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PROJECT MANAGEMENT DIGITALIZATION: A CASE STUDY OF NOKIA

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Abstract

Digitalization in the modern economy creates a productivity platform that is regarded by many experts and researchers as the 4th industrial revolution. The dramatic increase of the project management related software development, combined with the decreasing costs of these solutions, have spurred a remarkable interest in these digital PM-solutions reducing the gap between the theory and practice of project management. The selection process of a feasible digital project management solution can be a highly demanding task for any organization regardless of the field it operates in.

The aim of this study is to define the concept of project management digitalization, but also to evaluate how project management work can be further developed and supported by digital project management solutions. This research has a qualitative nature, and it is a empiria driven inductive case study, supported by a literature review. As a part of the case study, project management experts within the Supply Chain Engineering (SCE) -unit of Nokia have been interviewed.

The empirical case study consists of a current state analysis and requirement specification of project management in Nokia MN/BM/SCE, but also from a comprehensive feasibility study of three state-of-art digital project management solutions available in the markets: JIRA, HP PPM and MS POL. A digitalization proposal was given for the case company on how to proceed in the project management digitalization journey, and what commercial solutions need to be taken in use. These digital PM-solutions can support project planning, execution, monitoring and controlling, but also make projects more predictable and manageable in terms of schedule, costs and quality.

This study is strongly tied to recent development trends in the web- and cloud-based Project Management Information Systems (PMIS) and Decisions Support Systems (DSS), that set the basis for defining the new concept of project management digitalization. Several theoretical and business managerial conclusions can be drawn based on this study, that support the project management digitalization pursues of various organizations. Thus, most of the conclusions and results of this study can be exploited in organizations operating in other industries as well, especially when the target is in initiating the project management digitalization journey.

Keywords

project management, performance measurement systems, technical controlling, information systems, decision support systems, software development, digitalization, agile
FOREWORD AND ACKNOWLEDGEMENTS

The purpose of this research was to study digitalization in project management through a case study of Nokia MN/BM/SCE, but also through a review of the existing literature related to the topic. Simultaneously, the aim was in identifying and defining some of the key-steps that organizations should consider when starting the project management digitalization journey, but also some of the most significant business benefits that can be achieved in the process. From the case company’s perspective, the goal was in defining “the next generation digitalized toolbox for project managers”. This research was supported by my personal work history in Nokia, which provided a significant insight to the corporate culture, processes and practices. The writing process of this thesis was started in September 2017 and finished in March 2018. The thesis was published in April 2018.

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In Oulu, March 14th, 2018

Janne Saarela
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<tr>
<td>ASP</td>
<td>application service provider</td>
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<td>BM</td>
<td>business management</td>
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<td>DSS</td>
<td>decision support systems</td>
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<td>EIS</td>
<td>executive information systems</td>
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<td>ERP</td>
<td>enterprise resource planning</td>
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<td>MN</td>
<td>mobile networks</td>
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<td>MPCS</td>
<td>multidimensional project control systems</td>
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<td>PM</td>
<td>project manager / project management</td>
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<td>PMIS</td>
<td>project management information systems</td>
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<td>PMS</td>
<td>performance measurement system</td>
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1 INTRODUCTION

1.1 Background

Projects are one of the most essential structural elements of modern day organizations. Organizations and companies in almost any sector are becoming increasingly project based due to the modern management practices that are transforming organizational structure from a hierarchical to a flatter and more temporal one. (Hazir, 2014.) The ever-changing landscape of project management challenges experts and practitioners of the field to stay informed of the most up-to-date trends, research, tools and practices (IRMA, 2016). Today, project managers, PM’s, must take a large amount of information and variables under consideration in their daily activities and decisions. Thereby, project related decision making can be a highly complex undertaking for any project manager. (Marques, Gourc and Lauras, 2011.)

The main purpose of various measurements and metrics in project management is to create the means for monitoring and controlling and thereby, supporting the management work and decision making (Hazir, 2014). It is crucially important for project managers to know whether their project is running behind or ahead of schedules, and if the project is on budget or not. This information comes from comparing the planned, baseline, and actual values of several aspects. (Acebes, Pajares, Galan and Lopez-Paredes, 2014.) Thereby, complex decisions need support from advanced tools and solutions that can assess substantial amounts of project related information and data (Marques et al., 2011). Technical controlling with the help of various information systems are suitable application areas for supporting project managerial needs (Hazir, 2015).

Ever since the beginning of the computerized age, various software solutions and packages have been important tools for project planning, scheduling, monitoring and controlling (Archibald, 2003). Project management information systems, PMIS, are software solutions that help project managers to track, monitor and control projects from the initiation to the execution. Currently, many organizations have unintegrated solutions in use, that are not designed for managing complex and large projects.
PMIS increase efficiency of projects by making development cycles, task completion levels and overall project status & progression more visible for relevant project stakeholders. Furthermore, PMIS help project teams and other contributors to stay up-to-date by enabling coherent flow of information. PMIS are also found to have direct linkage to the project success as they increase the project budget control and support in meeting project schedules (Raymond & Bergeron, 2008).

Decision support systems, DSS, are computer based systems, that can provide substantial support for project decision making by combining and analyzing data, but also in providing analytical models and solutions that can make selection between various alternatives easier for project managers (Hazir, 2015). Furthermore, organizations need information systems and business management systems to automate, optimize and enhance workflows, but also to improve quality in every business activity and to standardize & control processes (Tarantilis, Kiranoudis and Theodorakopoulos, 2008). Integrating project management activities and functions with the advanced software solutions, with user-friendly interface design, are very challenging but critical topics when talking about advanced PMIS. The demand for more visual, interactive, integrated and dynamic project management support systems remains for easier project execution, monitoring and controlling. (Hazir, 2015.)

As technology has developed, it has been made possible to build decision support systems via internet to the web (Power & Sharda, 2007). Cloud computing enables many web-based solutions and services to be delivered through the internet (Chen, Liang and Hsu, 2015). The evolution of the stand-alone decision support systems has been transforming to a more web-based solution, where information sharing and decision-making within global teams have been made possible. Thereby, the DSS technology has developed due to the opportunities provided by the World Wide Web: browser servers have made the decision-making processes faster, more efficient and more widely used (Shim, Warkentin, Courtney, Power and Sharda, 2002.) The emergence of the web-based cloud environment is an extremely important aspect in the DSS development, but also as a solution delivery platform (Shim et al., 2002). These advanced solutions enable seamless data access for the
authenticated users from anywhere, at the right time, in real time and online, without the need of specific software installation (Tarantilis et al., 2008). Increasingly powerful data mining tools, statistical tools and artificial intelligence have enabled more sophisticated and “real-time” data analysis (Shim et al., 2002).

These modern systems are called web-based-DSS: the entire application is build and implemented using web-technologies and cloud-servers (Power & Sharda, 2007). Two crucial advantages can be gained through these solutions: significant cost reduction of the solutions and the ease of integration through hosted application models (Tarantilis et al., 2008). A new generation of web-based and model-driven decision support systems has started to emerge in the markets and these solutions widely utilize the web-service concept in their solutions. Multiple DSS subsystems from several sources can be used in the same time in an aggregated or summarized form. (Power & Sharda, 2007.) Furthermore, integration in project management can be gained with superior security, reliability, testing, manageability and overall effectiveness (Tarantilis et al., 2008). Major improvements have been also made in the user interface of the solutions: on-screen menus, interactive fields, graphic user interfaces and online servers make it possible to share, store and modify information in real time between project teams and other contributors (Archibald, 2003).

Digitalization in the modern economy creates a platform for productivity, that is regarded in several contexts as the fourth industrial revolution (Murthy, 2017). Digitalized cloud-based project management solutions enable individuals to collaborate more naturally and closely at all times. This development also supports the connectivity and usability of virtual project teams. (Shim et al., 2002.) The software solution market for project management purposes is rapidly growing, large and highly competitive. The selection process of a feasible solution, to support the project managerial needs of a specific organization, can be a highly demanding and complex task. The selection of these state-of-art project management solutions is wide, but these solutions also differ in several ways in terms of functionality, usability and visualization. (Archibald, 2003.) Furthermore, many organizations are using project management solutions that are not sophisticated nor sufficient enough to manage complex projects. Many of these organizations are also unaware of the possible benefits that can be gained by using advanced project management
solutions. (Braglia & Frosolini, 2014.) Many aspects need to be considered when organizations are initiating their project management digitalization journey.

1.2 Methodology and research questions

This research is carried out in accordance with the qualitative research methods and material provided by Oulu Business School. This research is an empiria driven inductive case study, that is supported by a literature review to the topic of project management digitalization (Eisenhardt, 1989). The main research questions of the study are as follows:

Q1. What is digitalization in project management?

Q2. How can project management work be further developed and supported through digitalization?

Q3. How can various digital project management solutions be evaluated to meet organizational needs?

Throughout these research questions, this study will strive to define the concept of project management digitalization, but also how digitalization can support and optimize the project management work within various organizations. Finally, a closer look will be taken to the steps that organizations should consider when evaluating different digital project management solutions available in the markets.

In the empirical part, the research data was collected through individual interviews, that involved 31 project management experts working in the Supply Chain Engineering (SCE) -unit of Nokia. The interviews were semi-structured. Theme-based categorization was used to identify the key-findings from the research data. All interviews were audio-recorded, documented and analyzed. Interpretations of the case study are based on the evidence collected through the interviews. The primary data analysis creates the foundation, not only for the case study, but also for the theoretical framework that was inductively developed during the research. More
detailed description of the methodology used in the empirical part is given in section 3 of the study. (Eisenhardt, 1989.)

As mentioned, the theoretical framework of this research is developed inductively during the case study. Secondary and tertiary literature is used in the theoretical framework (Saunders, Lewis, and Thornhill, 2007). Comparison between the empirical findings and existing theory and literature is made to illustrate how this research is informed and influenced by the existing theory, but also to evaluate how this research contributes to the existing knowledge. The theories also affect the way that the research findings are interpreted. The theory of this study is developed in a data-driven manner, utilizing the qualitative data of the case study. (Bryman & Bell, 2011.) In the case study, a contemporary phenomenon, the “case”, is investigated in a real-world context. This methodology is commonly used, especially when it is not clearly evident, what are the boundaries between the context and the phenomenon. (Yin, 2003.)

1.3 Goals and limitations

The main purpose of this research is to study digitalization in project management through the existing academic literature. In addition, the purpose is to evaluate how project management work can be supported through digitalization, and what steps organizations should consider in the project management digitalization journey. This research is supported by an empirical case study of Nokia MN/BM/SCE. This empirical context, provides an insight to the work that was carried out to support the project management digitalization journey of the SCE-unit. In the concluding part of this research, the goal is to evaluate how the empirical context supports the existing academic literature concerning project management digitalization, but also if new perspectives and knowledge can be derived regarding to the topic.

This study is limited by the timeframe of approximately six months, but also by the recourses available to complete the study. The scope is restricted to cover only the digitalization in project management, leaving out the portfolio- and program
management perspectives. It should be noted that in the empirical part of this research, also the portfolio- and program aspects were evaluated from the perspective of the SCE-unit. However, giving the vast nature of these topics, the findings are limited to cover only the project managerial aspects. The reliability and validity of this study are supported by the literature review to the topic of project management digitalization, but also by the empirical case study of Nokia SCE. Finally, the individual interpretations of the writer might have affected the topics and themes presented in this study.

1.4 Structure of the thesis

The structure of this thesis follows the guidelines and instructions of Oulu Business School. There are five main sections in this study, that that will be shortly summarized in the following text.

The first main chapter is a literature review to the topic of project management development and digitalization. The section 2.1, provides an insight to some of the basic terminology, practices and processes commonly recognized in the field of project management. The main focus is in section 2.2, which aims to describe the evolution towards the concept of project management digitalization. In subsection 2.2.1, the transition from measuring project performance and technical controlling, to the project management information systems is outlined. Subsection 2.2.3 and 2.2.4 focuses on explaining the importance of the Project Management Information Systems, PMIS, and Decision Support Systems, DSS, in project monitoring and controlling. The concluding subsection defines the concept of project management digitalization through the current trends in the PMIS and DSS development, but also through the emergence of the web- and cloud-based solutions and systems.

Chapter 3 introduces the empirical part of this study. In this chapter, the SCE-unit of Nokia will be shortly introduced and its pursue of beginning the project management digitalization journey. The case study was carried out as a project called DITOX: Digital Toolbox for Project Managers. In the chapter, the business requirements for
digitalization in Nokia SCE are described, as well as the methodology, goals, limitations and structure of the case study. An overview will be given to the various phases that were delivered for the case company, in the ambition of determining “the next generation digitalized toolbox for project managers” in Nokia SCE.

In chapter 4, the empirical findings of the case-study are presented together with the detailed description of the various phases. The chapter begins from the current state analysis of project management in Nokia SCE. Throughout the current state analysis, also the requirements and desired features were collected and defined for the digital project management solutions. Three state-of-art digital project management solutions were evaluated in the case study and detailed description of the various phases is given in the section 4.2. This chapter concludes to the digitalization proposal that was given for the case company. The proposal describes all the steps that should be taken in the SCE-unit in the ambition of proceeding in the project management digitalization journey. Digitalization roadmap for solution creation and implementation is also provided for the case company in subsection 4.4.1.

In the concluding chapter 5, the theories and trends in the existing academic literature of project management digitalization will be linked to the empirical case study of Nokia MN/BM/SCE. In this chapter, the scientific and business managerial conclusions will be drawn based on the literature review and the cases study. This research ends to the further research topics related to the concept of project management digitalization.
2 LITERATURE REVIEW

This literature review was developed inductively during the empirical case study of Nokia MN/BM/SCE. Thereby, it includes some of the main topics and themes, from the academic perspective, that were addressed in the case study. In this literature review, some of the most important terminology, fundamentals, methodology, processes and development trends related to project management digitalization, will be described and presented. In the section 2.1, the aim is to provide a theoretical understanding on some of the most important fundamentals of project management, but also to clarify some of the key terminology used in the study. The subsection 2.2.1, will shortly describe the key principles of measuring project performance. The concept of technical controlling, will outline the transition to more information driven perspectives that are presented in the subsection 2.2.3 and 2.2.4. In the concluding part of the literature review, the concept of project management digitalization will be defined though the existing literature to the topic.

2.1 Project management principles

2.1.1 Key terminology and definitions

This subsection is heavily based on the Project Management Institute’s Guide to the Project Management Body of Knowledge (PMBOK Guide) -Fifth Edition, and to the: Project Business (2011) by Artto, Martinsuo and Kujala. The principles, processes, knowledge areas and terminology presented are commonly recognized in the field of project management.

There are many definitions for a project, but one distinctive quality to other type of activity is that projects have a clear beginning and an end (Artto, Martinsuo, Kujala, 2011; PMI, 2013). A project can be defined as a unique process that consist of activities that are controlled and coordinated. Projects strive to achieve a specific goal or objective to conform to the initial requirement or need, but they also have predefined time-frames, goals, budgets and other specifications related to their
unique nature. (Marques 2011, Artto et al., 2011.) Project is a complex effort that consist of interrelated tasks. Projects last usually less than three years in time and the project related objectives, schedules and budgets are well defined in the initiation. (Archibald, 2003.) Many internal activities of firms are in many cases managed as projects. These internal activities consist from research, product development, and other development activities related to the organization or its processes. Projects are not only central instruments in solving particular technical problems and achieving goals, but also central in the overall strategy management of organizations. (Artto et al., 2011.)

Project management can be defined as the method of management practices that are used to achieve the project objectives and goals that were initially set to the project. Where projects are focusing on creating a desired solution or system, systematic project management on the other hand is used to minimize the risks of these activities undertaken during the projects (Artto et al., 2011, PMI, 2013.) Project are done to meet strategic goals of organizations and to enable business value creation (PMI, 2013). Management practices may vary depending on the project type and phases, but all project related knowledge, methods, skills and tools that are required to reach the goals and objectives of the project are considered management practices (Artto et al., 2011). Risks and uncertainty are the very nature of project management, giving the unique and non-repetitive nature of projects (Acebes et al., 2014).

The stakeholders of a project consist from various associations, organizations, private persons, official- and unofficial institutions etc. that can influence the project, but are also influenced by the project. These project related stakeholders in many case have a possibility to affect the overall project execution, success or failure. Thereby, one of the key issues in project execution is in meeting the variety of needs and objectives set by different project stakeholders. (Artto et al., 2011; PMI, 2013.) Managing projects typically include many activities, such as: identifying stakeholders and addressing various needs, concerns and expectations of these stakeholders in the project planning and execution. Also, setting up and maintaining effective and collaborative communication among the project stakeholders is crucially important. Balancing between various project constrains such as scope, quality, schedule, budget, risks and resources is also one of the many challenges in
successful project management. (PMI, 2013.) Project management is about applying knowledge, skills, tools and techniques to project activities in order to meet the project requirements. Planning, Scheduling and controlling a series of integrated tasks should be managed so that the project objectives are reached successfully, but also to the best interest of the stakeholders. (PMI, 2013; Artto et al., 2011.)

A project team is usually a small group of core people, that work collaboratively to complete required tasks so that project objectives can be met. The project team is accountable for completing project tasks that have been agreed with the project manager, but also for providing reports to the PM on progress, issues and other concerns related to the project. (PMI, 2013.) Project organization on the other hand, consist from the people, companies and groups that are taking part to the project implementation. Project organization usually include a project steering team, ST, project team and suppliers. (Artto et al., 2011.)

Managing the entire life-cycle of a specific project, includes activities also related to pre- and post-phases of the project. It is crucial that correct choices are made from the start so that the entire life-cycle of the project is managed in a professional way. (Artto et al., 2011.) Project life-cycle includes all project phases and tasks from the initiation to the completion of the project (Archibald, 2003). In a broader view of project management, professionally managing projects requires strategic targets and understanding of the benefits that the projects bring to the customers of the company, but also to the other business entities that are involved (Artto et al., 2011).

A milestone is a happening or a state that is closely linked to reaching project objectives. The milestone does not consume time nor resources but instead, it is binary in nature: it is either passed or not passed. A milestone is a critical point of the project where some predefined part of the project work should be completed. It also initiates the next phase of the project and it can represent a key decision-point. (Artto et al., 2011; PMI 2013.) A task is related to the mission or reason of a project and to the purpose that it exists for. Various projects and assignments are created for accomplishing a certain task in a broad sense. Tasks have a key role or meaning in accomplishing a certain work or job. Projects consist of tasks and tasks can be sliced down to a work breakdown structure (WBS) of the project. WBS demonstrates the
actual work that is being done in the project (Artto et al., 2011; PMI, 2013.) Tasks of a project are short-term efforts that usually last only weeks or months (Archibald, 2003).

Project constraints are the factors that are limiting the project. These constraints are time, quality, costs, customer satisfactory, risks, scope and resources (PMI, 2013). The key-constraints and objectives of a project can be defined through the iron-triangle of project management. The first objective is related to the Scope: what is to be done. The second objective is related to the Time: when it is to be done. The third objective is concerning the Costs; what resources and costs are required. (Artto et al., 2011.) A critical path of project determines the shortest project duration and the amount of flexibility in the project network paths. The critical path of project is the sequence of activities that have the least flexibility (zero float) in the schedules. Changes in the schedules of the critical path items will affect the whole schedule of the project. (PMI, 2013.)

Project baseline consist of the schedule-, cost- and scope baseline. Scope baseline contains the detailed project deliverables. Schedule baseline is the approved version of the project schedule model and changes in this baseline can be done only through change control procedures. Finally, cost baseline is the approved version of the time-phased budget and it can be changed only through formal change request procedures. Controlling the project baseline is about monitoring the status of various activities, but also reporting the project progress so that changes in the planned (baseline) can be detected. (PMI, 2013; Artto et al., 2011.)

Work performance data is all the data that is showing which activities are started, in progress and the ones already completed. It is the raw measurements and observations identified in the process of carrying out the project work. (PMI, 2013.) Work performance reports are representations of the work performance information stored in various project documents to raise issues, generate decisions, actions or some other awareness. A risk register is a tool that is used to identify project risks, but also enables them to be documented and maintained. Risk register also provides a plan for the risk mitigation. Various risk assessment tools exist for reporting the
information of the risks in the register on a regular basis. (Patterson & Neailey, 2002.)

2.1.2 Project management processes and knowledge-areas

The project management processes consist of five stages: planning, executing, monitoring, controlling and closing. Initiation defines the new project and authorizes the project to start. Planning defines the project objectives and courses of action that are going to be taken to meet the objectives and scope that was defined in the project initiation. Execution includes the processes performed to reach the project objectives defined in the project plan. The aim of monitoring and controlling is in identifying changes in the original plan, project baseline, and acting accordingly to mitigate these changes. Closing is about formalizing and approving the final product, service or other result, but also formally closing the project and all the contracts related to the project. These processes can be reflected through the project management knowledge areas, that are: integration-, scope-, time-, cost-, quality-, resource-, communication-, risk-, procurement- and stakeholder management. (PMI, 2013.) In below, the project management knowledge areas are summarized based on the Project Management Institute’s Guide to the Project Management Body of Knowledge (PMBOK Guide) -Fifth Edition:

1. Integration management. The aim of this area is in ensuring that all of the various elements are accordingly coordinated in projects, but it also refers to all the procedures that help to complete the project as an entity according to objectives.

2. Scope management is ensuring that the project includes all the work and steps necessary to successfully complete the project, but also that all of the initial requirements set for the project are met.

3. The aim in time or schedule management is in ensuring that the project, and all project related tasks etc., are completed within the agreed timeframes. Task management is related to schedule management, and it is about specifying activities, managing their length, managing dependencies among various activities, controlling
the schedule of activities and reacting if any changes occur in task specific timeframes.

4. Cost management aims to ensure that all the project related activities and tasks are completed within the given and approved budget. Thereby, estimating project costs, budgeting and monitoring these costs are the key activities in cost management that help to ensure that the project is not only profitable, but also operating cost efficiently.

5. Quality management is ensuring that the quality in the project satisfies the intended requirements.

6. The aim of resources management is to make the people involved to the project work in the most effective way as possible. Resource management is also about designing the project organization, acquiring people to the project and assigning responsibilities to the project team members.

7. Project communication management is about managing project information and ensuring the distribution, generation, collection, storage and disposal of this information. It is about managing information, and the channels, between the internal- and external stakeholders of the project.

8. Project risk management aims in identifying, analyzing and reacting to the project related risks.

9. Project procurement management is related to acquiring goods and services needed in the project outside the performing organization, but also managing the contracts and deliveries of these procurements.

10. Stakeholder management or stakeholder engagement includes the processes of identifying project stakeholders, analyzing and managing the expectations of the various project stakeholders. Different strategies are developed to manage these stakeholder expectations, but also prioritization is done to figure out the key-stakeholders and requirements.
Figure 1. Project phases and knowledge areas (After Artto et al. 2011, p. 80.)

The figure above illustrates how the project management knowledge areas are linked to the PM processes (Artto et al., 2011). All the knowledge areas can be viewed through the project phases: typically, each area is first planned and then monitored and controlled during the project execution. For an example, monitoring and controlling project risks requires a risk register, that is created in the risk management planning phase when various risks are being identified and documented. Knowing the basic terminology and fundamentals of project management presented in this section, will help to better understand also the phases in the case study.

2.2 Towards project management digitalization

2.2.1 Measuring project performance

Today, project managers must take a large number of variables into account in their daily decision making and activities. According to Marques et al., complexity of the information related to the decision making is underlined in several contexts. (Marques et al., 2011.) The main purpose of measurements and metrics in project
management is to create the means for monitoring and controlling and thereby, support the project decision making and management work (Hazir, 2014). According to Conroy & Soltan, the major challenges related to the modern-day project management is related to the overwhelming pressure of handling and communicating critical project related information between project team members and other contributors simultaneously (Conroy & Soltan 1998). The increasing importance of project based management in fast moving industries, such as communications, electronics, IT systems and health & medical technology is emphasized due to the fast and powerful development activity that often involve rearrangements in the value chains (Artto et al., 2011).

Maintaining the balance between delivering the project on time within the given resources and simultaneously satisfying the usual triple-constrains of quality, time and costs, a continuous flow of relevant and critical information is needed about the various elements and phases of the project by the project manager (Conroy & Soltan, 1998). Research on project performance indicates that creating a universal checklist of project performance criteria is a highly complex task, giving the context dependent nature of the project business. The project performance indicators vary depending on the users, stakeholders, project sponsors, project managers’ needs and so on. However, the area covered by these project performance indicators must be as complete as possible to form a complete picture of the project performance. (Marques et al., 2011.)

In most studies related to project monitoring and controlling, the focus is in examining the financial control tools and numerous accounting techniques (Rozenes et al. 2006 via Hazir, 2014). Controlling a project consist of comparing the project plan or baseline to the actuals, in order to identify deviations and acting accordingly to mitigate these deviations (Acebes et al., 2014). Through the control and monitoring functions of projects, the goal is in minimizing the possible deviations from the initial project plan. This controlling consists from identifying and reporting the project status, comparing the status with the plan, analyzing possible deviations, but also implementing the appropriate actions as a response to the deviations. (Hazir, 2014.) Measuring project performance is basically grounded on working-level data, but the intend of this data is in providing an overview to the current project status
Performance control is a recursive and cyclic process and it starts from measuring the actual performance of the project. After defining the actual performance of the project, it is then compared to the desired one to detect the possible deviation. After this, project manager can then try to analyze the reason behind this deviation and act accordingly. (Marques et al., 2011; PMI, 2013.) Aggregation of different metrics is needed to serve and control various project related objectives. Project Managers look for project related information such as budgets, schedules, deliverables to have a better visibility to the overall performance and progress of the project. (Ebert, 1999.) In many cases, the desired performance of the project is the initially planned one. However, as the project progresses the initially planned performance may be changed to reflect the decisions made concerning the project or other unexpected events that have occurred. (Marques et al., 2011.)

Problem faced by many project managers is that how can large amount of project information be easily stored and analyzed for decision making. Another issue is that which tool or technique should be used to analyze the data according to the need. (Marques et al., 2011.) In many companies, own project management models, practices and tools have been developed to decrease the uncertainty and chaos related to projects. Projects are managed through various chart visualizations, worksheets, checklists and other tools. Several visualizations are often created to keep track on different aspects of the projects, such as schedules, resources, costs, risks etc. Gantt-charts, S-curves, critical path methods and earned value methods are examples of these visual presentations. (Artto et al., 2011.) Performance Measurement Systems (PMS) are instruments that can give support to the decision making within various projects. PMS can be seen as multi-criteria support instruments that can support project managers in decision making by utilizing large quantities of project information. (Lauras et al., 2009.)

Project related stakeholders, such as testers and designers, need information related to their individual deliverables, work and contribution effecting the progress of the
project. Team leaders and coordinators need their share of the project related information to support their work. Department heads require program and project related information and metrics to form a picture on a higher level to various programs and projects. (Ebert, 1999.) Status variation can be defined as a gap between the baseline and the actual project performance. Reaching, or at least moving closer, the goals of a project is certainly essential, but it also requires an analysis of the path followed and choices made concerning the project. (Marques et al., 2011.) Clearly, many stakeholders need project related information and metrics for gaining immediate insight to various levels of the project, especially if targets are missed or the project exceeds given budgets or timeframes. Thereby, it is extremely important to have an easy access to the multiple levels of information. (Ebert, 1999.)

Current studies mostly focus on the financial control tools of monitoring and controlling, but one way of measuring project performance is paying more attention to the Earned Value Analysis (EVA) of the project. EVA is one of the most commonly used managerial control tool in the industry and it can be also linked to the Decision Support Systems (DSS) and project management related software development. EVA is a managerial methodology that uses monetary units as a basis to communicate the overall progress of a project. (Hazir, 2015.) According to Acebes et al. (2014), Earned Value Management (EVM) is based on three measures:

1. Budgeted cost for the work that was scheduled (planned),

2. The actual cost of work performed

3. Earned value

The fundamental in EVA is to compare the budgeted and actual values of the work that has been performed, but also taking into account the costs that incurred and the time that was spent. This methodology is used to evaluate the current project progress, but also to predict the project duration and total costs of the project. (Hazir, 2015.)
Complex measures that efficiently capture the essence of the subject, often require an expert to operate them. Thereby, project managers are in many cases reluctant to allocate scarce recourses in projects to hire various analysis experts. To address this problem, there is an increasing need for solutions that are able to model complex analysis and perform simply. (Diekmann 1992.) Project performance reports based on manual inputs to produce metrics is often inaccurate and faulty when it is recorder by individuals that are under time pressure of delivery (Ebert 1999, 19). New methodology and tools are required for project managers to monitor and control projects under high uncertainty. It is crucially important for project managers to know whether their project is running behind or ahead of schedules and if the project is on budget or not. This information comes from comparing the planned (baseline) and actual values of various aspects. (Acebes et al., 2014.)

2.2.2 Technical controlling

Formally, project monitoring and control systems are used to detect and minimize the deviations from the project plan and baseline. Control systems consist of identifying, measuring and reporting the status of the project, but also from analyzing deviations and implementing appropriate mitigation plans. (Hazir, 2015.) Technical controlling in this context, can be defined as managing project activities related with identifying, measuring, analyzing and interpreting various project related information to support project planning, tracking, decision-making, cost management and overall strategy formation (Marques et al., 2011). Decision making in projects based on metrics and technical controlling is more accurate and reproducible in the long run, compared to the more intuitive based managing approaches (Ebert, 1999). Probabilistic measures are recognized to be more beneficial by most project managers rather than using single-point estimates. However, probabilistic measures are often too complex for the normal project personnel to understand. (Diekmann, 1992.)

By setting formal objectives for quality and resources in a measurable way, is the single best technology achieving control over deadlines, resources and other deliverables. Technical controlling is in key-position when improving current
operational excellence in projects management to ensure that problems are not only detected and corrected through the metrics integrated to the system, but also eliminated from the beginning. (Ebert, 1999.) However, management procedures that are understandable by the project personnel are in many cases too simplistic to capture the nature of complex situations (Diekmann, 1992). The failure of various projects is not in many cases caused because an incompetent project manager or by designers working in the projects. Instead, the main cause of failure is many times related to the wrong management techniques and to the lack of technical controlling within the projects. (Ebert, 1999.) Also, by observing projects in a broader and more complex context it can be found that new perspectives, methods and solutions are required for project management purposes (Artto et al., 2011). One major issue encountered by management is the difficulty of integrating and analyzing the information collected, generated and stored in the database used by various parties of the projects (Shtub, 1996).

In today’s rapidly shifting and changing competitive environment, organizations must consider multiple alternatives in decision making. Technical controlling with the help of various information systems are suitable application areas for supporting project managerial needs. (Hazir, 2015.) Project related estimations and forecasts should not be based on individual judgement for their highly subjective nature. Instead, these estimates and forecasts should be relying on historical data and on average performance indicators based on the recorded metrics and technical controlling. (Ebert, 1999.) The importance of project management and control activities is highlighted nowadays, when companies are operating in a dynamic environment where requirements, processes, priorities, tools and even partners are continuously changing. Furthermore, having up-to-date project status related information available is critical for completing project management activities effectively and ensuring project success. (Hyysalo et al., 2006 via Hazir, 2015.) A project’s success is not only affected by the content of the technical, social and financial matters, but equally by the project management practices, methods, tools and techniques that are common success factors in all various projects (Artto et al., 2011).
When complexity in projects increases, the possibilities and interrelations become so fuzzy that the process must be supported by appropriate tools. Project managers facing complex projects need access to tools that can support the decision-making in projects, but also assist on the project performance evaluation. Thereby, complex decisions need support from advanced tools that can assess substantial amounts of project related information. (Marques et al., 2011.) There is an increasing managerial demand for visual interactive solutions that include appropriate data presentation formats to simplify project related decision-making and controlling (Hazir, 2014). This decision support requires the ability to characterize the current state of the project, but also evaluate the project performance. However, various project stakeholders do not have always aligned needs in terms of performance evaluation and thereby, multiple distinct reports are needed to serve the needs of these stakeholders. Controlling the elementary components of the iron-triangle (Cost, time and quality) alone are not sufficient enough to meet all needs but instead, more advanced solutions are needed. (Marques et al., 2011.)

2.2.3 Project management information systems

Ever since the beginning of the computerized age in the 1950s, software solutions and packages have been important tools for project planning, scheduling and controlling (Archibald, 2003). As competition is becoming more and more fierce in the modern markets, firms are seeking for excellence in accomplishing all project related tasks and activities by increasing coordination, monitoring and control with the help of various techniques, tools and information systems (Hazir, 2014). Project Management Information Systems (PMIS) consist from documents that contain project related information, but also from procedures related to the document preparation, preservations, maintenance and utilization. These procedures are used for creating, planning and executing projects within various organizations. (Archibald, 2003.) Project management information systems are software solutions that help project managers to monitor, track and control their projects from the initiation to the execution. Currently, many organizations have “disconnected”
solutions (unintegrated) in use, that are not designed for managing complex and large projects. (Braglia & Frosolini, 2014.)

Project managers have to consider many things and alternatives in their decision making before deciding on how to act. Data presentations and visualization are essential elements of the decision-making process that make it easier for the project manager to generate, modify and analyze various alternatives. (Hazir, 2014.) Computer-based software packages are crucial elements of modern day project management information systems. Automation in the handling of enormous amounts of highly complex and interrelated project information in dynamic and technology-driven environment, is a highly complex task for the modern-day project managers. However, the technology development of project management software’s has made it possible to effectively use integrated project management information systems. (Archibald, 2003.) Project management information systems are widely referred in the field of project management as a crucial building blocks in the project management of today (Ahlemann, 2009).

PMIS offer project managers support in planning, organizing and controlling projects, but also in the overall project decision making (Caniels & Bakens, 2012). Multi-criteria support systems make it possible for the project manager to analyze multiple criteria related to decision-making and to incorporate the preferences of the decision-maker into the analysis (Marques et al. 2011). Furthermore, PMIS enable individuals and teams to track project progression, but also provide crucial insight to the project related information, such as: schedules, budget, resources, suppliers, time, costs, quality and documents. Therefore, PMIS increase efficiency of projects by making development cycles, task completion levels and overall project status and progression more visible. Furthermore, PMIS help project teams and other contributors to stay up-to-date by enabling coherent flow of information. (Braglia & Frosolini, 2014.)

Nowadays, most of the project related documents can be managed electronically and created automatically. Electronic project related files and information can be easily created, updated, stored and manipulated. Vide range of reports, graphs, charts and formats can be easily produced in these electronic solutions. (Archibald, 2003.)
These visual and interactive capabilities supporting project related decision-making are increasingly embedded to commercial software solutions in the markets (Hazir, 2014). Project management related software development automating all of the PMIS documents consist from many packages, such as: resource planning and control packages, scheduling packages, risk analysis packages, documentations control packages etc. These packages are combined with various reports and other graphic output generators. (Archibald, 2003.) One core process of PMIS’ is human resource allocation. Managing the human resources is not an easy task in large and complex organizations, when also considering the various expertise requirements in multiple projects. (Silva & Costa, 2013.) However, the focus of the PMIS is no longer only in resource management and scheduling alone. Instead, the aim has been in creating a comprehensive system that can support the entire life-cycles of projects. (Ahlemann, 2009.)

PMIS can indeed provide substantial support for the project managers in project planning, execution, monitoring and controlling. PMIS are also found to have direct linkage to the project success as they increase the project budget control and assist in meeting project schedules. (Raymond & Bergeron, 2008.) However, many organizations use various tools (e.g. spreadsheets and paper based data collections) that are not sophisticated nor sufficient enough to manage complex projects. Many organizations are also unaware of the possible benefits that can be gained by using advanced PMIS. (Braglia & Frosolini, 2014.) One main problem causing projects to fail is that problems are often detected too late to be corrected. Clearly better tools are needed to detect and give early warnings on project risks before they actualize. Project management software systems help to identify risks related to products, processes, phases, tasks and organization. (Liu, Kane and Bambroo, 2006.)

Numerous of PMIS are available in the markets and it is up to the organizations to evaluate which one of them suits their organizational needs and necessities the best. Furthermore, tailored solutions are provided for companies to meet their distinct needs. Therefore, PMIS vary significantly depending on the solution provider, but also based on the type of project that they have been created to serve. (Braglia & Frosolini, 2014.) PMIS are expected to develop towards more integrated and extensive adaptation of web-based or cloud computing tools (McCullen, 2009 via
Braglia & Frosolini, 2014). In information system development, several stakeholders need to be involved, such as future system users, organizational management, internal- and external professionals. This development work can be difficult, as people have different backgrounds, technical skills and personalities. (Sakka, Barki and Cote, 2016.) Project-based organizations are facing new challenges as project management information systems have become more complex. Various stakeholder needs need to be taken into account, several processes need to be considered and software systems, to meet these requirements, carefully selected. (Ahlemann, 2009.)

2.2.4 Decision support systems

Decision support systems, DSS, are computer based systems that can provide substantial support for project decision making by combining and analyzing data, but also in providing analytical models and solutions that can make selection between various alternatives easier for the management (Hazir, 2015). According to Shim et al. (2002), DSS solution design is a combination of three elements:

1. Sophisticated database management capabilities with internal and external information, data and knowledge.

2. Modeling and simulation capabilities accessed by a model management system.

3. Easy to use user-interface that enables interactive reporting with graphical visualization and functions.

The role of decision support systems is to replace the subjective consideration and decision-making with objective ones (Hadad, Keren and Laslo, 2013). DSS might include several subsystems that provide advanced support for decision making. Various combinations of the DSS can be created by combining various subsystems: e.g. it might include both data-driven and model-driven subsystems. Distinction between automated decision systems and decision support systems should be made: automated systems make decisions in routine in well-structured situations. On the
other hand, DSS is meant to assists decision-makers in more difficult and semi-structured decision situations. (Power & Sharda, 2007.)

Model-driven decision support systems can assist project managers to make better decisions and choosing between several alternatives by utilizing analytics, financial information, simulation and optimization models. (Power & Sharda, 2007). One essential part of project management is planning. A lot of planning goes into the project initiation and these plans are often based on various assumptions related to some internal- and external stakeholders, such as the performance of the project team and availability of management support during the project. There is always inaccuracy in these assumptions and therefore, continuous monitoring and controlling is required by the project manager to keep track on the plan and the actuals. (Plaza & Turetken, 2009.) Model-driven DSS is designed to provide support for project managers to manipulate model parameters and to conduct ad hoc analysis. Several categories are included to the decision support systems: model-, communication-, data-, document-, knowledge-, database-, architecture- and user interface driven DSS. (Power & Sharda, 2007.)

Spreadsheet-based DSS is one important aspect that enables technologies and solutions to utilize model-driven DSS. In many cases, spreadsheets are created using tools that can contain substantial amounts of structured information; Microsoft Excel is perhaps the most commonly used solution for creating spreadsheets. Spreadsheet-packages can be said to be DSS generators. (Power & Sharda, 2007.) These systems with visual variance graphs and numerical tables are found to be an efficient addition to support project related decision making (Hazir, 2014).

Communication-driven DSS utilizes communications and information technology in the system to support shared decision-making. Data-driven DSS draws files from other systems and also includes data warehousing, management reporting systems, analysis systems and Executive Information Systems, EIS. This DSS enables the manipulation of large base of data that have been structured. Document-driven DSS is designed to support project decision making by integrating document storage and process technologies and by providing a sophisticated document retrieval and analysis support for the managers. Knowledge-based DSS recommends actions for
the management based on the data and knowledge that has been stored using Artificial Intelligence (AI) or other statistical solutions. (Power & Sharda, 2007.) Many project specific management tools have been developed with the help of IT systems and solutions during the past years. These computerized solutions have been developed to support the management of finances, resources, customer relations, risks and many other aspects of the project business. (Aitto et al. 2011, 29.)

Enterprise resource planning (ERP) is an important part of enhancing the competitiveness and sustainability of enterprises to make sure of efficient resource allocation. Initial resource needs and cost estimations rely heavily on the subjective estimates of a project manager, giving the fact that ERP software functions and specifications provide very little support in the initial stages of projects. The difficulty of estimating resources in the initial stages of projects, but also the challenge of retaining experienced personnel with project related knowledge requires more sophisticated solutions to support the project management work. (Chou, Cheng, Wu and Wu, 2012.) With the growth of Enterprise Resource Planning (ERP) solutions, supply chain management has become a large part of decision support applications within various organizations. With ERP, it has become easier to access data needed to model supply chains. (Hazir, 2014.)

Collaboration support systems or Group Support Systems (GSS) can be utilized to enhance the communication activities of project stakeholders. Web-based GSS can enhance the cooperative work of teams in communicating and coordinating activities. GSS also play a significant role in enhancing the communication of virtual teams. (Shim et al., 2002.) The best and most efficient workflows are created based on prior projects and the inputs of the most experienced managers, so that even the less experienced project managers and team members can get easily started in creating their project plans. However, the danger in this approach is having too much standardization and established routines that can smother creativity and continuous improvement. These templates should be used to make project initiation, planning, execution and monitoring & controlling easier, but simultaneously looking for better ways of doing things. (Archibald, 2003.) DSS should act as an early warning system to trigger corrective actions as a response to project deviations (Hazir, 2014.).
Combining project scheduling, resourcing, information sharing, controlling, coordinating etc. are all related to effective project management, but also to the usage of advanced DSS’s. These commercial solutions should include early warning mechanisms for projects, but they should also provide an easy-to-use solution for all project related stakeholders and contributors for easier project manageability. Integrating project management activities and functions with the advanced software systems with user-friendly interface design are very challenging but important issues when talking about advanced PMIS. (Hazir, 2014.) Project managers rely heavily on reliable project monitoring systems or tools when maintaining the project network and monitoring the project related costs, time and quality for the whole duration of the project. These assisting tools or systems can provide timely signals or notifications when project faces problems, or the actual project schedules or costs differ from the planned. (Xiaoyi, Dai and Wells, 2004 via Marques et al., 2011.)

Integrated project management information systems are increasingly being recognized as the fundamentally correct tools required for managing project like efforts in various organizations (Archibald, 2003). Multidimensional Project Control Systems (MPCS) offers a quantitative approach for identifying and analyzing deviations between the planning and execution phase of a project. The current state of a project must be analyzed and monitored through a set of yields that represent the gap between the planned and the actuals. (Rozenes, Vitner and Spraggett, 2002.) Furthermore, organizations need information systems and business management systems to automate, optimize and enhance workflows, but also to improve quality in every business activity and to standardize & control processes (Tarantilis et al., 2008). Fully developed software can provide substantial support to project related decision making, but also provide automatic reminders to the project team and relevant stakeholders concerning strategic points or changes during the project life cycle (Conroy & Soltan, 1997).

A large amount of the today’s IT software solutions focuses only on a specific task like planning, monitoring, estimating, designing etc. These stand-alone solutions have no integration with other solutions and no communication linkages. Thereby, there is a lack of integrated solutions that can facilitate a smooth flow of information, not only between the various solutions, but also in various stages of the project.
Advanced PMIS will continue to gain power when automated integration with other information systems are developed within organizations. Multi-project planning, monitoring and controlling systems will become more common as technology advances to cover teleconferencing, multimedia concepts with combined text, data, graphics, pictures, full-motion video and touch-screen accesses. This development will enable managers from chairman down to access and evaluate their multi-project PMIS files, but also enhance the project team planning and execution no matter how geographically widespread the team is. This future development will also enable project management training with simulated real-life situations and examples in the system, but also the project planning, scheduling, monitoring and controlling by capturing the total experience of an organization or even industry. (Archibald, 2003.)

The dramatic increase of the project management related software development, combined with the decreasing costs of these solutions, have spurred a remarkable interest in these applications reducing the gap between the theory and practice in project planning, scheduling, monitoring and controlling. The struggle of manually creating and updating project related plans, schedules and other templates is significantly reduced by the benefits of computer based project management information systems and solutions. (Archibald, 2003.) Monitoring through project management software is an essential tool in ensuring that the project progresses according to the planned budget and schedule, but also that quality expectations of various stakeholders are met (Hamzah & Mazni, 2017). Project simulation systems is used to sample activity costs and durations to provide and understanding to the complex, dynamic and stochastic behaviors of projects. Throughout the simulation, the overall project costs and completion times can be estimated. Visual representations of project data are often required by the project managers to support their decision making between various alternatives. These visual representations with interactive capabilities are increasingly being added to the commercial project management solutions. However, the demand for more interactive, visual, integrated and dynamic project management information- and support systems still remains for easier project execution, monitoring and controlling. (Hazir, 2015.)
2.2.5 Project management digitalization

One of the most important development trends in modern day has been the utilization of the internet, which also offers an unlimited platform for many solutions and services. The internet also provides possibility to transfer information quickly and accurately, but also in a way that can be traceable. (Alshawi & Ingirige, 2003.) As technology has developed in the past years, it has enabled to build decision support systems via internet to the web (Power and Sharda, 2007). The evolution of the stand-alone decision support systems has been transforming to more web-based solutions where information sharing and decision-making within global teams have been made possible. The DSS technology has significantly developed due to the possibilities and opportunities provided by the World Wide Web: browser servers have made the decision-making processes more efficient, faster and more widely used. (Shim et al., 2002.)

The emergence of the web-based cloud environment is an extremely important aspect in the DSS development, but also as a delivery platform for many solutions (Shim et al., 2002). The web-based solutions enable seamless data access for the authenticated users from anywhere, at the right time and in real time without the need of specific software installation (Tarantilis et al., 2008). Another crucially important aspect of the benefits of the web-based DSS is that, they reduce technological obstacles as well as make decision making easier between managers and stakeholders in geographically distributed organizations. They also reduce the costs of the DSS solutions, as they are web-based and require no software to be installed to the computers of the users. (Shim et al., 2002.) Most commercial project management software solution have some types of document-based data exchange and it is all underneath a umbrella of web-based project management (Alshawi & Ingirige, 2003).

A major trend of the DSS development is the web-utilization of the solutions in increasing collaboration and interactivity of the solutions, but also making the solutions available online and in real time (Shim et al., 2002). Through the availability of the web-based solutions, integration in management can be gained with superior security, reliability, testing, manageability and overall effectiveness.
Increasingly powerful data mining tools, statistical tools and artificial intelligence have enabled more sophisticated and “real-time” data analysis (Shim et al., 2002). These modern systems are called web-based-DSS. Web-based means that the entire application is build and implemented using web-technologies and cloud-servers. (Power & Sharda, 2007.) The web-aspect of the solutions provide significant addition, as the solutions are distributed through cross-platform, interoperable and highly pluggable web-service components. These web-based solutions often include a powerful workflow engine that can manage entire process event flows increasing control and efficiency at the same time. (Tarantilis et al., 2008.) This development has also made DSS technology more user friendly as solutions have been made easier to understand and use (Shim et al., 2002).

Cloud computing enables many web-based solutions and services to be delivered through internet (Chen et al., 2015). Two crucial advantages can be gained through web-based solutions: significant cost reduction of the solutions and the ease of integration through hosted application models (Tarantilis et al., 2008). Web-based DSS is a crucial element of making the solution more available to larger user group. Web-technologies should be increasingly used to implement the various aspects of the DSS. With the help of web-based DSS, there is no need to store any solution software on the desktop of the users; an internet connection will deliver the solution and support to the user. (Power & Sharda, 2007.) Web-based solutions are usually more efficient, less expensive and currently they have been the target in the development work of most of the solutions. Furthermore, recent development in both telecommunications and network technology has significantly increased the capacity and efficiency of the web-based solutions and enabled to unit different managerial focus areas into more manageable entities. (Tarantilis et al., 2008.)

A new generation of various web-based and model-driven decision support systems has started to emerge in the markets and these solutions widely utilize the web-service concept in their tools and solutions. Multiple DSS subsystems from several sources can used in the same time in an aggregated or summarized form. (Power & Sharda, 2007.) The structure of these solutions is entirely modular, extremely flexible and separable: no module or component of the solutions are necessary for the application’s operation (Tarantilis et al., 2008). Large data warehouse’s make it
possible to utilize accumulated historical data in analyzing and decision-making. One aspect of project management related software development is the online analytical processing, that enables managers and other contributors to gain insight to the project data. Interactive and quick access is provided in these online solutions to wide variety of project related information (Shim et al., 2002.) Issues that need to be also considered in selecting an appropriate Application Service Provider, ASP, are related to authentication, solution security and payment terms of the solutions. The next generation of the model-driven DSS might include utilizing several solutions from multiple ASP’s in an integrated manner. (Power & Sharda, 2007.)

The user interface of the digital decision support systems is an important aspect that should not be forgotten; design, capabilities and easy user experience are important parts of the solutions functionality and overall success. The user interface includes the aspect of easily inputting values, but also how the fields and results of the solution is understood by the users. (Power and Sharda, 2007.) Major improvements have been made in the user interface with the systems and solutions: on-screen menus, interactive fields, graphic user interfaces and online servers make it possible to share, store and modify information in real time between project teams and contributors (Archibald, 2003) Furthermore, rather than starting each project from a blank computer screen or an empty paper, it is much more efficient to utilize the previous project templates in the initiation and to provide a library of planning solutions that can be selected, adapted and linked to form a new project. (Archibald, 2003.) These web-based solutions are in the heart of project management digitalization; having access to multiple information- and decision support systems without the need of separate software package, enables project managers to have all required information available in a digitalized form on a web-based solution.

In summary, major changes have occurred in the past years in the project management software development and these changes consist from multiple factors. More automated linkages have been created between project planning-, scheduling-, resource management-, cost management-, labor reporting-, document controlling- and product controlling -systems. The shift has also been visible in a larger picture: instead of one, multiple projects are now managed in a common database. (Archibald, 2003.) Continuous improvements have been also made in the graphic
outputs of the systems: time-scaled histograms for people and money, Gantt-charts, time-scaled network plans (showing usage rates and cumulative amounts), project master schedules with integrated milestone and deliverable data, project and organization breakdown structures and other typical graphic presentations of project and business information are available in the most advanced solutions. (Archibald, 2003.)

Highly developed project management solutions enable electronic project drafting tables, where project plans and schedules can be instantly and quickly modified, but also the resources can be allocated by only few clicks of the mouse (Archibald, 2003). Web-based decision support systems should serve as an early warning system that can assist project managers to detect deviations in the project plan and baseline, but also as a trigger for corrective actions. The development of project management related web-solutions is in key position for reducing the gap between the theory and practice of project management, but also in providing better tools for the project managers. (Hazir, 2015.) Digitalized cloud-based project management solution enables individuals to collaborate more naturally and closely all the time. This development also supports the connectivity and usability of virtual project teams. (Shim et al., 2002.)

Digitalization is a concept that is too wide to be described by a constrained and precise definition. (Corracher & Ordanini, 2002). However, throughout the current academic research related to the project management software development, project management digitalization is about utilizing project management information and decision support systems that are operating via internet on a cloud-based server, so that all project management knowledge areas and processes can be managed in a single solution, or in an integrated set of solutions. The difference between the traditional project management software solutions (stand-alone solutions) and the digitalized solutions is that, all data is located in a cloud-based server where it can be modified, updated and viewed in real-time and online. The need for more efficient, more integrated and more user-friendly project management solutions will continue to grow also in the future, when large amount of project related information needs to be easily available, analyzable and utilizable by all project related parties. The
effective use of these solutions will be also a significant determinant for who will strive in the increasingly competitive global markets. (Archibald, 2003.)

The selection process of a best suitable solution to support the project managerial needs of a specific organization can be a demanding and highly complex task. The selection of these state-of-art project management solutions is wide, but these solutions also differ in many ways. (Archibald, 2003.) To compare the software packages available in the markets, several viewpoints need to be considered related to the various project management areas. The software solutions in the markets include resource and scheduling heuristics, and different views are displayed in the tools for more visual views (Gantt-charts, bar-charts etc.). However, there is a great variance among these solutions regarding to the basic usability, but also to the capabilities of the solutions. Furthermore, different project management solutions using the same data, can generate differing results, completion times or predictions for the future regarding the same project. These solutions use different algorithms to process the data and thereby, comparison between the solutions need to be made to figure out the most reliable one. Also, better performing scheduling methods should be introduced by the commercial software solutions. (Hazir, 2015.)

There are multiple steps that can be identified in the selection process of a digital project management solution. Defining the user needs is the first step of beginning the solution evaluation of a specific organization or a company. Sufficient analysis is required to understand, not only the current organizational needs, but also the future needs and desires of the organization. The selection of a feasible solution for a specific organization requires a systematic and throughout approach to ensure that the best possible decisions are made during the process of project management digitalization. Understanding the organizational needs for project management digitalization and completing the solution evaluation carefully is a small investment compared to the negative impacts and costs on the affected projects, if the wrong solution is taken in use because of a poorly managed solution evaluations process. (Archibald, 2003.)
3 EMPIRICAL STUDY -CASE NOKIA

3.1 Background

Over the years, partly because of various mergers and acquisitions (M&A’s), Nokia has developed and taken in use various guidelines, tools, templates and practices to manage different development and R&D -projects. This is also reflected in the diverse ways of planning, executing, monitoring, controlling, communicating, and reporting on the various stages of a wide range of projects. As a response to the lack of unified operating methods in the project execution, a global development project was launched in the Supply Chain Engineering -unit of Nokia to harmonize and further develop project management practices into more clear and manageable entities with a help of various digital project management solutions. Project managers within the unit are also seeking better tools for easier and more efficient manageability of projects. Here digitalization, and the benefits it brings, is in key position; it drives to integration, simplification and improvement of work productivity by supporting the strong Lean-mentality thriving in Nokia.

The Supply Chain Engineering -unit of Nokia is a part of Business Management function, which’s main purpose is to maximize the MN, Mobile Networks, product portfolio value in the supply chain over its entire life cycle. The SCE -unit operates globally, and its key role is to ensure the delivery capability i.e. production, purchasing and logistics capability in the various stages of R&D -projects, as well as enabling production capability throughout the whole supply chain, when products ramp-up to volume production. Supply Chain Engineering consists of various units operating in Europe, Asia and America increasing the valuable diversity of cultures within the organization, but also creating challenges in finding and defining common ways of managing operations.

The empirical part of this research is carried out as an assignment for the SCE-unit. The purpose of the case study is to determine and evaluate the benefits of digitalization in portfolio-, program- and project management, but also in defining “the next generation digitalized toolbox for project managers” in SCE. However, this study is limited to cover only the project managerial aspects of the digitalization
process. Giving the vast nature of the case study, the portfolio- and program managerial aspects are not introduced in this thesis. This case study is delivered as part of a comprehensive "Project Management Excellence"-program taking place in SCE, which aims to develop project management practices, competencies, processes, guidelines, templates and tools. One key-area of this comprehensive development program, was to evaluate various state-of-art digital project management solutions available in the markets, but also to benchmark some of the existing solutions in the other units of Nokia.

The goal of this case study is to evaluate various digital project management solutions available in the markets, but also in defining the “next generation digitalized toolbox for project managers”. The mission is in supporting, optimizing and simplifying project management work, but also in finding a common platform for project initiation. New projects should not be started from the “scratch” but instead, previous project templates should be utilized in the project initiation (Braglia & Frosolini, 2014). The shift from the current project management solutions, heavily based on the stand-alone Microsoft Office tools, to a more sophisticated and digitalized web- and cloud-based solutions could perhaps give the required support for the project managers, but also provide a relief to the project initiation and planning.

3.2 Research questions guiding the empirical study

In this empirical part, the research questions are slightly modified to meet the organizational requirements set by the case company. The assisting research questions guiding the empirical part are as follows:

Q1. What is the current state of project management, and what are the requirements for the digital project management solutions?
Q2. How can project management work be further developed and supported through digitalization, and what kind of digital project management solutions are available in the markets?

Q3. What kind of business benefits can be gained through project management digitalization?

Throughout these supporting research questions, the empirical part will strive to define the current state of project management in Nokia SCE, but also the requirements for the digital PM-solutions. Furthermore, the feasibility of various state-of-art digital PM solutions available in the markets are evaluated from the perspective of the case company. Finally, the business benefits of project management digitalization are evaluated.

3.3 Methodology in the empirical study

The empirical part of this research is carried out in accordance with the qualitative research methods and material provided by Oulu Business School. This research is a empiria driven inductive case study. Thereby, the empirical part gave a strong guidance to the themes presented in the literature review; it was developed inductively during the case study. (Eisenhardt, 1989.) The research data was collected through individual interviews. Overall, 31 project managers within the case company were interviewed. The duration of the interviews varied from 45 minutes to 1,5 hours. The interviews were held within a period of approximately two months: starting from mid-August to the beginning of October.

The interviews involved project management experts working in various levels of the global SCE-unit of Nokia, but also living in several geographical locations in Europe, Asia and America. The interview sessions with the local project managers in Oulu area were held in the premises of Nokia. However, the interview-sessions with the project managers operating abroad, were held through a WebEx video conferencing -system. This enabled face-to-face meetings with all the interviewees.
The interviewees of this study were selected by the guidance of the case company. The atmosphere of the interviews was overall relaxed and open.

All interviews were recorded and analyzed. The interviewees were also requested to make short notes of the key-topics during the interview-sessions to support the overall data collection. Practical examples of the methods, documents and tools used in managing the ten project management knowledge areas (PMI, 2013) were also shared by the interviewees to strengthen the current state analysis. The data collection followed a semi-structured interview method: an open question list was created to direct the interviews and to ensure that all the required themes and topics were discussed.

The current state analysis of the case study is based on the evidence that was collected through the interviews. The research data was structured and analyzed using Microsoft Excel. Theme-based categorization was used to highlight the key-points from the research data. Comparison between the empirical findings and the existing business literature is made in the concluding chapter of this thesis to point out the supporting or conflicting findings and views (Eisenhardt, 1989). In the empirical part, the findings of the case study are presented in detail. Furthermore, the current state analysis creates the foundation for the whole evaluation work that was delivered for the case company.

3.4 Goals and limitations

The main goal of the empirical part is to evaluate the project management digitalization process of the SCE-unit of Nokia. From the case-company’s perspective, the goal is in defining the “next generation digitalized toolbox for project managers”. Like mentioned, the portfolio and program perspectives are not presented in this research even though they were included in the overall evaluation work. The objectives of Nokia are in improving project planning, execution, monitoring and controlling, but also increasing the transparency and predictability of
projects through digitalization. The eight main goals set for the case study are as follows:

1. Make a current state analysis of project management in the SCE-unit of Nokia.

2. Collect & define the requirements and desired features for the digital project management solutions based on the analysis.

3. Benchmark existing digital project management solutions in other units of Nokia.

4. Evaluate and compare the usability of various digital project management solutions based on the requirements and needs defined through the current state analysis.

5. Build demos about the usability of the digital project management solutions to support the overall evaluation- and comparison process.

6. Define the best suitable digital PM-solution for the Nokia SCE, based on the overall evaluation.

7. Make a business case calculation to demonstrate the overall benefits and costs of the best solution.

8. Create a digitalization roadmap to support the solution creation and implementation.

The case study is limited to cover only the project management digitalization process of the SCE-unit. Furthermore, the digital project management solutions evaluated and compared in the case study, were selected according to the strategic linings and intents of Nokia Networks, but also based on the benchmarking that was done in the initial phases of the study. The research data, that was collected and analyzed throughout the individual interviews, creates the foundation for the whole evaluation that was delivered for the case company. The validity of this research is limited by
the timeframe of approximately six months, but also by the resources assigned to complete this study.

3.5 Structure of the empirical case study

The case study of this research was delivered for the SCE-unit of Nokia as a project called DITOX: Digital Toolbox for Project Managers. The DITOX -project was executed according to the project management guidelines of Nokia that are based on the Project Management Body of Knowledge (PM-BoK) -guide provided by the Project Management Institute (PMI). In the initiating phase of the case study, a steering team, ST, was nominated to support and advice the research progress, but also project planning and execution to ensure that all deliverables for each milestone were met. The steering team consisted of eight project management experts working in the SCE-unit. These members have a solid experience in project management, as well as a deep desire to develop the processes and tools within the organization. The progress of the case study was communicated weekly to the relevant stakeholders within Nokia SCE. The quality of the research was ensured in milestone meetings, PM1-PM5, that were set for the case study. The case study consisted of eight key-sections, that are shortly described in the following text. Also, the project schedule and deliverables are shown in the appendix 1.

1. Current state-analysis. The purpose in the first part of the case study, is to determine the current state of project management in the SCE-unit of Nokia Networks. In other words, the purpose was to define how several types of projects are initiated, executed, monitored and controlled currently within the unit, but also how the ten project management knowledge areas (PMI, 2013) are being managed. Furthermore, the tools and techniques of the project managers were evaluated. In addition, the goal was to determine how project reporting is currently carried out within the unit and how much time does it take in average. The current state analysis is based on the individual interviews that were held within the case company. The interviews were semi-structured and the data collection was supported by the notes,
examples and templates provided by the interviewees. The interviews were also recorded.

2. Collect and define the requirements and desired features for the digital project management solutions. This section is closely linked to current state analysis, which also aimed to determine the requirements and desired features for the digital PM-solutions. The requirements that were collected and defined through the current state analysis, gave the foundation for evaluation work that was carried out in the further parts of the case study.

3. Evaluate and compare the selected commercial digital project management solutions based on the defined requirements. The state-of-art digital PM-solutions, that were included to the overall evaluation work, were selected by benchmarking some of the existing solutions within Nokia Networks, but also by the guidance of the case company. The aim was to map out some the best practices and tools that were already used in other Nokia units, to evaluate how well they suited the SCE-purposes. The evaluation was limited to cover three state-of-art solutions available in the markets: Microsoft Project Online, HP PPM and JIRA. Close cooperation was done with the commercial solution providers, not only to communicate the SCE-requirements, but also to evaluate how well these solutions could serve the requirements and desired features of the unit. Each solution was evaluated and scored based on how many of the defined requirements they could meet. “Solution-scores” were defined for each tool to support the overall evaluation and comparison work.

6. Demonstrate solution usability. The purpose of this subsection was to build demos about the usability of the digital project management -solutions that were selected in the initiation of the case study. The demo-sessions were mainly held for the project managers that were interviewed during the current state analysis, but also other relevant stakeholders were invited to join the sessions. The goal of the demo-sessions was to provide an overview of solutions and to show how these solutions could support the project managerial needs of the SCE-unit. The demos were built in close cooperation with the commercial solution providers, and with other people closely associated with the solutions within the case company.
7. Create a business case calculation for the best suitable solution. The purpose in this phase was to identify and estimate some of the overall business benefits that could be gained through the project management digitalization in the SCE-unit. Also, the costs of the digital solutions were identified and estimated. The overall benefits of the project management digitalization process of the SCE, were estimated based on a simple comparison between the benefits and costs. Furthermore, several indicators were calculated to demonstrate the short- and long-term business benefits. It should be noted, that one possible scenario throughout the whole case study was that it might not be beneficial to take any of the digital PM-solutions in use, if it was not found to be beneficial in the long-run.

8. Digitalization proposal and roadmap for solution creation and implementation. The final phase of the case study, was to provide a digitalization proposal for the case company on which solution(s) should be taken in use in the SCE-unit for the project management digitalization purposes. In this digitalization proposal, the final estimation was given for the case company on which path should be taken in the project management digitalization journey, and which digital PM-solution(s) should be taken in use. The purpose of the digitalization roadmap was to create a directional plan and schedule for the solution trialling and implementation. The case study concludes to the digitalization proposal that was given for the case company.
4 EMPIRICAL FINDINGS -CASE NOKIA

In this section, all the phases and findings of the case study will be presented. It begins from the current state analysis of project management in the SCE-unit of Nokia. From the current state analysis, the chapter moves towards the requirements that were collected and defined for the digital project management solutions. These requirements set the basis for the commercial solution evaluation and comparison. From the various phases of the solution evaluation, this chapter concludes to the digitalization proposal that was given for the case-company. Several examples are provided in the text to support the findings, but also to give more concrete insight to the various phases and evaluations that were carried out in this case study. From the case company’s perspective, the goal was to define “the next generations digitalized toolbox for project managers” in the SCE-unit.

4.1 Current state of project management

This subsection explains the phases and findings in the current state analysis of project management in Nokia SCE. In this first part of the case study, also the requirements for the digital project management solutions were collected and defined. The current state analysis was based on the individual interviews that included 31 project management professionals working in various levels of the organization, but also in several geographical locations in Europe, United States and Asia. Most of the interviewees were from the Nokia site located in Oulu, Finland. However, two project managers were interviewed from Asia and five from the United States. All interviewees are working in the SCE-unit and are associated with various kinds of development- and R&D projects within the unit. The purpose of the current state analysis was to define how projects are currently being managed within the SCE-unit, but also what tools and techniques project managers have in use to manage various processes and knowledge areas.

In the interview invitation, the purpose, goals and other practicalities related to the interview-sessions were explained. The main interview questions were also attached
to the invitation so that the project managers could familiarize themselves to the questions, and even prepare some practical examples of the tools, templates and techniques, if they had time. The interview focus areas are also illustrated in the appendix 2. Preparing for the interviews was not mandatory, since the topics were discussed through in the actual interview-sessions together with some practical examples. Fortunately, all the invited interviewees were able to participate in the current state analysis and thus, gave an excellent contribution to the first, and crucially important, part of the case study.

The interviews began with a small introduction round, where the purpose of the interview was again explained, but also some short introductions were made concerning all the attendees. The atmosphere in the interviews was overall relaxed, although each session was recorded. In addition, all the interviewees were asked to make short notes of the main topics discussed during the sessions to support the data-gathering of the current state analysis. The five main interview questions guiding the individual interviews are presented in the appendix 3. Throughout these questions, together with the guidance of the ten PM knowledge areas and five process groups (PMI 2013), a clear picture was formed on how various product- and development projects within the SCE-unit were managed.

The cornerstone in the current state analysis was in clarifying how the ten project management knowledge-areas (PMI 2013) commonly recognized in the project management related literature (integration-, scope-, time-, cost-, quality-, resource-, communication-, risk-, procurement- and stakeholder management) were managed in various projects in SCE. Throughout the interviews, many themes arose concerning the current state of project management in SCE. Also, some of the tools, reporting practices, templates etc. were shared by the project managers to support the data collection and overall picture formation. The current state of project management was defined though the main themes (good and bad practices) that arose from the interviews related to the PM knowledge areas and processes. The research data that was collected, consisted of the interview recordings and meeting notes, but also from the various templates and practical examples that were given by the interviewees. All the research data was collected and gathered to a large Excel -sheet, so that common themes and topics could be identified from the extensive research data.
The overall finding based on the interviews was that there is no digitalized and integrated tool for project management purposes, that could serve all project related contributors and stakeholders. Instead, projects are managed through various PowerPoint, Word and Excel-based solutions that vary heavily between projects and user-groups. These manual and time-consuming templates are being updated and modified on a weekly or monthly basis by the project managers, depending on the purpose of the document. Various PowerPoint and Excel based templates are used to manage different project knowledge areas, such as: risks, communication, schedules, integration, procurement, resources, costs etc. These documents are often located in a cloud-based server, where they are being manually updated and viewed by the relevant stakeholders. Various meetings are being held by the project managers to collect and update the project information from the project team, and other contributors, to these documents. Some of these manual phases in the project execution, reporting, monitoring and controlling can take several hours monthly to update and maintain by the project managers. This time is away from the actual management work.

Besides manually updating various project related templates to follow up the status of the different PM knowledge areas, also some of the reporting practices consist of maintaining and updating several PowerPoint-based reports to serve diverse needs and stakeholders. Updating, maintaining and modifying these templates can take several hours in a month of the project manager’s time away from the actual work. Furthermore, maintaining the project backlog, that consists from all the project related tasks, are in many case managed in large Excel-files that are being manually updated in separate project meetings. The problem with these “stand-alone”-solutions is that they are not easily accessible by the project team, or other stakeholders, and they take a lot of time to be updated and followed by the project managers. Monitoring and controlling project related information can be a highly complex task, when the data is scattered in multiple templates and locations with no automated reports. In addition, having a visibility to the project related status and health (showing project schedules, costs, milestones, risks, latest achievements, next steps, critical path etc.) is extremely important so that the project manager can focus on the right things and plan corrective actions if deviation from the project baseline is detected. Currently, many organizations have unintegrated solutions in use, that
are not designed for managing complex and large projects (Braglia & Frosolini, 2014).

General themes were recognized from the research data that was collected from the individual interviews. Some of the topics, issues and requirements in the current state analysis were extremely context specific and general assumptions could not be made based on these observations. Instead, an insight to the most important themes, topics and issues concerning the current state of project management in Nokia SCE will be given. In addition, the requirements, that were collected and defined based on the interviews, for the digital project management solutions are linked to the main themes of the current state analysis. In total, 68 requirements were defined for the digital PM solutions that would make project management work easier and more professional. All the requirements will not be presented in the text giving their confidential nature. However, the general themes concerning the overall state of project management in Nokia SCE are presented, as well as the most important requirements (non-confidential) for the digital PM-solutions are described. The following themes, concerning the current state of project management in Nokia SCE, summarize the key topics from the research data. It should be noted, that the statements are not direct quotas.

No common collaboration platform.

This is one of the top issues that arose from the individual interviews and it is tightly linked to the project integration management knowledge-area. Like mentioned, there is no integrated and digitalized solution for managing projects in the Nokia SCE, that could serve all project related stakeholders and contributors. Instead, separate tools are being used to manage the work performance data of different PM-knowledge areas. The current tool selection for project managers, together with the desired solution, is illustrated in the appendix 4. The picture visualizes how project managers have several tools currently in use for managing the various knowledge areas, instead of having one integrated and digitalized solution. Having all project related information and performance data located in a single solution could significantly increase the data utilization, but also make it easier for the project stakeholders to stay informed on the project progress and overall status.
**Stand-alone Office-tools dominate**

Almost all the project related reporting and documentation is managed in some sort of Word-, Excel- or PowerPoint-template. In addition, these templates vary heavily based on the project type and user preference. In some cases, these documents are not easily available for the relevant contributors and stakeholders. Latest versions of different documents are said to be difficult to find, due to these documents are located in multiple cloud-based servers. This theme can be linked to many of the PM knowledge areas for the fact that most of the project information and performance data is maintained, managed, monitored and controlled in the Office-based templates. Instead, controlling these knowledge areas should be managed in a more sophisticated solution, so that changes in the schedule-, cost- and scope baseline can be detected more easily and mitigation plan created to reflect the changes. Having visibility to the status of various project activities is in key position of when seeking to detect, monitor and control the possible changes in the project baseline.

**Too much e-mail traffic**

One clear message through the interviews was that, there is simply too much e-mail traffic related to various project that should be decreased. This issue is related to the project communications- and integration management; the communication channels should be planned and developed based on the stakeholder’s information needs, but also to ensure that these information needs are met. Creating, collecting, storing, distributing, retrieving and disposing project information should be managed in a way that will not flood the project stakeholders by irrelevant e-mails. Currently, project managers and team members can receive tens, even hundreds, of e-mails per day and it can take several hours to go through these mails. Furthermore, some project related documents are sent to be updated and approved also via e-mail. Instead, project related information and work performance data of all knowledge areas should be managed in a more coordinated way. The number of communication channels should be limited by the project manager, but also more efficient ways of communication should be evaluated through the digital PM-solutions.
The requirements defined for the digital project management solutions, based on the above topics, are related to many of the PM knowledge areas. Digitalized and integrated collaboration platform is required to serve all project related user groups and collaborators. The digital PM-solution should provide a better visibility to the project related status, health and progress, but also make it easier to detect changes in the schedule-, cost-, and scope baselines. Project documentation quality and availability should be increased by developing the communications- and stakeholder management through the digital PM-solutions. Project related e-mails could be also decreased by doing so. In addition, the most commonly used project templates should be integrated to the digital solutions, so that there would not be a need for the stand-alone solutions that are currently being used. One example is a PowerPoint -template used for weekly project status reporting shown in the appendix 5. This template, together with many others, should be replaced with similar fields in the digital solution so that the project status would be immediately visible for the right stakeholders when updated. The fields in the status report (appendix) include fields and indicators that can be easily included to the digital PM-solutions.

Project related critical path and project dependencies are not visible

This theme is tied to the project schedule management and in more details, to the critical path management of projects. The critical path of a project visualizes the sequence of activities that determine the shortest duration of the project. These activities or tasks in the critical path have typically zero float and thereby, knowing these activities and dependencies is extremely important if the project is to be on schedule. Having visibility to the project critical path enables the project manager to focus on the things that have to be monitored and controlled more tightly in order to maintain the schedule baseline. Also, knowing the critical path enables PM’s to act more quickly if changes occur in the schedules. Different techniques (e.g. crashing, fast-tracking) can be then applied to mitigate these changes (PMI, 2013). In Nokia SCE, the critical path of product-projects in many case consist of things such as: long-lead-time material orders, software, testing solutions, design, build of materials (BOM), hardware, fixtures, build schedules etc. The digital PM-solutions should be able to create the project critical path based on the given time estimates and
schedules, but also help the PM to simulate different scenarios in order to predict the effect to the overall project schedules (positive or negative).

**Too much manual time-consuming work in reporting and no common practices**

According to many of the interviews, there is too much work done manually related to project reporting. Several, partially overlapping, reports are being put together by the project managers to serve various stakeholders. This theme is closely linked to the communications- and stakeholder management knowledge areas of project management. Project managers in Nokia SCE have many ways of managing their projects, but also in reporting their progress on weekly and monthly basis. Common reporting practices should be developed and specific templates should be provided for the project managers. Furthermore, reports should be automatically created and updated based on regular information inputs. Currently, manual and time-consuming PowerPoint -reports are being created, maintained, modified and updated by the project managers to serve internal- and external reporting requirements.

The requirement for the digital PM-solutions is to eliminate the manual and partially overlapping phases in project reporting by providing automatic reports that can be filtered & modified to serve the needs of various internal- and external stakeholders. Thereby, reporting related work should be reduced by standardizing and simplifying the reporting practices. Finally, more visual reports should be provided for the project managers. These reports should be dynamic and highly modifiable & filterable so that different views can be provided according to the need. Status tracking ability should be provided to detect changes in the project baselines. For an example, if there is a new project risk identified in the project, the program manager should be able to track down where is the risk related to and what is the mitigation plan. Throughout these requirements, the goal is in having less work for project managers to complete projects reporting and fill out the required information during the project execution.

**Projects related status is not visible in one place and in real time**
Project status consist of several knowledge-areas, such as schedule-, risk-, cost- and quality management. Determining the project status and identifying the influence factors that create changes in the project baseline is extremely important so that corrective actions can be made by the project manager. Schedule-, cost- and scope-baseline should be compared with the actuals to determine the necessary procedures. Having visibility to the project status is also important in identifying project performance trends and making forecast to the future. Online dashboards with visual status presentation should be available for easier project status visibility. The requirement is to enable the actual, latest estimate and baseline information for projects in real time and online for all related parties when status is updated. Status tracking ability should be provided for better visibility on why some project is in red, who is doing something and what is the mitigation plan. Dashboard of the tool should be easy to understand and it should give a quick and easy view to the project health (e.g. trafficlight visualization), scope and overall progression. Multi-project planning and analyzing should be also supported by the digital PM-solutions. This kind of a project dashboards would also enhance the project communication and decrease the amount of project related e-mails.

**Project decision making is slow and approvals take too much time**

Project related decision making should be made faster by removing the existing overlaps in some of the project related deliverable, task and milestone criteria approvals. This theme is linked to the project communications management knowledge area: document, task and other deliverable approvals should be managed in a way that only the relevant stakeholders receive the request to review & approve the documents with relevant completion evidence. By providing the ability to approve documents, tasks, milestone criteria’s and even project milestones online, the waiting times of approvals could be shortened and decision-making fastened.

The requirement for the digital solution is to provide “push-type” online approvals for faster decision making within various projects. By the push-type it is meant, that automatic notifications and reminders to relevant stakeholders should be send when a document, task or other deliverable should be approved. The approval hierarchy could be shortened, when the document approver(s) can be defined and selected in
the tool so that no irrelevant middlemen are included in the process. Furthermore, by providing the ability to see who has approved each document and when (change history recording), the transparency of the approvals and decisions would be significantly increased. In summary, PM should be able to assign tasks/deliverables for the project team members within the digital solutions, but also the team-members should be able to report the task completion levels in the digital environment. By enabling these online approvals, it could be possible to get rid of the Excel based solutions that currently take a lot of manual work and time from the project manager and the team. This topic is closely linked to the project backlog management ability described earlier. Complex decisions need support from advanced tools and solutions that can assess substantial amounts of project related information and data (Marques et al., 2011).

4.1.1 Requirements for the digital solutions

In summary, several themes can be identified from the research data concerning the current state of project management in Nokia SCE. These themes can be linked to the project management knowledge areas and to some of the requirements for the digital PM-solutions. The complete list of the requirements consisted of 68 requirements, that were used to evaluate the selected digital project management solutions in the further parts of this case study. The requirements covered all the project management knowledge areas, except procurement management. The key requirements for the digital PM-solutions are summarized as follows:

1. Improve transparency, collaboration and knowledge sharing within projects’ teams, contributors and stakeholders. Create an end-to-end solution for managing project information, knowledge areas and processes.

2. Ability to create project workflow automatically based on the project type to support project initiation. Also, ability to utilize previous projects in the workflow creation.
3. Ability to record planned business benefits and track realization. (KPI's)

4. Cost management: provide the ability to rollup actual, latest estimate, and baseline information at the project level.

5. Critical path management ability and visualization: highlight project critical path (e.g. in project Gantt-view). Also, project dependencies should be made visible in the critical path (time based and showing milestones).

6. Data integration to other systems (Office, SharePoint, PowerBI) with simple data export to Excel & PowerPoint functionality.

7. Need to digitalize/import current PM templates, guidelines and workflows. Only one data source for project management.

8. Ability to handle all project types: waterfall/agile, full-scale/lite project, global/local, process/IT/tester/... development projects.

9. Provide real time dashboards with online reviews and approval routines for decision boards and management. Dashboard should give a quick and easy view to the project health, scope and overall progression. Project status reporting included in the tool. (e.g. traffic light visualization)

10. Risk management capability and visualization (e.g. risk-map-view)

11. Provide better visibility of project scope (e.g. project summary for communication). Changes in project scope needs to be more visible and reflected in the actual schedules. Also, impacts to the critical path.

12. Task / backlog management: ability to assign tasks and track completion. Backlog management is one of the key requirements in agile project management. Task/deliverable status reporting included to the tool (including Nokia externals), but also task/milestone approvals should be managed in the tool. Automatic notifications
for relevant stakeholders when task is assigned/approved/rejected. Work and tasks prioritization ability.

13. Resource management: ability allocate resources to the projects but also to follow usage and costs of these recourses. Visualization of the project costs: OPEX and CAPEX information required.

14. Cyper security in place: NDA visibility and access issues

Finally, the overall usability of the digital project management solutions should not be forgotten, as the easy user experience is an important aspect of the solutions functionality and overall success (Power & Sharda, 2007). The requirements collected and defined through the individual interviews were reviewed with the project managers participating to the interviews to ensure quality. The results of the current state analysis, including the defined requirements, were also reviewed and approved by the Steering Team of the case study. The requirements were listed in more details to a Excel-sheet and priority levels & weights were set for each requirement. All the requirements are not presented in this sub-section giving the substantial number of the requirements, but also the confidentiality of some of the requirements. The figure below visualizes the current PM tool selection and the desired solution.

![Figure 2. Current PM tools and desired solution.](image)
4.2 Evaluating state-of-art commercial solutions

A new generation of various web- and cloud-based project management solutions have started to emerge in the markets and these solutions widely utilize the web-service concept in their solutions (Power & Sharda, 2007). Already in the initial phase of this case-study, it was clear that there are tens, even hundreds, of digital project management solutions available in the markets. They could not be all evaluated, nor it would be efficient. Instead, other Nokia -units were benchmarked and three digital project management solutions were selected to the feasibility study - part of the case study: HP PPM, Microsoft Project Online and JIRA. The development from the “stand-alone” -solutions towards a web and cloud -based structures (Alshawi & Ingirige, 2003; Shim et al., 2002) have been also visible in the development of these selected solutions, as they are delivered through the web without the need of installing separate software packages to the computers of the users. Data integration has been also enabled with other solutions to provide more flexibility. This sub-section of the case study, will focus on explaining how these solutions were evaluated and compared in the goal of determining the best possible solution for the SCE purposes.

Microsoft Project Online (later referred as MS POL) had already been selected in another unit of Nokia Networks for their main project management solution to be used. This made it possible to benchmark their work and activities concerning the usability of the solution from the SCE perspective. Hewlett-Packard (HP) had recently initiated their own development project in ambition to include project management capabilities into their digital solution (HP PPM), which had already been used in Nokia for cost management purposes. HP PPM Enhancement -team had a goal of releasing an updated version of their HP PPM -solution by the end of Q1 of 2018, which was also in line with the schedules of this case study. The requirements collected through the current state analysis were communicated to the HP PPM Enhancement -team, so they could be included to the final version of the HP PPM-solution.
JIRA -tool was included to the evaluation process since it was recommended by another unit within Nokia to be further studied. A development project had been also initiated to further develop JIRA capabilities in project management. Close collaboration with this development work was also done to determine which requirements the solution could meet from the SCE perspective. In collaboration with these development projects within Nokia Networks, and together with the commercial solution providers, it was possible to communicate the requirements to the development work of these solutions and simultaneously evaluate, how well these solutions could meet the requirements of the case-company.

In summary, three digital PM-solutions were selected to the feasibility study part of the research, based on the preliminary benchmarking that was done within the case company. This gave the direction on which commercial digital project management solutions should be further studied and evaluated. It should be mentioned that in the process of defining the solutions to be evaluated, several commercial solutions were limited out of the evaluation due their incapability to meet the preliminary requirements that were set for the solution selection (Archibald, 2003). A dozen of various digital PM solutions, e.g. ServiceNow, was already evaluated within Nokia and this information was utilized in the solution selection. In the following sub-section, the evaluation process of the selected digital PM-solutions is explained in more details and the results are summarized in the end. The solution evaluation consisted of three phases: 1. defining scoring method, 2. calculating “solutions scores” and 3. demonstrating usability.

4.2.1 Defining solution scores

In the first phase on the solution evaluation, the SCE requirements defined through the current state analysis, were prioritized and different weights were given for the requirements based on their importance. Requirements should be ranked and separated from those that are absolutely required of the solutions, and to those that are only wished to be included (Archibald, 2003). Points for the digital solutions were given based on the requirement priority levels. If the requirement had a priority
1 status (very important), it was worth 5 points. If the requirement had a priority 2 status (pretty important), then the requirement was worth 2 points. Finally, if the requirement was prioritized as Prio3 (nice to have) it was then worth 1 point. For each digital solution, points were given based on the priority levels of the requirements, but also based on whether the solution could meet the requirement fully, partially or not at all. If the requirement was met fully by the solution, then the priority-points were multiplied by one (x1). If the requirement was met partially, then the priority-points were multiplied by half (x0.5). Finally, if the requirement could not be met by the digital solution, then the points for that specific requirement were multiplied by zero (x0) and assigned for the solution. The requirements divided into the three-priority levels as shown in the table below:

<table>
<thead>
<tr>
<th>Priority-level</th>
<th>Number of requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prio1</td>
<td>55</td>
</tr>
<tr>
<td>Prio2</td>
<td>12</td>
</tr>
<tr>
<td>Prio3</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total amount of requirements:</strong></td>
<td><strong>68</strong></td>
</tr>
</tbody>
</table>

Table 1. Requirement priority-levels

Most of the requirements, 55 out of 68, were defined as priority 1 as shown in the chart above. Eight of the requirements were defined as priority 2, and only one of the requirements received priority 3 rating. After the requirements were divided into the three priority-groups based on their importance, then the solution scores were defined in cooperation with the commercial solution providers and other development projects within Nokia. This phase is also supported by Archibald (2003), as some sort of scoring method should be used to compare and evaluate the solutions.
Figure 3. Solution scoring method

The figure 3. illustrates the solution scoring method. Eight of the 68 requirements are added to the chart to demonstrate how each of the digital solutions scored based on the requirements. The chart is added as a reference and no actuals are presented due to the confidential nature of the information. Based on the requirement weights and multipliers, a solution score was defined for all the digital solutions to see which one of them scored the highest and thereby, fulfilled most of the SCE requirements. The requirement list was viewed and discussed through several times with each solution provider, to get a clear picture on how many of the requirements could be fulfilled by each of the solutions and how.

4.2.2 Demonstrating usability

In this part of the solution evaluation, the main purpose was to demonstrate the usability of each digital PM-solution and thereby, to support the overall evaluation process. The demos were built in cooperation with the commercial solution providers. All the project managers that were interviewed in the current state analysis -part of
this case study were invited to the demo-sessions to get a first glance at the digital solutions, and to provide valuable feedback concerning the overall capabilities of the solutions. This phase of the case study was extremely important, not only in ensuring the quality of the evaluation process, but also in gaining valuable feedback from the potential end-users and initiating change management i.e. positive mindset change towards the new digitalized solution. All the demo-sessions were recorded to serve later purposes of the case company.

Collaboration with HP PPM Enhancement -team had been initiated already in the early phase of case study to communicate all the project managerial requirements collected and defined through the current state analysis. Many sessions took place to go through the requirements that were collected and defined through the interviews. Throughout these meetings, a clear picture was created on how many of the requirements and wanted features could be included to the updated version of the HP PPM solution. Also, planning of the demo-session was started early to support the overall evaluation of the solution. HP PPM -demo session was organized to take place in the beginning on December 2017 and all the project managers that were interviewed in the current state analysis, were invited to join the session held through the WebEx -video conferencing system. Also, other relevant stakeholders were invited to join the session. The sessions were recorded and shared within Nokia Networks so that it can be viewed later on by all the relevant stakeholders.

The HP PPM-demo session consisted of three stages: first the agenda of the meeting was introduced together with the objectives of the case study. Secondly, the HP PPM-solution landscape was introduced by the HP PPM representative. Thirdly, the actual HP PPM-solution was introduced by another HP PPM Enhancement team -member and various features, capabilities and functions of the tools were demonstrated. Finally, time for questions and feedback from the audience related to the HP PPM -solution was reserved in the end. Feedback was gathered from the attending project managers related to the session. This feedback was also taken under consideration in the final evaluation of the solutions.

Close cooperation was also done with the JIRA development project to go through all the requirements that were collected and defined through the current state
analysis. The JIRA demo-session was planned together with the people associated with the solution. Several sessions were organized to plan the demo-session agenda and to prepare related materials. The demo-session consisted of similar stages as in the HP PPM demo session. An overview of the JIRA-solution was given for the attending project managers. In this overview, the basic capabilities of the JIRA-solution were introduced as well as some of the development work that is still ongoing related to the solution. Furthermore, various functions and visualizations were presented in the actual JIRA-environment to give the feeling of the solution for the audience. Finally, feedback of the session was gathered to support the overall evaluation of JIRA.

At this point of the evaluation process, Microsoft Project Online was removed from the final evaluation of the case study due to the decision of the case company. It was decided by the guidance of the DITOX Steering Team that no further effort should be put in building the demo-session of the solution. It should be noted that by this time, there was a much clearer picture on the tool landscape of Mobile Networks, but also how to proceed in the project management digitalization journey. In summary, the demos were built to support the overall evaluation process of the digital project management solutions. The goal was to demonstrate the overall usability of the solutions to support the project management purposes of the SCE-unit of Nokia Networks. Another important purpose of the demo-sessions, was to collect valuable feedback from the end-users of the solutions.

4.3 Business case calculation

A business case calculation was created in the final phases of the case study, to evaluate the costs and benefits of the project management digitalization process within the SCE-unit of Nokia Networks. Furthermore, financial reasoning and justification to the digitalization process were evaluated in this subsection. In the business case, the overall business benefits that could be established by taking the best suitable digital PM-solution(s) in use were estimated. Also, the overall costs were evaluated based on the known cost factors that consisted of license costs,
maintenance costs and other costs related to the solution implementation and training. The internet utilization significantly reduces the costs of these solutions, due to the flexible cloud-based structures (Shim et al., 2002). The benefit calculation - part of the business case was based on hourly estimates. Actual solution costs nor benefit calculations are not presented in this study giving the confidential nature of the information. Instead, some of the key-components of the business case will be described on a general level. The business benefits of the project management digitalization consisted of three estimated streams of productivity increases as follows:

1. Less reporting related work for the project managers and no overlapping reporting. Also, better visibility to the project status and critical path.

2. PM-templates integrated to the digital solutions: no need to update various PowerPoint, Word or Excel -based templates that take a lot of manual and time-consuming work.

3. All project related data stored in one place and in real time: no need to go through different sites and e-mails to find the required project information. Furthermore, online approvals for faster decision making: no need for separate meetings to approve tasks, deliverables, documents or even milestones.

These business benefit estimates can be also linked to many of the project management knowledge areas. The benefit estimates and cost drivers of the business case are described shortly in the following text.

The first productivity increase consisted of the time that could be saved in reporting related work within various projects. The benefit calculation was based on hourly estimates that were collected in the current state analysis, when project managers were asked to estimate how much time did they use in reporting on weekly and monthly basis. Hourly measures were collected through the interviews and the productivity increase was based on the cautious estimates that the project managers would have 25 per cent less project reporting related work through the digital solutions. In addition, time could be saved by the project managers when the project
status is more easily available (project dashboard) and the critical path of the projects more visible. This business benefit can be linked to the communication-, stakeholder-, schedule- and risk management knowledge areas, but also to the process groups of increased productivity in project execution, monitoring and controlling. Having better visibility to the changes in the project baseline (cost, scope and schedule), enables project managers to act more quickly to mitigate the changes.

The second part of the benefit calculation was based on the fact, that project managers used several hours monthly in updating and maintaining various PowerPoint, Word and Excel -based templates to monitor and control different project activities. The hourly estimates of this calculation were also gained through the current state analysis, and the productivity increase was based on the same 25 per cent productivity increase assumption used in the calculations. This manual and time-consuming work related to maintaining various project documents, templates and files could be reduced by the digital PM-solutions with less data to be entered to the tools, but also by integrating some of the current templates to the solutions. Assigning tasks could be managed in the digital solutions, but also the progress of these tasks and other project related deliverables could be monitored and controlled more efficiently in the digital solutions. This calculation is closely linked to the communication management knowledge area and more specifically in managing project related information.

The third benefit stream consisted of the productivity increase that could be gained by having all project related information stored in one place and available for all project related stakeholders and contributors in real time. From the individual interviews, it was discovered that project related stakeholders could spend several hours monthly to find correct project data from different sites and e-mails. In addition, deliverable, task and milestone criteria related meetings take a lot of time when various Excel -based checklists are being manually updated and maintained. This benefit calculation was also based on the hourly estimates gained from the project managers in the current state analysis. Cautious estimates were made on the productivity increase that could be gained through having all project related data in one place and in real time. Furthermore, increased productivity could be gained in project decision making by enabling project tasks, documents and other deliverables
to be approved online. Again, this calculation is linked to the communication- and stakeholder management knowledge areas and to the process group of monitoring and controlling.

The cost side of the business case consisted of the license- and maintenance costs of the digital solutions, but also from the evaluation, development and training costs related to the solution creation and implementation. The costs covered licenses for all the project managers in Nokia SCE. These costs were evaluated together with the commercial solution providers to get the exact figures. The business case highlighted the fact, that by taking the appropriate digital project management solutions into use in Nokia SCE, the business benefits would be significantly greater than the overall costs of the solutions. In the calculations, the payback time of this case study was measured, but also the return of investment over the next three years was estimated for the digitalization journey. The actual business benefits of project management digitalization in Nokia SCE remains to be seen, when solution trialling and implementation is initiated. It should be noted that in this business case, the benefit estimates were extremely cautious so that the actual benefits of the case company could be also significantly higher.

4.4 Digitalization proposal

Throughout the various phases of the case study, a proposal was given for the case company on how to proceed with the project management digitalization journey. The utilization of the internet in the Project Management Information System and Decision Support System development, such as HP PPM and JIRA, makes it possible to transfer and share information accurately, quickly, effectively and with superior security and traceability (Archibald, 2003; Alshawi & Ingirige, 2003). The web-aspect of the solutions provide significant addition, as the they are distributed through cross-platform, interoperable and highly pluggable web-service components (Tarantilis et al., 2008). The SCE-unit of Nokia Networks should take both HP PPM and JIRA in use for digitalizing, supporting and optimizing the planning, execution, monitoring & controlling and closing of the various projects and knowledge areas. It
was noted for the case company, that it is still uncertain what is the specific scope of these two solutions and whether these are complementing or competing solutions. The scopes of both solutions should be clarified throughout a solution trialling, before making decision on full-scale implementation. The picture below demonstrates the ideal solution for the case company, and how the solutions are linked to the PM knowledge areas.

Figure 4. PM knowledge areas linked to the digital solution

As shown in the figure, all the PM knowledge areas (PMI, 2013), except procurement management, can managed in the digital solution set. Ideally, HP PPM should be used mainly for managing project related, costs, resources, risks and schedules (project milestones and critical path). JIRA should be used to manage project related task and deliverables as a project backlog. Quality management is also mainly managed in JIRA when documents and other deliverables (even milestones) can be reviewed and approved in the solution. Various boards can be created in JIRA to keep track on the completion levels of various project related deliverables. PowerBI is a reporting tool, already used in Nokia, designed to produce dynamic reports that can be easily filtered and modified based on the user preference. Through PowerBI, data can be collected from various sites and sources to produce visual reports. Integration between HP PPM and PowerBI is already existing, but integration between JIRA and HP PPM should be further studied and developed. Stakeholder and communication management (internal and external) could be
handled through PowerBI, if the integration between the solutions can be created in the further evaluation and trialling.

In addition to the proposal that was given for the case-company, solution trialling should be initiated to determine how various development- and product -projects can be managed in this solution set. The proposal given for the case-company was based on the several phases of the case study: current state analysis, requirement collection, solution evaluation and comparison, demo-sessions, business case calculation and on the overall feedback from the possible end-users. The actual benefits of the project management digitalization process are to be seen and validated throughout the solution trialling. Furthermore, the actual project managerial benefits in project planning, execution, monitoring & controlling and closing remain to be seen.

4.4.1 Digitalization roadmap

A digitalization roadmap was created to support the proposal given for the case company. In the roadmap, the schedule was drafted on how the trialling of these solutions should be managed. The roadmap consisted of five phases: 1. Solution how to apply HP-PPM and JIRA in product – and/or development -projects defined and tested. 2. Make development- and product -project trialling in HP PPM and JIRA to determine how well the solutions actually meet the needs and requirements of the project managers, but also to validate the actual business benefits. First-hand user feedback is to be collected through the trialling from the project managers. 3. Clarify the scopes of the solutions throughout the trialling and determine whether the best solution is a combination of the solutions, or if either one of them should be selected and developed to meet all the SCE requirements. 4. Give go/no go proposal for full-scale implementation. 5. Create an implementation plan (including training materials) for the case company. A picture of the digitalization proposal is not included due to its confidential nature.
4.4.2 Summary of the case study

Overall, the project management digitalization journey consists of several phases that organization need to consider when seeking for a digital solution to support their project managerial purposes. The ending criteria of the case study were met and approved by the DITOX -steering team in the project closing meeting. Digitalization proposal was given for the case-company according to the outcomes of the case study. The goal of project management digitalization should be in providing better tools and solutions for project managers to complete their work, not only in providing more visual reports for the senior management. Furthermore, if the digital solutions provide no additional value to the end-users, it is highly likely that the solution implementation will encounter heavy resistance. Thus, the actual end-users of the digital solutions need to be tightly included to the evaluation, development and implementation work in the project management digitalization journey (Archibald, 2003).

Digitalization in project management drives to integration, work simplification and to improvement in work productivity. Several important benefits can be identified in the development of the web-based solutions as project data can be accessed from anywhere and anytime, but also decision making can be made easier between managers and stakeholders in geographically distributed organizations. Furthermore, the internet utilization significantly reduces the costs of these solutions, due to the flexible cloud-based structures. Having the web-based solutions available online and in real time, has also increased the modifiability and tailoring possibilities of the solutions toward the user needs. (Shim et al., 2002. Power & Sharda; 2007, Archibald, 2003; Braglia & Frosolini, 2014.)

Multiple digital project management solutions are available in the markets and it is up to the organizations, operating in various fields, to evaluate and determine which one of them suits their purposes and requirements the best. Digital project management solutions can provide a substantial support for the project management work, so that more focus can be given to the things that truly matter; project management isn’t just planning, executing, monitoring, controlling and closing.
things but instead, it is also about leadership. Leadership is an aspect that should not be forgotten in the increasingly digitalized world of project management.
5 CONCLUSIONS

In this concluding chapter, the scientific and business managerial conclusions are presented together with the further research topics. The aim of this research was to study digitalization in project management through the existing academic research and literature related to the topic, but also through the case study of Nokia SCE. The main focus was in technical controlling, decision support systems, information systems, software development and digitalization. This study examined both the progress in academic knowledge related to the topics, but also the needs of the practitioners. The main research questions of this thesis were:

Q1. What is digitalization in project management?

Q2. How can project management work be further developed and supported through digitalization?

Q3. What steps can be identified in the process of evaluating various digital commercial project management solutions?

Also, the questions guiding the empirical part were: 1. What is the current state of project management in Nokia SCE and what kind of requirements there are for project management digitalization? 2. How can project management work be developed/supported more through digitalization, and what kind of commercial solutions are available in the markets? 3. What kind of business benefits can be gained through project management digitalization within the SCE-unit?

The scientific conclusions consist from the main points and trends in the field of project management, but also the concept of project management digitalization is defined based on the existing research and literature. In the scientific conclusions, the links between the existing research and literature and the knowledge gained from the empiric case study of Nokia Networks, concerning project management digitalization, are presented. The business managerial conclusions focus on describing and summarizing the key findings that were made through the empiric case-study. These findings consist from the steps that business managers in various
organizations could utilize when seeking to begin the project management digitalization journey. Thus, other companies working in the same field can adapt and utilize the results of this thesis into their own development work. Some conclusions and results can be exploited also in organizations operating in other industries as well. Finally, the further research topics are presented in the end of this concluding chapter.

5.1 Scientific conclusions

Major changes have been visible in the project management related software development and these changes consist from several factors. More automated linkages have been created between project planning-, scheduling-, resource management-, cost management-, labor reporting-, document controlling- and product controlling -systems. (Archibald, 2003.) The shift has also been visible in a larger picture, as multiple projects are now managed in a common database instead of treating projects as separate entities. (Power & Sharda; 2007, Archibald, 2003.) Currently, organizations and companies in various fields have several tools and solutions in use that are not simply sophisticated nor sufficient enough to manage complex projects. Many organizations are also unaware of the possible benefits that can be gained by using advanced information- and decision support systems. (Braglia & Frosolini, 2014.)

One of the most essential development trends in modern day project management solutions, has been the increasing utilization of the internet and cloud-based systems. The utilization of the internet in the Project Management Information System, PMIS, and Decision Support System, DSS, development, makes it possible to transfer and share information quickly, accurately, effectively and with superior traceability and security. (Archibald, 2003; Alshawi & Ingirie, 2003.) The web-aspect of the solutions provide significant addition, as the they are distributed through cross-platform, interoperable and highly pluggable web-service components (Tarantilis et al., 2008). This evolution creates an unlimited platform for many PMIS’ and DSS’, but also makes information sharing, collaboration and decision-making with global
teams possible (Shim et al., 2002). The development has also been visible in the commercial solution development as the so called “stand-alone”-solutions have been shifting towards web and cloud-based structures, that enable seamless data integration also with other solutions and systems (Alshawi & Ingirige, 2003; Shim et al., 2002).

Several important benefits can be identified in the development of the web-based solutions: authenticated users can access relevant project related data from anywhere, anytime and without the need of any software installation to the laptops or computers (Tarantilis et al., 2008). Another crucially important aspect is, that these web-based solutions reduce technological obstacles as well as make decision making easier between managers and stakeholders in geographically distributed organizations. Furthermore, the internet utilization significantly reduces the costs of these solutions, due to the flexible web- and cloud-based structures. (Shim et al., 2002.) Having the web-based solutions available online and in real time, has significantly increased the modifiability and tailoring possibilities of the solutions toward the user needs (Shim et al., 2002). Increasingly powerful data mining tools, statistical tools and artificial intelligence have enabled more sophisticated and real-time data analysis and integration through hosted application models. These web-based solutions often include a powerful workflow engine that can manage entire process event flows increasing control and efficiency at the same time. (Power and Sharda, 2007; Tarantilis et al., 2008.)

The recent development in both telecommunications- and network technology has increased the capacity and efficiency of the web-based solutions, but also enabled to unite large entities into more manageable and integrated solutions (Tarantilis et al., 2008). Multiple DSS and PMIS subsystems from several sources can be used in the same time in an aggregated or summarized form. This has also made DSS and PMIS technology more user friendly as solutions have been made easier to understand and use, but also more visual in appearance and graphics. (Power & Sharda, 2007.) Large data warehouses allow to utilize accumulated historical data in project analyzing and decision-making (Shim et al., 2002). A new generation of various web- and cloud-based project management solutions have begun to emerge in the markets and these solutions widely utilize the web-service concept in their solutions. The structure of
these digital solutions is completely modular, highly flexible and separable as no single module or component of the solutions is necessary for the solutions’ overall operation. (Power & Sharda, 2007.)

In summary, the web-based DSS and PMIS -solutions are in the essence of project management digitalization; having access to multiple decision support systems without the need of installing any software packages to your computer, enables project managers and teams to have all required information available in a digitalized form on a web- and cloud -based solution. The user-friendliness of the digital project management solutions should not be forgotten, as design, capabilities and easy user experience are important parts of the solutions functionality and overall success (Power & Sharda, 2007). Furthermore, rather than starting each project from the “scratch”, previous project templates should be utilized in the project initiation and planning (Braglia & Frosolini, 2014; Archibald, 2003). Continuous improvements have been also made in the visual and graphic outputs of the systems: time-scaled histograms for people and money, Gantt-charts, time-scaled network plans (showing usage rates and cumulative amounts), project master schedules with integrated milestone and deliverable data, project and organization breakdown structures and other typical graphic presentations of project and business information are available in the most advanced project management solutions. (Archibald, 2003.)

Based on the empirical case study of Nokia MN/BM/SCE and the existing academic research and literature, project management digitalization can be defined through the project management information- (PMIS) and decision support systems (DSS) that are delivered and managed via internet on a cloud-based server, so that all project management knowledge areas and processes can be managed in a single solution, or in an integrated set of digital solutions. The difference between the traditional project management software solutions, stand-alone-solution, and the digitalized solutions is that, all data is stored in a cloud-based server where it can be maintained, modified, updated and viewed in real-time and online. Also, in these digital PM-solutions no software is needed to be installed to the computer or a laptop, but also the data can be accessed anywhere and anytime by authenticated users (Tarantilis et al., 2008). The case study on Nokia SCE gives an insight to the steps that should be considered when initiating the project management digitalization journey. Close cooperation is
required with the commercial solution providers to, not only communicate the organizational needs, but also to evaluate the solutions and possibly tailor them according to the need. Digital PM-solutions can provide a substantial support in managing the PM knowledge areas and processes (PMI 2013), but also in increasing organizational efficiency and project managerial professionalism.

As a last point, considering the academic studies and literature and projecting them to the practical requirements of various organizations, a gap between the theory and practice can be identified related to project management digitalization. Organizations are investing significant amount of time and resources in digitalizing project management processes, practices, templates and tools to further develop their operations and increasing efficiency (lean), but the academic support to this development seems to follow behind. More research should be done related to the topic to provide support to organizations, operating in various fields, that are considering initiating their project management digitalization journey. More theoretical approaches should be provided on the steps that need to be considered in this journey, but also further research on the digital project management solutions available in the markets, and their practical usage in project management, could reduce the gap between the theory and practice of project management digitalization.

5.2 Business managerial conclusions

The literature review and the empirical case-study that was delivered for the Nokia MN/BM/SCE, gives an insight to the factors that business managers should consider when seeking to digitalize project management practices, processes and templates to support the management of the various PM knowledge areas and processes. Some of these steps are supported in the existing academic literature, but also new perspectives can be found through the case study. The key business managerial conclusions are presented in the following text.

The first step in initiating the project management digitalization journey, is to understand the organizational needs for digitalization, but also some of the future
desires and needs (Archibald, 2003). Taking digital project management solutions in use can be also extremely harmful, if the organizational requirements are not understood and defined profoundly. Research within the organization must be done to better understand the project managerial needs, challenges and requirements, before starting to look for a digital solution. Evaluation on how the PM knowledge areas are currently managed within the organization, together with the current tools, practices, processes and guidelines is required. Therefore, the first step is identifying what could and should be digitalized in terms of project management. This preliminary evaluation is a small investment compared to the costs on the affected projects, if a wrong solution is taken in use as a consequence of a poorly managed evaluations process (Archibald, 2003).

Secondly, within a large multinational organization, like Nokia, the other units should be benchmarked to determine what kind of project managerial solution already exist within the organization, but also whether these very same solutions could serve the needs of other units as well. In the case study of Nokia, there was a mutual desire to digitalize project management processes, practices and guidelines within various units. However, some units had already begun to evaluate various digital project management solutions available in the markets, and others had already chosen a solution that they were going to take in use based on their requirements. This conclusion is perhaps more relevant for large multinational organizations, that have subsidiaries located in multiple countries and the organizational structure is more complex. Within these large and complex organizations, it is not always clear what kind of tools other units are using due to the autonomous nature of the subsidiaries.

Thirdly, various digital project management solutions should be evaluated in the process of project management digitalization, to determine which one of the solutions can meet most of the organizational needs. Throughout the case-study of Nokia, it was discovered that there are tens, even hundreds, of various digital PM-solutions available in the markets, and these solutions differ in significantly in terms of capabilities, functionality, usability and visualization. Thereby, an effort should be given within the organization to figure out which ones of these solutions available in the markets should be evaluated. Preliminary culling should be done to eliminate the
solutions that do not meet the early phase requirements (Archibald, 2003). One way of determining which solutions should be evaluated, is benchmarking other companies that are operating in the same industry. Commercial solution providers have in many cases listed companies that are using their solution in project management as a reference. This information is available in the websites of these commercial solution providers and can be then used in the early phases to determine which solutions should be evaluated. When the solutions are narrowed down to few selected “finalists”, then demonstrating and testing the usability of these solutions should be initiated to more specifically determine, which is the most suitable one (Archibald, 2003).

When the “finalists” are chosen, a cooperation with these commercial solution providers should be initiated. This cooperation is crucially important, since these companies have experts with the best knowledge concerning the solutions and thereby, the best knowledge where the solutions are capable of. The requirements and desired features should be communicated to the solution providers to determine how various requirements and desired features can be delivered by the solutions. In the case study of Nokia SCE, close cooperation was done with HP PPM, JIRA and MS POL-solution providers. Throughout this cooperation, it was possible to determine how these solutions could serve the needs of the case-company and which requirements could not be met. This cooperation is crucially important when determining which one of the commercial solution meet most of the requirements of the organization. Once cooperation with the solution vendors has been initiated, the solutions should be ranked based on some form. In this task, some sort of scoring method should be used to compare and evaluate the solutions (Archibald, 2003). Setting priority-levels for the requirements that have been defined through the current-state analysis is extremely important. Requirements should be ranked and separated from those that are absolutely required of the tools, and to those that are only wished to be included. These requirements should also include the processes, practices, system functions and characteristics of the organization (Archibald, 2003).

When business management have a rough idea on how various digital and commercial project management solution can serve the needs and desires of a specific organization, then also demos are very efficient way of evaluating how
different project management areas can be managed in the actual solutions, but also how easy they are to use. Building these demos should be in cooperation with the commercial solution providers, and these demos should be shown to the end-users and other important stakeholders to collect their feedback regarding the various solutions. (Archibald, 2003.) Based on the case-study, it is recommended that feedback from the end-users is collected in every phase of the solution evaluation process. This aspect is also very closely linked to the change management concept, when positive attitude is created towards the possible new solutions. Getting people’s support behind the new digital PM-solution is a crucial part of the implementation process. Education regarding the solution should be also initiated already in the preliminary stages.

Estimating the business benefits and costs of the digital PM-solutions is a very important and challenging stage in validating what kind of benefits and productivity increases can be gained within the organization, but also in identifying the costs that are caused by taking new solutions in use. (Archibald, 2003, 310.) In the empirical case study, the benefit estimates of project management digitalization were based on current state analysis. Throughout the analysis, it can be determined how much time different project management functions take time in average. Comparison can be done with the current and future time estimates. These productivity increase estimates can be then compared to the license, maintenance, implementation and training costs of the digital solution. This way the profitability of the investment that is required can be determined, but also to figure out some of the key figures (e.g. return on investment, investment payback time etc.) for the senior-management of a company.

The final business managerial conclusion of this research is that when an organization has gone through the evaluation process of various commercial digital PM-solutions, then a solution piloting or trialing should be initiated to test the solution in actual use, but also to validate the business benefits estimated in the evaluation phase. This solution trialing should be done before making the decision on full-scale implementation. Without testing the solution in this piloting, the risk is that the tool is too complex to use by the project managers or the business benefits that were estimated were too high compared to the actual benefits that can be gained. If
these business benefits were estimated too high and the actuals do not reach the level of the estimates, there is a risk that the investment might not be beneficial for the organization at all. Thereby, caution in the benefit estimation of project management digitalization is in place.

It can be found that there are many aspects that need to be considered when evaluating various digital project management solutions available in the markets. There is also a relatively high mortality rate among software and other solution providers in the markets. It can be extremely costly, if a solution provider suddenly disappears from the markets and substantial amount of effort and resources have been put to implement a specific solution. In this situation, the solution- and user support is no longer available, and the tool will not be updated nor improved in time to reflect the rapid development and changes in technology. This is something that needs to be considered as well in the highly competitive and ever-changing environment of project business. (Archibald, 2003.)

5.3 Further research topics

Project management digitalization is a field that is examined relatively narrowly in the existing academic research and literature. However, digitalizing project management processes and functions is a topic that is increasingly fascinated by various modern-day organizations that are running the business as projects. One aspect that was not included to this study was the organization maturity models, that could be used to determine the organizational readiness for digitalization. These models could be further utilized and studied when defining the current state of a specific organization. Analyzing the organizational maturity is a way of determining whether the target organization is ready for beginning their project management digitalization journey.

Another interesting research topic, also initiated in Nokia SCE based on the case study, is solution trialing/piloting. Furthermore, solution piloting is an extremely important phase before making decisions on full-scale implementation within an
organization. Identifying, defining and examining the steps that need to be considered in the solution piloting is the key in determining how well the digital solution can actually support the project management work (real business examples), but also in initiating the change management towards the new solutions. Key-users of the possible digital solution should be involved to the development work already in the early phases to ensure that the user requirements are understood correctly. Also, evaluating how larger entities (e.g. programs and portfolios) can be managed in the digital solutions is a fascinating topic.

Thirdly, examining how digitalization can support the deployment of new business models is an extremely current and interesting topic. Many organizations operating according to the traditional project management principles and methodology, are increasingly seeking for new business models, that can assist in adapting to the ever-changing business environment, but also in creating additional customer value in a more sufficient manner. Currently, Agile Methodology (AM) has received a large recognition within project management practitioners due to the flexible and effective ways of operating (Hamzah et al., 2017, 1). As agile adaption has been increasing during the past years, many organizations are seeking scaling methodologies to assist in the planning, delivery and tracking progress across teams and units. The Scaled Agile Framework (SAFe) is one of the methodologies commonly adapted by large organizations (Leffingwell, 2016). Examining the relationship between digitalization and various scaling methods is also a topic that could be further examined.
REFERENCES


Archibald, R., 2003, Managing high-technology programs and projects, 2nd edition, John Wiley & Sons Inc, Toronto, Canada


Plaza, M., Turetken, O., 2009, A model-based DSS for integrating the impact of learning in project control, Decision Support Systems 47, 488-499


### Appendix 1. Schedule and deliverables of the case study

**Project Proposal**
- Project charter
- Draft Project Plan
- Draft resourcing
- Risk assessment
- High level requirements

**Project Plan**
- Deliverables list
- Project schedule
- Project resource plan
- Risk register
- Business case
- Deliverables for the next milestone/checkpoint

**Current State Analysis**
- Completed and conclusions drawn.

**Requirements**
- Defined for the digital PM-tools.
- Deliverables for the next milestone
- Project schedule and resource plans updated

**Benchmark existing solutions in NOKIA Preliminary Solution comparison.**
- Project schedule and resource plans updated
- Deliverables for the next milestone

**Demos**
- Built with selected commercial solution providers
- Solution comparison completed and best suitable solution selected.
- Project schedule and resource plans updated
- Deliverables for the next milestone

**Current state of Project Management in SC&PE defined.**
- Requirements and wanted features for the next gen digitalized PM toolbox defined.
- Evaluation of chosen Digiteam tools completed.
- Demos built.
- Digitalization Proposal with Business Case created.
- Roadmap for solution creation & Implementation
- Lessons learned
- PM5+ date agreed

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<th>Planning</th>
<th>Definitions and comparisons</th>
<th>Finalization</th>
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<td>22.11.2017</td>
<td>19.12.2017</td>
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Appendix 2. Interview focus areas

Current State
How are programs/projects managed in terms of progress, goals, risks, schedules, costs, changes etc. according to your view in SCE?

Requirements
According to your view, how can the Project Managers work be simplified, eased and supported more? What kind of requirements there are for digital PM-tools?

Interview Focus Areas

Tools
What kind of tools are being used to manage different PM areas in your programs/projects?

Reporting
What kind of reports and KPI’s are being used to manage programs/projects? How much time they take in average and to whom are they visible to? Is there something that could/should be automated in terms of reporting?
**Appendix 3. Interview questions**

<table>
<thead>
<tr>
<th>Interviewees</th>
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<td>Project Managers</td>
<td>Nokia MN/BM/SCE</td>
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**General info**

These questions are used in the current state analysis of project management in the SCE-unit of Nokia Networks. The interviews follow a semi-structured interview method. The interviews are also recorded.

**Questions:**

1. How are projects managed in terms of progress, goals, risks, schedules, costs, changes etc. (PM knowledge areas and processes) according to your view in the Nokia SCE? What kind of tools are being used to manage these areas and processes in your projects?

2. What kind of reports and key performance indicators are being used to manage projects? How often are these reports composed and how much time they take in average? To whom are these reports and indicators visible to? Is there something that could/should be automated in terms of reporting?

3. Is there something in the processes, templates, tools or procedures of Project Management that is working well at the moment and why?

4. According to your view, how can the Project Manager work be simplified, eased and supported more? Is there deficiency or overlaps in the current processes, templates, tools, reports and procedures of project management? What kind of requirements there are for digital PM-tools?

5. Are you aware of any tools or processes that should be evaluated more / benchmarked in other Nokia organizations to support project management work?
### Appendix 4. Project weekly status report

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<tr>
<th>Project name</th>
<th>Achievements (last week)</th>
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<th>Deviations and issues (previous periods)</th>
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<tr>
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