EXPERIENCES OF EDM USAGE IN CONSTRUCTION PROJECTS

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SUMMARY: In the past few years the fastest growing e-business application in construction has been the use of electronic document management systems (often also called project extranets and project webs). This paper first outlines the historical developments of the adoption such systems, and then discusses results from some earlier research. The key issues in taking EDM systems into use are no longer technical or cost-related, but are rather related to business models and psychology. Initial results from an on-going case study with end users of an EDM system in a large construction project are reported. The key results are that users cannot be treated as a homogeneous group but differ considerably in attitudes towards the system, based on previous EDM experience, differing roles in the construction project (designer, contractor, subcontractor) and usage pattern.

KEYWORDS: EDM system, construction, E-business.

1. INTRODUCTION

The construction industry has a vast potential for the uptake of e-business (Anumba and Ruikar 2002), (Mohammed and Stewart 2003). There are, however, several barriers for rapid uptake, including the fragmented nature of the industry and psychological resistance to change. A central one is the local nature of the industry where global competition plays a minor role, which means that companies invest very little into new technology and process development. The pressures to take IT and the Internet into effective use for the data interchange between the different partners in the supply chain has thus been low, compared to other industries (i.e. the production of cars or mobile phones). One of the areas in which a considerable uptake of e-business has taken place in recent years is the use of document management for construction projects, using Internet solutions. This has been achieved with very low investments into new technology by the companies themselves, since a commercial supply of such services by ASP third parties has emerged. This article takes a closer look at the uptake of this type of e-business, and reports on results from a case study in the Finnish construction industry to illustrate the developments.

The effective management of the vast amount of information needed to design, construct and maintain buildings is a formidable challenge. The impact on overall construction costs of out-of date, missing or contradictory information, causing delays, mistakes and expensive re-building, is well known both to practitioners and researchers (Alshawi and Ingirige 2003). Today the widespread availability of personal computers and the "information superhighway" created by the Internet provide the necessary infrastructure for efficient computer-aided document management.

Construction documents have not undergone major changes since the middle of the 20th century. Plan drawings, sections and elevations, bills of quantities, specifications etc. look much the same as decades earlier. The technology for producing, managing, duplicating and distributing such documents has, however, undergone a number of fundamental changes.

The first important step was the introduction of photocopying in the 60's, which significantly lowered the cost for duplicating information. This development spawned a great number of dedicated copying firms, which handle the large sizes typically needed in the construction industry in a cost-efficient way.

The second wave of technological innovation occurred during the 80's and involved the proliferation of personal computing. Even before the emergence of the PC some larger design consultancies used minicomputer-based CAD-systems, but it was the affordable applications like Autocad that started to raise the share of CAD-produced drawings dramatically towards the late 80's. The production of documents was of course also greatly facilitated by word-processing and spreadsheet software. The transfer of the information was, however, still mainly done as paper copies in the mail or using couriers. At best diskettes were personally handed out so that the receiver could reuse the information in digital form.

The fax became a popular data transfer method in a very short time during the 80's. It spread as fast as the Internet or mobile phones some years later, due to the network economics of this type of innovations, where its value to the individual users becomes bigger for each new user who joins the network. The fax was superior for handling offers, quick changes, and small-scale graphics, but not good for large drawings and absolutely useless for reuse of the data in digital form at the receiving end.

In the late 80's and early part of the 90's, computer networking, both in the form of local area networks, as well as using point-to-point bilateral lines and modem dial-up, made possible the use of document management systems for project documentation. The effort to set up point-to-point connections and of teaching the personnel involved how to use the systems often offset the potential benefits and the use in the construction industry was limited to isolated pilot projects only (for instance JM-Bygg in Sweden).

Since around 1995 the widespread use of the Internet also in the construction industry has radically enhanced the possibilities for data transfer and management. The key characteristic of integrated document management is that only one master copy of each document is kept somewhere on a server and that it is possible to search for the required document using some classification or meta-information. Also within this category there are several options. Early systems tended to be customised applications, where a copy of the application needed to be installed on each workstation that was using the system. The last few years the trend has been towards solutions based on Internet technology where all that is needed is a standard web client and passwords.
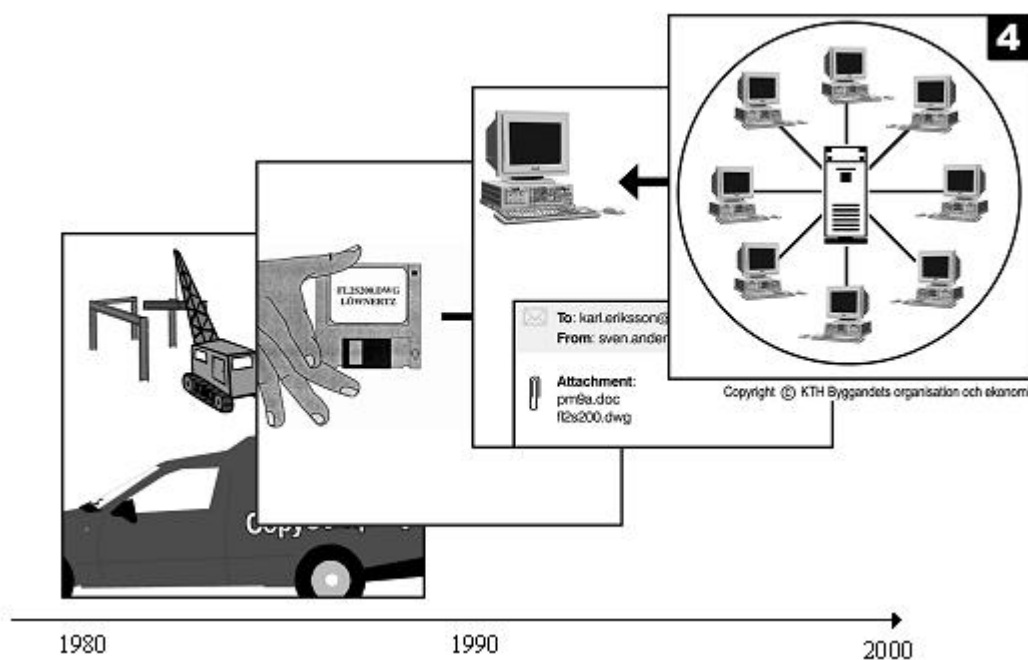

FIG. 1: *The evolution of construction document management methods over the last decades*

The current situation in the construction industry is that a mixture of different generation methods is used for managing the documents (Fig. 1). Hardly any documents are today produced by hand, but many are still transferred by printing them out and sending them to the other parties by mail or couriers, often using copying companies as intermediaries. A slightly more sophisticated method is that documents are produced digitally and transferred digitally as e-mail attachments. In terms of document management, this offers only minor improvements over the earlier paper dominated situation since finding a document in another person's personal

computer may be even more difficult than in his shelves. Retrieving a document may often as a last resort require asking a person to deliver it. On the other hand it enables the receiving party to continue working on the same document in electronic form, which is a significant improvement.

In the last few years the use of EDM systems has been the fastest growing IT-application in construction. The barriers to EDM systems were significantly lowered by the shift from expensive and often complex software, which needed to be installed on the computers of all project participants, to subscription-based software which is located on servers only and used through ordinary web browsers. At the same time a clear trend has been away from in-house solutions, typically provided by one of the dominating project participants such as the architect or the main contractor, towards outsourcing of document management to third party application service providers.

On the level of the industry as a whole there have been a number of recent general studies of IT usage. The most comprehensive study has been the Swedish IT-barometer study which has been carried out twice in 1997 and 2000, and amongst the different technologies studied included questions about the use of document management systems (Samuelson 2002). The same survey has also been conducted with a more restricted sample in Finland and Denmark (Howard at al 1998). According to the study in the year 2000 around 47 % of Swedish architects worked in a company where an EDM system had been used in at least one project, whereas the figure for contractors was much lower, 16 %.

In a later study in Finland the overall use of systems was studied using a different methodology (Bäckblom et al 2002). An existing commercial database of on-going Finnish construction projects was used as a starting point to establish a stratified sample of projects of different sizes. Key personnel from 100 projects were interviewed concerning the use (or non-use) of EDM systems in their project using telephone interviews. The overall result concerning use of EDM systems as a function of project size showed that whereas none of the small projects (< than 8,5 million Euros) in the sample used an EDM system the penetration was almost 50 % among projects > 16,5 million Euros).

The latest empirical findings concerning EDM use in Finland were obtained in a case study survey with the EDM users in the Kamppi Center project. The results showed that roughly 60 % of the individual architects and other designers, had earlier EDM experience, whereas the figures for project management where around 40 and 20 %. Although not directly comparable with the results from the earlier studies the figures indicate a significant increase in EDM usage.

2. EDM SYSTEM FUNCTIONALITY

Systems on the market differ in technical functionality. In a study conducted by VTT in Finland the features of EDM systems on the market were systematically studied, comparing them with the requirements of companies (Luedke et al 2001). A questionnaire was sent out to document management companies in both the Nordic countries and the USA and 18 companies provided detailed answers. Features found in most systems included:

- a main retrieval mechanism based on either hierarchical folders or metadata,
- handling of revisions and change management,
- viewing of CAD-files using special purpose software.

Features found in only a few systems were for example:

- electronic authentication of user identity (i.e. smart cards),
- full text search capability.

Also others have studied system features with rather similar results (Hartvig 2000), (Nitithamyong and Skibniewski 2004).

Only one of these features will in the following be discussed more in detail, namely the main search and retrieval capability. An efficient but at the same time user-friendly search mechanism is quite central to the success of a document management system.

A larger construction project may eventually result in the production of tens of thousands of documents and a system must provide users with some easy to use method to find the appropriate document. For example in the Kamppi Center project, which will be discussed later in this paper, there were more than 16000 uploaded documents in the system, used by 249 individual users from 94 different companies.

Technically there are several ways in which document retrieval can be facilitated (Löwnertz 1998). One option would be to use full text search. This works much the same as the general web search engines and the results are equally unpredictable. An additional difficulty is that drawings are a very important document category in the construction industry and are difficult to include in such searches. Recently some systems have appeared on the market which claims to offer the capability for searching for text strings inside the DWG-files used for drawings.

The two currently mostly used options are using a hierarchical folder structure or using metadata as a basis for searches. The hierarchical folder structure is very easy to understand for end users, since it works exactly the same way as the folder structure in the Windows operating system. It also resembles the ways construction professionals have traditionally classified and archived paper documents. The drawback of this is that usually one particular view on the total document base is enforced. In many systems the folder structure has been predetermined by the system vendor, whereas other systems allow the users quite a lot of freedom in creating a folder structure of their own. Less common is a solution which allows two or more alternative folder structures superimposed on the same documents.

This latter multiple solution is in fact a step in the direction towards meta data based search. By meta data (or reference data) we mean certain pieces of information which describe essential attributes of a document as a whole. In metadata based systems the data is placed separately from the documents in a database, which provides versatility for automated searching which the hierarchical folder structure doesn't have. For instance the information given about the literature references in the references section of this paper is meta data. Such meta-data enables other researchers or practitioners to retrieve the document through library services.

In the case of construction documents meta data is related to attributes such as type of software with which a document was created, engineering discipline, phase of the construction process, part of the building described, scale (for drawings), revision etc. This type of metadata is in fact already included in traditional documents in the form of drawing headers etc. but not in a computer searchable form

In view of the fact that there are several competing document management systems on the market and that companies may need to switch between different metadata from project to project, it would make a lot of sense to develop standards for the meta data needed for construction document management. This would increase the interoperability between systems and would for instance facilitate the automated transfer of large document repositories from one system to the other. Such standardisation was suggested in the early 90's (Björk at al 1993) and an early attempt to formalise the central metadata needed was reported by Turk et al. (1994). In Denmark the Association of IT-users in Construction IBB has also suggested a neutral format for the exchange of construction document metadata (IBB 1999). Such standardisation has also been a long-term aim of ISO committee TC10/SC8.

Many practitioners dislike having to fill in forms with metadata, despite the obvious advantages for later users who wish to retrieve documents. In practice the easy to use folder structure is much preferred to filling in meta data for each document to be uploaded. One possible solution could be to develop software, which automatically creates as much as possible of the metadata, based on contextual information

3. A CASE STUDY OF THE USE OF AN EDM SYSTEM IN A BIG, COMPLEX PROJECT

Some earlier studies carried out in Finland have used the case study method to investigate various aspects of EDM usage in Finland. In the PROCE project, carried out by VTT, the focus was on finding out the measurable benefits of using the systems by interviewing key personnel (Sulankivi 2004). The main result was that directly measurable monetary savings where rather small and that most benefits where difficult to measure. Four cases from different countries were used, and the benefits were evaluated by a panel of expert users. In a study made at the Swedish School of Economics and Business Administration the detailed web logs of one building project were analysed and conclusions about usage were drawn based on the analysis (Ruohtula 2003). Here one of the main results was that the EDM system was not used comprehensively for all documents in the project, which significantly reduced the benefits, due to the use of parallel and partly overlapping practices. Andresen et al (2003) have also used the case study method to study use of EDM systems in four different projects in Denmark, and among other results presented sociograms of communication patterns used.

All the above studies have been made on EDM usage in projects carried out during 2000-2003, that is at a time when usage was still a novelty to many of the participating companies and individuals. The case study which

will be reported on in the following section differs from these significantly. Firstly it is a rather big project, the construction of the new bus terminal and shopping center in the center of Helsinki. Secondly, many of the heavy users in the project had already had experience of EDM in earlier projects. Thus this is as far as we know one of the first reported studies of mature, rather than pilot EDM usage.

In order for EDM to deliver any of the potential benefits within a construction project, it must be properly implemented throughout the entire project organization at hand. Being a relatively new tool for many practitioners (as shown by the survey results presented in this study), the implementation process must be planned and executed carefully. Researchers agree that proper implementation requires strong management commitment, detailed document management guidelines, sufficient training etc, resulting in widespread and proper use of the tool (e.g. Sulankivi et al 2002, O'Brien 2000). While EDM adoption causes changes in work routines across the entire project organisation, it is often thought that the realised benefits are distributed unevenly among the participants. Project management is in a position to dictate EDM use and receives the majority of the benefits – but co-operation of the entire organization is required.
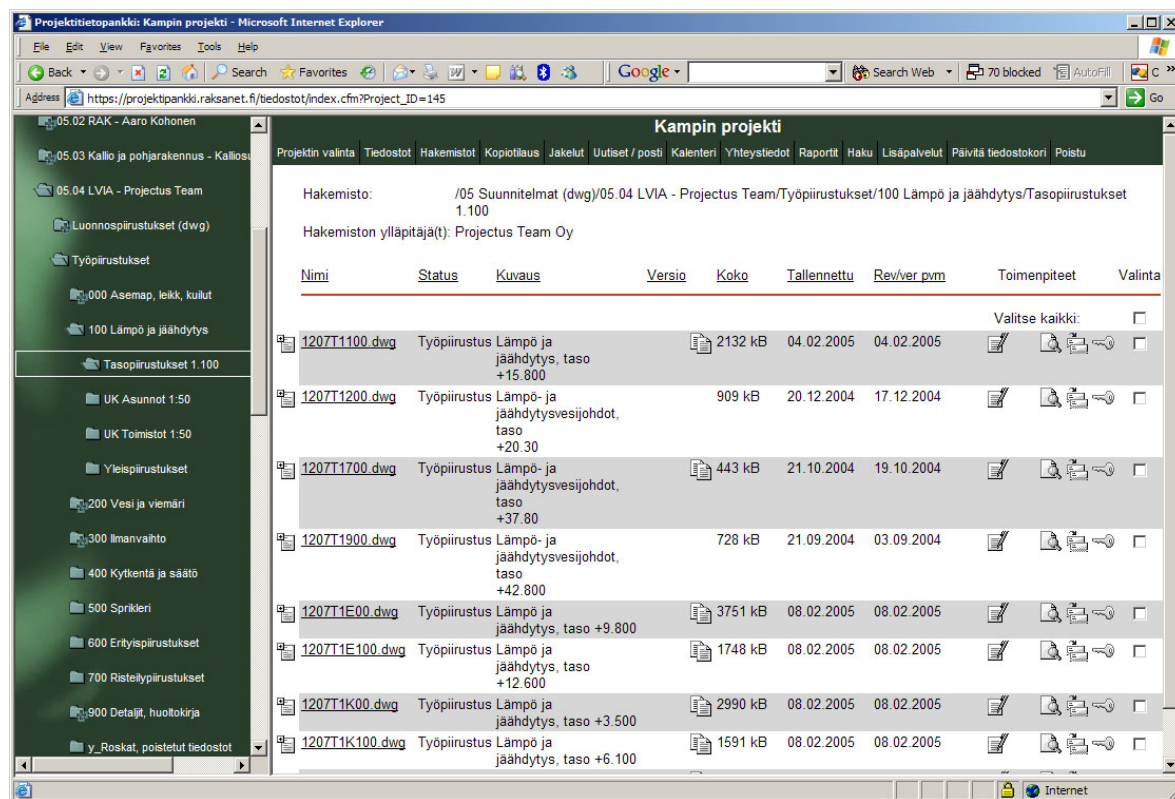

FIG. 2: The Finnish Raksanet (www.raksanet.fi) is an example of the third party Internet based document management service. The screen dump is from the Kamppi project. On the left is the hierarchical folder structure used in the project. The documents shown in the window are plan drawings in scale 1:100 including information about revision history, brief content description etc.

The idea and research topic of this case-study emerged from this apparently uneven distribution of efforts/benefits and decision power across the organisation. Where many previous case studies on the topic of EDM adoption and usage are based on data collection among project managers, this current study sets out to explore attitudes towards EDM *across various segments* of the construction organisation on an *individual level*. In pursuing the individual end-user perspective, the study draws on theoretical models of ICT adoption and technology acceptance. A model of particular interest is the Unified Theory of Acceptance and Use of Technology in which Venkatesh et al (2003) have synthesised the best parts of several widely cited frameworks such as the Technology Acceptance Model and Innovation Diffusion Theory. The Updated DeLone & McLean Information System Success Model (DeLone & McLean 2003) is used as framework for understanding the relation between various dimensions of system quality and end-user satisfaction.

With a total budget of 400 million euros, the Kamppi Center has been described as the single most expensive construction project to be carried out in Finland to this date (not counting infrastructure projects and nuclear plants.) The aim of the project is to transform the former open-air bus station of Helsinki into a complex consisting of two underground bus terminals hosting over 1700 departures a day, a cargo handling centre handling 10,000 parcels a day, a total of 5,700 m² of residential apartments, 12,500 m² of office space, a shopping centre of 37,000 m² and an underground parking facility.

Actual construction was initiated in 2003. Keeping the original schedule, the bus terminals and parts of the shopping centre were opened to the public in early summer 2005. The entire complex will be finished by March 2006. Well aware of the size and complexity of the Kamppi Center project, the main contractor SRV Viitoset Ltd decided to utilize only familiar and thoroughly tested software in the project at hand. Their choice regarding which EDM system to use was made prior to joining the design competition announced by the City of Helsinki.

In terms of document management, the Kamppi Center project relies on Raksanet, a web based EDM solution provided by Buildercom[1]. The main driver behind the choice of system was SRV Viitoset Ltd's previous experience with the system. The construction company had successfully been using Raksanet as their main EDM system in several large projects since the late 1990s. One important factor contributing to SRV Viitoset Ltd's previous satisfaction with the system lies in the development team behind Raksanet, which has showed strong commitment to implementing new features and improvements as suggested by customers at short notice. (Harmaajärvi 2005)

Raksanet is a web based, ASP-hosted document management application specifically targeted at the construction industry. The EDM features are fairly basic, with support for access control, revision and version control. Only a static hierarchical folder structure (partly visible at the left hand side of FIG. 2) is provided for navigating the information mass, and the meta-data stored with each document is basic; a status field and a free-text description. The location of a document within the folder structure should, however, be considered as a source of meta-data.

In addition to downloading documents for viewing, users can also view documents online. This is facilitated through a Java applet, AutoVue, which is capable of viewing a large number of different file formats online. The applet also provides basic drawing tools which allow the user to add comments and drawings on top of the document viewed. These additions, however, cannot be stored directly back into the EDM; the user has to save a local copy or print it out.

The folder structure was designed primarily by SRV Viitoset staff. The typical structure SRV has used in previous, smaller projects, partly based on the Talo80 building element classification system, had to be expanded significantly in the Kamppi Center project. One challenge lies in the fact that three different architectural offices are working alongside in the project, each assigned a different segment of the complex. The resulting folder structure contained 1680 folders as of Aug 2005. Some 16.000 documents used by 334 users over the course of the project were stored in these. Typical users have read access only to folders they specifically need, and write access is only given to users who actually need to update contents in specific folders.

At the outset of the project, SRV chose to deploy a system which allows power users to set up automatic distribution of paper copies. This was agreed upon after certain parties insisted on having easy access to paper rather than only having access to documents through a web based software. The system allows for distribution lists to be defined on a per-document level. Whenever a document is stored or updated in a folder linked to a distribution list, the system automatically orders a predefined set of print-outs to be sent to the members of the assigned recipient list.

The upside of this arrangement is that it bridges the gap between traditional ways of working with the brand new EDM world, alleviating adoption resistance among users who are uncomfortable with the practice of personally ordering print-outs they need. The downside, however, is that the automatic print-outs cause some of the most important EDM-related benefits to remain out of reach; documents are distributed in a just-in-case fashion rather than just-in-time, and due to the coarse granularity of the distribution lists defined, a lot of unnecessary print-outs are produced.

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[1] Buildercom at http://www.buildercom.fi

4. THE EMPIRICAL STUDY

The first phase of the empirical research focused on obtaining an overview of how the EDM tool was used and perceived among the different groups of practitioners involved in the Kamppi Center project. The main objective was to get rough user experience measures covering a large portion of the population. A secondary objective of the first phase was to refine the research questions and, most importantly, identify interesting user segments and individuals to be studied at greater detail in the second phase. This first phase was carried out by performing an online survey and combining questionnaire responses with log file measures. The second phase of the empirical research aims at obtaining more detailed insight into end-user attitudes and experiences by the means of semi-structured interviews, and will be reported in later papers.

A quantitative survey was carried out among the end-users in order to measure prevailing opinions, attitudes and experiences and receive demographic data. A satisfactory 167 of the 269 reachable individuals responded, giving an active response rate of 62 %. This rather high response rate for a web survey can partly be explained by the fact that prices were promised to a number of randomly selected respondents. The obtained survey data covers 50 % of the actual Raksanet user base. The respondents were responsible for 59 % of all logged actions, indicating that the respondents have been more active than the users on average. Further analysis of event logs reveal that the respondents were responsible for 92 % of all logged upload events, 75 % of all downloads and 63 % of the online viewings. As such, the sample can be considered large enough to provide a representative view of the user base as a whole. However, these findings indicate that the obtained data is skewed towards more active and thus, perhaps, more positive users.

The survey was executed as a self-administered online questionnaire. Each respondent was sent an email message containing a brief description of the study and a personalized link to a web site hosting the actual questionnaire. Respondents were required to answer all questions before submitting the responses, eliminating the risk of receiving partially filled-out questionnaires. The personalized link contained a unique ID tag which allowed for easy tracking of respondent actions. With the help of the ID tag, each response was be identified and coupled with data from the user database (e.g. role) and measures extracted from log files as will be described in greater detail below.

The questionnaire was designed to gather information on the following topics:

- basic demographic and profiling data such as age, length of personal involvement in the project, amount of work hours devoted to the project and previous EDM experience,
- end-user perceptions about the EDM systems,
- freely formulated qualitative comments on EDM use in the project.

The questionnaire contains one free-text question and 19 quantitative questions, of which 15 follow a four-point Likert-scale (*agree completely*, *tend to agree*, *tend to disagree*, *disagree completely*.)

Based on the logfiles of user actions, users were classified into three groups. For the sake of analysis, the measure was further banded into three categories:

- "Heavy uploaders" (download/upload measure of < 50 %, i.e. users who have uploaded more files than they have downloaded or viewed),
- "Mixed usage" (50%...99%),
- "Pure downloaders" (100% downloads, no uploads whatsoever).

In the following only some of the results of more general interest are discussed. Results related to training, support etc. are not reported, since these are quite specific to the EDM-system used and the project. The full research report will be made available on the web at a later date (Hjelt 2006).

Previous EDM experience. As demonstrated in FIG.3, roughly half of the respondents were first-time EDM users. 36 % had used EDM in 1-4 projects and 10 % possessed more extensive EDM experience.

Based on these figures, it can be concluded that the construction industry still is in a rather early stage of the EDM adoption process. A closer look at the variance between project roles reveals architects as the most experienced users, while this technology still is new ground for the vast majority of subcontractors.
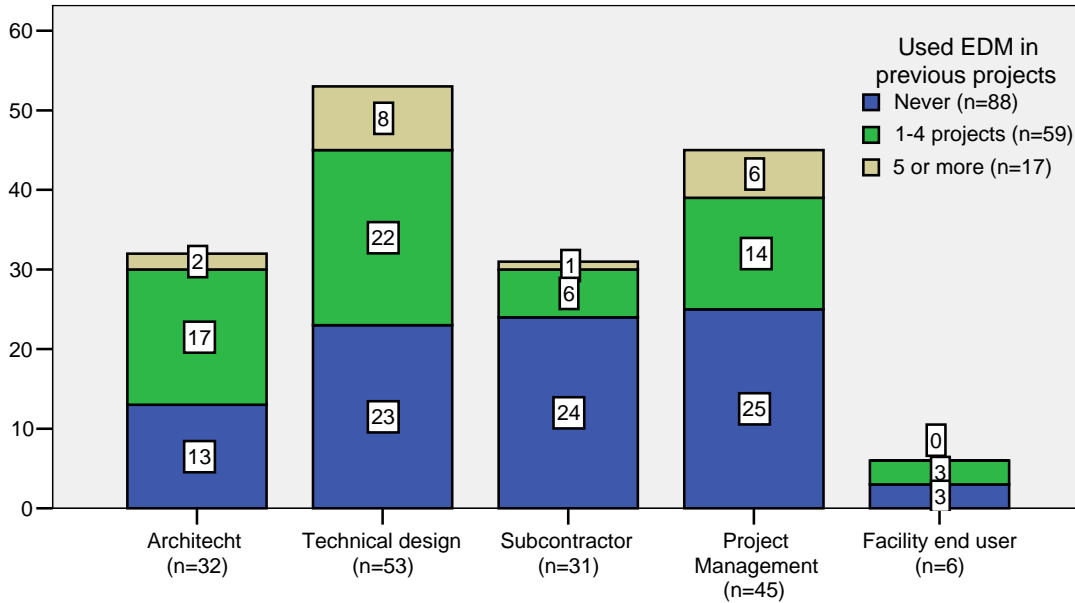
FIG.3: Respondent roles and previous EDM experience

Usage behaviour: As previously mentioned, the parties involved in a construction project play different roles in the information process. Fig. 4 shows clearly that architects and technical consultants are the biggest information providers while subcontractors primarily are pure information retrievers who never store any documents in the EDM. Only 2 of 31 subcontractors have uploaded documents to the system, while half of the architects have uploaded more than they've downloaded. The implication of this is that users from different roles use the EDM tool in remarkably different ways. Consequently, individual perception of factors such as ease of use and usefulness are bound to differ between e.g. architects and subcontractors since they utilise entirely different parts of the software in their daily work.
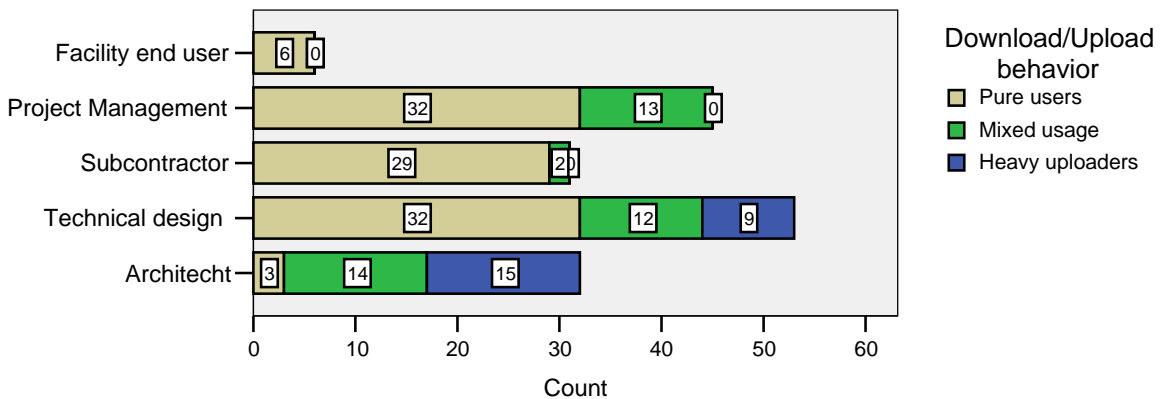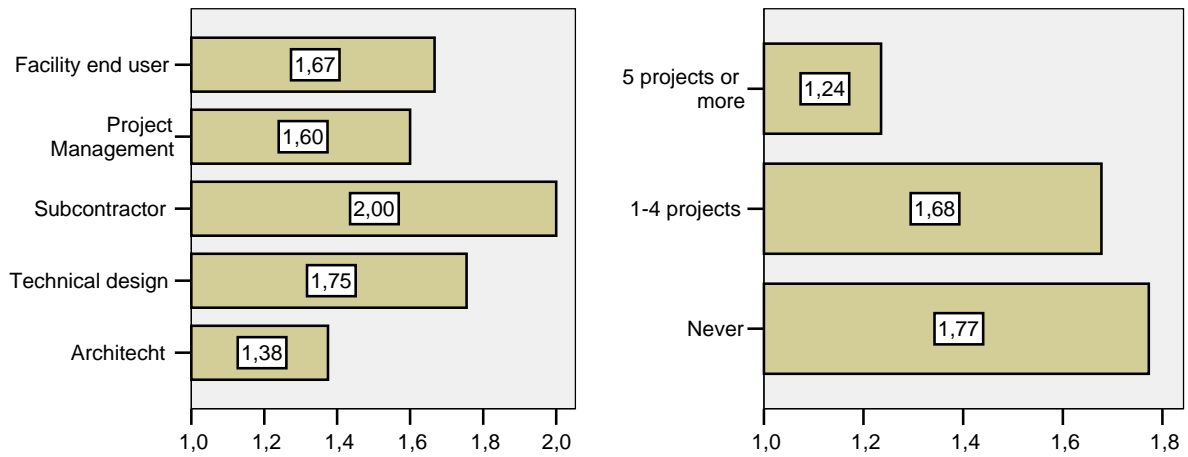

FIG. 4: Respondents' upload / download behaviour

Initial scepticism: The Initial scepticism towards the benefits of EDM usage was surprisingly low. Only 10 % agreed somewhat and 2 % agreed completely with the statement. As demonstrated by Fig. 5 below, users who had previous experience of EDM use appeared less sceptical regarding the benefits. The fact that subcontractors seemed more sceptical than architects can presumably to a large extent is explained by the fact that subcontractors in general have had less EDM experience than e.g. architects. Another explanation may lie in the fact that the inner workings of the information process only affect subcontractors to a very little extent. One subcontractor commented that EDM usage *"pushes too much work from designers to subcontractors!",* probably indicating a lacking understanding of the EDM concept.

Scale used: 1=disagree completely, 4=agree completely

FIG. 5: Initial scepticism towards EDM benefits

Ease of storing and retrieving files: A majority of respondents considered EDM usage in terms of storing and retrieving files to be quick and easy. The more complex the information structure, the greater the need for flexible, easy-to-use search tools that assist users in locating documents, folders etc based on a various types of search criteria. Several respondents commented on the search engine available in Raksanet, with complaints regarding speed, ease of use and usefulness.

Some suggested increased search functionality that would assist in the task of locating documents, e.g. based on actual contents or context such as location within the 3D space of the construction site. Implementing these features would require more detailed meta-data to be collected for each drawing – yet some respondents commented that filling out the meta-data fields is time-consuming as such.
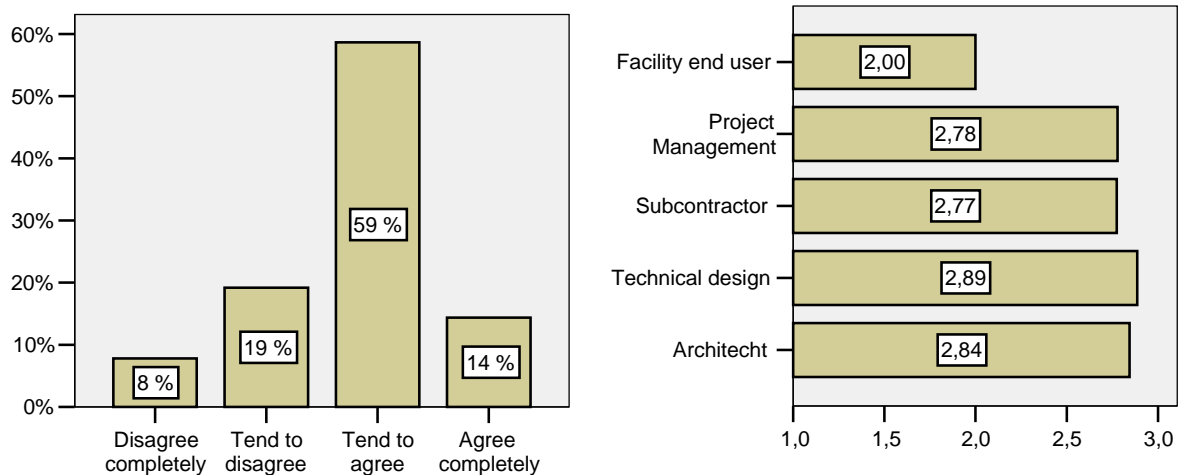

FIG. 6: Ease of use

Quality of the folder structure: To the statement "The folder structure is well designed, making it easy to find the right folder despite the extensive amount of information", only 4 % disagreed completely, 25 % disagreed somewhat, 60 % agreed somewhat and 11 % agreed completely, the mean score across all respondents was 2.78 on a 1-4 scale. Comparing the means across different segments reveals that heavy uploaders (i.e. architects and planners) were considerably more satisfied (mean score 2.92) with folder structure than pure downloaders (2.77). Furthermore respondents who had previously used EDM in five or more projects were more satisfied (3.06) than first-time EDM users (2.72)

Yet a considerable number of respondents used the free-text field to comment on the folder structure, most of them expressing dissatisfaction with the amount of folders and complexity of the tree, asking for a more consistent and self-explanatory structure.

- "In a project of this size, it would have been valuable to design the structure well, having one person in charge of it."
- "In my opinion, the folder structure should have received more attention. Sometimes it was very difficult to find drawings."
- "The complexity and amount of folders made it difficult to find files, even with the help of the search engine."
- "Folder structure is too complex; it's difficult and slow to find what you're looking for."

Confidence that all relevant documents are available in the EDM system: Unless users are confident that all relevant documents are available in the EDM, and that the contents of the EDM are up-to-date, users may revert to other channels of communication. This puts information providers in an important role.

While the responses to the question "I feel confident that the latest versions of drawings and documents are available in the EDM" seemed largely positive (80 % tended to agree or agreed completely), several comments indicated a slight doubt regarding the availability of up-to-date drawings.

- "It worked great, but updates were sometimes late for some drawings. In urgent situations we had to call the designers directly. This is understandable when a drawing needs to be updated often."
- "I think [EDM] is a great tool if everyone keeps the information up to date."
- "As a concept, EDM use is OK, but there's always a slight doubt whether the latest files have already been uploaded. Naturally, EDM works better in smaller projects. In a project of this size, there's bound to be problems with file management."
- "It's always a good idea to check with the designers whether the latest revisions are available in the EDM."

Suitability of EDM based work routines: All in all the response was very positive to this question, as shown in the figure below. Those who already had a lot of EDM experience were even more positive than the novice users.
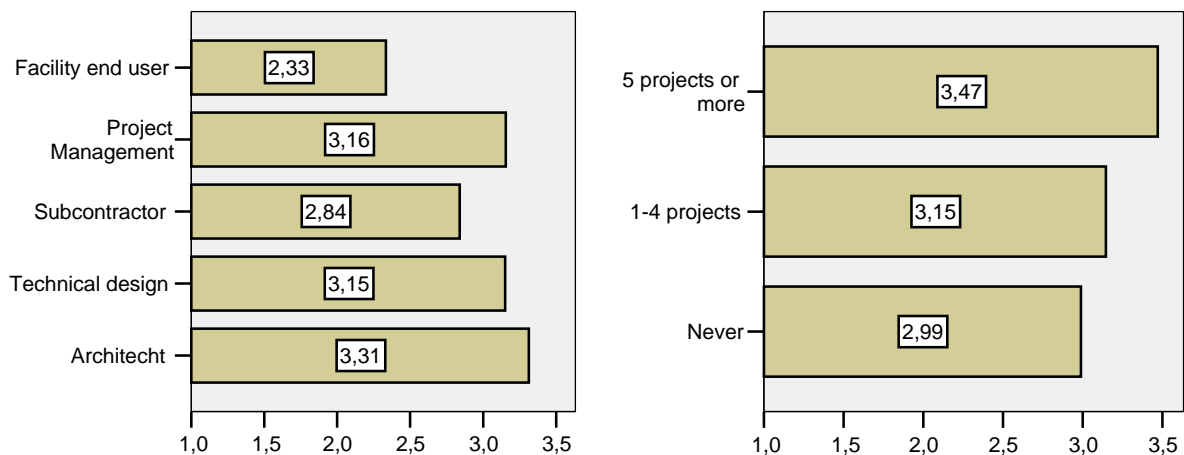

FIG. 7: Suitability of EDM based routines.

- "The important features of EDM are: archival of previous document versions, huge capacity compared to email, and up-to-date drawings made available for everyone. Nevertheless, I still consider paper based documentation important."
- "All in all, a quick and practical way of receiving drawings. "
- "New designs arrived at my desk quickly and easily."
- "Fetching big drawings from the EDM worked much better than having architects sending them by email."
- "A great way for distance workers to keep up to date with plans."

Importance of using email, fax and courier for sending drawings within the project group: It seems that using these parallel means for information transfer are still considered very important. Mean values ranged from 3,00 to 3,35 (on the scale 1-4) for the different project roles, with architects and subcontractors having the highest scores.

Could we have done as well without the EDM system: The answers to the question "The company or organization that I represent could have performed its tasks just as easy - or even easier - without the use of EDM" divided the respondents very clearly depending on from which project participant companies they came.
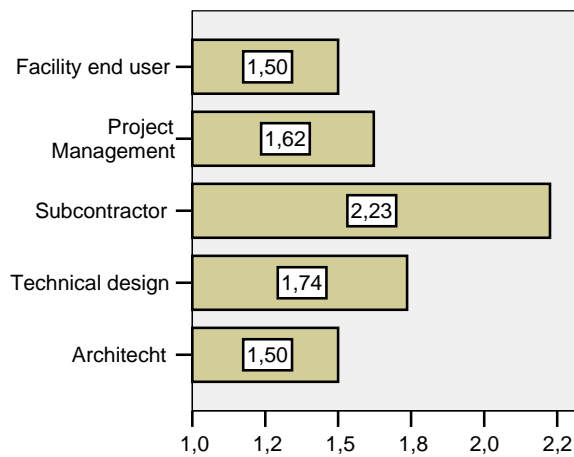

FIG. 8: We could have done as well without EDM

The subcontractors' personnel were clearly the most critical of the benefits of using the EDM system.

- "Without EDM, this amount of information cannot be managed or distributed successfully."
- "Very much needed – without EDM it would've been pretty impossible to pull this through."
- "I do endorse the use of email and digital transfer of drawings, but this kind of project-wide document management is slow and cumbersome. No one has time to read all the reports flowing in from Raksanet."

Attitude change to EDM: *My attitude towards EDM has changed for the better due to this project.* Recalling that subcontractors were most sceptical regarding the benefits in the beginning of the project (Q5), it is pleasant to find that the same group reported the biggest attitude shift towards the better. The answers to the question "My attitude towards EDM has changed for the better due to this project were distributed as shown below.
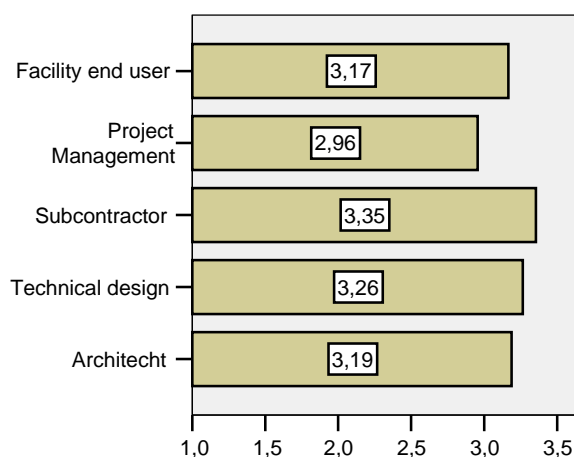

FIG.9: Attitude changed.

5. CONCLUSIONS

Currently the use of Internet based document management services, after a few years of pilot use, is in the steeply rising part of the S-curve, which the adoption of new technologies tends to follow. Most large construction projects already use such systems, and professionals who have used such systems for some time say it would be very difficult to go back to for instance a situation where email attachments would be the main technique. The situation in terms of market saturation is comparable to the CAD-market in the late 1980-ies.

This paper has not dealt with research concerning the measurable or perceived benefits of using project webs, in the form of direct cost savings or qualitative benefits. For instance the Proce research of VTT demonstrated that direct measurable cost savings are rather small, but that qualitative benefits are substantial (Sulankivi 2004). One of the problems with measuring the effects of using new technology is that some of the effects will only start to emerge fully after systems have been used by project participants in several projects.

The case project studied demonstrated some interesting finding concerning the perceptions of EDM system end users. In particularly it clearly emerged that individuals working in different project roles looked at the system in different ways. Architects, who also typically are heavy uploaders of documents, are starting to be quite used to EDM, whereas subcontractor representatives, who often receive more documents than deliver, being the most sceptical.

All in all electronic document management is starting to be technically quite mature. The main challenges currently lie in the psychological factors of taking the systems into comprehensive use and overcoming mental resistance. O'Brien (2000) for instance made the observation that end users of systems cannot be treated as a homogeneous lot but rather includes different substrata which need to be treated in different ways. In the near future the non-technical aspects of this type of e-collaboration techniques would be an important area for empirical research.

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