

UNIVERSITAT POLITÈCNICA DE CATALUNYA

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**LIFE CYCLE DOCUMENT MANAGEMENT SYSTEM
FOR CONSTRUCTION**

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Terrassa, February 2005

DEDICATION

I would like to dedicate this thesis to my family.

To my husband Raul, who has impressed me with his maturity, intellect and loyalty to his family. Throughout my research, he has always been there to offer words of encouragement. Without his support this research would never have been completed.

To my mother Joana, who has shown us the true meaning of love and commitment to the ones she cares most for. Her steadfastness and resolution in the face of adversities have made her into a truly remarkable person, and one whom is looked upon with the greatest of respect and admiration, not only by her family and myself, but also by her friends and colleagues.

To my father Francesc, who through his courage and determination has shown how to face up whatever difficulty in life. He has always been next to me and he has shown great interest in my research.

To my brother Jordi, the best brother in the world who has been encouraging me in every aspect of the life.

ACKNOWLEDGMENTS

First and foremost, I would like to express my most sincere gratitude to my supervisor, Dr Miquel Casals. I am truly grateful to him, for his consideration and help which has been invaluable to me in carrying out my thesis. His expertise, intellect, persistence and motivation have provided me with the foundations with which to build my skills as a researcher. He has instilled in me a sense of diligence and academic rigour, which very few postgraduates will ever receive to such a high standard.

I would also like to thank Dr. Halim Boussabaine from the University of Liverpool for the highly professional support he has provided throughout the research and his selflessly help during my stay in Liverpool. Without his skills, competence and willingness to help, I feel my progress would have been hampered severely. Together with Dr. Halim Boussabaine I would also like to thank Dr. Richard Kirkham from Jones Moore University for his encouragement and help during all my research and specially for volunteering to help while I was in Liverpool.

Similarly, I am grateful to other colleagues and friends I have worked with in the department, in particular Mr. Xavier Roca and Miss. Marta Gangoells. I consider myself extremely privileged and fortunate to work with such honest, hardworking and loyal friends.

ABSTRACT

The construction industry is fragmented due to the many Small and Medium Enterprises (SMEs) and phases involved in a construction project. This fact has led to well documented problems with project management and concretely communication and information processing.

What most SMEs require in terms of project management is the ability to manage and share the company's documents. This is achieved by removing certain core applications from individual PCs and running them on a server such as an Electronic Document Management System (EDMS). Such tools should centralise the information specific to the organisation in an easily accessible environment, allowing users to store, access and modify information quickly and easily.

On the other hand, large companies, often early adopters of IT, demand that SMEs that work with them adopt the same management systems. Currently, the most popular option used by larger companies for the project management is web based tools such as Web based Project Management Systems (WPMS) that are applications designed to store and manage project information. Quite simply project collaboration applications allow disparate groups of people such as engineers, architects and clients to control access and automate dissemination of information. The most WPMS used in the construction sector is to rent a completely developed WPMS from an Application Service Provider (ASP) for a usage fee. The development and operation of this option require a minimum of technical, financial and human resources.

The start point of the thesis is survey carried out in several SMEs in the construction sector in Spain in order to acquire a general idea of their working methodologies and the deficiencies on document management.

From the SMEs standpoint, the main challenge of WPMS still lies within the lack of a standardized document organization and the inefficiency of the information flow from different sources (Documents stored in their EDMS and those stored in the WPMS).

The suggested remedy for this inefficiency and the aim of this thesis is to create a tool to improve both internal and external document organization. This *Life cycle Document Management System for Construction* automatically creates a folder structure for each specific project to be download into each company's server and into the WPMS which is being used for the project management. This folder structure will be the same to the folder structure of

the WPMS with the consequent improvement of document storage, interaction and exchange of information between all the actors working in the same construction project.

To do this, the flow of information between the different parties involved in a construction project is mapped out and a *Concept Model for Information Flow* is designed to store all the documentation of a construction project and its metadata throughout the life cycle of the project. Different approaches are analyzed to obtain the most accurate solution.

Moreover, when these actors are working with WPMS sharing documents all the stakeholders should have the same working standards. This thesis also provides a *Guidelines for Document Management through WPMS* to unify the different working processes of all the companies involved in the project. These guidelines are applicable to projects of varying complexity, size and duration. Document codification, organization of folders and documents, publication dates, documentation control, and so on, are some of the aspects that these guidelines are oriented to.

Finally, the system is submitted for criticism and evaluation by several academics with the aim to verify its contents and consistency. A survey is also carried out in 30 SMEs out of a variety of project types, sizes, values, and Project Management utilized to validate the system.

The system will serve as a demonstration for all the participants in a construction project that a good document management is basic for the fulfilment of the project objectives.

Keywords: documentation, web based project management systems, information management, project management, communication.

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1. Introduction

1.1. Introduction

The construction industry is fragmented due to the many stakeholders and phases involved in a construction project. This fact has led to well documented problems with communication and information processing and has contributed to the proliferation of adversarial relationships between the parties to a project.

Information Technology (IT) is starting to be used in the construction industry as a tool to reduce some of the problems generated by fragmentation. Its benefits include an increase in the quality of documents and the speed of the work, better financial control and communications, and simpler and faster access to common data as well as a decrease in documentation errors. Among all IT applications, **Internet** is the technology that best **facilitates a collaborative working environment in a construction project**. Its use as a communication medium can **help information transfer** occurs faster and more effectively and can provide new opportunities for the development of distributed systems that can cross organization boundaries and provide a unique opportunity for teamwork and workflow automation. The web can also overcome the incompatibilities of data formats through smart browsers and servers; therefore, independent project participants using different hardware platforms can share the same applications over the web (Rojas & Songer 1999).

Recently, a concept of how the web and its associated technologies can be used to manage construction projects has been widely acknowledged by practitioners. This concept is often referred to as a **Web-based Project Management System (WPMS)**, a promise to enhance construction project documentation and control and to revolutionize the way in which a construction project team conducts business. **WPMS is an electronic project-management system conducted through the 'Extranet'**, which is a private network that uses Internet protocols to transmit information. The system is only accessible by a project team, but team members can be located in different organizations. It basically provides a centralized, commonly accessible, reliable means of transmitting and storing project information. Project information is stored in the server and a standard web browser is used as a gateway to exchange this information, eliminating geographic and boundary hardware platform differences. Currently, the most popular WPMS option being used by Architecture, Engineering and Construction (AEC) firms is to rent completely developed WPMS from an Application Service Provider (ASP) for a

usage fee, which is normally charged per project, per the amount of computer storage space required, and/or per user. This option requires minimal technical, financial, and human resources to develop and operate. Since a WPMS is outsourced to an ASP, it requires no effort to develop and maintain the system in-house, involves comparatively low initial investment and overhead cost and is convenient for keeping up with cutting-edge technology. Therefore, it is a **viable solution for Small and Medium-sized AEC Enterprises** (SMEs) that do not have enough resources to maintain an in-house IT department and/or sophisticated networking infrastructure. In addition, WPMS are also capable of performing electronic commerce, such as online bidding and procurement, which are difficult to develop and conduct through in-house WPMS (Nitithamyong & Skibniewski 2004).

1.2. Problem statement

More and more the Internet is becoming more accessible due to the cost of both equipments and Internet connection, which simplifies things especially for SMEs. In addition to that, bandwidth tends to get better and better, solving the problem to exchange design models or other big files. Above all, there is a market waiting for and that has started to discover the advantages of, for instance, project management supported by ASP providers.

The AEC sector has a delay with regard to make business electronically, what can be explained by two reasons: the 'traditional side' of the sector as well as the power of the equipments used by SMEs.

The sector is willing to invest on this area as soon as the real benefits are categorically demonstrated. **One key concept in this scenario is: simplicity.** SMEs are not interested in the complexity of the technological solutions; they rather prefer to interact with some very simple mechanisms (that might hide and handle complex issues) that can help them to make business in a better way. In fact, SMEs do have IT but in general they do not get profitable results from it. In order to get the gain, they have to change the way they work, which is not an easy thing to accomplish because it creates a natural barrier to overcome. For instance, when dealing with the adoption of standards by SMEs, the business target has to be clearly identified. SMEs have to see clearly the reasons why they would change, if it is the case.

In order for a construction organization to successfully embrace WPMS, many factors such as technology, process, personnel, procurement, legal issues and knowledge management must be considered equally. Although there have been some studies conducted to solve these problems, Spanish SMEs use of WPMS is low as compared to other European countries.

There is a special need to redesign traditional working procedures and one important aspect is the exchange of data between different companies. This is to take advantage of the new possibilities of WPMS and especially Electronic Document Management Systems (EDMS), so that working procedures are better and more efficient.

Few traditional companies don't feel comfortable implementing some kind of Information Technologies in all the aspects of the company but they should take into consideration how these changes will affect their business trying to redesign part of it. So, there is a clear need of tools to help SMEs to use all the WPMS to reduce these companies' fear of Information Technologies (Forcada et al. 2002).

1.3. Possible solution

Although the WPMS concept is of increasing importance to practitioners as well as researchers in construction, it is still relatively new and its optimal styles and extensions of use have not yet been thoroughly investigated. According to Kraker (2000), there is still a debate among AEC firms whether or not to move permanently to WPMS. **Most companies have used WPMS either because their competitors are influencing them or they are being forced to adopt WPMS by their clients.** The usefulness of WPMS in construction is still not as initially expected, and factors such as sociological and personnel issues still need more attention as they could greatly impact the system's performance. Industry practitioners must consider not only the technology but also give equal prominence to processes and people who are involved in the system in order to successfully embrace WPMS and achieve business benefits (Alsawi & Ingiride 2003). In general, most IT projects do not meet their performance objectives, the main reason not being related to technical issues. Nevertheless, technically-related factors have often gained the sole attention while non-technical factors are considered separately, overlooked, or even completely ignored. Research studies conducted to date have still either aimed to solve existing technical problems of WPMS or to introduce new advanced techniques to improve the current systems, ignoring the fact **that technology push is not the only critical success factor for effective implementation of new technology such as WPMS.** Unlike other technologies, WPMS is very much **concerned with the exchange of information across the project life cycle.** Its successful implementation, therefore, will not only require a state of readiness within one organization, but also within every organization involved in the construction processes.

1.4. Aims and Objectives of the Thesis

The principal hypothesis is that WPMS for the construction companies don't pay special attention to document organisation. Consequently, the objective of the study is to establish the necessary basis and criteria to facilitate integral project management and to help SMEs use Information and Communication Technologies (ICT), so as to counter the aversion to these new tools in this traditional and fragmented sector. To do this, a new standard working and organizational model for WPMS of construction companies (*'Life cycle Document Management System for construction'*) will be developed.

The scope of this thesis is such that all the AEC companies (especially SMEs) were able to improve their working processes using ICTs and learn the benefits of using these new technologies in a reliable way. However, in the immediate future, these technologies will become a critical barrier that the companies will have to overcome if they are to participate in many projects. The research also attempts to achieve the following specific objectives:

- To develop Guidelines for any Small and Medium Construction company aiming to define the basis of a quality Document Management System.
- To create a generic system/database to facilitate the use Document Management of Web based Project Management Systems by SMEs (*'Life cycle Document Management System for Construction'*).
- To identify and define the relations of all the documents generated in a project and the interactions and responsibilities (create, receive, etc.) of the actors taking part in a project to the specific document. The aim is to identify the main documents used, created, exchanged, etc. by the different actors in a construction project and throughout its life cycle.
- To create a web based tool incorporating the system/database to give access to all the authorized people to the system. This web based tool will allow users to download to their PC or server the same folder structure for Document Management as the WPMS they are using. Moreover, each user will be able to consult whatever information of a specific document to be uploaded or downloaded from the WPMS.
- To evaluate (verify and validate) the web based system in different companies.

This system will serve as a demonstration for all the participants in a construction project (architects, constructors, clients, suppliers, etc.) working with WPMS or not, having a quality system or not, that a good document management related to a specific project is basic for the

fulfilling of the project objectives. In addition to that, if they are working with WPMS where different actor are sharing documents and don't have any kind of Quality System the '*Guidelines for Document Management through WPMS for Construction*' will be the solution to the documentation chaos that is usually generated in a company. On that ground, all these companies will understand the advantages that new technologies offer over traditional working methods.

This model will be based on the Management of the Information flow during the construction entire life cycle to improve the information management among the project parties utilizing IT in the whole building process.

1.5. Limitations and delimitations

- The model will only be focused on the management of project documentation and not the records management of the company.
- The system will consider each document as an entity, and not as a possible group of information to be split.
- The system will give the organizational structure (folders, subfolders, documents, etc.) to be used in whatever construction project (depending on the contractual arrangement), and will give the location of each document along the life cycle and from different aspects. But documents won't be templates to be filled according to the type of document.
- For the present, the system will be translated into Spanish and English. Other languages will be able to be implemented just translating the words.
- The system doesn't provide the tools for document searching, uploading, retrieving, etc. These functions are supposed to be provided by WPMS.
- The system will be tested in companies having at least an Internet connection and a minimum structure such as to enable them to use WPMS in a near future.
- For the moment, the system will allow to create the folder structure into the PC or a server of each partner to the WPMS. In this version, each partner will have his/her folder structure to organize the information in his/her PC (or server) and will know where (from the WPMS) to upload each document but, for the time being, WPMS documents are not automatically updated.

1.6. Outline of the thesis

Chapter 1 provides an introduction, theoretical grounding and justification for this research. The purpose of the thesis is presented in addition to the main aims and objectives. An introductory coverage of the research methodology used to achieve these goals is also demonstrated.

Chapter 2 presents the evolution of Project Management in Construction Projects. The chapter begins with an Introduction to Project Management and the different parts that Project Management involves: Communication Management and Information Management. The chapter also presents the challenges facing Project Management and the Limitations of the current Project Management.

Chapter 3 addresses the technical aspects of the current Construction Project Management tools, and in particular, presents a review of the prevailing Information and Communication technologies for the Construction Sector.

Chapter 4 reviews one of the main Project Management services: Electronic Document Management (EDM) due to the importance of the Information Management in Construction Projects. The chapter also reviews the problem of interoperability between computer services, different solutions to this problem and the strengths and weaknesses of these systems. The chapter then moves to different approaches to Document Management: those ordered to provide information about the product, called 'engineering information management systems', and those ordered to provide information about the process, named 'enterprise resource management systems'.

Chapter 5 reviews current Web based Project Management Systems (WPMS) for Construction Management, applications that, altogether with many other services, provide Electronic Document Management to improve communication between partners and the management of the project. Taking into account the evolution of Project Management tools and the Information and Communication Technologies (ICTs) nowadays available for the Construction Sector, this chapter deals in depth with WPMS. It starts with different types of Web based Software for the Construction Industry such as Information Portals, Enterprise Portals, Electronic Marketplaces and WPMS. A critical review of different approaches of WPMS provides the foundation for a detailed commentary on the importance of well structured information to fulfil the objectives of the project. The chapter also presents the results of an international survey on the utilization of WPMS in the Construction Industry, and relates the study of different Spanish companies using these tools.

Chapter 6 concludes the first part of the thesis by stating the clear need of tools to help SMEs to use any Web based Project Management Tool to reduce these companies' fear of Information Technologies. The chapter also reports the research methodology that will be focused on developing a *Life cycle Document Management System for Construction*.

Chapter 7 describes the *Concept Model for Information flow* by revising the literature review on Structuring Project Information. Different methodologies for organizing information in a construction project are analyzed and a comparison between them is provided to conclude with the most suitable document organization for managing projects through WPMS.

Chapter 8 describes the development of *Guidelines for Document Management through WPMS* for whatever SMEs who is taking part in a Construction Project and uses WPMS for the management of the project.

Chapter 9 describes the development of the *Life cycle Document Management System for Construction*, the elements and functionalities of the database, the database design criteria, the implementation of the database and the system functioning.

Chapter 10 presents the rationale used to validate and verify the system. Following, the results of the survey on the use of IT in AEC carried out during the research and the conclusions of the validation and verification of the system are presented.

Chapter 11 discusses the results of the thesis. The thesis is summarized; the main contributions to knowledge highlighted and suggestions for further research are made.

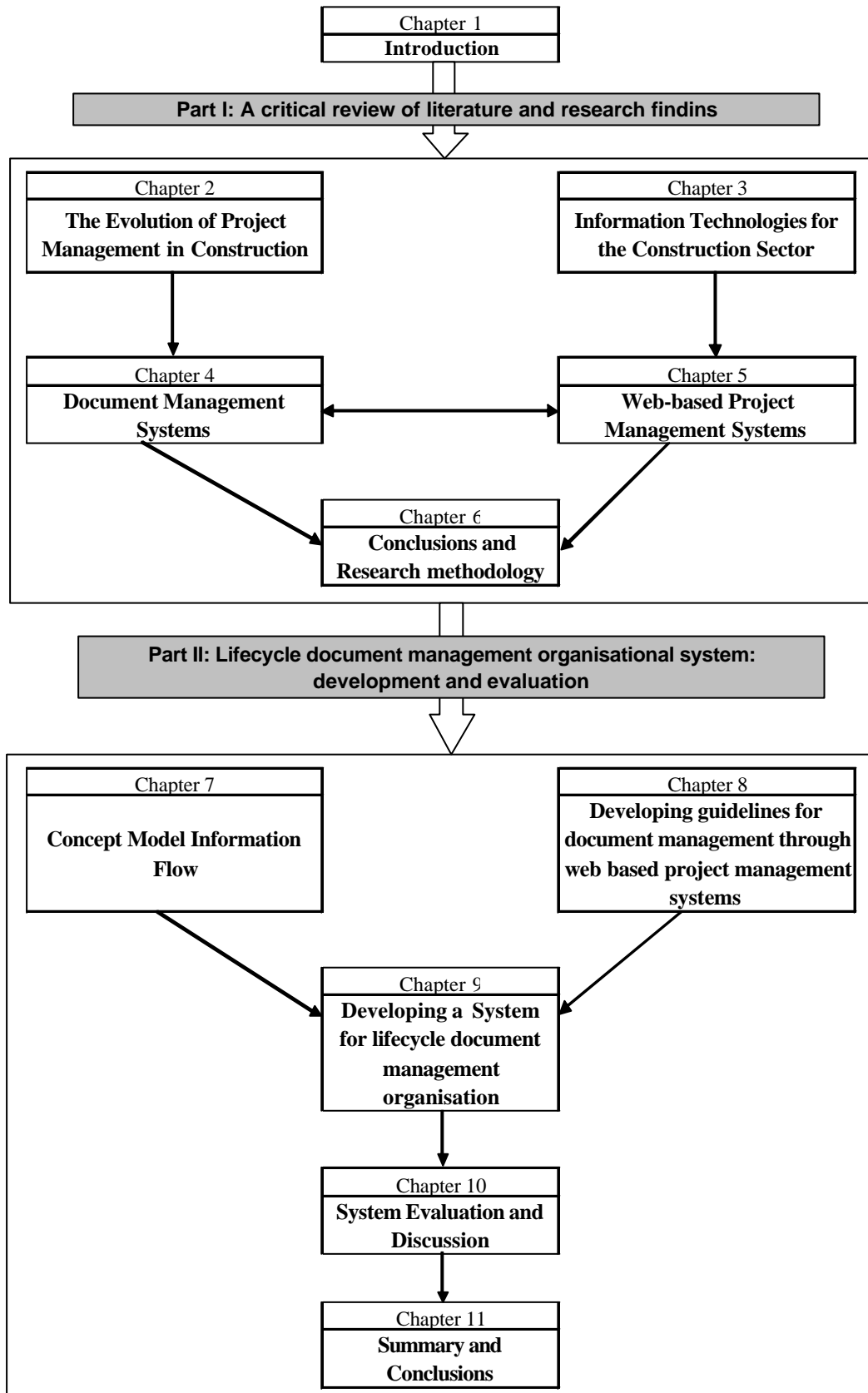


Figure 1. Thesis layout