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**COLLABORATION REQUIREMENTS FOR PROJECT MANAGEMENT**  
**INFORMATION SYSTEMS AND ITS IMPLICATIONS TO PROJECT**  
**KNOWLEDGE MANAGEMENT**

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## LIST OF ABBREVIATIONS AND TERMS

<b>KM</b>	Knowledge Management
<b>PME</b>	Project Management Environment
<b>PMIS</b>	Project Management Information Systems
<b>KS</b>	Knowledge Sharing
<b>GDSS</b>	Decision support systems
<b>CSCW</b>	Computer-supported cooperative work
<b>CPMF</b>	Collaborative Project Management Framework
<b>PBO</b>	Project-based Organization
<b>TBO</b>	Traditional Business Organization
<b>GANTT/PERT</b>	Diagrams used in project management to describe tasks, schedules, resources and progress.

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**ABSTRACT:**

More and more organizations are changing their way of managing projects, switching from a traditional and controlled to a more flexible bottom-up paradigm, where collaboration and knowledge sharing between internal and external project members are critical factors. In addition, the role of technology is increasing in the context of project management due to greater challenges in today's technology-enabled work environment, where technology tools are habitually used for collaboration, communication, and deployment of project management practices

The purpose of this thesis is to identify and analyze current requirements of project management in project-based organizations regarding collaboration and knowledge management, as well as the impact of these requirements in use by practitioners on improving the management of projects.

The research design and methodology were supported by main research questions. In order to collect the evidence to answer the questions a comparative case study approach was selected, which included several project-based organizations in Finland belonging mainly to the IT industry. In addition, the evolution and roadmap of a project management information system was presented and analyzed.

The findings reveal the influence of collaboration and knowledge management to be incorporated in the management of projects through the use of socio-collaborative tools. An integrative project management framework combining these tools is presented.

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**KEYWORDS:** project management, collaboration, knowledge management, social technologies, collaboration technologies

## 1. INTRODUCTION

Due to highly dynamic environments that face modern project management, organizations need more attention in the way projects are being managed and executed. Project management has been shifting from the traditional, restrictive and controlled management approach toward a more collaborative approach, including knowledge sharing (KS), enhanced communication both top-down and bottom-up (Chen et al., 2006). Therefore, managers are required to enforce collaboration between team members, stakeholders and steering groups, and to implement strategies to manage and share knowledge produced in projects.

Indeed, knowledge is a vital resource for organizations (Halme, 2001) and developing the capability to manage knowledge across projects is seen as an important source of competitive advantage for organizations (Bresnen et al., 2003). Lots of knowledge is generated on a daily basis, from project deliverables to project meetings and informal chats. This knowledge is typically lost due to a lack of mechanisms for knowledge capturing, storing and disseminating and for organizational learning, forcing companies to *reinvent the wheel* in every project (Disterer, 2000; Prencipe & Tell, 2001; Sydow et al., 2004).

Due to misleading communication and collaboration difficulties between project actors and improper handling of project knowledge, the risk of project failure is increased. For example, previous reports have demonstrated that more than 50% of projects presented difficulties to succeed or did not succeed at all due to incomplete requirements and specifications (The Standish Group, 2004). Defining requirements is a critical activity and involves complex knowledge transfer processes where stakeholders and project teams need to heavily collaborate and communicate discover what needs to be done (Yang et al., 2008).

As a result, project-based organizations need firsthand access to knowledge about what customers and prospects want and must be able to turn deliver successful products and services. There are currently a plethora of separated tools that can manage and control

certain areas of the project; however, there is a need for an integrated tool to centralize project knowledge. The challenge is to find out these needs to incorporate them in contemporary project management, for increasing efficiencies and facilitate communication and information distribution (Van Donk & Reizebos, 2005).

Although software tools will not eliminate the need for project managers, the emergence of socio-collaborative technologies can enable teams to collaborate more efficiently by creating access to computerized networks that allows real-time interaction, regardless of physical distance. This will reduce project failures, delays and expense overruns attributable to poor communication. In fact, previous surveys of best Knowledge Management (KM) practices have revealed that most organizations implement some kind of technology to connect people and enable their interaction and collaboration. (Handzic, 2005).

For knowledge creation and transfer to take place, organizations need to know how to collaborate. Enhancing project management information systems with socio-collaborative functions can create a collaborative environment to connect people, process and knowledge to improve project performance and add value (Payne, 2008). In fact, different activities such as team coordination, meetings, and execution of tasks can be accomplished via information systems and even dispersed team members can achieve specific team missions without being limited by geography or time constraints. Therefore, it is important to examine closely the collaboration and KM requirements from real organizations for project management, from a technology perspective.

### 1.1. Research areas

Along the thesis, there are three basic areas of research that will be studied and analyzed:

- (1) Knowledge Management, which refers to the holistic way to manage the complex relationship between business and IT. From the perspective that IT is

useful for efficient conversion between data and information but it is a poor alternative for converting information into knowledge, and that conversion from information to knowledge is best accomplished by human actions. However, humans are slow as compared to IT systems for converting data into information (Anantatmula, 2008).

- (2) Social and collaboration technologies, which refers to IT products and services that enable the formation and operation of online communities, where participants have distributed access to content and distributed rights to create, add, and/or modify content (McKinsey Global Institute, 2012).
- (3) Project Management Environment (PME), refers to the organizational settings by which project management is executed. Project management means the application of knowledge, skills, tools and techniques to project activities to meet project requirements and it is accomplished through the implementation and integration of the project management processes of initiating, planning, executing, monitoring and controlling, and closing (Harley, 2009). In addition, the research focus on project management information system (PMIS) as a subset of the project management area, which refers as the tool for project management to support and facilitate the delivery of any project, particularly those which are complex, subject to uncertainty, and under market, time and money pressures, or difficult to manage.

## 1.2. Goals of the study

In harmony with the research areas, the present study emerged from a constant need from organizations to find better ways to manage, be effective and efficient in projects. Therefore, this study will basically focus on providing qualitative evidence and critical analysis to answer the following research questions:

- (1) *What are collaboration needs in contemporary project management? Find out how communication and collaboration works in project environments and what is the impact of these factors for knowledge project management.*
- (2) *Discover what features can be included to project management systems to improve collaboration in the project.*
  - (2.1) Brief comparison of traditional project management systems and online project management systems in terms of facilitating collaboration and KM in project-based organizations
  - (2.2) Identify what state-of-the-art technologies for project management in terms of collaboration and KM are being used by project-based companies.
  - (2.3) Identify requirements or challenges in project management to support collaboration needs for organizations.
- (3) *Find out how current social and collaboration technologies can facilitate project knowledge management.*

### 1.3. Research methods used

Due to the nature of the research questions, a set of qualitative methods were appropriate to be considered for this thesis. After reviewing the literature, it was selected to implement a comparative case studies strategy, which takes into account targeted perspectives from different companies. The researched organizations are based in Finland and belong to the IT industry.

In addition, several data collection techniques were applied for the case studies. The strategy started with the elaboration of a questionnaire, where the questions were built jointly with experts in the area of project management. While semi-structured interviews were carried on to project managers and team members to a group of

organizations, the questionnaire was distributed to another group. Moreover, to complement missing gaps from the interview and questionnaires, several business documents were reviewed.

#### 1.4. Limitations

Few limitations were found during the implementation of the research strategies. However, academic and practical contributions were identified inside the research framework.

At early stages of the research, it was experienced a low response rate of the questionnaires sent to the organizations, restricting the variety of perspectives and increasing the risk of leaving relevant data out of the research. As a result, a combination between theory and research strategies was done. Therefore, the main contribution of this thesis includes a framework that combines methodological and technological aspects relevant for project management.

The aim of the framework is to provide general guidelines for project managers for selecting tools for supporting their projects and, at the same time, for software companies to detect potential features to enhance in development of their project management applications.

#### 1.5. Structure of the thesis

This work was structured according to the guidelines of the Department of Technology of the University of Vaasa. The guidelines suggest to start with relevant literature review, following by explanation of the research strategies, continuing with discussion of the results and conclusions. The chapters developed for this thesis include:

- (1) Knowledge management. This chapter presents relevant literature about the knowledge of this field of study. It includes a basic definition of knowledge and the elements that are involved in the management of knowledge in organizations.
- (2) Collaboration. This chapter introduces the concept of collaboration as an important factor of KM as well as the required elements needed to stimulate collaborative environments. In addition, it reviews the different types of collaboration technologies and the evolution of web-based socio-collaborative technologies
- (3) Project management environment. This chapter starts analyzing the different between project-based and traditional-based organizations together with basic literature about project management. Moreover, it discusses different project management systems and its main functionalities used nowadays.
- (4) Research methods. It presents a detailed explanation of the selection of the case studies used for research, including the techniques and strategies, description of the organizations as well as details of a project management tool, taken as an example of the evolution of these applications.
- (5) Results and discussions. This is the core chapter of the thesis, where it summarizes the findings and formulates a collaborative management framework. The framework is further analyzed by the author, showing the implications to project managers and software development organizations.
- (6) Conclusions. Summarizes the research presenting the connections between theory and practice and it also includes suggestions for future research in this area.

## 2. KNOWLEDGE MANAGEMENT

### 2.1. Definitions

In essence, KM is about making available the right knowledge at the right time (Frost, 2010), in order to stimulate mental processes of knowledge creation to the right person or group to address a particular situation. Therefore, it is important to understand first what the scope of knowledge in this research is and what kind of knowledge is intended to be managed in the scope of project management.

At an individual level, considering the controversies that have emerged from the concept of KM, this research has strongly followed a more realistic and practical approach from the KM field and agrees in the definition that:

*Knowledge is a subset of information; it is subjective; it is linked to meaningful behavior; and it has tacit elements born of experience (Leonard & Sensiper, 1998).*

In other words, knowledge represents what we know and humans may not know what they know until actions at a certain time trigger cognitive process to respond to specific issues. As Wilson (2002), expressed recently:

*Knowledge involves the mental processes of comprehension, understanding and learning that go on in the mind and only in the mind, however much they involve interaction with the world outside the mind, and interaction with others.*

Following the knowledge definition, many scholars have distinguished two types of knowledge for an individual. Tacit knowledge or implicit knowledge –or more practical know-how– which is *hidden* (Polanyi, 1958), resides in people’s perceptions and behaviors (Duffy, 2000), involves an inexpressible process (Wilson, 2002) and therefore is hard to express through words (Nonaka & Takeuchi, 1995). Explicit knowledge –or critically considered as synonym of *information* (Wilson, 2002)– can be formulated in

the form of words and numbers (Nonaka & Takeuchi, 1995), accessible through consciousness (Lindner & Wald, 2011) and can be communicated and shared using information technology (Ajmal & Koskinen, 2008).

Furthermore, from the inclusive perspective defined by Holsapple (2005), which means that knowledge –mainly explicit knowledge– can be viewed in a more tangible way and can be transported by usable representations such as symbols, graphics, sounds, behaviors and other patterns related to time and space. Therefore, he concluded that *all information is knowledge, but not all knowledge is information* and that information represents one of the progression states that lead knowledge creation: data, information, structured information, evaluation, judgment, and decision. See **table 1** for examples.

Knowledge states	Progression sample
Datum	240
Information	240 is the level of cholesterol
Structured information	240 is the current level of cholesterol for John Miller
An evaluation	John Miller's level of cholesterol is now too high
A judgment	John Miller's health is presently in severe jeopardy
A decision	John Miller gets a prescription for Lipitor

**Table 1.** Progression of knowledge states and examples (Holsapple, 2005)

These knowledge states can be even more conceivable and tangible when relating them in an organization level. In this case, knowledge may be viewed as an organizational-level phenomenon, embedded in organizational forms, social expertise bounded to the historical, socio-material and cultural context they occur.

Accordingly, only explicit knowledge can be part of this organization's knowledge base (Lindner & Wald, 2011) and therefore knowledge can be treated as a critical resource and a source of competitive advantage (Swan, 2001; Wu et al., 2006). New

organizational knowledge starts with the initiative of an individual's personal knowledge and the interaction within the group through *discussion, experience sharing and observation* (Nonaka & Takeuchi, 1995).

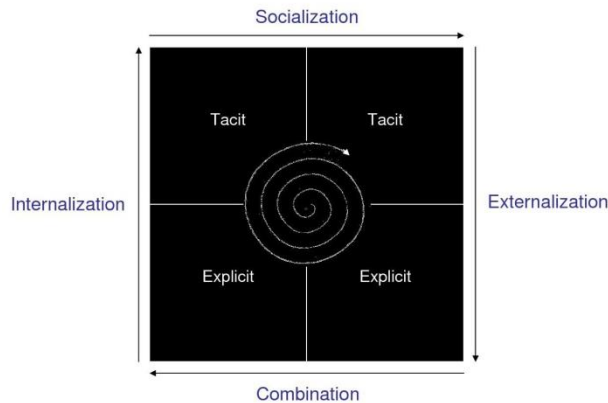
Organizational knowledge is a wide concept that could include all knowledge functions of the organization. Instead, for the purpose of this research project knowledge has been defined as a subset that only involves organizational knowledge bounded to the project.

Differentiating the two types of knowledge will help to identify during the research that every reference regarding knowledge or organizational knowledge is mainly related to explicit knowledge. As mentioned earlier, tacit knowledge is not –yet– easily transferrable or sharable through the use of technologies nowadays, therefore, the analysis of such is out of the scope of this thesis.

## 2.2. Knowledge Management framework

In order to understand the boundaries of the research, a review of the KM framework is presented. Nonaka and Takeuchi (1996) have defined a clear and straightforward model called The *SECI model*, which shows in a simplistic quadrant, key basic concepts for knowledge creation and transfer.

Also referred as the spiral model, it describes a dynamic and continuous cycle in which explicit and tacit knowledge are exchanged and transformed. As shown in figure 1, they point out that this conversion process can be achieved by the presence of four modes: *socialization, combination, externalization and internalization*. (Nonaka & Takeuchi, 1996).



**Figure 1.** The knowledge management spiral model. (Nonaka & Takeuchi, 1996)

In *socialization* mode, individuals transfer tacit knowledge through, guidance, imitation and observation, and practice (Nonaka & Takeuchi, 1996). It is implied that these activities require social behaviors of humans to interact each other and also the closer the exchanging relationship is, the more effective the transmission of knowledge can result.

The *externalization* mode is related to the conversion from tacit to explicit knowledge through a difficult –but important– transformation mechanism (Nonaka & Takeuchi, 1996). This particular process has been widely discussed in the knowledge management literature, stating that tacit knowledge cannot be virtually possible to codify into documents. Instead, what it is made available to other individuals is codified explicit knowledge (Wilson, 2002). This mode may also require human skills and technology intervention to mainly transform what it is inside of an individual’s mind into an understandable format for other people.

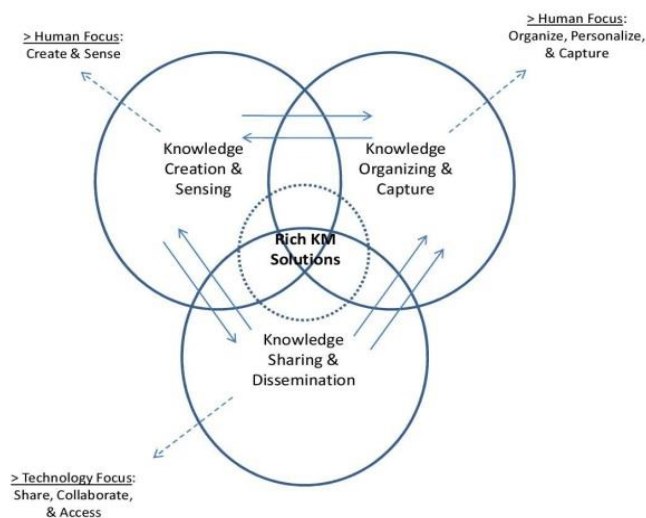
In the *combination* mode, explicit knowledge represented in different forms, such as documents, manuals, etc. can be collected and linked with other explicit knowledge to create new valuable knowledge (Nonaka & Takeuchi, 1996). An important role of technology may be required to achieve this process.

Lastly, the *internalization* mode refers to the conversion from explicit to tacit knowledge, by which explicit resources are used to modify individual’s tacit knowledge

(Nonaka & Takeuchi, 1996). This is also challenging to achieve and it varies depending of individual human understanding. And if technology is implemented, then some technology skills are needed.

All of the reviewed modes are crucial for effective KM, showing how knowledge is shared and created in the organization. The focus of this analysis will be principally limited to the technology aspects of this conversion process.

Consequently, the definition of knowledge management spiral model leads to introduce three key KM perspectives: *human*, *process* and *technology*. Figure 2 shows a simplistic process model to identify the generic components of a KM solution under these key perspectives (Botha et al., 2008).



**Figure 2.** Knowledge Management process model. (Botha et al., 2008)

In the model, it is observed the interconnections between KM activities under their correspondent perspective. Indeed, the KM model has to be embedded into a context of organization, personnel development and system technical infrastructure (Radermacher, 2001).

Even though there have been a numerous debates whether the technology focus has a major role in KM or not (Handzic, 2005), this thesis takes the position that technology

can be used as a facilitator for KM. In fact, in accordance with the model, it is agreed that through technological infrastructure –such as information and telecommunication technologies– KS, collaboration and dissemination can be accomplished.

Particularly, the challenge of this research is to find out organizational requirements that mainly comply with the socialization, externalization and combination modes from the technology focus of the KM model. Therefore, identify technologies that support such requirements to boost the development of organizational knowledge stocks: explicit, know-how, know-what.

### 2.3. Organizational strategies for Knowledge Management

The KM literature has emphasized the importance of management strategies that can be implanted in organization for reaching KM capabilities. The aim is to handle the problematic of dispersed knowledge in organizations as a result of the large numbers of dispersed actors and contexts, individual differences in interpretation and understanding and the variety of knowledge sources in firms that makes difficult to resolve for decision makers (Swan, 2001).

In his paper, he has collected from other scholars, five basic and theoretical management strategies for handling dispersed knowledge in organizations. According to Frost (2010), the strategies initiatives should include investments for supporting and changing organizational structures, competencies, culture and systems.

The *first* strategy suggests developing ways to connect people with similar knowledge-bases and allow access to knowledge by sharing it between them. The *second* strategy aims at finding missing knowledge and performing *tacit repairs* in individuals. The *third* strategy focuses on designing coordination mechanisms to strengthen the relations inside and outside the organization. The *fourth* strategy involves structural organization changes by splitting functional units into smaller sub-units, so that the delivery of knowledge is economized, even though there is a risk to increase knowledge dispersion.

Finally, the *fifth* strategy deals with making information available to decision-makers (Swan, 2001).

These strategies are only general guidelines to be considered in organizations as an initial step to identify requirements for KM. The implementation, however, involves much more complexities such as process changes and technology investments that may affect the entire organization. In essence, it involves *personalization* mechanisms focusing on people and cultural issues to establish knowledge communities, and *codification* mechanisms, using information technology to deal carefully with behavioral aspects of individuals, where knowledge and experiences are codified, stored in databases and easily accessible by other individuals (Hansen et al., 1999).

### 3. COLLABORATION: A KEY FACTOR FOR KNOWLEDGE SHARING

#### 3.1. Overview of the concept of collaboration

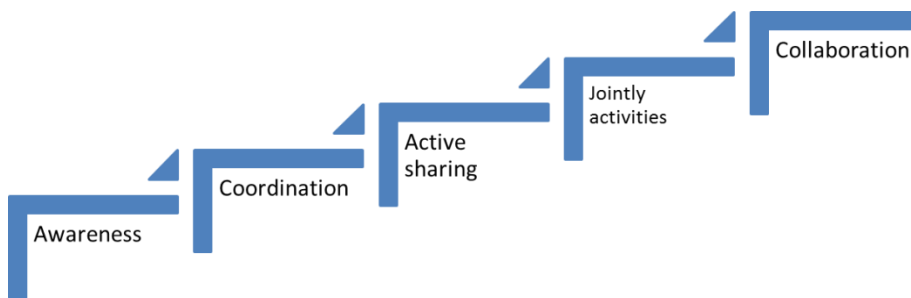
A pool of definitions has been collected in previous researches about collaboration in organizations or project environments. For instance, Harley (2009) distinguishes the concept of participation from collaboration stating that collaboration not only involves the transmission of data and information between people. In addition to this, it needs the intervention of individuals or a group of individuals which interact and establish strong, long-term and persistent relationships to pursue common goals.

Moreover, the collaboration theory points out the distinction between cooperation, coordination and collaboration to avoid misleading uses of the terms at an organization level or better to say, in a project environment (Harley, 2009). Whereas the three concepts involve strong relationships between individuals, complex and structured activities and mission achievement (Chi & Holsapple, 2005), some authors argue that a collaborative environment includes a *commitment to mutual relationships and goals, jointly developed structure and shared responsibility, mutual authority and sharing of resources* (Mattessich et al., 2001).

From this latter description, it can be deduced that the elements to achieve a collaboration process can be restricted mainly by the degree of complexity of these relationships, which at the same time are determined by complexity of business or project activities. As a result, the literature determines four different levels of collaboration (Waltz, 2003), and each level is reached depending on the necessities of the interactions among individuals.

For instance, at the very basic awareness level, the process of collaboration may involve activities related to the publication of information and delivers it to the entire organization or only certain groups. Increasing the level –from coordination to joint

activities– means adding complications incrementally to the collaboration process, so that it requires, among other things, following task schedules, constant sharing of experiences, formation of teams –or virtual teams– and joint analysis or decision-making.



**Figure 3.** Levels of collaboration. (Waltz, 2003)

The latter would imply that collaboration is an important part of the KM episode. Joint activities may also comprise joint intellectual efforts among participants forming communities or teams, who are committed to communicate, share and diffuse knowledge resources to pursue common ends.

### 3.2. Essential elements needed to achieve collaboration

It is not new at this stage to corroborate that through collaboration, it is possible to perform several functions in an organization: coordination of tasks and workflow to achieve common goals; share information, knowledge, beliefs; problem-solving and decision-making cooperatively. In project-based organizations, for example, the process of collaboration can occur in different types of teams, in different context and complexities. Teams may be temporary (project teams) or distributed geographically and have people with knowledge-based roles (managers, planners, analysts, operators). Collaboration across the extensive variety of teams can be achieved by the *establishment of an appropriate environment and collaborative business process* (Waltz, 2003).

In order to support collaborative activities, the development of virtual environments is presented. Collaborative environments involve complex information exchange as a result of individual and group effort, requiring considerable explicit and tacit communication between collaborators. It is fundamental that these collaborative environments provide *means to access appropriate information as well as communication tools*. For example, in project-based collaboration, it is important that collaborators share project plans and goals, task decomposition, resource allocation and current work done in the context of the project goals (Snowdon et al., 2000).

For collaborative environments –virtual or not– to occur and succeed, some authors have identified key elements of collaboration (Harley, 2009; Snowdon et al., 2000). In summary, the most relevant elements for analysis in this thesis are:

Element	Description
Shared context	Share knowledge of current and past activities at an individual level and group level. Share perceptual information of related artifacts and events in a shared environment, where relevant personnel can access, explore and manipulate. The object to be shared, for example a document, becomes immediately a mean of communication between editors. The collaboration environment should provide meeting capture, version control, audits, especially in asynchronous work collaborations.
Awareness of others	Understanding of the activities of others or outside related activities, which provides a context for your own activity. Meaning that at certain time, some collaborators may not be available or don't even work on the shared task and some information is needed from it. In this case, the collaboration environment should provide awareness to other collaborators to adjust project plans, scope and so on.

Negotiation and communication	Discussions are crucial for negotiation and communication, especially, in project environments. Collaborative work needs negotiation for task-related content, structure, activities and resources in order to achieve common understanding and goals. Also, informal conversations are important to establish communication links and collaborative relationships. Collaborative environments make available a variety of channels for negotiation and communication to occur.
Flexible and multiple viewpoints	Related to the visual representation of information generated as a result of the collaborative work. Conversations, shared objects, people's roles and activities should be structured in a clean and organized fashion to allow clear visibility to relevant people.
Interorganizational KS	Distribution of knowledge to other members and integrate knowledge available to them. It is important the creation of linkages among units in an organization through policies, guidelines and standards. Knowledge developed in projects can be copied, transferred or imitated through various communications channels in order to allow multi-project organizations to support different decisions, for example, in resourcing and skills development.

**Table 2.** Essential elements of collaboration. Adapted from: (Harley, 2009; Snowdon et al., 2000)

### 3.3. Importance of collaboration in Knowledge Management

Collaboration is extremely important to create and transfer knowledge and organizations need to know how to collaborate (Payne, 2008). In addition, for collaboration strategies to be implemented, knowledge distribution and integration between partners and team member should be enabled (Halme, 2001). A collaborative exchange of information, ideas, experiences, and insights occurs when the exchange is jointly undertaken and

purposeful, with the expectation of mutually beneficial outcomes. The ability to develop true collaboration relationships –for example in projects – is essential, where each party accept responsibility for their own inputs as well as for the equitable sharing of returns on outputs (Miles et al., 2000).

In the SECI model, it was stated that socialization is a key human behavior for knowledge transactions to occur (Nonaka & Takeuchi, 1996). Social methods such as stories and dialogue are strictly essential for collective learning and problem solving. Moreover, if collaboration is based on a culture of trust, shared values and goals, social behaviors may enable collaboration environments with KS capabilities (Waltz, 2003). Therefore, it is implied that collaboration technologies can be based on socialization technologies.

One of the roles of technology in KM aims to *promoting virtual socialization and collaboration*. Technology boosts KS and group learning by enabling interaction between people (Handzic, 2001). Here, communication and collaboration technologies are used to facilitate communication and regulate interaction depending on place and time of participants. Modern technologies include computer supported meetings, video conferencing, mailboxes, bulletin boards and activity streams. In the case of virtual teams, geographically dispersed people that communicate and collaborate electronically, the use of technology can be beneficial to enable project and management teams to complete tasks, develop communication for coordinating activities and to build interpersonal and social relationships among them (Beise et al., 2010).

This particular role has provoked discrepancies in the KM field about the effectiveness of virtual communication to connect people to interact and collaborate. For example, Bender and Fish (2000) have found out a *decrease of emotions, real and live interaction* when using collaboration technologies in complex environments. Other researchers state that face-to-face or technology-based interactions are effective (Warkentin et al., 1997). In this analysis, we agree in both perspectives, but emphasize more in the latter. Project environments can exploit the benefits of virtual technologies in a way that technology

can facilitate agile connectivity between project team members or other stakeholders when critical situations arise and people are not physically available.

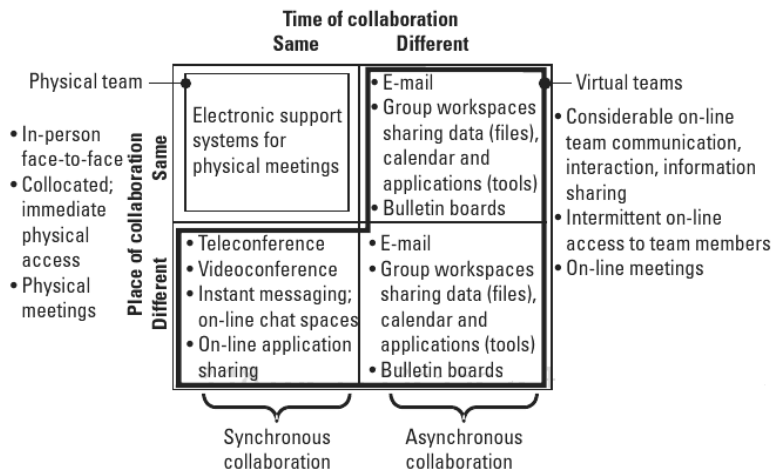
Thus, the main role of KM is not only to build a large electronic library as it may usually be believed; instead it has to connect people so they can think together and constantly build knowledge collaboratively (McDermott, 1999). In this sense, KM integrates process, strategy and technology (Frost, 2010).

### 3.4. Types of technologies to create and support collaborative environments

Collaboration support systems have been categorized according to their primary goals. First, *group decision support systems (GDSS)* provide communication support to help remove communication barriers and reduce *uncertainty* and *noise* from group decision processes. Second, *computer-supported cooperative work (CSCW)* systems emphasize data sharing among participants for specific group tasks (Weiser & Morrison, 1998).

To address these issues, the collaboration theory proposes two basic forms of interaction for collaboration technology: *synchronous* (same time, same place or different place) and *asynchronous* (different time, same place or different place) communication (Yang et al., 2008). These types may give initial directives for team support capabilities of collaboration tools.

Scholars have also classified common used technologies according to the collaboration modes. Synchronous collaboration occurs when participants interact at the same time – video, teleconferences, face-to-face meetings– without necessarily being located in the same place. On the other hand, asynchronous collaboration occurs when participants interact with time delay, at different times –email, bulletin boards– (Yang et al., 2008).



**Figure 4.** Classification of collaboration modes. (Yang et al., 2008)

Groupware is a formal term of socio-collaborative technologies which provides the broad set of tools developed to perform different collaboration modes, both synchronously and asynchronously. They are social tools that can support formal gatherings, capture and record daily interactions in working environments, provide spaces to share explicit knowledge in the form of files and processes, facilitate communication and cognitive support resources for a group to communicate effectively across time-space and decide and produce any artifacts (Waltz, 2003).

Other technologies can also be combined with groupware to create more collaborative environments. For example, content management systems can have content and document management functions to enhance collaboration, productivity and socialization. They act as a repository for embedded knowledge where content and documents can be versioned, published, stored, indexed and retrieved (Frost, 2010).

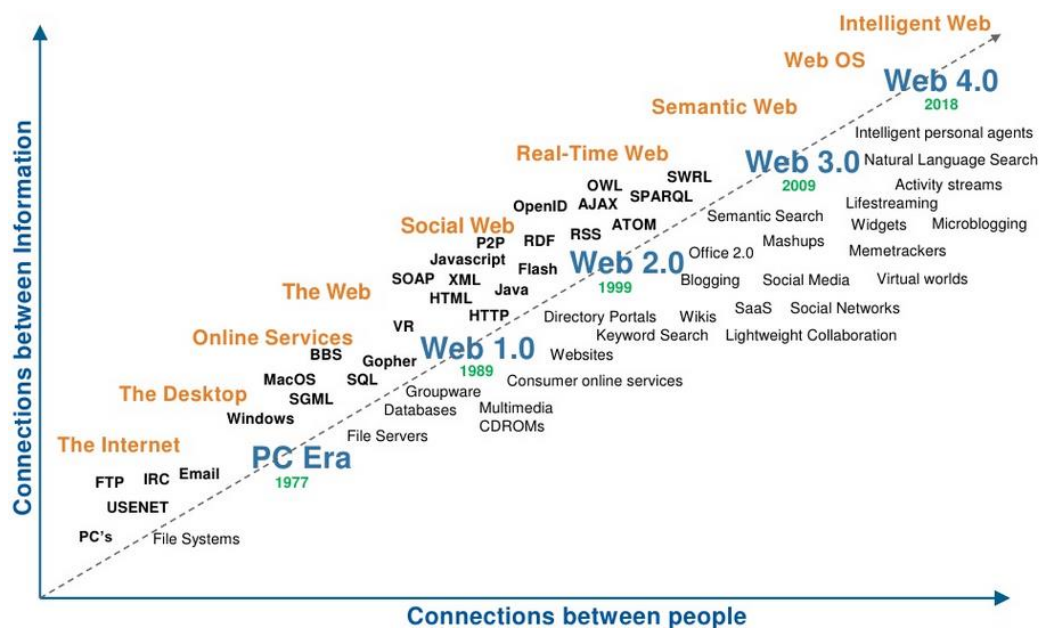
### 3.5. The rise of web 2.0 and socio-collaborative technologies

The basis of new enterprise business models is to deliver anything, anytime, and, anywhere to potential customers by using of technology. Earlier research estimated that 49% of organizations will have invested in enterprise social software by the end of 2012. The drivers include better access to information and expertise as well as a desire

to drive collective action (Koplowitz et al., 2012). It would be done by connecting digitally distributed computers across organizational and geographical boundaries. Incidentally, the distribution and digitization of enterprise business processes goes in hand with the evolution of technology architectures from mainframe and client-server to the internet and modern web services (Malhotra, 2005).

Socio-collaborative technologies have evolved along with the new enterprise business model. They now require web technology to exploit their benefits and to be enablers of collaboration environments. Having information online does not only allow collaboration, it is also an enabler for KM, especially for remote teams and global companies.

Different benefits deriving from the use of the Internet and the web technologies have been suggested in the literature. The evolution of web-based technologies, for instance, since the rise of Web 2.0 approximately 13 years ago, has focused in reducing communication costs, enhancing communication, accelerating the distribution of knowledge, and facilitating knowledge service delivery. Internet can link knowledge workers to a vast quantity of digital records stored on the web all over the world (Laudon & Laudon, 1998).



**Figure 5.** Web evolution. (Spivack, 2009)

According to the picture above, the roadmap for web technologies and the development of socio-collaborative tools rely mainly on the relationship between people and information. Therefore, it is implied that the more connections between people the more information and knowledge to be managed. Spivack (2009) stated that generally Web 2.0 is being about collective intelligence and Web 3.0 as being about *connective intelligence*. It's about connecting data, concepts, applications and ultimately people.

Collaboration and social technologies are now typically implemented in internal corporate networks, so that global enterprises can handle all kinds of communication needs with ease. For example, Intranet is implemented in *a private, secure space on the web where only members of an organization can communicate with each other, share and distribute information and collaborate on projects* (Awad & Ghaziri, 2004).

To be a successful enabler of KS, the contents of an intranet need to be organized and structure so that all resources can be accessed and it should contain, for example, the *news feed section* that replaces daily unnecessary email bombing to inboxes (Nielsen, 2002). In addition, it needs to include social networking features to boost online socialization in the organization. This means there is an open shared space where employees can post messages, questions, ideas, suggestions for improvements and request advice (Arnott, 1999).

In the picture below, basic contemporary web-based socio-collaborative technologies and a brief description are presented. These are generic approaches demanded by any internet application in order to support social and collaboration environments.

**Social technologies include a broad range of applications that can be used both by consumers and enterprises**

NOT EXHAUSTIVE

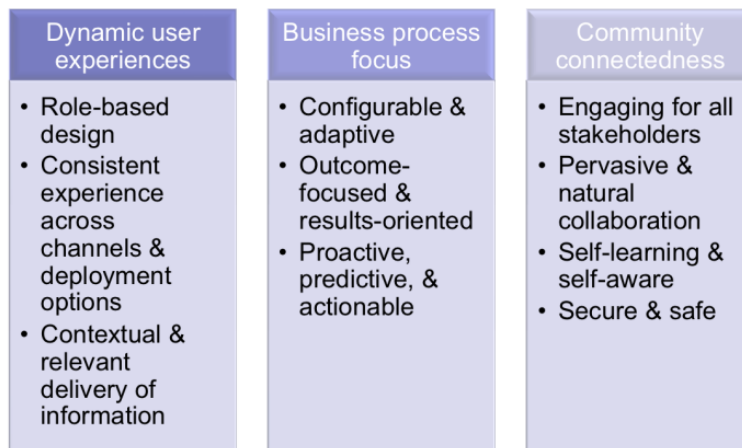


<sup>1</sup> Social analytics is the practice of measuring and analyzing interactions across social technology platforms to inform decisions.

**Figure 6.** Networked tools features. (McKinsey Global Institute, 2012)

Not surprisingly, the application of each of these online collaboration features should be accompanied with proper design and user interface principles in order to obtain major benefits. In a recent study, Zhang and others (2010) found out that systems including design features that support distributed collaboration, such as user login, information retrieval and notification system, collaboration know-how or communication and integration of people's ideas, were positively related to collaboration development, effective communication of different ideas, understanding of people working in different locations, integration of complex knowledge and coordination of challenging group tasks. The essential elements for these systems as instruments of collaboration and information management can be found in APPENDIX 1.

In the same way, experts in this area have identified three categories that contain 10 essential elements of social enterprise platforms, or in other words, software that organizations use for fostering communication and collaboration among their employees (Software Insider, 2009).



**Figure 7.** Essential elements of social enterprise platforms. (Software Insider, 2009)

From left to right, the picture emphasizes the importance of each category of elements, considering the *dynamic user experiences* the most critical element for the development of these applications. For example, one of the solutions that have been included in recent years as essential part of social enterprise platforms are the so called *activity streams*, which is basically a list of contextual and relevant information performed by a certain person as a result of its interaction with the system. According to analysts in information workplace and collaboration strategy, activity streams are *the base of the social layer* and it connects workers to each other and to information, by pulling together in events, along with their context, background, and required actors, in a manner that is attractive and easily consumable for knowledge workers. And all this is performed in real-time (Koplowitz et al., 2012).

These basic and essential elements can be obviously applied in more specific applications such as PMIS. Similarly, in later chapters this study will present the inclusion of these principles in a collaborative project management framework (CPMF).

## 4. THE PROJECT MANAGEMENT ENVIRONMENT

### 4.1. Project-based organizations and main motives for choice of research

The present study has been limited to take into consideration only project-based organizations (PBO) instead of other types of organizations, such as traditional business organizations (TBO). This limitation has been decided because of particular characteristics in the nature of PBOs that make them suitable for this research project. Thus, we find important to describe differences between PBOs and TBOs to study collaboration and KM in project based businesses. These distinctions may also leave an open path for future research in other type of organizations not covered by the present research.

According to Sandhu & Ajmal (2011), the main characteristics of PBOs are described in three basic factors: (1) *complexity*, in terms of technical, financial, social and political factors; (2) *uniqueness*, because projects have different sizes, types, customers, teams, budget, etc; and (3) high degree of *discontinuity*, in the sense that economic relationships between suppliers and customers end after the project closure.

The main differences between PBOs and TBOs are highlighted in the table below. The distinction between the two forms of organizations are emphasized mainly in time-frame (temporary vs. continuous arrangements), environment (dynamic vs. stable) and decision making (decentralized vs. centralized). Moreover, project businesses involve intra-organizational (inside an organization) and inter-organizational (between organizations) interactions, while traditional businesses focus only on the intra-organizational perspective (Sandhu & Ajmal, 2011). Thus, project-based companies face new challenges due to this dynamic environment, forcing them to adopt new strategies in terms of collaboration, communication and knowledge management (Lindner & Wald, 2011).

Project-based organizations	Traditional business organizations
Uniqueness	Continuous operations
Complexity	Emphasis on working processes
High degree of uncertainty	Low degree of uncertainty
Discontinuity	Stable processes
Temporary arrangement	Permanent arrangement
Emphasis on goals	Inflexible
Dynamic	Hierarchical organization
Flexible	Centralized decision-making
Non-hierarchical organization	Bureaucratic
Decentralized decision-making	
Adhocratic	

**Table 3.** Characteristics of project-based and traditional organizations (Sandhu & Ajmal, 2011)

Thus, there are different motives that have arisen as a result of these implications, which have served for choosing project-based organizations for this research. The main reasons are summarized as follows:

- (1) In general, there are no methods of capturing the knowledge and experience obtained and collected during projects. When a project is finished, normally there is no institution or group left from which to access the stored knowledge. Meeting points, such as groups, departments, plants, branches in the regular organizations, are dispersed after the ending of a project (Sandhu & Ajmal, 2011). This creates a barrier for transferring knowledge between projects and therefore organizational learning (Lindner & Wald, 2011).
- (2) Communication and collaboration are a key issue in storing knowledge and experiences in projects (Sandhu & Ajmal, 2011). Thus, studying collaboration and the adoption of collaboration technologies throughout the project lifecycle is

required to achieve efficient interactions in inter- and intra-organizational networks (See Table 4).

- (3) The evolution of software programs for project actors have changed from the traditional paradigm –rigid, slow, knowledge-centralized-to-experts– to a more social approach –flexible, quick, knowledge-accessed-by-everyone– (Payne, 2008).

Form of organization	Main focus of e-communication
Project-based (PBO)	Collaborative, inter-organizational emphasis
Traditional (Traditional)	Functional, intra-organizational emphasis

**Table 4.** Communication diversity in organization types. (Sandhu & Ajmal, 2011)

#### 4.2. Project types in project-based organizations

The project management literature defines a project as *an endeavor in which human, material and financial resources are organized in a novel way, to undertake a unique scope of work, of given specification, within constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives* (Turner, 1993).

This definition leads to distinguish two ways to categorize projects. The complexity of projects is determined by many factors such as size, budget and other resources, but also by the different locations where the project is performed.

Project type	Single location	Multiple locations
Single projects	Traditional project – minimum complexity with single project in single location	Distributed project – single project in multiple locations
Multiple projects	Increasing complexity – multiple projects in a single location (co-located)	Most complex – multiple projects in multiple locations

**Table 5.** Typology of project. (Evaristo & van Fenema, 1999)

As a result, Katzy et al. (2000), define the PME in terms of project organizations. They identify four main project types ranging from the traditional to the complex. The table above is shown descriptions of the four main project types including traditional, distributed, inter-organizational and virtual.

The literature of project management generally addresses the *traditional* type of project, performed in the same location and a homogeneous team, belonging to the same organization and often related to the similar departments. Typical issues facing in these projects are linked to resource assignment, task sequencing, coordination mechanisms, and management styles.

In *distributed* projects, organizations attempt to increase the sophistication of communication technology due to geographical dispersion of the project personnel. In addition to human coordination as in traditional projects, more technology intervention is needed to cope with information distribution, coordination of work practices changes and traditional structural boundaries. Even though teams are located in different places, they belong to the same organization and the PME is not as complex as the rest of the project types.

Moving towards a more complex typology, the *inter-organizational* projects involve workforces from a variety of organizations including independent consultants or experts. This means teams are heterogeneous and more difficult to manage. In these projects, project management face socio-cultural problems due to organizational environment differences.

The most complex and challenging in terms of collaboration, knowledge management and project management is the *virtual* project. Project team members result of combination of the previous types because they are geographically dispersed and belong to different organizations. The virtual project environment needs appropriate technology infrastructure for achieving effective virtual project management (Katzy et al., 2000).

From the characteristics of each type of projects, it is inferred that project management need to utilize different collaborative mechanisms to enhance collaboration, communication and KM. These mechanisms are fundamental if the management component of projects is to be carried out effectively (Harley, 2009). Moreover, we can assume that the use of online collaboration tools is crucial, especially for distributed and virtual projects. This assumption has helped to identify the connection between PME and collaboration, important for this research.

#### 4.3. Generic project lifecycle and knowledge areas of project management

From the literature, it is implied that a project is a temporary form of organization with defined start and finish dates. This time constrain determines the duration and stages of the lifecycle by which a project goes through. For our research, there is no need to dig into each phase, but brief descriptions will be provided. The purpose is to identify main activities, roles and information flow in each stage, for later relevancy inside the collaboration and KM framework.

Even though there is a debate that not all projects goes through a lifecycle, Turner (2008) suggests that the lifecycle happens in strict series, sometimes are run in parallel, or like in some agile methodologies, they are cyclic. However, the lifecycle is inherent to the project and are defined in five stages: *concept & initiation, feasibility & definition, design & appraisal, execution & control* and *finalization & close-out* (Mishra, 2005; Turner, 2008).

In addition, for each phase, specific roles are defined to perform respective processes and to deliver outputs. These roles would help to identify profiles that could make use of collaboration technology.

External and internal roles exist depending on the project type. The *sponsor*, defines the objective of the project, the outcome and outputs; the *steward*, defines the means of achieving the outputs; the *project manager* and *team members* executes the project and

make sure the output has been delivered; and, the *project owner* (sometimes the project manager) monitors the performance of the output and checks if the desired outcome has been achieved (Turner, 2008).

After identified what a project entails and examined its lifecycle, the literature different key knowledge areas for further understanding and classifying the specific operations contained within the PME (Harley, 2009; PMI, 2004). In APPENDIX 2, we show an overview of these knowledge areas and provide a list of the activities or tasks that are involved for each area.

Moreover, given these knowledge areas for project management and the roles they each play within the PME, this list identifies the actual management work required on projects, and introduces the conceptual background for building a more collaborative project management system.

#### 4.4. Sharing and reusing knowledge to prevent project amnesia

This section attempts to combine concepts learned in previous chapters and it will cover the relationship of KM and the project environment or project knowledge management. The main purpose is to identify different types of project-based explicit knowledge brought up during the project lifecycle and that is useful for project management.

The project literature suggests that a project is a *system for processing information*, where lots of information is created and exchanged continuously. Information is a critical resource in the project; therefore information management is an inherent component of project management (Turner, 2008).

In addition, briefly recalling the KM concepts, information is one of the knowledge states and it is usually represented as explicit knowledge. Thus, we can infer that KM is also an inherent part of project management. Consequently, the KM process is an on-

going process by which team members use technology to achieve project goals (Katzy et al., 2000).

According to the literature, it has been identified three main aspects of knowledge in PBOs (Van Donk & Reizebos, 2005; Ajmal & Koskinen, 2008):

(1) *Project-related knowledge* refers to knowledge about the customer and other people or entities that are of significance for the future business of the company such as feasibility studies, summary or technical reports or user manuals.

(2) *Technical knowledge*, which involves the technical sense that is applied to the project such as work processes, costs, technologies used. This knowledge is produced to address discipline-specific issues of the project.

(3) *Project management knowledge* combines the theoretical knowledge on project management such as techniques and real experience in conducting and managing the project. This category includes deliverables produced by the knowledge areas of the project: contracts, project charter, project plans, budgets, quality plans, communication plans, risk management documents and acquisition plans. In addition, post-mortem project documents should be recorded: failure reasons or how efficient solutions were built or how special issues were solved, key project experiences of general business relevance, and conclusions or recommendations for improvement in future projects.

Because the amount of project-created knowledge is initially carried out only by project team members, it needs to be integrated into the organizational knowledge. In fact project knowledge is a subset of organizational knowledge (Weiser & Morrison, 1998). However, knowledge and experiences are not being recorded, causing project amnesia (Schindler & Eppler, 2003). The rationale behind this problematic is related to lack of time, motivation, discipline and skills. Relevant project information only captures business figures, reports or project's results, resulting in isolated and useless information. In addition, recording specific solutions on how to solve a particular problem are often omitted and restricting its use in other projects.

Collaborative environment is required. Collaboration enables organization to communicate, cooperate and learn (Payne, 2008; Yang, 2004). Thus, there are technology approaches that have addressed specific aspects of project information management which includes features for project information and documentation management with collaboration support. These technologies have enabled methods for capturing project contexts, processes, rationales and artifacts. In following sections it is described the application of project management systems for KM and how collaboration features could help to create an appropriate environment for project learning.

#### 4.5. Project Management Information Systems

In essence, PMIS –like many other types of systems– can be built as an independent system or, part of an integrated global system, for example, Enterprise Resource Planning) systems. In recent years, it seems the trend is switching from an integrated to an independent approach. Therefore, many software vendors are specializing in particular functionalities for development to address specific knowledge areas of project management.

Each of these two approaches has important implications for project knowledge and organizational knowledge. Project activities are usually triggers of other business activities, e.g. sales, finance, warehousing; therefore, project knowledge should be delivered on-time. Considering PMIS as isolated systems can result in knowledge loss. This already occurs in integrated systems, where information is collected from different sources and stored in databases that cannot be found easily afterwards. Thus the importance to improve collaboration functions in PMIS.

#### 4.5.1. Basic functionalities of PMIS

In essence, the literature suggests four basic category functions required for any typical PMIS: *scheduling, resource management, document management* and *collaboration support* (Weiser & Morrison, 1998).

Scheduling and resource management support commonly use Gantt and PERT charts to develop task timetables, assign resources such as equipment and personnel and status reports, including expense information.

Document management is usually accomplished by systems that create indexes to document files or store linked references to documents or document data. Documents may be stored either as graphic images, online publications or in their native application formats (e.g., word processor, spreadsheet). Users can index or link related documents with phrases and subsequently retrieve them using keywords, links or other string searches. Document versioning is also part of document management to keep track of changes.

Collaboration support involves a set of functionalities and features that helps to improve the communication and collaboration between project internal and external members. These features include mainly decision support systems and computer-based cooperative systems, described in earlier chapters. In addition, collaboration support should be present in all of the other PM functionalities and it must be designed in a way that people can collaborate and share project knowledge easily. Determining the requirements for the design of the collaboration support is one of the outcomes of this thesis.

Above we mentioned only basic category functions of a typical PMIS; however, a complete solution contains specific functionalities and features. We have collected a detailed list of features suggested by the literature and also by observing a few project management solutions. Purposely, the list has been enhanced with extra collaboration and KM practices also suggested by the literature (see APPENDIX 3).

#### 4.5.2. Web-based collaborative toolsets for project management

Currently, there is urgency for enterprise project management tools to be in sync with the development of web-based solutions (Infoworld, 2000). Internet applications are taking place in many software vendors because it enables information to be centralized in the web and accessed by many individuals at the same time in different locations.

In addition to enhance communication in the project, web-based project management tools attempt to reduce the project workflow because information can be spread efficiently. The incursion of collaboration tools in the project management arena enables project managers, teams, customers and stakeholders to interactively formulate project plans, discuss changes and keep track of activities as project progresses.

Next, we will present a brief review of modern web-based out-of-the-box project management toolsets to recognize trends, features and functionalities that software vendors are offering in nowadays. Thus, this analysis will be beneficial as a benchmarking of features in order to develop a desired PMIS from a collaborative project management perspective. Intentionally, it was added to the list our case study company was to contrast differences with other tools and to recognize initial requirements for improvement. See APPENDIX 3.

The range of toolsets included in this review was all sourced from the internet. The inclusion criteria used in this research was subject to a number of elements; however the key selection criterion was that vendors described their products as a collaborative tool that is used over the internet to manage projects. Note that most of these toolsets only concentrate in a specific knowledge area of the project, trending to a more data-dispersed approach. However, the KM principles suggest an opposite direction, this is, concentrate project knowledge in centralized repositories. Thus, there is a need to find features to be developed as integrative tool.

## 5. RESEARCH METHODS AND IMPLEMENTATION

### 5.1. Research strategy: Comparative Case Studies

The literature mentioned several approaches for use in research work. After reviewing different methods, the most appropriate approach according to the research environment and budget capabilities was the *comparative case studies* strategy. Some methods were considered too complex and expensive to implement, while others reduced the scope to a single case study. Our objective was to find a qualitative-supported method that takes into account different perspectives, thus the data collected from each case could be analyzed and combined to produce single results.

The case study comparison has the capacity to develop an in-depth analysis of multiple cases. It means that the approach catered for the analysis from multiple sources of data, including documents, interviews and surveys or questionnaires. For the interest of this research, it was necessary to analyze multiple organizations. The organizations are located in Finland from different industry types, but mostly belonging to the IT sector. The organizations included a software producer company and some of its customers, as the software manufacturer want to find out current trends in project management and transform these needs in software functionalities.

For this reason, the comparative case study approach enabled the research to capture material on the expected variations and needs from the collaboration and KM areas within the different project environments. The case study approach is considered the most suitable tradition to identify these differences and use these differences in the subsequent analysis because it provides the investigator with the opportunity to select a variety of cases from which to fulfill the research propositions (Harley, 2009). It also enables a mixture of qualitative and quantitative data collecting methods to be used, including participant observation, structured and unstructured interviewing, and questionnaires. In our case, we are more interested in a qualitative data approach.

The use of qualitative data collection methods *enables the research to gain a broader understanding of the rationale or theory that may emerge, whilst the quantitative evidence assists in identifying relationships or correlations that may not be obvious to the researcher and which can bolster findings from the qualitative evidence* (Harley, 2009).

Below we present a summary of the methods reviewed, including a description and the justification for its choice for inclusion or exclusion in this research.

Research design	Description	Reasons for use/not use
Experimental	<p>Uses an experimental design to undertake quantitative comparisons between experimental groups and control groups</p> <p>Two types – laboratory and field experiment</p>	<p>Even though it is the most accurate and nice-to-have approach, it is also the most expensive and time consuming.</p> <p>In this research, an experimental approach is not needed. In addition, the application requires high intervention and commitment from organizations for data collection. This is usually difficult to achieve.</p>
Cross-sectional	<p>Uses a survey research or structured observation on a sample at a single point in time</p> <p>These variables are then examined for the presence of patterns</p> <p>Closely associated with questionnaires and structured interviews</p>	<p>Our research focused solely on specific areas of project management and very limited amount of organizations, thus this research design is exploited in larger samples to cover multiple areas of research.</p> <p>However, some of the techniques were applied: questionnaires and semi-structured interviews.</p>

Longitudinal	<p>Survey research on a sample on more than one occasion</p> <p>Uses content analysis of documents relating to different time periods</p>	<p>This design type was excluded as the research seeks to collect data in a short period of time and does not need to map changing behaviors in a PME over time.</p>
Case study	<p>Survey research on a single case with a view to revealing important features about its nature.</p> <p>Most commonly associated with the location of the study such as community or organization</p> <p>Three types – critical, unique and revelatory (and exemplifying)</p>	<p>This approach focus on an intensive examination of a single community of practice or organization, and it can deploy both quantitative and qualitative research methodology structures.</p> <p>As this research wants to reveal important requirements for collaboration and KM within the project management area, this design does not necessarily examine patterns across multiple case studies.</p>
Comparative case studies	<p>Extension of a single case study design type, where it deploys direct comparison between two or more cases, as in cross-cultural research</p>	<p>This design compares cases or situations in order to better understand a social phenomenon. This approach is considered most appropriate to the study, as it allows comparison and contrast between different organizations and their project settings, seeking the identification of common attributes and conditions.</p> <p>We have applied mainly qualitative data collection through questionnaires and semi-structure interviews</p>

**Table 6.** Research design types. (Harley, 2009)

## 5.2. Case studies selection and techniques used

For the selection of the multiple case studies for the research, it was required that project-oriented businesses have already implemented or are planning to implement or improve some sort of a project management tool in their project environment. In addition, it was considered initiatives in improving collaboration and KM for their projects or organization in general.

As an initial strategy for selection, a project management software manufacturer was chosen. Not surprisingly, the rationale for this selection was that software manufacturers are constantly looking for innovation in their software products, in this case, related to the project management area. In addition, we identified a win-win partnership, as the software producer would provide the necessary inputs for the research and the manufacturer would also benefit from the outcomes of the analysis.

Therefore, after revision of the from the manufacturer's customer portfolio, a preliminary list of strategic customers from different industry types were identified. The revision included business documents, feedback from senior business analysts in the company and also the degree of customer activity of the different project management functionalities. The latter was measured by identifying the number of projects in a year, the size of the team, project complexities, budget, and the activity of team members using the specific functionalities of the project management tool. In addition, it was required that project roles were clearly defined in the teams, so that it is easier to see collaboration interaction between roles.

Given this, cases were not randomly selected, but focused not only because of their environments and organization structures, but in relation to their project activity and the diversity of these activities in comparison to each other, so that more accurate requirements could be identified. In the case study list, the software manufacturer was also included as it uses its own tool to manage their projects portfolio.

After selection, several data collection techniques from the case study approach were applied in the research. The implementation of the techniques was applied in four stages:

- (1) First stage included the design and distribution of an initial questionnaire across the software company for piloting purposes. The questionnaire approach was selected due to this research is mainly based on qualitative data. This strategy helped to identify flaws, relevancy and accuracy of the questions.
- (2) Second stage focused on the execution of a second round of piloting through a semi-structured interview using the questionnaire to one of the strategic customers. Again, this helped to identify additions and modifications of the questions.
- (3) Third stage included a mass-distribution of the questionnaire to the other key customers. Activities for building distribution lists, monitoring responses and feedback provision were performed.
- (4) Fourth stage (improvised) focused on the revision of customer-specific business requirements through different business documents, due to the low response rate of the questionnaire. This helped to complement the data gathered.

In the following sections we are going to review specific details of the techniques used in the comparative case study approach. Details about case studies information, questionnaire sections and interviewing techniques will be provided.

### 5.3. Data collection

As noted in previous sections, the research method initiated with the selection of a group of key organizations relevant for the research. The organizations belong to the IT and consulting industry types due to the highly dynamic project environment, which was considered to be more attractive for the research. After analysis, the preliminary list

of organizations was agreed between the software manufacturer and the researcher, which included eight organizations (including the software manufacturer).

On the other hand, the case study approach selected for this research developed two basic strategies to collect data. The first strategy focused on a piloting stage and it used two different questionnaires administered to the project teams of the organizations: (1) questionnaire for project managers and (2) questionnaire for team members. The second strategy utilized a semi-structured interview to one of the key customers to address in detail specific questions to the PME and to find flaws in the questionnaire.

From the organizations, the selection of participants for both strategies was based on two criteria:

- (1) Project managers (PM), who have been working in projects for more than a year.
- (2) Team members (TM), who have been involved in projects for more than a year.

In addition, the case study approach also allowed for additional material or documents to be collected. In some cases, they are the main source of information for the case study due to the low response rate, and in other cases, to complement the participant responses. These documents referred basically to initial project management and business requirements that the software manufacturer has used for its software implementation and consultation projects.

	Questionnaires		Interviews		Documents reviewed
	PM	TM	PM	TM	
<b>Relevant responses</b>					
Org A	4	7	4	10	Organization's internal processes
Org B			2	2	
Org C	1				

Org D		1			Integration between PMIS with other systems
Other organization (4 in total)					Organization-wide project management functionalities Resource allocation for projects External project time report acceptance. Project and task control through interactive boards
<b>Total</b>	<b>5</b>	<b>8</b>	<b>6</b>	<b>12</b>	<b>4</b>
<b>Non-relevant responses</b>					
6 organizations	35	61			4
<b>Total</b>	<b>40</b>	<b>69</b>	<b>6</b>	<b>12</b>	<b>8</b>

**Table 7.** Summary of data collection strategies per case study.

The above table synthesizes how the data was collected in the research. Initially, 11 organizations were considered for the study, but only 6 were finally accepted as a result of higher relevancy in the participant's responses and in the customer case documents. A total of 40 questionnaires and 6 interviews were carried on to project managers and 69 questionnaires and 12 interviews to other team members. In addition, around 8 customer cases were reviewed which mainly included information about requirements for project management implementation solutions.

Not surprisingly, even though the small number of cases considered resulted in a low rate of response of the questionnaires (only 5 for project managers and 8 for other team members), the information obtained was sufficient. The rationale behind is that this research is looking for particular key customer requirements related to collaboration and KM in projects that can be later implemented by the software company. However, the small sample size used could raise future research in the same areas with wider samples in order to identify global trends.

### 5.3.1. Interviews and Questionnaires

The design of the questions for the interview and questionnaire was initiated by observing the interaction inside different project teams, performing informal discussions with project managers and also reviewing other similar studies collected from the literature. Therefore, a preliminary set of questions were produced for project managers and other set for team members (check APPENDIX 4 and APPENDIX 5 for questionnaire details).

For project managers, the questions were categorized in different sections:

- (1) Background of the project manager: Get to know more the professional background and personality of the interviewee to find out what kind of manager use project management software and what kind of toolsets is selected depending of his/her background.
- (2) Project management process: Identify if project managers are familiar with existing standard project management methodologies or if they have modified/implemented their own process to manage projects. The idea is to understand the way they do project management related to their products/services. Another purpose is to find out what features need to be incorporated in the project management process in PlanMill.
- (3) Project management information systems: Discover how project managers and team members use project management software, what are the basic functionality they commonly use and investigate typical problems and new requirements for future enhancements.
- (4) Collaboration and knowledge management: Find out communication strategies, collaboration and knowledge management initiatives used within the projects.

For team members, the questions focused mainly in the use of collaboration and KM systems and how the communication works inside the team among team members.

These preliminary questions were slightly modified after executing an exploratory round of interviews to one of the case studies. In these sense, the interview served as a prescreening of the questions to be asked. However, no major changes were made to the initial set of questions.

### 5.3.2. Business documents

Different confidential document were reviewed as part of the main strategy for collecting data for the research. Initially, customer cases documents were planned as a contingency strategy to complement missing information from the interviews or questionnaires. However, as it was experienced a low rate of response from the participants, business documents were taken into account as a main source of data collection.

As shown in table 7 earlier, a total of 4 customer cases were finally selected for the study. These cases included project management requirements to be implemented in each organization. In summary, the cases contained information about:

- (1) Improving stage control of project activities.
- (2) Basic project management functionalities including reporting, resource allocation and finance control.
- (3) Integration of project knowledge among different systems.
- (4) User interface and user experience enhancements to improve the interaction within the system
- (5) Internal project communication process

Due to the confidentiality policies, customer cases can be obtained upon formal request.

#### 5.4. Data validation

A study is valid when it measures its proposals defined in the research questions. Data validity aims to reduce logical errors, threats and biases in drawing conclusions from the data, which would undermine the meaningfulness of research (Harley, 2009).

The literature has defined five different data validity approaches for case study research: *construct validity*, *confirmability*, *internal validity/credibility*, *external validity/transferability* and *reliability/dependability* (Christie et al., 2000). They are applied according to the nature of the research regarding the complexity of the study, data collection sources and techniques, research goals and availability of resources in the research. However, the researcher has the final decision of which data validation technique to use.

For this study, the *internal validity/credibility* approximates closely to a valid strategy. In accordance with the literature, to establish internal validity it was used (Christie et al., 2000): case analysis and cross case analysis, linking of the analysis to prior theory identified in a literature review, presentation and analysis of pilot case studies, pattern matching, assurance of internal coherence of findings and development of diagrams (framework).

#### 5.5. The researched company and its strategic customers

The following sections will describe the cases studies considered for the research. The main organization corresponds to a software development company, which provided the initiatives for the study and also broad information from its customers

### 5.5.1. About the software manufacturer: PlanMill Oy

PlanMill is a software development, small-medium enterprise based in Finland and established in 2001. PlanMill has been developing project management planning and reporting software since the beginning and the product has been around under different names according to the evolution of the product.

After years of evolution, currently its main product is a *software-as-a-service (SaaS)* solution for organizations of any different industry type that needs to control generic business activities such as customer relationships, resource management and projects management including, resource utilization, time tracking and project-related finances. Due to the flexible architecture by which the product is built, PlanMill software allows to customize its different modules depending on the customer's needs.

Being a web-based solution in essence, the main business model of the company follows the subscription based model, by which the company's revenues primarily depend on the monthly number of user accesses to the application and the number of modules and functionalities activated to these users. In addition, PlanMill offers local implementations of the application for customer restricted network access, on-site training and consultation, customer-specific feature enhancement developments and continuous service support.

After more than 10 years of operations, the company has registered over 20,000 subscriptions worldwide coming from around 100 leading service companies in 25 countries operating industries such as IT, legal, marketing and research & development units (PlanMill, 2013).

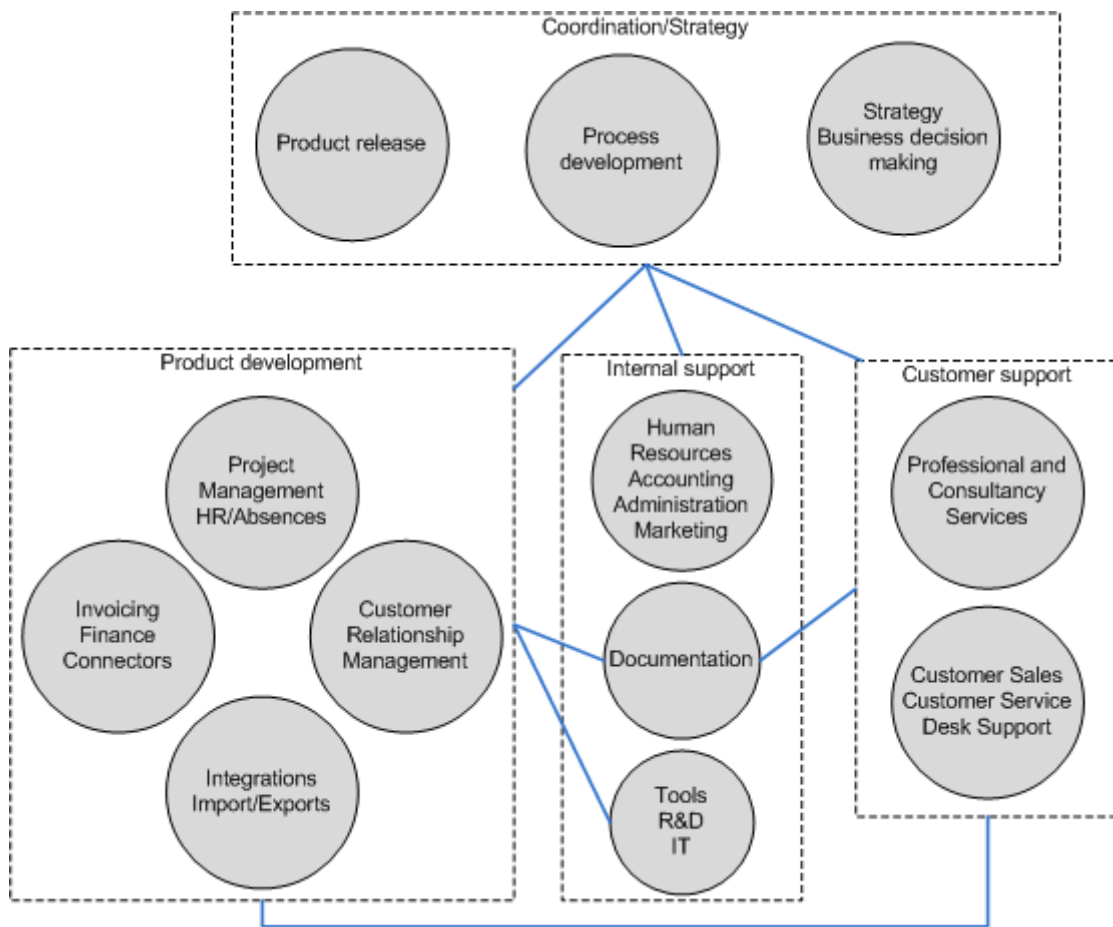
### 5.5.2. PlanMill organization structure

Since the start of business, PlanMill has been constantly growing and developing its organizational structure. Even though it is still considered a SME (Small and Medium Enterprise) in size, during the last 5 years, the number of employees has grown about

25%, allowing the company to establish different functional teams in accordance to employee competences and expertise.

Basically the company has a simple and flexible structure divided in four main virtual units and each unit is composed by cross-functional teams. Currently, these units are only figurative divisions of the company, thus, there are not managerial representations. Teams are organized according to the personnel competencies and depending on the development needs, team members are utilized and relocated in different teams simultaneously.

The coordination and strategy unit provides high level decisions and strategies developed by top management and decision makers that concern all other units related to product development and business processes. Product development unit is composed by analysts, developers, testers and project managers, where each functional team is responsible of development and implementation of the main modules of the product application. Internal support unit is responsible of all organization related activities from Human Resources, marketing and administration to internal IT and R&D. And finally, customer support handles all customer-specific activities on a daily basis and its functional teams are formed by project consultants, service desk and sales personnel.



**Figure 8.** PlanMill organizational team structure. Source: Author

### 5.5.3. Technology roadmap: Evolution of PlanMill

The project management needs of PlanMill's customers and prospects have evolved towards a more simplified, agile and more collaborative compared to earlier requirements where project management tools were required only to do basic Gantt charts, Pertt charts and complex critical path or resource based schedule calculations.

During the research, it was found that one of the reasons for this evolutionary process the continuous development of internet technologies. For instance, as shown in Figure 5, from Web 1.0 to Web 2.0 the interaction and behavior between users and systems has changed, resulting in new user experiences. Currently, PlanMill needs to research what are its customer's requirements in terms of collaboration, communication and KM and combined them with state-of-the-art technologies. PlanMill needs to identify what are

the critical, technical and business-related priorities to enhance PlanMill Project Management with modern features that meet customer's business needs.

The roadmap of the system needs to be in harmony with the development of web technologies. In the past, specific modules were enhanced with searching capabilities, project communication, email and wiki integrations, documentation management, interactive web elements and other technical implementations mainly related to web 2.0. Currently, the application needs to move on to a new generation including socio-collaborative functions.

## 5.6. Case studies for the research

Next, it is presented a description of the case studies with general information about the organizations and important points of the data collected for each case.

### 5.6.1. Organization A

<b>Industry</b>	IT and Consulting
<b>Number of employees</b>	25
<b>Products or services</b>	Web-based software for businesses. Product related consulting and support services
<b>Avg projects per year</b>	24-30
<b>Avg project size</b>	3-4 members, 1-2 months duration
<b>Tools for collaboration and communication</b>	Instant messaging (Skype), PlanMill notifications sent to email, Google calendar, Email, Confluence (Wiki)
<b>Tools for Knowledge Management</b>	Confluence (Wiki)
<b>Tools for Project Management</b>	PlanMill, Google calendar

**Table 8.** Organization A details.

Organization A can be defined as the pilot organization, where the questionnaires and even the research proposals were originated. As stated before, being a software manufacturer of PMIS, the organization is interested in investigating, analyzing and collecting customer needs to deliver a more collaborative project management tool. However, due to the organization uses its own software for project management, it wanted to take the lead in the research prior initiating a study of its customers. Accordingly, pilot questionnaires were delivered to experienced developers, project managers, who have been actively participating in projects in the last years.

The data collected from this organization can be summarized in the following points:

- (1) Due to the dynamism of the business, it is critical a high degree of agility regarding daily communication and collaboration between project managers and team members. The dynamism is mainly determined by the number and complexity of functionalities the organization internally prioritizes and is able to deliver in a certain period of time. The features to develop could include software enhancements, customer-specific projects and software fixes as a result of flaws found in previous deployments.
- (2) The communication of the developer-project manager, developer-service desk person and project manager-customer can vary depending on the complexity and criticalness of the issue being resolved. In general, there are three main collaboration channels that people use for daily and instant interaction: emails, Skype and notifications in PlanMill. Communication with the customers is mainly done by email or through PlanMill when customers deliver to the specific system address.
- (3) Project managers use PlanMill project management for basic project management functionalities such as to create projects, tasks, assign resources and check project finances. Also team members use it for time reporting. Project

complex documentation is usually stored in an external wiki system, which is also used for internal process and requirements documentation.

- (4) Google calendar is mainly used as a source for checking people's availability, where each team member has its own calendar. However, this is not integrated with PlanMill to check resource availability for project allocation. In this case, for project resourcing and scheduling this information is not easily found and it usually depends on the project manager guesses.
- (5) Project team members has found difficult to project related information as the information is widespread. In addition, due to daily changes in priorities (usually triggered by customers) and task specification, it is not easily visible what needs to be done daily.

#### 5.6.2. Organization B

<b>Industry</b>	IT and Consulting in Market Intelligence
<b>Number of employees</b>	150+
<b>Products or services</b>	Web-based market intelligence software for enterprises. Product related consulting, events and online resources
<b>Avg projects per year</b>	400
<b>Avg project size</b>	3-5 members, 1-2 months duration, 20 000e project revenues
<b>Tools for collaboration and communication</b>	MS Communicator, Email
<b>Tools for Knowledge Management</b>	Network drives, MS Sharepoint
<b>Tools for Project Management</b>	MS Excel, PlanMill

**Table 9.** Organization B details.

Organization B represents a valuable case study for analysis because of the complexity of the organization, strong interaction between the team members and its high commitment in using project management and communication tools in projects. After the pilot questionnaire was produced and tested by Organization A, few interviews were conducted to project managers and team members of Organization B. The interviews were performed in two different sessions where the project manager and its correspondent team member participated in the same session.

The results of the interview can be summarized in the following points:

- (1) Projects are mainly based on Market Intelligence deliverables. Projects range from data gathering, competitor landscapes, and product market entry for industrial manufacturing companies. Typical projects activities include interviewing experts, looking at databases. For smaller projects, the need of using software to manage project information is low.
- (2) Information management regarding projects, project teams use network drives organized in customer folders and these are shared among team members. In this case, the project documents are isolated in external drives and not in the PMIS due to the high amount of files and material. For project managers, sharing network drives are an easy-but-not-efficient way to manage project information.
- (3) Documents stored in network drives range from project plans, quality reports and cost information to all the interviews conducted, surveys and transcripts. All the project managers manage the files in the drives as they want, they create the structure and restrictions for project team.
- (4) Projects are mainly initiated by the sales support person and the sales person, who are involved in the planning. Basically, they use an excel sheet, where time is estimated for each task. This estimation is mainly based on senior project manager's expertise, for example, to conduct 50 interviews, they know by experience what kind of interviews are needed and the approximate cost.

- (5) Using excel sheets to create initial project plans was found to be inefficient but necessary, as these sheets contain own organization's rules and calculations. Later, they have to input this information in PlanMill project management to continue managing information of the projects such as costs and time reporting.
- (6) When the project is formed, the communication is usually very informal. Daily meetings as needed are performed either through video conferences or MS Communicator, depending on the proximity of the people.
- (7) Resource allocations are basically done by the resource allocation department. They carry out informal discussions with the project managers about the appropriate persons for the project. In different situations, for example, if a person has been allocated for a project drops off the project, then the plan hours of the person is deleted. If no replacement is found, then external resources can be allocated and they are considered as purchases of the project.
- (8) Project information sharing stage updates in a daily basis is often done face-to-face when people are physically reachable; otherwise, through email or MS Communicator. Updating information of where we are in certain stage of the project. In addition, the need of a real-time dashboard with projects, tasks, profitability split by tasks, traffic lights of real status of projects, purchases and recent discussions of the project has been identified as priority. The tool should be an integrated communication and collaboration tool, so that using email for project communication could be left behind.
- (9) Intranet based on MS SharePoint was found useful to consult previous customer cases. Sales people have their own intranet. Customer documents, for example fees and costing information. In some cases, partner information is in sync with the intranet.
- (10) Project members are often required to store their lessons learned, but in general, this is not done because of lack of availability. In addition, freelancers or

externals are usually rated, so that project managers can check the freelancer's performance for more accurate selections. All this input is done separately, different from the main project management tool.

### 5.6.3. Organization C

<b>Industry</b>	IT and consulting
<b>Number of employees</b>	72
<b>Products or services</b>	Web portals for enterprises and e-governance. Product related consulting and support services
<b>Avg projects per year</b>	35-40
<b>Avg project size</b>	1-3 members, 1-5 months duration, 150 000e project revenues
<b>Tools for collaboration and communication</b>	Instant messaging (Skype), email, PlanMill
<b>Tools for Knowledge Management</b>	Alfresco
<b>Tools for Project Management</b>	PlanMill, Jira, Excel

**Table 10.** Organization C details.

Due to similarity in the implementation projects in Organization C, the questionnaire was sent to one experience project manager, who answered on behalf of other project managers. As a result, one document was returned which collects and summarizes the project environment in the company.

In general, project managers have had more than 5 years of expertise managing projects but without holding any formal certification. In addition they don't recognize the appliance of any formal project management methodologies in the organization; however, they follow their own organization standards and practices which include the standardization of well-defined roles in projects such as team leader, process master,

architect, developer and quality assurance, and also a well-defined generic project deliverables including project definition, quality assurance plan, test plan and project backlog.

In terms of communication processes, collaboration and project management needs, the project managers provided the following information:

- (1) The organization's top management is responsible to define project plans, priorities, and estimations and to select the project manager, who will later form the project team. The project initiates with one startup meeting between project managers together with finance managers to create high-level project tasks and estimations according to contracts. Tasks are recorded by an administrative team using PlanMill system according to the information shared in the startup meeting.
- (2) A second startup meeting is conducted together with team, where goals of the project, estimations and detail planning are carried out. Further meetings depending on the complexity of the project are conducted on a daily basis, where work efforts estimations, reported and remaining hours are mainly discussed. Regarding project time reports and remaining hours visibility, most of the project managers emphasized the need of a simpler, easier and quicker way to check own project manager's project information.
- (3) Depending on the project, the project manager and sometimes other project managers will participate in project change management related activities such as project plan re-estimation and reallocation of resources. In this kind of situations, the communication flow between project managers is critical. They at least meet weekly in production meeting and also daily when needed.
- (4) The organization faces a high level of customer involvement in projects. Their customers frequently request information about project status including work effort estimations and up-to-date time reporting.

(5) Regarding usage of communication and collaboration tools, the organization uses instant messaging (Skype), especially for remote teams. In addition, email communication is essential on a daily basis. Other project management tools in addition to PlanMill are also used such as Atlassian Jira and MS Excel, to handle specific project issues. Regarding KM tools, even though there are not strong initiatives in this area, the organization is using document management tools such as Alfresco and also Atlassian Jira for project specific documentation, resulting in dispersed project knowledge.

#### 5.6.4. Organization D

<b>Industry</b>	IT and consulting
<b>Number of employees</b>	35
<b>Products or services</b>	Web-based accounting and e-invoicing software. Training services
<b>Avg projects per year</b>	30
<b>Avg project size</b>	3-4 members, 0,5-1 month duration, 10 000e project revenues
<b>Tools for collaboration and communication</b>	Email, instant messaging
<b>Tools of Knowledge Management</b>	Not specified
<b>Tools for Project Management</b>	PlanMill

**Table 11.** Organization D details.

Organization D provided very short but relevant information about their project environment from a project team member's perspective. It means that even though only one participant responded the questionnaire, the case was still considered valid for the research. In addition, documentation the previous initiatives to implement PMIS was reviewed to complement the questionnaire.

From the team member's point of view, the communication of the project goals is mainly done by email. A document including all the needed information about the project is saved to a sales type project in PlanMill system, where at the same time project activities are created. Being a small organization, team members decide for themselves task estimations based on experience.

On the other hand, task assignation is almost never done nowadays in a PMIS because they find it "time-consuming". But when they do it for more complex projects, project allocations are not clear visible in the system, which makes "hard to find" activities assign to a person. In general, they urge a tool that supports agile assignation.

Due to small team sizes, project communication is done weekly through face-to-face meetings. However, for daily communication they use mainly emails and instant messaging. Some information about projects and tasks is stored mainly in PlanMill, but also other information such as internal guides, contracts can live in emails and project finances are usually stored in other systems, demanding integrations between systems.

#### 5.6.5. Other organizations

In this category belong a total of three organizations that were considered for the research without interview or questionnaire as data collection strategies but only by reviewing customer case documents and discussing informally with senior consultants. Customer cases contained specific information about PMIS needs to be implemented in their companies.

Among the evident problems in project management was the dispersion of project knowledge as a result of the use of isolated systems. One of the organizations, for example, reported the use of five different systems for managing projects: MS Project for handling project tasks and allocations, QuickBooks for project finances, MS SharePoint and SalesForce for project customer information, again MS SharePoint for calendar and resourcing information of consultants and finally MS Excel for recording

time reporting. Not surprisingly, the result of this was to have an intense manual work, duplicated and erroneous data, leading to inaccurate project information.

The same organization has required a more “automated and integrated solution” to reduce the use of some of the systems used that includes all basic project management functionalities such as scheduling, budgeting, reporting, time tracking, finances and integration with other accounting systems and MS Project. In addition, project managers want to see a project dashboard with interactive real-time time reports, allocations, upcoming invoices and different kinds of notifications, for example, when costs and efforts overpass project estimations. Customer involvement is critical in the system by granting them limited access for particular activities including time reporting acceptance and notifications.

Another desired feature for better handling project backlogs and activities daily, customers pointed out a solution consisting in an extensive project board for controlling tasks, assignments and statuses in an interactive and easy way. Even though the term *interactive* was not clear defined, they mentioned capabilities such as *intuitively* and *few steps* when changing statuses of tasks, reallocating team members and creating or changing activities. It was also mentioned the possibility to escalate to a higher level of visibility, which could also show portfolio related projects instead of just displaying single project-specific information.

Another requirement that has been already partially described for other organizations relates to project allocation. After reviewing the customer cases, it was evident that this area requires more coordination and collaboration between project managers, team members and resource managers. In fact, in one of the cases reviewed, the organization demanded a robust notification system to be included in the PMIS to keep track of approvals, denials and work efforts of project allocation requests.

## 6. ENHANCING PMIS WITH SOCIO-COLLABORATIVE FUNCTIONS

The aim of this chapter is to present an analysis of the data collected from the case studies, pointing out the existent connection between the research areas –collaboration, knowledge management and project management from the technology perspective. The final result of the analysis consists of a prioritized list of socio-collaborative technologies that can be included in PMIS to foster collaborative project environments. In addition, it was found important to depict a generic CPMF in order to visualize the role of these technologies within the project context.

### 6.1. Presentation and analysis of results

In the following table, it is presented a matrix contrasting the data collected from each case study regarding technology requirements for project management and additional collaboration functionalities. The generic list of requirements has been previously identified in the literature (see APPENDIX 3); however, some of them have been removed as a result of the data collection.

The matrix will be important to determine: (1) which traditional functionalities are currently required strongly by the customer cases and which might be deprecated, (2) what collaboration and knowledge management initiatives are needed. In combination with the literature, the latter will help to describe generic ideas that could be translated to technical features for later implementation in PMIS. It should be emphasized again that technical implementation descriptions are out of the scope of this thesis; however general guidelines and principles of implementation will be provided.

Requirements	Organization				
	A	B	C	D	Other
<b>Basic functionalities</b>					
Project proposals	✓		✓		
Project templates	✓	✓	✓		✓
Project creation wizards	✓	✓	✓	✓	✓
Import external files (.mppx, .mpp, etc). Export data. Integration with other systems.	✓	✓		✓	✓
Work breakdown structure	✓		✓	✓	✓
Gantt charts, CPM/PERT analysis	✓				✓
Cross-project resource tool					
Personnel directory	✓	✓	✓		✓
Resource assignment by role or skill level	✓				✓
Work schedulers	✓		✓		✓
Progress and time logging by team members					✓
Timesheet tracking and approval	✓	✓	✓	✓	✓
Cost accounts and expense tracking	✓	✓		✓	✓
Task monitoring by threshold					✓
Issue tracking	✓		✓		
Risk management					
What-if analysis					
Change tracking	✓		✓		
Calendar and schedule	✓		✓		
Lessons learned and best practices repositories	✓	✓			

Administration and security	✓		✓		✓
<b>Reporting</b>					
Executive overview (status of multiple projects)	✓				✓
Project overview (milestones and overdue tasks)	✓	✓			✓
Actual schedule vs. baseline					
Actual costs vs. budgeted for project tasks	✓				✓
Report wizard/customize report writer	✓				
Project profitability reports	✓	✓			✓
<b>Collaboration and knowledge management</b>					
Task notification by email	✓		✓		✓
Document sharing	✓	✓	✓	✓	✓
Threaded discussions	✓	✓			
Instant messaging	✓	✓	✓	✓	✓
Central ideas area/wiki	✓	✓			
Project dashboard	✓	✓		✓	✓
Application and screen sharing					
Video and audio conferencing		✓			
Searching and retrieval	✓	✓	✓	✓	
Capturing and classification using metadata	✓	✓	✓		
Versioning	✓		✓		

**Table 12.** Summary of results of case studies.

From the table it can be seen that the organization's requirements are slightly dispersed because organizations are different and have distinct needs, even though they belong to

the same industry. However, highlighted elements have coincided by the organizations as being the most important for their PME.

It was expected, of course, that a majority of the basic project management functionalities are still taking into account by organizations in the case studies. The rationale behind embrace the existence of a specific body of knowledge with respect to the processes, methods and techniques for maximizing the management of projects in areas including time, schedule, scope, cost, quality, human resources, communication, risk, integration and contract and procurement (PMI, 2004).

On the other hand, it is visible that collaboration and KM functions are gaining importance in the analyzed organizations, especially for keeping project teams synchronized and integrated, while mountains of knowledge is generated by project management and project operations. In this sense, PM systems are necessary to furnish information to project teams to achieve project goals, while providing real-time performance feedback of where the project is in relation to its target values (Jaafarit & Manivong, 1998). It has been emphasized earlier in the literature that one essential requirement of social-collaborative systems is the deployment of contextual and relevant information in real-time in order to provide more or less instantaneous response to any question or query input (Koplowitz et al., 2012).

## 6.2. Towards a collaborative project management framework

One of the major outcomes of this thesis is to formulate a theoretical solution that can describe the integration of collaboration and KM within the project management functions. Recent studies in the literature were aligned with this initiative and provided interesting; therefore, it was decided to consider four major components or layers of the collaborative PM approach (Chen et al., 2006):

- (1) Methodological components including basic PM support and process management support.

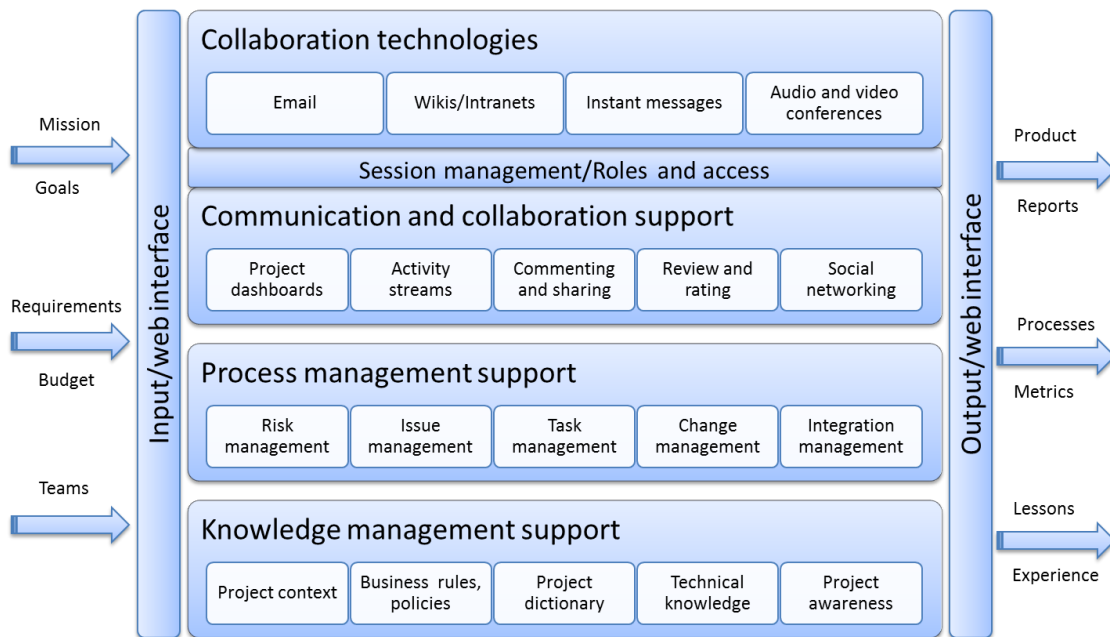
- (2) Technological components including communication and collaboration support and KM support.

At this point most of the mentioned components have already been covered in earlier chapters, except for process management due to has been out of the scope of this thesis. However, it should be emphasized that the latter is an important pillar in the framework as it attempts to achieve project goals efficiently and effectively. This layer includes critical activities all the way through the project lifecycle, such as to increase process visibility, ensure task quality, enhance communication among members, avoid unnecessary rework, identify problems and solutions, control changes (Chen et al., 2006).

The framework shown in the picture below represents the connection between all research areas of this thesis from a systemic point of view. In this sense, a project can be seen as a collection of inputs (mission, goals, requirements, budget and resources), which are processed (management and support functions) to produce results (products, reports, processes and metrics).

While methodological components haven't radically changed from the original framework, technological components were slightly updated in order to include the essential elements identified in the literature and in the research through the case studies. This is indeed because methods and techniques have practically remain the same for years, however technology evolve at a high pace, always trying to adapt and find new ways to support processes.

On the other hand, communication and collaboration support component is presented on top of KM support functions because collaboration is needed to happen for KM (Payne, 2008). The inclusion of collaboration functions such as KS, ideas generation, commenting, dynamic user experiences, and community connectedness are critical for KM and they can be implemented through socio-collaborative technologies such as activity streams, content management systems, wikis, shared workspaces and social networks.



**Figure 9.** Collaborative Project Management Framework. Adapted from: (Chen et al., 2006)

### 6.3. Implications for project management

The framework offers to project managers a holistic view of the PM process as well as a support in visualizing the aspects of projects need to be considered when implementing a collaborative PMIS in their organizations. The benefits of using a tool under this framework could create an appropriate collaboration environment, where project members can communicate and collaborate synchronously for group meeting, discussion and problem solving in day to day operations. As the literature suggested, this social synergy among project actors is crucial for effective KM.

As revealed in the case studies and in other observations during this research, more and more organizations are switching to use more social and integrative systems in their project environments. The rationale of implementing an integrated Web-based project collaboration system lies down in preventing to generate duplicated, outdated and conflicted information that is stored in different databases through different systems.

The challenge for project managers is to leverage collaborative technologies by promoting collaborative practices among internal and external members. Internally, there are different approaches to increase team collaboration, e.g., creating interdependent tasks to offer opportunities for interactions or relationship building among team members, using team-based rewards such that team members would pay more attention to collaboration and fostering learning from project experiences. Externally, managers can offer to stakeholders and steering groups an easy and quick access and support to relevant information to collaborative systems (Zhang et al., 2010).

All project knowledge triggered by social and collaboration interactions, which include project budgets, schedule, tasks, resources, decisions and meeting minutes, can be stored and indexed in the repository for quick consultation, which would serve to detect issues in early stages in the project. By seeking and updating information efficiently and effectively, project members could increase their individual work productivity, resulting in an increased team performance.

For this reason, it is important to identify, assimilate and retain useful information both at an intra-project and inter-project level, so that intellectual capital can be reused at all phases of a single project and also passed to other projects. Therefore, the challenge for project managers is to look at the process to capture and reuse this intellectual capital leading to achieve a continuous organizational learning.

#### 6.4. Implications for software development

Software technicians have also a heavy duty challenge to carry on the technical aspects. The framework could serve as a starting point to design and develop a web-based project management tool including all the social and collaboration functions. Thanks to web 2.0 technologies, software companies can utilize a variety of elements to transform PMIS into a flexible, interactive and more agile system and create easy access and sharing of information in a coordinated way.

On the other hand, as the framework suggests an integrative approach, it means that software development should focus on a global application with centralized databases that can be accessed through the internet to exploit the benefits of collaboration and KM. Therefore, all other external systems should also be connected to provide data consistency, accuracy and availability in real-time.

To summarize the findings of the research and to provide an initiative towards a more social and collaborative PMIS, it is presented a list of functions collected from the literature, the research's case studies and observations, and experts in this field. These are general features that need to be converted in specific system requirements.

Feature	Description
Activity streams	List of brief, consistent, contextual and relevant information of specific interests, e.g. activities from a task, a project, documents upload, relevant comments of a task. It is updated constantly and each item provides details of the referred object of the system such as timestamps, responsible and access to the object. New activities should be visible all the time in the system, so individuals can clearly notice them
Commenting and share	Each activity performed to an object in the system, e.g. project plans, budgets, assigned resources, uploaded documents, should include a particular space where people can write quick feedback about the activity. At the same time, the feature should instantly allow individuals to share their opinions with other members in the team or the organization. Also, other objects in the system should be sharable
Ratings and reviews	Another alternative to provide easy, fast and massive feedback about objects and activities. Evaluators could express their approval or disapproval as well as object creators can obtain instant evaluations about a certain action for quick decision-making. Current rating and review systems vary from a single <i>Like and dislike, star rating, thumbs up and down</i>

Personalized access and control	Role-based access to the system is critical for a collaborative environment. For example, project managers and team members should have different commands to interact with system objects and actions. Object visibility should be personalized according to different roles of the project
Social network	Individuals can keep connected through personal and business profiles in the same system. In a project environment this is crucial for fast search and retrieval of knowledge workers needed in specific project activities.
Integrated wikis	Wikis are a powerful tool to search, create and adapt articles, where stored knowledge can be accessed rapidly. These tools shouldn't be isolated in different databases; on the contrary, they should be integrated with the core systems of the organization and connected with other systems such as project management applications

**Table 13.** List of social and collaborative features for software development. Source: Author

## 7. CONCLUSIONS

The management of projects has significantly changed together with the evolution of information technologies. The dynamic nature of projects has made organizations to switch from a rigid and controlled management to more collaborative environments, where project managers, stakeholders and team members are the owners of the project knowledge produced in every endeavor and use it effectively to achieve project goals.

The evidence from the literature and research case studies have demonstrated that project managers are voting for a more collaborative PME and it is reflected in certain characteristics nowadays required in their project processes and in the tools they use. Therefore, these requirements include the delivery of project knowledge at the right place and at the right time, easily distribution and sharing of knowledge at both intra-project and inter-project levels, through enhanced collaboration.

These requirements led to identify another research goal, which includes the relationship between collaboration and KM, in this case, in a project environment. It turns out that both serve as support functions for the project and according to the literature, however, effective KM can happen if collaborative settings are included. The KM literature points out social processes are essential for recurrent tacit-explicit knowledge conversion. Therefore, it should be emphasized the importance of enforcing and promoting socialization among team project teams.

To achieve this collaborative project environment results challenging for project managers, who have to drive team members towards working in a more coordinated way. From the social point of view, several strategies can be considered organization-wide to change to a collaborative team culture. The creation of interdependent tasks in the project to enable interaction among individuals, increasing trust levels in the team by setting up clear rules for problem solving and rewarding collaboration initiatives, are few examples of this goal.

Another aspect strongly covered along this research is the technology perspective. It was found out that the use of collaborative technologies is critical to create collaborative environments and to implement KM strategies. The literature has suggested various types of collaboration technologies enabling teams to communicate and share knowledge. Synchronous and asynchronous technologies such as emails, instant messages and group workspaces are available to enable interaction between project teams in order to reach collaboration levels in relation to team awareness, coordination, active sharing and joint activities.

The rising of internet technologies, in particular the Web 2.0, is affecting the evolution of collaborative toolsets towards a web-based approach. More and more, organizations are using tools on the web to support their project management process. The fact of finding on the internet a wide-range of tools that address particular needs have caused organizations to spread their information across different systems, resulting in duplicated data, rework and inaccuracy. For example, it was apparent from the case studies that organizations use different tools for building project plans, managing documents and communicating with others. The results of these experiences implied poor and inefficient project and team performance.

To address the problematic of project knowledge dispersion as a result of using a variety of unconnected systems, this thesis has proposed a CPMF, which was adapted from the literature. In essence, it provides a holistic view of a combination of methodological and technological elements of project management in a single entity. While the methodological aspect includes essential project and process management elements found in the body of knowledge, technological elements incorporate socio-collaborative and KM support functionalities. The latter elements require challenging efforts from software development companies to implement this kind of technologies and integrate them into a one global application.

In this sense, technical limitations from the outcomes this research are visible and further software requirements need to be carried on for implementation. In addition, next generation of web technologies, web 3.0 and web 4.0 are evolving at increased

speed into more intelligent applications. Future research needs to be considered urgently towards the development of smarter technologies that support the socialization processes for exchanging tacit knowledge. This could involve the integration of intelligence agents into the organization as help resources, mentors, and ultimately as collaborating peers for fast problem-solving and decision-making and, at the end, to enhance the performance and effectiveness of organizations.

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APPENDIX 1. Characteristics of collaboration and information systems. Source:  
Adapted from (Pereira & Soares, 2007)

Characteristic	Description
Personalization	Easy adaptation to the user style (easy personalization), that it guarantees a good acceptance of the system
Integration	Easy integration of new modules or functionalities in agreement with the needs of each user
Structured/unstructured	The fact of supporting unstructured and structured collaboration
Content distribution	Easy edition, actualization and share of contents
Shared spaces	The ability to construct shared spaces to store documents, to exchange information and to work collaboratively in the execution of the various projects
Knowledge base	Allow the construction of an information and knowledge base in the organization;
Shared documents	Supply to the project teams or groups of the organization an on-line shared space to store documents; to exchange information and to work collaboratively
Idea sharing	The simplicity to use these systems enables a more easier sharing of ideas
Interaction	Fast and simple actualization of the published information;

## APPENDIX 2. Knowledge areas of projects. Source: (Harley, 2009)

Key knowledge area	Outline of knowledge area, process or activity
Project organization	May include: contract negotiation, assigning roles and responsibilities, adopting reporting structure, developing project charter, developing preliminary project scope statement, developing project plans, directing and managing project execution, monitoring and controlling project work, preparation of a project management framework, implementing a methodology and associated PM processes, integrated change control, close project documentation, and an understanding of the organizational culture.
Scope	May include: managing the project through a work breakdown structure (WBS), being results focused, balancing objectives and levels of ambition through scope definition, scope verification, scope planning and control and resource allocation methods
Time	May include: activity definition, activity sequencing, activity resource estimating, activity duration estimating, schedule development and control
Cost	May include: providing a measure to control costs, assessing project viability, obtaining funding, managing cash flows, allocating resources, estimating durations, preparing tenders, budgeting
Quality	May include: meeting specifications, being fit for purpose, meeting requirements, satisfying the customer, quality planning, quality assurance and quality control
Human resources (HR)	May include: HR planning, acquiring the project team, developing project team, managing and structuring the project team, ethics and project management, understanding organizational factors and work cultures

Communications	May include: communications planning, information distribution, performance reporting, managing stakeholders and customer relations, social network building, knowledge and information sharing, implementation of virtual teams, building authority
Risk	May include: identification of risks, assessing individual and joint impact of risks, developing strategies for risk, monitoring and controlling risk and the associated strategies, risk management planning, qualitative risk analysis, quantitative risk analysis, risk response planning, establishing contingency reserves, and risk reward trade-offs
Procurement	May include: planning purchases and acquisitions, contracting, requesting seller response (RFI, RFQ, RFT), selecting sellers, contract administration and measurement against key performance indicators, contract closure

APPENDIX 3. Review of functions of project management solutions with enhanced collaboration and Knowledge Management capabilities. Source: Adapted from Lierni et al (2008), Harley (2009), Infoworld (2000), Jaafarit et al (1998) and observation of PM solutions by the author and consultation of experienced professionals in the area

Functionalities	PlanMill	Projectplace	BaseCamp	Teamwork	Attask	TeamGantt	Microsoft Enterprise Project Management
<b>Basic features</b>							
Portfolio management/analysis	✓				✓		✓
Project creation/ template wizards	✓	✓	✓	✓	✓	✓	✓
Gantt Charts	✓				✓	✓	
Work Schedulers	✓				✓		✓
Time reporting/tracking	✓			✓	✓		✓
Issue management	✓	✓			✓		
Expense management	✓						✓
Resource assignment	✓	✓	✓	✓	✓	✓	✓
Team management	✓						
Project indicators	✓						
Import/Export data	✓			✓	✓		
Project timeline		✓			✓		
Contact management	✓	✓		✓	✓		
Kanban charts		✓					
To-do lists			✓		✓		

Team management	✓		✓				
Project dashboard				✓			✓
Calendar				✓			
Risk management				✓			
Security and privacy control	✓	✓	✓	✓	✓	✓	✓
<b>Collaboration functions</b>							
Document management	✓	✓				✓	
Discussion board	✓		✓				✓
Email Notification	✓	✓		✓			
Task commenting	✓			✓	✓	✓	
Document commenting/review/approval				✓		✓	✓
Project activity streams/Status updates				✓	✓		
Meeting management		✓					
Social networking				✓			✓
Instant messaging				✓			
Team collaboration workspace							✓
Wiki, blogs							✓
<b>Reporting</b>							
Profitability reports	✓						
Finance reports	✓						
Activity reports				✓	✓		
Standard project progress			✓				
Custom reports and business intelligence							✓

## APPENDIX 4. Questionnaire for project managers

## General information of the project manager and projects

---

Please, specify the business unit or department you belong in your company.

Q.1

---

What products or services are your projects related to?

Q.2

---

How many years experience do you have as a project manager?

Q.3

- less than 2 years.
  - between 2 and 5 years.
  - 5+ years.
- 

Do you have a project management certification?

Q.4

- Yes
- No

If 'Yes', please provide brief details of your certification.

Does your organization use formal methodologies for project management?

Q.5

- My organization follows international recognized methodologies. Example: PRINCE2, Agile Project Management, Lean Project Management.
- My organization has its own standards and practices.
- My organization doesn't follow any project management methodology.

If applicable, please mention the project management methodology you use in your projects.

## Project management process

The idea is to understand the way you do project management related to your products/services. Another purpose is to find out what features need to be incorporated in the project management process in PlanMill.

---

What kind of projects do you manage?

Q.6

Short example of a typical project. If it is related to a product or service, its main activities, typical duration and team size.

---

Do you have defined roles for other project team members?

Q.7

Examples of defined roles for team members: consultant, developer, analyst.

- Yes
- No

If 'Yes', please mention what are the typical roles in your projects.

Describe the phases for a typical project and what kind of documentation produced in each phase

Q.8

General description of the lifecycle of a project and its documents/deliverables. For example, in the initiation stage, project plans are produced.

---

How do you create project plans and estimate time of project? Who is involved in this process?

Q.9

Describe what information is needed to define the project tasks, to estimate dates, resources and assignments. How the project manager and members are selected and what other people of the organization are involved. Also mention how and where is this information available.

How do you establish priorities in tasks or requests? Who is involved in this process?

Q.10

Remember that in PlanMill, project 'requests' can also be defined and assigned to project members and later, members can report time, bill hours, etc.

When requirements change or are added during a project, how do you usually re-estimate a project plan? Who is involved in this process?

Q.11

---

Do you use other tools in addition to PlanMill to complement your project management process?

Q.12

- Yes
- No

If 'Yes', which tools and which features of these tools do you find important to complete your work?

## Collaboration, communication and knowledge management

Help us to understand communication strategies and tools, collaboration and knowledge management initiatives used in your projects.

---

What tools do you use for communication in your projects?

Q.13

- Email
- Instant messaging (e.g. skype, ms communicator)
- Wikis
- Intranet
- Sharepoint
- Enterprise social networks (e.g. Yammer, Jive)

If you use other tools, provide a brief description of them.

---

How do you communicate the project goals to your team members?

Q.14

What type of information do you need to communicate to your team on a daily basis? Q.15

---

How do you communicate with other project managers? Q.16

*For example, when contacting other experienced managers for problem-solving.*

---

How would you describe the level of involvement of your customers and other stakeholders in the project? Q.17

*Do they need direct communication with the team? Do they need direct access to project information or project reports?*

Do you have remote teams in the same project?

Q.18

- Yes
- No

If 'yes', how do these teams communicate during the project?

---

Do you or team members need to access PlanMill by mobile devices to enable communication and/or update project information?

Q.19

- Yes
- No

If 'yes', please provide details of the functions you need support on a mobile device.

APPENDIX 5. Questionnaire for team members

Please, specify the business unit or department you belong in your company Q.1

---

What products or services are your projects related to? Q.2

---

How are project goals communicated to you? Q.3

---

How are your project tasks communicated to you and who sends this information? Q.4

Remember that in PlanMill, assignments can be done through project tasks and requests. So, in this and other questions, tasks and requests are the same.

How do you find a list of tasks you should be working on everyday?

Q.5

Explain for example, who and how this is communicated to you, what tools or systems you use. Mention how often and when do you need to check this information.

---

How do you know how much time you should spend on each task?

Q.6

Explain for example, who and how this is communicated to you, what tools or systems you use. Mention how often and when do you need to check this information.

---

How do you let other people know that you have completed your part of the task and that they should continue?

Q.7

---

How do you communicate when there is a problem with a task?

Q.8

For example, you communicate this to customer, project manager, team members, superior, no one. Mention what tools do you use to communicate these issues.

---

Where do you look for additional information relating to tasks or requests needed to complete your work?

Q.9