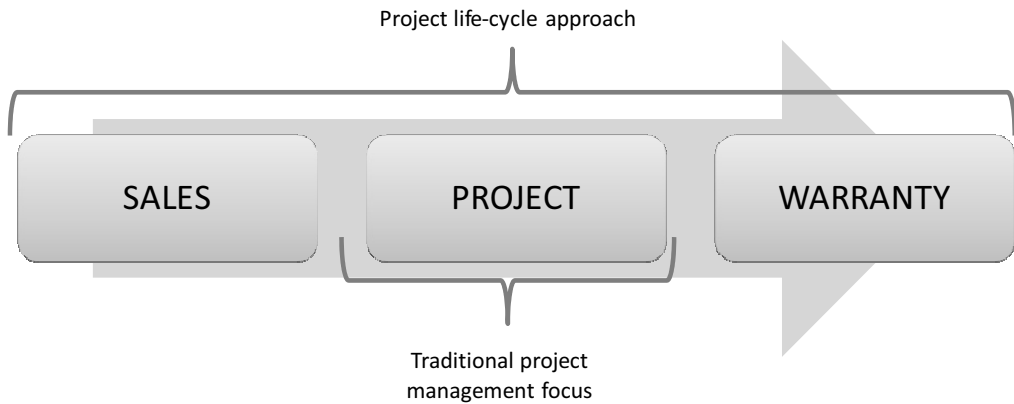
Figure 1. Project life-cycle approach in comparison to project execution focus

At the same time, the warranty phase appears to be a convenient observation point with regard to studying the events and their outcomes that took place during the project's execution. Handing-over to warranty is also the point when the performance of an installation (e.g. engine, power plant, etc.) is tested to verify that the technical performance parameters are in accordance with the ones agreed with the customer contractually. At this point many companies prefer to measure the customer or other stakeholders' satisfaction using different methods. An example of such a method is a relationship monitoring process with the aim to reflect both the customer representatives and the project team's internal perception of the project, expectations and satisfaction with the overall project results (Gustafsson, Smyth, Ganskau and Arhippainen, 2010). Ultimately, the internal level of satisfaction with the project work, the output and the customer's — or any other stakeholder's — perspective on it can be grasped and evaluated, so that corrective actions can be implemented accordingly.

The start of the operations marks the beginning of the warranty phase in the project. At this point, it is the customer (or the customer's representative), who is at the helm of the operations. However, the supplier company stays in the picture: its role as a contractor is to provide a guarantee for the performance of the project. The operations management literature describes warranty as a guarantee that holds the contractor accountable for the repair and replacement of

deficiencies under his/her control for a given period of time (Cui et al., 2004). Most of the warranty provisions require that the contractor agrees to compensate the customer for the failed items within a certain time limit — after the time of sale or/and after a certain time of usage (Samatli-Pac, and Taner, 2008). The warrantor evaluates and accepts the warranted items according to the performance criteria, which are stated in the contractual documentation.

The operational research field addresses warranty in two distinct dimensions. On one hand, the authors in the field explore different cost reduction strategies for the warrantor, focusing on the methods of warranty claim, data analysis, and cost analysis (e.g. Thomas and Rao, 1999; Karim and Suzuki, 2005; Samatli-Pac, and Taner, 2008). On the other hand, they see warranty as a marketing tool used by producers to differentiate their company from their competitors (Wu et al., 2009). Indeed, the length of warranty is often associated with the reliability of the offering in the customer's eyes. Furthermore, both these parameters have a strong impact on the supplier's pricing strategy determining the total cost of the offering.

In general, the warranty phase determines to a great extent how the project is evaluated by the main stakeholders, especially the customer. The costs stemming from the customers' claims represent the main impact that the project faces during the warranty phase. Moreover, they affect not only the financial result of the project as such, but also the performance at the company level. In the operational research literature the duration of warranty coverage and the costs are closely linked with the issues of risk and uncertainty. Namely, the longer the coverage period of warranty the greater the risk due to uncertainty of failure mechanism and costs (Chattopadhyay and Rahman, 2008). Some authors in operations research link negative business consequences of uncertainty to customers' imperfect beliefs about the quality of products and services of the producers. In the case of manufactured products, the negative consequences of such uncertainty are mitigated by offering warranties (Bhargava and Sun, 2007).

1.6   Selection of methods for the study and personal motivation

The diploma work that I defended at St. Petersburg State University, Faculty of Economics, as a result of my 5-year graduate studies, was dedicated to the insurance market for international aerospace projects. It indeed enhanced my pre-understanding of the topic, especially in terms of the difference between the concepts of risk and uncertainty, which are central to the insurance field. However, this work explored the insurance provider perspective rather than that of a project-based company. The latter perspective was gained through my participation as a researcher and a member of the Research Institute for Project-Based Industry in several studies and development and implementation projects for various industrial suppliers (e. g. Westerholm and Perminova, 2007; Perminova, Gustafsson, and Arhippainen, 2007 (a), (b); 2008). These projects served as a platform for data collection, investigation, development and testing of the concepts and processes, which will be presented in this thesis. I was part of the team of researchers and practitioners, who were pursuing a common goal to explore the relevant issues and interdependences, to analyze their relevance and impact and to co-create and test the management processes in the projects. PBI Research institute employed a wide variety of methods including those under the umbrella of clinical, collaborative management and constructivist research in line with the more conventional approaches. This fact explains the choice of methods employed in this thesis, especially when it comes to Company B cases which constituted a part of the development and implementation research project (Perminova, Gustafsson, and Arhippainen, 2007 (a), (b); 2008). These methods assume that the role of the researchers and the practitioners in the projects was not equal. While my role as a researcher assumed involvement in all the stages of the research: from the problem formulation to data collection and analysis, as well as the development of the concepts and models, the role of the practitioners was mainly concerned with shaping the problem, providing the data for the research and the practical verification of the results. I will return to the description of the methodology of the study in detail in the respective chapter (III).

1.7   Outline of the study

This study is structured as follows. In the following chapter, *Theoretical framework*, I will discuss the existing literature on the subject of uncertainty paying special attention to the relevant fields of project management, strategic management and organization theory. The third chapter of this thesis is dedicated to the methodological standpoints. The research process adopting the multiple case study approach is described following the logic of the acquisition of empirical data, analysis and validation of results. The empirical core of the study, the eight cases, are described in the forth chapter. They are divided in accordance with the industry and the companies from which they originated. The *Data analysis and discussion* part includes the classification and comparison of the studied cases as well as the results of the qualitative analysis of the main concepts in question. These are discussed in the light of the extant literature. The last chapter is dedicated to summarizing the conclusions of this thesis and provides insight into the possibilities of future research.

II   THEORETICAL FRAMEWORK

Uncertainty has long been a central "ingredient" in a wide array of theories of organization and strategy. As for project management, the concept of uncertainty needs to be further clarified in order to justify its practical relevance. This chapter has two tasks to fulfill. Firstly, I aim to define the concept in relation to the other terms, which are closely associated with it — risk and opportunities. Secondly, I will address how uncertainty is related to organizational issues and organizational action.

2.1   An overview of the concept of uncertainty in relation to risk and opportunity

Uncertainty has been named a fundamental problem with which top-level organizational administrators must cope in organization theory (Thompson, 1967). Strategic management literature views uncertainty as a major factor affecting key strategic decisions (Porter, 1980; Sutcliffe and Zaheer, 1998). Indeed, uncertainty is one of the most important topics in theories of organization, strategic management and organization economics, especially those that seek to describe the interrelations between organizations and their environments. In other sciences, uncertainty concept is also widely used (see). Generally speaking, project management, as well as other branches of administrative science, builds the understanding of uncertainty upon the constructs employed in economics and psychology. Quite commonly, uncertainty is defined in contrast to risk (or vice versa), which is why these two definitions are juxtaposed in Table 1.

Table 1. Views on uncertainty and risk derived from different disciplines (adopted from   Perminova et al., 2008 (b)

DISCIPLINE	RISK	OPPORTUNITY	UNCERTAINTY
Economics	Risk refers to events subject to known or knowable probability distribution (Knight, 1921)	In business literature, a positive environmental impact is usually described as an opportunity (Ansoff, 1980)	Uncertainty is a situation for which it is not possible to specify numerical probabilities (Knight, 1921) Uncertainty is a state in which individual actors find it impossible to attribute a reasonably definite probability to the expected outcome of their choice (Keynes, 1937)
Psychology	Risk is the fact that the decision is made under conditions of known probabilities (Stanford Encyclopedia of Philosophy, 2009)	Opportunity consists of the particular configuration of the field of forces surrounding a person and his or her task that enables or contrains that person's task performance and that are beyond the person's direct control (Blumberg and Pringle, 1982).	Uncertainty is a state of mind characterized by a conscious lack of knowledge about the outcomes of an event (Head, 1967)
Philosophy			Doubt presupposes certainty (Wittgenstein, 1986)
Org. theory			Uncertainty emanates from a set of objective but largely unmeasured environmental characteristics (Jauch and Kraft, 1986)
Common sense (dictionary)	The possibility of something unfortunate happening at some time in the future; the situation that could be dangerous or have a dire result (Oxford Dictionary of Current English, 2005)	A favorable juncture of circumstances; a chance of advancement or progress (Merriam-Webster Dictionary on-line, 2011)	Uncertainty is the state of being uncertain; something you cannot be sure about (Oxford Dictionary of Current English, 2005)
Project management	Risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on at least one project objective, such as time, cost, scope or quality (PMBOK, 2004)		

On the basis of the information shown in Table 1 it is possible to conclude the following:

- The concept of uncertainty is different from the concept of risk in the presented fields of science. However, project management does not make a straightforward distinction between uncertainty and risk.
- Risk is described as an event, a fact or a condition with certain expected consequences with known probability distribution which makes it possible to assess, predict, or measure it, and thus, plan for it. Risk is objective.
- Uncertainty is described in two ways: as an objective phenomenon (e.g. a situation or a state of nature) and as a subjective phenomenon (it exists in the mind of a person who perceives it).
- In a general sense risk has a negative meaning. A mirroring concept for risk is opportunity, which is "*a favorable juncture of circumstances*", or a good chance of advancement, progress or gain (Merriam-Webster Dictionary on-line, 2010). Risk management integrates risk and opportunity under the umbrella of one construct.

As one can see from Table 1, project management discipline includes uncertainty into the concept of risk. This is an important standpoint, which has implications for how the concept of uncertainty is operationalized. If risk and uncertainty are one and the same concept, the ways to deal with them are somewhat similar, too. Despite the lack of conceptualization, there has recently been an increasing number of attempts to formulate what management of uncertainty in projects — or uncertainty management (a concept similar to *risk management*) — could entail (Atkinson et al., 2006). The common drawback is the fact that more empirical research is needed regarding the issue (Jaafari, 2001). Such empirical evidence is intended to help define the uncertainty concept and its management methods for project management, and not limiting it to only being a part of *risk* management. More importantly, it will provide necessary evidence as to what kind of actions and processes, as well as elements of project organization structure, etc. influence uncertainty. As mentioned earlier, significant research attempts to define uncertainty and its impact on organizations have been made in the fields of strategic management, organization economics and organization theory. They will be the subject of the next sub-chapter.

2.2   Uncertainty as a perceptive phenomenon

The Knightian definition of risk and uncertainty from the seminal work "Risk, Uncertainty, and Profit" (1921) is most frequently referred to (in Table 1). Due to the influence that *Knightian uncertainty* definition has had on management research, it is useful to take a closer look at the thoughts of this scientist. According to Knight, the word *risk* is ordinarily used in a loose way to refer to unfavorable contingency, and the term *uncertainty* similarly with reference to the favorable outcome. However, more importantly, Knight postulates that uncertainty — or *true uncertainty* — exists in junction with unique, very complex events, circumstances or contexts which cannot be assessed or predicted in advance by any logical means:

> *"Business decisions, for example, deal with situations which are far too unique, generally speaking, for any sort of statistical tabulation to have any value for guidance. The conception of an objectively measurable probability or chance is simply inapplicable... the... more important task is to follow out the consequences of that higher form of uncertainty not susceptible to measurement and hence to elimination...[4]"*

Although it is not susceptible to measurement and elimination, it can be acted upon, even with benefit, in other words, an opportunity can be pursued from it (as one might conclude given the parallel with the entrepreneurial income):

> *"It is this true uncertainty which by preventing the theoretically perfect outworking of the tendencies of competition gives the characteristic form of "enterprise" to economic organization as a whole and accounts for the peculiar income of the entrepreneur" (ibid.)*

In other words, one speaks of the risk of a loss, but to indicate the possibility of a gain, one uses the concept of *uncertainty*. Knight's explanation of profit as a reward for bearing uncertainty

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[4] retrieved from http://www.econlib.org/library/Knight/knRUP6.html#Pt.III,Ch.VII, last assessed on 30.08.2010.

stresses the understanding of uncertainty as opportunity. Indeed, this citation relates well to the nature of projects and the project-based firms activities.

Conceptualization of uncertainty represents a difficult challenge because this is a complex and a philosophically loaded issue. The problem of uncertainty conceptualization is related to another important consideration, which tends to disturb the methodological soundness of the research on uncertainty in general. Namely, is uncertainty an objective phenomenon or is it a matter of the individual's perception? In this light, another statement of Knight is crucial:

> *"We can also employ the terms "objective" and "subjective" probability to designate the risk and uncertainty respectively, as these expressions are already in general use with a signification akin to that proposed"[5]*

He postulates that uncertainty is inherently a subjective, perceptive phenomenon. Thus, in a given situation different individuals will experience uncertainty differently, and some will not experience it at all. A similar definition is used in decision theory, which denotes by uncertainty *"a condition of the environment of the decision maker such that he finds it impossible to assign any probabilities whatever to possible outcomes of an event"* (Head, 1967: 206). Hence risk is assumed as a condition in the environment in which the decision-maker presumes himself/herself able to give probabilities to outcomes of events, each probability being greater than zero.

To summarize, Knight shows that risk and uncertainty are different concepts. Risk is known, calculable and it can be foreseen, hence eliminated or avoided. Uncertainty is not subject to calculations, it cannot be eliminated completely, but it can be acted upon, for example, to gain benefits. However, the validity of the Knightian constructs is questioned by some scholars (Friedman, 1976; LeRoy and Singell, 1987).

In defense of the thought of Knight one can turn to quantum physics. The foundational

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[5] retrieved from http://www.econlib.org/library/Knight/knRUP7.html#Pt.III,Ch.VIII on 30.08.2010.

principle it builds upon is the uncertainty principle asserted by Werner Heisenberg. The implications of the uncertainty principle are of great value not only for quantum theory, but also for their profound impact on other scientific and philosophical disciplines due to the fact that uncertainty issues are not delimited to mathematical relationships — a conclusion similar to that of Knight. By showing that certain pairs of physical properties, such as the position and momentum of a particle, cannot be known simultaneously with any precision (in other words, cannot be certain), Heisenberg challenged the notion of simple causality in nature (American Institute of Physics and Cassidy, 2002). The logic is the following: if we cannot establish the state of nature (in this case, a particle) at a given instant, we cannot determine its future state. The philosophical implication of this work does not conclude everything in this world being uncertain; it rather suggests, according to Heisenberg, where the limits of uncertainty lie (1927)[6]:

> *"In the sharp formulation of the law of causality-- "if we know the present exactly, we can calculate the future"-it is not the conclusion that is wrong but the premise".*

The concept of uncertainty in physics builds upon the individual's lack of knowledge and understanding about the current state of the nature and the way this state might evolve. In other words, it is subjective as well. Compare this definition of uncertainty to the one that comes from psychology, where it is described as a state of mind characterized by a conscious lack of knowledge about the outcomes of an event. This description, in contrast with the ones presented above, allows us to assume that the external environment is not the only source of uncertainty; the latter can take the form of mental reaction of a human to the external environment. In this sense, uncertainty exists *"in the mind of the person who doubts"* (Head, 1967: 206). In management science, this approach gained support of the authors distancing themselves from a deterministic and rationalistic view in favor of a more relativistic view. At

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[6] According to www.aip.org/history/heisenberg/p08.htm by American Institute of Physics and David Cassidy, retrieved on 25.05.2009.

the same time, similar understanding of the concept can be traced in organization theory (e.g. state uncertainty as defined by Milliken (1987), which will be the subject of the next sub-chapter. A summary of the definitions of uncertainty as a perceptual phenomenon, its variables and the processes aimed at coping with it derived from the literature review are presented in Table 2.

Table 2. Definitions of perceived uncertainty and the processes and variables to manage it

STUDY	DEFINITION OF UNCERTAINTY	PROCESSES AND VARIABLES RELEVANT FOR COPING WITH UNCERTAINTY
Downey and Slocum, 1975	"Uncertainty can be defined as a state that exists when an individual defines himself as engaging in directional behavior based upon less than complete knowledge of (a) existing relationship with the environment, (b) existence of and knowledge of conditional, functional relationships between his behavior and environmental variables to the occurrence of a future (t_1) self-environment relation and (c) the place of future (t_1) self-environment relations within the longer time-frame ($t_2...t_n$) of a self-environment relations hierarchy ." (p. 571).	Uncertainty arises from the individual losing control of both of the situation and of one's self. Need for control, in turn, is dependent upon learning. Interpretative process of cognitive mapping of the environment is triggered by uncertainty in order to gain the meaning of the signals coming from the environment. The result of the mapping process is *less than complete* perceived knowledge.
Weick, 1995	"…in case of uncertainty, [people]… are ignorant of any interpretations." (p.91)	More information is required to remove ignorance. Sense making is seen as means to create more information and remove *equivocality* or confusion through managerial group discussions, trial and error, sounding out and the other similar means. Meanings are created though a collective process of interpretation. This is seen as an important part of organizing by clarifying and establishing values.
Brashers, 2001	"[Individuals] experience increasing uncertainty as the likelihood of event occurring or not occurring becomes equal." (p. 479)	Seeking or avoiding information, adapting to (chronic) uncertainty, social support and managing uncertainty management are stated as focal for the theory of uncertainty management process.
Sommer and Loch, 2004	"Unforeseeable uncertainty refers to the inability to recognize influence variables or interactions at the outset (the system state space is not fully known)." (p. 1343)	In situations when unforeseeable uncertainty is present two strategies can be used: selectionism or trial and error learning. The choice between the two depends, among other parameters, on the nature of complexity. In situations where the project team could have foreseen the variables and interactions, project risk management methods and contingency planning is recommended to be used.

McMullen and Shepherd, 2006	The authors adopt the definition provided by Lipshitz and Strauss (1997, in McMullen and Shepherd, 2006): "uncertainty in the context of action is a sense of doubt that blocks or delays action." (p. 135)	Action, specifically entrepreneurial action, is a result of either willingness to bear uncertainty or less perceived uncertainty. The lack of entrepreneurial action is often the consequence of unperceived opportunities.
Atkinson, Crawford and Ward, 2006	The authors treat uncertainty as somewhat a perceptual phenomenon. They conclude that "uncertainty results from vagueness, ambiguity and contradictions associated with lack of clarity because of lack of data, incomplete and inaccurate detail, lack of structure to consider issues, the working and framing assumptions being used to consider the issues, known and unknown sources of bias, limited control of relevant project players, and ignorance about how much effort it is worth expending to clarify the situation." (p.688)	Knowledge management and learning, both organizational and individual, are emphasized as major contributors to uncertainty management.
Chapman, 2006	"Uncertainty is lack of certainty in the simple common language sense… risk is the possibility of departures from expectations which matter." (p. 309)	Application of "Indentify", "Structure" and "Ownership" phases of PRAM 2004 (in Chapman, 2006) "to associate each source of uncertainty with a preliminary view of appropriate responses, each source of uncertainty and possible responses combination being referred to as an 'issue' (p. 311). Corporate learning is emphasized.

2.2.1   Uncertainty in the organization theory perspective

The dominant theme in the rational current of organization theory has been internal uncertainty reduction strategies. Most research in this field has focused on identifying and prescribing the ways managers can either reduce or absorb the negative consequences of environmental uncertainty, which has been recognized as an important variable in the explanation of organizational stability and performance. It has been noted that firms do not necessarily receive negative impact from uncertainty and risks; they can create opportunities out of it.

At a first glance, it may seem as if there is a common understanding as to what uncertainty stands for. At least, the researchers in many fields of management science, including theories of organization, interpret it as if there is agreement, when in fact, this concept does not have a common interpretation. One can take environmental uncertainty literature as an example. It interprets uncertainty as both a state of the environment of a firm, and a state of a person who perceives herself/himself lacking critical information about the environment (Milliken, 1987). Consequently, there are different definitions and operationalizations of the construct: *environmental uncertainty* and *perceived environmental uncertainty*. Generally, environmental uncertainty is defined as a perceptual phenomenon, especially within the contingency and behavioral streams (Lawrence and Lorsch, 1967; Tosi at al., 1973; Duncan, 1972; Downey and Slocum, 1975; Milliken, 1987, etc.), but the definitions diverge when it comes to specifying the nature of uncertainty which is anticipated. Milliken (1987) lists three common interpretations of uncertainty in organization theory:

1. An inability to assign probabilities as to the likelihood of future events (Duncan, 1972; Pfeffer and Salancik, 1978).
2. A lack of information about cause-effect relationships (Duncan, 1972; Lawrence and Lorsch, 1967).
3. An inability to predict accurately what the outcomes of a decision might be (Downey and Slocum, 1975; Duncan, 1972).

These definition are, indeed, building upon the same line of thinking as, for instance, in economics and psychology (see some of the examples in Table 1).

Milliken's definition of uncertainty (1987) somewhat summarizes and generalizes the existing variety of definitions stating that (p.136):

> *"Uncertainty is an individual's perceived inability to predict something accurately. An individual experiences uncertainty because he/she perceives himself/herself to be lacking sufficient information to predict accurately or because he/she feels unable to discriminate between relevant data and irrelevant data."*

The merit of Milliken's work (ibid.) is in providing a useful categorization of uncertainty, which takes into consideration not only the source of uncertainty (such as market, technical, etc) but also specifies the types of it (e.g. lack of knowledge or understanding, or inability to predict something). The author identifies three main categories of uncertainty:

1. *state uncertainty* is experienced by organizational administrators as a lack of understanding of how components of the environment might be changing. This construct is the only one in the typology that reflects the state of the world.
2. *effect uncertainty* is defined as an inability to predict what the nature of the impact of a future state of the environment or a change in the environment will be on the organization. Essentially, it reflects a lack of understanding of cause-effect relationships;
3. *response uncertainty* assumes a lack of knowledge of response options available to the firm and the value of those response options for it. At the same time, it is an inability to predict the possible consequences of the response choice.

The author suggests that state uncertainty is equal to the perceived environmental uncertainty concept in the sense that the latter is used by, for example, Duncan (1972) and Pfeffer and Salancik (1978). Milliken's response uncertainty is very close conceptually to the description of

uncertainty and ambiguity[7] in decision theory literature (Conrath, 1967; Weick and Sutcliffe, 2001). The benefit of the framework proposed by Milliken is in its ability to explain the inconsistencies in the results reported in the research, particularly when it comes to measurement of uncertainty.

While some researchers in the field supported the need to study (and measure) uncertainty as a perceptual phenomenon (Child, 1972; Downey and Slocum, 1975), the others stated the need to measure uncertainty stemming from organizational environments objectively and compare it with perceptual measures in order to avoid the trap of studying the minds of managers rather than organizations (e. g. Starbuck, 1976). In pursuit of the latter trend, the researchers have used several measurement scales for both objective and perceived uncertainty (e.g. Tosi et al., 1973; Lawrence and Lorsch, 1967; Duncan, 1972). Their studies showed confusing and often not easily interpretable results due to the way the constructs were developed and operationalized. Milliken (1987) argues that there should be no expectations of correspondence between objective uncertainty measures and subjective measures, because "*perceptions vary as a function of contextual factors and as a function of individual attributes*" (p.135).

A more important merit of Milliken's framework is in explaining how different types of

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[7] The latter, to which project management adepts often adhere to when it comes to the issues of uncertainty (as *known unknowns* in widely cited Donald Rumsfeld's terms (Department of Defense, 2002) and ambiguity (as *unknown unknowns* (ibid.), describes ambiguity as the inability to recognize and articulate relevant variables or interactions (Sommer and Loch, 2003). Weick and Sutcliffe (2001) provide an example of ambiguity, which arises from coordination in complex projects when some agents are not aware of other agents and the dependencies among them. As suggested by Duncan (1972), certain individuals have a higher tolerance of ambiguity, and thus may perceive some situations as less uncertain compared to how other individuals may find them. In general, the differences between uncertainty and ambiguity are not explicitly articulated, and there is a strong tendency in the literature to confuse these two concepts.

uncertainty might affect the strategy of an enterprise. In order to cope with *state uncertainty*, which assumes unpredictability of the environment, the author suggests "muddling through" (Lindblom, 1958, in Milliken, 1987) or garbage can (Cohen et al., 1972, in Milliken, 1987) approaches to decision-making and strategic planning rather than the linear models of strategy development. *Effect uncertainty* is associated with the inability of decision-makers to understand the impact of events. It triggers the process of analyzing the environment in terms of threats and opportunities, in which administrator(s) judgment is at the core. In this case, strategic planning can be negatively affected if the administrators take much time in arguing about whether and how their firm might be affected by the environmental changes. Outlining threats (risks) or opportunities is a significant part of the process. Milliken (ibid.) suggests that this type of uncertainty is mostly associated with contingency planning. *Response uncertainty* is experienced by decision-makers as they try to understand and assess the range of strategic responses that are available to them in the light of the benefits the response outcomes might bring for their endeavor. Strategically, this type of uncertainty is characterized by the tendency to implement the actions that imitate those of e.g. competitors, segment leaders, business partners, etc. Thus, response uncertainty is associated with the need to acquire information and discover how similar organizations have coped with similar problems in the past. Forecasting techniques and modeling of the effects of various responses under varying conditions are expected to be utilized by managers that experience response uncertainty. To summarize, the framework constructed by Milliken provides an important insight into how different types of uncertainty experienced by decision-makers correlate with the organizational internal strategy formation process. However, the author concludes that the uncertainty constructs need to be better related to the organizational processes that they evoke, which could extend the knowledge on how organizations are different in terms of effectiveness. Milliken particularly stresses the need to investigate the process, by which the managers *become certain* that this or that event or condition represents a threat or an opportunity for their organization: sense-making. In the following sections of this chapter I will continue to explore the processes and issues of an organization, which has been found relevant for coping with uncertainty.

2.2.2   Uncertainty in relation to internal processes of a firm

The idea of how uncertainty can be acted upon — or in other words, managed — plays a significant role in the works of organization theorists. Organization theory researchers see uncertainty as *"emanating from some set of objective (but largely unmeasured) environmental characteristics"* (Jauch and Kraft, 1986, p. 778), thus proclaiming that uncertainty sources are external to organizations. However, there are several concepts referring to firm's internal processes and attributes that have close relevance to the uncertainty construct. The relevance of managing uncertainty can be traced in Max Weber's work (e. g. 1968), whose views on the issues of fact and value impacted the formation of the organization theory. His ideas on bureaucracy and rationalization (and the problems associated with those issues) gave ground for the ideas of March and Simon (1958) that highlighted internal variability of goals and goal displacement in organizations. The goals — which can be also interpreted as values — are different among individuals that constitute different groups within the organization due to differences in sets of facts, resources and immediate aims that they have. In other words, the experiences and situations that they operate in vary. Not only are values, at the individual and group levels divergent, but they might create conflict at the organizational level making the overall organizational goals fail in favor of those of individuals or groups. Variability in goals stresses the likelihood of organizational conflict, and so does the inherent interdependence between the goals on different levels. Facts, values and information are seen as a basis for decision-making, and communication is regarded as means for conflict resolution.

The contingency theorists take the ideas of March and Simon further by stating that there is a correspondence, or even a direct relationship, between the organization's task environment and the structure (Galbraith, 1977; Mintzberg, 1979) with the latter correlating with the organization's profitability and effectiveness (Lawrence and Lorsch, 1967). Thus, uncertainty stemming from the organizational environment is seen as a significant factor influencing the performance and structure of an organization, where the latter includes not only the formal rules, goals-values, and policies of a firm, but also the communication style and frequency,

network parameters, internal hierarchy and influence, etc. For example, organizations operating in highly uncertain environment are associated with denser communication networks allowing the avoidance of internal boundaries (e. g. Hage, 1965). Lawrence and Lorsch (1967) provide a particularly interesting result showing that subgroups (departments) within an organization, possessing different values and experiences, to deal with different segments of the environment, and thus, the uncertainties that they face also differ. The study that the authors performed shows, among other results, that communication as part of the integration processes help to resolve internal conflicts and achieve competitive success for the whole organization. The processes of communication and information acquisition, and organizational structure are recognized as having an effect on uncertainty.

To summarize, the theories represented above look at the structure of an organization and its communication patterns as decisive factors for managing uncertainty. In fact, uncertainty is regarded as a continuous organizational situation. Some authors regard uncertainty as negative for the firm because it withdraws organizational equilibrium, and thus managers attempt to eliminate it (Lorenzi, Sims and Slocum, 1981). Others came to the conclusion that managers cannot control uncertainty (Ford and Hegarty, 1984), and therefore they ignore it (March, 1981). However, most of the works mentioned focus on uncertainty reduction strategies and information gathering for the purpose of facilitating decision-making, especially if we consider contingency theories. These theories discuss decision premises such as goals, values, information and communication in the light of rational thinking and view organizations as somewhat fixed, stable structures. Organizational routines are seen as somewhat of a facilitating procedure in dealing with unexpected (or uncertainty), because they free up attention that then can be used to assess *non-routine events* (March and Simon, 1958).

However, this view on organizations as programmed and rigid stable structures faced certain criticism from the adepts of the other stream of thought in organizational theorizing. This stream proposes a social construction and sense-making point of view on the nature of a firm and its processes (Weick, 1995; Schön, 1983). This trend has gained considerable support in the current literature on organizational communication, knowledge management and integration processes that traditionally considered uncertainty as an important variable (McPhee and Zaug, 2001).

2.2.3   Coping with uncertainty by reflective processes

One of the latest trends originating from cognitive sciences, and one that is gaining a stronger presence in economic and management literature is taking into consideration a relational individualistic perspective versus that of straightforward rational thinking. Such an approach implies that a wider variety of elements of economic and managerial interactions are given value, such as for example, emotions and other, rather individual, manifestations. However, and most importantly, these streams in research pay much attention to the element of uncertainty in economic and managerial action, and they do it from a different angle. The researchers adopting a relational approach regard uncertainty as an element complicating means-ends logic of rational decision making, leading to the fact that there is a need to adopt management principles different from utility maximization (Bandelj, 2009). There are several different management principles that are proposed in the literature: improvisation (Bandelj, 2009; Wikström and Rehn, 2002), adaptation (Hammer et al., 1998; Armitage, 2005; Donner, 2008), situational adaptation (Håkonsson, 2006) and, adaptive management (Walters and Hilborn, 1978). The core point of all of these processes is that they are individualistic and reflective.

The majority of works in the existing body of knowledge on reflective processes contributes to the understanding of reflection at the level of the individual (Popper, 1996; Weick, 1995; Reynolds and Vince, 2008). Although the individual actor's level is the starting point of the discussion, uncertainty at the organizational level is not a sum of individual perceptions; neither is it such at the project level. Rather, the perception of uncertainty impacts the way the tasks are performed (see also Galbraith, 2002).

Any human action is constituted of the three main elements: the actor's past experience, the perception of the present context and the intentions to achieve certain future contextual changes. According to Lane and Maxfield (2005), action can be interpreted as:

> *"A bridge that actors construct in the present, liking their past towards a desired future"*
> *(p. 8).*

One of the strong features of action is not only its temporal nature, but also the fact that that its consequences are dependent on a complex network of interrelationships between the context of the present and other actors' manifestations. The time and space — or the present context, in which each single action takes place, are in a constant state of change incurring many other actions, contextual developments, as well as the natural and "human-made"[8] laws guiding the processes. That is why the outcome of an action does not necessarily match the original intention of the actor, because the context, in which the action has been executed and the results that occur, may have changed during the process due to the above-mentioned factors. This process is continuous: humans act to adjust the future context based on their experience and the current situation, yet the desired future changes might be different from how they were previously conceived. The more important fact is that the continuous transformation of present reality implies that there is a strong link with the concept of uncertainty.

According to Lane and Maxfield (2005), in any particular theory of action, the uncertainty that actors experience is manifested by any issue that the theory stresses as problematic in any of the following elements:

- the way in which actors interpret their present context,
- how they desire to change the context,
- what kind of action options or modalities are available to them, and
- how effective in achieving the desired transformations they regard
  each possible action modality.

As the first bullet point suggests, reflective processes (e.g. interpretation, sense-making, judgment) are at the core of coping with uncertainty. As proposed by Milliken (1987), environmental sense-making can be affected by the experienced uncertainty, but it also might

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[8] Here I refer to the governing principles in social sciences: economics, politics, sociology, jurisprudence, etc.

appear to be the process of making things certain. As it will be shown in the following sub-chapters, there is a growing tendency to recognize reflection as an essential part of management practices aimed at managing uncertainty within the project management field as well (e.g. Gustafsson and Wikström, 2004; Maytorena et al., 2007; Olsson, 2007; Perminova et al., 2008 (a), (b); Atkinson et al., 2006).

Reflection has been one of the central concepts of the management and organizational learning fields for over two decades. The classical description of the reflective process is to be found in the seminal work of Donald Schön "The reflective Practitioner: How professionals think in action" (1983). He refers to "reflection-in-action" as embedded in:

> *"On-the-spot surfacing, criticizing, restructuring, and testing of intuitive understanding of experienced phenomena; often it takes the form of a reflective conversation with the situation." (pp.241-242)*

Similar definitions of reflection and learning can be found in the works of Kolb ("*experiential learning*", 1984) and Knowles *("self-directed learning"*, 1975). These scholars use the conceptions of learning and experience as the standpoint to draw upon. One of the scholars that has had the most influence, particularly on the work of Schön is John Dewey, who depicts reflection on experience as a process of thinking with the processes of sensing, observing, elaborating and empirical testing also being a part of it (1916). An important aspect of reflective experience is action aimed at achieving the anticipated result, which is the equivalent of testing the hypothesis. All these scholars share a common focus on individual learning and the application of learning rather than observing the reflective processes on an organizational level. Organizational learning is the most recent field under the umbrella of learning theory and practice and has the process of reflection at its core. Taking into consideration the fact that reflection is strongly related to the experience of the individual through the processes of decision-making, action and problem-solving, it has taken its rightful place both in theory and practice.

In the last decade, there were multiple attempts to bring this concept into the management field. As Reynolds and Vince (2008) notice, the concept of reflection has become somewhat unquestionable, a process that needs to be done by the managers to strengthen the abilities of

the organization to survive. This concept is closely related to the issues of knowledge creation and exchange within firms as well as with the outside world. As Grant (1996) states (p. 375):

> *"If the strategically most important resource of the firm is knowledge, and if knowledge resides in specialized form among individual organizational members, then the essence of organizational capability is the integration of individuals' specialized knowledge".*

It is important to mention that the concept of reflection is often linked not only to the experience and learning — or knowledge creation — of an individual, but also to emotions. Several authors including Raelin (2001), Vince (2002) and Swan and Bailey (2004) indicate that emotions can be seen as a source of critical reflection, while reflection is seen as:

> *"...a process of periodically stepping back to ponder the meaning to self and to others in one's immediate environment about what has recently transpired"* (Raelin, 2001, p.11)

While reflection has its managerial value in detaching managers from their habitual behavior, ways of thinking and use of power — in other words, it gives the ability to critically review; individual manifestations (emotions, behaviours, attitudes) act as a lens enhancing or distorting the facts within a situation, and even influencing the learning process (Swan and Bailey, 2004). They are seen as a part of the reflection process, their effects cannot be neglected while interpreting and implementing reflection on and at an individual level. The trend to recognize the impact and value of personality-related issues is penetrating into the project management science. Although the traditional rational approach to project management professed by the various "Bodies of Knowledge" is the prevailing trend, the emerging literature on *soft issues* — the effects of changing morale, schedule pressure, political issues within the company, loss of trust between client-supplier, etc. — is providing evidence that the factor of human sensitivity and emotions can be considered as a determinant of project behavior (e.g. Williams, 2005). Building upon the work of Hofstede (2001), which stresses the importance of looking at national culture rather than just organizational, Winch, Clifton and Millar (2000) attempted to classify different project management styles. In a similar vein, Muriithi and Crawford (2004) look into masculinity as a management reasoning supporting great fidelity to initial project plans and objectives, and femininity as a management style supporting intuitive

reflective processes in decision-making and acting that builds upon real-time situational contexts. Williams (2005) summarizes the attempts of project management researchers to analyze the value of soft factors and their strategic implications, and concludes that they need to be taken account of especially for projects that are structurally complex, uncertain and heavily time-bounded. He particularly stresses that the conventional methods of project management that focus on following a strict plan tend to be disadvantageous for projects under high uncertainty, whereas the methods based on real-time considerations and what is best for the project and the stakeholders are more appropriate for coping with uncertainty. This is the logic that the reflective approach assumes.

The reflective approach evolved on the basis of rational thought, but went beyond its premises. As compared with the rational approach, the theorists of reflective stream look at the organization as an evolving endeavor with its specific qualities emerging as a response to the situations that occurred in the past. Organizations, together with the processes and elements which constitute them, are viewed from a different angle: as being socially constructed. Organizations are seen as:

> *"nets of collective action, undertaken in an effort to shape the world and human lives"*
> *The contents of the action are meanings and things (artifacts). One net of collective action is distinguishable from another by the kind of meanings and products socially attributed to a given organization." (Czarniawska-Joerges, 1992, p.32).*

The processes that take place within firms are, consequently, socially constructed by everyday interaction between the members constituting them, their beliefs and interpretations (e.g. Bittner, 1965; Weick, 1977, 1995; Giddens, 1976). Salancik and Pfeffer (1978) go even further suggesting that not only attitude-needs, but also task environment characteristics are socially constructed. Interpretation is seen as one of the most important mechanisms of organizing, which both emerges from it and constrains it (Ranson et al., 1980; Louis, 1980). In other words, organizations are viewed as only temporarily stable. Karl Weick's research showed examples of organizations *"proactive toward their environments rather than reactive to them"* (1977, p. 271). Furthermore, he argues that understanding and sense-making affect strategic decisions, and consequently, the performance of the firm.

Decision-making theories try to develop systematic approaches to giving answers and directions in situations of uncertainty. However, the traditional decision-making theory approach is quite deterministic, focusing on what the decision should be. This can be compared to the notion by Drucker (in Weick 1995, p. 15) citing Japanese philosophy: the crucial steps are to decide whether there is a need for a decision and what the decision is about. Indeed, modern complex organizations and their environments require a reflexive approach in management in order to grasp the changes and increase the flexibility when adapting to them. If we speak about a project and its environment that are in a continuous process of change, there is obvious importance in reflection — in order to foresee potential dangers and opportunities to the fullest possible extent (Schön 1983). In this context, the principles of sense-making can make a solid contribution to the management of uncertainty in projects.

The core of this process has been described by Karl Weick (1995, p.15):

> *"…to talk about sense-making is to talk about reality as an ongoing accomplishment that takes form when people make retrospective sense of the situations in which they find themselves and their creations. There is a strong reflexive quality in this process. People make sense of things by seeing a world on which they already imposed what they believe…"*

One should not mix the process of sense-making with interpretation. The former is a much deeper process. In contrast, interpretation implies that the reality is taken for granted; the objects of this process are evident, whereas sense-making does not have such presumptions. Thus, sense-making implies a less deterministic approach. It addresses the issues of complexity and ambiguity from the perceivers' point of view with major processes grounded in description, observation and reflection. Weick (1995) sees uncertainty as a condition for sense-making that could be transformed into risk or opportunities. In general, sense-making includes very many valuable principles that can be utilized in project management in respect of the management of uncertainty. This is especially true considering that sense-making implies dynamic, flexible, adaptive processes, precisely those that the current state of the art project management needs to address in greater detail (Floricel and Miller, 2001; Pich, Loch and De Meyer, 2002; Gustafsson and Wikström, 2004; Maytorena et al., 2007).

Table 3 summarizes the variables that are emphasized in literature in relation to uncertainty.

Table 3. Variables and processes associated with the concept of uncertainty

VARIABLE/PROCESS	EXAMPLES OF STUDIES THAT DISCUSS THE VARIABLE IN RELATION TO UNCERTAINTY
Information	Duncan, 1972; Tversky and Kahneman, 1974; Huber, O'Connell and Cummings, 1975; Feldman and March, 1981; Weick, 1995; Pich, Loch and De Meyer, 2002; Chapman, 2006
Knowledge/experience	Knight, 1921 ; Scott, 1967; Downey and Slocum, 1975; Fuglseth and Grønhaug, 2000; Loch, Solt and Bailey, 2008; Chapman, 2006
Communication	March and Simon, 1958; Hage, 1965; Giddens, 1984; Brashers and Babrow,1996; Brashers, 2001; McPhee and Zaug, 2001
Organizational structure	Weber, 1968; Lawrence and Lorsch, 1967; Duncan, 1972; Child, 1972; Pfeffer and Salancik, 1978; Mintzberg, 1979; Ranson et al., 1980; Louis, 1980; Giddens, 1984; Szulanski, 1996; Sutcliffe and Zaheer, 1998; McPhee and Zaug, 2001
Reflection-based processes (sense making, interpretation, adaptation, learning, etc)	Close, 1974; Downey and Slocum, 1975; Weick, 1977; Ranson et al., 1980; Louis, 1980; Milliken, 1987; Weick, 1995; Golding, 2000; Raelin, 2001; Vince, 2002; Swan and Bailey, 2004; Atkinson et al., 2006; Gustafsson and Wikström, 2004; Maytorena et al., 2007; Meijer, Hekkert and Koppenjan, 2007
Individual manifestations (perception, emotions, behaviours, attitudes, etc).	Kahneman and Tversky, 1979; March and Shapira, 1987; Babrow, 1992; Sitkin and Weingart, 1995; Brashers, 2001; Galbraith, 2002; Lane and Maxfield, 2005; Kutsch and Hall, 2005; Håkonsson, 2006; Wittgenstein, 1986
Complexity	Simon, 1969; Huber, O'Connell and Cummings, 1975; Shenhar and Dvir, 1996; Sommer and Loch, 2004; Williams, 2005; Floricel and Miller, 2001; Shenhar et al., 1995; Baccarini, 1996; Laufer, Denker and Shenhar , 1996; Williams, 1999; Kerzner, 2001; Fuglseth and Grønhaug, 2000; Windischhofer et al., 2009

To summarize, uncertainty and the question of how it can be handled is at the core of organizational theorizing. The research in these fields has considered the following elements as of high relevance for managing uncertainty which will be discussed in this thesis:

- Organizational communication and information handling,
- Organizational learning,
- Experience on the individual level and organizational expertise as a knowledge in use by the organization.

2.2.4.   Risk in organization theories

Much attention within organization theory has been paid to managerial perspectives on risk taking and perception of risk by managers (e.g. March and Shapira, 1987; Sitkin and Weingart, 1995, Kahneman and Tversky, 1979). The definition of risk has been a point of discussion in this field as well (see March and Shapira 1987). One important conclusion that can be drawn from organization research and applied to project business is that most managers do not treat uncertainty about positive outcomes as an important aspect of risk. Briefly stated, "risk" is associated with the negative outcomes (ibid.). Furthermore, a study of managers performed by Shapira (ibid.) showed that risk could be better defined in terms of the amount that could be lost rather than in terms of outcome distribution. March and Shapira (1987) have stated that by seeing risk as controllable (as compared with uncertainty), managers avoid accepting risk. Managers do not accept the idea that the risks they face are inherent in the situation. In contrast, they think that risks can be reduced by using skills to control the threats. It is important to mention, that these authors make a clear distinction between gambling *("where odds are exogenously determined and uncontrollable"*) and risk taking (ibid: 1410). The latter is associated with uncertainty, which can be reduced with the help of skills or information. Risk taking propensities vary across both individuals and contexts. They depend on personal qualities such as experience, incentives and interpretation (ibid.).

 If business managers tend to avoid risk rather than accept it (e. g. Cyert and March 1963/1992), the handling of risk will be emphasized as compared to identification and analysis: risk management becomes insurance oriented (Close, 1974). If management theory takes an external viewpoint on the organization as an entity, seeing risks as forces acting upon it; organization

theory treats organizations as a complex goal-oriented system with subparts that are in a constant process of change in response to external and internal forces (ibid.). Consider, for example, William Scott's model (1967) that prescribes the search for certainty and knowledge as a way of reaching organizational stability. Following such logic, Close (1974) concludes that the task of managers is in the reduction of uncertainty by making the state of things certain. In other words, risk managers should begin by attempting to identify and classify risks in relation to different sub-parts of the system/organization (or project) that form the sum of risks acting upon it. Here the connection to coping with uncertainty becomes evident: when uncertainty has been "made certain" via e. g. sense-making process, and interpreted as a risk (a threat), then the risk management procedures can be applied to it.

2.3   Uncertainty, risk and opportunities in project management field

With regard to the project management field, the issue of uncertainty has gained attention in conjunction with the concepts of risk and risk management (Jaafari, 2001; Ward and Chapman, 1995; Chapman and Ward, 2004; Flyvberg et al., 2003; Olsson, 2007). According to various "Bodies of Knowledge", there is a tendency to see uncertainty as an issue embedded in the notion of risk. From this perspective, it is only natural to reexamine the three constructs — risk, opportunity and uncertainty — simultaneously.

PMBOK (2004: 238) presents a traditional view of project risk management, defines project risk as *"an uncertain event or condition that, if occurs, has a positive or a negative effect on at least one project objective, such as time, cost, scope, or quality"*.   Several editions of PMBOK (2001, 2004) describe risk through the notion of uncertainty, however it does not specify what uncertainty is. Moreover, not only uncertainty appears to be a part of the construct of risk, but also opportunities as events that have positive consequences on project objectives. The definition implies that risk is objective and measurable (and so are uncertainty and opportunities). In general, this definition is accepted by the

research in the field, but as in the case of the environmental uncertainty concept in organization theory, there are many interpretations. Let us take Miller and Lessard (2001) as an example. They adopt the following definition of risk (p.438):

> *"Risk is the possibility that events, their resulting impacts and dynamic interactions may turn out differently than anticipated. While risk is often viewed as something that can be described in statistical terms, uncertainty applies to situations in which potential outcomes and causal forces are not fully understood: we refer to both as risks".*

Here risk is not an uncertain event; rather it is a possibility that an event (interaction, condition) turns out to be different than expected. The authors classify risks as endogenous — specific and controllable — and exogenous "surprises" that cannot always be anticipated in advance. According to the description, one can draw the conclusion that risk is both uncertainty (exogenous surprises, uncontrollable) and opportunity (specific, controllable, positive risk). Another way how researchers describe both positive into the construct of risk, interestingly, the authors include a subjective angle into the definition. If the word "anticipated" might be referred to project objectives (e.g. a defined project plan), the expression "understood" (when referring to uncertainty) indicates that risk becomes somewhat a perceptual phenomenon. Unger and Eppinger (2006) present a *"traditional categorization of risk by source of uncertainty underlying the risk"* (p. 2), describing each risk category as an objective uncertainty, which stems from project organization's internal processes and/or the environment: technical, schedule, market and financial. Their definition of risk equals uncertainty, which in turn equals lack of information and/or knowledge and/or understanding about the future. Similarly to Unger and Eppinger, PMBOK (2004) states that causes or conditions of risk arise from the project's or organization's environment, such as on-going multiple projects, poor management practices, dependency on external participants, etc. As argued by some researchers, the main source of risks is the project work as such. Barber (2005) adopts the following definition of risk stating its main sources:

> *"A risk is a threat to project success, where the final impact upon project success is not certain. Some risks may appear to be internally generated but in fact are inherent to the nature of the project. For example, creating a breakthrough new technology carries a risk of failure simply because it is pushing the boundaries of what is possible. That risk would apply to any project team, in any organisation, that was trying to do the same work. It is inherent in the nature of the work and does not arise from the rules, policies, processes, structures, actions, decisions, behaviours or cultures of the project organisation or its host." (p. 584)*

Barber's definition is different to the ones presented above because it stresses the negative nature of risk by describing it as a threat, and positions it as an important project success factor. There are many other definitions that are essentially similar to the ones presented above. One of the most popular definitions recently quoted in different sources (Chapman and Ward, 2004; Hillson, 2002, 2003) is the one from the PRAM Guide by the APM (1997, In Chapman and Ward, 2004). According to this definition, risk is an uncertain event or set of circumstances that, should it occur, will have an effect on the achievement of the project's objectives. In general, the definitions of risk in project management could be classified in the following categories:

1. Definitions of risk as an uncertain event/condition/interaction with both positive (opportunity) and negative consequences on project's objectives.
2. Definitions of risk as a possibility that events/interactions/conditions/, are different than to those anticipated.
3. Definitions of risk as an event/condition/interaction with negative consequences on project's objectives. In other words, it is a threat to a project.

The best way to summarize the multitude of perspectives on risk is by quoting Healy (2004):

> "Risk is conceived as either an objective, numerical property of the external, material world or as a qualitative, human or cultural construction" (p.277).

There are more variations in opinions regarding the issue of risk among writers in this field. Nevertheless, there is one feature in understanding this term that all the scholars agree on. They refer to risk as uncertainty, indicating that it could be also interpreted as the chance of loss or hazard. For example, The International Organization for Standardization (ISO) Guide 73:2002 (Risk Management) specifies risk as the combination of the probability of an (unwanted) event occurring and the consequences thereof. In this interpretation, risk resembles the description of threat. Some authors might even go as far as claiming that managing such risks is what project management in essence is all about. As projects are about creating something new, i.e. hence something uncertain, what project managers have to do is to cope with that uncertainty. In that sense uncertainty is mainly derived from the unknown things. In traditional projects where

project managers' main concern were meeting time, budget and quality constraints this was very likely to be the case. As a consequence project (and) risk management became equal to information collection (see e. g. Armour, 2002). Despite this, it still does not mean that uncertainty can be managed by the risk management means.

Projects are influenced by internal and external risks. Under internal risks the researchers understand the risks that originate within the project. This category includes all processes, policies, actions, behaviors, cultures relevant for the project. Externally generated risks arise from the project environment (Barber, 2005). These two categories of risk are mutually exclusive, that means, internal risk cannot be generated by project environment — or contextual uncertainty — as Christensen and Kreiner (1991) refer to it. All the types of risk play equally significant role for the project success and require awareness from the project management. In sum, understanding both positive and negative effects under the term "risk" is a crucial difference in the view of risk by project management compared to other disciplines.

2.3.1   Project risk management

There have been a number of distinctive approaches to project risk management since the emergence of the discipline. Project risk management is understood as the systematic process of identifying, analyzing, responding to project risk, monitoring and control, with the aim to maximize the probability and outcomes of positive events and minimizing the probability and consequences of negative events to project objectives (PMBOK, 2004). In general, project risk literature defines this process in a similar manner (e.g. Artto, 1997; Chapman and Ward, 2004; Barber, 2005). Risk management in projects includes several steps. PMI defines 6 stages (see Figure 2): identification; qualitative risk analysis, quantitative risk analysis; response planning; monitoring and control, advocating strongly the importance of the planning stage for the purposes of risk management as well as for the project as a whole. Some researchers reduce the number of process steps or phases (Boehm, 1991; Turner, 1999), some extend it further (Caño and Cruz, 1998; Chapman and Ward,

2002). However, there is a general understanding among researchers regarding what is included in these stages of the risk management process. As an ongoing process present at all stages of project development, Project Risk Management is often described as a life cycle process.

Today one might argue that successful project management is much more than merely risk management (Shenhar, 2001). Nonetheless, risk management can in part be seen as the creation of previously unknown information. For instance, in product development projects some of the risk involved in projects at least originally derived from the system complexity itself and thereof the systematic uncertainty (Bonaccorsi, Pammolli and Tani, 1996).

PROJECT RISK MANAGEMENT

11.1 Risk Management Planning

.1 Inputs
  .1 Enterprise environmental factors
  .2 Organizational process assets
  .3 Project scope statement
  .4 Project management plan

.2 Tools and Techniques
  .1 Planning meetings and analysis

.3 Outputs
  .1 Risk management plan

11.4 Quantitative Risk Analysis

.1 Inputs
  .1 Organizational process assets
  .2 Project scope statement
  .3 Risk management plan
  .4 Risk register
  .5 Project management plan
    • Project schedule management plan
    • Project cost management plan

.2 Tools and Techniques
  .1 Data gathering and representation techniques
  .2 Quantitative risk analysis and modeling techniques
.3 Outputs
  .1 Risk register (updates)

11.2 Risk Identification

.1 Inputs
  .1 Enterprise environmental factors
  .2 Organizational process assets
  .3 Project scope statement
  .4 Risk management plan
  .5 Project management plan

.2 Tools and Techniques
  .1 Documentation reviews
  .2 Information gathering techniques
  .3 Checklist analysis
  .4 Assumptions analysis
  .5 Diagramming techniques

.3 Outputs
  .1 Risk register

11.5 Risk Responce Planning

.1 Inputs
  .1 Risk management plan
  .2 Risk register

.2 Tools and Techniques
  .1 Strategies for negative risk or threats
  .2 Strategies for postitive risks or opportunities
  .3 Strategy for both threats and opportunities
  .4 Contingent response strategy

.3 Outputs
  .1 Risk register (updates)
  .2 Project management plan (updates)
  .3 Riskrelated contractual agreements

11.3 Qualitative Risk Analysis

.1 Inputs
  .1 Organizational process assets
  .2 Project scope statement
  .3 Risk management plan
  .4 Risk register

.2 Tools and Techniques
  .1 Risk probability and impact assessment
  .2 Probability and impact matrix
  .3 Risk date quality assessment
  .4 Risk categorization
  .5 Risk urgency assessment

.3 Outputs
  .1 Risk register (updates)

11.6 Risk Monitoring and Control

.1 Inputs
  .1 Risk management plan
  .2 Risk register
  .3 Approved change requests
  .4 Work performance information
  .5 Performance reports

.2 Tools and Techniques
  .1 Risk reassessment
  .2 Risk audits
  .3 Variance and trend analysis
  .4 Technical performance measurement
  .5 Reserve analysis
  .6 Status meetings

.3 Outputs
  .1 Risk register (updates)
  .2 Requested changes
  .3 Recommended corrective actions
  .4 Recommended preventive actions
  .5 Organizational process assets (updates)
  .6 Project management plan (updates)

Figure 2. Project Risk Management process as defined in PMBOK (2004, p.254)

Thefore, one key area becomes a structured approach for that information creation (Eppinger, 2001; Browning and Eppinger, 2002) or even a structured product itself (Sosa, Eppinger and Rowles, 2004). This is certainly a key to better conformance in projects, but this view might be too narrow to consider uncertainty since it is restricted to the downside of the complex category of risk. In a general sense, there is a tendency to associate the term risk with adverse results or situations. Traditional project risk management identifies the so-called *upside (with positive impact on the project's outcomes) and downside (with negative impact on the project's outcomes)* risks. However, the focus of management lies on the planning of activities for mitigation and prevention of the negative risks (or downside risks).

A concept which is worth mentioning in relation to risk management is the issue management. Project issue, as described by Chin (2004: 209), is a technical or business situation with no known — or not yet implemented solution — that affects the project negatively. The difference between a risk and an issue lies in the fact that a risk is forward-looking, whereas an issue is real-time (ibid: 210). Basically, an issue is a realized risk. However, the methods that are suggested for managing issues are rather close to that suggested for risks. The specific attention is paid to tracking of the issues and monitoring of the development of the situation. As stated by Ansoff (1980, p. 136):

> *"Since response to some urgent issues may be started when their ultimate significance is still unclear, a critical general management responsibility is to exercise strategic control over such issues. This means continual re-evaluation of the significance of issues and redefinition of both priorities and the direction of projects"*

However, this assumes the implementation of actions when the issues are known; their probable consequences are evaluated as well as their priority for the organization. When you know that something is an issue, you are certain. There is no uncertainty any more. Issue management assumes that there should be enough of information and knowledge to act upon the issue. Ansoff continues (ibid: 144):

> *"Every new event will pass from a sense of turbulence to the 'full knowledge' level, but the speed of evolution will differ. From the point of view of an enterprise, the important moment in the history of an event is the time of its impact, which is the point after which it is too late to respond: either the opportunity will 'have passed by' or a threat can no longer be avoided. If the response is to have a chance of being effective, it must be completed before the time of impact".*

However, there is a need to address uncertainty precisely during the time, when an event is only "a sense of turbulence" or even before that. The project issue management discipline is concerned with issues as realized events. This process is not enough to address uncertainty, but some elements of it are of value: for example, continuous monitoring, tracking of changes, assigning responsibilities to the members who possess control over the issue, etc.

The methodology of systematic project management of organizations with a special emphasis on effective planning, communication and evaluation to achieve the desired outcomes is still dominant today as admitted by the researchers (Maylor, 2003; Alderman et al., 2005, Wikström, 2005). As a result, the traditional view on project risk management (as well as project management on the whole), stresses the importance of planning as one of the major routines, as well as supporting other activities such as risk identification, analysis, monitoring and control. In this respect, the role of the project manager (or warranty manager) becomes merely "follow the project plan". This limited view on project management strategy which focuses on avoiding the negative issues in projects is harmful, of not destructive, when it comes to the project-based firm's goal of creating competitive advantage through projects (Maylor, 2001). Risk itself is traditionally described as an uncertain event both in normative and research literature, which gives some scholars ground to argue that project risk management should be referred to as project uncertainty management (Chapman and Ward, 2003; Green, 2001; Jaafari, 2001).

2.3.2   Uncertainty management stream in the project management field

The new trend opposing the traditional view on project risk and uncertainty management emerged from strategic management literature (Mintzberg, 1994) and represents a critical insight into the role and influence of strategic planning on the performance of a project company (Andersen, 1996; Dvir and Lechler, 2004). The main assumption is that planning of project activities at an early stage is necessary, but not a sufficient criterion for project success (Andersen, 1996). Taking into consideration the fact that projects are complex endeavors with

restrictions on time, costs, resources and precise specifications of the product to be delivered, planning seems to be a difficult task. However, there are constraints and unclear areas, that neither the customer nor the project company is able to recognize at an early stage. The real difficulty project managers meet is making an optimal choice among the alternative actions, which requires knowledge about outcomes of preceding activities (ibid.).

In support of the latter, it must be said that projects are unique only to a certain extent. Project managers often expect a number of risks to occur, which will be similar from project to project. As illustrated by Shenhar (2001), project managers can apply routine, formal procedures to projects with low uncertainty, whereas higher levels of uncertainty will require more flexible approach. In a similar vein, Loch, Solt and Bailey (2008) suggest that neither selectionism nor learning are needed when uncertainty (or unforeseeable uncertainty or *unknown unknowns* as uncertainty is sometimes referred to e.g. in Sommer and Loch, 2003 and Wideman, 1992) and complexity are low. Instead, the authors suggest that the classical planning approach to project risk management is sufficient. According to Davies, Brady and Hobday (2006), project managers can employ experiences gained through the course of one project for the next one in the form of standardized successful processes and procedures. From this perspective, repetitiveness of such procedures not only from one undertaking to another one, but at different stages of the project, is the core element in the success of project risk management practices. The main danger in this respect is that the acquired knowledge will be lost after the project is finished. When adding the fact that the project and its environment are in a continuous process of change, it is turbulent and creates uncertainty, there is obvious importance in reflection — in order to foresee the possible extent of potential dangers and opportunities (Schön, 1983; Loch, Solt and Bailey, 2008; Olsson, 2007; Maytorena et al., 2007). Indeed, projects are better described as journeys of exploration in a given direction, rather than strict plan-following endeavors (Perminova et al., 2008 (a), (b)). Nevertheless, large-scale industrial projects are very complex and, thus, uncertain, which emphasizes the need for greater flexibility and reflection as a new way of generating knowledge and functioning (Wikström, 2005).

As noted by Lundin and Söderholm (1995), the prominent argument in normative theories on project management suggests planning as a means of ensuring project success. The same

statement applies to control and monitoring procedures, which help to clarify the company's standpoint at a particular moment. They are indeed necessary in order to provide a database for evaluation of potentially risky situations during the course of the project. In this sense, they help to answer the question of how much risks the company can take. However, it is important to keep in mind that when a hazardous event — risk — occurs, precautionary measures are already insufficient because project is a time-bound process (Nikander and Eloranta, 1997). In addition, it is not possible to foresee all the potential threats and opportunities at the project planning stage (Andersen, 1996). Similarly, control and monitoring are aimed at stating facts and thus represent limited sources of help in decision-making under uncertainty. Consequently, uncertainty as a context for risks and opportunities requires a different, less mechanistic approach, than traditional project risk management is currently suggesting. The critique of traditional project risk management as promoted by the normative project management literature is rather strong due to the fact that the need to manage uncertainty by different means than risk management is recognized (Williams, 2005). Reflective processes emphasizing flexibility and learning are suggested for managing uncertainty (Gustafsson and Wikström, 2004; Loch, Solt and Bailey, 2008; Atkinson et al., 2006; Maytorena et al., 2007). In this context, organization theory can provide an important insight into how uncertainty is defined and managed. As expressed by Close (1974), by looking for *"theory in organization"*, one can find *"theory in uncertainty management"*.

Project risk management scholars describe uncertainty from the point of view of not only negative impact on the project outcomes and danger of not meeting project's objectives, but also as changes that might bring new opportunities into the project (Chapman and Ward, 2002). Thus, risks are understood as one of the implications of uncertainty, in contrast to traditional risk management approach, assuming risk is uncertainty. Such an interpretation has given ground to a new trend in project risk management science referred to as project uncertainty management (Chapman and Ward, 2003; Green, 2001; Jaafari, 2001). However, this approach cannot be considered as "strategic". For the most part, project uncertainty is described by the project uncertainty management school as probability that the objective function will not reach its planned target value, or as an unknown probability of occurrence of an event (e.g. Jaafari, 2001: 89, 101). From this perspective, uncertainty is closely related to project performance measures: time, budget, scope and quality (Atkinson, 1999).

The weakness of this approach, in my opinion, is in its similarity to traditional project management view in terms of over exaggerating the planning procedures as being crucial for the project's success. However, project planning and documentation is seen not only as an administration and statutory requirements, but as means of information collection, integration, evaluation and proactive decision-making.

Uncertainty often means not only danger of not meeting the objectives, but a change, that might bring new opportunities in project development (Olsson, 2007). Thus, risk can be described as a known, yet unrealized situation (Hällgren and Maaninen-Olsson, 2005), which implies the lack of clarity regarding project data, knowledge of behavior of the parties involved or other details. Improvement in effectiveness and efficiency in decision making is a key process in clarifying situations. The success factor lies in the ability of the management to see, understand and handle accordingly different project-specific aspects of risk and uncertainty- threats and opportunities — that emerge throughout different stages of the project development. According to Karl Popper (1996, p. 24): *"the situation changes the possibilities and thereby the propensities".* The philosopher emphasizes that a deterministic approach fails in most of the cases. These ideas are of special importance for management of complex and innovative projects as an encouragement for greater flexibility as opposed to strict plan-following (Floricel and Miller, 2001; Gustafsson and Wikström, 2004), new ways of functioning and generating new knowledge (Atkinson et al., 2006), especially learning (Meijer, Hekkert and Koppenjan, 2007; Loch, Solt and Bailey, 2008). In a similar vein, it can be argued that learning through improvisation should be seen as a legitimate, if not profound, approach to managing projects (Rehn and Wikström, 1999; Lindahl, 2003). In sum, the uncertainty management adepts consider reflective processes of importance for the projects and project-based organizations as tools on increasing flexibility in decision-making and response implementation. There have been certain attempts in research to show the value of uncertainty management by reflective practices for project performance (Shenhar, 2001; Meijer, Hekkert and Koppenjan, 2007). But in general, it can be concluded that most of the research on uncertainty management methods is of conceptual nature, and the thoughts lack empirical justification. This concerns not only the project management field, but also strategic management and organization theory. The examples of the empirical research on uncertainty are presented in Table 4.

Table 4. Empirical research on uncertainty

AUTHOR(S)	OBJECTIVES OF THE STUDY AND THEORETICAL PERSPECTIVES	EMPIRICAL DATA	DEFINITION OF UNCERTAINTY	FOCUS ON UNCERTAINTY	MAIN RESULTS
Miller, 1993	To develop and test a perceived environmental uncertainty measurement instrument grounded in strategy and international management theory.	A survey among managers in firms representing different industries in several Spanish-speaking countries.	"Uncertainty refers to the unpredictability of environmental or organizational variables that have an impact on organizational performance" (p.694).	Perceived environmental uncertainty measurement.	The paper argues that perceived uncertainty is a multidimensional construct. Findings provide initial evidence that many uncertainties are firm, investment or country-specific rather than industry-specific.
Bourgeois, III, 1985	To investigate the relationship between the top management perceptions of uncertainty, corporate goal structures, and industry volatility in explaining economic performance of the studied firms. The study builds upon normative strategic management and empirical organization theory perspectives.	An empirical investigation including interviews with top managers, questionnaires and secondary data (industry statistics and annual reports) among 20 nondiversified public firms.	The perceived environmental uncertainty construct is grounded in Duncan's (1972) work.	Perceived environmental uncertainty.	Firms should only reduce uncertainty in stable environments. In volatile environments uncertainty may be functional, at least if experienced at the strategy-making level of the firm.
Meijer, Hekkert and Koppenjan, 2007	To investigate which types of perceived uncertainties are dominant for the innovation decisions related to a specific empirical case, and to study how actors react to the perceived uncertainties. They build the argumentation	A study of the grey literature (newspapers, professional literature, policy documents) as well as the interviews of the min actors involved in the development of an innovative technology named micro-CHP in The	"The term uncertainty is defined broadly as any deviation from the unachievable ideal of completely deterministic knowledge of the relevant system... uncertainty also relates to aspects that are by definition indeterminable, such as the	Perceived environmental uncertainty.	The two most dominant uncertainty sources in the pre-development phase of micro-CHP are technological uncertainty and political uncertainty, followed by consumer uncertainty. The activities that the actors undertake clearly focus on the

	upon innovation and uncertainty literature.	Netherlands.	behavior of other actors" (pp. 522-523).		dominant uncertainty sources. For example, in order to cope with technological uncertainty, technology-developers invest in knowledge development.
Maytorena, Winch, Freeman and Kiely, 2007	To describe a method for studying how project managers acquire information in order to make a judgment of what is a risk in a project. The authors draw upon the research in project management and the decision-making under uncertainty perspective.	Interview-based AIS (active information search) and cognitive mapping study of 51 managers in four British firms.	Uncertainty is roughly defined as a situation or a condition. The understanding of uncertainty stems from the works of Kahneman and Tversky (1979) and Rosenhead and Mingers (2001, in Maytorena et al., 2007)	Uncertainty as a perceptive phenomenon: "Understanding how individuals respond to uncertain situations… requires an understanding of how individuals intuitively assess the situation they perceive, before expressing a response" (p. 323).	Relying on project management experience alone is inadequate for identifying project risks as it leads to establishment of "check-list" mentalities. Reflective practices as defined by Donald Schön are recommended for project risk management.
Zayed, Amer and Pan, 2008	To identify the key sources of risk and uncertainty for highway projects; to design and test an assessment model for the effect of the risks and uncertainties using analytic hierarchy process. The authors emphasize the normative project management, especially project risk management.	A questionnaire-based survey of 17 highway experts in China.	The authors apply the PMBOK (2000, in Zayed, Amer and Pan, 2008) definition of risk-as-uncertainty through the paper: "risk is an uncertain event or condition that, if it occurs, has a positive or a negative effect on at least one project objective, such as time, cost, span, or quality, which implies an uncertainty about identified events and conditions" (p. 409)	Uncertainty as such is not clearly defined.	The study provides practitioners with a tool to evaluate and prioritize their highway construction projects based on risk by proposing a risk index (R). The paper provides the model to evaluate the risk in highway projects, and methodology of quantifying the qualitative effect of subjective factors.

2.4.   Conceptual framework of the study

The purpose of this chapter is to summarize the more important implications that arise from the literature review into a theoretical framework. There are two bodies of literature that I considered most relevant for the thesis: project management literature and the literature on perceived uncertainty within strategic management and organization theory fields. In order to relate the existing theory and research with the empirical case study of the thesis, I shall construct a framework combining the literatures in question. There is no risk that the thesis will become too deductive merely supporting the chosen theories. This is due to the fact that the starting point of this research, which to a large extent determined the choice of the literature, was the need to contribute to the solution of practical problems. The use of the results in practical empirical cases also supports the inductiveness of the undertaken research. As it will be shown in the next chapter on methodology, the methods used in data collection and the iterative process of data analysis represent the induction-deduction cycles.

There are several limitations of the research in the studied fields of science, especially project management field that this thesis strives to overcome by answering the research questions Qa, Qb and Qc:

- poor and/or inconsistent conceptualization of uncertainty,
- lack of explanation as to how uncertainty, risk and opportunity concepts are related,
- lack of empirical research regarding the actions that the managers take in response to uncertainty,
- lack of explanation of what uncertainty management stands for,
- lack of attention to the early post delivery stage and its importance for strengthening learning and knowledge practices as part of performance-oriented project management.

In line with the argument of Eisenhardt (1989), the construct of uncertainty (as well as the constructs of risk and opportunity) for this thesis has been developed on the basis of the iterative process, which assumes sharpening of the concept through its application. Drawing

from the reviewed literature and with regard to the stated research questions (Qa, Qb and Qc), I define uncertainty as follows:

Uncertainty in relation to projects is the individual's (e.g. the manager's) lack of knowledge and/or understanding of the relevant project elements, its environment and their interrelationship, so that no conclusion can be made as to if and/or how any of those can impact the project success.

This definition adopts the view on uncertainty as a perceptive phenomenon (Milliken, 1987; Meijer, Hekkert and Koppenjan, 2007) which encompasses the view on uncertainty as e.g. lack of information (Duncan, 1972; Lawrence and Lorsch, 1967; Håkonsson, 2006 referring to Galbraith, 1974), inability to predict accurately the outcomes of events or decisions (Downey and Slocum, 1975) or inability to assign probabilities to their likelihood (Pfeffer and Salancik, 1978). It addresses the unforeseeable uncertainty or *unknown unknowns* as they are sometimes referred to in project management literature (e.g. in Sommer and Loch, 2003, Wideman, 1992), while the *known unknowns* (as defined by e.g. Loch, Solt and Bailey, 2008) are included into the following definitions of risk and opportunity which are formulated for the purposes of this study:

Risk is an event, condition or interaction with the negative consequences on the project's objectives and consequently, project success. Opportunity is an event, condition or interaction with the positive consequences on the project's objectives ensuring success of the project activities.

In contrast to uncertainty, risk and opportunity are fact-based, concrete, knowable issues. It is important to note that this interpretation of opportunity treats it not only as favorable events or cumulative good luck in projects, but also as more effective responses to both negative and positive events, or any (inter)action that affects project performance positively. This extended view on opportunities in projects has been gaining attention in project management field recently (Chapman, 2006; Olsson, 2007).

Having constructed the uncertainty definition with regard to research question Qb, it is

important to outline the variables which affect it to be able to address the Qa. The literature review showed that there are several variables that have an influence on uncertainty in the context of complex large-scale projects: complexity (Sommer and Loch, 2003, 2004; Williams, 2005), information: its availability, relevance, correctness, etc. (Weick, 1995; Pich, Loch and De Meyer, 2002), availability of project managers' knowledge to perform the task and/or the experience in performing it (sometimes it is also referred to as innovativeness, novelty, or lack of knowledge/experience, as in e.g. Atkinson et al., 2006, Meijer, Hekkert and Koppenjan, 2007), project managers' individual characteristics and manifestations (Håkansson, 2006; March and Shapira, 1987) as well as the organizational structure (see Table 3 for a review). Considering the adopted project-based supplier firm perspective, the organizational structure parameter was divided into supplier firm (internal) organization and the project organization. The latter takes into account customer- and other stakeholders — related uncertainty. Sometimes the outlined variables are referred to as sources of uncertainty (e.g. Meijer, Hekkert and Koppenjan, 2007).

Both Qa and Qc assume an inquiry into the methods that the project management professionals apply to cope with uncertainty. As argued in the reviewed literature, in complex large-scale projects which are often subject to uncertainty, the management mechanisms based on reflective processes are required to cope with it (Downey and Slocum, 1975; Milliken, 1987; Weick, 1995; Shenhar, 2001; Gustafsson and Wikström, 2004; Loch, Solt and Bailey, 2008). These mechanisms foster flexibility and learning. As a result of reflection-based mechanisms functioning, uncertainty is resolved into knowable issues which are, according to the adopted definition, risks and opportunities. They are successfully addressed with risk and opportunity management mechanisms because there is no high uncertainty any more (Shenhar, 2001; Davies, Brady and Hobday, 2006; Loch, Solt and Bailey, 2008). It is stated that learning has a significant potential to reduce uncertainty (Levitt and March, 1988; Atkinson et al., 2006; Meijer, Hekkert and Koppenjan, 2007). Learning is emphasized as a mechanism to secure that the experience gained in a project stays within the organization as a part of the organizational culture (Lundin and Midler, 1998, Atkinson et al., 2006) and is further utilized as a part of strategy formation process (Milliken, 1987), as the common policies and practices of the project-based organization. Thus, project strategy contributes to the organizational strategy and vice

versa supporting the focus on competitive advantage rather than merely avoiding the negative potential of projects (Maylor, 2001).This is how project performance is related to the performance of the project-based organization. Shenhar and colleagues (1995) as well as Atkinson (1999) point out the importance of early post delivery stage (warranty) in evaluation of the project performance and success. Atkinson et al. (2006) argue that post delivery (or *the post implementation* stage, as they refer to it) is crucial for knowledge management and organizational learning as the results of the managerial actions may not be realized for some time after the project execution is finished. Consequently, focus on the life cycle of the project, as compared to focusing on project execution only, emphasizes value management (ibid.), customer orientation and trust between the project stakeholders (Gustafsson et al., 2010) as well as communication (March and Simon, 1958; McPhee and Zaug, 2001) and learning from the others (Levitt and March, 1988). In the context of projects as temporary organizations (Lundin and Söderholm, 1995) which a subject to continuous change (Eisenhardt and Brown, 1998), learning and knowledge management represent a challenge (Atkinson et al., 2006), especially if the judgment about the project success is based solely on project management professional's intuition and individual expectations of performance (Jaafari, 2001) without considering the expectations of other project parties. In this respect, warranty is crucial for ensuring that the experience and knowledge acquired during the project course is not lost, but rather gathered, communicated and applied from project to project. Strategy-based project management puts the project management professional (a project manager in the context of this study) in the role of both a decision-maker and a strategist who is responsible for the achievement of project goals during the project life-cycle including the post delivery/post implementation stage. Thus, it is important to study uncertainty and the reflective processes aimed at dealing with it from the project management professional's perspective. At the same time, it implies getting better understanding of the relation between uncertainty, project performance, leaning in projects and the impact these issues have on the strategy and culture of the project-based organization.

To the latter belong the psychological climate (James and Jones, 1974)[9] and the organizational climate (Denison, 1996). They are interrelated with the individual manifestations of the organizational members.

The conceptual framework of the study is presented in Figure **3**. In line with the research questions, the idea is to test this framework on the basis of the multiple case study, and specifically gain more understanding of the reflection-based processes that are associated with uncertainty management.
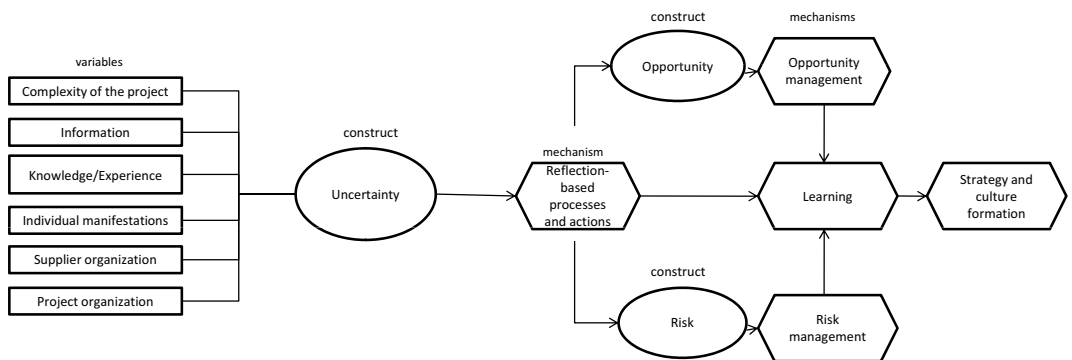
Figure 3. Conceptual framework of the study

[9] James and Jones (1974) define the psychological climate to be a summary of global perceptions held by members about the environment of their organization.

III   RESEARCH DESIGN AND METHODOLOGY

In this chapter, I will present the means by which the empirical data for the thesis was collected and analyzed. In order to bring transparency to the logic of the empirical process, this will be done in accordance with the sources of the empirical data and the research process. The chapter is structured as follows. First, I will outline the methodological and philosophical assumptions of this study as well as describe the research approach. Second, the data collection methods will be explained. Thirdly, the data analysis and interpretation are going to be envisaged together with the quality criteria applied to this study.

3.1   Philosophical commitments

With reference to Denzin and Lincoln (1998), this thesis adopts the qualitative research perspective. As the authors state, the choice of research practices and tools available for the qualitative researcher, is not set in advance. Furthermore, the authors state that qualitative research is inherently multi-method, attempting to achieve an in-depth understanding of the phenomena in question. As is the case with most qualitative research, generalization to a broader perspective is not the main concern of the studies in this field (Lincoln and Guba, 1998), which are thus descriptive having implications for the choice of method explaining the phenomena. Nelson et al. (1992, in Denzin and Lincoln 1998, p. 5) attributes selection of those methods and tools to the research questions and their context.

However, simply admitting that this research is of qualitative nature is not enough to justify methodological choices. I need to allocate myself within the fundamental domains of

epistemology, ontology and methodology. To start with, this research is driven by and aims to contribute to the world of practice, which is in line with the pragmatist and critical realism philosophy (Putnam, 1995; Johnson and Duberly, 2000; James, 1907). The account of truth employed within this tradition stands for any solution or multiple solutions that work to satisfy the human need, and does not seek validation outside itself (Bradbury, 2008 referring William James and John Dewey). It does not imply that there is one universal truth governing the social world. Rather multiple socially constructed truths can exist simultaneously.

To summarize, this tradition within which I am positioning myself, provides a good balance between relativism and determinism ontologically. In terms of epistemology, it is considered to be subjective (at least in contrast to positivism), since it allows researcher to intervene and maintain a dialogue with the research object. In fact, the pragmatic-critical realism tradition sees this subjectivity as an advantage for solving the problem and completing successfully the research mission. Such collaboration brings in the hermeneutical perspective by enriching the interpretations and ensuring the quality of the research result.

3.2   Research strategy

Although qualitative research, as a set of interpretive practices, does not imply preference to any single methodology over any other (Denzin and Lincoln, 1998), the methodological choices of this work are influenced by the adoption of pragmatic-critical realism view of social science. Hence, given the above mentioned metaphysical commitments and keeping in mind that this research is driven by an endeavor to build a bridge between theory and practice, it is descriptive, explanative and explorative; it is best described as mainly qualitative multiple case study with a grounded approach to data gathering and analysis with the focus on critical events. The rationale for multiple-case design and the selection of the cases were theory-driven to some extent and derived from the expectation of replications (Yin, 1994), and the aim to

achieve a certain degree of generalizability of the research outcomes. As suggested by Eisenhardt (1989), case study is appropriate for the research with the aim to provide descriptions, build theories, or verify them without preconceived expectations.

This thesis is partly descriptive because answering the research questions entails describing of the concept of uncertainty in projects and the related terms of risk and opportunity as well as the process of managing uncertainty. By answering the research questions the explanation will be given as to how the studied concepts are related and how uncertainty is managed in projects by project management professionals, which is why the thesis is explanatory. The explorative nature of the work is marked by the ex-post reasoning.

The selection of cases for this thesis was not a subject to random sampling; rather, a theoretical sampling logic was applied. The selected cases have the following similarities:

- Each studied project case was in the early post delivery stage (warranty) during the data collection phase;
- Each of the projects included the following project phases: sales, engineering and design, manufacturing, transportation, installation, testing and handover, warranty. Duration of each of the case projects was between 1,5-3 years from the sales until the warranty phase;
- Each of the projects belonged to the core activities, the specialization of the studied suppliers (Company A and Company B).

As argued by Eisenhardt (1989), there is no ideal number of cases to be suggested for a multiple case study. The recommended range is between four and ten cases. For this thesis, seven cases were selected. The choice was led partially by the theoretical requirements and by the availability of the data. While working in research projects I had the ability to observe different interesting cases, but only seven of them were chosen because they represented the problem area best. As evaluated, the increase in the number of cases would not add more value, but rather make it difficult to cope with the increasing volume and complexity of the data.

The research within the scope of this thesis was conducted as a part of on-going research

projects within Research Institute for Project-Based Industry (hereinafter referred to as PBI Research Institute). The fact that PBI Research Institute employs a variety of methods, which can be classified under the collaborative management research, constructive research and clinical action research approaches and methodologies, influenced the selection of the projects to be utilized in this study. PBI Research Institute is an independent research institute supporting and promoting research in project-based industry. Although it is independent, it is closely related to Åbo Akademi University and the Laboratory of Industrial Management where I carried out my doctoral studies. The approach that PBI employs is developed on the basis of collaborative management research of the Scandinavian School of Management, with particular influence from SIAR, a Scandinavian research group focusing on applied research (Rhenman, 1970). The applied research projects that PBI is carrying out are practitioners-driven (or *client-driven* in action research terms) seeking to provide deeper understanding of the phenomena from multiple perspectives and give answers as to how to solve the problem. Such an approach can be paralleled with Lewinian or, perhaps even better, the Scheinian traditions of action research. However, it is more than that, since not only establishing questions, but also seeking the answers is a joint effort between the client-practitioner and PBI-agent. A continuous dialogue is maintained through organizing workshops and meetings at different phases of project development to discuss and validate — or rather falsify, as Popper suggested (1934/1959) — both intermediate and final results.

The role that PBI takes is somewhat of a combination of academic and consultants' perspective as described in collaborative management research (see, e.g. Werr and Greiner, 2008). The projects that were carried out as a part of this thesis pursued not only the academic goal of knowledge generation and distribution (Galbraith, 1958; Selznik, 1949) through describing the organizational realities (Argyris and Schön, 1978, Lawrence and Lorsch, 1967) of project-based firms but also strived to provide functional and specific industrial knowledge. It is argued that the latter is lacking in traditional academic research, mainly because of it is driven by the universality and commonality of results and an overemphasis on scientific methods and data (Werr and Greiner, 2008). Thus, the goal of this thesis — is not only in providing applied knowledge, but also in the development of methods, tools and approaches to comprehensively

solve the contemporary problems of management in project-based industries and to outline "best practices" within the field. In other words, the development of *purposeful designs* as Pasmore et al. (2008) describe them.

The combination of these two perspectives helps to avoid the trap often associated with pure consultant research: criticism and unrecognized accomplishments in the eyes of the scientific community (Salaman, 2002, in Werr and Greiner, 2008). An important part of the knowledge creation process within the PBI Research Institute is supporting doctoral thesis' projects in maintaining a continuous dialogue with the academic world: documenting knowledge in the form of scientific articles, presenting findings to peer academics (and practitioners) at conferences, seminars, etc. This dialogue with a larger audience provides a basis for maintaining the quality criteria of qualitative (Denzin and Lincoln, 1998) and case study research (Eisenhardt, 1989) as well as collaborative research by maintaining validity and quality criteria of a*ctionability* (I will elaborate more on the subject in the section regarding the quality criteria and the validity of the research), not mentioning the validation methods for construction research, particularly whether the construction has been widely adopted in companies (Kasanen et al., 1993). This is in line with Popperian thinking (1934/1959), which this thesis adopted in seeking falsification rather than validation of conclusions for theoretical contribution. Thus, the present study includes aforementioned methods in some way or the other.

Table 5 provides a summary of the methods of data analysis and verification in accordance with empirical data and the phases of the research.

Table 5. Methods of data analysis and verification

PHASE	CASES	DATA	METHODS
Phase I	Company A: the Offshore case (2006)	Qualitative data: 1. semi-structured open-ended interviews with Project Managers and a Project Controller involved in the Offshore project conducted in English language, transcribed; 2. project documentation: memos of meetings, project contracts and charts, project plan, etc.	• content analysis of the qualitative data to categorize main concepts and their attributes using the NVivo N6 software program and MSExel (as in Yin, 1994); • forming a narrative sequence of events for the project case (as in Tenkasi and Hay, 2008; Silverman, 2001); • systematic development of the coding system to achieve the common dynamics of integration of theory and practice observed across cases (as in Tenkasi and Hay, 2008); • systematic construction and development of the relevant models and processes (Kasanen et al., 2003)
Phase II	Company B: 7 cases, part of the collaborative management research project, documented in the project reports: Perminova O., Gustafsson, M., Arhippainen, T. (2007 (a)), 2007 (b))	Qualitative data: 1. semi-structured open-ended interviews conducted in English language over the period of one year, transcribed; 2. project documentation: memos of meetings, project contracts and charts, project plan, etc.	• content analysis of the qualitative data to categorize main concepts and their attributes using the NVivo N6 software program and MSExel (as in Yin, 1994); • forming a narrative sequence of events for each of the project cases (as in Tenkasi and Hay, 2008; Silverman, 2001); • systematic development of the coding system to achieve the common dynamics of integration of theory and practice observed across cases continues (as in Tenkasi and Hay, 2008); • within-and-across case analysis to compare the projects, events and outcomes with the aim to outline similarities and differences (as in Eisenhardt, 1989; Tenkasi and Hay, 2008), • systematic construction and development of the relevant models and processes (Kasanen et al., 2003)
Phase III	1st set of iterations, part of the collaborative management research and implementation project, documented in the project reports:	1. Qualitative data collected during Phases I and II. 2. Interviews with the Project Controller at Company A; 3. Several workshops at Company B with the PMs and Warranty Managers participating in the study as well as their superiors and senior company administrators. Conducted in English language. 4. Memos of meeting and relevant e-mail correspondence between the	• enriching a narrative sequence of events for each project case with relevant information collected in the form of memos of meetings and e-mail correspondence; • within-and-across case analysis to compare the projects in Phase I and Phase II, events and outcomes; • systematic development of the coding system to achieve the common dynamics of integration of theory and practice observed across cases;

	Perminova O., Gustafsson, M., Arhippainen, T., 2008	researcher and the key informants collected into a single document log, in English language.	• mapping the projects using the framework of Fuglseth and Grønhaug (2000, see Table 19 and Table 20 in the Appendix); • Forming a narrative of each case project, also in the form of pictures (see subchapter 4.4 Case Descriptions); • systematic construction and development of the relevant models and processes (Kasanen et al., 2003); • external verification of preliminary results (uncertainty management process) within Companies A and B via workshops and discussions with practitioners: project and warranty managers, their superiors as well as executive company managers (as in Bradbury, 2008).
Phase IV	2nd set of iterations, documented in Perminova, Arhippainen and Gustafsson, 2009	1. Qualitative data collected during Phases I and II. In addition, 2. The data acquired during the 1st iteration of results, 3. Several workshops and meetings with the Company B with the project managers and senior company administrators.	• Refining the results of the study based on the results of the 1st iteration; • Final verification of the uncertainty management process model with the Company B practitioners; • Early phases of implementation of the results (uncertainty management) in the Company B's business processes (as in Kasanen et al., 2003).

As it will be explained later, the Company B cases (Phase II, III and IV) were studied as a part of on-going projects at PBI Research Institute (see summary in Table 5). Along with the conventional methods, the collaborative management research principles were applied, especially when it comes to research life cycle.

Collaborative management research is an emergent fast-developing research approach, which is yet not well defined in the vocabulary of social scientists. There are multiple interpretations of what this concept entails. When I refer to this term, I assume the understanding of collaborative research in the way William Pasmore and his colleagues propose: as aiming at bringing researchers and practitioners closer together to boost the progress in understanding and addressing various issues concerning management professionals, organizations and their relation to society, such as innovation, organizational effectiveness, change, etc (Pasmore et al.,

2008). Speaking of research activities, collaborative management inquiry does not imply that the roles and contributions of researchers and practitioners are equal, nor does it assume that the goals and motivations of the participants are exactly the same. It allows for different degrees of collaboration, including only minimal influence and interest of managers with regard to the research agenda, formulation of research questions, choice and application of methods, etc. Rather, the fundamental interest in learning about the issue under scrutiny is shared. Collaborative research goes beyond collective inquiry because it strives to avoid the "studying of a closed system" trap, which is common for the latter, by involving outsider experiences. In sum:

> *"Collaborative research is an emergent and systematic inquiry process, embedded in agreed-upon partnership between actors with an interest in influencing a certain system of action and researchers interested in understanding and explaining such systems" (Pasmore et al. 2008, p. 13).*

The core of this inquiry process is in integrating the scientific knowledge and methods with practical knowledge and relevance. The main quality criterion for collaborative research is the same as for the action inquiry: *actionability* (as in Bradbury, 2008). In other words, the results should be actionable for those who intend to practically apply them to influence the system.

I would like to highlight the fact that collaborative research is often mixed with action research as it is grounded in similar principles. In general, action research studies are considered to be under the umbrella of pragmatist philosophy, hermeneutics and phenomenology as a scientific legitimating basis (Susman and Evered, 1978), which is also true for collaborative research. The other commonalties include three other aspects: (1) the integration knowledge production and action processes, (2) binding the researcher and the researched in a team to work together and learn using scientific methods and (3) combining inquiries from inside and outside by forming a joint insider/outsider research team (Pasmore et al., 2008). Action research can be seen as a mode of mutual learning, and thus, as the case with learning, requires transformation of experience through reflection in order for action to take place (Kolb, 1984). A similar statement can be made about collaborative research. However, there is a significant difference between action and collaborative research in terms of aims. Collaborative research is specifically interested in *purposeful*

designs that are intended to manage the systems towards desired outcomes and the *understanding* of e.g. firms and other organizations as complex systems of members, actions, interpretations that constitute them (Pasmore et al., 2008). Action research has wider interests than that. At the same time, application of collaborative research methods does not assume that the researcher is a part of a studied subject (in the case of this research, a part of a project or a warranty management team).

As will be explained in the following paragraphs, the study of Company B cases has some characteristics of collaborative research, partly in terms of the research cycle (diagnosing —> action planning —> action taking —> evaluating the consequences —> learning) and orientation towards the interests of the collaborating partners-practitioners. However, such elements are not unique in collaborative inquiry. Furthermore, adopting a collaborative research strategy allows me to utilize different elements of (action) research practices to pursue my goals. For instance, the chosen approach assumes that the research process is driven by multiple goals of the participants, and thus does not require to be strictly followed phase by phase, as is the case with the above-mentioned traditional action research cycle. On the contrary, collaborative research encourages a combination of descriptive and prescriptive elements of the process, provided such a combination aims at solving the problems and questions of the research. This thesis project can be related to some elements of action research traditions: primacy of the practical element as in client-driven clinical research (Schein, 2001), encompassing action and reflection (Argyris and Schön, 1996), stressing dialogue as a way of achieving better understanding (Bohm, 1996) and so forth.

Being field-based, longitudinal and engaged, collaborative research is often associated with action inquiry in terms of method, but is not limited to it. In fact, it is suggested that researchers committing to collaborative inquiry employ a combination of experimental and unobtrusive methodologies that provide the most rigorous explanations of the phenomena in question (Pasmore, Woodman and Simmons, 2008). In line with this thinking, I am applying a variety of methods that are associated not only with action research, but also common to other approaches such as grounded theory or case study research. These methods of data collection and analysis will be described in the following paragraphs.

The research projects in PBI are carried out in teams with members of such teams participating at all stages of the project development: from problem formulation to data collection and analysis, and the reporting of results. This process of maintaining collaboration and verification (in the sense that the collaborative research approach gives to this word) within the organization is yet another characteristic of a collaborative research approach. In general, PBI exploits methodologically an inductive approach.

In sum, the PBI Research Institute provided a platform for this doctoral thesis by making available the means by which to carry out real-time empirical studies in terms of tools and means for data collection and analysis, generation of knowledge and testing of the findings both within practitioner and scientific communities. Some of those studies that I participated in as a member of PBI constitute the empirical data of this thesis (see Table 6). Table 6 indicates the articles and conference papers that were produced as a result of the studies in attempt to bring the results for discussion to a larger audience of academics and practitioners. However, these contributions indicate only intermediate results. This thesis study builds upon some of those findings as milestones in the research process, but strives to provide a better, more thorough understanding of the issues at stake.

In addition to empirical data collection and analysis, I continuously performed the literature studies within project management and other relevant fields. Before I started data collection, I had already familiarized myself with the perspectives of a project-based industrial company and project business as such. Although some initial conceptualizations of risk, opportunity and uncertainty were made, the research questions, however, were not yet formulated in the current form (they are documented in e.g. Perminova, Hellström and Wikström, 2006). Rather, these attempts could be labeled as a search for a theoretically urgent and interesting subject in the field. On-going discussions with my colleagues from the PBI Research Institute as well as with other academics helped me to outline the phenomena of interest for project management science. When I began the data collection phase, I could test my initial beliefs with practitioners.

Table 6. Project logs, reports and documentation of results according to industry

OIL AND GAS OFFSHORE PROJECTS	MARINE PROJECTS	POWER PLANT PROJECTS
Pre – understanding and literature review (Perminova et al., 2006)		
A detailed study of one project with the focus on risk, uncertainty and opportunity management 2006-2007 (Perminova, Hellström and Wikström, 2006; Perminova, Gustafsson and Wikström, 2007; Perminova, Hellström and Wikström, 2007; Perminova, Gustafsson and Wikström, 2008 (a), (b); Perminova and Hellström, 2008)		
	A research project for Company B aimed at developing and implementing a method for uncertainty, risk and opportunity management at warranty phase of industrial projects with a special emphasis on competence management 2007 - 2009 (Perminova, Gustafsson and Arhippainen, 2007(a), 2007(b), 2008; Perminova, Arhippainen and Gustafsson, 2009)	

3.2.1 Data collection

In this section I will describe how the data was acquired. This will be done in relation to the specific data source since it had an impact on the formulation of the research problem and conceptualization. Figure 4 illustrates the research process in terms of timeframe and sequence of research actions undertaken according to the sources of data stemming from the two sources: the two industrial project-based companies operating globally. For the sake of confidentiality, I will refer to these companies as Company A and Company B.

Figure 4. The research process
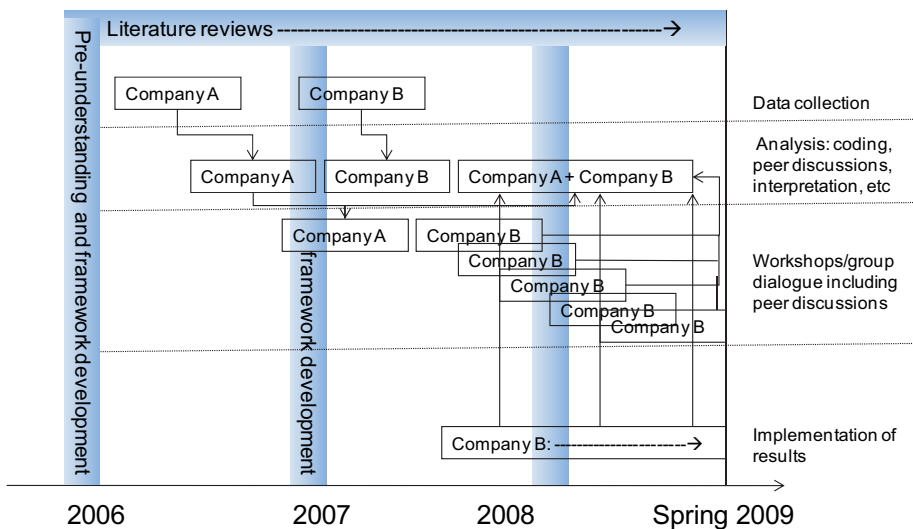
It is necessary to mention that I have not been a part of the studied organizations at any point of time, rather I am regarded as an outsider towards these firms. The members of these organizations, who participated in this research, represent the practitioners' side, whereas I took the role of a scientist.

In the following chapters I will describe this research process step by step.

3.2.2   Phase I: Company A case

The starting point of this thesis is the interviews and discussions, held in English language, with project management professionals at Company A, a Finnish firm providing engineering, project management and contracting services for oil and gas exploration and production companies. This company can be characterized as an entrepreneurial (Bird, 1992; Krueger and Brazeal, 1994). Although the company is characterized as small in size, in terms of personnel (less than 50 people employed in the head office), the scope of delivery that the company provides concerned a wide range of project management services for the upstream industry of offshore oil and gas.

The discussions were not only concerned with general business practices for the industry. The central subject was their participation as one of the two main contractors in a large offshore project, the aim of which was to produce the oil and gas drilling and production platforms to be operated on the Far East offshore of Russia. In the scope of their contract for the oil and gas platforms of a CGBS type were: coordination of MMO engineering including method statements, schedule and follow-up, fabrication engineering supervision, job cards, material flow control and site assistance on the two locations in Russia[10]. While this project remained the

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[10] Information according to: www.deltamarin.com/references/**offshore/Offshore** reference list.pdf, retrieved on 16.12.2008.

main topic of my interviews with managers of this company, the other examples from their project portfolio were mentioned quite frequently as examples of somewhat similar endeavors for the oil and gas industry.

I performed the investigations in this project in two steps. Firstly, I conducted five interviews with the project team members and associates in autumn 2006 during the installation/commissioning phase. One year later, in October 2007, I returned to the Company A office to hold a workshop.

The first round included 5 interviews (4 of them tape-recorded and one summarized based on the hand-written notes) and was performed in autumn 2006, when the project was already at the warranty phase. The interviews were as follows:

- one interview with the Project Controller, whose responsibilities included coordination of the project activities both within Company A and with the other stakeholders,
- one interview with the managing director, who took an active role in the bidding and sales phase of the project as well as in coordinating the project management activities,
- one interview with the project manager, who became a member of the project team for the period of this project, his base organization being the other main contractor,
- one interview with each of the two other members of the company staff acting as project managers. They did not have any responsibilities assigned in this project, but they took an active part in assisting with issues in the project requiring their competence, brainstorming sessions and other formal and informal discussions/seminars together with the project team members.

At that point in the timeline of my research, I was particularly interested in how project uncertainty and risk are managed. Special attention was drawn to grasping whether there is a difference between risk and uncertainty and how this difference is reflected in management practices. All the interviews were transcribed and combined with the additional data (memos of meetings, relevant e-mail correspondence, project notes, etc.). After the first round of the content analysis was performed using the QSR NVivo 7 tool, the research question was reformulated. This study resulted in the development of a conceptual

framework differentiating uncertainty from risk, which was published in several scientific and practitioner project management journals, and also presented at several international management conferences (Perminova, Gustafsson and Wikström, 2007; Perminova, Hellström and Wikström, 2007; Perminova, Gustafsson and Wikström, 2008 (a), (b); Perminova and Hellström, 2008).

The second part of this study was conducted in autumn 2007, when the warranty phase had partly ended. However, the contract had not yet been closed due to several open issues between the stakeholders in this project. During that phase of the study I held a workshop, which included one detailed discussion (56 minutes tape-recorded interview and memos of the rest of the meeting) with the project coordinator. The other part of the workshop included discussions of my results and interpretations with other members of the company's management. The aim was to understand how the project had developed within one year as well as how it had affected Company A as a whole. Theoretically, my intention was to increasingly focus on verifying how risk, uncertainty and opportunity are understood by project management professionals in this company. I used this session as one of the points of verification of my results from the first phase of the study. I was particularly focused on uncertainty management in my interviewing (for the explanation of the interview techniques, please see the *Conducting interviews* chapter).

Apart from the interviews, the sources of data included:

- the complete set of contractual documentation for the project under scrutiny;
- general manuals describing management processes used by Company A in their business practice, particularly change management and risk management;
- other public sources of information about the project, such as the websites of the project stakeholders, journal and newspaper publications.

3.2.3 Phase II: Company B cases

This study is based on the results of the development and implementation project that the PBI Research Institute executed for the industrial supplier acting in a global setup within the segments of ship building and energy (Perminova, Gustafsson and Arhippainen, 2007 (a), (b); Perminova, Gustafsson and Arhippainen, 2008). This industrial supplier will hereafter be called *Company B.* I participated in this project as a researcher in a project team providing expertise on project risk and uncertainty management. The objectives of this project were:

1) To classify the risks and uncertainties at the early post delivery stage (warranty),
2) To clarify the role of customer operating competence in creating risk at warranty,
3) Develop and implement a method for screening and managing warranty risk and customer operating competence in Company B.

The project consisted of three phases, which can be interpreted as stages of collaborative action research:

1. Current state analysis of the company practices on a broad level, with specific interest in the issues of uncertainty, risk and opportunity (refers to diagnosis and action planning).
2. Development of the management process to address the needs of the company under scrutiny (refers to action taking) involving regular dialogue with the company in the form of workshops, formal and informal discussions, etc. (refers to interpretation and evaluation).
3. Implementation of the co-developed management process into the business practices of the company with continuous on-going dialogue (validation and evaluation).

For each phase of the research a one day long workshop was organized to present the findings to the company management, discuss them and develop an action plan on how to proceed further. All of the activities including the interviews were held in English language.

The data and the results of the first two phases are used in this thesis as the empirical data. The third, implementation phase of the project, was on-going during the time this thesis was being finalized (Spring 2010). My practical tasks as a project participant included data collection (interviewing, participation in discussions, reviewing relevant documentation, etc.), qualitative

analysis of the data and reporting of the results (written reports and workshop contributions) as well as theoretical development of the model of the management process. The outcomes of this work are presented in this thesis in the following chapters.

During the first phase, a study of the current state analysis of the risk management practices under warranty within Company B was performed on the basis of the observations of the sample of 10 projects. The projects that I observed were evenly split into two groups within the sample: shipbuilding projects and power plant construction projects. The scope of supply for these projects ranged from large equipment deliveries, to EPC (engineering, procurement, construction) and turnkey projects. These projects for the sample were chosen by Company B themselves. The main criterion for the choice was that the projects were at the beginning of the warranty phase or commissioning at the time of the selection. This gave our research group the possibility to follow them up to the end of the warranty. The analyzed data consisted of different sources (all of them in English language):

a. Interviews with the warranty managers responsible for these projects as well as with some of the project managers for the chosen projects regarding risks, uncertainties and opportunities that appeared in the projects in question, the causes of that as well as other problems and obstacles in their current way of working and ways to improve the drawbacks; held in English;

b. Specific project documentation: contractual agreements, memos of meetings (e.g. kick-off, customer meetings), project plans, etc.;

c. General policies, manuals and procedures used by Company B (e.g. risk registers, warranty management process guidelines, etc.);

d. General discussions in the form of memos regarding risk management practices with the company experts from sales, project execution and technical service departments delivering projects for marine and energy systems (power plant) industry.

The second phase of the research concluded with the development of a risk/uncertainty screening, a management process, and a tool using the results of the previously conducted current state analysis. The tool and the process were tested within a period of 8 months on a

similar sample of another 10 projects. In August 2008, another workshop with the senior management of Company B was held to evaluate the first results of the test.

The third, implementation stage of this research project, has started in autumn 2008 and is on-going at the moment, while this thesis is being completed (Spring 2010). The implementation stage involves all the projects in the portfolio of Company B. During the period from August 2008 until May 2009, two more workshops were held to address the results. It is necessary to mention that I have not used the project data from the implementation stage in the analysis in this thesis. Rather, at that stage, I used the opportunity to further discuss with the managers the model of uncertainty that had emerged, as well as test the ideas and fine tune it for implementation. Hence, that period served as a validation of the thesis results.

The summary of the projects and interviews that I used as cases in this thesis is presented in Table 7. Although the number of projects that I observed during the assignment with Company B was much more than seven, I ultimately only included seven of them as stand -alone cases. The reason for this was the limited access to project data, since the assignment restricted the period when the data analysis had to be complete. Thus, the rest of the observed endeavors affected the analysis to some extent as they were discussed during the interviews and workshops, but mostly as examples or comparisons.

3.2.4   Conducting interviews

There were no strictly followed questionnaires at the interviews. Rather the managers were encouraged to tell their *"stories"*: to give examples of different occurrences/ events, the unforeseen situations that took place during the course of the projects. However, I employed a general topic matrix as a personal reference tool to ensure that the relevant themes were covered during the meetings (see Figure 26 and Table 13), although these t ools were not strictly followed. The interviews were conducted in English language by the author of the thesis, and then transcribed by a professional translator for the English language. In addition, the correctness of the transcription was verified with the interviewees to avoid misinterpretations.

Each interview started with a brainstorming regarding how uncertainty is perceived in relation to risks and opportunities. I asked the interviewees what uncertainty in their projects meant to them and how it was different to risk and opportunity. Additionally, I avoided describing, or even using, the words *risk, uncertainty and opportunity* in questions unless the interviewee had already expressed his/her point of view regarding these issues. Such a method allowed the interviewees to provide examples and explain issues in terms they considered relevant in the context of risk and uncertainty. This technique possesses an advantage which lies in the fact that the interviewees might feel more open and free to express their opinion rather than politely follow the opinion of someone who is believed to know the issues. They are motivated to give richer, not by-the-book, explanations.

The interviewees were asked to provide an example of the situation involving uncertainty and the methods/actions that the interviewee applied to it. Then, the respondents were asked to compare their stories and strategies of dealing with uncertainty to the other projects supervised by the other managers that they were aware of. This was done to avoid the bias of strategically correct but unrealistic answers. In addition, triangulation was used to ensure the correctness of interpretations (which will be discussed in the next sub-chapter). Somewhat similar data collection technique was used in the study of managerial perception of uncertainty performed by Meijer, Hekkert and Koppenjan (2007).

Table 7. Projects and interviews used as cases in the thesis

	OIL AND GAS OFFSHORE PROJECTS	MARINE PROJECTS	POWER PLANT PROJECTS
Phase I	*Number of Projects* 1 *Number of Interviews* 6		
Phase II		*Number of Projects* 2 *Number of Interviews* 5	*Number of Projects* 5 *Number of Interviews* 11
		Discussions during workshops 6	
Total:	8 projects	22 interviews	6 workshops

3.3   Data analysis and validity of the research

My analytical strategy assumed an iterative approach: regularly revisiting data, going back and forth between the data and the emerging answers to the research question. The qualitative research tradition assumes that a wide array of methods can be applied to analyze the data. It can be argued that the method per se does not matter, but rather that it is the manner in which it is applied that is important. The following methods were applied in this thesis (see also Table 5):

1) content analysis of the qualitative data to categorize main concepts and their attributes using the NVivo N6 software program (as in Yin, 1994),

2) forming a narrative sequence of events for each observed project case (as in Tenkasi and Hay, 2008; Silverman, 2001),

3) within-and-across case analysis to compare the projects, events and outcomes with the aim to outline similarities and differences (as in Tenkasi and Hay, 2008),

4) regular workshops and peer discussions both with fellow researchers and practitioners to report and verify the results of the research. The latter, in accordance with collaborative research principles, served as means of data collection, interpretation, analysis and verification,

5) systematic development of the coding system to achieve the common dynamics of integration of theory and practice observed across cases (as in Tenkasi and Hay, 2008),

6) systematic construction and development of the models of the processes on the basis of the analysis. The latter, in accordance with collaborative research principles and constructive research methods, is aimed at managerial (and scientific) problem solving (as in Kasanen, Lukka and Siitonen, 1993).

The analytical process steps (performed in the English language) were not held in the sequence presented above. As one can see from Figure 2 and Table 5, I returned repeatedly to the results of the analysis, developing the coding categorization as soon as there was a possibility to enrich and verify them according to new emerging understandings. All the interviews were transcribed; the data from Company A and Company B was combined and transferred to QSR

NVivo 7 software program which enabled content analysis and categorization. I worked towards validity of the constructs (uncertainty, risk, opportunity, etc.) by categorizing the data in such a manner that relationships between the categories were evident. I strove towards connecting the elements of the categorization to achieve process logic in their interrelations. What I call initial coding analysis was done immediately after all the interviews and materials were collected from the projects. After the initial coding, I continuously revisited and significantly developed the emerging model with the latest version being the one discussed here. The inspirations behind the model development were the workshops with practitioners and the peer dialogue with fellow research communities as well as conceptual development of the framework and continuous literature studies. My position in the project as an actively involved researcher, an insider participant in the projects, facilitated the testing of the model with the practitioners. These activities which assured that there were dialogue and application meetings in terms of the research results of this study have ensured the validity of my research according to collaborative research criteria (David and Hatchuel, 2008; Bradbury, 2008).

One limitation of the study, which needs to be spelled out, is that the interviews and workshops were carried out in the English language and not in the interviewees' or the interviewer's native language which may have distorted some of the information. However, it must be said that the English language is the official language used in Company A and Company B in their local offices all over the world including Finland. Thus, the good command of the English language a prerequisite for all of the employees including the respondents in this study. At the same time, this bias was triangulated methodologically via application of several data gathering and analysis methods (e.g. workshops and discussions with practitioner during which the unclear issues were resolved, brainstorming sessions, using the other PBI research projects as sources to confirm the data) and by involving several investigators (the PBI colleagues who participated in the research projects involving Company B and could provide meaningful insight into understanding of the context). In addition, the author used the services of a professional English language translator for the transcription of the interviews. Theoretical triangulation took place via performing continuous literature reviews to investigate the issue of uncertainty and the management practices related to it in several scientific disciplines (outlined in the Theoretical Framework chapter).

3.3.1 Quality criteria and validity of the research

The present study belongs to non-positivistic qualitative research tradition. Generally, it is not possible to apply the same quality criteria to different inquiry paradigms (Susman and Evered, 1978; Lincoln and Guba, 2003). In positivist science, the quality criteria for research are determined by internal and external validity, reliability and objectivity (Bryman, 2001). Non-positivistic research does not seem to have such a widely established set of evaluating methods; however, as noted by Argyris (In Bradbury, 2008), it pursues the conventional notions of validity, especially with regard to organizational science.

This thesis builds upon the philosophy of practice, which calls for the establishment of validities that emerge from the context of the study. As proposed by Kasanen et al. (1993), the findings of applied research are evaluated from several perspectives such as relevance, simplicity and ease of practical application. The validation was done usually done employing the following two methods:

- regular workshops during the project between the research team and the extended team of practitioners including operational and top administrative levels of the participating companies (see Figure 4),

- testing and shaping of the results through implementation in the participating companies.

The research projects that this thesis builds upon (e.g. Perminova, Gustafsson, and Arhippainen, 2007 (a), (b); 2008) include both methods. The implementation and testing phase has not been included into the scope of this thesis due to the time limitations of this work. These criteria can be paralleled with the concept of *actionability*, which is considered today as the core of quality in collaborative management research (Bradbury, 2008; Argyris, 1996). Bradbury (2008) outlines the following sub-criteria included in the concept: practical value (1), social interaction (2), cycles of action and reflection (3), and active experimentation (4). *Actionability* encompasses, among other attributes, the ability of the research to help people and organizations to systematically meet their goals with regard to sustained desired practice (Bradbury, 2008). The more the researcher addresses the needs of the research object, of the co-

inquirers (which can be the same as the research object), the better the research quality is deemed to be. The notion of *actionabilibty* is similar to the concept of *credibility* actively used in qualitative research (e.g. Guba and Lincoln, 1998; Bradbury, 2008). The principle itself is in the emphasizing of collaboration, continuous dialogue between research subject and research object, especially if we consider how the concept of truth is interpreted in pragmatism-based research.

As for the evaluation criteria for case study research, the triangulation was used to ensure more robustness of evidence (Eisenhardt, 1989). In accordance with the classification of Denzin (1970), this thesis utilizes data triangulation, investigator triangulation, theory triangulation and methodological triangulation in some way or another (see e.g. the two previous sub-chapters).

IV   CASE DESCRIPTIONS AND ANALYSIS

4.1   Introduction to the cases

In this chapter, the cases illustrating the process of uncertainty management are presented. The cases represent the situations that happened at some point in the project life-cycles as told by the managers in charge of them. The respondents considered that these events were significant and as having an impact on the respective projects' results as well as on the organization as a whole. The described projects represent different industrial segments: shipbuilding and energy. The descriptions of the cases-situations are presented together with the analysis, and aim to explain the phenomenon under scrutiny, and the elements and actions managers undertake to address it.

To begin with, I would like to point out that the set of data that I analyzed includes different examples of risks, uncertainty and opportunities. In this chapter, I provide the descriptions of stories — situations in projects — that presented themselves in my interviews with managers from the two companies, which will hereafter be named Company A and company B.

As was already mentioned in the chapter on methodology, the entire set of data includes not only the descriptions of stories and personal managerial reflections that can be found further on, but also other material on *routine processes* (as in terminology used by March and Simon, 1958): the applicable company policies, project plans, charts, meetings memos, etc. set of data was combined with the managerial reflections to provide a more complete picture in the descriptions. The general discussions regarding business processes of the project-based companies as well as seminars and workshops with both practitioners and academics played an equally important part in the data analysis, and especially in verifying the findings.

Since the cases as such represent only part of the data, the content analysis results will be discussed at the same time. The cases are presented in the following steps:

- *Project outset*, which represents the known certainty,
- *Unforeseen event*, which evokes uncertainty,
- *Action* in response to the situation ,
- *Outcomes,* which equal to the project performance
- *Lessons learned* in the form of managerial reflections on what could have been done to improve or alter the outcomes.

As it is often argued in the project management literature, nearly any project can be labeled unique. However, the practitioners in the companies that I have studied tend to see patterns and commonalities in the projects that they deliver, and thus operate with the terms "standard" or "non-standard" project. Both approaches to assessing projects have their truth since it is merely a matter of perception i.e. which characteristics of the project the judgment is based upon. In order to escape the trap of superficially naming the project under scrutiny either unique or standard, I introduce several parameters into the project; these descriptions made at the outset supersede / replace the main project characteristics. These parameters, existing in all the projects, help understand the project situation better, without operating with exaggerated terms that have varied meanings.

The coding analysis shows that there are two main parameters or sets of factors, under which all the relevant characteristics can be grouped. One parameter, *project organization*, encompasses the issues that are project-specific. The other is *internal organization*, which includes the characteristics of either one of the two studied project-based organizations: Company A or Company B. The parameters are as follows (see also Table 8):

• **Project organization factors:**

      i. Technical complexity

     ii. Customer

   iii. Contractual terms

   iv. Network

    v. Location

- **Internal organization factors (of Company A or Company B):**

    i.   Experience
    ii. Communication
    iii. Reflective processes
    iv. Routine processes

The specific characteristics that fall under the project and internal organization parameters stem from the data analysis. They serve as a basis for comparison between the outsets of the projects. It seems quite natural that at least one factor representing project organization might be different or similar to that of other projects. For example, several projects with the same intended outcome are delivered to one and the same customer. However, it does not necessarily mean that the contractual terms, location of a project site or a network of stakeholders involved are also the same in those projects. Thus, the projects can be practically characterized as ordinary or standard in terms of scope of supply and the customer. But at the same time, they might be non-standard or unique in some other factors.

In a similar vein, the set of internal organization factors that have significant impact on how a project is managed can also vary from project to project. There two reasons for this. Firstly, organizations are constituted of the processes that originate from their members, who are by nature different. Secondly, even one single person under changing circumstances would most likely act differently. Organizational elements — management processes, hierarchy, power relations, experience, — change over time. Considering this logic, organizational factors vary in impact and significance that they have on different, even simultaneously delivered, projects.

In the figures illustrating the case descriptions (Figures 7—15), I am illustrating the factors that the managers indicated as being the important facts, in other words, the certainties that they learned at the beginning of their project duties. A short description is provided for each of these along with markings in color: red indicates a weak point and green is a strong one according to the manager's opinion. Since most of the situations occurred and were resolved before the interviews took place, at least the intermediate result of the actions targeting the impact of the event were known to the respondents. From this perspective, the color of the outset facts can be understood as an indicator of the possible cause of the occurred event, or even the cause itself.

Table 8. Project parameters and the project characteristics that are associated with them

PROJECT PARAMETER	CHARACTERISTICS OR FACTORS OF PROJECT	DESCRIPTION OF THE FACTOR
Project organization	Technical complexity	Technical complexity is a category that encompasses the issues that are related to the hardware outcomes of the project – the product, its components and tools associated with it. It is an internal parameter of the supplier organization. It must be noted that the processes that are associated with the product, such as the technology and the product development, its new applications, the services around it, - are included into the following category – internal processes, management and organization.
	Customer	It is an external parameter that refers to the characteristics of the customer organization as such. The respondents stressed several qualities of the customer company: knowledge of the industry of the project (marine, energy, etc.), experience in the industry (number of years, projects, etc.), number of projects delivered together with the supplier in question, experience in how to operate supplier's equipment (knowledge of specifications and operator/user requirements by model), customer's commitment to the project goals (perceived as willingness to communicate/cooperativeness), region-specific way of working. It is an external parameter from the perspective of the supplier's own organization. Thus, it does not include the relationships and other processes that take place between the customer and the supplier.
	Contract	From an execution point of view, the contract is a formal agreement outlining the tasks and responsibilities of the counterparts that enter into such an agreement. In other words, it is a formal statement of the responsibilities of the parties executing the project. The contract and its supplementary documentation, including amendments stating the changes in the originally agreed scope of supply, constitute one of the main sources of relevant information influencing managerial activities in the project.
	Network	The term network I understand as concerning the issues related to the structure of project stakeholders' network, the hierarchy and power relations between the actors, the goals pursued by them and attitudes that they express towards the project as perceived by the interviewees in comparison to that of Company A and Company B.
	Location	Location refers to the geographical location of the project site and the peculiarities related to it.
Internal Organization		Internal Organization parameter refers to processes of organizing and management and their elements.
	Experience	What is meant by organizational experience here is the sum of single individual experiences, results of reflective learning-by-doing processes, a tacit knowledge that the members of the organization in question possess and utilize in their work. Indeed, experience is by definition reflective, as well as communication.

Communication	Communication is seen on two levels taking the perspective of the supplier firm in question: internal within the company (between departments, divisions, etc.) and external (with the project stakeholders, authorities, etc.).
Routine processes	In contrast to experience, skills (explicit knowledge) of the organization members are included into the notion of the routine processes. Routine processes are the processes and procedures established at a company during the time of their operation in the business. It is the business practices that are outlined in manuals, policies, guidelines, etc.
Reflective process	The category of reflective processes includes such issues as information interpretation, evaluation and judgment, formation of values and goals of the members of a firm.

4.2   The industry introduction

In the cases, I use examples from three industrial segments:

- Ship building, both cruise vessel and cargo,
- Energy systems, and
- Oil and gas/petroleum offshore industry.

All the three industries have their own specifications, although the two latter industries — power generation and the offshore oil and gas segment — are encompassed by the general tendencies taking place in the energy business. In the following sections, I will explain the general characteristics of the industries, to which the cases belong.

4.2.1   The ship building industry

The developments in the ship building industry at the end of the twentieth — beginning of the twenty first century have been influenced by the trends in shipping, especially those of the continued expansion of world trade, fleet renewal and capacity expansion, all of which led to its

current status of being truly global (Hellström, 2005). Although traditional shipping nations maintain a significant market share in ship building, the competitive edge has moved to the East with Japan and South Korea already being the tend setters by the 1960's and 70s. Due to the over-capacity in the industry followed by the price slump in the early 1980s, the regime of rationalization and subsidies, that still currently characterize the industry, was adopted. Another price slump at the end of the 1990s resulted in a loss to the EU yards of the major part of the volume segments of bulk carriers, container ships and tankers. Due to these changes in the market that occurred at the shift of the century, the EU shipyards pursued a niche strategy, focusing on the building of vessels requiring higher technological sophistication and specialized know-how, such as cruise ships (ibid.).

In general, the luxury cruise vessel industry is a special segment in shipbuilding, aiming for more than just transportation of passengers from one geographical point to another. The core of the cruise business is the unique combination of sailing with a wide array of customer-oriented services, which can be generally classified as leisure and entertainment. The modern cruise ships are often described as floating towns or luxury hotels with all the necessary attributes to justify the name: restaurants, wellness and fitness centers, swimming pools, casinos, night clubs, shopping areas and more. In terms of shipbuilding this means that a greater focus is put into the outfitting work; and the traditional importance of assembling the steel structures in the cruise vessel segment has somewhat diminished as compared to the volume segments of the industry (Andritsos and Perez-Prat, 2000). However, the custom-made outfitting is not the only reason why the cruise vessels deserve their status amongst the very unique and most complex products in any industry. The machinery requirements are high as well: the vessel needs to maintain high maneuverability together with speed.

The safety of the equipment aspect is also very demanding since the vessel operates in high seas with a significant number of passengers onboard. Any cruise vessel must comply with the demanding safety standards before it leaves the building dock, both those imposed by International Maritime Organization as well as the Convention for Safety of Life at Sea (SOLAS) being a necessity. From this perspective, there is no room for traditional risk management with the aim to minimize potential negative impact of the event on the outcomes (or the safe

transportation of a passenger to the destination, in this case) since the risk of negative impact on the passengers' lives should be zero according to the procedures. While it is a necessity to apply precautions prescribed by the maritime standards, — the action that can be regarded as risk management per se, — one cannot prevent a force majeure event on board because of its nature of being unknown in advance. Even what was not supposed to happen, happens. Moreover, it can be difficult at times to judge the severity of its impact on the equipment and people on board beforehand. In other words, the event and its causes are uncertain and not known in advance. If the event occurs, it has to be handled not only according to the rules and procedures, but more importantly, in such a vein that passengers and crew have no danger to their lives. The actions that have to be implemented to reach an acceptable level of safety can sometimes go beyond the recommendations and require proactive thinking. This is an example of the relevance of uncertainty management, where risk management becomes a supportive function in preparation for any potential negative impact even at the vessel assembly. In this sense, the uncertainty management process becomes an on-going process having continuous relevance throughout the whole project, from vessel design and construction to warranty, when the ship is out into operation.

Generally speaking, ship building is composed of information processes and production processes, which are inherently integrated (Andritsos and Perez-Prat, 2000). The information process covers information-intensive activities related to the design of the ship, including:

- concept design activities, with pre-contractual phase feasibility studies and preparations of pre-design documentation such as specifications, principal system descriptions and diagrams, etc.,
- basic design activities including coordination engineering, master scheduling and building procedure planning among other design-related processes, and
- detailed design, including work planning and other preparations.

Planning and coordination of the production process are also an important part of information process.

The production process is the process of transforming raw material into vessel structures. As it

was mentioned above, this process consists not only of steel cutting, assembly and erection of blocks or units of a ship, but also outfitting work, which is of special importance for the cruise vessel segment.

In terms of the contracting of the work, ship builders — ship yards — commonly use the following types (Hellström, 2005):

- turnkey delivery or the full responsibility from design to commissioning
- design
- manufacturing
- installation
- other works and services.

The current trend in terms of responsibility for the execution of the work in the ship building industry is oriented towards a more extensive use of subcontractors consisting of inter-disciplinary teams, which are expected to assume turnkey responsibility for whole systems or segments that they deliver (ibid.). Consequently, the corresponding concept for the ship builder is named *"assembly yard"*. In contrast to using field- or profession-specific subcontracting (e.g. electrical, mechanical etc), the use of turnkey deliveries is expected to give multiple benefits: shorten lead times, provide highly skilled personnel to execute demanding work in limited periods of time. One of the greatest challenges with the *"assembly yard"* concept in practice has been to teach the new first tier suppliers to handle their projects in terms of planning and scheduling, which was earlier done by the yard (Brady and Davies, 2004; Hellström, 2005). A shift from traditional subcontracting to the turnkey deliveries employing modular approach constitutes a significant institutional change for both the ship yards and the subcontractors. The example of the modular approach is reflected in Figure 5. Ship production and assembly hierarchy.
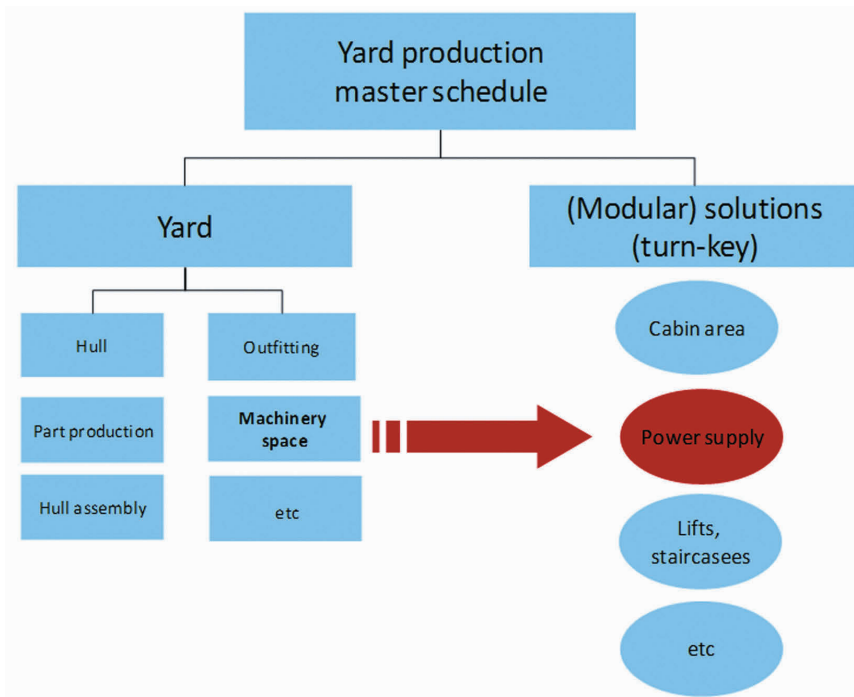
Figure 5. Ship production and assembly hierarchy (adopted from Wikström, Hellström and Westerholm, 2005)

4.2.2 The common trends in energy and petroleum offshore businesses

Generally speaking, the present status and the changes that are taking place in both power generation systems business and oil and gas offshore industry, are influenced by several common factors, among them being (Hellström, 2005):

- liberalization of energy markets, which particularly influenced the electricity business,
- a special emphasis on the environmental issues, and
- rapid development and commercialization of new technologies.

The general trends in the petroleum production industry indicate that the sustained growth in gas production is recently accelerating due to the appearance of new technologies (Ronalds, 2006). In addition to its traditional use of heat generation, gas receives new applications as a

substitute for coal in electricity generation because of lower carbon dioxide emissions. It also shows potential in displacing oil in transport fuels through gas-to-liquids and gas-to-hydrogen technologies. These trends justify the emergence of a new era which has been dubbed the *"methane economy"* (ibid.). The current situation with the oil price volatility and supply constraints justify the predicted shift towards the more extensive use of gas-based technologies (see Figure 6).
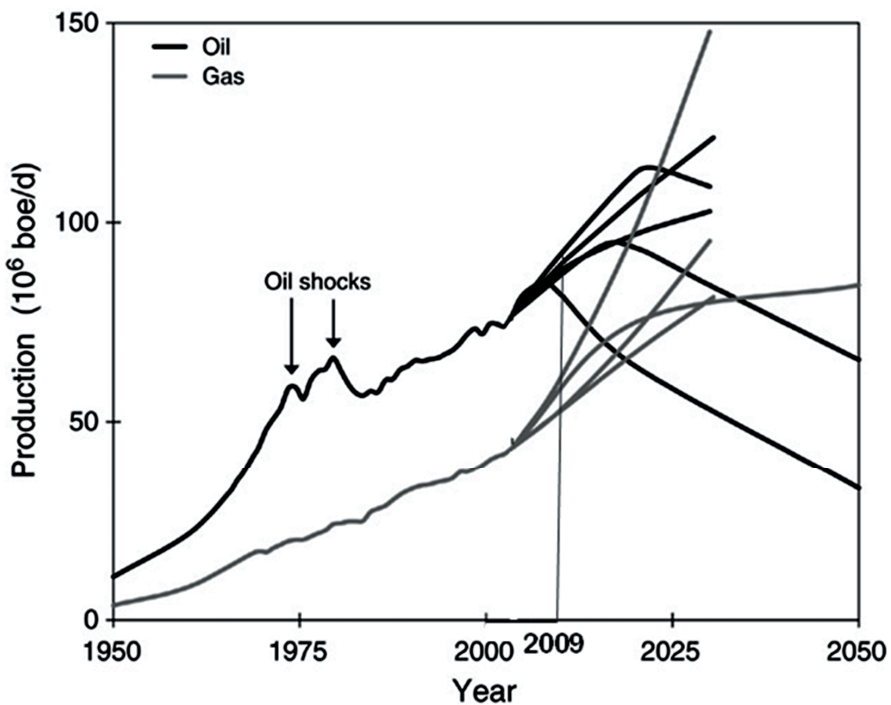
Figure 6. Worldwide oil and gas production (adopted from Ronalds, 2006)

These tendencies create a need for the fast development of the respective technologies to explore new opportunities for both oil & gas and power generation market actors, whilst at the same time maintaining cost efficiency. For the power business this means that there is a change

in the optimal plant size shifting from that of centralized large-scale systems to distributed energy systems. In terms of equipment manufacturing, economies of scale are likely to be realized through moving towards smaller generating units (IEA, 2002).

In terms of oil and gas offshore production efficiency and effectiveness, the complexity of the offshore installations and their operating processes are going to increase due to specific features of gas extraction, processing and transportation. Oil is much more valuable than gas in terms of unit volume, and its transportation less expensive than that of gas. Moreover, the new promising offshore gas fields that are to be exploited are mostly in deep water, whilst deepwater production has been cost-effective to date only for oil-dominated fields (Ronalds, 2006). All of this combined with the price volatility the petroleum markets are presently facing calls for the rapid development of a wide range of technologies to exploit the opportunities the demands on the global gas market offer.

In general, the tendencies and changes in energy markets are expected to evoke the appearance of new market players whilst also changing the roles of the existing ones. In addition there is likely to be an emergence of new kinds of services, together with the need for different types of management processes and skills (Hellström, 2005). For example, the offshore petroleum industry has recently been emphasizing the importance of development and implementation of the managerial processes aiming at uncertainty management that would provide, among other commercial benefits, a solid contribution towards a regulatory policy.

In addition to the trends discussed above, the offshore petroleum industry is characterized by a special emphasis on the uncertainty aspect due to the nature of this business. Oil rigs are highly complex systems consisting of drilling and production units destined to work in harsh offshore environments. There is a diverse typology of offshore installations according to different criteria, in this case the water depth and well count (Ronalds, 2006):

- fixed production installations: jackets, concrete gravity structures (CGSs) and production jack-ups
- floating production installations: FPSOs and production semi-submersibles
- tension leg platforms
- remote subsea tiebacks

Additionally, the offshore installations differ in terms of operator presence (attended and unattended) and well exposure. In this thesis, I analyze a fixed production installation: a concrete gravity structure (CGS).

The technologies in the power plant cases of this thesis concern a diesel and natural gas fuelled reciprocating engine. This power production technology can be considered an old invention used as early as the 19th century, which at some point lost competition to steam turbine. Nowadays, the demand for higher operating efficiency and environmental concerns support an increasing use of this technology especially through the projects delivered to the remote parts of the world. Currently, this technology is continuously being developed in order to address the cost-efficiency challenges. Moreover, the suppliers are requested to provide diverse technological solutions due to the increasing customer demands for not only electricity or heat, but both, or even including air conditioning capacities. For example, combined heat and power (CHP) and chill, heat and power (CCHP) solutions are among the newest technological concepts that the suppliers have developed in order to stay competitive on the market (Hellström, 2005).

The researchers studying the trends in the oil and gas industry indicate that in spite of the common endeavor towards developments that are mainly high-tech driven, thus far the human and organizational aspects have become the greatest challenges that require addressing strategically (Liyanage, 2006). It implies that more holistic socio-technical approaches are necessary to develop and implement high-performing systems given the level of complexity and the nature of change (ibid.). One of the main themes in this respect has become the human safety aspect along with the increasing concern for environmental performance. The special attention to health, safety and environmental (HS&E) performance from operators, contractors and regulators worldwide is transforming the industry's culture (Jablonowski, 2007).

In the last decade, significant efforts have been made to develop and implement state-of-the-art procedures for evaluation and assessment of accidents taking place on the offshore installations — or unplanned situations of hazard and accident, as they are sometimes referred to in the literature (Vinnem et al., 2006). In this respect, risk and uncertainty management practices are of

high relevance. It is often argued that the potential of future major accidents cannot be measured directly, thus constituting uncertainty. However, it is possible to study prior accidents that have taken place at some point in the past: factors behind their evolution and physical phenomena in question (fire, leaks, gas dispersion etc.), which are considered as a substantial basis for performing an analysis of hazard risk (ibid.). Although such a method gives a necessary overview of areas which need specific attention in terms of safety as well as helping to establish the main causes of accidents, it has certain limitations:

- it is based on historical data with a limited number of events implying that the changes in underlying conditions having an impact on risk will not be observed until some time later,
- the documentation of the occurred events is incomplete or imprecise in some cases, which has an impact on the way data is interpreted.

In general, uncertainty has been one of the widely used concepts in the oil and gas offshore sector in different contexts: technological, technical, social etc. For example, some studies discuss the potential threat of terrorism and its influence on the perception of uncertainty in oil and gas supplies by market actors. The studies reveal the different effects that these perceptions have on the energy business, especially in terms of pricing (Tørhaug, 2006).

The energy systems and offshore installations have much in common, not only in terms of industry trends but also in terms of the delivery process consisting of two major types of projects:

- product development, and
- construction.

Both power plants and offshore installations essentially consist of standardized parts, but the engineering work may differ significantly from project to project. The way standard technical processes are embodied into the structures and components depends foremost on the type of the project, yet there is a wide array of other factors (e.g. floating power plant barge vs. mainland power generation plant; floating offshore installation vs. fixed concrete gravity structure etc.). The detailed design is usually performed by an engineering company or the supplier of the component in question (Hellström, 2005). The companies that I have studied

execute the design according to a discipline which starts by choosing the equipment to fulfill the promised outcome (mechanical), followed by the electrical specifications and then the outlining of the structures to support these systems (civil).

The procurement of materials starts after the design specifications are clear, and imposes special requirements in terms of management processes. The materials and parts are either bought and manufactured locally or, if this is not possible, delivered from other destinations to the building site. The aspect of transportation might constitute a problem for the project deliveries executed in remote areas of the world considering the weight and dimensions of the equipment parts to be transported. However, in certain cases the decentralized deliveries might constitute a problem in other perspective. In certain countries it is not possible to use industrial equipment or parts of it manufactured abroad, as was the case with the offshore project in my study. Thus, the supplier Company A had to establish local manufacturing in the country of delivery.

In contrast to ship building, which is executed at yards, the building sites for power plants and oil rigs are at least slightly different from project to project. The delivery of power plants starts with civil structures to incorporate the mechanical parts to be assembled, after which the electrical equipment is installed. The commissioning phase ends the construction process. In practice, the delivery activities overlap to some extent. Although the construction process starts with civil structures, it very often ends with their development after the mechanical and electrical parts have mostly been completed.

Whilst the oil and gas offshore installations follow three similar steps in their construction process, they require further transportation to the operation site at some point. Hence the building site and the place of future operations at the oil field are not the same, in contrast to the power plant deliveries considered in this study. In the case of delivery of a fixed concrete gravity structure, Company A used several building sites in different parts of the country of delivery with varying geographical and climatic properties. They were thousands of kilometers away from the operational destination of the installation at sea. The control system together with production equipment is the most sophisticated part of any offshore facility. The former ensures the integrity of work between the two systems — drilling and oil/gas production —

while maintaining the safety of operations. In the case of fixed offshore installations, production and control equipment is installed on top of the tower above the sea level after it is permanently fixed on the bottom of the sea. The underwater drilling systems are located in the lower part of the facility and are thus integrated into the structure before it leaves the building dock.

4.3   The role of the warranty phase of the industrial project

The final period in the project life-cycle from the supplier's perspective is warranty. The warranty phase starts the day the commissioning process ends and lasts 1—2 years on average for the facility. In comparison, power plants are expected to operate for several decades. From the day the operations start, installations require more or less continuous maintenance works and possibly other supporting services. This is the reason why even small issues in the installation structure might result in significant costs both for the supplier and the customer, with the former especially affected during warranty.

The specific characteristic for the warranty phase of the project as compared to the other stages of the project life-cycle is that the project outcomes — an engine, a power plant or an offshore installation — start operating the day this phase begins. In general, there is a trend indicating a shortening of the warranty period for industrial products. Most of the equipment in the studied cases had only a 1 year standard warranty unless specified otherwise. However, the observations in different industrial projects, also by investigating customer opinions[11] on the

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[11] Here I refer to the investigations my colleagues regularly perform using the CROL tool and process in order to assess customer opinions for industrial suppliers cooperating with PBI Research Institute. CROL stands for Customer Relationship On-Line.

products and services they received from industrial suppliers, indicate that the warranty period is associated with the functional reliability of the installation in question (cf. Perminova et al., 2009; Gustafsson et al., 2010). In addition, if the customers are satisfied with the way warranty issues are handled by the supplier, they are more likely to cooperate with the supplier in other potential projects.

The studied warranty events are mostly equipment failures or malfunctions. The central part of the product structure in the studied projects is the engine. Consequently, most of the situations described in the following cases relate to engine issues.

When the warranty event takes place, the customer has to report it to the supplier. In addition to filling out warranty claim documentation, the customer's contact person who is usually a member of the technical staff, contacts the respective supplier's pre-appointed representative — a warranty manager. Warranty managers, the main interviewees in the Company B cases, are all members of a special division within this company handling warranty issues and other customer support activities, such as supervision on site and maintenance assistance. Basically, the warranty manager meets the customer representative(s) during commissioning and at this point the project manager helming the project passes his duties of project management on to the representative(s). Thus, when the warranty issue takes place, the initial contact can be less formal in the form of an e-mail or a telephone call to the assigned warranty department representative.

For the claim to be accepted, the customer has to provide substantial evidence that the failure is not a result of negligence on their part. As was mentioned before, most industrial equipment requires at least some sort of regular maintenance. For the engine to operate without breakdowns, certain elements such as rollers have to be replaced at regular times. This type of basic maintenance work is normally also the responsibility of the customer during the warranty,

unless the contract suggests otherwise[12]. The maintenance intervals differ depending on the engine type and operational conditions (e.g. type of fuel) and are stated in the equipment manuals. The warranty manager's responsibility is to verify that the cause of the event is the issue with the product structure, and not failure to perform maintenance on the customer's part. Although the latter is no case for warranty compensation, the studied projects show that in certain situations a supplier might provide the warranty cover for the event, even if it is not obligatory under contract terms. The interviewed warranty managers characterize such actions on the supplier's part as *goodwill gestures.* They are believed to boost customer satisfaction and support trust among partners (Gustafsson et al., 2010).

If the case for the warranty coverage is established (e.g. engine breakdown due to breakage of thrusters), the supplier is obliged to provide a full repair of the equipment, and /or substitute the broken spare parts, and/or supervise the installation of substituting equipment depending on the contractual agreements.

I would like to stress again that although this study focuses on warranty as a reflection point, its importance for the outcomes should not be overemphasized. The purpose of this study is not to study only warranty issues but rather to achieve a wider perspective on the project life-cycle to be able to establish cause-effect relationships. As it will be shown later, the warranty period proved to be a good time in which to analyze the results of managerial decisions and actions that were undertaken during the sales and execution phases. This was because the performance results of the project delivery were already available making it possible to evaluate the effect of the actions on the outcomes of the project.

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[12] However, when the contract terms are not clear enough, customers may object to such responsibility under the warranty.

4.4 Case descriptions

Case 1A Offshore

Project outset

This project which had the aim of delivering two concrete gravity structures (CGSs) — fixed offshore installations — belonged to the scope of Company A, a medium-sized engineering firm based in Finland, which acted as one of the two main contractors.

The project organization, project team composition and scope of work were described by the project coordinator as *outstanding* in their perspective as a key supplier. To put it briefly, it was a consortium of multinational private and state-owned companies from different business segments. From the perspective of the offshore installation delivery, there were two main contractors, one of which was the supplier in question — Company A. The core project management team was composed of members from Company A as well as representatives of the other contractor and key sub-suppliers.

The team used Company A's office as headquarters for the complete life cycle of the project to perform project management and controls, procurement and support services. The scope of work of the company in question concerned mainly mechanical outfitting work for the installation and its integration into civil structures and electrical systems, and all the related project management activities related. The project management plan stated the following scope of work for the project team (Table 9).

Table 9. The phases of the mechanical outfitting work

Phase I	Early Work
	Concept Design (after the contract is awarded)
	Detailed Engineering and Prefabrication
Phase II	Installation and commissioning
	Offshore installation and commissioning

The project management scope of work was also divided into separate activities:

- General project management, project controls and reporting,
- Procurement and logistics,
- Workshop engineering management including interface coordination,
- Prefabrication management,
- Installation management,
- Commissioning management.

The country of delivery was the Russian Federation. Due to legislation concerning industrial products, the prefabrication and other manufacturing activities had to be executed in the country of delivery together with the assembly of the structure. The engineering and procurement work was done in Norway and Finland. The industrial and environmental mandatory requirements, as well as the standards for civil building and construction, differ in the Russian Federation from that of the EU. In order to comply with all the specific legal issues, the project team used the services of professional legal consultants and attorneys. Not the least factor in taking this decision was the continuous changes in the legislation concerning the operations of foreign companies in the Russian market which imposed additional responsibility on the company to follow these changes carefully. The legal establishment of such ventures required extensive juridical work. Furthermore, all the interviewees noted that the above mentioned arrangements were possible due to the network of local business contacts they established with the help of the other contractor and the Russian end customer. The end customer, a Russian state-owned organization, was an experienced party that had considerable influence on the activities of the project.

To be able to meet the demanding circumstances, Company A acquired a local ship yard specializing in offshore construction, which became the main one of the three building sites for the installations. Additionally, Company A established its own recruitment agency to delimit the dependency on the availability of the skilled workforce in the Russian market for mechanical services. Most of the personnel working on the building site in Russia including senior administrative staff were local natives. Despite the fact that the team members helming

the project were established in Finland, at least one manager of the team was present during the weekly project meetings at the site. This required the team members taking shifts in continuously shuttling between the headquarters and the site. The general management style of Russian counterparts was described by the team members as somewhat different with extensive use of prolonged meetings, bureaucratic working routines and a need for authority. The burden of bureaucratic procedures in general was described as quite heavy in Russia.

Financially, Company A had been relatively secure since the price of the contract was not fixed. To be more precise,, in addition to the pre-paid sum, they reported their costs to the customer. If the cost was justified, it was covered by the customer. For an extra efficient performance, a bonus system was arranged by the customer.

The fixed offshore drilling and production platforms in question are highly customized products. These facilities are part of a larger offshore project in the Russian Far East, which bears the title of the world's largest integrated oil and gas project (according to http://www.sakhalinenergy.com[13]). The installations have the functionality not only to extract, but also process the hydrocarbons before they are transported by two separate subsea pipelines (one for gas and another for oil) connecting the platforms with the shore. One of the two facilities under scrutiny operates in waters at a depth of 30 metres and the other at 60 meters, which implies that the total height of the entire structure operating in shallower waters is more than 50 meters (and the second one is up to 100 meters). Each platform — or topside — is positioned above the sea level and supports control systems, an accommodation module for the personnel, processing (e.g. hydrocarbons and liquid/water separation systems) and power generation facilities. The facilities are permanently attended by the operators. Each accommodation module provides living space for more than 100 people at a time. To maximize safety, all the topside modules for the respective processes and living headquarters are located in different sectors of the platform.

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[13] Last retrieved on 15.04.2009.

The topside stands on four legs, which contain drilling equipment. The facilities are designed with high precision to fit the sea bed they are fixed on. Since they are destined to operate all the year round in harsh climatic conditions out in the open sea, the equipment is designed to withstand severe ice, rough winds and seismic challenges of the Far East region. The installations comply with all the relevant national and international standards on health, safety and environment (HS&E). After the last grey literature review in April 2009, both installations were operating.

Unforeseen event

After the partial assembly at the building docks, the civil structure with drilling and partly installed production equipment (both mechanical and electrical) was transported to the oil field. According to the project coordinator, most of the pre-installed equipment concerned offshore drilling and were located in the lower part of the tower-like structure.

It must be noted that any fixed offshore facility is more than 80% under water with the most sensitive and essentially vital production and controlling equipment on top of it, above the sea level. In order to order to ensure integrity and perfect functionality of all the three essential segments of equipment — drilling, production and controls — the top equipment (mechanical, electrical and civil) had to be installed after the structure was permanently fixed on the seabed. In order to achieve that, a series of operations has to be performed including seabed preparation and leveling, scour protection operations, etc.

The unforeseen event that changed the outset in the project took place when the lower parts of the structures were already installed on the location. Continuation of the topside installation work required obligatory tests to be performed to confirm that the four legs of each structure are stably fixed on the seabed.

The evaluations of the seabed condition in the location of one of the CGBS had shown that it had changed since the time of the last measurements. In terms of project execution, it meant that certain additional work on the concrete structure had to be performed to secure its permanent position on the oil field. In accordance with regulatory requirements, specific tests had to be performed to prove the stability of the structure before the topside installation process continued.

Actions

As the project controller expressed it, neither of the project stakeholders expected this situation to occur. The end customer was especially concerned over the situation. As the Project Controller expressed it:

> *"I think this is… uncertainty which is very hard to think of beforehand, if there is some remarkable additional scope… in this case it has affected on the long run…it has changed the whole focus [of the project]…"*

It was decided by the management team that there would be an extra phase to the project aimed at completing the mandatory requirements in the fastest manner possible. The project contractors and the customer expressed mutual understanding that the issue was unforeseeable and although effort was required to eliminated the problem, it essentially did not represent a threat to the project outcomes. However, it was clear that the event would affect the originally planned schedules for all the stakeholders. As for the responsibilities for the work, both the additional engineering work and stability tests were out of the scope of responsibility of Company A contractually, so they were not directly involved in it. The other contractor was in charge of the work to be executed.

The execution of the additional project phase included a significant effort in engineering. The other contractor responsible for the matter did not have enough means to handle both the responsibilities under the original contract and the additional, problem-related scope of the work. The management team including the end client representatives agreed to join forces with the different stakeholders to contribute the necessary resources and support the contractor in question, in order to complete the technical requirements and be able to continue with the installation process.

Outcomes and lessons learned

After the necessary engineering work had been performed the results of the stability tests were approved. This was considered as an achievement. The additional phase affected the project schedule for all the stakeholders causing a delay in topside equipment installation by many months. Even after the troubleshooting works had been completed, there were certain points of

concern for the stakeholders. As for Company A, which was not directly involved in the execution of additional work, their working routines were still affected by the delay. All things considered, they had to extend their original schedule by almost one calendar year. First and foremost it was their internal bookkeeping and division of staff resources that were affected. Consequently, the profits of the company were affected, too. This issue was emphasized by the fact that the responsibilities of the stakeholders in terms of additional scope were not as clear cut as those in the original contract. The stakeholders failed to divide the scope of troubleshooting in a clear and concise form: the documentation related to it was scarce or even missing. There was also lack of agreement as to how to continue with the installation work under the original contract partly because the additional scope issues were not fully settled in terms of bookkeeping. It caused further disputes as to financial compensations to different parties.

These consequences of the unforeseen event had been related to several factors. The project organization as a consortium with a common management team was named as one justification for both beneficial and negative outcomes of the unforeseen event. The members of management team attributed the fast decision-making and ease of reaching agreements, communicating and mobilizing resources on time to positive aspects of organizing by the consortium. Thus, the success in technical completion of the structure stability problem was attributed to the way project stakeholders and the management team was organized. At the same time, all the stakeholders — no matter if they were involved in solving the problem directly or not — faced the negative effects of it. As one of the respondents mentioned:

> *"...the consortium agreement is of such a nature that if one of the parties wins, everybody wins; if one of the parties loses, everyone loses; it will have an effect on your company no matter whether it is directly involved or not [in the task execution]"*

Many of the problems that followed the event, especially those of division of responsibilities, were attributed to the fact that the people, who were involved in the project execution from the beginning and handled the problem, were about to leave their management posts. This gave rise to problems in coordination, communication and information handling within the consortium. This situation combined with the fact that there was a lack of documentation,

contributed to the problem's escalation resulting in a lack of knowledge of the circumstances under which the project had been developing over time.
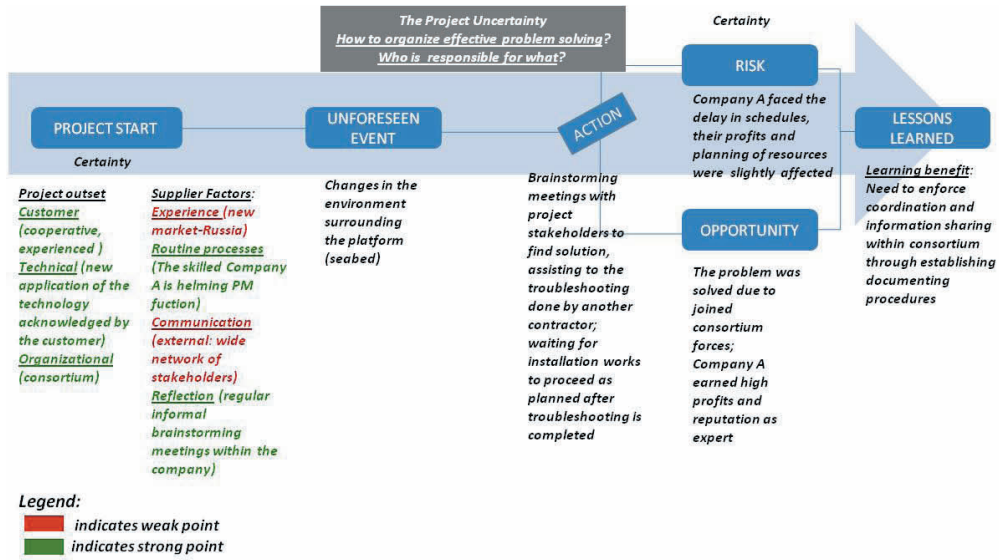
Figure 7. The Offshore Case

Case 1B SOLAS

Project outset

The first case is based on the discussion of a cruise vessel delivery project with the warranty manager, for which company B delivered part of the machinery equipment including the engine. From the supplier's point of view, the project under question can be labeled as standard: the scope of delivery, the contractual obligations, and the assembling yard were familiar to Company B. Moreover, the project customer in this case was not new either: Company B had a long history of cooperation with this organization. For example, the ship-owner was described by the warranty manager as *trustworthy*, *experienced* and *reliable* with professional attitude towards running the projects. Since the customer was operating company B's equipment on a regular basis, they were therefore aware of the strengths and weaknesses that it had. This is an

important aspect since the customer plays a considerable role in not only choosing the suppliers for the equipment of the future ship, but also the shipyard where the vessel is to be built. While the customer influences the whole process of building the ship starting from the design to the commissioning phase by setting the preferences, the shipyard is responsible for assembling the final product in such a way that those preferences are met and function. Contractually, it is normally arranged so that the supplier of the equipment (Company B in this case) signs a separate agreement with the shipyard. In this project, the responsibility between the shipyard and the supplier was split so that the installation of the engine room equipment was done by the shipyard, but the supplier was to provide the recommendations for it by keeping the supervising engineer on site for an agreed period of time.

Unforeseen event

The outset described above is common for the marine equipment deliveries supplied by Company B; it is their everyday business. The routines and processes to manage such a case are rather standard. However, there was another aspect of certainty that was not known explicitly. Namely, that there were weaknesses in the supplier's technology that would affect the outcome of the project in question. This became apparent due to an unexpected event. The warranty manager received claims from the customer related to the safety standard regulations — SOLAS in this case — that the required parameters of engine functionality were not met. Namely, the engine surface temperatures were above the maximum limit at certain spots. This is how the manager described the situation in his own words:

He added that these types of problems usually took time to be settled.

> *"…it was not known that it was coming, absolutely not. It was an unforeseen claim…"*

Actions

The result of this event had a serious impact: the vessels that do not fulfill the SOLAS requirements cannot be operated. Although Company B was the organization receiving the claims from the customer and the shipyard was the one handling them, Company B was facing

uncertainty. At which level was the problem caused: was it the equipment or the installation routines that were to be blamed? In other words, was the problem of a purely technical nature or was it an organizational and contractual issue meaning that the ship yard did not follow the recommendations of the equipment supplier?

In terms of the contract, both the shipyard, where the installation took place, and the supplier that provided the equipment in question had responsibility for the situation. From Company B's side, a series of actions were taken. A special project manager (and eventually, the project team) was appointed to communicate and reach an agreement between the parties involved. The supplier treated it as a separate sub-project:

> *"There had been a project manager and a project team nominated to deal with this special claim…and [also] fuel pressure problems…now we seem to have a solution [for these problems]".*

The tasks of the sub project team included investigation of the cause of the overheating, communicating with the ship yard and the customer to plan the actions to be taken to resolve the problem and mobilizing and coordinating internal resources to eliminate the problem as quickly as possible.

The claim investigation revealed that the cause of the occurrence was the shipyard's neglect of the supplier's recommendations as to the installation process. It also became apparent that the supplier's technology was partly to be blamed. The technical weakness due to the in-built faults exposed itself in the specific technical setup of the overall installation. Quoting the warranty manager:

> *"Some [specialists] from our technical department said that there might be problems with these [elements of equipment before the event], and then it happened…we could have predicted the event, but not the level of it [impact on the project]."*

The decision was made to replace the equipment on the ship with a new set that would fulfill the safety requirements. These actions are better described as "troubleshooting" since they were aimed at eliminating the consequences of the event.

Outcomes and lessons learned

This large equipment replacement caused significant delay to the project schedule. The whole set of machinery with modifications had to be manufactured from the scratch and tested. From the supplier's perspective, it assumed substantial losses at the company level. Since the ship yard was also liable in this case, the total costs of troubleshooting were split between the supplier and the ship yard. Such an agreement was negotiated with the help of the special project team.

As to the opportunities, the interviewee and the workshop members — project managers familiar with the situation — expressed an opinion that it facilitated the development of the technology. The technical cause of the problem was discovered and eliminated, although at the cost of time and resources for this project. There was a benefit perceived at the company level. The modifications were applied to other vessel deliveries where similar technology was applied. In some cases, this was done early enough during project execution to avoid large scale replacements. Company B had a chance to prepare for possible malfunctions taking place on the vessels in operation by arranging adequate stocks of spares, scheduling and maintenance, etc.

On the other hand, the event forced the company management to think of how to reinforce the recommendations for installation of the equipment so that they are followed more carefully. Different means for doing this were pointed out during discussions at the workshops: through contractual means, through training of the contractor's own personnel working at the site, or by involving customer more in the decision-making process, etc.

The interviewee stated that similar situations had happened prior to the discussed event. He described another marine segment project of Company B, which concerned a cargo vessel installation. The project concerned delivery of equipment where the company was to provide only the engine system. The problem appeared at a technical level: a mechanical part connected to the lubrication system tended to break at regular intervals: first during the sea trials, then during the commercial voyages of the ship. When the malfunction took place for the third time, a supervising engineer from Company B was sent onboard the vessel to investigate the cause. It

was discovered, that the lubrication pipe had been built ignoring the instructions of the supplier. This was why the mechanical component did not receive enough lubrication to perform as it was originally intended to. The customer received the appropriate repair work from the supplier in accordance with the warranty terms at the supplier's expense. The latter was able to forward the claim to the shipyard asking for compensation for the work since the shipyard ignored its liability to follow the instructions of the supplier. The negotiations were being handled by a representative of Company B, a project manager working in the country where the shipyard is located. At the time of the discussion the shipyard had not yet accepted the claim.
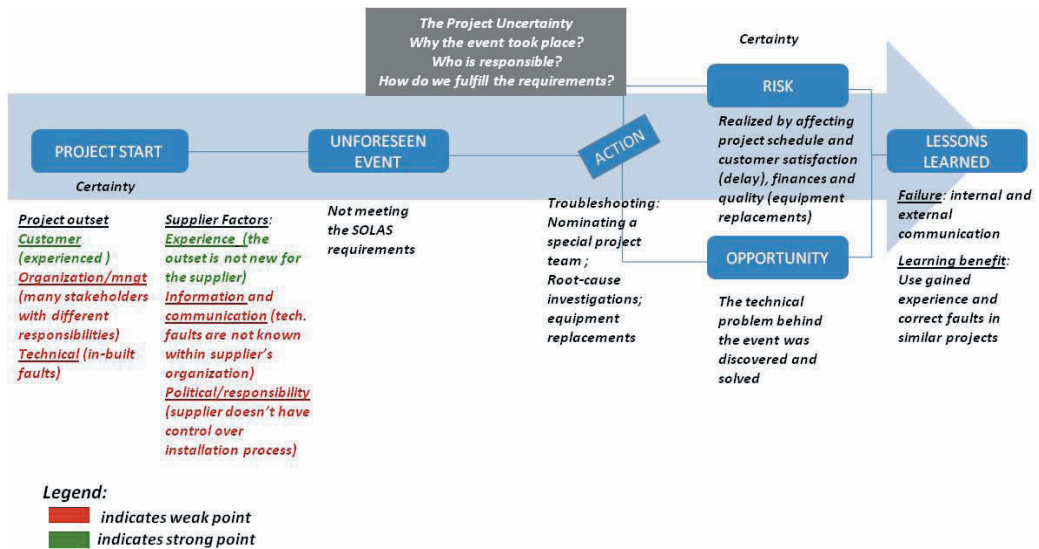
Figure 8. The SOLAS Case

Case 2B Design Phase Failure

Project outset

This project by Company B is a turnkey delivery of a power plant barge. It is a so-called extension project meaning that the company had been delivering projects of the exact same type, in the very same setting to that particular customer before. The location on the Jamaican coast where the barge was meant to operate did not represent any particular concern: the engines were tested in those conditions and had run without any serious problems. The responsible warranty manager as well as some upper management representatives involved described the prior project as a successful endeavor. They stressed the importance of the fact that the customer was well-known to them and had the experience in working with their equipment. In the warranty manager's words:

> "The customer has been operating the engines of the same type for ten years already; they know what they are doing."

The fact that the contracts in both South and North American regions include the so called *no cost to the owner* clause played a significant role for Company B. The clause imposes an obligation on Company B, as a supplier, to cover all the costs during the warranty phase whenever the equipment fails: be it an engine valve or just a bulb in the corridor of the barge. Although it assumed extensive obligations, this clause was common to the contracts used by Company B. As the interviewee explained, such a formulation served as means to support the customers' assurance in the products and services provided by Company B. However, the way in which the clause was interpreted depended to a large extent on the traditions of legal interpretation in the country of delivery. The managers of Company B were aware of this and were prepared for the fact that the understanding of "no cost to the owner" in the American market could imply more extensive, or even somewhat extreme (such as the case with changing the bulb), liabilities.

At the time when the discussions took place, the project was at the warranty stage. To summarize, the warranty routine was standard and clear for the company.

Unforeseen event

The situation that occurred was the replacement of the design team at the design phase of the project. This change was unexpected and not planned at the project kick off. The reason for the change was that some key members of the originally appointed team left their posts at the company. As a result, a completely new team had to step in. As the warranty manager described it:

> *"The whole design team was changed in the middle of the project. The people who were in the project at first, they ordered everything; they made the design… and then, quitted. The new team stepped in, and they had no clue about what was going on."*

The new team faced the challenging task of continuing with the already on-going project. The new designers joined the project when a significant amount of detailed design had already been performed by their predecessors. Rather than starting from scratch, they had to continue with the on-going work, which implied learning about the previous activities, agreements, weaknesses and strengths. As the warranty manager explained, the key to understanding the result of the event lies precisely in the way that this information was handled by the newcomers, and the supplier's organization as a whole.

Actions

Since the project tasks were considered to be rather clear and straightforward due to the repetitive nature of the project, the newcomers relied upon their existing skills, experience and knowledge. There were no meetings arranged with the customer to present the new team and discuss the next steps. The event was not considered unusual, rather the routine work continued. Furthermore, it was the interviewee's understanding that the two project teams did not communicate extensively at the time of the transfer. Moreover, after a certain time had passed, when it became clear that some internal meetings and discussions might be necessary, there were difficulties to reach the former employees from the original team, who had left the company.

It transpired that the replacement of the design team carried a lot of unexpected consequences

for the project's outcomes. As a result of the change, there faults have been found in the later designs that have affected the performance of the product in a negative way. Those faults concerned both the hull structure of the barge and the engine components. For the installation to function properly, considerable technical modifications needed to be done during the commissioning and warranty stages, causing a delay.

Outcomes

The identified outcomes were negative. Most of the design errors were corrected only at the warranty phase in the form of equipment replacements. For this Company B managed to contact the former design team involved, which was not easy since some of the key actors had left the company by the time of the event. There also had to be additional brainstorming sessions with the external and internal experts, interviews with former employees, etc. Finally, the customer had to be involved to resolve the situation in the quickest manner possible. During the workshop with the managers, who were familiar or took part in this project, it was said that the latter action was taken too late resulting in significant project and warranty costs.

The project was severely delayed. Consequently, the contractual obligations were not met. At the time of the interview, the contractual issues were still open meaning that the supplier and the contractor still had to reach a suitable agreement. The upper management of Company B perceived the problems with the long term partner as serious damage to the company's reputation. The customer was not satisfied with the outcome due to the need to replace equipment thus causing delays. Financially, the supplier had no possibility to make change orders that could cushion them from severe financial loss. The project that was taken for granted to be a success turned out to be a failure according to the interviewee.

Figure 9 describes how the project proceeded from the perspective of the unforeseen event — the replacement of the design team. As one can see from the diagram, the project did not represent any particular concern for the supplier — Company B. Even the region-specific peculiarities were known and accounted for. One can even claim that the supplier was assured of the success of this endeavor. This partly explains why the former design team was not involved in the project after the replacement (unforeseen event) took place. The actions that

were taken by the supplier internally as a response to the situation were not sufficient to resolve the uncertainty in order to obtain an opportunity. In fact, no action was taken in response to the uncertainty; more accurately it can be said that only normal routine work was performed.
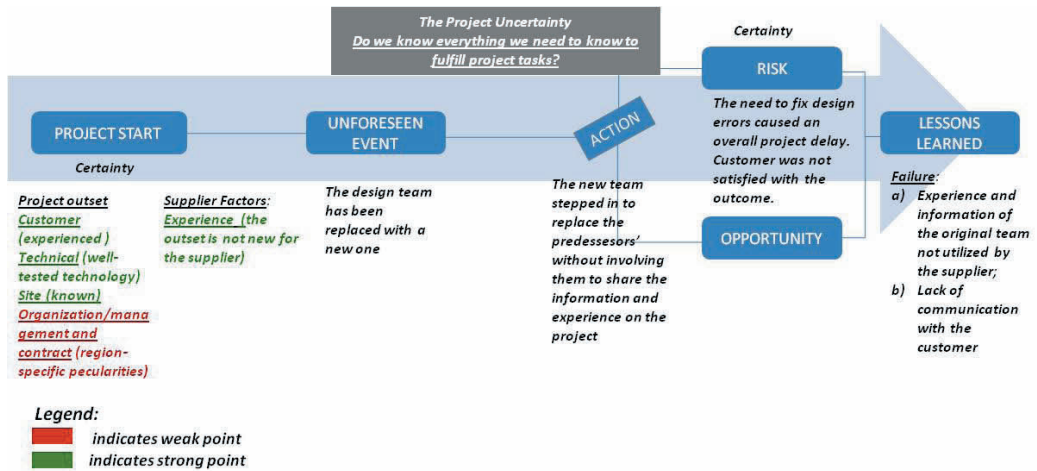
Figure 9. The Design Phase Failure Case

Lessons learned

As the warranty manager indicated, the failure to handle the information can be attributed to three specific levels:

1. When the design team left, the experience they possessed was lost, it did not stay within the organization. Neither was it shared with the members of the replacement team:

    "we should have used the same designers [up to the end of the project] or at least consulted with them, I mean, interview, discuss, check…"

2. The experience gained from previous project has not been utilized:

    " we should have done a proper design review, checkups and discussions with the other personnel, for example, the warranty managers, who handled the earlier project…because the knowledge exists in this organization";

3. There was a lack of information communication and coordination, particularly with the customer:

"the customer could have helped us at the design stage [when the replacement took place] to realize what was done incorrectly, even though they do not go deep into details".

It is worth to note that the warranty manager did not indicate that the cultural differences in doing business between the South American company and the European-based Company B were the obstacles in executing the work, although he admitted that there are certain peculiarities. In his words:

"there are not more [working culture-related] problems [in this region] than anywhere else...although they [the American customers of the Company B] are not trying to fix the problems themselves, they try to invoice as much as possible [put it as the warranty cost]...due to the special provisions of the contract [replacement of spare parts at no cost to the owner]".

For the warranty manager, cultural differences do not represent a barrier to successful project delivery. Rather they are an issue that the (project/warranty) manager has to be aware of and take into careful consideration before implementing any actions. Similar opinions have also been expressed when discussing the other projects as well as during the workshop meetings. The coding analysis showed that the region-specific way of working is linked to communication from the supplier's perspective. Furthermore, it has an effect on how information is perceived and co*mmunicated with the other project stakeholders, especially the customer.* Case 6 The Japanese approach, explores these issues in more depth.

Case 3B Lack of Reflection

Project outset

This case is based on a power plant project delivered by Company B, a turn-key delivery to the United States, the core of which constituted a set of prototype engines. The latter means that

these types of engines, operating on gas, included modifications that have not been tested in the particular environmental conditions before: the power plant site is located in Nevada desert. Technologically, the scope can be characterized as novel, or event innovative, for the supplier at the time of the project kick off. However, the supplier had already delivered projects to the North American market, also in similar environmental conditions. The customer financed the project, however the future power plant will be run by another American company. Although modern power plant operations are mostly automatic, the personnel have to be skilled enough to recognize early signs of functionality loss, to change spare parts in due time, etc. The supplier provided basic training for the operators, which was included in the scope of the contract. As for the organization of the project, Company B acted though its local representation in the country, although the warranty manager for the project was established in Finland. Moreover, local sub-suppliers and a local workforce were used in the project. The country of delivery, the United States of America, is known to its customs for its extensive use of legal methods of managing customer-supplier relations, which is different to the circumstances in which the supplier is used to operating.

Unforeseen event

The unforeseen situation took place when the project execution phase had already come to an end, and the customer started operating the power plant. The warranty manager described the situation:

> *"…it took only two weeks before the engine start [up] to fall apart…"*

The problems and failures concerned not only the main element — the engines — according to the controlling measurements, but also the electrical and the construction parts of the overall work were involved. The technical failures were described as:

> *"…unexpected, yes, because we could not imagine that it should be something wrong with the catalysts, but when the government [environmental controllers] came and made the exhaust emissions [measurements], and it showed that the limits were exceeded…"*

To summarize, the equipment failed to pass the start up tests, which was not expected to happen.

Actions

The supplier had to take immediate actions to correct the faults, so that the requirements on environmental safety were met in order to start the operations of the plant. As a result, the equipment had to be replaced, partially causing a delay in the project schedule. The warranty reservation, which the company intended to apply to cover the costs of replacements, was not sufficient, so they had to draw extra funding from other sources. It was not possible for Company B to use the change orders system to cushion themselves from the financial damages due to the contract terms. In terms of quality of the outcome, Company B had to reach the specified level of performance in a short time span to fulfill its obligations to the customer according to the contract.

Outcomes

The incident resulted in customer dissatisfaction with the project both because of the delay and the lack of quality. The availability and performance of the power plant was unsatisfactory from the owner's perspective. As the warranty manager put it:

> "...the owner said that all these issues must be fixed [before certain date] ...this was not the installation the customer had been buying..."

Company B faced excessive warranty costs, which overran the warranty reservation. In fact, the supplier suffered warranty losses estimated to be millions of dollars, because part of the equipment had to be replaced. As was noted by the warranty manager, the weak points in technology used in the installation were, only to a certain extent, to blame. The parts that needed untimely replacement were sub-supplied by the company's local American vendors. The product as a whole system originated from Europe and thus the European technical standards were applied, which are not the same as the American. The warranty manager suggested that Company B should be more precise and detailed in the specifications they

provided to their sub-suppliers, and then the quality and functionality of the overall installation would not suffer in such a severe way.

The location of the plant site in the Nevada desert with the changing conditions from +50 degrees Celsius in summer to -10 degrees Celsius in winter season also had an effect on the event. That autumn in which the event took place saw the winter season starting unusually early with heavy snow and minus temperatures at night. As the warranty manager claimed, at the time when the project was contracted, the sales department was not aware that the environmental conditions were so unpredictable in the region. In his opinion, selling a prototype engine installation to the climatic zone of the Nevada desert is risky, although the sales department did not seem to perceive it as such. From this perspective, it was the choice of technical specifications of the product that were inappropriate for the operational purposes, not the technological weaknesses.
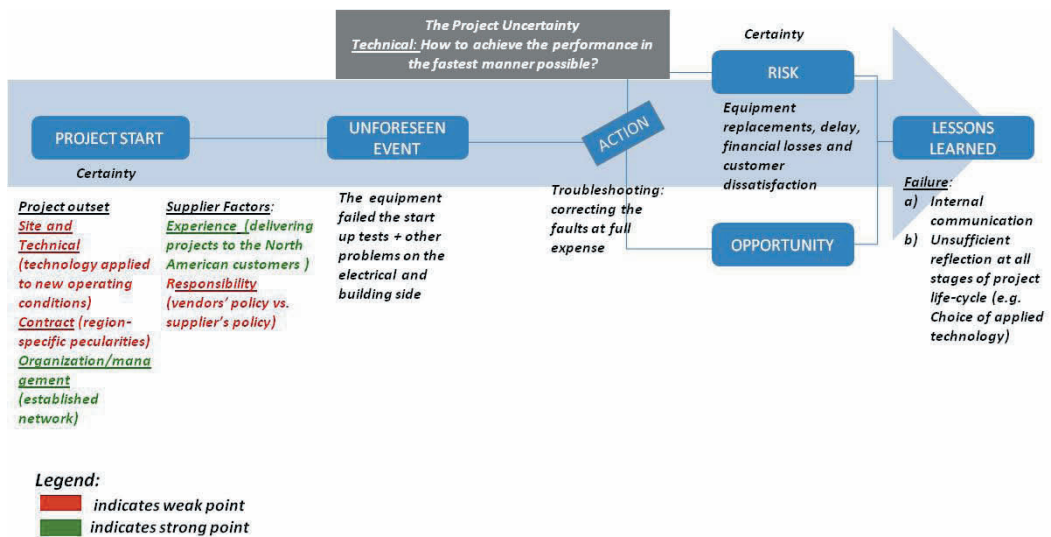
Figure 10. The Lack of Reflection Case

Lessons learned

According to the respondent words, the company learned a great deal from this event in an expensive way. He suggested several measures that could be done to lessen the possibility of such unexpected events:

1. The interviewee pointed out the need to address the internal communication in the company by utilizing extensively the opinion of technical experts before the project is sold in order to determine the ability of the future product to perform according to the required level.

2. In his view, the supplier organization needs to pay more attention as to the terms on which the product is sold, the relevant information such as environmental conditions at the site and the locally applied standards should be known and taken into account by the responsible personnel:

   "I would say that the project people should be able to think a little bit deeper what they are doing…If I should sell [a power plant] I should take [it] carefully and look what are the …environmental [conditions] and… look at the whole scope…"

In other words, the warranty manager in his suggestions refers to reflection as the process of assessment of the given conditions of the project. Reflection can be described as the process of considering thoroughly the situation from multiple angles, so that the level of uncertainty is substantially reduced. In fact, he points out that reflection is needed not only as a way to cope with the uncertainty in response to the occurred situation, but as means of managing the project throughout its life-cycle: from sales to warranty.

Case 4B Blackout

Project outset

In the scope of this project was an installation of several engines for the vessel owned by a Swedish company: main engines — to enable the ship functions, and auxiliary engines — for the support of the on-board equipment such as containers. The scope of responsibilities and the work routine was similar to that described in the SOLAS case. Technologically the project was not novel, but the application of the technology was new. It was the first time in Company B's practice when engines of that particular type were used as main engines. Previously they were used only as support. The project in terms of organization and management was seen as straightforward, not representing any concerns. The customer company had cooperated with the same supplier in the other projects, and thus was considered experienced, trustworthy and reliable. Moreover, the customer was aware that a totally different concept of engine application was to be used in this project. They understood the threats of it as well as advantages right from the start.

Naturally, if the engines stop working completely as a result of blackout at high seas, the vessel would stand still. There is only a limited time, during which the engines could be started on an emergency mode for the ship to be taken to the nearest port. The blackout is the worst situation, which could happen both for the owner and the supplier. On the one hand, it is rather dangerous for the crew and passengers to reside in an unmovable vessel out in the sea. On the other hand, the vessel is not serving its commercial purpose. If the event happens during warranty, the supplier would be obliged to pay both the warranty costs and the consequential damages related to lost profit for the customer from the commercial operations of the vessel due to the installation failure.

Unforeseen event

During the time when the ship was still at the warranty stage operating out in the high seas, a blackout occurred that caused damage to the main engines, which stopped immediately. Luckily, the crew was skilled enough to get the engines running in emergency mode, so that they could make it to the nearest harbor. The request for assistance was sent immediately to Company B's warranty and customer service office. The local port authorities requested that the

cause of the problem on the ship was investigated and resolved in a proper way. Until this was completed the ship had to stay in the harbor according to safety regulations.

Actions

For the supplier the local authorities' request meant that a *quick fix* until the moment when the ship could get into the harbor where the supplier's services were represented was not possible. As for the investigation of the failure, a special project team was nominated within the service department of Company B. The warranty manager describes this:

> *"at first, we weren't even sure…they [the customer] weren't sure as to how to deal with [the problem], since we did not know what caused the failure…"*

The confusion on how to proceed was fuelled by the fact that there were three different components that were under suspicion as the causes of the problem. To cut down the time the ship had to be out of commercial operations and, thus, minimize the costs on consequential damages, all the three components were replaced. This, however, was not easy:

> *"with the pilot [project] it is always that the availability of spare parts is difficult… and skilled service men availability as well…the whole service department was not ready for it".*

The internal supplier investigations took place later on, and the problem part was discovered. However, it did not affect this project. The customer's awareness of the novelty in the purchased product and their active assistance helped the supplier to resolve the situation:

> *"they were patient, acted upon the information they received from us…doing troubleshooting, testing the new parts on-board and so on".*

Although the customer was aware of the application novelty and gratefully recognized the supplier's efforts to eliminate the problem, the respondent stressed that this should not be the case for not reaching the agreed performance level:

> *"as the warranty ended last month, we still have a couple of issues we promised to take care of, but this is goodwill from our side [to the customer]".*

Outcomes

The performance level of the installation as was stated in contract was not reached, and the customer was affected by that in a negative way. In the end, the supplier managed to settle the warranty issues, and replace the necessary parts. Company B faced extra costs due to the contractual arrangement prescribing an extended warranty time instead of the normal, but mostly the expenses were due to the need for extensive, and in fact unnecessary replacements. Since these actions were unforeseen and thus not anticipated, obtaining spare parts in time proved to be a challenge. The process was time-consuming since the supplier's own production factories were overbooked at that particular moment with orders for the other on-going projects. Active cooperation with the customer as well as agreements based on goodwill helped to amortize the customer dissatisfaction.
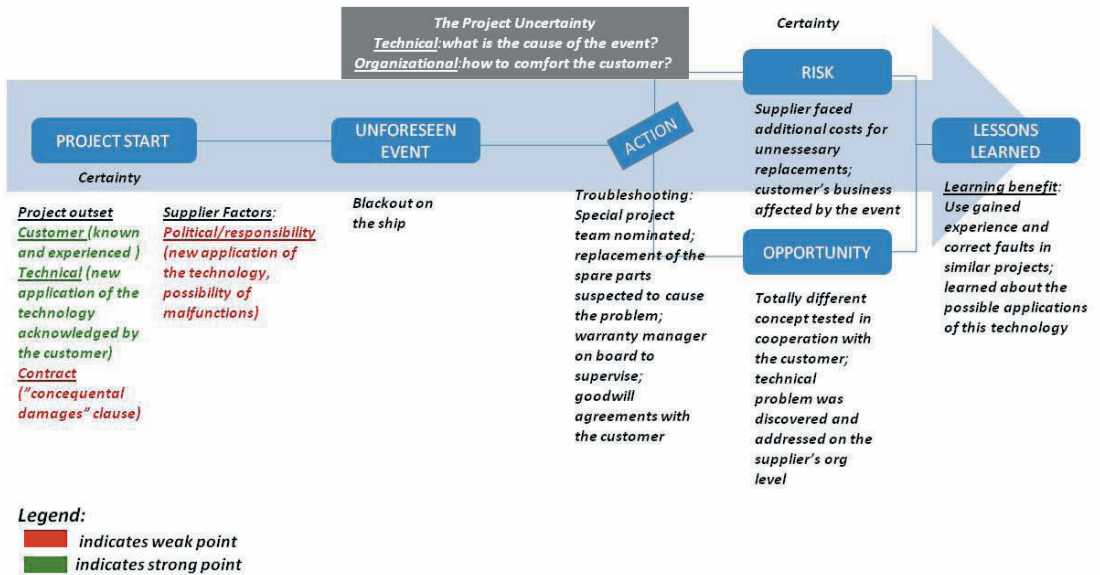
Figure 11. The Blackout Case

Lessons learned

The warranty manager at the helm of the project characterized this endeavor as "totally different concept" for Company B, in which the customer played an important role. It made the team re-evaluate the importance of cooperation with the client:

> *"we were lucky to have this kind of a customer"*

as the interviewee noted. Special attention in the interview in terms of the learning was dedicated to the contractual arrangements of the company, which should reflect more, not only at the outset of the project at stake: stakeholders, network, country of delivery as well as the supplier's current status in terms of production volumes and occupancy with the other projects, etc. It was stressed that the supplier should not think in terms of project execution only, but rather be concerned with the delivery and the warranty:

> *"[They] are actually short term, but we are taking care of the [product's] life-cycle that might be up to 25-30 years".*

Thus, the responsibility for the installation performance level stays with the supplier, explicitly or not, throughout this time span.

The interviewee brought some examples from other projects to confirm the importance of direct and personal communications with the customer and the operators. One example was a power plant project that was delivered to a town of Magnitogorsk in the Ural Mountains region in the Russian Federation. The manager noted that most of the problems that this project faced were due to the specific business conditions in the country, which, once they became familiar with them were easier to cope with. He briefly mentioned the specific management style, extensive bureaucracy and logistical difficulties that are part of the business culture in Russia. At the same time, he stressed that the Russian customer was also aware of these problems. These are his comments when comparing the two projects:

> *"if [the claim] comes from Sweden, they would expect [a fix] tomorrow. If I receive it today from Russia, they expect it within next week…there is a cultural difference…I have to keep it in my mind when I deal with [customers]".*

Overall, the relationships with the customer were characterized as *very good.* The warranty manager admitted that there have been no claims from the Russian customer related to the engines, which to him was an indication of a good project performance. The project manager confirmed this evaluation by noting that the customer was satisfied with the outcome of the project. He attributed it to the fact that there has been *direct contact* with the customer and the operators through the local office in the country and the supervising engineers on site. The local branch had been in touch with the customer and immediately reported any events to the managers responsible through an on-line communicating tool. The on-site representatives trained the operators how to use and maintain the equipment, explaining the warranty terms. Moreover, the warranty manager had *personal meetings* with the responsible operators. He particularly stressed this fact. He noted that the communication should take place at the right time:

> *"already during commissioning those [operators] who will be running the plant are on site, helping out, learning during that period, then they have a better understanding of the whole system. Because it is not just pushing the button and the engine will run… Because every power plant is different, it is working in a different way."*

Since the supplier's local office was situated in one of the main cities of Russia, the internet and telephone connections were available and working properly. In contrast, the on-site internet connection was missing, which made the correspondence between the on-site supervisors and the responsible warranty manager *not immediate, causing problems and delays* until the moment when it was fixed. This obstacle was the main problem in this project, according to the warranty manager. Inability to get the information in time combined with the fact that it takes a minimum of a week to deliver spare parts from the production facilities in Finland to the site in the Urals, could potentially lead to performance disasters such as engine breaking down, he explained. In this project there were no occurrences that affected the overall performance, and the project goals were achieved.

Case 5B Japanese Approach

Outset

Another on-land power plant project that I studied and discussed with a warranty manager, who had an extensive 13 years of experience at leading project deliveries in many eastern countries, was delivered to Japan. The project, at the time of discussion, was at the beginning of the warranty phase. The discussion concerning this particular project was only brief as the scope was rather standard, no new technology and operating conditions were involved. The contract was standard for power plant deliveries, apart from the fact that the contract with Japanese companies is usually more detailed than that used in other countries, with a longer warranty period. The customer was also well-known. During the discussion, it became clear that there was only one peculiarity in this project: that it had been executed for a Japanese customer. As the manager explained, the attention to detail and perfectionism when it comes to technology are the core traits of Japanese managers that Company B had to face:

> *"we have to pay full attention to them… a claim in Japan is something much bigger than anywhere in the world…they have extremely high demands".*

The Japanese, by right, consider themselves as the world leaders in technological development, so being chosen as a supplier for them had been regarded as a great achievement for the company in the manager's eyes. At the same time, it implied that the supplier would prioritize the Japanese customer, immediately reacting to any claims and demands, and implementing corrective actions:

> *"When the other customers are happy with receiving a new component, the Japanese may require very detailed investigations leading to the fact that we made a mistake… [if so], they will require redesign for not only that engine, but all the engines we supplied for them in the past".*

Unforeseen event

In this case, the event concerned not the particular project that we were originally to discuss with the warranty manager, but the projects delivered to the same Japanese customer prior to

that. The scope of supply was nearly the same in every project — power plant engines of a particular type. The supplier had a specific technological weakness in these engines: an electronic component called CCU-box lacked stable performance, which in turn affected the engine. In the worst case the component would need urgent replacement. However, at that time the company was not capable of solving this technical difficulty on a permanent basis. The supplier would simply replace the component for the customers owning engines with the CCU-boxes, although this seemed to incur a considerable expenditure. The engines were in demand with the customers, and it was considered strategically important by the supplier to provide the solutions to the Japanese market. The manager explained there was no significant evidence that by developing a better CCU-box an improved performance in the engine would be achieved:

> *"... we could not tell that this [component] was the problem... we were not willing or capable [to develop it]..."*

Once the engines were sold to the Japanese customer, the CCU-box problem *"hit the bottom line"* — the CCU-boxes started to break down. The customer not only requested the immediate change of the failed component, but also performed a root cause analysis that revealed the grounds for the poor performance of the CCU-box:

> *"the Japanese themselves made strength calculations, risk analysis; they told us which improvements to make".*

Actions

As a result, more than 300 CCU-boxes were sent back to the factories of the sub-supplier, where the CCU-boxes were originally manufactured, to receive the necessary modifications.

Outcomes

The modifications of the CCU-box, sending them back to Japan, updating the engines of the other customers using similar technology — all these actions were a significant expense for Company B. At the same time, the problem that remained unsolved for many years was finally solved.

Considering the project that was under question at the beginning of this discussion, the warranty manager said that there had been no occurrences. He evaluated the performance of the project as *well* because the project outset was not new to the company. The technology employed in the project was mature and, thus, they did not have the technology-related, as he called it, *initial failures* any more. To him, the key to the successful performance so far in the project was the fact that the supplier and the customer were collaborating extensively. Due to several prior incidents (including the above-mentioned CCU-box), significant technical improvements were made, which affected positively the current projects.
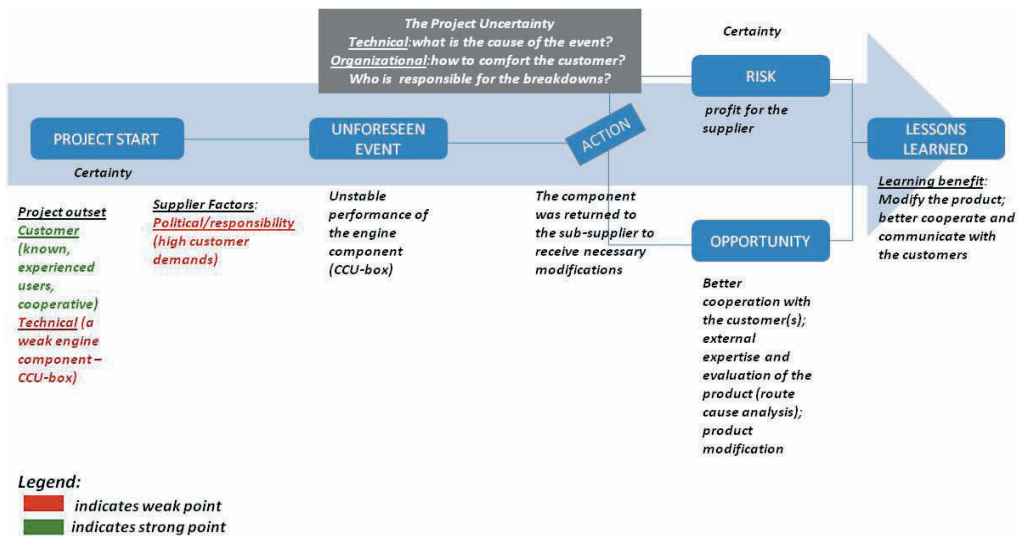
Figure 12. The Japanese Approach Case

Lessons learned

As the manager put it:

> *"we can thank the Japanese for being so tough that we have been developing our products at a pace which was much faster than we have ever seen before…we developed and improved our products, and the Japanese with their high demands have forced us to do it much quicker".*

He added that the company does not make good profit with Japanese customers, but still called this situation *a benefit* meaning not only the development of the existing technologies, but also

research on new products, the outcomes of which is succeeding on the other markets:

"all our customers are happy to get new improved technology".

The manager particularly stressed that it is absolutely impossible to make any job instructions or manuals, and project plans that give guidelines on how to act in the different situations occurring in projects. When it comes to unforeseen situations, the manager in charge has to respond quickly:

"It takes too much time to search the answer in a book. You have to react very quickly and work based on your experience. Working based on written instructions appears to me to be very inflexible… I rely on my conscience and my experience".

This quote indicates that the flexibility in actions (and decision-making regarding which actions to implement) requires prior knowledge in the form of experience. At the same time, he stresses the conscious element of the action process: you have to be aware that what you do or do not do has a result. He also pointed out the importance of understanding the project partners:

"I was nominated to be a warranty manager for Japan because I have extensive project management experience; I lived in the Middle-East. I know the oriental way of thinking".

Here he talks about understanding as a form of experience, also a conscious form of information processing.

This is an example of how the successful collaboration with the customer enables:

1) supplier's internal flexibility (the need to react fast on the customer's demands, implement change),
2) organizational learning and reflection, both reflection-in-action and action-in-reflection.

Case 6B Cambodian Endeavour

Outset

For this project I interviewed both the project manager and the warranty manager. It might be important to mention that the discussions took part separately within the space of a few days. The respondents did not know that both were to be interviewed about the project before the interview.

This power plant delivery to Cambodia by Company B was characterized as having a *repeat setup*. As with most of the other cases, the outset was quite standard for the power plant deliveries in that geographical area. However, as the project manager for this delivery admitted, from the organizational point of view the project was somewhat different. It was a consortium:

> *"it is not so easy from the management point of view, but we had done before similar projects, we knew the basic setup, what to do and when to do it".*

In contrast to the Japanese approach case, the customer, a local company, deliberately chose not to be involved in the technical details of the solution because they relied on the experience of the provider, Company B. As the project manager commented:

> *"they expected us to be able to handle that… and it [such approach from the customer side] made the execution easier".*

Moreover, the customer followed the supplier's advice by hiring experienced operators to run the power plant, which is not so common in the power plant business. Otherwise both the project and the warranty manager agreed that the project was routine.

Since for this project I had two interviewees responsible for the project (however, the project manager carried the overall responsibility), there are two views both worth presenting. That is why this case is in a slightly different format. First, I will describe the unforeseen event that happened at the project execution phase, the actions taken, the outcomes and the lessons learned. Second, I will present the warranty manager's perspective.

Project Execution Phase

Unforeseen event

The first one took place during the execution phase. As the project manager put it:

> *"There are always unforeseen situations [in projects]".*

Two days before the engines were to be delivered to the site in Cambodia, the road, along which the equipment was to be delivered, was blocked. A huge pile of soil and gravel appeared in the middle of the road. The location of the *soil mountain* was quite close to the future power plant. It was, unfortunately, a perfect location to disturb the engine transportation plans. It was obvious that the road would not be used since the conditions were miserable. There was no possibility for the road to be restored quickly. The project manager had no doubt that it was a political gesture purposefully performed by some local group against the power plant project.

Actions

Alas, the political gesture was successful, and the supplier had to urgently conceive a new transportation route. Fortunately, the geography of the area allowed for fast changes to be made. The local river transport was used to carry the engines to the power plant, and this means of transport was already planned for before the event. The only difference was that the place, where the vessel had to embark, was on the opposite side of the river from the previously agreed location.

Outcomes

From the project execution point of view, the project was evaluated by the project manager as successful. Although the road block event was labeled as

> *"a really bad example of what can happen in not so developed countries",*

the project schedule did not suffer from any major delays. The project manager could not give any explanation as to why the event took place:

> *"I do not think we did anything really different compared to other projects [in the same country]".*

Lessons learned

The project manager for the Cambodian endeavor pointed out that, to him, one of the biggest issues in projects is the commitment of stakeholders to the work:

> *"if the people are not committed, it does not matter how well prepared the contract is… it is a bigger issue than contractual or technical risks".*

He linked this organizational issue with performance of the project:

> **"***Speaking of the performance… we have the system [process of project delivery] in place, but at the end of the day, it is the people who are working with you [that matter]".*

He added that the project team needs to be bonded not only by the execution of mutual work, but also on a personal level. The role of the project manager as a team builder and supporter was emphasized, especially in terms of facilitating internal communications. He explained his position by saying that it is not the machinery or equipment that makes faults, it is the people.

Figure 13. The Cambodian Endeavor Case: Project execution phase
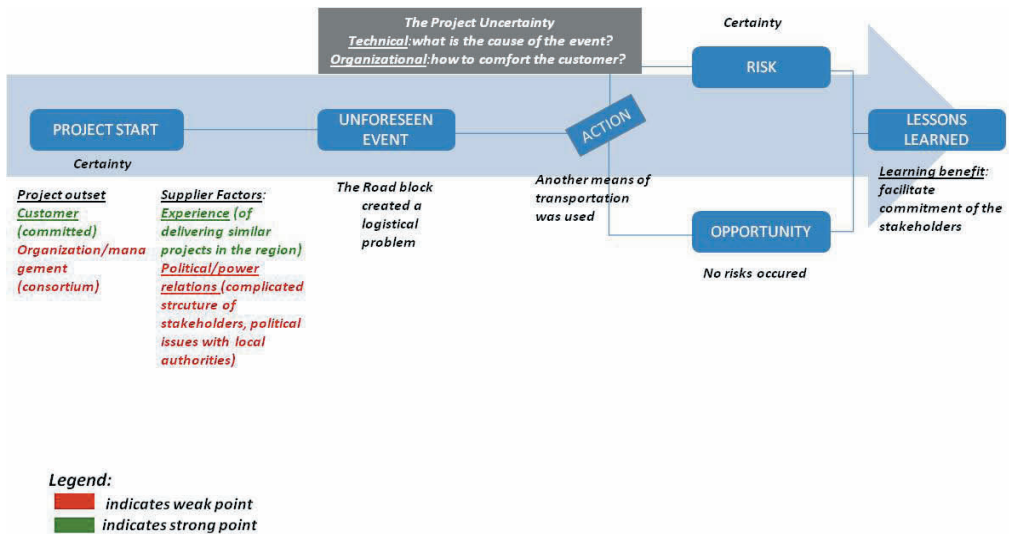
The warranty phase

Unforeseen event

At the time of the interviews the warranty period was already over, but the warranty end certificate had not been approved by the customer because of an open issues with spare parts that still needed to be resolved. The reason for this lay in the technical solution provided for the Cambodian customer. The field tests of the equipment showed there appeared to be a problem with the engine mechanics: the rollers and the lifters.

Actions

The engines were at the field test on time, and the replacements of the above-mentioned elements were due as soon as the technical services department found a better solution. Although the warranty manager admitted that he could not judge these technical aspects as an expert would do, he maintained the position that:

> *"Nobody could foresee that we would have a problem with the rollers and lifters. It was a surprise for everybody".*

In the manager's opinion, this was not an uncommon situation for the Company, it was quite normal to have such issues. The manager admitted that the problem was purely internal for the supplier, especially considering the fact that the customer employed trained operators to run the power plant.   He said:

> *"A great deal of claims is strongly connected to the quality issues [with our current technical solution]".*

Outcomes

Replacements are always expensive for the supplier. Nevertheless, the warranty manager saw a potential opportunity here:

> *"I assume that the technical service discussed these issues with the technology R&D department. The quality mistakes will be corrected in the new engine models and solution designs… if not, it will be a disaster".*

Lessons learned

Regardless of the quality problems, the warranty manager was similarly positive about the outcome of the project. There were no claims coming from the Cambodian customer. He attributed this to the fact that it was very easy to communicate with the customer. On the one hand, the customer trusted the supplier to perform the work and did not interfere and on the other hand, they showed involvement in the operations issues opting for experienced personnel to run the power plant. The local supplier's representative in the region had been actively involved in the project, also supervising the operators on site.
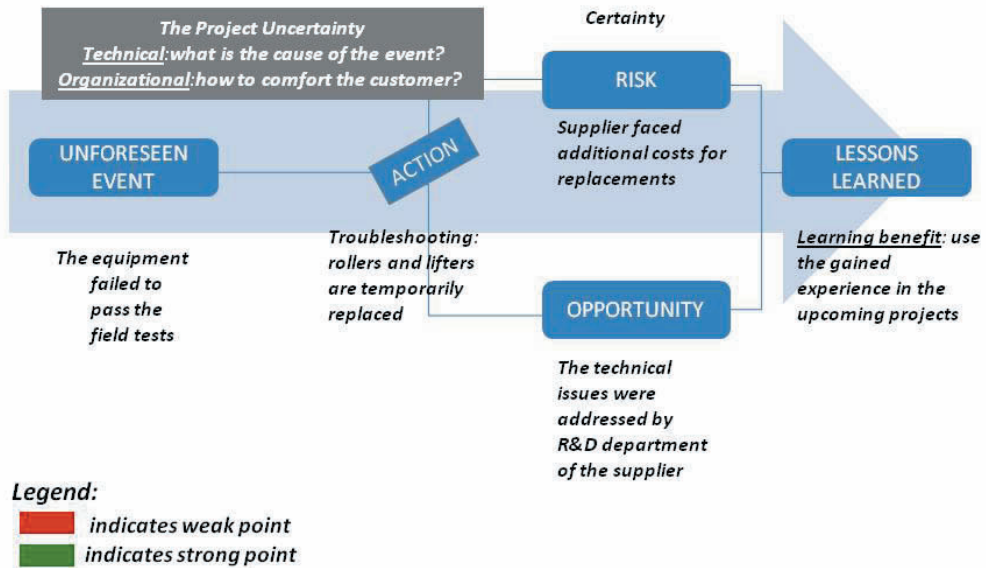
Figure 14. The Cambodian Endeavor Case: warranty phasy

Case 7B Sudan

Project Outset

This project concerned a power plant supplying energy to an oil field in Southern Sudan. Once again, Company B acted as a turn-key supplier in this case. The solution that Company B provided was rather standard, the technology was tested, so that the possible faults were known in advance. The project organization was rather complicated, according to the warranty manager. The end customer was a consortium of companies from different regions that outsourced the power plant operations to a specialized company, which was not involved in the ownership. Company B provided the plant supervision and training services to the latter. The operations company lacked power plant management skills. The end customer was described as:

> *"having internal problems, not communicating internally".*

The manager said that they were difficult to collaborate with. However, the most confusion from the warranty manager's point of view was caused by the location of the plant in the middle of the desert. It was erected in a remote area 700 kilometers away from the capital, where the local representation of Company B was established. Moreover, the country of delivery is known for its bureaucratically extensive customs clearance procedures. Politically the country was perceived by the supplier as highly unstable.

Unforeseen event

At some point during the project execution, the customer ordered extra spare parts from the supplier in an amount that was evaluated by the manager as more than necessary for the purpose of the plant. The order was taken, but since it appeared that products from the United States of America were not welcome in the Sudan, the supplier could not use their usual sub-supplier who they normally employed for such product deliveries.

Actions

A different sub-supplier was used, this time a European company, which was known to the

supplier, but rarely engaged. Due to the fact that the sub-supplier's factories were fully booked with other orders at the time, it took them an extra 6 months to produce the required equipment. There were certain complications with the customs as well.

Outcomes

After the spare parts had been manufactured, they were delivered to Sudan at the supplier's expense and installed. From the interviewee's perspective, the actions that the company performed represented troubleshooting. The supplier had to cover the costs of the factory delay, which affected the project schedules and constituted a large sum. As the manager concluded:

> *"it was a big disaster… but it was the only unforeseen event I can remember [in this project]".*

At the same time, he pointed out that this situation had another aspect: the customer perceived their efforts as a gesture emphasizing the commitment of Company B to the customer. The interviewee stressed that the event could have been avoided if the supplier had had more intensive communicated with the customer, both at the sales and project execution phases.

Figure 15. The Sudan Case
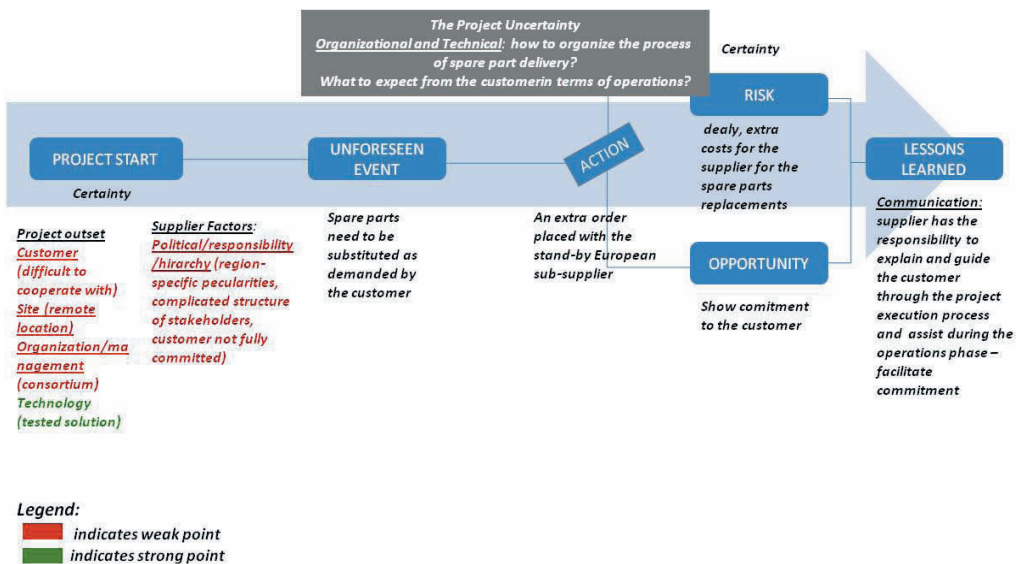
Lessons Learned

As the interviewee added, it was difficult to persuade the customer to become involved in the management process, especially with regard to the logistics and to arrange meetings in Sudan:

> *"if there is emergent meeting to be held, the visa is a problem for our manager, although we have a good agent locally. When it comes to the management meetings, the operations company [not the end customer] is the one we talk to [when we have to fix a problem]. But nobody seemed to be interested to deal with problems. The clients were a big mess"*.

The customer involvement was of special concern because of the further problems or risks that they had already anticipated. Even though there was supervision on site provided by the supplier, there was a great risk that the operators start running the equipment with the wrong type of oil, the crude oil. If this happened, the fuel injection system would be badly damaged. The replacement of the fuel pipes is not only costly, but also takes a long time, up to half a year, taking into consideration the customs of the country of delivery. For the customer such delay would mean a loss of business: power production would be interrupted. From this perspective, there is an emphasis on the supplier's role as an expert company that needs to be proactive, taking the initiative to communicate their advice and guidelines to create trust and mutual learning, so that mistakes resulting from lack of communication are avoided.

V   DISCUSSION

This chapter is dedicated to the discussion of the concept of uncertainty as such, its elements and actions that constitute management of uncertainty in projects. It is done by comparing the cases in the light of coding analysis results and contrasting them with the extant literature in order to achieve a comprehensive answer to the research question.

5.1   Classification of the studied projects

To begin with, there is a need to classify the projects so that it is possible to compare them to one another. In order to do that, I have used a framework, which builds upon the logic adopted in existing classifications in the field of project management (Fuglseth and Grønhaug, 2000; Windischhofer, Perminova and Gustafsson, 2009; Wikström et al., 2009; Loch, Solt and Bailey, 2008; Hobday, 1998). The idea behind it is to map the studied projects in terms of uncertainty and complexity using the available data about the projects. Complexity has been chosen as the comparative parameter because of the context of the study: large-scale complex industrial projects. Most project categorizations and conceptualizations, including those by Baccarini (1996), Laufer, Denker and Shenhar (1996), Williams (1999), Kerzner (2001), analyze projects mostly using the complexity dimension. Uncertainty is treated as either a part of complexity construct (Baccarini, 1996; Williams, 1999, 2005) or, when looked at as a separate dimension, it refers to the environment in which the project takes place and its dynamics (Loch, Solt and Bailey, 2008). I take the standpoint that complexity and uncertainty are independent issues, even though they are interrelated. Adopting the logic of Fuglseth and Grønhaug (2000) and Windischhofer, Perminova and Gustafsson (2009), the studied projects are categorized along the two dimensions, uncertainty and

complexity (Figure 16). The evaluations on both parameters were performed first during the interviews based, on the answers of the managers for the respective projects, and then combined with the project's data and workshop discussions to avoid a subjective bias.
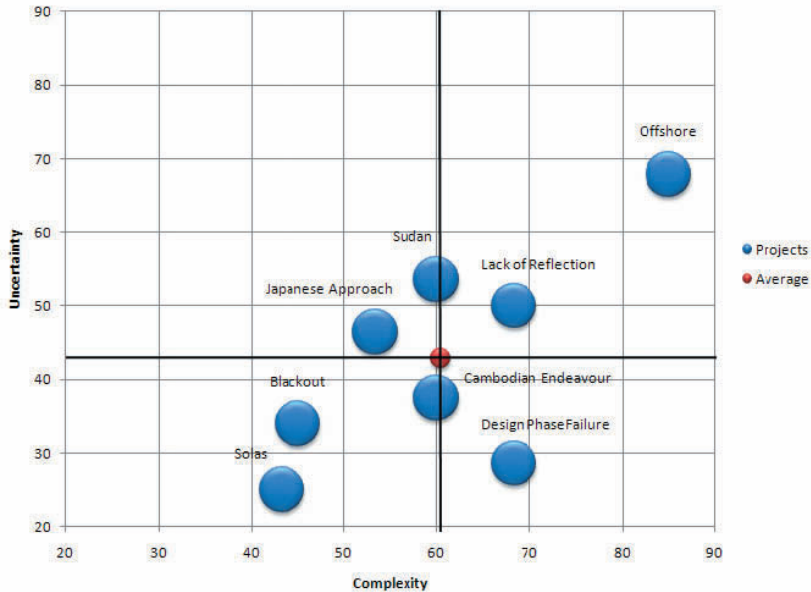
Figure 16. Mapping of the case projects

As already maintained several times, the definition of complexity that I operate with is widely represented in the project management literature, and is sometimes referred to as structural complexity (Williams, 2005; Baccarini, 1996). In the interpretation adopted here, complexity is a parameter that constitutes of size, volume, variety, intensity or number of elements in the project and the interdependence between these elements. In basic terms, complexity is understood as a number of variables and the interactions among them: the more interactions, the higher the complexity (Sommer and Loch, 2004). According to Simon (1968, In Loch, DeMeyer and Pich, 2006), complexity is grounded in:

> "*a large number of parts that interact in non-simple ways [such that] given the properties of the parts and the laws of their interactions, it is not a trivial matter to infer the properties of the whole.*"

In order to position the studied projects along the complexity dimension, I have adopted the complexity parameters (see Table 20 in the Appendix) from Hobday (1998). A similar approach to the evaluation of projects was used in Wikström et al. (2009). Table 20, in the Appendix, shows that the elements are both organizational (e.g. intensity of supplier involvement, intensity of regularity involvement), and at the same time reflect the complex nature of work that has to be executed (e.g. variety of distinct knowledge bases). The importance of such an assessment is that it includes multiple dimensions in the complexity construct and stresses that complexity and size are not the same thing. The financial scale of the project is also one of the important parameters that affects, to a large extent, the project's positioning on the map (Figure 16). The numerical scale, I have used a scale from zero to a hundred which is divided in five sectors: 0-25-50-75-100. The logic is the following: the higher the number that is given for a statement, the higher the complexity of the project at stake.

Although the unforeseen events took place at different phases of the studied projects, and the causes of those were not necessarily related to the warranty phase, comparing them to one another on one map is argued to be important. Some authors in the project management field (see e.g. Loch, DeMeyer and Pich, 2006) believe that the level of complexity of the project changes during the course of the project. This finding is relevant if it is assumed that uncertainty is a part of the complexity construct. The managers might think that the complexity increases during the course of the project because they perceive uncertainty: things tend to appear more complicated when people are not certain of things. This study is limited in testing this assumption due to the fact that complexity is treated as a static parameter. The perspective of the studied companies is taken into account here: what kind of complexity level is usually expected in a project of a particular type. Thus, it is not possible to test the dynamics of complexity during the project and its dependency on the changes in uncertainty perception and the outcomes of the implemented actions. The applied complexity parameter is oriented towards identification of complexity of the end product (see the statements in Table 20). It was proposed and used by the companies in their project portfolio assessment. The evaluations are normally done during the project kick off by project managers, and then the information is passed on to the warranty managers. The projects remained active in the warranty stage, so that

the overall performance of the projects — the financial result and customer satisfaction — was determined after the warranty stage was over. In practice, it is often so that while one part of the overall product to be delivered is at the project execution stage, the other is already at warranty or in use by the customer. This was the case with many power plant projects I observed. All of this leads to the conclusion that in context of the large industrial projects, it is better to look at the life cycle perspective, which assumes a wider view than by only looking at the project execution phase.

Building upon the studied literature and particularly upon Milliken's (1987) definition of uncertainty, I have evaluated the studied projects along several parameters, which reflect the interviewees' lack of knowledge, experience or understanding of how the elements of the project and its environment might be changing (state uncertainty), how the events, issues or parties, not necessarily directly related to the project, will affect the outcomes of the project (effect uncertainty), and what kind of response options are available and the value of those to the project (response uncertainty). Table 19 in the Appendix shows the statements, which have been formulated to reflect all the three types of uncertainty: state (e.g. lack of knowledge about the country of delivery), effect (e.g. lack of knowledge about the possible influence of the applied technology on the project outcomes), and response uncertainty (e.g. lack of experience from the other projects of the same kind). The formulations of the statements seem to fit with Olsson's (2007) two-dimensional definition of uncertainty as the lack of information (epistemic uncertainty) and the lack of knowledge (aleatory[14] uncertainty). The aim, nonetheless, is to find as many as possible of the dimensions of uncertainty or (and) the factors that affect it in a positive (increasing) and negative (eliminating, transforming) way. This implies that not only will the already known attributes (information, knowledge) be tested, but also that some others will be discovered, perhaps in the form of processes. The statements in Table 19 are formulated

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[14] According to Olsson (2007), the adjective *aleatory* originates from Latin word *alea* roughly meaning *chance.*

in a negative sense as *lack of,* so that the higher given grade stands for higher uncertainty associated with the issue. As the literature review shows, this way of referring to uncertainty is common for the researchers (Chapman, 2006; Atkinson et al., 2006).

It must be noted that certain formulations of statements in Table 19 in the Appendix might subsume both state and effect uncertainty. Following Milliken's logic (1987), if the project manager cannot predict future developments in the country of delivery or if he or she has little knowledge of the regulatory authorities, the manager perceives state uncertainty. In order for the manager to perceive effect uncertainty, there must be some confidence and understanding that a particular change in the country of delivery's environment, which is viable and relevant, might have an impact on the project's outcomes. Thus, some level of certainty is required to perceive effect uncertainty. However, my analysis revealed that when project managers do not possess knowledge or understanding of the event or issue, which they know is relevant for their project, they are very likely to also be uncertain about its impact on the project outcomes. In fact, project management literature (see the review in Williams, 2005) often combines the uncertainty about project elements (state uncertainty in Milliken's terms) and the uncertainty about how the change in these elements might affect the project (effect uncertainty) into one uncertainty construct. The explanation lies in the nature of project work.

The range of expressions used for describing uncertainty, except the rather straightforward *"lack of knowledge",* might need more explanation. For example, by using the statement *lack of familiarity with task execution process,* I am trying to establish whether the managers had enough skills and experience to perform the task. A high grade for the statement presupposes that there was a less experienced manager with possibly fewer skills and little experience in charge of the project. A high grade can also suggest that the task execution process is not established or only partially established within the organization, thus the manager at stake is not familiar with it. The statements using the expression *lack of understanding* are mostly target skills as a management factor. The interpretation of the grade is conducted on the basis of the available project information.

5.1.1 Comparing the projects

The categorizations that are currently popular within the project management field are supposed to demonstrate the degree of challenge in projects based on a three-dimensional scale of basic-medium-advanced, which tends to be biased towards the size of the projects under scrutiny. In line with Windischhofer, Perminova and Gustafsson's (2009) argument, such an approach results in practitioners directing their attention towards medium-sized and large projects, while asking themselves why some of their seemingly basic, repetitive, routine or just small in size projects conclude in failure. In this thesis, all of the cases are considered at the warranty stage, when the administrators make conclusions about how successful the projects were both financially and in terms of customer satisfaction among other parameters.

For example, high levels of repetitiveness and lower levels of novelty are common for Company B's marine segment projects. The weaknesses and strengths are known and considered when choosing the appropriate solution for the specific customer. The projects are moderate in size, mostly representing equipment deliveries, thus they are considered routine. During one of the workshops, one of the interviewed managers, who specialized in marine segment projects of Company B, had a difficult time remembering any of the unexpected events that had happened. He partly linked this to the fact that the technologies employed in the marine segment by the Company B are well tested. There are differences between the technologies employed in each case depending on the customer desires and other project collaborators' capacities. The marine projects of Company B are mostly equipment deliveries or EP (equipment and procurement) with a limited range of services included, which implies that there is a high dependency on the other stakeholders' decisions. Company B in such cases acts as one on the suppliers, only supervising the installation work performed by the shipyard. In fact, the projects of Company B are more or less repeat endeavors with mostly incremental innovations, or *market-based projects* in Mintzberg's terms (1979). This is especially true as the company has been used to applying similar solutions to a series of ships that it has built for the same customers at the same shipyard, as in the SOLAS case. Naturally, there are differences in size, volume, capacity of engines and systems that are adjusted to the particular customer needs and then fitted into one system. Nonetheless, the concept behind the solution does not significantly differ. Thus, the

complexity alone cannot be used as an explanation for the failures (after all, the SOLAS project was considered routine, as it assumed application of well-tested technologies and work with known partners). Rather, it is the common interpretation of complexity as a synonym for difficulty, which leads to the assumption that low complexity means a non-challenging project and vise versa. Whereas uncertainty is not considered at all, or considered only as a complexity dimension, which means that low complexity is counted as low uncertainty. Complex projects are not necessarily challenging and less complex, easy projects are not successes by definition. The key, of course, lies in the actions that are taken to target uncertainty.

The Cambodian Endeavour case and Sudan case projects have been recognized as more complex than most of the marine segment projects, but they required familiar, routine tasks to be performed, even though the setup was complex. The level of complexity of these two projects was estimated to be nearly the same, but the uncertainty level differed significantly (see the mapping of projects in Figure 16). The Sudan case and especially the Lack of Reflection case also assume a higher level of novelty and variability of parameters, which resulted in positioning them as more complex. One can assume that the uncertainty profile of any of the studied projects evolved during its life-cycle, reaching a peak at the time of the unforeseen event happening, and lowering after certain measures were applied.

Both the customer and the supplier's expectations (and thus, success in terms of satisfaction) regarding how such projects should be performed are, to a large extent, dependant on how the previous projects of the same kind were executed. The repetitive projects (where the scope of supply, and often the customer, is precisely the same as in the preceding project) have never been labeled unique or even complex by the respondents, although there were unforeseen events in some of those projects. As one can see from the data, most of the analyzed projects had at least one repetitive project element or even a combination of them. I would even argue that there is hardly an industrial project that has a completely unique setting. There are almost always certain points of reference to previous projects: a known sub-supplier or customer, familiar scope of work, etc. However, in the Offshore case, the innovativeness or novelty is somewhat higher than in the rest of the sample, which is why it can be labeled, at least to some extent, as unique.

Less complex projects are not necessarily lacking in uncertainty. There is a group of projects among those that I have studied, namely the SOLAS, Blackout and Japanese Approach case projects, that were described to me as not presenting any particular concern in terms of complexity: the scope of delivery was relatively small, financially the projects were not extensive, and the other relevant elements of complexity according to Table 20 (in Appendix) also received relatively low scores. The managers characterized them as *pretty straightforward, normal, fairly well, with no expected difficult issues.* An example of such a project is the Japanese Approach case, where no critical situation was assumed to have happen, partly because the scope of delivery was small as compared to other projects. In addition to this, there had been a lack of evidence that the technical issue — the malfunction of the CCU-box, an engine component — would cause the unforeseen event, prior to the event. There was no reason for the manager to regard this issue as a threat or a risk to this particular project, because he could not assess the relevance of the component's unstable performance to the project before the malfunction took place. According to him, there was uncertainty in Company B as to whether the performance of this particular component would have an impact on the engine's functioning (state uncertainty), and consequently, on the projects involving deliveries of the engines (effect uncertainty). The interviewee questioned the ability of Company B to find the relevant actions to solve this dilemma (response uncertainty). However, in the course of next similar project with the same customer and identical scope of supply, the manager was aware that this engine component might cause an effect on the warranty outcomes, and of how exactly it could impact the overall results of the project. The issue was no longer uncertain. The manager was more positive about the latter project, describing its performance as fairly well, possibly because the technical issue had already been addressed in the course of the previous project involving the failure. He reflected upon the factors that he found most valuable to achieving a successful problem (and uncertainty) resolution, and to him these were extensive collaboration and communication with the project customer.

One could argue even that the technology-related uncertainty about the CCU-box was an example of what is referred in the literature as *unknown unknowns* (e.g. Sommer and Loch, 2003; Wideman, 1992). However, although the manager at stake might have not been aware of the

malfunction possibility before it actually happened, his interview states that there had been experts in his organization, who were knowledgeable concerning the issue and its potential impact on the company's projects. To those experts, the uncertainty was no longer unconscious *unknown unknowns*. According to the interview, it was conscious lack of knowledge (*known unknowns*), skills, resources or other means to develop the product (*not capable* to develop the CCU-box), or ignorance (*not willing*). The interviewee attributed resolving the issue to the interference of the Japanese customer and to the active collaboration with them. Nor was there any perceived customer-related risk. The Japanese company was a well-known customer for Company B.

In sum, the Japanese Approach case shows the reverse example of "complexity equals difficulty" logic. The case project was assumed to be easy and certain because of the seemingly low complexity. At the same time, the uncertainty factor (technological and organizational) was not taken into consideration and managed accordingly. This view goes hand in hand with classical project management which regards uncertainty as a dimension of the complexity construct, where low complexity equals to low uncertainty. The two-dimensional perspective to classification of projects helped to visualize whether it is the complexity or uncertainty associated with the case projects, which played the role in choosing a particular set of actions to address the event, and consequently, the outcome.

All of this provides grounds for the conclusion that regardless of complexity, projects are still exposed to various effects of uncertainty. Consequently, if the project and/or its elements, the environment and/or any other relevant variables are perceived as uncertain, they need to receive adequate attention from managers in order to adapt to their challenges.

The summary of the cases is provided in Table 10. In the following subchapters I will explain some elements that, according to the interviewees, are associated with uncertainty, risk and opportunity, and the prospective management practices of these issues.

Table 10. Summary of the cases

CASE	STARTING POINT	CAUSE OF UNCERTAINTY	RESPONSE ACTION	OUTCOMES	INTERPRETATION
The SOLAS case (marine)	Standard project	Technical, organizational, contract	1)special project team to fix the problems; 2)root-cause investigation; 3)equipment replacements	**Risk** (delay, customer unsatisfied, considerable costs, quality of the installation affected); **Opportunity** (tech. problem discovered and solved)	Failure in internal and external communication and coordination
The Design Phase Failure case (Power plant)	Repetitive project with legal peculiarities	Organizational, contract	Troubleshooting to correct errors	**Risk** (delay, customer unsatisfied, costs, quality affected)	Failure in internal and external communication, unclear responsibilities within the project
The Lack of Reflection case (Power plant)	Standard delivery, but new operating conditions and legal peculiarities	Technical, contract and organizational	Troubleshooting to correct the errors	**Risk** (financial losses, delay, customer unsatisfied)	Failure in reflection: unclear responsibilities, internal communication
The Blackout case (marine)	Standard project	Technical and organizational	1) special project team to fix the problems; 2)extra supervision on-board; 3)goodwill agreements	**Risk** (costs for replacements, customer's business affected) **Opportunity** (tech problem behind the event addressed on the supplier's org level)	Forced reflection (authorities as a catalyst). Internal communication failure
The Japanese Approach case (Power plant)	Standard project, but demanding/committed customer	Technical, customer	Component modifications based on customer's root-cause analysis.	**Risk** (no profit for the supplier) **Opportunity** (better relationship with the customers), product modification	Forced reflection/pro-activeness (customer as a catalyst)

The Cambodian Endeavour case (Power plant)	Extension project with committed customer	Project phase: organizational. Warranty phase: organizational and technical.	Shift in planning of logistics. Troubleshooting – component replacements.	**Opportunity** (no risks occurred, although expected) **Risk** (costs) **Opportunity** (technical issues were addressed by R&D)	Forced reflection/pro-activeness (need to overcome the obstacles), facilitating the commitment of stakeholders
The Sudan case (Power plant)	Standard with complicated hierarchy of stakeholders	Organizational, contract, customer	Spare parts to be replaced with those of another origin -> ordering them from another sub-supplier	**Risk** (delay, extra costs for the supplier for the spare parts replacements) **Opportunity** (show commitment to the customer)	Failure in external communication
The Offshore case	Unique project with complicated structure of stakeholders, product to be delivered	Organizational, contract	Consortium joined forces to execute the work	**Risk** (delays, costs) **Opportunity** (a difficult technical problem solved, which benefits the image of the supplier)	Forced reflection due to obstacles. Lack of coordination

5.2   The factors influencing uncertainty

This chapter discusses the main concepts that emerged from the data analysis. Regarding the way the interviews were conducted, my aim, as an interviewer, was to make the managers discuss uncertainty without giving them any of my own pre-understandings. That is why the "storytelling" approach was employed. The consequence of such an approach was that the research collaborators: the interviewees, the participants in the workshops — the experts who contributed with their opinions and knowledge for this study — brought in many other examples and experiences that concerned not only the main cases of this study, but also the issues beyond that.

The discussion during the interviews focused on the concrete events that took place throughout all the stages of the case projects: from bidding/sales to the start of the operations by the customer. At the same time, the examples from the other undertakings that the interviewees knew about or participated in were mentioned many times, especially as means of contrasting with the main project of interest. To be completely truthful, I was more interested in learning about uncertainty, the management practices related to it, than merely learning more about the case project. That is why I used the aide memoriam (see Figure 26 and Table 18 in Appendix) rather than a structured list of questions. However, my aim was to be persistent in acquiring the information I needed. In general, the interviews and partly the workshops focused on four main topics, which again, were not forced upon the interviewees. In contrast, they fitted in logically. These were:

    a. risks as foreseen negative events,

    b. uncertainty in the examples of situations that were not expected to happen and the reaction of managers to that situations in terms of actions,

    c. the two aspects of performance: as an outcome of the events taking place during the project delivery, and as a result of implementing certain management practices, if the data allowed to establish those,

    d. opportunities as an upside of uncertainty and a result of implementation of certain

actions with the aim to improve performance. The topic of opportunities was strongly attributed to performance. In other words, the interviewees saw the opportunities as a positive outcome of their actions in response to uncertainty.

Following the logic of the coding analysis, I present the attributes that were associated most with uncertainty. Then, I will explain them individually.

The views on risk and uncertainty derived from different disciplines have their merits and drawbacks, however, all of them are taken from a standpoint which assumes that there exists some sort of common truth, which is relevant for any situation and any party involved in it. This is a deterministic presumption. In order to define uncertainty for project business I have adapted a relativistic view (Popper, 1996; Putnam, 1995). Various propensities impact on the decisions regarding how to handle uncertainty. The mere understanding of this phenomenon is formed through individual experiences and beliefs. Consequently, each actor involved in project has his or hers own view on uncertainty. Given these characteristics of the phenomenon, one should not fall in the trap of perceiving uncertainty as everything and nothing. The purpose of this study is not to study the issue of uncertainty as a philosophical category, but rather to define uncertainty in projects from the point of view of the actors involved in them. Thus, the meaning that I assign to the phenomenon of uncertainty is limited by the scope of the study. The idea is not only to regard uncertainty in the terms of Frank Knight (1921) i.e. as probability distribution. Such an understanding of uncertainty leads to the fact that it is often interpreted as ambiguity, — or the absence of probability distribution (also as inability to recognize relevant variables).

The analysis of the coded data on the basis of the verbal reports of managers enabled me to arrive at a number of elements constituting uncertainty management. In order to provide a comprehensive answer to my research questions, I will answer them separately. In the first section, I will show how uncertainty is understood and handled by managers and propose a categorization of uncertainty based on the sources from which it stems. In the second, I will explain how uncertainty relates to project risks and opportunities by reflecting on the analyzed empirical data and comparing the result to the existing research on the subject. The third section

will be dedicated to the analysis of methods or actions the studied companies used to cope with uncertainty and the results such methods led to. Then, I will conclude by answering the research questions of this thesis.

By addressing the first two questions (How do project professionals manage uncertainty? How does uncertainty in projects relate to risk and opportunity?), I strive to show the differences between the concepts of risk and uncertainty from the practitioners' perspective. The fact that risk and uncertainty are not synonymous terms in the project context and require different actions in response can provide the basis of an explanation as to why traditional project risk management practices are not enough to mitigate and benefit from uncertainty.

The important characteristic of uncertainty that is mentioned here is its dual nature. From the perceiver's point of view, uncertainty is a state of not knowing or not understanding/realizing the consequences of the situation. The non-stability of this state implies that the perceiver strives to resolve the situation to move into the state of certainty, which is common and natural. In other words, action is needed. Furthermore, the instability of the phenomenon does not imply that its outcomes are strictly negative. However, I must admit that some of my respondents had a tendency to think of uncertainty in a negative way. This might be due to the fact that some people are less comfortable in situations of uncertainty and, thus, interpret them only as a risk. At the same time, the majority of the respondents perceived instability of the uncertain situation as an opportunity to gain benefit from it. In sum, the phenomenon of uncertainty has the following characteristics that are relevant for the study:

1) the way it is perceived by the individual depends on the personal traits,
2) uncertainty is an unstable state, which requires resolving,
3) actions need to be taken for uncertainty to be resolved,
4) the consequences of uncertainty can be both positive and negative.

Table 14 (in Appendix) shows the results of the coding analysis of the empirical data:

- Sources of uncertainty: project organization-related grounds for uncertainty and scope of supply-related grounds for uncertainty, with the latter being strongly related to

technical aspects of the work and outcomes;

- Reflective processes that resolve uncertainty: communication, experience and information;

- Unforeseen situations or events that are seen as the attribute that uncertainty is strongly associated with.

The same results are presented in the Figure 22 as a chart. Figure 22 shows that uncertainty is mostly associated with project organization-related factors, namely the project network structure (it refers to project organization variable in the framework Figure 3). It relates to the findings in the studied literature that emphasizes organizational structure as an important variable (see Table 3). The analysis showed that the uncertainty associated with this aspect results in difficulties in obtaining information or communication difficulties as a risk event (28 references in 13 analyzed sources). The opportunity associated with this cause of uncertainty is better bonding with the stakeholders: flexible engagement of the relevant parties into the work process, better quality of cooperation between partners (27 references in 10 analyzed sources). These aspects proved to be closely associated with contract-related grounds for uncertainty, which stem from the way work is divided between the parties in the project[15], and whether that division is clear to everyone.

With regard to the scope of supply-related grounds for uncertainty, it appears to mostly affect not the project performance per se, but the way the managers perceive the situation. The risk that is associated with this type of uncertainty lies in urgent changes in the scope of supply to be delivered. This is quite in line with human psychology: we tend to see more risks in change than in going with the flow or standing still (Schuler, 2003). However, the number of respondents that indicated this as a risk is rather small in the studied population (6 references in 3 sources). The other respondents, although they were quite skeptical about the changes in the

[15] In this context, a contract represents the official division of work between the parties adhering to it, hence it states the division of responsibilities between the parties.

scope to be delivered, indicated that such changes, if taken into account, increased the value of the contract and, in general, led to better customer satisfaction. The latter was considered to be better project performance. On the other hand, when the changes appeared to be at a later stage in the project completion, especially after the detailed design phase, they were associated with a significant impact on the timing of the project (negative — delay, positive — on time). One interesting aspect that appeared during the discussions is the pro-activeness — or the reflective process of sensemaking in Weick's terms — this, as the managers explained, is needed in the situations of change. This aspect exhibits similarity with the discussion that Eisenhardt and Brown (1998) provide on time and continuous change in organizations. If changes are perceived as a normal way of working (and this is a feature of managerial sensemaking), then they no longer represent a cause for uncertainty since they become a known fact. Indeed, they can be turned into risk or opportunity depending on whether the rigid plan-conforming or the flexible-sensemaking way of working is applied. Reflective management established human element as its focal point (Gustafsson and Wikström, 2004), which is why the psychological climate of the organization (James and Jones, 1974) and the organizational climate (Denison, 1996) can be considered of importance for managing uncertainty.

In the following chapters, I will present the difference between uncertainty, risk and opportunity concepts and discuss the various factors that affect (experience, communication) and are affected (performance) by uncertainty.

5.2.1   Defining uncertainty from risk and opportunity

To summarize, from the project point of view, uncertainty appears to be a source of risks as events having a negative impact on the project's outcomes, or opportunities, as events that have beneficial impact on project performance. Based on the literature review, the following definition of uncertainty is proposed in the thesis:

Uncertainty in relation to projects is the individual's (e.g. the manager's) lack of knowledge and/or understanding of the relevant project elements, its environment and their

interrelationship, so that no conclusion can be made as to if and/or how any of those can impact the project success.

Uncertainty can arise from sources both internal and external to the project. The external uncertainty includes all the factors that lie outside the project organization such as market conjuncture, the political and legal systems of the country of delivery, etc. These factors cannot be affected directly by the project, rather the project has to adapt to them. In literature this type of uncertainty is referred to as *environmental uncertainty* (in e.g. Starbuck, 1976) or uncertainty induced by environmental variables (as in e.g. Jaafari, 2001). The other type of uncertainty is internal, which emerges from the project and the project company's organization. In contrast to external uncertainty, this type of the phenomenon is not only created by the organization, but also works as a catalyst for the development of the organizational structure. As an example of internal uncertainty, one can take certain types of projects where the risks, at least partly, originate from the system complexity, which is referred to in the literature as systematic uncertainty. In such projects, the structured approach for information creation or a structured product itself becomes a key factor in better project conformance (Browning and Eppinger, 2002; Hellström, 2005). In this context, the managerial actions targeted at uncertainty and risks are seen as the way to create previously unknown information.

The content analysis of the interviews clearly shows that the managers perceive uncertainty and risk in different ways. To begin with, most of the respondents only associated risks with a negative impact on the outcomes of the project. The events with perceived positive implications on the project are often referred to as opportunities. The empirical study does not confirm that managers perceive the event that has positive effect on the project's objectives as risk. In the projects that I observed risk management is performed in terms of considering the costs in the form of risk coverage: reservations in the budget, insurance policies, hedging, etc. As one interviewed project manager put it: *"Risk is cost for us"*. As one can see from the descriptions in Table 11, which summarizes the understanding of the main terms by the interviewees, the meaning of risk is negative. Risk has negative impact not only on the financial aspect of a certain project (which was almost always cited as the first meaning), but also on other projects, relationships with the customer or other stakeholders, supplier's brand image. If the issue is labeled as risk, it is generally known how it relates or affects the project outcomes. The

managers verify that a lot of emphasis is put on the planning stage, especially in terms of forming a reservation for risks. This is valid for the projects of any scope.

This finding shows that the managerial understanding of risk appears to be more definite and negative-sense oriented than is stated in the traditional project risk management literature (e.g. PMBOK, 2004). In other words, risk is perceived as a hazard. Furthermore, the interviewees often used the word risk as synonymous with loss, claim, cost or damage. In contrast, when speaking about uncertainty the interviewees assumed lack of knowledge or understanding, which implied difficulties or even inability to draw a definite conclusion: the probability of a loss and the probability of a gain seemed equally viable. In this respect, the concept of uncertainty from the managerial perspective seems to be somewhat less precise than the concept of risk, because it depends on individual qualities (e.g. experience, skills or information possession). Thus, the uncertainty about the positive outcomes cannot be treated as an aspect of risk from the managerial perspective. Similar findings on the managerial perceptions of risk can be found in the research of March and Shapira (1987).

Table 11. Description of the main terms

TERM	DESCRIPTIONS GIVEN BY THE MANAGERS	SUMMARY
Risk	a. Cost, damage or failure (to perform as planned/expected); b. Damage to the company's reputation; c. Loss of business.	*Risk is seen only as a negative event that impacts the project performance.*
Opportunity	a. Preventing costs; b. Creating trust in the relationships with business partners; c. Securing future business; d. Improving the image of a company.	*Opportunity is seen as a positive, often long-term, outcome.*
Uncertainty	The perceiver's state of not knowing or understanding described as: a. totally unforeseen; b. not expected to happen; c. not imaginable.	*Uncertainty in relation to projects is the individual's (e.g. the manager's) lack of knowledge and/or understanding of the relevant project elements, its environment and their interrelationship, so that no conclusion can be made as to if and/or how any of those can impact the project success.*

5.2.2 Individual manifestations and the concept of uncertainty

The weakness of the Project Uncertainty Management approach (Chapman and Ward, 2002, 2003) lies in the fact that it provides too little empirical support on how uncertainty is actually managed in projects. This gives ground to the critique: why do we need to distinguish uncertainty from risk if we have no evidence of the phenomenon?

The purpose of this empirical study is to provide the evidence for uncertainty as a concept, which objectively exists in project management reality, and has an impact on how projects are managed. I believe that uncertainty itself is better described as a cognitive process because of its perceptual nature. In other words, uncertainty is bound to the reflection process: thinking through, considering, doubting, etc. Being subjective, uncertainty is tied up with the personal traits and abilities. What is considered to be uncertain by one person can appear certain for another. That is why the descriptions of uncertainty given in the interviews are different. In a similar vein, March and Shapira (1987) explain that perceptions of risk are strictly personal. They depend on the individual's traits, skills, experiences, etc. The researcher in the field of organizational science tend to support this view (see the review in Table 3). This empirical study shows that at a certain point the descriptions of uncertainty might appear contradictory or very close to that of a risk. However, if to go deeper into the descriptions of uncertainty and risk, it is possible to see that the issues are clearly not the same. It is the *emotions and other individual manifestations* that uncertainty and risk awake in the managers: fear, confusion, regret, disappointment just to name a few. Clearly, these feelings can be easier labeled as negative rather than positive.

Uncertainty in the studied project was associated with a sudden change or challenge, which brought confusion into the routine work and disturbed the plans. At the warranty stage, it also meant that any unexpected events could potentially affect the project outcomes and image, especially for projects that were assumed to be a success at the project execution phase. It should be noted that the emotions are not always attributed to the end result of the situation. As a matter of fact, they express only the person's attitude towards the experienced. This applies

not only to the *ex post facto* reflections, but also to the forecasts that the managers made regarding the events to come. However, emotions blur distinctions only to a certain extent. Moreover, it is quite natural for the human being to perceive the unknown and uncertain as negative, because of the confusion and instability that it brings.

At the same time, emotions as well as the other individual manifestations are the source of reflection (Raelin, 2001). Vince (2002) shows the connection between emotions and other individual manifestations, learning and reflection by stating that emotions are generated by learning and reflection. Swan and Bailey (2004) demonstrate that emotions are in fact the catalysts for reflection. In this sense, uncertainty in itself calls for the most effective way of managing: reflective processes of sense-making, experience sharing, knowledge sharing, etc. Emotions are themselves the sources of learning (ibid.). They are the enablers of the creation of new understandings of the project elements and its environment: within the project team, the project department, the project-based firm, the project organization and so forth. The results of this study show that in fact, when the voiced experiences (both in form of facts and opinions) accumulate not just on a single project level, but on multiple projects' level encompassing the project firm, the reflection and learning expand to multiple levels of the organization. They are the force that can bring operational level management and top organizational administrators together to share information, experience and understanding thus reducing uncertainty about the current state.

Let us consider the SOLAS case. From the manager's point of view, the negligence on the shipyard's part determined the situation. If the installation instructions had been followed, the technical weakness would never be have been revealed or appeared on a much smaller scale. In other words, one cannot be sure if the initial technical weakness of the offered solution would have ever been discovered but for this particular installation arrangement in the project. At the same time, there were no reasons to expect the shipyard not to follow the recommendations. The challenge came very suddenly. The combination of the two factors — technical and organizational — gave ground to the unforeseen event. These two issues (the technological imperfection and the shipyard's negligence) were not yet facts before the malfunction occurred and could not be treated as a risk, which could have been identified earlier in the project and

prepared for (e.g. by planning the actions). Although the investigation revealed that there were suspicions regarding the technology among the technicians, these suspicions were not justified sufficiently to be treated by the supplier's organization (and the project and the warranty managers) as threats — risks. Not to mention that it was a project in a routine setup, similar to several ones delivered to the same customer previously. Thus, Company B had no ground to evaluate these speculations as risk. This is the same uncertainty situation as was discussed earlier in the Japanese Approach case in the section 5.2.1.

When the event took place, reflection was triggered both at the project level and at the company level. The former took the form of warranty claim investigations by a special project team with the aim to find ways to adapt to that particular challenge (by troubleshooting and dividing responsibilities between the project parties). The project resulted in such a severe delay, that when the case was studied, the project was already at warranty, but the ship was still not delivered to the customer. This negative project result combined with the similar experiences from other marine projects triggered organizational reflection in a form of brainstorming workshop between the top management and the operational level experts to identify ways to better prescribe and influence the fulfillment of supplier recommendations by the project stakeholders. Uncertainty resulted in a positive development by triggering reflection and learning processes. Another positive dimension of uncertainty, which was described as opportunity, was that the technical issues were finally brought to light and acted upon. In a way, a negative experience worked as a catalyst for a sense-making and learning process, which in turn, helped to reduce uncertainty. This is the example of how response uncertainty can be reduced by learning from the past experience and taking the new knowledge to the strategic level by revising the firm's policies.

5.2.3   Uncertainty and project success

It can be seen to follow from the previous discussion of the SOLAS case, that the project performance and uncertainty are related parameters. The coding analysis revealed the

dependencies between the project performance and uncertainty. The results of the empirical analysis are presented in the Appendix: Table 15. Table 15 and Figure 23 present the factors that affect performance negatively, whereas Table 16 and Figure 24 indicate the parameters that improve performance.

According to the coding analysis, the main negative factor that appears to boost uncertainty emanates from the internal project-based firm set up. Among the issues that proved to be of significance in this category are the internal integration issues. As compared to the conventional issues of integration and the building of the firm's core competences around them (Brady and Davies, 2004; Hamel and Prahalad, 1994; Foote et al., 2001; Galbraith, 2002; Davies, 2004), internal integration is concerned with the ability to transfer best practices within the company (Szulanski, 1996). It is also potentially related to the supplier organization climate and the psychological climate that its members have to deal with, a factor of internal company politics (James and Jones, 1974; Denison, 1996; Milliken, 1987). As argued by Williams (2005), the internal political issues are rarely addressed by the prescriptive project management science, as they have such a strong presence in the everyday project work. Managers might hesitate to act upon the issue if the actions potentially harm their professional image or the image of a successful project. In order to strengthen the brand, companies might pursue delivering a particular solution in an attempt to increase business with the customer, who it is considered strategically important to collaborate with, without being certain that the solution is adequate for the purpose. A good example of this is the Lack of Reflection case. Although it is difficult to argue whether the decision to supply the power plant was reinforced by the company's politics, it is clear that the performance of the project at warranty was influenced by the state uncertainty.

Following the logic of Grant (1996) and the knowledge-based theory of the firm, internal integration of knowledge is the core capability of the firm and its main task is to secure and sustain the competitive advantage. Hence, it affects the performance of the project and the firm. The negative effect of uncertainty associated with internal company issues can be traced to internal integration problems, which is manifest in a lack of internal communication and coordination (again, The Lack of Reflection case is a good example, as well as the Sudan, the

Design Phase Failure, and the Blackout cases). The reflective, learning-oriented processes supporting information and experience exchange within the company and between projects are needed to address all types of uncertainty in Milliken's (1987) classification. Similarly, the successful management of the Cambodian Endeavour project phase suggests that pro-activeness based on reflection is necessary to adapt to the sudden challenges in projects. Nevertheless, the reflective approach should be supported by the top management. At times, pro-activeness at the project management level is stopped by the fact that the project-level managers do not have enough power within an organization, both in terms of job description and personal reputation, to reinforce the needed actions. Thus, the companies need to cultivate the suitable systems or processes for the support of project-level managers, as well as the mechanisms of interdepartmental integration so that there is a knowledge-sharing platform between them. This is especially true in the light of the understanding of the firm not only as a knowledge-creating mechanism, but also as a knowledge-applier (see e.g. Argyris and Schön, 1978; Levitt and March, 1988, Grant, 1996). The Offshore case is something of an example of such a system on a project network level, where all the stakeholders were connected via a project management company with an integrator function.

The external grounds for uncertainty: contract/scope of supply and customer/operator/user causes of uncertainty belong to project organization parameters. The former has already been discussed in section 5.3.1., where it was paralleled with the notion of change that is widely used in management literature. Here is a quote by one of the interviewees explaining how it might relate to uncertainty:

> "I think that and in our normal scope of work we did it quite well, with all the time schedule and technical and economic [issues] it went very fine this project. But this [item in the scope of work], which normally don't belong to our scope, this was more or less a surprise…"

In engineering terms, such changes in scope of supply are known unknowns representing the effect uncertainty; in other words, they can be, to a certain extent, forecasted based on experience. However, they are difficult to be prepared for since the timing of the event is not known (and of course, it might not take place at all). They affect the performance negatively in

cases where there is lack of clarity regarding contract terms or division of responsibilities (for example, the SOLAS case or the Offshore case), lack of understanding or communication between the supplier firm and its customer or among other stakeholders (the Sudan case, the Design Phase Failure, and Lack of Reflection cases). A positive example of eliminating customer/operator/user grounds for uncertainty is the Cambodian Endeavour case, where the customer was persuaded to follow the directions given by the supplier and thus, many problems and uncertainties were avoided right at the start of the project. This is an example of how pro-activeness in information sharing and communication — or applying reflective management — with the customer can positively affect performance of the endeavor.

Another example can be found in the description of the *project outset* of the Offshore case. There it was mentioned that Company A decided to establish their own recruiting and training agency in order to avoid the problem of the availability of the skilled workforce in the country of delivery. There were no unforeseen events or situations that could influence the decision to establish the recruitment branch. It could have been a decision based on an entrepreneurial hunch or an informed guess inspired by marketing research. It brings to the conclusion that the company had been employing proactively the reflective process of investigating the environment. Regardless of the reason, Company A avoided the uncertainty related to the *lack of reflection*. The workshop that I held in the second round of data collection at the company confirmed that many of their competitors in the country of delivery actually suffered from the scarcity of an engineering workforce in the market. In fact, for those companies this lack-of-reflection-inspired uncertainty was perceived as a threat. The issue at stake is uncertainty, because the companies were aware of their dependency on the workforce, but they were not concerned as to whether the issue would escalate, therefore this it turned into a problem. On the contrary, Company A could use this situation as an opportunity to establish itself more firmly on the new market. For this company, the uncertainty was successfully managed and turned into the opportunity to do better than their competitors in terms of workforce. The company managed to address all the three types of uncertainty in the Milliken's framework: state (by investigating the relevance of the issue), effect (by investigating how the issue would affect the projects and planning for actions) and response (by establishing their own concept of workforce management).

Technical uncertainty (which can be paralleled to *unknown unknowns* in engineering terminology (Wideman, 1992 or that of Shenhar, 2001) does not come first on the list of uncertainties significantly affecting performance according to the analysis (Table 15 and Figure 23). It is assumed that managers dealing with highly complex systems and structures are better prepared (at least mentally) for facing problems with technology. The example of the Blackout case is very illustrative of this issue: once both the supplier's management team and the customer realize and are prepared for uncertainty, its effect on the performance is easier to manage at least in terms of customer satisfaction. In addition, the latter comes as the first on the list of variables affecting uncertainty positively (see Figure 24 and Table 16), gathering more votes than the financial results of the project.

That is why I do not consider ambiguity in the sense that it is referred to in the decision theory literature[16] as a separate issue in this analysis. The industrial engineering companies, such as those discussed in this thesis, are experts in their field. Thus, it would not be reasonable to assume that it is impossible for them to recognize the relevant information or functional relationships related to the work that they do on an everyday basis, be it marine installations, power pants or oil rigs. I come to the conclusion that they meet uncertainty because they do not know when or how the unforeseen event will take place, or because they do not reflect enough on the situation. Of course, if an engineering company becomes engaged in, let us say, the insurance or agricultural business, they might face ambiguity since they naturally will lack knowledge and skills in these fields. Nevertheless, when they operate in known terrain, they manage to turn the uncertainty into opportunity.

As for the variables, positively relating to performance, and thus eliminating uncertainty (or better said, turning it into certainty) the top three are somewhat a reflection of the variables affecting performance negatively (Figure 23 and Table 15). Apart from the *fulfilling obligations to*

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[16] Ambiguity in the decision theory literature is referred to as inability to recognize the relevant variables or interactions (Sommer and Loch, 2003)

the customer and *benefit secured through the contract*, which clearly relates to customer satisfaction, there is the reflection versus extensive planning. The latter stresses the importance of pro-activeness in managing uncertainty and performance as is argued in the literature (Maylor, 2001; Atkinson et al., 2006; Gustafsson et al., 2010; Smyth et al., 2010) .

There are a number of suggestions that the managers brought up during the meetings, which reflected on how to address uncertainty in projects in order to affect the performance in a desirable way. I have summarized those suggestions together with the results of the coding analysis, which will be presented in the following two sub-sections.

5.2.3.1 Technology and time

Several managers pointed out the importance of communication aspects, especially in repeat projects. One manager said that there had been no unforeseen situations in projects under his supervision at any time. According to him:

> *"[from the experience] with the sister vessels we already know that we might need several modifications in spare elements. This is the only risk that we face there at the moment".*

More importantly, for this manager, risk does not lie in the fact that there is a need in modifications of the existing technology, since there is always room for technical improvements. Rather he stressed the time factor: when such improvements are done.

> *"Surely, there are some modifications that we are forced to include, but then need to be done already at the factory [where the equipment is produced]. It is easier to do it at the factory than on the vessel, which is already sailing".*

The interviewee pointed out that most of the time the improvements are done when the final product has left the production facilities. This is a costly way to improve the product. It is logistically complicated as well, since the ship is sailing constantly, and it can be difficult to

allocate a harbor where the maintenance work can be performed. At the same time, he admitted that what usually happens is that the modifications are done after the product leaves the factory.

5.2.3.2 Repetitive maintenance

Regarding risks in innovative large scale projects, all the respondents pointed out that most of them are technology or operation-related. The most common case is the *weak product components or weak system elements* that may fail under certain operational conditions. In the observed projects such elements are the mechanical components of the engine, e.g. bearings in the rollers. If a roller brakes down, it will destroy the crankshaft and may even lead to the collapse of the engine. The loss of an engine, especially during the warranty stage, is a huge expense both for suppliers and their customers. To avoid hindrance of the normal operations, the industrial companies use preventative maintenance, which means regularly scheduled inspections, part replacements, repairs, etc. Preventive maintenance measures are performed at established time intervals. For example, if the estimated life of the spare part is 10 000 working hours, the part needs to be changed before that.

One of the respondents noted that there are three important aspects of managing the operations so that the risk (and uncertainty) level is minimized:

> *"…The information, ability to understand [interpret] the information and ability to follow and implement instructions…"*

The suggestions presented above — communication versus planning in time management, repetitive maintenance — can be seen as examples of how uncertainty is addressed in practice. However, what appears as a "red thread" throughout the project descriptions is the importance of establishing underlying processes and procedures as a means of supporting reflective thinking at a managerial level. The reflective project managers and their superiors are the

practitioners that can "see the forest through the trees": they can think in terms of a broad, long-term perspective for their projects and project portfolios respectively. However, effective managers should not abstract themselves from daily routine. The project management literature outlined the need for a project management professional who is a strategist and a good supervisor; however the practical mechanism of enabling the strategist function has not been outlined (e.g. Jaafari, 2001). Once again, the need to integrate organizational top level administrators with the operational-level managers needs to be stressed in this context, as the analysis shows. As Mintzberg (1994) notes, effective strategists are those individuals who immerse themselves in daily detail while being able to see the strategic messages involved. In this sense, the routine and traditional project management processes are of immense support for managers. In fact, uncertainty management builds upon the project risk management, change management, time management and the other functions that PMBOK (2004) states. But this conclusion is valid only if planning is seen as a supportive, not the main function, of project management (Maylor, 2001; Andersen, 1996). Uncertainty management — or coping with uncertainty, acting in the situation of uncertainty — requires reflection, whereas risk management stresses rigid planning.

Planning versus reflection is not the only difference between risk and uncertainty management. The other attributes, such as information, experience and communication seem to have different values for these two management functions.

5.2.4   Communication and experience in managing of uncertainty

The managers pointed out the extensive network of the stakeholders involved in the project deliveries. The power plant projects, where Company B was usually a turn-key supplier, can also involve several parties, besides the end customer and the sub-suppliers. For example, the operations company, the local branch, the outside consultants, etc. For the marine projects, the shipyard is one of the main contact organizations besides the customer, not to mention the

several main suppliers, sub-suppliers, etc. The company, which operates the vessel, is not necessarily the owner of it. Still, the supplier has to communicate with all of these parties throughout the life cycle of the project: from the project initiation and designing phase to the post-project operations. In many cases, it is precisely the intermediate organizations, through which the communication between the end customer and the supplier takes place. The information communication is often biased by these long communication chains. According to the warranty manager:

> "...it takes a long time to communicate the information through such long chains [of command]… the problem gets escalated before it reaches [the target audience], it becomes a big problem".

Therefore, establishing a suitable and efficient communication chain in the project network is one of the mechanisms that can significantly reduce uncertainty by providing all the parties with up-to-date and relevant information. The interviewee also stressed the need to identify the source of the known problem (risk) and, if possible, to solve it without involving extra unnecessary parties. At the same time, the experience and ability to manage the situation on one's own should be evaluated appropriately. For example, the routine everyday tasks and problems in relatively easy non-complex projects might not require top management attention. However, a manager who has just been appointed to head a complex multi-million project in the middle of its execution might need involvement of his peers or even superiors. Communication becomes a tool for information gathering, verification of information importance in the context and for improvement of the abilities to judge the relevance on one's own. It is in the interests of the project manager to be proactive once the issue raises doubt:

> "...you can get hold of a problem in an early stage and solve it. Many times the [communication] chain is too long with many parties involved in it, the problem will grow bigger before we start to deal with it….   You can solve it by phone or by e-mail directly".

Although the manager mentioned these aspects, he noted that the marine installations are mostly low- risk. This is because he thought that the company possessed sufficient technical knowledge and experience to provide desirable solutions for its customers. In other words, he

addressed the fact that the firm needed to take the role of the expert for the customer. On the other hand, he stressed that the process of the solution delivery is an issue that has to be flexible, and allow for fine-tuning. Similar aspects were mentioned by most of the respondents.

The content analysis shows that uncertainty is closely linked to the mechanism of communication, and the variables of information and experience. The region-specific ways of working proved to have relevance for uncertainty management from the communication function point of view. Another mechanism that concerns the cultural perspective and is attributed to experience in the analysis is organizational adaptation. The analysis shows that this is a mechanism of uncertainty management. The respondents while discussing 10 different projects referred to it as means of taking advantage of opportunity (Table 12 lists the types of organizational adaptation in relation to uncertainty). In other words, they believed that uncertainty could be resolved and be of benefit to the project if the supplier's organization adapts to the environment. Here is an example — a quote by a warranty manager from a power plant delivery in the Middle East region:

> *"Of course, people have difficulties to adjust sometimes while being surrounded by different cultures, when they have to face different ways of how people behave. That is always normal. Some people don't fit in, so we have to replace them… that happened nearly in every project."*

Here, he speaks about personnel replacements as a means of managing project organization — related uncertainty. The quote illustrates that a project as any organization is an evolving endeavor, which is constructed and re-constructed continuously. The people constituting it change, and so are the beliefs and interpretations while the experience expands. Adaptation to the new environment takes place.

The specific results of the data analysis (Figure 25 and Table 17) pinpoint that region-specific ways of working are a driver of uncertainty, particularly state uncertainty, which is best addressed by promoting communication as a means of information collection and distribution within supplier organization and on the project level. Information appears in the analysis not as a separate factor, but rather as an element of the communication function. An interesting fact is

that analysis clearly indicates that the information communication function directly relates to *the internal project firm uncertainty* (Table 15*)*.

The design phase of the project was quite often mentioned as the most vulnerable in terms of uncertainty and its effect on the project's outcomes. The situation is common for several of the analyzed cases: the Design Phase Failure, the Lack of Reflection, and the Offshore case.

As for the actions that are strongly associated with communication, they were gathered under the label *commitment*. They are characterized by the extensive business commitment and involvement of the supplier with the business partners and the customer. The typical examples of such actions are: goodwill agreements (discounts, special services, cost-free maintenance or supervision), long-term partnership and cooperation agreements as well as the other means of showing a long-lasting bond with the customer or any other stakeholder. Commitment actions are believed to have a negative impact on uncertainty by resolving it into certain opportunities for securing future business and market position, gaining improved image, etc. The lack of external continuous communication provokes uncertainty with greater possibilities for negative impact (risk) in terms of losing continuous contact with customers and stakeholders, and thus the common understanding of goals. In a similar vein, the literature on trust and value co-creation particularly stresses the importance of continuous, dynamic business-to-business relationships with the customers based on easy communication and cooperation as a risk reduction method both on strategic and operational levels (Smyth, Gustafsson and Ganskau, 2010; Gustafsson, Smyth, Ganskau and Arhippainen, 2010).

Coding analysis shows that the project manager's experience factor seems to be of more significance for managing uncertainty than the information as such. This finding has a functional interpretation. The experience as a basis for reflection and making sense of information in the project and/or firm's context is more valuable for managing the state and especially effect uncertainty, because it aims at gaining an understanding of whether and how the information is related to the context. This extends the discussion in the traditional project risk management literature, where risk (and uncertainty) is strongly associated with information, and even sometimes paralleled to information creation (Eppinger, 2001; Browning

and Eppinger, 2002). To manage uncertainty, there is a need not only to have tools to acquire information, but also to have mechanisms to interpret and make information useful and applicable in a particular contextual setting. This finding of the thesis extends the understanding of uncertainty beyond that of *lack of information* (Duncan, 1972; Tversky and Kahneman, 1974; Pich, Loch and de Meyer, 2002; Chapman, 2006).

5.3   Uncertainty as a characteristic of projects

The result of the analysis of the empirical data shows that there are several variables — or sources of uncertainty as they are referred to in the literature (Atkinson et al., 2006; Meijer, Hekkert and Koppenjan, 2007) — from which project uncertainty can stem. In other words, these are the issues that the project managers can be uncertain about. Each of the sources triggers different managerial actions. Such a categorization of uncertainty by the source does not contradict with the Milliken's (1987) framework and correlates with the conceptual framework in Figure 3. The empirical analysis shows that there are two main sources of uncertainty experienced by project managers, which subsume different elements:

1. Internal (supplier firm) organization — related uncertainty.
2. Project organization — related uncertainty.

These sources were observed to trigger different uncertainty management processes on different organizational levels. The internal organization-related uncertainty represents a project-based organization level or a multiple-project level, and the other category is addressing the single project level. The elements of the project outset referring to project certainty in the descriptions of the cases, quite naturally fall under this categoriza*tion:*

- **Project organization — related variables affecting uncertainty:**

    i. Scope of supply or technical complexity

    ii. Customer

    iii. Contractual terms

    iv. Network of project stakeholders

    v. Project site/location

However, the internal organization-related uncertainty sources appear to differ slightly according to the results:

- **Internal supplier organization — related variables affecting uncertainty:**

    i. Lack of experience in managing/executing the activities

    ii. Lack of organizational goal integration

    iii. Lack of reflective processes

    iv. Lack of routine processes (e.g. planning, business development)

These variables positively affect uncertainty — they increase it. They are also believed to have a negative effect on the performance of the studied projects. In this respect, performance is seen as an evaluation parameter of the uncertainty management efficiency. Figure 17 shows the structure of variables having an effect on the perception of uncertainty.

Figure 17. The structure of variables that influence uncertainty

Lack of processes aimed at situation assessment in multiple perspectives

Lack of tacit and explicit knowledge and/or their practical application

Formalized company policies and processes (risk, quality, safety etc) to be created or/and developed

Single project goals vs. overall goals of the organization: commonalities and contradictions

The customer's attributes as perceived by the supplier's managers

The formal description and commitment to responsibilities in the project

The structure of stakeholders in the project and its attributes

Geographical, product market, etc.

How complicated is the task overally, considering all the elements and processes at all stages of the project

How complicated is it to execute each single physical product/service

How strong are the interdependances between elements of the final project outcome

The tools and means for executing the project excluding processes

| Lack of reflection |
| Lack of skills and experience |
| Lack of routine processes |
| Lack of goal alignment |

Internal (supplier) organization

| Customer |
| Contract |
| Network |
| Location |

Project organization

| Technical/task/solution complexity |
| Product complexity |
| Tech. Intergration |
| Resources |

Scope of Supply/complexity

UNCERTAINTY

For the factors negatively affecting uncertainty, in other words, transforming it into certainty the following drivers appear to be relevant in terms of internal supplier organization:

• **Internal supplier organization — related certainty drivers:**

    i.   Experience

    ii. Communication

    iii. Reflection

 iv. Development of routine processes (risk, opportunity, quality management, etc) on the basis of continuous reflection

The variables discussed above can be further subdivided along two other dimensions: process and structure. While project-related uncertainty drivers refer to structure mostly, the certainty drivers and internal supplier organization uncertainty drivers seem to be more process-focused. Subsequently, one of the most significant causes of uncertainty appears to be the scope of supply-related technical complexity. The operations management and project management literature refer to it as *systematic uncertainty* (Bonaccorsi, Pammolli and Tani, 1996). A structured approach to creation information of previously unknown information (Eppinger, 2001; Browning and Eppinger, 2002) or even a structured product itself (Sosa, Eppinger and Rowles, 2004), are suggested to be key functions in order to be able to address this problem. This is the reason why current project risk management is in part seen as the creation of previously unknown information (Browning and Eppinger, 2002). This approach has its merits. The importance of the information creation aspect is partly confirmed by the findings of this thesis as only one element of uncertainty handling. However, this view has strengths in terms of risk management function as an important part of planning.

The drivers have relevance not only for uncertainty, but also for risk and opportunity. This builds upon the understanding of project uncertainty as a concept encompassing both project risk and opportunity supported by the findings. From this perspective, risk is viewed as a result of acting (or not acting)[17] under uncertainty as if the latter would have a potential negative impact on the project's results. In some of the studied cases, defensive, passive way of approaching uncertain situation was observed. The reactive or passive ways of coping with uncertainty has been summarized in the project management literature as delay, denial, avoidance and ignorance (Kutsch and Hall's (2005) classification), which are the conscious decisions-actions of the project managers, who are not willing or capable (for different reasons)

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[17] I interpret the decision not to act as a reactive way of coping with the issue.

to resolve uncertainty. I agree with Kutsch and Hall (2005) that the reactive way of coping with uncertainty and risk is in many cases explained by the fact that the interests of at least some of the project parties (including the manager personally) can be negatively affected should the manager be proactive. The issues that the authors listed such as the unspoken internal political issues, fear of damaging professional reputation or the relationship with the customer and the other stakeholders, excessive managerial self-confidence resulting in unwillingness to spend resources on the verification of facts among other things, are the themes that were mentioned in the interviews used in this work. They can be used to explain why some of the projects resulted in a materialized risk. However, my attention was drawn not only to the explanations why they do not act, but rather how they need to act upon uncertainty, or what elements they need to address, in order to cope with it. I focus on the proactive approach towards uncertainty stressing the ability of any project manager to gain opportunities out of it.

5.3.1   Characteristics and types of uncertainty

When the interviewees were asked to give explanations as to why they consider the event to be a risk, their reasoning was based on facts. Commonly the following description was given in respect to the risk: *"I assume it to be a risk, because…"* followed by a detailed line of argumentation based on evidence. The managers referred to risk as a fact, a concrete situation, the outcomes of which would affect the project in negative way. Even referring to a hypothetical risk situation, they could give examples and imagine possible consequences in terms of loss rather than in terms of possible benefits for the project. Almost all of the respondents noted that risks can be foreseen in advance due to the fact that projects are more or less repetitive and are unique only to a certain extent. Thus, most of the risks can be planned for and managed on the basis of relevant information (e.g. in the form of company's policies, manuals and other supportive data) and professional experience. The ability to recognize the risks in advance, plan the response measures and implement them is seen as a part of a professional project manager's skills. As one of the respondents commented, *"Risk is not a problem if you can handle it"*. In fact,

dealing with risks was seen as the essence of the project manager's job. So was dealing with uncertainty. While speaking of uncertainty the managers referred to an *"unforeseen situation absolutely not known in advance"*. In contrast to risks, uncertainty is not a fact, and thus cannot be planned for or resolved by an informed guess in an instant. Speaking of coping with uncertainty, the respondents indicated that to be successfully managed, it required pro-active approach, going further than what the risk management plan states. As mentioned before, the sudden events somewhat mixed the original project plans, so that the routine setup had to be reconsidered. The data states that professional experience and the ability to interpret facts in the context plays a greater role in dealing with uncertainty than in that of managing risks. Since the analyzed case descriptions were retrospective, the respondents were aware of the results of the actions in response to the occurred unforeseen situation. Thus, the attitudes and other individual manifestations of the respondents give uncertainty *a flavor*, negative or positive, depending on the result, which was already known.

In sum, the project managers do perceive uncertainty and risks differently. There are two main attributes that are associated both with risk and uncertainty: the information and the experience of the project manager. However, for management of risks the availability of information seems to be more important than for managing uncertainty. In a similar vein, the experience level of a project manager has more importance in the case of uncertain situations than for handling risks. The result can be explained by the fact that in the context of the complex industrial projects the availability of information, even relevant, is not sufficient for successful management in an uncertain context. Moreover, unforeseen event evolve at a fast pace, which sometimes require fast, if not immediate, decisions and actions. Experience is also information in the form of knowledge and skills. It assumes the individual's ability to interpret information coming in the form of different signals, extract the relevant facts and implement the response actions.

In project management literature, the issue of uncertainty is closely linked to project complexity (Kerzner, 2001). I argue that uncertainty and complexity are interrelated issues. The categorization in Figure 17 shows that uncertainty is associated with the technical complexity (or scope of supply sources of uncertainty as in e. g. Table 15). However, I also found that the projects that are similar at the complexity level can have different uncertainty levels. Thus,

looking at complexity and uncertainty as different dimensions of projects helps to better visualize the challenges of the project compared to the situation when uncertainty is included into complexity as one of dimensions of the construct. Many respondents have identified several *grey areas* or uncertainties that could potentially give rise to warranty costs (and thus, overall project costs):

1. Technical uncertainties.
2. Contract uncertainties.
3. Management/organizational uncertainties.
4. Customer (owner) and operator — related uncertainties.

These issues represent risk only to a certain extent. They are rather the sources of uncertainty that can be turned into opportunities for better performance in terms of both customer satisfaction and decreasing the amount of warranty claims. If these uncertain issues are not managed, they become realized in the form of risks and ultimately warranty costs. Table 12 provides the answer to the research question *Qc: What kind of methods do project companies use in order to lessen the negative impact of uncertainty and take advantage of it?* by summarizing the findings of the analysis. It lists the four main categories of uncertainty that I observed as well as the causes of their appearance and action to target uncertainty. If the causes are not known to the supplier (and the project manager) the risk as a negative event is most likely to occur and the opportunities will be missed as well. If the causes are known, then actions can be taken to prevent the risks from happening and ensuring that opportunities take place. The opportunities need to be actively pursued, thus uncertainty has to be proactively managed in order for it to have a positive impact on the outcomes of the project, and subsequently, the firm. A reactive approach to uncertainty appeared to be resulting only in negative consequences for the project outcomes. In the next sub-chapter I will present how these methods fit into the model of uncertainty management.

Table 12. Types of uncertainty and respective actions to target it

CATEGORY OF UNCERTAINTY	DESCRIPTION OF CAUSES FOR UNCERTAINTY	METHODS OF MANAGING UNCERTAINTY
Technical uncertainty	a. Certain in-built faults related to new technology (cannot be foreseen in advance, but can be significantly minimized); b. Faults in well-tested technical solutions as a result of operating conditions or operator skills (can be foreseen and significantly diminished or even eliminated).	a. Uncertainty cannot be eliminated completely in the short term. In the long term they can be significantly diminished or turned into an opportunity through *investigations* (root cause analysis, follow up, internal communication between customer service and technical/R&D departments); b. *Training of* operators, communication with the customer to monitor the situation.
Contract uncertainty	a. Warranty articles are not always aligned and/or are contradictory to the general terms and conditions of the contract. This usually results in significant costs during the warranty period; b. Additional services (e.g. training) are left out of the scope of the contract to cut down the price of the offering; c. The focus is on selling more hardware products rather than solutions, of which services (maintenance, training) constitute a large part; d. The agreements with sub-suppliers are not aligned with the other policies, terms and conditions that the company employs in its business practice.	Organizational *adaptation* through: 1) Revision of policies, contractual terms on a regular basis; 2) Establishing processes to obtain and communicate information throughout the organization and between project partners.
Organization/ management uncertainty	a. No proper handing-over procedure between the project and warranty manager at the commissioning stage of the project execution; b. Important information in the form of the contract, amendments to the contract, meeting memos and other standard documentation, is not necessarily accessible for warranty managers for two reasons. First, they are not always authorized to access this data. Second, the data is often missing from internal databases; c. The warranty risks are documented in the form of technical descriptions of claims and cost per item in the company's internal database, suggesting that all costs are technology-related; d. Root-cause analysis of the claims is seldom performed. Thus, it is often difficult to understand the sources of risks and opportunities. In the long run it increases both uncertainty and the probability of unforeseen events taking place;	Organizational *adaptation* through: 1) Considering region-specific ways of working in the country of delivery by establishing communication patterns with project stakeholders; 2) Establishing processes to obtain and communicate information throughout supplier's organization and with the other project stakeholders.

	e. Poor documentation and statistics of claims for different categories of projects (e.g. marine, offshore etc)	
Customer (owner) and operator/user – related uncertainty	a. Lack of knowledge about the competences of the customer (owner) and/or the operators; b. Lack of communication with the customer and their representatives or contact persons; c. Lack of communication with project stakeholders other than customer.	*Communication:* 3) Commitment to common project goals; 4) Organizational adaptation through establishing processes to obtain and communicate information throughout supplier's organization and with the other project stakeholders.

5.3.2 Differences in managing risk and uncertainty

Risk taking propensities vary both across individuals and contexts. They depend on personal qualities such as skills, incentives, interpretation and the ability to select and process information. The same statements also apply to uncertainty. Uncertainty, risks and opportunities are different but at the same time interrelated terms. The definition of Milliken (1987) describing uncertainty as a lack of individual's perceived ability to predict something accurately because of the lack of information or inability to discriminate between relevant and irrelevant data is relevant in this context is valuable for interpreting the results. Taking it as a standpoint, the definition of uncertainty can be the following: *Uncertainty in relation to projects is the individual's (e.g. the manager's) lack of knowledge and/or understanding of the relevant project elements, its environment and their interrelationship, so that no conclusion can be made as to if and/or how any of those can impact the project success.* It follows the logic of *uncertainty being a context for risks and opportunities in projects* (Perminova et al. 2008 (a)). There is a temptation to say that risks and opportunities are *objective* uncertainty in Unger and Eppinger's (2006) terms. However, I think that such a definition gives too much space for interpretations, and it can easily lead into the trap of misunderstanding the concepts. It is important to understand that for uncertainty to become certainty action is needed. Using the terminology of Unger and Eppinger (ibid.), it needs to be *objectified.* Uncertainty has to be enacted in order for it to be resolved in objective certainty: risks and opportunities.

Clearly, the perception of uncertainty impacts the way it is managed in projects. The link between risk, opportunity and uncertainty implies that the management routines have certain commonalities. For example, while doing project planning, the manager assesses risks and opportunities, uses different methods and techniques to gain information about the future tasks and its elements. Planning assumes that corrective actions are assigned and a reserve budget is in place should the risk occur. Without doubt, the actions can be considered as part of managing uncertainty. Except that dealing with known risks and opportunities assumes a rather mechanistic approach, especially in the meaning normative project management apply to it. The managers often cope with risks by implementing the corrective actions according to the plan to minimize costs and using reserve budgets only when absolutely necessary. The main task of the warranty manager in terms of risk management is to minimize the negative impact on the financial performance of the project by preventing losses (claims). This is the job, which is similar to that of the project manager. In this perspective, there are no differences between a project manager and a warranty manager: the issues, tasks, processes and constraints that they deal with are similar. Consequently, how can both project managers and warranty managers manage uncertainty?

In contrast to risk, uncertainty cannot be planned for; it has to be managed on-the-spot. In the situation of uncertainty, the manager's actions are not so straightforward since the outcomes of the situation might be both negative and positive. Moreover, the plans are not valid any more. Thus, there is a need to act on-the-spot, maybe even in contradiction to what was previously planned. The data shows that risks and opportunities can be foreseen in advance due to the fact that projects are more or less repetitive (and so are the warranty issues) and are unique only to a certain extent. The same applies to opportunities. The analysis shows that risk, opportunity and uncertainty management are dependent on the two factors:

- The relevant information (in the form of the company's policies, manuals, memos, statistics on claims and the other supportive data), and
- The professional experience.

However, experience showed to be of more significance for managing uncertainty in terms of

obtaining benefits (opportunity) from them rather than for the managing of risks. Experience more effectively reduces uncertainty because it assumes that one not only possesses information and/or has skills to acquire and use it, but also has the knowledge to interpret it and apply it to the context in order to receive better results. While information and skills can be studied, experience has to be achieved by practicing, by doing. The ability to recognize the risks, plan the response measures and implement them is seen as a part of both the warranty manager's and project manager's skills. Risk management in practice is strongly linked with the ability to obtain, collect and process the relevant information in the form of planning and to respond to the occurrences based on the planned *preventive* actions. In sum, there is a need to recognize that risk management is a process that has two distinct features:

- its core function is prevention and planning,
- it is aimed at risks as issues that have negative impact on the project's outcomes.

Considering these points, risk management can be seen as a process with an emphasis on effective planning using information collection and analysis techniques. However, only when they are performed continuously and systematically, do they work to fulfill their purpose. This study shows that the risk management actions support uncertainty management by providing tools and means for *investigation* process, but only in a limited way.

The interviews with the managers and the analysis of project documentation indicated that the way of working at the warranty phase is to a large extent reactive. For example, at the warranty stage the actions that are taken only occur after the claim (which is a realized risk) is received from the customer. Thus, very often they had to turn to *troubleshooting*, which understood as a series of actions, which are aimed at an immediate response to the already failed processes or products. As many of the interviewees expressed it, they see their role primarily in managing claims that come from the customer: to accept them and take appropriate action (e.g. send a spare part to the customer, provide assistance engineer to the site, etc.), or to reject them based on the terms of the contract. This situation suggests that warranty managers themselves have very little impact on minimizing or eliminating the cause of the claim. Moreover, there are very few tools or organizational processes for problem detection available to them. They need to

investigate the project that enters into warranty stage to get better knowledge of it. It is often done by communicating with the project team, the customer, and the other stakeholders, in formal (e.g. warranty kick-off meetings) and informal way (discussions in the corridors). Usually, they have to rely on their professional experience. Most of my interviewees had a background of being project managers prior to taking their current positions. In this respect, they could relate to how the occurrences at the project execution stage affected the warranty stage.

When plans were disturbed in the case projects, the managers had to cope with uncertainty by reconsidering the new context in which to establish the relevant facts (*investigation by sensemaking*), explain how they related to the project (which often involves *communication*), and how to achieve the best result possible by implementing actions (action, *adaptation* to the situation) and face the time constraint. These actions have experience-based reflection at the core. Thus, the logic was different from risk management, which practically focuses on preventing and planning. As was already noted, risks are treated as negative events by the managers, whereas uncertainty is not necessarily negative. The unexpected events change the certainty in the projects by bringing uncertainty into it. Uncertainty can be transformed by action[18] either into a risk or an opportunity (see Figure 18). The action is based on the relevant information and experience, which are enacted after the reflective processes.

In sum, I propose the following definition of uncertainty management:

Uncertainty management is as a reflective process of considering all of the elements of a current evolving event, situation or interaction from different angles to find acceptable actions to resolve the situation for the benefit of the project.

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[18] In this perspective, deliberately not taking any action is also considered an action.
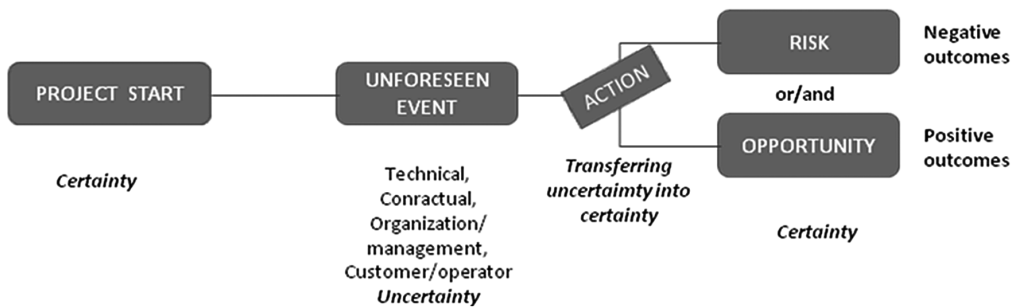
Figure 18. The uncertainty management process

The observations indicate that in order to resolve uncertainty the managers have to employ the reflective approach, which represents the process of considering the actions from different perspectives (Perminova et al. 2008 (b)). Its purpose is in making the knowledge decidedly explicit in the situation of uncertainty. Experience of managers affects the way managers "make sense" of the situation and decide on alternative actions under the pressure of the situation. The unforeseen and unexpected situations that cause uncertainty often require a learning-by-doing scenario (or *reflection-in-action* in Schön's (1983) terms). At the same time, the reflection on the results of actions and the experience (*action-in-reflection* (ibid.)) creates practical knowledge that takes the form of the procedures and best practices after the project. The analysis shows that uncertainty management is strongly linked with flexibility in making the decisions that come from the reflection process and the experience. As suggested by Karl Weick (1995), the reflection-based process of sensemaking, with the help of which *"people make retrospective sense of the situations in which they find themselves and their creations"*, can be considered an important tool in transforming uncertainty into risks and opportunities.

5.4   Model of uncertainty management

The model of uncertainty management at the single project manager's level consists of the following stages (see Figure 19): uncertainty, reflection, communication, action and "certainty". While it is difficult to state that at any given moment in the project there is certainty, it still could be defined as absence of uncertainty in the mind of the perceiver (in this case, project management professional). Because risks and opportunities are known facts at a given moment, they are certainty until it will be proven otherwise, if we apply Wittgenstein's (1986) logic. This picture represents a detail of the conceptual framework discussed on the Chapter II (Figure 3). Here uncertainty and certainty (risks and opportunities) are the constructs used in this study, whereas reflection/making sense, communication, action and learning are the mechanisms linking the constructs. As the analysis shows, learning is not only the outcome but also the reflective mechanism which is crucial for uncertainty management in line with the reviewed literature (e.g. Atkinson et al., 2006).
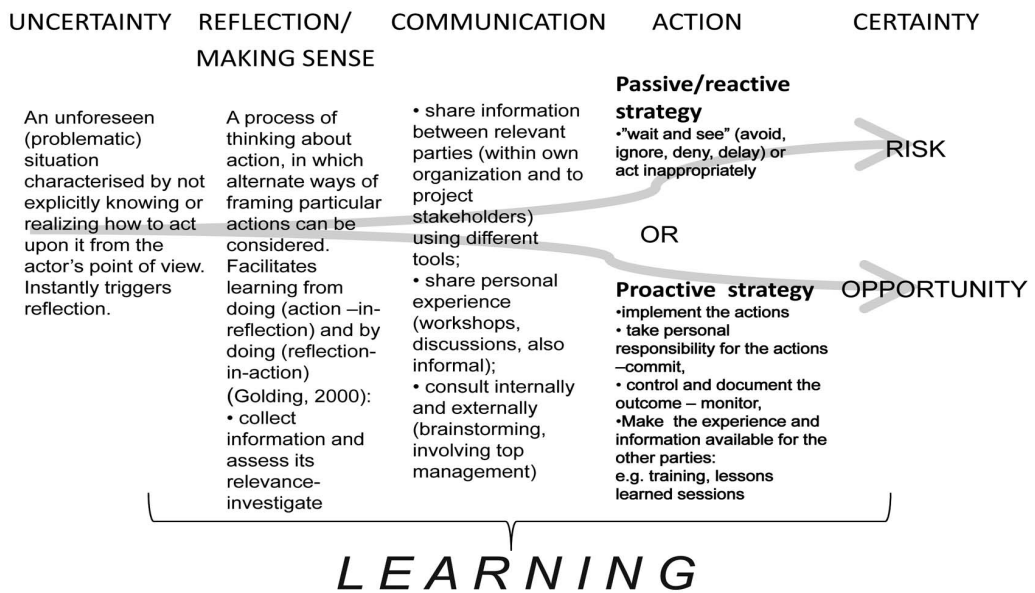
Figure 19. Model of uncertainty management on the project manager's level

The stages from uncertainty state to certainty can be labeled processes, because action is embedded in them. For uncertainty, it is the thinking, considering, making sense of the situation and communicating it — those are the processes that are inseparable from the whole understanding of what it means. This presupposition does not come into conflict with the point of view suggesting that uncertainty or certainty is a state of mind. Uncertainty is an unstable state. Following the logic of Lane and Maxfield (2005), in the state of uncertainty people feel the need to regain stability, return to certainty. "*Being uncertain*" means that the mind instantly starts searching for a release to escape back to the familiar state of certainty. In other words, we humans reflect on the situation, make sense of it, trying to find a solution to the problem. The strategy that is going to be chosen — passive (or reactive as it was previously referred to) or proactive — depends on the result of the reflective processes and the experience of the manager. The Communication stage is important here: even if the manager possesses enough knowledge, information and experience to come up with the solution on his or her own, there is still the need to share the results of the reflection, which is the cornerstone of the learning process. The model above (Figure 19) is an attempt to show how professionals think and behave in action. The methods for managing uncertainty (Table 12) are included into this model. However, this is an individual perspective. In fact, the uncertainty management process as well as the understanding of uncertainty as such, is a social phenomenon as the analysis of the cases shows.

Figure 20 summarizes the mechanisms crucial for coping with uncertainty — or uncertainty management on the project-based organization level. They are not sequential; rather they are continuously on-going. Uncertainty itself becomes realized in a social context, and is often regarded as such not only by one single manager, but also by the other members of the project. However, handling of uncertainty at its foundation is an individual process since it is done by individuals. Uncertainty management is a concept subsuming the project-based organization level, which summarizes the attitudes, processes, behaviors and practices of its members. In a similar vein, reflection is both individual and collective because of its purpose: to establish the individual person's view and then communicate it to the collective, so that the shared values are developed and acted upon (see also Raelin, 2001). Following this logic, uncertainty as a phenomenon in projects — is a social activity — and has to be communicated from the

individual's level (in this case this is the project manager) to the social context in order to be understood and transformed.

Figure 20. Mechanisms of uncertainty management at the organizational level

Following the logic of Wittgenstein (1986), achieving the uncertainty state assumes that the well-known facts that constituted the basis of the situation to be considered certain and known are not valid any more. Being uncertain requires that one takes certain issues for granted. Arguing that since one cannot be absolutely certain at a given point of time (here one can draw a parallel to the Heisenberg's uncertainty principle), therefore it is possible have a constant state of uncertainty become meaningless as it can be countered with the question: how can we be certain that we are not completely certain? However, this does not mean that uncertainty does not exist. Uncertainty can rather be seen — or objectified — as a state of affairs that arises (Perminova et al., 2008 (a)).

The results of the thesis show that the unforeseen, unexpected events "visualize" uncertainty and make it possible to be perceived by the managers. The process of reflection is imbedded in the perception of uncertainty. The projects, their environment and other relevant elements are reconsidered: new facts come into the picture. Old beliefs and knowledge are revised (made sense of in a new context), shared (communicated within the project(s), the supplier organization and/or further to relevant stakeholders) and applied to the new emerging contexts (enacted). In sum, the certainty is reconstructed and the new knowledge is created. If the communication process guarantees that the acquired knowledge will be distributed along the organization and formalized in the processes, policies and practices. Adaptation and creating the new context for business are the processes that follow (I will turn to them later in the text). If all the mechanisms outlined in Figure 19 work continuously, uncertainty is managed in the organization.

At the organizational level, uncertainty triggers the need to address the validity of the established routines — processes and procedures, forms, rules and strategies — for the changing situation. According to Levitt and March (1988), organizational routines are grounded in interpretations of the past, they reflect history, rather than anticipation of the future. Thus, the adaptation process takes part in steps depending on the experienced outcomes of the situations. For project-based firms, the business of which constitutes of a set of simultaneously on-going projects in different stages of completion, the experience from these multiple projects — with the uncertainty that arises within them — is the context that will affect the adaptation of routines. Using the same logic as Levitt and March (1988), the changes in the routines of a project-based organization will depend not only on the situations and outcomes of those situations that they experience, but on the aspirations that they have for the situations and their outcomes.

Adaptation to the new context by dealing with uncertainty within projects and project-based companies takes place through the 3 processes: reflection, communication, action and learning (see Figure 20). These processes are simultaneously on-going in the organization, and thus the flow presented in the Figure 20 is in a way superficial. For example, it is quite difficult to separate reflection and communication processes since reflection at the organizational level

involves communication and vice versa. By reflection in project-based company I understand the processes of gathering feedback from individual projects, assessing the outcomes from the perspective of the firm's aims and goals and comparing them to the anticipated outcomes. The process involves communication as a crucial step to creating a shared understanding. Karl Weick (1995) states that the reflective processes at the company are supported by individuals. The stimuli for reflection go from the lower — e.g. project or warranty manager, team or department — level to the higher level of company decision-makers. In the SOLAS case, the project failure evoked the strategic discussion in the form of workshops regarding the mechanisms to reinsure fulfillment of recommendations by the shipyards and the other stakeholders. During the workshops at Company B, the feedback on customer cooperation issues from projects, especially the Design Phase Failure case, raised top administrators' interest to create a process of collaboration with the customers as a way to ensure active customer involvement in the project. The Japanese Approach and the Blackout cases show how collaboration with the customers (which inevitably involves higher administration) can contribute to value creation not only at the project level, but also becomes a source of innovativeness and means of achieving a competitive edge as a strategic level issues.

As Weick argues (1977), understanding and sense-making affect strategic decisions and, consequently, the performance of the firm. Reflection constructs the grounds for reformulating and reconstructing the routines in order to adapt to change, become more innovative, competitive, etc. At the firm's level, it is a way to establish best practice. In terms of uncertainty management, the main task at this stage is to find out what is certain and what is not. In other words, it is about both questioning and confirming whether the current management principles, strategies, processes, routines as well as the perception of the environment and all its elements is valid. It is also about discovering what the governing principles in the current situation are: why the management mechanisms work or why they fail. It is essential to provide the evidence of successful management practices. Communication is a crucial step in bringing uncertainty to the collective level, at which it can be critically assessed and acted upon. If the communication phase does not take place, the recognition of uncertainty on a personal level stays a mere illusion that will either release itself in the form of risk to the project's outcomes or disappear as

a consequence of luck. By verbalizing it uncertainty claims its right to existence. In this sense, it becomes a fact: a concern (risky side) that has a potential to become a positive breakthrough (opportunity side). As the data analysis show, uncertainty always has two sides. It is never either a straightforward sheer risk or opportunity. Its existence is never straightforward either. Even if this issue is brought to the collective table, it can still be considered a worthless concern of a single person even if this person is a project manager. At the same time, uncertain situations can be overlooked by the project organization.

The continuity in the reflection process ensures that not only gaps or problems in the current firm's situation are discovered, but also its strengths. The result of the reflection process is again communicated from the decision-makers level to the departmental level. This is already a part of the learning process: the organization is studying itself. Then, the project firm has to act upon the received result, which could be done in two ways:

1. Building of a knowledge and competence base through continuous reflection.
2. Creating new contexts by changing the organization — or adaptation.

The extant literature on organizing reflection (see Reynolds and Vince, 2008 for a review) suggests the following dimensions subsumed by the creation of the new contexts:

- Hierarchy;
- Motivation and identity of members;
- Creating access to activities, resources and info and achieving transparency;
- Narrowing down meanings for further changes in the company routines.

By engaging and constantly fostering of the above-mentioned activities, a project-based firm can manage uncertainty — or absorb uncertainty in Keegan and Turner's (2002) terms. However, the success of these processes depends on the actions that are taken at the level of the individual project.
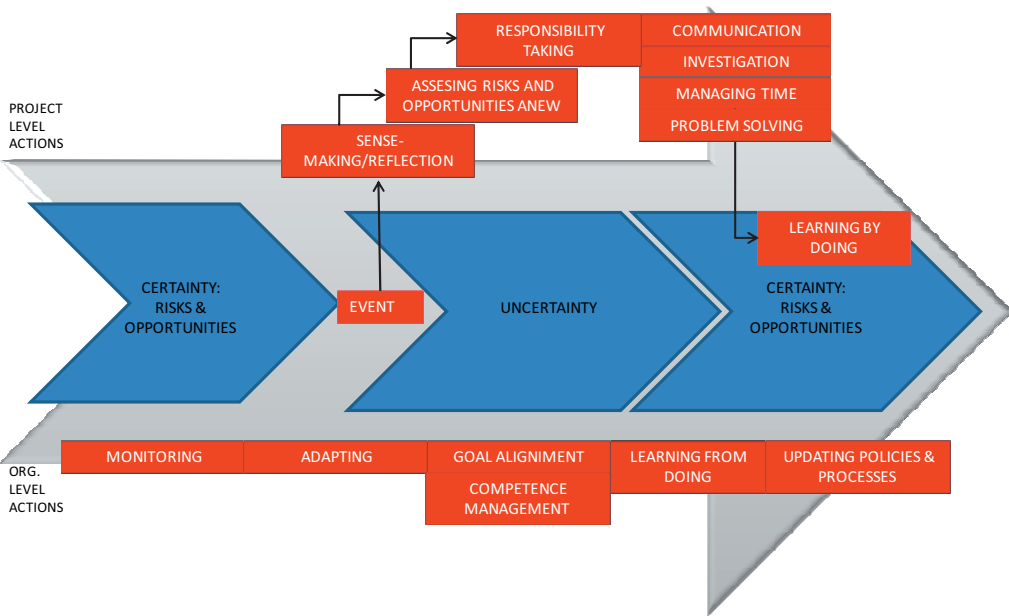
The integrated uncertainty management model is presented in Figure 21. The blue-colored arrows present the state of affairs in terms of certainty: the situation when the project outset in terms of risks and opportunities is known and understood. Uncertainty is evoked by an event

that takes place first at the project(s) level. It triggers a reflection process, the outcome of which is the new re-assessed context in terms of risks and opportunities. The adaptation processes are started by the project manager taking responsibility for the actions necessary and followed by these appropriate actions, which are also communicated to the project team. As a result, uncertainty is turned into certainty — and a new context for the project.

The organizational level follows the project level logic. By creating a monitoring system, a firm establishes a process for better assessing the current situation of affairs. It is a tool for reflection and a key for the successful adaptation of the processes, be it a current state of analysis, a risk and opportunity assessment tool or a customer feedback monitoring program. Monitoring allows an understanding of the underlying trends of today in a given industry, and thus forecasting the future, which is per se an uncertainty reduction management tool. Adaptation processes result in a modification of the company's routines — processes, strategy, norms, etc. They lead to better managing competence at an organizational level both in terms of portfolio management and improving the skills of individual managers. It is a way to understand and strengthen core competences of an organization, which ultimately leads to improving competitiveness in the market.

By implementing project portfolio analysis in terms of complexity and uncertainty *continuously at* different stages of projects (e.g. similar to that utilized in this thesis in section 5.1.), the companies get the understanding how the uncertainty level evolves and what kind of actions are needed to affect it. This is the way for the information to be collected and accumulated in the company, which can be utilized for the administrators to develop the strategy, policies, and processes, in other words, establish best practice. Then such an assessment becomes a tool not just for the information gathering, but rather for continuous monitoring, which supports reflection and learning activities. For example, Windischoffer, Perminova and Gustafsson (2009) suggest employing the framework (see Figure 16) for competence management. Their findings are somewhat similar to that witnessed in the analyzed cases: the industrial projects with high uncertainty require communication (skills). The analysis indicates that communication with the customer, with the stakeholders and between departments at different levels of the supplier organization is associated with resolving uncertainty (see Table 12 and Table 14).

Figure 21. The integrated model of uncertainty management

The integrated model of uncertainty management combines the individual and the collective, organizational processes into one frame. While in the case of uncertainty management on the project manager's level (upper part of the Figure 21) the processes are sequential, the lower part does not have a strict timeline. The collective actions in the project-based organization level are continuously on-going, they are the reflection of the results, challenges and changes that the organization members face and cope with at the level of projects. The experiences from single projects become crystallized in the form of organizational processes, policies, vision and strategies. The process is a part of the socially constructed world where meanings and significances are shared. Uncertainty management is a process, but also more than just that. It is a proactive, entrepreneurial approach to dealing with the unknown and unexpected, which forms a part of the company's culture. It assumes a certain mindset, behavior and attitude towards uncertainty:

- *Enacting responsibility* to the project — is acting in a professional manner with due diligence in order to fulfill project obligations with the main goal being satisfaction of the customer and the other stakeholders.

- *Enacting commitment* — is acting in a professional manner, so that the common interest in achieving project goals is understood and shared by the other project stakeholders. It assumes the emphasis on *communication* both internally in the supplier organization and externally with the project stakeholders and the relevant parties.

- *Reflection* as an organizational mindset, which is an individual process at its core.

5.5   Validity of the research and limitations

The credibility of my interpretations and conclusions are ensured by fulfilling the validity criteria, which were already outlined in the methodology chapter.

The *practical value* requirement presupposes that a researcher prioritizes topics originating from the current practical needs. This criterion is ensured through, first and foremost, the aim and purpose of this research to address both the scientific and managerial needs to:

- understand the relevance of the uncertainty concept for project management and explain its relevance to the concepts of risk and opportunity,

- outline its elements and the factors that influence it,

- develop the management methods for addressing uncertainty in projects.

It is fair to say that the research questions were shaped to a large extent as a result of collaboration with the members of Companies A and B. My active participation in the projects delivered by the PBI Research Institute maintained the practical focus throughout the research process. As was mentioned before, the whole process and the results of this research had been shaped by the fact that it has been a part of a real-life process development project (Perminova, Gustafsson and Arhippainen T. 2007 (a); 2007 (b); 2008). If to interpret practical needs as the needs arising in the project research community, this thesis fulfills the validity criteria by describing the concept of uncertainty in projects and the variables related to it, addressing the

need to provide empirical evidence of uncertainty management, and to explain how uncertainty management can enhance project management practices.

The *social interaction* criterion implies that the results are regularly checked with practitioners. Through continuous dialogue and collaboration in the form of workshops and meetings with the representatives of the two companies I ensured that throughout the time span of this research this aspect of validity was covered. All the results and reports at different stages of the process development have been presented and discussed together with the companies' representatives. Thus, the participating practitioners have continuously verified, or helped to shape or even co-design (referring to Pettigrew, Thomas and Whittington, 2002) the outcomes of the work that you are reading at the moment. The fact that the outcomes of this research are acknowledged by practitioners as addressing their current needs and some of the outcomes are even being implemented in practice, speaks in favor of the credibility of this research as collaborative management research.

The social interaction also has one more dimension in the form of internal discussions with the members of the project management scientific community. As a doctoral student, I presented these research results at conferences, seminars and meetings at different levels, where I received comments and perspectives from the experts in the project management field. Needless to say, I had a continuous dialogue with my colleagues at the PBI Research Institute and the members of fellow research groups from different universities. A project involving Company B, which is a part of this research, has even earned me an award as a researcher.   I included this paragraph not for the sake of mentioning my own merits and not only as means of acknowledging my fellow colleagues in the research field, but rather to stress the point proclaimed by Bradbury (2008): the more dialogue is engendered, the better are the chances of the success of the research and, thus, credibility. It also strengthens the fact that the third and fourth criteria of action research are met: active experimentation, which assumes that the result of the research is brought back to an insider audience to obtain their response and opinion on the result, and cycles of action-reflection. Presentation of the research results to peers, also in the form of articles, conference papers, seminar presentations served as a catalyst for reflection in just the same way as workshops and discussions with practitioners. Cycles of reflection and action are

about how the methods were applied in the research. The open-mind, in terms of allowing new interpretations, continuous longitudinal reflection through the methods discussed in this thesis and reflection upon the implementation of the result, are all oriented towards supporting the validity of the research.

Having said this, I need to also admit that this research could benefit from further uncertainty management process testing as a complete model, and thus strengthen the validity in terms of *active experimentation*. This work is based on the collaborative research projects that are continuing to test and further develop its results, at least at the present time as this thesis is being completed (Spring 2010). Being descriptive in nature, the thesis combines the theoretical views on the concept of uncertainty and its elements and proposes the elements of uncertainty management as a business concept. However, further investigation will require several more years of work, and therefore cannot be accomplished in this doctoral thesis project. I leave this task to future research.

Although it is claimed in classic social research that it attempts to generalize to a larger population from a representative sample (e.g. David and Hatchuel, 2008), I conclude that the results of this study are context-specific. I propose that the conclusions of the work can be transferred to project business including project-based companies, firms, industries, etc. (in the meaning of these concepts that I described in the Theoretical Framework chapter), and especially to those engaged in the creation of large complex systems described by Hobday (1998). However, this does not imply that the convinced audiences in other fields of social science are not welcome to apply and test the achieved results in their environments.

The fact that the projects have been analyzed at the early post delivery warranty stage is both a merit and a limitation of this study. The merit is in the fact that the warranty phase of the project is interpreted as an important stage of a project life-cycle, which has relevance for the overall project performance. This is in line with the results of the research of Shenhar and his colleagues (1997). On the other hand, it is just one, although convenient, observation and analysis point on the project time-line. The study could benefit from having several assessment points within the uncertainty-complexity framework, preferably at different stages of the

project. Although this was not possible in the context of this thesis, similar analysis is advocated for the future research in order to enrich the understanding of the concept of uncertainty and its management methods.

As to the other limitations, especially in terms of the theoretical background, I need to point out that the following issues were left out of the scope of the research:

- the behavioral theory,
- the decision making theory is only partly presented,
- the quantitative measures of performance have not been addressed in this work, rather performance is regarded as a function of project professionals' individual and collective opinions.

VI   CONCLUSIONS

The main findings of this thesis are outlined in this chapter. This thesis aims to answer three research questions. The presentation of the findings will follow this logic. Firstly, I will outline how uncertainty is perceived and handled by members of project-based organization. Secondly, the interrelation between project uncertainty and risk will be presented in terms of underlying management processes. Thirdly, I will present methods that the managers use to tackle the possible negative impact of uncertainty or to take advantage of it. I will conclude by answering the main research question by showing how uncertainty management is connected to the performance of a project company.

6.1   Definitions of risk, opportunities and uncertainty as basis for identification of the management methods

The following definition of uncertainty is proposed in the thesis based on the literature review and the empirical analysis: *Uncertainty in projects is the individual's (e.g. the manager's) lack of knowledge and/or understanding of the relevant project elements, its environment and their interrelationship, so that no conclusion can be made as to if and/or how any of these can impact the project success*. It is associated with the unforeseen, unplanned events that take place at different stages of the project, which do not necessarily affect projects in a negative way. As for uncertainty, *it can be described as a context for risks and opportunities within projects*. Uncertainty brings instability, which can be seen as a ground for flexibility (e.g. Wikström, 2005). In order for it to be transferred into certainty — risks and opportunities that is; — it needs to be acted upon. This thesis concludes based on the empirical study that the reactive strategies (avoidance,

denial, delay and ignorance in Kutsch and Hall's (2005) classification) result in risks as negative impact on project's outcomes, while proactive strategies (*investigation, communication, adaptation*) based on reflective processes (Schön, 1983; Weick, 1995) are strongly associated with positive outcomes. One of the main achievements of thesis is that it proposes the framework for understanding how the concepts of risks, opportunities and uncertainty are related (Figure 3 in the Theoretical Framework Chapter) based on the literature review as well as provides the model of how uncertainty is managed by reflective processes on the project manager's level through empirical investigation (Figure 19 in the Discussion Chapter). It even extends it further by providing implications for the project-based organization level (Figure 21 in the Discussion Chapter).

The concept, which is presented in this thesis -managing uncertainty (also sometimes referred to as uncertainty management) is a concept which subsumes risk and opportunity management as they are discussed in the project management literature. The concept of managing uncertainty/uncertainty management, which is presented in this thesis, contributes to the project uncertainty management literature (Chapman and Ward, 2003, 2004; Green, 2001; Jaafari, 2001) by clarifying what the concept of uncertainty stands for in terms of its relation to project risks and opportunities. This work, which is based on the collaborative research project (Perminova O., Gustafsson M., Arhippainen T. 2007 (a); 2007 (b); 2008), provides empirical evidence for the need to address project uncertainty on the project and multi-project level. It also contributes by defining what uncertainty management stands for as well as by outlining its mechanisms (e. g. Figure 20) based on both the literature review and the empirical multiple case study.

Uncertainty in projects is perceived by the managers in charge of projects as a different issue to that of risk and opportunity. The results show that project risk is associated with a negative impact on the project outcomes. It is identified in this study as *an event, condition or interaction with the negative consequences on the project's objectives and consequently, project success.* Adding to the normative literature on project risk (PMBOK, 2004; APM, 2008) and the popularized definitions in the project management and organization research (Unger and Eppinger, 2006; Miller and Lessard, 2001, March and Shapira, 1987, etc.), this definition combines the following features under the common umbrella of the concept:

- risk subsumes *only* negative impact on the project outcomes and project success,
- it is objective,
- it is associated with a loss, threat or hazard,
- it is inherent in the nature of project work.

The nature of project work assumes risks, thus risk management is seen as a vital part of the managers in charge of the project. If the concept of risk is limited to the negative interpretation, it is appropriate to consider planning and establishing preventive measures based on the relevant information, which is continuously gathered and reflected upon, as the main functions of project risk management as the empirical investigation shows. In this respect, managing of risks contribute to managing uncertainty in terms of partly eliminating state and effect uncertainty (in Milliken's (1987) terms) by contributing to the *investigation* practices (different information collection techniques and assessment of its relevance in the context, establishing preventive actions). In this sense, risk management contributes to uncertainty reduction (and consequently, uncertainty management) by providing a structure approach to information creation (Eppinger, 2001; Browning and Eppinger, 2002). Risks are not a product of the manager's imagination since the risk assessment and analysis has facts — the certainty — at its core. In practice, to make a budget reservation or to assign resources to solving the potential problem, the manager has to have the proof of the probability of the negative impact. The empirical analysis suggests that the complex industrial projects can have a low level of uncertainty even though the risk level is estimated as high and vice versa. This is because fact-based risks are the threats that can be assessed even before the project starts and planned for by assigning concrete actions. There is nothing uncertain in knowing what you are going to do should the probable event take place, because you are aware of it: you have a plan. As one of the interviewees pointed out, *risk is not a problem if you can handle it.* The result of the analysis is as follows: the success of the risk management measures will depend on how and when the identified actions will be implemented to combat the negative impact, which in turn depends how successfully the reflective uncertainty management methods — *investigation, communication and adaptation* — are utilized.

However, management of risks as the negative impact on projects does not take into account the opportunity as a positive influence on the projects' outcomes. In a similar way as the project risk

concept, project opportunity can be identified *as an event, condition or interaction with the positive consequences on the project's objectives ensuring success of the project activities.* This concept is:

- related *only* to the positive effects on the project, including those of the successful implementation of actions to handle risks and uncertainty (similarly to the review performed by Chapman, 2006),
- objective,
- inherent in the nature of project work.

The proactive approach to managing uncertainty by doing project management activities ensures that the risks are successfully avoided and the benefits are achieved through implementation of the actions. It means that uncertainty management reflective functions have to be performed on a continuous basis, with commitment and responsibility towards the project, to be able to indicate the change in the context and adapt to it. Monitoring techniques (e.g. regular revisions of plans and of portfolio assessments) as part of reflective *investigation* and loss reduction/prevention activities (e.g. increasing competences of the managers and the project stakeholders via training) are essential here. This thesis emphasizes *troubleshooting* as means to correct — or minimize the impact of — the already occurred damage, which was a result of the lack of proactive strategy. Yet many practitioners think that this is what risk management in projects is all about. In this respect, the issues pointed out by Maylor (2003) and in Alderman et al (2005) such as effective planning and continuous monitoring of the outcomes of the previously implemented actions (in other words, reflection) to obtain a better understanding and experience of the context are vital both for project management; therefore, project risk and uncertainty management practices are a part of of this. The reflective processes provide flexibility in decision-making and allow project managers to grasp the nature of the unforeseen event as a risk or an opportunity.

Based on the literature review and the empirical case study, Uncertainty management is defined as a reflective process of considering all of the elements of a current evolving event from different angles to find acceptable actions to resolve the situation for the benefit of the project. Uncertainty management and risk management differ along different parameters. Firstly,

uncertainty management includes reflective experience-based processes as opposed to more mechanistic, planned conformance-based risk management processes that are the cornerstone of risk management in its traditional understanding (PMBOK, 2004). While a project risk management process is seen as information collection (Eppinger, 2001) or as a collection of methods to prevent and minimize the consequences of the negative impact of events on projects and achieve opportunities by doing it (Boehm, 1991; Turner, 1999; Chapman and Ward, 2002), uncertainty management is best interpreted as a mindset, a project-based firm's culture, which is aimed at securing success of the projects, and hence its business. The latter is the entrepreneurial thinking the way Knight (1921) understood it. Uncertainty management builds on the experience of organizational members, which constitutes organizational expertise. The latter can be understood as special knowledge (in terms of Fuglseth and Gronhaug, 2000). Uncertainty is more dependent on the experience of the managers executing the projects than the availability of quantitative and qualitative information as such (e.g. statistics, probability forecasts etc). In a way, uncertainty management supports the point of view on current project management practices, especially risk and opportunity management, as part of an information collection process (e.g. Browning and Eppinger, 2002, Armour, 2002). Project risk management, as it is currently outlined in the project management literature, supports uncertainty management by providing an informational basis for the reflection processes.   From a larger conceptual perspective, uncertainty management is linked to risk management in the following way:

Table 13. Uncertainty and risk management processes and their relation to opportunity

	UNCERTAINTY MANAGEMENT	RISK MANAGEMENT IN TRADITIONAL UNDERSTANDING
Main processes	Communication Investigation Adaptation	Planning Troubleshooting (immediate response to negative impact) Conformance
Basis	Builds on the analysis of present (current situation)	Builds on analysis of past (historical data)
Elements	Professional experience/expertise; Interaction/communication	Information Information collection
Approach	Reflective	Conformance-based
Aim (relation to opportunity)	To achieve benefits (opportunities) for the project	To prevent and minimize the predicted negative impact of the event (risk)

6.2 Uncertainty management methods

In contrast to risk management the main goal of which is to address negative and positive impacts of events, uncertainty management methods are oriented towards better understanding the interrelations between the elements and environments of complex industrial projects and enacting the new knowledge to achieve benefits for the projects or even the project-based firm as such. Taking an individual relativistic and reflective approach into consideration (e.g. Popper, 1996; Weick, 1977; Schön, 1983; Wikström and Rehn, 2002), the three main methods have been outlined in this thesis: *investigation, communication and adaptation*. These processes support a proactive attitude to uncertainty, which aims at achieving benefit from uncertainty by minimizing it. Project risk management, if the reflective processes are applied to it, can be seen as being included under the umbrella of uncertainty management. In addition, the following elements of the proactive strategy were proved to resolve uncertainty into opportunity:

• **Enacting responsibility and commitment by investigation and communication:**

    i. commitment to common project goals within supplier organization (and possible among all project stakeholders) by establishing communication procedures,

    ii. following up the change in project certainties (facts),

    iii. communication of project goals among different stakeholders to increase awareness and commitment.

    iv. continuous communication with project stakeholders through forming common project teams,

    v. creating sources of relevant project — related information through establishment of contacts through representatives and network partners,

    vi. cooperation with project stakeholders in task development, especially with customer etc.

• **Organizational adaptation:**

    i. considering region-specific way of working in the country of delivery in terms of work organization and responsibility division (contract),

ii. training of the companies own staff to increase the overall expertise of the organization (competence management),

iii. implementing regular on-going procedures aimed at transferring uncertainty into perceived risk or opportunities including risk/opportunity management as a basis for information collection: regular risk/opportunity assessments at regular points (e.g. at the end of each project phase), communication with project stakeholders (e.g. participation in meetings, follow up of developments), brainstorming meetings with the aim to involve experts to give more complex interpretations of future scenarios, enabling inter-departmental communication.

The results of the empirical study suggest that if uncertainty has been addressed using the reactive strategy, then the following mitigation methods have been employed to minimize the negative impact of the unexpected event:

- Troubleshooting at the supplier's cost (equipment replacements, additional supervision),
- Goodwill agreements,
- Special project team arrangements to investigate the negative issue.

In sum, managing uncertainty is a mindset, which emphasizes proactive, reflective and even an entrepreneurial approach to dealing with the unknown and unexpected, which encompasses all the levels of the project-based organization.

6.3   Contribution of the thesis and suggestions for future research

This thesis provided the empirical evidence for uncertainty management to stress the importance of recognizing uncertainty as an essential part of projects which needs to be managed by project management professionals (project managers and warranty managers) to

ensure that projects meet their goals. As the results of the study show, defining and explaining the phenomenon of uncertainty and the way it can be managed in projects is an important element of performance-oriented project management. This thesis contributes to the field of project management in several ways. First and foremost, the thesis provides a definition of the concept of uncertainty in the context of large scale complex projects in relation to the concepts of risk and opportunities by combining the existing definitions with the understanding of uncertainty from organization theory and strategic management. The thesis outlines the interrelationship between the studied constructs by constructing a framework, on the basis of which the model of uncertainty management of two interdependent levels is proposed (Figure 19 and Figure 21). Second, it provides empirical evidence and justification for uncertainty management practices as well as describes the methods, which project-based companies use to address uncertainty. The contribution to the project management literature is in describing the reflective mechanisms transferring uncertainty into certainty, foster flexibility and robustness. Third, it explains the relevance and the benefit of the reflective approach (e.g. Popper, 1996; Weick, 1977; Schön, 1983) for managing projects on the example of risk and uncertainty management. Forth, the warranty stage of the project life cycle has been highlighted as an important point of reflection. The warranty stage itself is often seen as being of less importance than the project execution or the sales phase, especially in terms of the project performance. The hand-over from project to warranty is seen as the end of the project rather than the continuation of it. Warranty is the start of the operation from the customer's point of view, and it has an impact on how the project is evaluated by the main stakeholders (Shenhar, 2001). This thesis provides the empirical evidence that the warranty stage is a time for either being faced with risks or benefiting from emerging opportunities. My findings indicate that the warranty stage needs to be regarded as equally significant in terms of the overall project performance and the management processes. More focus on the warranty stage of projects is needed both in project management research and practice. Uncertainty management needs to be performed at this stage not only for the sake of decreasing the financial costs of a particular project, but also as having a long term impact on the customer relationships at the company level by establishing trust among partners, supporting the brand image of the supplier, etc. The latter aspects require further attention of the researchers in the field. An interesting dimension and a natural continuation

of this research would be establishing the value (e.g. in monetary terms) of uncertainty management functions at different stages of the project, and on the overall project level.

To summarize, in this work, uncertainty management for projects and project-based companies is approached as a mindset, or a set of practices, which includes attitudes, behaviors, systems and processes of the project-management organizations and their members. The empirical analysis shows that the managers do perceive uncertainty and risks differently, and this affects management practices. There are two main attributes that are associated both with risk and uncertainty: the information available and the experience of the warranty manager or the project manager. The findings show that for handling risks the information factor appears to be more significant than professional experience. In a similar vein, the professional experience has more importance for managing uncertain unexpected situations than information as such. At this junction, it is competence and knowledge management in association with uncertainty that are the two themes which ask for further scientific exploration. Uncertainty has been long associated with entrepreneurial behavior (Kinght, 1921), which gives an interesting dimension for research in the context of project business. According to the results, the managers taking care of projects with a high degree of uncertainty are expected to have different capabilities, for example, in terms of experience, than those who manage complex routine projects with less uncertainty. This observation can be further addressed to investigate the implications for the development of competence and expertise of managers in project based companies to deal with uncertainty.

The reflective process of uncertainty management, as compared with the rigid and mechanistic traditional risk management, represents a better way to manage the unforeseen and unexpected situations that arise in projects as the findings suggest. The managers dealing with uncertainty are encouraged to take a proactive role rather than just conform to the plan. This research can be extended by looking at what kind of informal organizational practices exist within project-based organizations or projects that support a proactive approach when dealing with unexpected events.

Project management practice shows that not only is it important to consolidate knowledge, but

also make it explicit for each and every member of the project team. I argue that such actions are not only an important part of a company's strategy implementation, but also help to utilize competitive advantages. Furthermore, continuous reflective learning based on reflective processes can be considered a competitive advantage. The same rule applies to the attitudes of each responsible person towards risk, opportunity and uncertainty, which will affect the ability to foresee both the potential dangers and opportunities. In fact, it is much more difficult to determine what is certain in projects rather than list all the possible risks. Can a solution provider be certain at any moment of the changes that might occur as regard the environment of the project, the behavior of the stakeholders, or even customer demands? The obvious answer is no. Can these questions have answers, which are desirable for the supplier? Yes, because they are achieved by the reflective process of managing uncertainty. For example, project risk management has been associated with impact prevention (and avoidance) methods. By employing this logic to the statement of Barber (2005), who concludes that new breakthrough technology applied in projects carries risk, one should conclude that innovative projects should be avoided. By rephrasing that innovative projects are more uncertain (thus they can result in both negative and positive outcomes), a wider horizon to interpretations is open, which provides for a greater flexibility to thinking through, assessing, making decisions and most importantly, acting.

This work has highlighted the importance of reflective processes in management. It reinforces the idea that uncertainty in projects plays a crucial role. Uncertainty management is one of the dominating topics in the field of project research. The findings of this thesis offer a potential for the researchers in the field of project management to develop, test and, perhaps, discover new mechanisms by which uncertainty is managed in projects of different types. In connection to this proposition I suggest additional studies to determine how the uncertainty profiles of projects evolve during the different stages of the project life-cycle, so that the applicability and the effect of different uncertainty management methods can be further tested in different project contexts.

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VIII   APPENDIX

Table 14.   Uncertainty and the variables that influence it

DEALING WITH UNCERTAINTY IS MOST ASSOCIATED WITH	SOURCES	REFERENCES	REFERENCES PER SOURCE
Project organization	15	47	3.1
Unforeseen situations	15	41	2.7
Communication	14	36	2.6
Experience	16	41	2.6
Scope of supply	11	26	2.4
Information	5	9	1.8
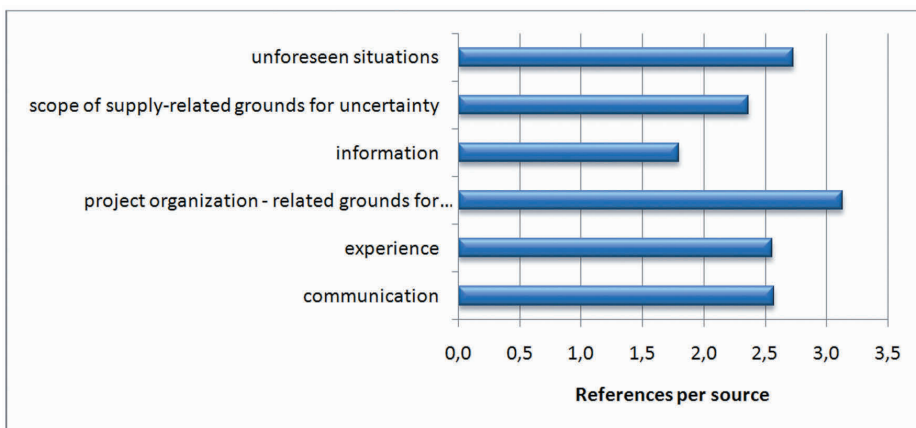
Figure 22. Uncertainty and the variables that influence it (chart)

Table 15. Variables that lead to negative performance

NEGATIVE PERFORMANCE	SOURCES	REFERENCES	REFERENCES PER SOURCE
Internal project firm uncertainty	14	47	3.4
Customer or operator or user-created causes of uncertainty	11	29	2.6
Technical uncertainty	14	32	2.3
Lack of reflection	8	15	1.9
Contract or scope of supply-created causes of uncertainty	13	19	1.5
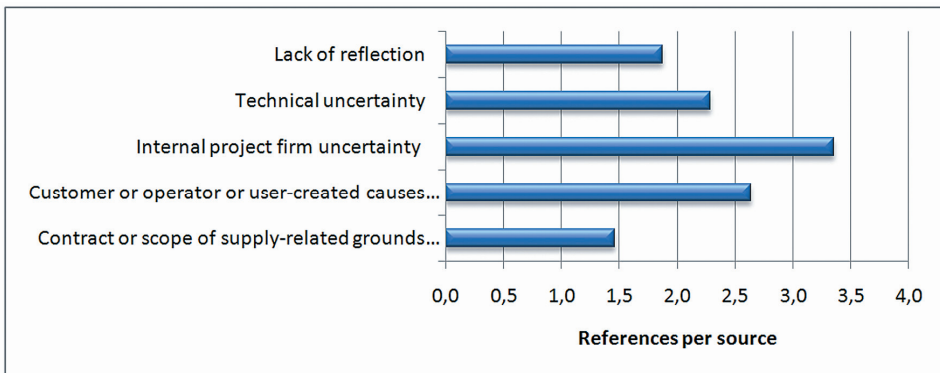
Figure 23. Variables that lead to negative performance (chart)

Table 16. Variables affecting performance positively

PERFORMANCE	SOURCES	REFERENCES	REFERENCES PER SOURCE
Fulfilling obligations to the customer	4	15	3,8
Project participant's benefit secured through the contract	5	18	3,6
Reflection vs extensive planning	14	42	3,0
Managing time	5	13	2,6
Financial results	4	9	2,3
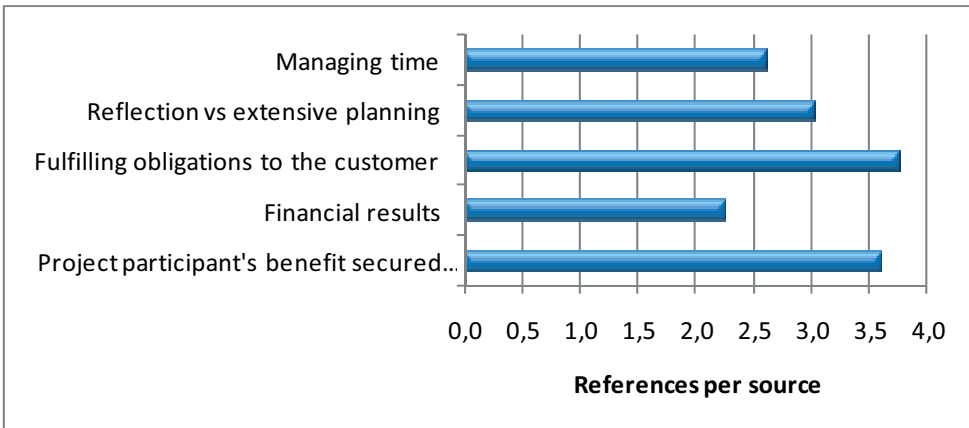
Figure 24. Variables affecting performance positively

Table 17. Communication and the factors influencing it

COMMUNICATION IS DEPENDENT ON	SOURCES	REFERENCES	REFERENCES PER SOURCE
region-specific way of working	13	35	2.7
commitment	17	39	2.3
lack of information communication internally within supplier firm	8	17	2.1
customer-related uncertainty	9	15	1.7
design phase — related uncertainty	8	12	1.5
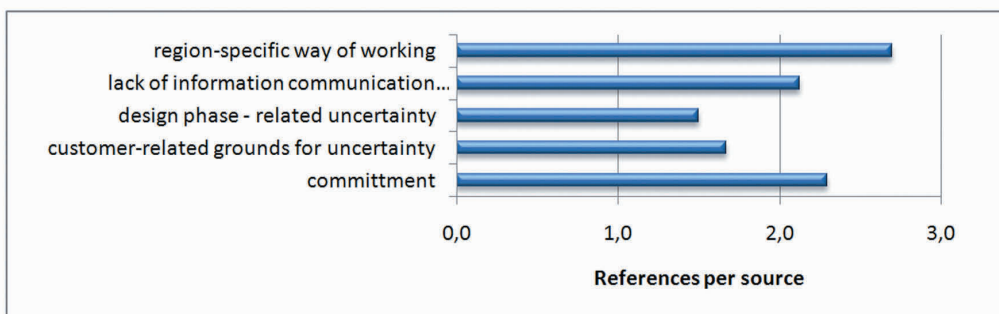
Figure 25. Communication and the factors influencing it (chart)

OUTSET:
- Contractual terms
- Project plan and risk plan
- Contingencies
- Expected difficulties
- etc

REALIZATION:
- Major unexpected events
- Non-conformities
- Change orders
- Transportation issues
- Commissioning issues
- etc

EXPECTATIONS: were they met?
- Handing-over
- Warranty issues
- Characteristics of overall performance

Figure 26. Aide memoriam for the interviews

Interview topics matrix

	Sales Manager/ Risks	Planning of PRM/Project Manager	Control/Warranty Manager	Experience utilization/ Competence Management
Project Performance	What kind of warranty risks appear? Which ones actually do?	Which types of risks are expected to have the most severe impact?	Is there any training quality measurement? Levels of training?	Measures for turning "lessons learned" into practical experience (company manuals, policies)
Customer	Who decides on the terms of the contract relating to training? Split of responsibilities?	How is training perceived in terms of cost and risk mitigation? Can training lower insurance costs?	How are the customers evaluated in terms of operator competence?	Does the supplier and the customers share experiences in terms of training?
Information	What is the procedure regarding the decision on training: to be or not to be?	Whether training is included in the offer- how is that information transferred from SM to PM and onwards?	Are there any statistics on the quality/customer satisfaction from training?	Whether is training perceived as means of risk reduction? Ability to utilize experiences from previous projects
Project environment	What are the main uncertainties related to warranty?	What is the role of PM in the decision regarding training?	Monitoring procedures	Policies development

Table 18. Aide memoriam for conducting the interviews

UNCERTAINTY	OFFSHORE	SOLAS	DESIGN	LACK OF REFLECTION	BLACKOUT	JAPANESE APPROACH	CAMBODIAN ENDEAVOUR	SUDAN
Lack of knowledge about the possible influence of applied technology on the project outcomes (e.g. due to technological novelty or need to operate under new requirements)	100	25	25	100	100	25	25	25
Lack of understanding (knowledge) of the responsibilities under the contract	25	25	50	50	25	50	25	25
Lack of experience from the other projects of the same kind	75	25	25	50	75	50	25	50
Lack of understanding/knowledge of the management tasks to be performed	25	25	25	25	25	25	25	25
Lack of familiarity with the task execution process	50	25	25	25	25	25	25	25
Lack of knowledge of the parties influencing the execution of the task internally (assistance from departments, superiors, peers)	25	25	25	25	25	25	25	25
Lack of knowledge of the parties influencing the execution and outcome of the task (not participating in project, e.g. non-governmental organizations, PP operating companies)	100	25	25	100	25	100	75	100
Lack of familiarity with internal supporting processes and procedures (manuals, policies, supporting documentation)	25	25	25	25	25	25	25	25
Lack of knowledge of the customer (their way of working, experience in doing projects, history of cooperation, demands)	100	25	25	75	25	75	75	100
Lack of knowledge of the contractors participating in the project (their way of working, experience in doing projects, history of cooperation, demands)	100	25	25	50	25	25	25	75
Lack of knowledge of the subcontractors participating in the project (their way of working, experience in doing projects, history of cooperation, demands)	75	25	25	75	25	50	25	50
Lack of understanding the requirements that the geographical location of the project site imposes	50	25	25	25	25	25	25	50
Lack of knowledge about the country of delivery (political and legal environment, way of working, culture)	100	25	50	50	25	100	75	100
Lack of knowledge about the regulatory authorities	100	25	25	25	25	50	50	75
AVERAGE	68	25	29	50	34	46	38	54

Table 19. Evaluation of uncertainty level of the studied projects

COMPLEXITY	OFFSHORE	SOLAS	DESIGN	LACK OF REFLECTION	BLACKOUT	JAPANESE APPROACH	CAMBODIAN ENDEAVOUR	SUDAN
Unit cost/ financial scale of project	100	25	100	100	25	25	75	75
Product volume (inverse of)	75	50	100	75	50	25	50	50
Extend of embedded software in the product	75	50	75	75	50	50	75	75
Quantity of sub-systems and components	75	25	75	75	25	75	75	75
Degree of customisation of components	75	25	25	75	50	25	25	25
Degree of customisation of final system	100	25	50	75	25	50	50	50
Variety of system architectures	100	50	75	75	50	75	75	75
Quantity of alternative component design paths	50	25	50	50	25	50	50	50
Feedback loops from later to earlier stages	100	50	50	50	50	50	50	50
Variety of distinct knowledge bases	100	50	75	75	50	75	75	75
Variety of skill and engineering outputs	100	50	100	100	50	25	75	75
Intensity of user involvement	75	50	50	50	50	50	50	50
Change in user requirements	50	25	25	50	25	50	50	50
Intensity of other supplier involvement	100	100	100	25	100	100	50	50
Intensity of regulatory involvement	100	50	75	75	50	75	75	75
AVERAGE	85	43	68	68	45	53	60	60

Table 20. Evaluation of the complexity level of the studied projects

Recent studies in project management show that the risk management practices are ineffective. When an unexpected event takes place, risk management is rarely enough to guide how the managers should act. In these situations, project managers face uncertainty about the new state in the project, the effects of the situations on the project outcomes as well as uncertainty about managerial actions and their respective effect. This book presents and explains the management methods and principles to successfully address uncertainty to ensure the project performance.

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