

## 11. Conclusions

### 11.1. General conclusions

The final objective of whatever research is to improve the knowledge and provide tools to improve it. In whatever company and in whatever project the end objective is to meet project's overall objectives as defined by the scope, time, cost, quality and client satisfaction. The overall role of PM, in this scenario, is to harmonize the functions of planning, communicating, monitoring and control the project in order to meet this project's overall objectives. This research was focused on the improvement of Project communication and documentation, one of the main functions of PM. In this sense, the improvement of DM implicates an improvement of PM. And if we improve PM, the project overall objectives are indirectly improved.

Therefore, this thesis aims to contribute to improving productivity of SMEs through DM and Project Communication.

Larger business partners (often with bigger IT budgets) and early adopters of IT, demand that the small companies working with them adopt the same systems. In order to meet at least some of these demands, small companies are forced to invest in isolated solutions that fix immediate problems. This approach results in unnecessary expense and purchase of disparate systems which eventually need to be replaced.

The best course of action is to adopt the same enterprise-wide infrastructure and technology as larger companies, but on a smaller scale, and implement a scalable solution which can grow with the company. The tools are readily available and can be bought at a moderate cost, using standard "off the shelf" components, and tailored custom-designed solutions should be avoided at all cost.

Basically, what most small companies in terms of Project Management **internally** require is the ability to manage and share company's documents.

The real benefits start to become visible when certain core applications are moved away from the individual PCs and run on the server such as an EDMS. These tools should centralize the specific information to the organization in an easily accessible environment, allowing users to store,

access, and modify information easily and fast. The main basis for effective EDM is that all the information (letters, reports, databases, drawings, etc.) must be in electronic format, which is either created electronically or scanned in from a paper version. This includes hand written notes and sketches as well as large maps and complex drawings.

Many companies use EDMS to standardize the way information is accessed and passed through the company. This makes it easier for anybody with correct privileges to find and access the document they want. An EDMS helps users to perform their work easier and provides the company with security, data reliability and work process management. Many of these features eventually save time, simplify work, protect the investment made in creating these documents, enforce quality standards, enable an audit trail and ensure accountability.

Besides that, most small companies will be **externally** obliged to adopt the same systems as those adopted by the large companies who are working with them for the management of the whole project.

While the emphasis has traditionally been on the need to manage the interface between the project and the client's organization, it is now shifting towards the need to manage the flow of activities and information through the project life cycle.

In doing that, electronic data exchange, in particular WPMS, has shown to have tremendous potentials not only in adding value to the internal performance of an organization, but also to the whole supply chain and therefore to the client. Unlike many IT tools, web-based tools are very much concerned with the exchange of information across the project life cycle. Their successful implementation therefore will not only require a state of readiness within one organization, but also within all those involved in this process. This makes the successful implementation of such tools difficult to be planned for and managed.

Today, the traditional approach of PM has shifted from e-mail notification with attached changed document, to a series of total WPMS solutions. Widespread use of various networks, Internet, server and database technology, enables WPMS systems to provide up-to-date document-related information and management tools like document version control, retrieval, review, approval, etc. Project partners have the opportunity to choose the manner of notification through local PCs, faxes or mobile phones.

In order for the construction industry to successfully embrace WPMS, it must equally consider technology, process, people, procurement, legal issues and knowledge management.

All the attempts to make all the partners of a construction project use WPMS are basically technology driven, and process, people, procurement, legal issues, and knowledge management are not fully addressed.

It is much more difficult to successfully embrace WPMS for SMEs because of the *different practices used in different organizations* and the extra complexity dimension which is added by the type and level of *incompatible computer systems* used by these organizations.

The efficiency of current processes must be carefully addressed and re-engineered to take advantage of the latest advances in technology. The industry should work towards minimum common standards to facilitate the flow of information across the supply chain. Such standards will add significant value up the chain by allowing exchanged information to be *fully integrated with business processes*. People must have the necessary skills and the rewarding environment to harness the benefits of the Internet.

It will be extremely difficult for construction firms to achieve the required results of implementing web-enabled tools without fully addressing the management of change and how people can best be taken on board.

The teething problems and change in working culture and practices, which is initially required, very often deters the users. Achieving the kind of targets that are needed in today's environment requires major change in the organization, including practices, systems, processes and workflows. The right strategies and implementation plans have to be developed, communicated and brought to life.

The thesis so far has been analyzing WPMS and different Spanish AEC SMEs, and how they currently work.

We have seen that effective document management probably is the most crucial part in project management during the project.

Besides, WPMS basically identify the different group members of the project, the revision status, date, responsible person and other notes, and it provides document viewing, uploading, downloading, reviewing, approving, etc., in order to help actors monitor the actions related to that document. But the main challenge of WPMS still lies within *the inefficiency of exchanging information among the actors involved in a project*. Both WPMS and project partners involved could create this inefficiency. A major obstacle in AEC is the lack of a standardized document organization.

The suggested remedy for this inefficiency was to create a tool to improve both internal and external document organization. This tool should automatically create a folder structure for each specific project to download it into each company's server and into the WPMS which is being used for the project management. To help all AEC SMEs integrate their business to these WPMS, the *Life cycle Document Management System for Construction* was developed.

## 11.2. Life cycle document management system for construction projects

The *Life cycle Document Management System for Construction* aims to help those SMEs define each document structure, based on 'Explorer', for each project with the added value of being the same folder structure as the one used by all the other partners involved in the project, and as the folder structure to the WPMS being used by the management of the whole project. It can be used alone, as a system that creates a folder organisation for specific projects, and also as a function of the WPMS once it's implemented in the same web system. But in both cases it's to be used at the beginning of the project with the aim to have all the documentation well structured and in the same way the other actors organise their documentation. Because of this, the functions of uploading, finding, downloading, accessing, etc, whatever document in the WPMS or in the DMS will be easier and it will facilitate project communication and document organisation.

From this idea, the basis of the system was defined. Firstly, a *Concept Model for Information Flow* was created with the aim of obtaining a database and the relations among all the information, characteristics, documentation, actors, life cycle, etc., of a construction project. Different approaches were analyzed for to obtain the most accurate solution. This information was used to generate the *System requirements*.

The first prototype was submitted for criticism and evaluation by several academics. Their suggestions were included and the system was modified.

Once the last version was ready, informal validation by domain experts was used to test the system.

The validation was carried out in 30 SMEs out of a variety of project types, sizes, values, and Project Management utilized.

The findings indicated that architects and engineers are most likely to use WPMS because they have the necessary infrastructure to support them and their employees are more familiar with technological solutions such as CAD design. On the other hand, subcontractors are the most

resistant to adopting these tools because currently they don't perceive value, and, basically, because they have not been exposed yet and they lack education about these tools.

From the survey carried out in this thesis it can be concluded that there is a need to redesign traditional working procedures to facilitate the exchange of data, so as to be able to take advantage of the new opportunities offered by a project web, so that working procedures are better and more efficient.

Nearly all the companies have a centralization of documentation in a server but they are not keen on having all their documentation in Internet because of security reasons. The AEC SMEs in Spain generally have their templates of documents and they are satisfied with them, but the main problem is the organization of documentation. Although most of them have never been exposed to use WPMS, they are very interested on a tool like the *Life cycle Document Management System for Construction*; on the one hand, because they are convinced that in the near future they will be obliged to use WPMS; on the other, because it will be really useful to already have a Document Management System compatible with the system to be used in the future. For the moment, some of the companies judged the system interesting for their internal document organization.

Furthermore, the validation has shown that the *Life cycle document management System* solution provides a flexible document organization to satisfy the requirements of the interested project partner.

In parallel, *Guidelines for Document Management through Web based Project Management Systems for construction* was developed. These guidelines attempted to provide a concise way of (internal and external) document management to use in each company among all the employees, and outside the company among the other partners of the project using WPMS. 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.

From the validation, we could observe that most SMEs have neither a Quality System nor document management standards. Because of this, these guidelines will help SMEs, whether working with WPMS or not, whether endowed with Quality Systems or not, to improve their internal and external document management.

### 11.3. Knowledge contribution

This work has advanced on knowledge on the following areas:

- State of the art and review of DM in the context of Construction Industry.
- DM in SMEs.
- Improving productivity of SMEs through DM.
- Integration of PM documentation
- Improvement in PM information and communication.
- Improvement in internal DM of SMEs.
- Improvement in the exchange of information among different actors of a construction project.
- Development of an organisational model for information flow of construction projects.
- Development of a web based system for DM within SMEs.
- Development of an innovative structure for DM within SMEs.
- Development of quality guidelines for DM through WPMS for construction projects.

This thesis has contribute to improving productivity of SMEs through DM and Project Communication and therefore the improvement of scope, time, cost, quality and client satisfaction.

Referring to time, the system improves access to information and reduces the response time for RFI (Requests for Information), CO (Change Orders) and specifications clarification. It also shortens the project life cycle. The fast dissemination of information shortens consultation cycles and speeds up decision making. When you send an electronic document to a website it is immediately available for viewing; likewise, if it can be easily found, written feedback is available without delay. If the cycle-time taken to turn around a RFI/CO is shortened, this could have a direct impact on the length of the project: with fewer delays and quicker response times, the life cycle of a project can be shortened. Shortening the life cycle of construction brings benefits such as reduced expenditures in man-hours, equipment rentals, project site office costs and security costs and allows the project team to begin working on new revenue-generating projects. By completing the project sooner, tenants can occupy the site earlier and owners/developers can enjoy earlier rental/lease revenue.

In term of cost, the main contribution of this system is the reduction of costs and wasted time. Printing and postage costs are reduced and also document administration as all documents are stored centrally

Quality is also improved by the reduction of risk and potential errors. The latest information is always available as soon as it is published, minimizing the risk of working on old information.

Finally this system will increase transparency as barriers to communication are removed. It will also improve project control because all actions are recorded to be audited and monitored with the consequent client satisfaction.

As researchers address real problems developing new tools and/or improving the existent ones and the AEC industry moves to embrace these tools, all participants will realize additional benefits progressively. It's foreseen that as understanding of client needs and adoption increases, product offerings will be developed to meet the needs of all industry players; in turn, these will increase overall usage of online project collaboration tools. It's believed that the AEC industry will open itself up and adopt the changes brought about by the development of online collaboration tools.

#### **11.4. Future work**

In order to take full advantage of the potential provided by rapidly developing IT, it is essential to intensify co-ordination between research and industry in this domain.

Basic EDM and WPMS skill education and training in the construction industry is an urgent demand in order to improve construction Project Management, due to the incompetence and immaturity of IT knowledge in the industry. It is hoped that further research in the above field will contribute to the improvement of construction Project Management as well as document management in the future.

Once the companies get used to these IT tools, extended work should be done in the development of the *Life cycle Document Management System for Construction* such as to improve the document organization by incorporating not only the project documentation but also the records management of the company. The Concept Model of Information Flow for this possible system must be much more difficult to obtain because of the different internal information of each company; but if it's possible to create this Model, it might be a big step on this field.

This system allows creating the folder structure for both each company and the WPMS. A further step might be to create a routine to update automatically those documents stored locally (in the server of a company) to the WPMS, so as to avoid uploading the last version to the WPMS with the consequent save of time and reduction of possible mistakes.

Industry Foundation Classes (IFCs) to allow full interoperability between systems are still being developed, and for the moment only prototypes are being tested. Once this model is absolutely defined as the basis for whatever AEC information, it will be very easy to adapt the *Life cycle Document Management System for Construction* to this model because the attributes, metadata and life cycle used in the system is partially base on IFCs.

For the moment, the *Life cycle Document Management System for Construction* is just a prototype. It might be interesting to implement this system in a WPMS and develop a Case Study to get quantifiable results of the use of it. Then, it can be broadly used by those companies working with WPMS and the working processes might unify with the consequent improvement of interoperability.