PROPOSITION OF A METHOD TO DESIGN TAILOR-MADE KNOWLEDGE MANAGEMENT SYSTEMS FOR SMALL AND MEDIUM ENTERPRISES

Tapissier Edouard[*] – Mantelet Fabrice – Aoussat Améziane

LCPI, Arts et Métiers Paris, 151 Boulevard de l'Hôpital, 75013 Paris

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Abstract:

The aim of this paper is to propose a knowledge management system design method for small and medium enterprises that addresses the problems encountered on the existing ones. A literature review highlighted 5 main concepts that have a crucial role in knowledge management system design. To take these recommendations into account, a knowledge management system design method was designed. It uses the small and medium enterprises characteristics, needs and problems to select adapted knowledge management tools and practices, and offers a comprehensive and tailor-made knowledge management system. This method was used to design a knowledge management system for a high-tech small and medium enterprises from the navigation sector. It allowed to choose from the adapted knowledge management tools and practices and to write a set of requirements for the knowledge management system while taking the user into account, thus easing the knowledge management system implementation and ensuring its sustainability.

1 Introduction

Knowledge is one of the most important assets of enterprises. It allows them to perform better in most domains. Enterprises of any size and from all around the world have increasingly started to leverage their knowledge in their activities, as it is a key factor to success. Knowledge Management (KM) is gaining a growing attention from both practitioners and academics, as it proposes tools and methods to ensure that knowledge is created, stored, updated, shared and used in the best way possible in firms. The body of research shows that its usefulness in organizations has already been demonstrated multiple times. Implementing KM allows companies to obtain multiple benefits such as a greater growth, better reactivity, innovation capabilities enhancements, greater efficiency in processes and procedures, and market shares gains [1], [2], [3], [4], [5], [6], [7].

Knowledge management systems (KMS) are systems that allow the application and use of the KM principles in organizations. By implementing KMS, firms can benefit from the KM advantages described above. This is particularly important in SMEs, which have to do more in order to survive in an environment where large firms operate with less. Because of the lack of time, financial and human resources intrinsic to their size [49]. Another reason why KMS are important, specifically in SMEs, is that these firms are prone to knowledge losses relating to key employees leaving the company to seek better careers or jobs prospects in larger organizations [49]. When these employees are single point of failure, it can endanger the whole firm. Managing critical knowledge through the KMS mitigates such risks. To sum up, using KMS in SMEs grants them advantages allowing them to compete with large firms.

Since the 2000s scholars have started working actively on implementation of KM and KMS in SMEs, as well as on KM strategies, tools and practices suitable for SMEs. But as stated by Durst & Edvardsson, this field of research is young and requires more attention [4], and there are currently only few links between

[*] Corresponding author
E-mail address: edouard.tapissier@ensam.eu

literature hypotheses and KM practices in SMEs [21], [25].Wong also underlines that KMS design frameworks found in the literature are not well suited for SMEs, as they present multiple problems such as the fact they remain mostly theoretical, are too complex, not sufficiently comprehensive, or lack means to take SME's needs into account [8]. One of the results of this lack of suited KMS design framework is that KM initiatives in SMEs often fail. Ben Moussa even sets forth that only 16% achieve a sustainable KMS [15].

It was thus interesting to include literature recommendations on how to design KMS for SMEs and SME's important characteristics regarding KM in order to higher the KM initiative success chances by designing a functioning and sustainable KMS for a SME. The purpose of this work is thus to design and implement a tailor-made knowledge management system (KMS) in a high technology Small and medium enterprise (SME), and, on a wider scale, to provide a method for any SME wishing to implement light and easy to use KMS. The key concepts of this work are taken from multiple literature findings:

- Firms' specificities must be taken into account, as they provide useful data to make the right decisions during the KMS design and ensure that the resulting system is adapted to the enterprise [1], [8], [9].
- The KMS design complexity must be low. By guiding the user through the KMS design process, it will be easier and accessible to every SME [8].
- SMEs resources must be taken into account. By using just the right tools and avoiding unnecessary functionalities, the complexity and the time needed to use the KMS is reduced. By keeping the time low which is needed to operate the KMS, users will more likely continue using it, thus risks of KMS desertion will get minimized. The ability of the firm to use the KMS with its available resources must be ensured by taking resources into consideration during the design phase [1], [4], [8].
- The KMS must be complete in order to be functional. It is thus necessary to address the 4 main KM processes: knowledge creation, storage, transfer and use [4], [10], during the KMS design [8], [11], [12] and address the interactions between people, process and technology [46], [47].
- The KMS needs to answer how to practically carry out KM in the firm. This can be done by providing guidelines and examples of KMS specifications during the design and performing training and change management [1], [8].

To take these findings into account, a method to design tailor-made KMS was designed. It begins with a description of a SME, thanks to important characteristics of SMEs found in the KM literature. Needs and problems analysis is also performed in the firm to understand the expected aim of the KMS. This description is then used to make an assessment on the firms' readiness level and the amount of work that needs to be done to implement KM. It also allows the design of the specifications for a tailor-made KMS, and the choice of the right set of KM tools and practices. Change management is then performed to implement the KMS in the SME, where it will be improved through iterations to make it sustainable.

The aim of this paper is to present the KM tools and practices of selection steps of this KMS design method. This paper is organized as follows: section two focuses on literature review on the existing KMS and KM tools, as well as SMEs KM related characteristics. Section three introduces the KMS design method, describes how the enterprise audit is performed, and how gathered data is used to prepare the firm for KM and choose need-fitting KM tools and practices. Section four describes a practical use of the method in a high-tech SME through an example of a case study. Section five concludes on this work and suggests future research directions.

2 Literature review

2.1 Knowledge management systems in small and medium enterprises

Knowledge management systems are widespread in large companies, for which abundant literature on implementation exists [3]. However, studies suggest that SMEs do not manage their knowledge the same way large firms do, thus making systems and concepts suitable for large companies such as knowledge-engineering based practices like MOKA or CommonKADS unusable [1], [3], [9], [13], [14], [15], [16], [17].

This is because SMEs are not scaled down large companies and have characteristics that make them different than for large firms [18], as well as unique regarding each other [19]. Even though knowledge is a key element for SMEs [20], [21], literature on KM in SMEs is scarce, especially on subjects such as KMS implementation [1], [3], [19], [22], [23], [24], [25] despite the fact that SMEs represent 99.8% of the world enterprises and employ more than 67% of active workers [26], [27]. In term of numbers, BenMoussa [15] states that only 16% of KM implementation attempts in SMEs are successful, because of the lack of suitable KMS. The problems cited are often related to too much time and resource consumption [8] and failure to maintain KM on the long run [15].

2.2 SME's characteristics

To better understand how KM works in SMEs, it is necessary to understand what factors impact it in SMEs. A previous work on this subject [28] identified 96 unique characteristics that were sorted in 4 categories, according to their use for KMS design.

The "supporting" category gathers characteristics facilitating KM implementation and use in the firm. A readiness assessment of the firm preparation for KM implementation and use can also be performed by using these characteristics.

The "existing" category gathers characteristics based on the firm's existing processes and KM related practices. These characteristics will facilitate the implementation of a KMS in the firm's workflow.

The "KM nature" category gathers characteristics that have a direct impact on how the KMS is built, its processes, its actors, etc. It consists of SMEs' specificities that give them their uniqueness, and that needs to be taken into account to create a KMS that best suits their needs. Identifying the firm's needs makes it possible to obtain a KMS that strictly fits them, without any unnecessary elements.

The Critical Success Factors and Critical Failure Factors (CSFs and CFFs) of KM are areas that must receive attention during the KMS design, implementation and use, in order to guarantee its success [18], [29], [36], [38], [49]. These factors are broadly studied and are often sorted as important, depending on their impact on KM success [18], [36]. Based on the literature, we sorted them in 3 categories: crucial CSF have strong impact on KM, major CSF moderate impact, and minor CSF a low impact. Crucial factors must be addressed to ensure the KM implementation success. Major factors can be addressed if the underlying cost is acceptable. Minor factors can be addressed if the underlying cost is small, as their impact on the KM implementation success is low. Depending on what they focus on, the CSFs can be useful for enterprise preparation, during KMS design or during its operation in the firm.

These characteristics are useful to perform a precise and comprehensive description of the firm on KM-important aspects. They can be used to provide an enterprise readiness statement [30]; to define the changes needed to ensure a functioning KMS; and to provide decisional elements during the KM strategy design and the tools and practices selection.

2.3 KM tools and practices

KMS is a set of practices, tools and activities allowing KM to be achieved. According to Cerchione & Esposito [24], KM practices are defined as a set of methods and techniques to support the organizational process of KM activities, and KM tools are the specific, often IT based, systems supporting KM practices. A literature study was performed to list simple and easy to use KMS, tools and practices suitable for SMEs, and then focused on more complex and integrated practices and systems, commonly used in large firms or to achieve a specific knowledge capitalization goal. It allowed the identification of multiple KMS for SMEs, but as Wong [8] underlines it, they come with multiple drawbacks. They provide no clear answer on how to achieve KM, assume a vast availability of resources, are very complex to use, or do not support some of the usual KM activities. It was thus necessary to find the right set of KM tools and practices usable in SMEs to design a sustainable KMS while addressing these problems.

The literature study yielded 84 KM tools and practices [9], [24], [31], [32], [33]. KM is not always the main purpose of these tools and practices, but they can still be used to address KM problems and activities [31]. It also allowed the identification of 21 KM methods to achieve more complex activities, such as knowledge elicitation (MASK, MOKA, CommonKADS), knowledge databases creation (CommonKads, MOKA, MEREX), or case-based reasoning (CBR). Each tool and practice listed was studied in order to

describe them and understand how to use them, as well as their goals in a KM perspective. Through two brainstorming sessions, CSFs were used to exclude tools and practices that were not suitable for SMEs, such as those needing too much time, human or financial resources, as using moderate resources is a major critical success factor [18]. The current database contains 80 relevant tools and practices for SMEs.

Because of the numerous KM tools and practices, it is hard to choose the right ones, to know if they are suitable to the needs of the firm or if they will be used. Multiple tools and practices selection systems were created, such as AHP [34], the House of KM Tools Selection (HoKMTS) [31], or fuzzy logic methods [35], but are complex to set up and use without preliminary training. The selection step of this method offers solutions to assist the user during the KM tools and practices selection process while keeping its complexity low.

In order to produce a tailor-made KMS, as recommended in the literature [8], [18], [19], it is necessary to choose the tools and practices and design of the KM strategy according to the enterprise characteristics. The main hypothesis of this work is that, by taking into account the right characteristics and the needs of the SME, it is possible to choose the right tools and practices to guarantee a sustainable and functional KMS.

3 The KMS design method

To obtain a suitable KMS for a firm, all the elements that might have an impact on how KM will be done must be taken into account. The KM literature reveals multiple important points. By taking them into account from the beginning of the KMS design, a better suited, functional and sustainable KMS for the enterprise could be obtained. To facilitate the design, a 3 step method was created (Cf. Figure 1). The first step (S.I) consists of the SME to gather KM-relevant data usable to create a resource efficient, functioning and sustainable KMS. It makes it possible to take the findings and recommendations on KM in SMEs into account during KMS design by establishing an enterprise description regarding the important characteristics of the SME (S.I.1); studying its KM related needs and problems (S.I.2); making a readiness assessment for KM implementation (S.I.3); and taking a decision on continuing or abandoning the KM initiative (S.I.4). This output is then used to establish a first set of requirements for KM (S.I.5), partly specific to the firm, and to determine the required resources investments.

This data will then be used during the second development step of the KMS (S.II). The second step (S.II) is divided in 2 main parts: The first one (S.II.1) consists in practically preparing the firm for operational KM, based on findings and recommendations of the literature, as well as the CSF studied during the first phase. This will allow the SME to implement the necessary adaptations identified during the firm audit and study (S.I) and to prepare for KM use. This part is generic as the theoretical requirements for KM are the same in all SMEs. The second part consists in selecting the right tools and practices to implement in the firm to meet its needs and solve the problems identified during the first step (S.I.2); studying them to understand how to use and implement them (S.II.3); and aggregating these tools to remove unnecessary functionalities (S.II.4). It allows the customization of the KMS and leads to a set of requirements for the selected tools and practices.

The second step ends with the creation of a list of functional requirements for the KMS (S.II.5). These specifications come from the firm preparation to meet KM needs (S.II.1) as well as from the selected tools and practices (S.II.2-3-4). The third step (S.III) consists in realizing, implementing and ensuring the sustainability of the KMS. It includes employees, managers and the firm owner training to use the KMS, the implementation of the tools and practices selected during S.II, and the promotion of their use in order to initiate a change into the enterprise organization and habits. If new KM needs to appear, this step also allows iterations to add new functionalities or to remove unused features. These three steps must be executed in the right order, as outputs are the next steps' inputs. Each step of the method is detailed below.

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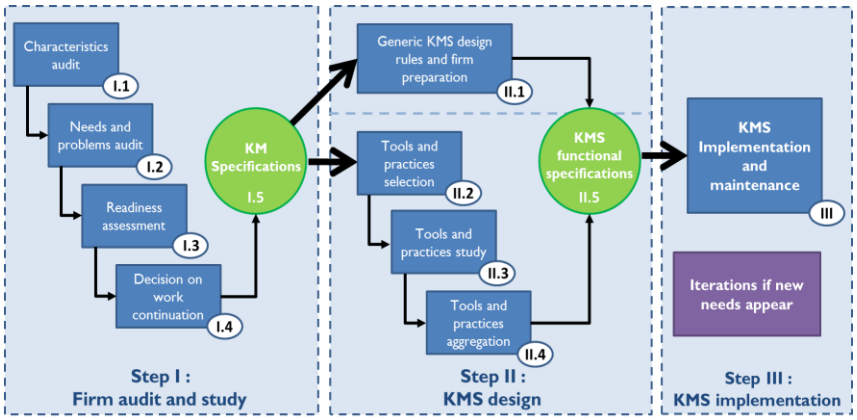

Figure 1. Proposed KMS design method.

3.1 Step 1: Enterprise audit

The design method begins with an audit of the studied SME, in which its needs and problems, its characteristics regarding KM, and its readiness for KM implementation are studied. The breakdown of this audit is given below (cf. Figure 2).

3.1.1 Firm's characteristics audit

The enterprise characteristics audit highlights the important aspects of the firm that can be used to guide the KM strategy design and make adaptation in the firm to prepare it for KM. It is performed through the use of a table containing the important characteristics of SMEs for KM taken from the work of multiple authors [1], [3], [8], [13], [16], [18], [23], [36], [37], [38]. This table is described in the work of Tapissier et al. [28].

The description is done through one or multiple semi-structured interviews with the top management of the firm, such as the CEO, the CTO or a manager, allowing to have a comprehensive view of the firm.

This interview can be carried out multiple times with different employees in order to ensure accurate results. It can also be performed without a KM expert. At the end, a description of the firm regarding important factors and characteristics to implement KM and perform KM activities is obtained.

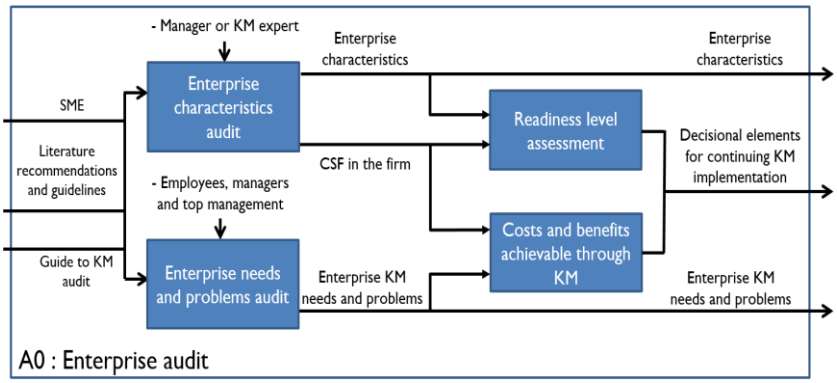

Figure 2. SADT A0 of the enterprise audit.

3.1.2 Needs and problems audit

The analysis of the needs and problems of the firm allows to determine what objectives the firms aim to achieve by implementing KM, as well as how KM could be used to solve operational or organizational problems in the firm. It is performed through semi-structured interviews with employees, managers and top management of the firm based on a list of questions about the enterprise activities; it's organization; the encountered problems; the potential lack of tools and methods to perform the activities; the employees need of KM; and knowledge flows in the firm. After identifying the work context of the employees, they are asked question about the management tools and methods they use in their projects, how knowledge is managed inside and outside of projects in the firm, where the knowledge they use in their activities comes from, how problems arising in their activities are solved, which tools they use, or lack of, and what could be improved in the firm's activities and processes.

At the end of the interviews, a summary of the answers is done to formalize the needs and problems and is presented to the interviewees to make sure it is accurate.

This summary will be used to guide choices during the KMS design, thereby allowing the integration of the needs and problems of the firm in the KMS design process. The aim is to make the KMS more sustainable by making sure it is adapted to the firm context and useful to the employees.

3.1.3 Readiness assessment

The readiness assessment step consists in its evaluation of the enterprise preparation to set up a knowledge management strategy and implement a KMS [39]. To perform a readiness assessment, enterprise processes and employees' minds [40], CSF related to enterprise preparation [30], [41], pertinent characteristics [39], [42], [43], and the employees' will to take part in the KMS development in the enterprise can be used.

The assessment results are on a list of elements in favor of a KMS implementation, as well as the ones that could be improved by working on the firm's organization, its culture or the employees. If the enterprise is ready for KM or if changes are planned to make it ready, the design work can continue. Otherwise, work will be necessary to address as many criteria defined above as possible to ensure a successful KMS. Planned changes can be performed as part of the generic design rules and firm preparation part of the method (S.II.1).

3.1.4 Decision on the design work continuation

The results of the previous steps can be used to conclude if the work should be continued, by comparing the gains achievable through KM implementation and the costs associated with such implementation. The gains come from the KM needs answered and the problems solved, as well as the global advantages brought by KM in the firm. Costs come from the resources needed to adapt the firm in order to improve its readiness

level; to design and implement the KMS; and to train the users and give them time to use it and maintain it. Depending on the results of the comparison, the work can either be continued or abandoned, avoiding additional resources expenses.

3.1.5 KM specifications

If the work is continued, the requirements based on the literature findings and recommendations; the enterprise needs and problems; and the enterprise characteristics are formalized as a first set of requirements: the KM specifications. It contains elements relating to the following points:

- Solve the enterprise problems or provide support to solve the problems
- Use KM tools and practices suitable to the firm's characteristics
- Verify as much critical and important CSF as possible, as well as important characteristics for KM readiness to ensure the KM success.
- Take literature findings and recommendations into account.

Some requirements such as literature findings are generic and can be applied to every SME. These KM specifications can be used to determine the work needed and move on to the next step of the design method: The KMS design (S.II). The generic KMS design rules and the firm preparation part (S.II.1) and the tools and practices selection, study and aggregation (S.II.2-3-4) can be performed in any order.

3.2 Step 2: The KMS design

3.2.1 Generic KMS design rules and firm preparation

In order to guarantee that the KMS will have high success chances and that it will be operational, some preparation work is needed, and the necessary adaptations identified during the audit must be performed. If the enterprise is willing to invest more resources, work can also be done on minor CSF and some of the characteristics proposed by Razi & Karim [43]. This step consists in listing all the elements that require attention and modification in the firm to obtain optimal conditions to implement a KMS. They may come from different sources:

- The crucial and major CSF relating to the firm preparation, and to the use and sustainability of the KMS
- Elements identified during the audit
- Elements that impact the KM strategy
- Elements whose implementation has a negligible cost in term of resources
- Literature recommendations presented in the introduction

These elements can be formalized as specifications for the enterprise KMS and can then be performed, resulting in actions such as fostering corporate culture changes by encouraging employees to share more knowledge and work together, or adding new communication means, such as chats, etc. At the end of this phase, enterprise readiness can be reassessed to make sure that the performed changes were efficient or if more work is needed

3.2.2 Tools and practices selection process

Thanks to the data of the enterprise audit, KM tools and practices that will be used to support knowledge creation, storage, transfer and use in the firm can be selected. This step covers the selection process and the optimizations to the tools and practices that can be performed.

By using the previously mentioned list of 80 KM tools and practices usable in SME, as well as literature guidelines, findings and recommendations, the SME's problems, its needs and its description, the user can select the most suitable tools and practices for the firm. This step by step selection method answers to the fact that finding the right tools for a firm is complex because there are many existing ones, and that existing selection methods such as AHP, Fuzzy logic or HoKMTS are too complex to use in SMEs without the prior training.

The selection method contains 3 phases, and calls upon a KM expert, a top management employee (or the owner of the SME) and employees from the domain in which KM will be used. These actors make it

possible to have a comprehensive view of the SME and its organization. The SADT diagram above (Cf. Figure 3) summarizes the resources and the actors involved in each selection phase.
The first phase consists in verifying if the tools and practices of the database are usable in the firm by using the result of the characteristics audit. The second selection phase consists in verifying if the tools and practices could likely be used in the SME. The last selection phase consists in choosing only the tools and practices to get implemented in the firm to answer its KM needs.
The following Verification and validation criteria were used:

- The set of tools and practices must allow the creation of a comprehensive KMS, covering the 4 KM activities (knowledge creation, storage, transfer, and use);
- They must answer to all the firms KM needs and problems;
- The tools must likely be usable in the firm, and adapted to its specificities;
- The set of tools and practices must consume as less resources as possible to avoid being abandoned (time needed to use them, cost of implementation, etc.);
- Employees having prior knowledge or training on the tools and practices is beneficial, as less training will be required.

For further details, a full description of the tools and practices selection method is given in the previous works [44].

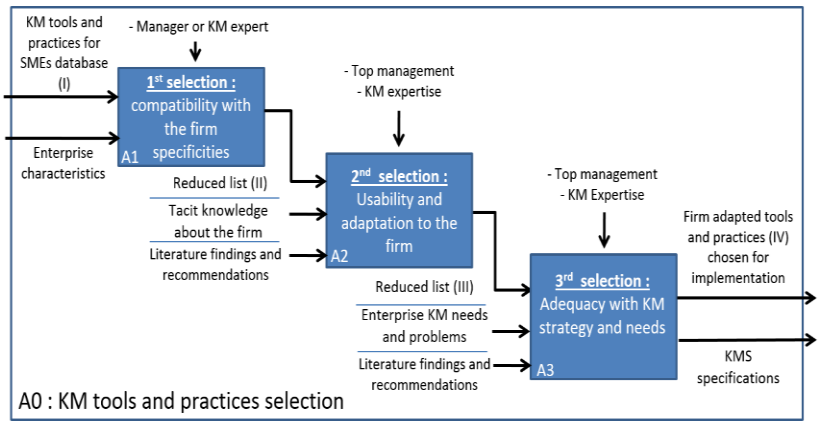

Figure 3. A0 diagram of the KM tools and practices selection.

3.2.3 Study and use of the selected tools

Once the tools and practices are selected, a study step is necessary, as it allows to highlight functionalities, recommendations and requirements needed to integrate them in the KMS. Three major steps were identified to perform this study: The first step consists a comprehensive definition of the tool or practice. A literature study must focus on its principles, functionalities, implementation and usage requirements. During the second step, the purpose of the tool or practice within the KMS and the KM strategy is defined. It also studies the potential aggregation of multiple tools and practices. The third step lists all the requirements of the KM specification designed during the first step the tools and practices or their potential aggregation must answer to, and to what need or problem they solve.

3.2.4 Tools and practices aggregation

In some cases, aggregation between multiple tools and practices can be achieved. A study of the potential advantages of such synergy can be conducted following the tools and practices selection [31]. The aim is to make the KM tools and practices more usable, consistent between them and less resource consuming. To achieve this, useless or redundant functionalities can be removed; the use process can be planned to leverage functionalities from a tool in another one; or they can be included in existing tools or practices of the firm, such as ERP systems.

Data from the firm's KM strategy, its needs and problems, its characteristics, and its operating habits can be useful to perform such tools and practices aggregation. One way of doing it consists in breaking

down the tools and practices in multiple functionalities and position them on the use process of each of them. Combinations of different functionalities that answer to the needs defined above can then be identified, as well as redundant and useless functionalities. It allows the construction of a less complex usage process for the tools and practices, without unnecessary elements.
Following this step, all the requirements needed to design and implement the tools and practices in the firm are available. By adding them to the requirements from the generic KMS design rules, specifications for the KMS of the firm can be created.

3.2.5 KMS specifications

The KMS specifications gather the requirements from the KMS design step (S.II), originating from the generic KMS design rules and from the tools and practices. This specification also allows a traceability of the requirements of the KM specifications from step S.I.3 as the tools and practices, the CSF and the literature findings and recommendations answer to the needs and problems of the firm. Thus, by dealing with the requirements of the KMS specification, all the requirements of the KM specification will be met.
Requirements relating to generic KMS design rules allow setting up elements needed to ensure a functioning KM in the firm. They come from different sources:

- Requirements linked to KM CSF allow the setup of new elements in the firm, and the adaptation of existing elements (e.g. enterprise culture, top management attitude, etc.) to prepare it for KM.
- Requirements linked to literature findings allow taking into account the necessary elements that fosters KMS success in SMEs.
- Requirements linked to literature recommendations allow taking into account the important elements to obtain a functional and sustainable KMS for a SME.
- Requirements linked to user training allow to ensure that users understand the aims of KM and will have the necessary knowledge to use the designed KMS.

Requirements relating to tools and practices are directly taken from the literature study performed after their selection and their aggregation. They come from different sources:

- The intrinsic requirements of the tools and practices allow their operation and use.
- Requirements linked to the solutions provided to the needs and problems of the firm by the selected tools and practices.
- Requirements linked to aggregation with other tools and practices.
- Requirements linked to the implementation of the tools and practices in already existing tools or methods of the firm allow to introduce the KMS in the work practices of the employees.

The specification obtained ensures that the KMS respects literatures guidelines and meets the enterprises expectations. This increases the success chances of the KMS implementations and guarantees its sustainability. If new needs appear, it is possible to iterate on the second step to add the necessary functionalities. The KMS can then be implemented in the firm, and employee training on its use and its maintenance can begin. This step is currently underway in the studied SME and will be presented in future works.

3.3 Step 3: KMS implementation

Once designed, the KMS can be implemented in the firm. Implementation is based on 3 phases. The first one consists in practically creating the KMS processes and tools, and implementing them in the firm. The second phase consists in training the user to use the KMS, its processes and its technological tools. The third phase consists in the KMS usage by the firm, and its improvement through iterations to answer to emerging needs or problems and ensuring it will be sustainable and functional.
The outcome of the KMS process and tools design must address the interactions between people, process and technology [46] [47]. The users must rely on a defined process relying on technological tools to make sure that KM will be comprehensive.

4 Case study: designing a KMS for a high-tech SME

A case study of the use of this KMS design method was performed in order to verify that each step was functional, and to improve them if necessary.

4.1 Firm presentation

Sysnav is a high technology SME created 9 years ago, in France, and produces medical devices. Its annual turnover and its 25 employees categorize it as a SME according to OECD [27]. Because of its accelerating growth and a wish to better protect its crucial knowledge, Sysnav wants to set up a KM strategy and start using KMS. It would also allow its employees to work more efficiently and reuse already existing knowledge generated in research projects more easily. The method described above was thus used to design a tailor-made KMS for the firm.

4.2 Step 1: Enterprise audit

4.2.1 Characteristics audit

The Sysnav characteristics audit was performed through a semi-structured interview with a top management employee that knows the enterprise and its activities well. It provided the necessary data to understand the critical elements in the firm to design and implement KM.

4.2.2 Enterprise needs and problems

The enterprise needs and problems were identified through 5 semi-structured interviews with 5 employees. A list of 21 needs and problems was constituted and validated afterwards with the participants. For example, the lack of tools to share and manage feedbacks or the need of a process to store and retrieve knowledge in the firm were identified thanks to these interviews. The conclusion is that Sysnav needs KM to create, store, transfer and reuse its knowledge. Thus, implementing a KMS would answer to its needs and problems, providing that the firm is ready to perform KM.

4.2.3 Readiness assessment

Based on the information from the previous phases, the enterprise readiness for KM implementation was analysed. It was performed with its critical success factors related to enterprise preparation, its characteristics and the motivation level of the employees.

The CSF analysis yielded the following results:

- 8 crucial factors out of 13 are respected in the firm.
- 3 major factors out of 4 are respected in the firm.
- 3 minor factors out of 6 are respected.

For example, the crucial CSF regarding the need of a strong will from employees to share knowledge was initially respected. The major factor regarding the familiarity of the employees with KM related vocabulary was not respected. Preliminary training was thus needed. The minor factor regarding the presence of communication IT tools (chats, newsletters, blogs, etc.) in the firm was already respected, as the firm had group chats and a weekly newsletter on what happened the previous week.
It appears that multiple CSF require attention. However, the important ones are easy to address in the firm and mostly rely on top management attitude towards KM. A review of the characteristics impacting enterprise readiness was then performed. It provided relevant data to use Rakhman et al. [39] method. The results are presented in Figure 4.

Scores were calculated based on the characteristics in favor of KM and the help of a top management employee. Weights were taken from the work of Rakhman et al. [39]. The obtained score of 3.44 puts the firm over the 3.41 limit at which an enterprise can be considered ready.

Employee motivation was assessed through their participation in the KM project and during the interviews. It appeared that multiple employees were strongly involved in the design and implementation of the KMS, which was deemed favourable to KM readiness.

Factors	Weights	Scores	Weighted scores
Management leadership and support	0,2793	4	1,1172
Strategy and purpose	0,0672	4	0,2688
Performance measurement	0,0796	1	0,0796
Organizational structure	0,0077	3	0,0231
Process and activities	0,0273	2	0,0546
Training and education	0,0323	2	0,0646
Organizational culture	0,1786	4	0,7144
Motivational aids	0,0428	2	0,0856
Communication and group working	0,151	4	0,604
Information technology	0,025	4	0,1
Integration of operations	0,0879	3	0,2637
Security	0,0212	3	0,0636
Results			3,4392

Figure 4. Sysnav results to Rakhman et al. readiness assessment method.

Based on the readiness criteria described above, the enterprise can be considered ready to implement a KMS and perform KM activities. It is therefore realistic to start designing a KMS for the firm.

4.2.4 Decision on the design work continuation

The enterprise audit allowed to determine multiple advantages of KM use in the firm. It was thus decided to continue the design work.

4.2.5 KM specification

The KM specifications for Sysnav was based on multiple main topics:

- KM must answer to the needs and problems of the firm.
- The firm must validate crucial and major CSF.
- The KMS must include tools and practices adapted to the firm's characteristics and needs.
- The KMS must consume as few resources as possible during its use.
- The KMS must not have useless or redundant elements.
- The KMS must have a user guide.
- The KMS must allow to perform all KM activities: knowledge creation, storage, transfer and use.

These requirements will then be developed during the second step, by setting up the generic KMS design rules and choosing the right tools and practices to answer to the firms needs and problems.

4.3 Step 2: KMS Design

4.3.1 Generic KMS design rules and firm preparation

Multiple CSF and characteristics were identified as not optimal for KM during the audit, and some improvements were decided during the readiness assessment. Modifications consisted of working on top management attitude regarding KM; communication means in the firm; information communicated in the firm; corporate culture; and the use of tools such as indicators. It resulted in 36 requirements in the KMS specifications.

These requirements were directly derived from the CSF found in the literature that must be taken into account during the KMS design and the KMS operation phase. For example, a requirement deals with the need to maintain knowledge stored in the KMS up to date to avoid its obsolescence. Another one deals with the need to create user manuals to explain, to train, and remind the user how KM processes functions or how to perform KM activities and use the KMS technology.

4.3.2 Tools and practices selection

The tools and practices selections consisted in the application of the selection method described above. The 3 selection steps were performed with a project manager from the top management through multiple interviews. They allowed the selection of 3 tools and practices: Wikis, knowledge mapping and knowledge modelling.

4.3.3 Study of the selected tools and practices

A study of knowledge mapping, knowledge modelling and wikis was then performed. It allowed to better understand the use processes of this tools and the wiki technology. It appeared that knowledge mapping was suited to identifying knowledge stored in the firm's projects, and that knowledge modelling was suited to identifying knowledge stored in the firm's processes. The functionalities, recommendations and requirements identified through this study where then used to perform an aggregation.

4.3.4 Tools and practices aggregation

The feasibility of an aggregation was studied, and allowed the removal of redundant and useless functions, and to allow the use of the different elements in a same process. The wiki is used as a support to knowledge identified and formalized by mapping and modelling. This step yielded 55 requirements for the KMS specifications. The details of the tool selection, study and aggregation are presented in previous works [44], [48]. The tools and practices were validated using the criteria defined above.

4.3.5 KMS specification

The second step of the method ended with the KMS specification. It gathers the requirements related to generic KMS design rules, firm preparation, tools and practices, and enterprise needs and problems requirements. In total, 103 requirements were established:

- 55 requirements related to the implementation of a wiki, knowledge mapping and knowledge modelling.
- 36 requirements related to enterprise preparation and generic KMS design rules.
- 12 requirements related to enterprise needs and problems not directly related to KM.

These 12 additional requirements were added to set up unified supports and best practices in the firm, that will be contained in wiki pages.

4.4 Step 3. KMS implementation

The implementation of the KMS in the firm (S.III) could then begin. It consisted in:

- Making the decided modifications to the firm to ensure the sustainability of the KMS.
- Creating knowledge mapping and knowledge modelling procedures and user guides.
- Designing an architecture for the wiki.
- Identifying what knowledge should be stored in the wiki and how it should be presented.
- Setting up a wiki usage procedure and user guide.
- Creating user training supports and training the users to use the wiki.
- Setting up best practices for some activities of the firm with the help of experts.

4.4.1 Knowledge mapping and modelling procedures

Knowledge mapping and modelling procedures were created to guide these activities in the firm and ensure that all the employees perform them the same way by following a step by step process. Only the functionalities that were deemed useful in the aggregation of tools and practices were kept, such as the ones related with discovering knowledge in projects and processes of the firm. Functionalities such as drawing visual knowledge maps were discarded, as they were considered useless in this case. User feedbacks will allow iterations on missing or useless functionalities in this aggregation.

4.4.2 Wiki design

To comply with the KMS specification, a study to identify the most fitting wiki software was performed. Dokuwiki was selected between 5 other candidates. The software was installed on an enterprise internal server, and it is not accessible from the outside. Employees can access it with personal logins inside the firm. This allows user action logging and linking knowledge to its creators. The recorded user activity can be used as an indicator [45].

4.4.3 Wiki architecture

The Dokuwiki wiki is composed of multiple parts, with as much subparts as needed, just like in a usual computer folder structure. They contain pages of the wiki where the users can write text, place images, tables and references to other wiki parts. It also contains a search tool that searches keywords in pages, which allows to find knowledge stored by anyone more easily.
As wiki pages are created to store knowledge, they can be considered as knowledge objects. Knowledge objects are sets of interrelated data, information and knowledge formalized in a physical form. They can be composed of text, tables images or any other structure allowing knowledge support. These pages can be created and stored by any identified user and allow sharing with other users by simply providing a link. Knowledge storage and transfer are thus addressed.
Sysnav wiki is composed of 4 parts that allow the storage of different kind of knowledge objects. These parts are:

- Portals, which contain pages on global knowledge related to enterprise expertise domain.
- Projects, which contain pages related to project-specific knowledge hardly reusable outside of it or that must remain partitioned to avoid critical knowledge leaks.
- Activity support, which contains pages about procedures and processes documented in the firm for specific activities.
- Personal notes, which contain pages only accessible to their creator.

Wiki uniformity is guaranteed by predefined templates for the different type of pages. These templates will evolve if needed depending on the user feedback. An example template and multiple templates for each kind of expected pages were designed to help the users get used to wiki and learn its syntax. These templates can easily be reused by the users, and their structure answers to the KMS specification.
In order to train the employees to use wiki, a usage case on a finished project was done, and it helps to understand how the wiki works and how to determine what knowledge can be stored.

4.4.4 Format and location of the knowledge objects

One of the main goals of wiki is to store knowledge created in the projects. Some knowledge can easily be reused (e.g. guidelines to design a printed circuit board), and some is useful only in some specific cases (e.g. the electronic interfaces of a specific product). Knowledge broadly reusable outside a project must be accessible to every employee for them to reuse it. Knowledge unusable outside specific projects should only be accessible to employees that might need it to work on the project in order to avoid interfering with more reusable knowledge. As a matter of fact, it is easier to find relevant knowledge objects by removing irrelevant knowledge from the search.

After identifying knowledge that needs to be formalized with knowledge mapping and modelling, the format of the knowledge object and its location on wiki (e.g. projects, portals, etc.) must be determined. To ensure the relevance of knowledge stored in wiki and manage the time needed to use the KMS, it was necessary to set some predefined formats for the knowledge objects. A knowledge object can have 3 formats: A complete wiki page, a short abstract and a reference to an existing document, or a simple reference to a document.
To determine the format and the location of a knowledge object, 3 criteria can be used:

- The knowledge reusability. It is high if knowledge can be easily reused inside or outside of the project by other employees, medium if knowledge can be reused in some cases, and low if knowledge is very specific to a context and hardly reusable.

- The knowledge formalization cost. It represents the time needed to create a wiki page containing the knowledge on a subject. The cost is high for the creation of a full page without any support, which can take a few hours; medium when reusing an existing document to simply make an abstract, which takes less than an hour; and a low for a simple reference to a document containing the knowledge, which takes only a few minutes.
- The knowledge extent. It is high if it is usable in multiple projects and situations, and low if it is only usable in a few projects.

Format is chosen with the reusability and the formalization cost of the knowledge. The location is chosen with the reusability and the extent of the knowledge. The CTO of the firm can help determine reusability and extent of technical knowledge, as he has a vision of all the projects in the firm. The above Figure 5 and 6, summarize possible different cases.

Knowledge objects are thus formalized and stored in wiki, while minimizing the resources needed to use the KMS. By doing so, the necessary resources are reduced without losing knowledge or wiki functionalities compared to a systematic formalization of knowledge objects as full wiki pages.

		Knowledge reusability			
		Unknown	Low	Medium	High
Knowledge formalization cost	High	Decision with the CTO	No capitalization	Reference to existing document	Full page, abstract or reference to existing document. Decision with the CTO
	Medium or low	Decision with the CTO	No capitalization	Abstract	Full page

Figure 5. Format of the knowledge object: Formalization cost vs reusability.

		Knowledge reusability	
		Medium or low	High
Knowledge extent	High	Projects	Portals
	Low	Projects	Projects

Figure 6. Location of the knowledge object: Extent vs reusability.

4.4.5 The KMS implementation and user training

Once the KMS was created, it could be deployed in the firm environment. It started by the installation of wiki on the enterprise servers, making it accessible to employees through the intranet, just like online wikis like Wikipedia (CF. Figure 7).

The global KMS use process and sub-processes such as the ones to perform knowledge mapping and modelling, chose the format and location of the knowledge object, store them in wiki and reuse them (Cf. Figure 8). User training on how to achieve KMS processes and KM activities could then begin. Highly motivated users that would act as KMS "champions" [45] and guide other users in KM related activities were first trained. The other employees were then trained by these champions, making the firm self-sustainable in KMS training. The interactions between people, process and technology were thus addressed

by training users to perform KM activities supported by the KMS process, which relies on the wiki technology, accessible by every employee.

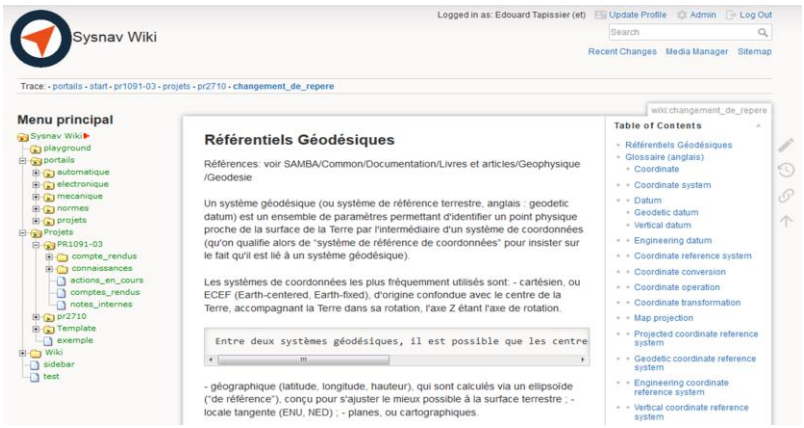

Figure 7. screen capture of wiki installed on the enterprise servers.

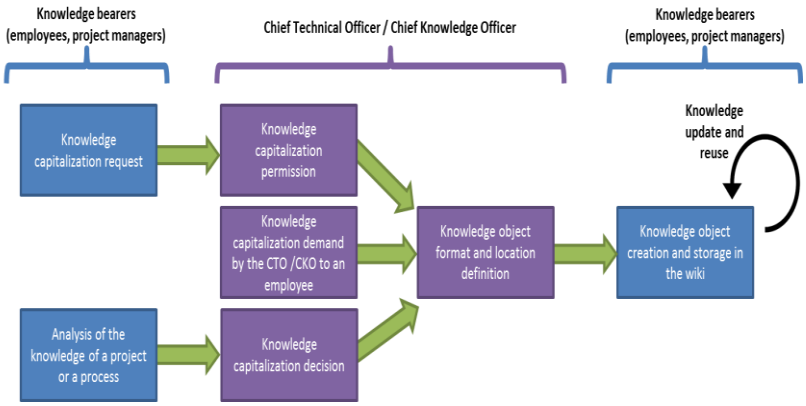

Figure 8. Global KMS process.

The firm could then start to use its KMS. Depending on the feedback of this first use, or emerging needs, iterations will be performed to improve the KMS and ensure it will be sustainable and functional.
This implementation process is detailed in previous works [48].

4.5 Conclusion on the designed KMS

By applying the method presented in this paper, a tailor-made KMS accessible from each employee's computer was designed for a SME. Interesting and relevant knowledge is identified through knowledge mapping and modelling and is stored in t wiki. Rules on format and location allow to organize knowledge in order to avoid time loss during formalization and research, which reduces the KMS impact on the employees work and should be in favor of KMS sustainability.

4.6 Verification of the KMS design

A verification was performed to make sure that the KMS respects literature findings and recommendations:

- Enterprise characteristics were taken into account during its design, which resulted in the choice of a tool that fits in the employee's workflow.
- Resources needed were optimized. The selected tools and practices are free and the time needed is controlled through the knowledge object formalization rules. Moreover, the KMS is easy to use, and only minimal training is needed to start creating wiki pages.

- The KMS handles knowledge creation through knowledge mapping and modelling, and knowledge storage, transfer and reuse through the wiki.
- Through user guides and examples, all of the KMS use process is explained, practically answering how to carry out KM activities. It guides users in their KM work, while maintaining enough flexibility thanks to the freedom offered by the wiki.

A validation phase will also be performed before the first iterations phase, thanks to user feedback and KM-related indicators, in order to make sure that the KMS is functional and is used as expected.

5 Conclusion

The proposed method allows the design of a tailor-made KMS for SMEs and assists the user from the need expression, to the specifications, and implementation of the KMS. The first step consists of an enterprise audit to determine its characteristics, its KM-related needs and problems, and assess its KM readiness level. The second step consists in planning adaptations in the firm to prepare the KMS implementation and selecting tools and practices that fit the firm in order to ensure the KMS sustainability. The third step consists in realization of the KMS, its implementation, and iterations to improve it thanks to user feedback.

The requirements designed using the generic KMS design rules and the firm preparation guide the implementation and improve the KMS sustainability. The requirements from the KM tools and practices ensure that the enterprise needs and problems are addressed.

This method was used to design a KMS for a high-tech SME. It allowed to identify and proceed to necessary adaptations to prepare it for KM and select 3 KM tools and practices adapted to its needs: wikis, knowledge mapping and knowledge modelling. During its first trial, the firm audit proved to be efficient, as the firm description was deemed representative of the firm by the owner and provided the required information on the following steps. The tools and practices selection process seemed more accessible than the solutions proposed in the literature to the firm's managers. This addresses the design complexity of KMS problem raised by some authors.

The implementation of the KMS designed for the studied SME is currently in progress. It is performed through a pilot project, to allow a first iteration before extending it to the whole firm. The work will then continue through iterations on its contents to determine what adaptations are necessary and if they could have been planned during the design phase. The method will then be evaluated in another SME, similar to the one presented in this paper.

6 Contributions and future works

The major contribution of this work is a method that takes literature findings and recommendations into account and allows KMS design for SMEs. The KMS design is guided and free of complex tools or methods, thus keeping the complexity low. The 3 steps use the important characteristics of the firm to perform KM, its needs and problems and available resources, and make sure that the KMS will be sustainable.

The main interest of this work also lies in the fact that it brings KM theory into practice, which is actually lacking in the literature, especially for SMEs. The constituted CSF list helps to identify "universal" KM elements that must be planned to ensure KM success. The tools and practices database allow an easier choice of tools and practices by providing data on each element through their description and guiding the user during the selection. The proposed aggregation of tools and practices step helps to reduce the use costs of the KMS by removing the unnecessary elements, thus reducing the work that needs to be done to operate the KMS.

By applying this method, a tailor made KMS based on the use of a wiki was designed and implemented in a SME. Although it is too soon to present the results, the user feedback is encouraging.

This work will continue with the validation of the KMS in the SME, followed by multiple iterations to improve it. The method will be improved by adding change management support, KMS scalability and evolution possibilities. It will then be applied to another SME to verify its universality.

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