

# End user attitudes towards EDM use in construction project work – a case study

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**Abstract:** This article reports on a cross-sectional case study of a large construction project in which Electronic document management (EDM) was used. Attitudes towards EDM from the perspective of individual end users were investigated. Responses from a survey were combined with data from system usage log files to obtain an overview of attitudes prevalent in different user segments of the total population of 334 users. The survey was followed by semi-structured interviews with representative users. A strong majority of users from all segments of the project group considered EDM as a valuable aid in their work processes, despite certain functional limitations of the system used and the complexity of the information mass. Based on the study a model describing the key factors affecting end user EDM adoption is proposed. The model draws on insight from earlier studies of EDM enabled projects and theoretical frameworks on technology acceptance and success of information systems, as well as the insights gained from the case study.

**CE Database subject headings:** Information management, construction, communication, computer applications, implementation.

## Introduction

### Background

Although construction may intuitively be perceived as an industry concerned primarily with labor and material intensive processes, construction work is highly dependent on information and communication. Software developers and practitioners within the construction industry have realized the benefits achievable by the means of electronic communication and storage, and a large number of software solutions for electronic document management (EDM) have emerged on the market. Declining costs of end user computing and network communication have further fuelled the development and adoption of such technologies. EDM software, sometimes integrated in larger project management solutions, is referred to using a variety of terms in the literature and among practitioners; *project webs*, *project banks*, *project (collaborative) extranets*, *concurrent engineering (CE) software* are commonly used terms.

The aim of electronic document management systems (EDM) is to support information processes by providing users with simple, logical and quick ways of storing, finding and retrieving documents in an electronic format. (Degerstedt 2000; Löwnertz 1998). Early systems used tailor-made network

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solutions, but since the mid 1990's systems have almost exclusively relied on the Internet and its protocols. This has markedly lowered the entry barriers for new users, since a basic Internet connection and a web browser is all that is needed.

The use of EDM and related technologies in construction projects has been the subject of a growing body of research. Previous research indicates that EDM technology has a huge potential as an enabler of quantitative and qualitative benefits in construction. While it appears difficult to empirically prove financial savings of significant magnitude, case studies report that EDM use allows for improved speed, quality and cost efficiency in the information process (Sulankivi et al 2002), thus affecting the entire construction project positively.

However, in order for EDM to deliver the potential benefits within a construction project, it must be properly implemented throughout the entire project organization. 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). EDM adoption requires efforts from everyone involved, but yet it is often thought that the realized benefits are distributed unevenly among the participants.

The idea and research topic of this study emerged from the uneven distribution of efforts/benefits and decision power across the organization. Where many previous case studies on the topic of EDM adoption and usage were based on data collection among project managers, this current study set out to explore attitudes towards EDM *across various segments* of the construction organization on an *individual level*. In pursuing the individual end user perspective, the study drew on theoretical models of information technology adoption and technology acceptance.

## **Aim and objectives**

The aim of the study was to explore end user attitudes towards EDM usage in a large construction project. Research questions of interest were:

- i. How do users across the project organization perceive the implementation efforts employed?
- ii. How do users across the project organization perceive the benefits of EDM?

These research questions, which are largely of an exploratory or even descriptive nature, served two purposes. The first objective was to provide insight into the practical issues of EDM adoption in the case project studied, adding to the existing body of data on EDM use. Such findings may be of value for future research, but also for practitioners planning future implementation efforts. The second objective was to propose a theoretical model for understanding factors affecting end user adoption of EDM in project organizations.

## **The case project and EDM system used**

### **The case project**

With a total budget of around 700 million USD, the Kamppi Center has been described as the single most expensive construction project to be carried out in Finland to this date, excluding infrastructure projects and nuclear plants. The aim of the project was to transform the former open-air bus station of Helsinki into a complex consisting of two underground bus terminals, a shopping centre, residential apartments and office space.

SRV Viitokset Ltd was appointed main constructor for the entire complex. Three separate architectural offices were contracted, each given responsibility for a distinct part of the complex. Roughly 20 structural and technical design offices participated in the design phase, and hundreds of subcontractors were involved in the actual construction work. Construction was initiated in 2002. 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 was finished by March 2006.

## **The EDM system used**

The Kamppi Center project relied on Raksanet, a web based EDM solution provided by Buildercom Ltd. The EDM features are fairly basic, with support for access control, revising and version control. A static hierarchical folder structure was provided for navigating the information mass. The folder structure, partly based on the Talo80 building element classification system, was designed primarily by SRV Viitosen staff with help from Raksanet consultants. The resulting folder structure contained 1680 folders as of Aug 2005. Meta-data stored for each document included a status field and a free-text description. Users were able to locate documents either by browsing the folder structure manually or by issuing search engine queries on meta-data properties such as status, document description, file name, date and ownership. Documents in all common file formats could be viewed online using a Java applet.

In addition to working with and viewing documents in the digital domain, users were also able to order full-size printouts of any documents through the web interface. Automatic paper copy distribution covering selected folders and documents was also provided. By providing such means for working with paper copies, project management chose not to pursue savings in terms of reduced copying costs. This choice was guided by skepticism towards the viability of paperless construction.

EDM usage increased steadily over the course of the entire project, peaking in late 2004. By 2005, the system hosted some 17,000 documents used by 334 users from 90 different organizations.

The most common uploads were CAD drawings in AutoCAD format (DWG) and as plot files (PLT). Text documents in Microsoft Word (DOC) format, mostly used for meeting minutes, accounted for 16 % of all downloads and online viewings. Other frequently used file types were documents in Adobe PDF format and Microsoft Excel spreadsheets (XLS).

## **Earlier empirical studies of EDM use in construction**

This section summarizes a number of empirical studies that have been carried out regarding different aspects of EDM in construction.

### ***Adoption and use***

In order to examine the penetration of EDM in the Finnish construction industry, Bäckblom et al (2003) carried out a study where project managers from 100 ongoing construction projects were interviewed by phone. The data was stratified on the basis of total project budget. In projects exceeding 100 Mill FIM, usage of EDM was quite common, while none of the projects under 50 Mill FIM utilized any form of EDM.

Thorpe and Mead (2001) and Howard and Petersen (2001) have studied the role of project webs in the communication within construction projects. Both studies are based on *social network analysis* which aims to determine the frequency of communication between group members. Thorpe and Mead (2001) examined the degree of centrality obtained by the EDM system in three different cases. EDM was utilized extensively and, as a result, reached a high degree of centrality in two of the cases.

Andresen et al (2003) studied EDM usage by examining log files extracted from a particular EDM system used in three different construction projects. In all three cases, the architect was found to be the most significant information producer, storing large amounts of CAD drawings in the system. However, usage patterns among the other parties varied from case to case, making it impossible to draw any general conclusions.

One further approach to examining EDM use by the means of analyzing log files is presented by Ruohtula (2003) who conducted the analysis on a per-user level. The study reported that only a small share of the users used the system frequently. The study also revealed that very few documents were modified after being stored in the EDM, which indicates that the system mainly was utilized as a storage point rather than a collaboration tool.

### ***Measured benefits in terms cost and quality***

Early EDM research estimated that the cost savings of utilizing EDM could rise to 5-10 % of the total costs of a construction project (Johansson et al 1995). Yet it has been difficult to present empirical results that prove financial benefits of this magnitude (Björk 2003).

As part of the ProCE project, Sulankivi et al (2002) developed a model for formulating, evaluating and applying metrics on individual construction projects. The ProCE study classifies benefits in three categories:

- cost benefits which can be measured directly in financial terms
- other benefits which can be measured quantitatively but not in financial terms
- qualitative and functional benefits that can primarily be described verbally

Sulankivi et al (2002) applied their framework on four different construction projects. The financial savings identified in each project were of limited significance. However, other significant quantitative and qualitative benefits, which are difficult to translate into financial terms, were identified in the study. The key qualitative benefits of EDM as identified by Sulankivi et al (2002), Ruikar et al (2005) and Andresen et al (2003):

- Distributing documents across the project organization is easier
- Easier access to up-to-date information
- Easier to keep up with updates and news
- Easier to communicate with other participants of the project
- Good support for telecommuting

### ***Implementation challenges***

Much in line with Rogers' (2003) work on the diffusion of innovations, several studies (e.g. Thorpe & Mead 2001; Andresen et al 2003) emphasize that strong commitment regarding EDM among the central parties constitutes a key prerequisite for widespread EDM adoption, which in turn is of key importance for reaching benefits (Sulankivi et al 2002).

**Early initiative.** Choosing and implementing an EDM system should be considered a task of high priority at an early stage of any construction project (Löwnertz 1998; O'Brien 2000). Case studies show that significant savings can be achieved if the EDM system is utilized in the early tender rounds, i.e. at a stage where the final project group composition is yet to be defined but large amounts of documentation are already being exchanged (Ruikar et al 2005, Sulankivi et al 2002).

Several studies (e.g. Lakka et al 2001; Degerstedt 2000) summaries both the features considered important in a construction oriented EDM and the features available on the market, and Hartvig (unpublished working paper, May 2001) presents a framework for evaluating project webs.

**Guidelines.** Project management should produce a set of guidelines concerning document management within the project, describing *how* the system should be used (what kinds of communication should be committed through EDM?) and *why* (which are the actual benefits that are targeted?) (Andresen et al 2003). Furthermore management needs to define how the contents should be structured, how meta-data should be used and how access privileges are to be assigned.

**Problems in EDM based projects.** EDM competes with numerous traditional, well-established channels of communications such as facsimile, e-mail, phone, courier services etc. As these still play an important role in EDM-enabled projects, users may be quick to revert to these (O'Brien 2000). Andresen et al (2003) found that especially users who face technical difficulties in using EDM are quick to fall back to traditional channels of communication.

# Adoption of ICT innovations

## The successful innovation

In his work on the innovation diffusion theory (IDT), Rogers (2003) lays out a framework for understanding how ideas or practices are adopted by individuals or organizations. Diffusion is defined as “the process by which an *innovation* is *communicated* through certain *channels over time* among the members of a *social system*.” In the process of introducing a new ICT solution in an organization, both the ICT in itself and the changes in work processes it brings can be regarded as innovations.

However, as Gallivan (2001) among others points out, much of the traditional innovation diffusion theory is based on studies of how individuals make *independent* (albeit socially shaped) adoption decisions, limiting its applicability on the study of information technology implementation within an organizational context.

Based on management objectives, intentions for change and knowledge of available technological innovations, a primary adoption decision (i.e. “*should the organization adopt this?*”) is made by top management. Depending on the type of secondary adoption strategy chosen (i.e. “*how do we communicate this to the employees and partners?*”), the actual end users may have little or no decision power regarding individual adoption. Gallivan (2001) describes three different management approaches to promoting secondary adoption, each giving end users a different degree of freedom regarding adoption decisions: *Total commitment implementation strategy*, *Support strategy* and *Advocacy strategy*.

Regardless of which secondary adoption strategy is chosen, a number of factors will influence the end users’ perception of the new technology. In a voluntary setting, these factors affect the rate of adoption, whereas in a mandatory setting, the factors rather predict user satisfaction. In either case, the outcome is equally important, as lacking user satisfaction easily erodes the benefits envisioned for the new system.

Over the past decades a number of competing theories and models of factors governing user acceptance or actual usage of ICT systems have been presented. Venkatesh et al (2003) compared a number of earlier models testing each of them on the same data set. Based on their findings, they propose a unified new model, the Unified Theory of Acceptance and Use of Technology (UTAUT).

The model defines three factors (*performance expectancy*, *effort expectancy* and *social influence*) having impact on *behavioral intention* to use. Actual *use behavior* is in turn influenced by the behavioral intention and a fourth factor, *facilitating conditions*. The actual impact of the factors is affected by four moderators (*gender*, *age*, *experience*, and *voluntariness of use*).

Another model of interest is the Information System Success Model, originally proposed by DeLone and McLean in 1993 and revisited with modifications based on empirical testing and peer scrutiny in (DeLone & McLean 2003). The Updated D&M IS Success Model describes causal relationships between various properties of an information system and the net benefits enabled by the system. It highlights the fact that *system quality*, which can be interpreted as the technological features of the system, by no means is the mere driver behind benefits. *Quality of service*, e.g. support resources, and the *quality of information* present in the system are equally important drivers behind user satisfaction, end users’ intention to use and actual usage, which in turn are the key drivers behind net benefits.

## End user personalities

While the UTAUT and underlying models do account for end user perceptions of various factors and moderating variables, little attention is paid to the influence of personality. A classification initially coined by Moore (1991) and later adopted by Rogers (2003) groups individuals on the basis of how quick they are to embrace available innovations: *innovators*, *early adopters*, *early majority*, *late majority* and *laggards*. Based on observations, O’Brien (2000) suggests that EDM users can be categorized along the Bell curve in a similar manner:

*Innovators* – who intuitively see possibilities offered by new technology

*Pragmatists* – the majority of the population – who are willing to adopt new methods once they see proof of benefits

*Skeptics* – who resist change and are likely to avoid the innovation if at all possible

## **Application to construction project EDM**

The literature presented above is mostly concerned with the process of implementation and adoption behavior within a single organization. However, many construction projects occur in inter-organizational project group settings, where the end users are spread across numerous companies and geographic locations. The basic concepts used for describing the individual end user's intention to adopt are rather universal in the sense that they can be used for modeling the behavior of individuals in a wide range of settings. The personality types proposed by Rogers (2003) and the UTAUT factors of performance expectancy, effort expectancy, social influence and facilitating conditions (Venkatesh et al 2003) affect the intention to adopt regardless of whether the subject of study is an independent consumer or perhaps an employee within a large organization. Presumably, the same concepts are equally valid in an inter-organizational project group setting.

The two-stage innovation adoption process proposed by Gallivan (2001) is also consistent with the adoption process of a project group. *Primary* adoption occurs as project management decides to utilize certain technology in a forthcoming construction project. *Secondary* adoption occurs as the participating companies adopt the technology which is either mandated, advocated or supported by project management, depending on which secondary innovation adoption strategy is employed. It could be argued that the secondary stage should be divided into an additional stage of *tertiary* adoption, referring to the phase where project managers of the participating companies promote the technology to individual end users.

To summaries, the innovation adoption models presented in this section appear suitable for the study of how end users perceive implementation of new technology and practices in project groups.

## **Research methods**

The research design decided upon for this study attempts to combine the strengths of quantitative and qualitative methods by employing a two-stage data collection process encompassing a quantitative survey, log file analysis and interviews. Due to the limited time scale and resources available, only one case was selected. The combination of data collection methods, however, attempts to extract as much data as possible from this single case.

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 second phase aimed at obtaining more detailed insight into end user attitudes and experiences by conducting semi-structured interviews with project participants. Finally an expert interview was carried out with the intention of obtaining a further point of triangulation, representing the perspective of an industry specialist.

### ***Phase one – survey and log analysis***

**Survey method.** 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. The personalized link allowed each response to be identified and coupled with data from the user database and usage measures extracted from log files.

**Population and sample frame.** The population of interest was defined as the group of Kamppi Center project participants who had used the Raksanet system within the scope of the project (n=334). After omitting inactive users, the resulting sample frame was reduced to n=282.

**Questionnaire content.** The questionnaire was designed to gather information on the following topics:

- a) profiling data such as age, length of personal involvement in the project, amount of work hours devoted to the project and previous EDM experience
- b) end user perceptions along the dimensions of the DeLone and McLean Updated IS Success Model and the Unified Theory of Acceptance and Use of Technology,
- c) freely formulated comments on EDM use in the project

Rather than directly adopting the questionnaire contents proposed by any of the underlying acceptance models, a set of 19 quantitative questions was freely formulated to address specific issues which have been recognized as important in previous EDM research. The complete questionnaire is available in (Hjelt 2006).

**Response rate issues.** As Saunders et al (2003) predict low response rates for questionnaires of the e-mail / online type, several measures were taken in order to secure a satisfactory number of responses. The details can be found in (Hjelt 2006). The achieved response rate of 62% can be considered very high for this type of survey.

**Usage log data.** In order to add a dimension of actual EDM usage to the data set, certain usage statistics, were calculated per user and linked to the questionnaire responses. A usage amount indicator was constructed by banding respondents into four quartiles based on the number of file access events (uploads + downloads + online viewings):

Q1 "Light users"

Q2 "Medium light users"

Q3 "Medium heavy users"

Q4 "Heavy users"

In order to categorize users based on how they utilize the system, a usage type indicator was derived from the ratio of uploads to downloads performed by each user. 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% downloads)

"Pure downloaders" (100% downloads, no uploads whatsoever)

**Methods of analysis.** The resulting data set, consisting of questionnaire responses combined with usage statistics, was loaded into SPSS for analysis. Given the objective of the survey, the relatively small sample at hand and the coarse four-point Likert-scales used, no attempts were made at proving significant correlations between variables through the means of advanced statistical methods. Primarily methods of descriptive statistics, such as comparing means across groups, were used.

### ***Phase two – interviews***

Semi-structured interviews were carried out with a limited number of users, selected among the survey respondents. The selection was guided by an intention to interview people from different segments along the dimensions of group role, previous EDM experience and focus and length of involvement.

Interviews were conducted face-to-face and in several cases with a computer at hand, allowing the interviewee to demonstrate certain procedures on screen. Rather than having a set of written-out

questions, the semi-structured interviews were guided by a list of themes. This approach gave each interviewee an opportunity to focus on issues particularly important for his or her job role, allowing many interesting details, nuances and sub-themes to emerge.

## Empirical results and analysis

### Survey

#### Introduction

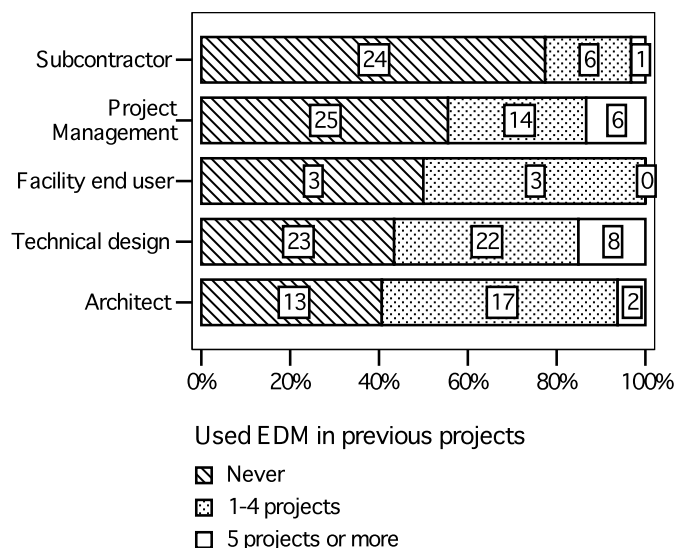
A satisfactory 167 of the 269 reachable individuals responded, giving an active response rate of 62 %. As such, the sample can be considered large enough to provide a representative view of the user base as a whole. However, the fact that respondents were responsible for 92 % of all logged upload events and 75 % of all downloads, shows that the obtained data is skewed towards more active and thus, perhaps, more positive users. Some of the results of the quantitative survey part of this study have also been reported in a separate article (Hjelt and Björk 2006)

#### Respondent background

**Roles represented.** The respondents were categorized in the following groups based on their employing organization as recorded in the EDM user database: *architects, technical design, subcontractors, project management* and *facility end users*. It should be noted that a share of the users within each group are project assistants rather than technical professionals. Age bracket and gender were also recorded for analysis purposes. 24 % of respondents were female.

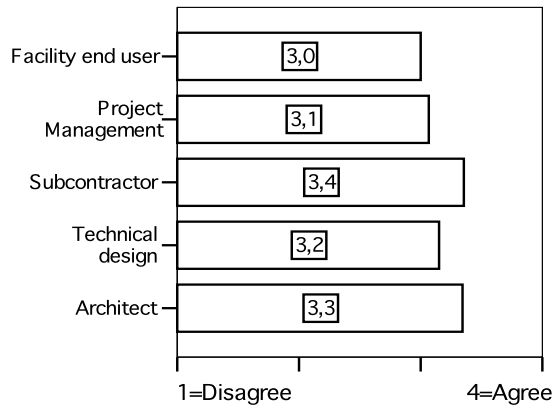
**Previous EDM experience.** As demonstrated in figure 1, roughly half of the respondents were first-time EDM users. 36 % had used EDM in 1-4 projects and a modest 10 % possessed more extensive EDM experience. Based on these figures, it can be concluded that the construction industry still is in a rather 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.

Figure 1 Respondent roles and previous EDM experience



**Usage behavior.** Figure 2 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. As users from different roles use the EDM tool in remarkably different ways, individual perception of factors such as ease of use and usefulness are bound to differ between user groups.

**Figure 2 Distribution of file transactions**



***Initial attitude towards the benefits of EDM***

Initial skepticism towards the benefits of EDM usage was surprisingly low. Only 10 % agreed somewhat and 2 % agreed completely with the statement “*At the outset of the project, I was skeptical about the benefits of EDM*”. The rest of the users disagreed somewhat or completely. Users who had previous experience of EDM use appeared less skeptical regarding the benefits. The fact that subcontractors seemed more skeptical than architects can presumably be explained by the fact that subcontractors, in general, have had less experience with EDM and IT than e.g. architects.

***Support quality***

Two questions in the survey were intended to measure the degree to which appropriate training had been received, and two further questions sampled the respondents’ awareness and satisfaction with support resources.

**Q: Training need and quality**

A slight majority of the users reported that they felt a need for training upon joining the project. Hardly surprising, the need for training was higher among first-time EDM users than among those who had used EDM in 1-4 projects or more. It was curious to find that 40 % of all respondents and 47 % of the first-time EDM users had not received any training at all. The voluntary comments shed further light on this issue.

*“I missed the introduction events as I joined halfway through the project. I learned the system by myself, with the help of other users at the office. Later on I’ve instructed technical designers on the use of the system. They haven’t received enough information about the system.”*

Among those who received training, however, the majority were completely or somewhat satisfied. This indicates that the actual training was of rather high quality, but targeting was far less successful.

### **System quality**

A few questions were intended to measure respondents' perception of *system quality* as a function of ease of use and frequency of technical problems. While the answers to the Likert-scale questions were quite positive (only 14 % felt that there were a lot of technical problems with the system), a large number of free-text comments regarding nuisances and suggestions for improvement were received.

Several respondents commented on the search engine available in the EDM system, with complaints regarding speed, ease of use and usefulness.

*“Finding documents with the help of the search feature didn't work. Maybe it was because I didn't know the precise file name, author or date.”*

One worthwhile suggestion was a “*most recently used*” –feature, giving the user quick access to folders and documents that he or she recently has worked with.

Other comments found the system very slow in the downloading of drawings for on-screen viewing. The system also seems incompatible with certain web browsers and CAD-systems.

### **Information quality**

According to the Updated D&M IS Success Model, information quality is concerned with the quality of the actual data that is processed within an information system. Two questions in the survey aimed at sampling two aspects of perceived information quality; folder structure and the degree to which users trust that contents are up-to-date and complete.

Q: I feel confident that the latest versions of drawings and documents are available in the EDM.

25 % of respondents agree completely and 55 % tend to agree that they can rely on EDM contents to be up to date. Interestingly, technical consultants were less confident than architects in this regard, despite the fact that they were responsible for a large share of all uploads.

Although the responses to the Likert-scale question seem largely positive, 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.”*

Q: The folder structure is well designed, making it easy to find the right folder despite the extensive amount of information.

*“The folder structure was well planned, and files were usually found easily.”*

With only 4 % disagreeing completely, 25 % disagreeing somewhat, 60 % agreeing somewhat and 11 % agreeing completely, the majority of respondents seemed rather satisfied with the folder structure. Yet a considerable number of respondents used the free-text field to comment further on this, many expressing dissatisfaction with the amount of folders and complexity of the tree, asking for a more consistent and self-explanatory structure.

Comparing the means across different segments reveals that heavy uploaders (i.e. architects and technical design) were somewhat more satisfied with the folder structure than pure downloader. Again, this gives further weight to the presumption that the degree or type of involvement in the information process affects the way end users experience EDM. Furthermore, it was found that respondents who had previously used EDM in five or more projects were more satisfied than first-time EDM user. This may indicate that the learning curve of handling construction information through a hierarchical folder tree is considerable.

### Process fit and user satisfaction

Moving to a more general level, the following questions attempt to describe the overall satisfaction with EDM work and ultimately measure the actual benefits as viewed by the individual users.

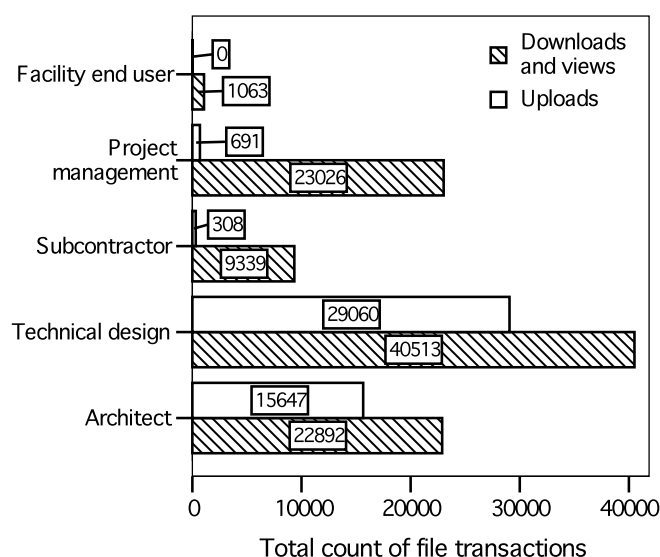
Q: EDM-based work routines suit me.

Recalling that 54 % of the users had no previous EDM experience, their responses to this question are solely based on the Kamppi Center project. This stands in contrast to respondents with a more extensive history of EDM use, whose answers may be based on the cumulative experience gained during several previous projects. The survey indicates that users with previous experience were considerably more content with EDM-enabled work processes than the first-time users.

Q: Email, facsimile, courier etc are still important methods of sending drawings within the project group

The responses to this question leave no doubt as to whether an EDM system can replace the traditional channels of document distribution in a construction project entirely. As shown in figure 3, a majority of the respondents considered that email, fax and courier are still important.

**Figure 3 Email, fax and courier still important**



The survey data does not give insight in the underlying reasoning, but this issue will be discussed in further detail in the interview section. One respondent mentioned email as a convenient way of exchanging drafts of upcoming revisions which are not yet ready for public release.

Q: The company or organization that I represent could have performed its tasks just as easy - or even easier - without the use of EDM.

The net benefit of EDM usage, as perceived by the project participants, was measured by asking respondents if they feel they could have managed as well without the support of EDM. A convincing 84 % of the respondents disagreed somewhat or completely, thus validating the assumptions regarding actual benefits presented in previous EDM research. The size and complexity of the Kamppi Center project seems to be one factor contributing to the positive attitude.

Subcontractors appeared less dependent on EDM than the other groups. Again, this can be explained by the subcontractors' limited involvement in the information processes.

Q: My attitude towards EDM has changed for the better due to this project.

The attitude towards EDM improved among a majority of the respondents. Recalling that subcontractors constituted the most skeptical group regarding benefits in the beginning of the project, it is interesting to find that the same group reported the biggest attitude shift towards the better. As a majority of subcontractors were first-time EDM users, their attitude has shifted from being based on prejudice to actual personal experience.

### **Conclusions regarding survey data**

At an early stage of processing the survey responses, an apparent mismatch was found between qualitative and quantitative data. A majority of the free-text comments seemed negative, containing numerous complaints about problems encountered in using the system, giving a rather gloomy picture of EDM success. Nevertheless, the quantitative data indicated the opposite, showing that a majority of the users were rather satisfied with the EDM system and the benefits it had provided.

However, the negative comments concerned rather *specific, mainly technical details* (e.g. search engine being far from effective, folder tree being difficult to navigate, the system reacting slowly etc.) Respondents who took the opportunity to comment on the usefulness of EDM use on a more *general level* seemed far more positive, and thus more in line with the results found in the quantitative data. The responses to the question (“*we could’ve done it as well without EDM*”) leave no doubt regarding the benefits provided by EDM in this project

In the light of the survey data, the areas which need improvement cover all three dimensions of quality: *support quality* (implementation efforts such as training and guidelines), *system quality* (search engine functionality, user interface issues and cross-browser compatibility, overall speed and reliability), and *information quality* (especially folder structure and confidence in content being up to date.)

The most apparent shortcoming of the implementation process in the Kamppi Center project was related to training and guidelines. Analyzing mean scores on the various quantitative questions shows that those who received no or completely unsatisfactory training were more negative regarding both ease of use and usefulness of the system. By properly targeting training to *all* end users, project management could expect a higher degree of EDM adoption, which in turn would benefit all participants since more communication could be committed through this particular channel.

## **Interviews**

The objective of the interviews was to gain deeper insight into issues which the quantitative survey could not properly address. In an attempt to cover the wide range of user types involved in the project, the interviewees were chosen from different segments in regard to role, previous EDM experience, and system usage behavior. The resulting selection is outlined in Table 1. Each interviewee is identified by a label (e.g. A1) used in the following text.

**Table 1 Interviewees chosen from different parts of the information process**

A1	Architect	> 5 projects	Heavy uploader	Medium heavy
C1	City planning	None	Pure downloader	Medium heavy
C2	City planning	None	Pure downloader	Light
P1	Project management	None	Mixed usage	Heavy
P2	Project management	1-4 projects	Mixed usage	Medium heavy
S1	Subcontractor	None	Pure downloader	Medium heavy

## ***Getting started***

As the survey showed that a large share of the users were novices and training was insufficient, the interviewees were asked to elaborate on their first encounters with the EDM system used in the project studied and how they felt about the support provided.

**First impressions.** Only one of the respondents admitted to having felt some anxiety as she received knowledge that EDM will be used extensively in the project. The other respondents held a rather neutral or even positive initial attitude. It appeared as if they had taken for granted that EDM was a necessity in a project of this size.

The first actual encounters with the software provoked different reactions among the users. A1 testified that only a small share of the employees at the architectural office she represented had bothered to actually “get started” with the EDM system, despite the fact that they were active providers and users of information in the Kamppi Center project. A1 explained this behavior as a result of the overwhelming effort needed to learn the technical specifics of the system and, most importantly, to get a grip of the information structure:

*“When you log in for the first time and try to do something, you simply don’t get going. There’s a terrifying amount of folders, structured by some logic – and that logic doesn’t reveal itself.”*

**The need for training.** The interviews indicated that the need for training is influenced in part by objective system properties and in part by the subjective skills and previous experience of the end user. These findings undermine the EDM solution provider’s claim that the system is so easy to use that virtually no training is needed, and project management’s assumption that the folder structure was so clear that it could speak for itself. The system may indeed be self-explanatory for computer literate users, but as the amount of information stored in the system increases during the project, the learning curve for late joiners gets steeper – even for computer literates, such as the architect colleagues of A1.

**Formal training vs. informal knowledge sharing.** P1 acknowledges that project management provided organized training only at an early stage of the project, trusting that any users joining later would receive enough support from colleagues etc. Similarly, document management guidelines were discussed at early design meetings, but not communicated directly to users joining later. The results of this approach can be seen in the survey data, showing that almost half of the first-time EDM users had to train themselves through trial-and-error or by asking colleagues for help, and that roughly half of the respondents were more or less unsatisfied with the guidelines received.

Relying on support from colleagues can be a viable form of training in stable organizations. However, in case of the fast-paced but long-running Kamppi Center project, this prerequisite was not always fulfilled. Many subcontractors joined as late as three years after the project launch, completely missing the introductory training and not having any experienced colleagues within their own organizations to ask. Certain companies were indeed involved from the very beginning, but the quick rate of project staff turnover hindered organizational learning.

**Summary.** The interviews showed that the need for training varies from person to person. Even users who are familiar with EDM software may need training and guidelines explaining the folder structure and document management practices used in the project at hand. Self-learning is clearly not suitable for all users, and learning through support from colleagues does not necessarily work in a fragmented and constantly evolving construction project group.

## ***Usability issues***

These are not reported in detail here, since they are very specific to the EDM system used. A1 stated that using the EDM software is so slow and requires such attention that she needs to devote time specifically for dealing with the system, putting off all other tasks for the moment. Using it while on the phone with a technical designer, for instance, was considered impossible, resulting in extra use of email as a channel of communication.

Clearly, many of the usability issues such as speed and user interface ambiguities could be corrected or remedied by the solution provider, but given the current state of the system, users would have benefited significantly from more rigorous training.

### ***Information accessibility***

The folder structure and navigation tools available received criticism from survey respondents. Interviewees were asked to comment on the issue.

**Folder structure.** Representing different departments of project management, P1 and P2 were both in a position to develop the folder structure used. P2 viewed the structure as a “best effort” result of the co-operation between project management and the application service provider (ASP), and did not see any simple means of improving it. Satisfaction with the structure of various folder tree areas seemed related to actual usage and thus familiarity with each area. P2 and S1 who worked frequently with the technical design subfolders were completely satisfied with the structure, while P1 and A1 who only accessed these folders occasionally regarded them as chaotic. This indicates that the structure was far from self explanatory even for experienced EDM users.

**Tools for navigation.** P2 was the only of the interviewed users who reportedly used the document search functionality available in the EDM system. The other interviewees considered it easier to locate documents by browsing through the folder tree, despite the fact that the system often reacted so slowly to each mouse click that drilling down into several levels of subfolders could take up to 20 or even 30 seconds – even if you knew exactly which folder you are looking for.

**Summary.** Although the folder structure received criticism among survey respondents and the interviewees, none of the interviewed users were able to provide any substantial suggestions for improvement. It seems as if some of the criticism originated from the individual user’s lacking understanding of the folder structure as a whole. Proper training – with focus on the actual contents of the EDM – would probably alleviate the confusion regarding the structure and help users find the handful of folders they typically need in their work.

### ***Coping with the flow of information***

Perhaps reflecting the stress caused by the tight design/construction schedule, only 25 % of the survey respondents were entirely confident that the contents of the EDM are up-to-date and complete. The interviewees were asked to elaborate further on this and describe how they manage the constant flow of information in the project.

While the interviewees reported that architects and technical designers have been sufficiently quick in uploading their latest work to the EDM, other interesting issues regarding the availability of up-to-date information emerged. These are discussed below.

**Planning ahead.** C2 pointed out that even though designers upload their drawings without delay, and even though users are automatically notified whenever new files have been published, you still need to contact architects or technical designers directly to ask about upcoming revisions. P1 admitted that revisions not yet approved for release are kept entirely outside of the EDM. Consequently, there is no way an EDM user can know that a new, revised design may appear *in the near future*, rendering the revision currently available in the EDM obsolete.

**Paper delay.** While survey respondents expressed concern about how quickly / reliably new updates were published in the EDM, especially A1 and S1 were far more worried about the fact that the automatic hardcopy distribution often lagged several days behind the contents of the EDM. A1 pointed out that during phases of intense design work, the paper copies available on the construction site could be lagging behind by several revisions. With new revisions coming out daily during the construction phase, even a one day delivery delay could cause problems on the site, and the 4-5 day delays mentioned by A1 could be disastrous.

Considering the problems related to automated paper distribution, the question arises whether this functionality is necessary at all. P1 and P2 both agreed that it is. First of all, many subcontractors

supposedly don't have the equipment or skills needed to producing their own printouts from the EDM. Secondly, the steady inflow of paper copies can serve as a constant reminder for parties who otherwise might lag behind their schedule.

**End user solutions.** How, then, have the project participants managed to avoid problems related to information delay or overflow?

A1: Representing one of the architect offices, A1 testified that the office has used email extensively in order to keep the design processes running efficiently. In addition to storing new drawings in the EDM in compliance with the official document management guidelines, the architects have also emailed them to technical designers directly. This has meant double work for the architects and has made information management all the more complex for the recipient, who first receives a drawing by email, the following day receives a notification update email informing about the new drawing being available in the EDM, and a few days later received the same revision on paper.

C2: Remaining somewhat skeptic towards EDM technology, C2 always communicated directly with the designers in person to stay informed on what's happening ahead. In doing so, she avoided the risk of proceeding with her own work based on soon-to-be-revised drawings. C1 and C2 reportedly did not receive any automatic paper copies and were satisfied that way – they feared they would “drown in paper” if all revisions were distributed to them automatically on paper.

S1: Not receiving any update notifications by email, and dissatisfied with the slow delivery of paper copies, S1 took a strict *just-in-time* and *do-it-yourself* approach to information retrieval and printing. Prior to going out on the construction site, he manually browsed the EDM for any new revisions, produced copies on his personal printer, and handed them out to his crew. Sometimes he would phone the technical design office and ask if any new revisions are up and coming. Although this procedure caused an extra burden on him, it gave him the comfort of knowing that his workers were always doing the right thing based on the most accurate designs.

**Summary.** Unlike the survey respondents, the interviewees did not express any concern regarding the availability of up-to-date information in the EDM. Instead they commented on the confusion caused by paper copies arriving a few days late, often only to be passed straight to the recycle bin. The use of email as a parallel channel of communication was described as inevitable, despite the fact that it adds to the complexity of the information management activities.

## Conclusions

### Case study findings

An obvious limitation of the study is that data was collected from only one construction project. The findings are presumably colored by the unique properties of the case studied. This is further accentuated by the fact that many of the respondents were first-time EDM users; their attitudes towards the technology are entirely based on their experience with the particular EDM software chosen for the Kamppi Center project. Furthermore it should be noted that many of the challenges identified are related to the size and complexity of the construction project. Consequently, the general applicability of the results of this case study is limited. Nevertheless we hope the results are of interest to both other researchers and practitioners and help build the body of knowledge in this research field.

Roughly half of the users participating in the survey had no previous experience of EDM. This allowed the study to evaluate the effectiveness of implementation efforts provided by project management. Earlier EDM research stresses the importance of strong management commitment in planning, implementing and enforcing document management practices in construction projects. In the case studied, project management did indeed strongly promote the use of EDM, but nevertheless a majority of the end users received no training or guidelines whatsoever. Project management provided organized training for users joining the project at an early stage, assuming that later joiners would either receive sufficient support from colleagues or simply get started on their own. The EDM system

vendor suggested that the system is so easy to use that virtually no training is needed, and project managers hoped that the structure of the contents would be rather self-explanatory.

However, the case study shows that these assumptions did not hold true. The lack of training resulted in a higher barrier to adoption especially among users with limited computer skills and, consequently, suboptimal utilization of the technology available. Users unsatisfied with the training appeared less confident regarding several aspects of EDM use than those who received satisfactory training. Findings of this study suggest that self-learning by trial-and-error is time consuming and viable only for users with good computer skills. Learning through workplace knowledge sharing, on the other hand, requires availability of colleagues experienced with the system – a requirement which isn't necessarily fulfilled in the dynamic setting of a project construction group.

Particularly those joining later on in the project reported problems in getting started, often quoting the complexity of the contents as one of the biggest challenges. This can be explained by the continuous growth of the information mass and folder structure over the course of the project. It also leads to the important finding that training efforts should not be limited to the technical aspects of using the EDM software, but also cover the document management principles employed in the project and explain the logic and structure of the EDM contents

The findings of this study emphasize the need for providing formal, organized training and distributing guidelines to all EDM users across the project group. In targeting training efforts, project management should avoid the pitfall of focusing merely on the small group of heavy EDM users such as architects joining the project at an early stage. The numerous part-time users who may not get started on their own due to their short involvement in the process and lacking in-house experience should also be assisted as their adoption of EDM is of importance for project communication as a whole.

A strong majority of the users reported that the EDM system was of significant benefit throughout the project. Only one fifth of the respondents claimed they could've performed their part of the project just as easily or even easier without the help of EDM. This finding reinforces the results reported in earlier studies (e.g. Sulankivi et al 2002, Ruikar et al 2005) which suggest that a well implemented EDM system is far superior to traditional means of document exchange in project groups. Furthermore, findings indicate that the benefits of EDM aren't limited to the parties traditionally tightly involved in the information process. While subcontractors were more skeptical regarding benefits of EDM than other groups at the outset of the project, they reported the biggest improvement in attitude at end of the project.

Despite the apparent satisfaction with the support provided by EDM, the case study findings indicate that the full potential of EDM was not achieved in this project. Studying the communication habits and work routines of individual users revealed a paradoxical situation: traditional, non-EDM means of communication such as e-mail and paper copies were considered important by a majority of the respondents, but simultaneously the use of parallel channels was reported as a significant source of frustration due to the redundant work and "information overload" caused. Information producers were faced with the burden of distributing documents in several formats by different means, and information users struggled to cope with the inflow of data arriving asynchronously over different channels. In other words, the envisioned ideal situation where EDM minimizes copying costs, ensures that only the most recent revisions are available to information users, and reduces information overload by allowing users to fetch data just-in-time, was not achieved by far.

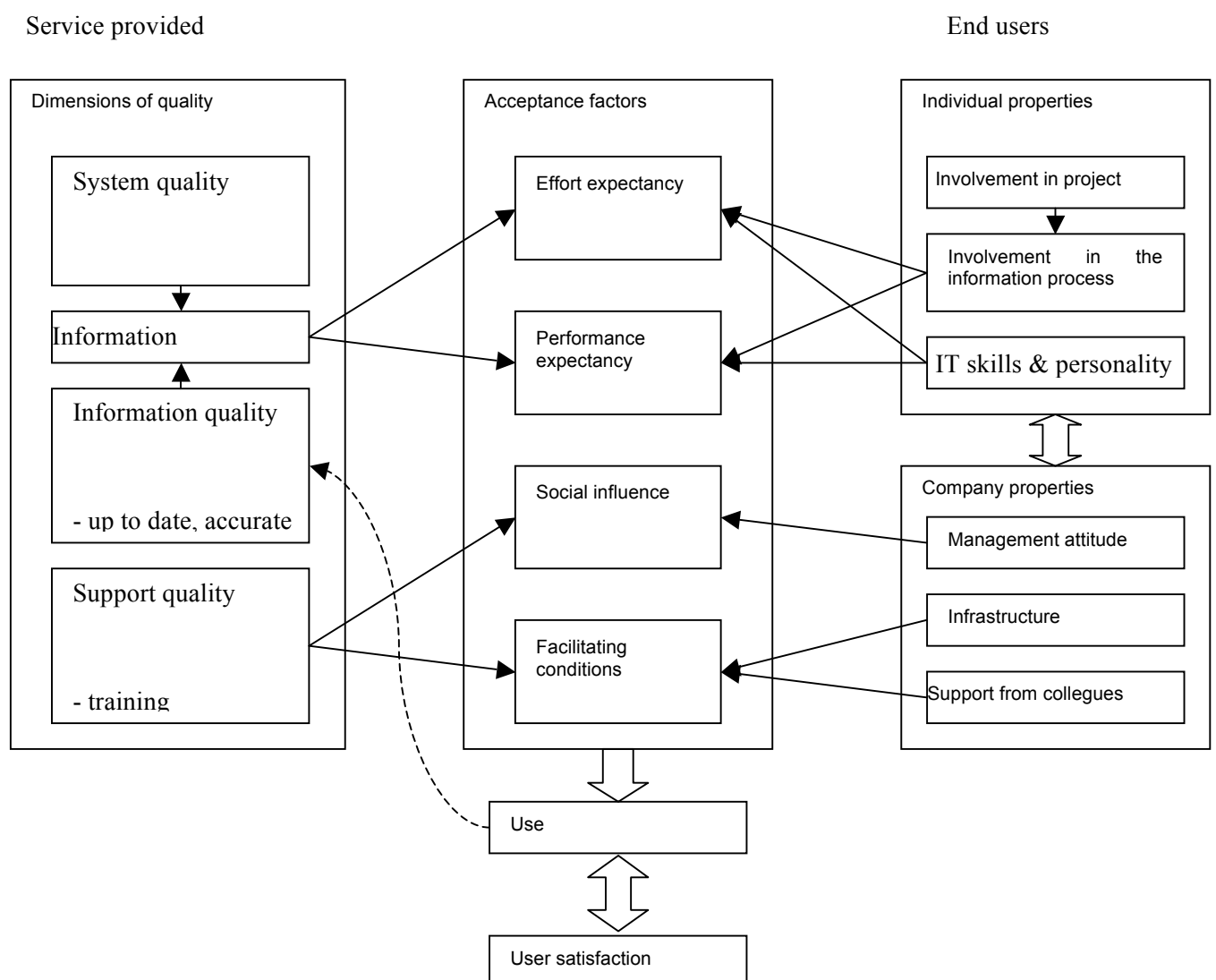
## **A proposed model for EDM adoption in construction projects**

In an attempt to integrate the findings of this study with existing literature, a model describing the key factors affecting end user attitudes towards EDM adoption in project work is proposed. The model draws on insight from earlier studies of EDM enabled projects (e.g. Sulankivi et al 2002, Ruikar et al 2005), generic theories on technology acceptance (e.g. Venkatesh et al 2003, Rogers 2003) and success of information systems (DeLone & McLean 2003). The core constructs predicting adoption are borrowed from the Unified Theory of Adoption and Use of Technology (UTAUT) (Venkatesh et al 2003). These are *effort expectancy* (perceived effort needed to use the system), *performance*

*expectancy* (perceived usefulness or benefit of using it), *social influence* (influence from others) and *facilitating conditions* (technological and organizational factors including training and support. Based on our empirical findings, the proposed model suggests that these four factors are influenced by *service properties* and *end user properties*. The latter can be further subdivided into individual properties (relating to the individual end users) and company properties (referring to the different companies participating.)

In the model which is shown in figure 4, the properties related to the service offering are shown on the left-hand side. These are largely under influence by project management and the EDM system provider. The right-hand side of the model represents the end user perspective. These end user factors are divided into individual properties such as skills, innovation personality type and involvement in the information process, and company properties which refer to the different companies participating in the construction project group. The dashed connection running from *use* to *information quality* illustrates the role played by end users in creating and maintaining the actual contents of the system.

**Figure 4 Factors influencing EDM adoption and end user attitudes in project groups**



### ***Service properties***

The three dimensions of quality borrowed from the Updated IS Success Model (DeLone & McLean 2003) are used to structure factors describing the service provided. The proposed model defines information quality as the degree to which the EDM contents are:

- up to date
- accurate
- complete (i.e. all necessary information is available in the EDM)
- properly structured and meta-tagged

As both information quality and system quality (covering functionality and usability) determine how well the system fulfils the ultimate purpose of EDM, the proposed model includes a construct labeled *information accessibility* measuring the degree to which the system gives users easy access to valid and relevant information

The model also underlines the need for two different types of support: *software training* – relating to the mechanical aspects of using the system, ensuring that users are aware of the functionality available and *project specific guidelines* – relating to the contents of the system, ensuring that users understand how the structure and contents of the EDM relate to the document management practices used in the project

### ***End user properties***

The model suggests that certain end user specific properties affect adoption, one of the most important factors being the end user's position and *involvement in the information process*. Other user specific properties included in the model are *ICT skills* and *innovation personality type*. Company specific properties included are *infrastructure* and *support from local management and colleagues*. In the following, these issues are discussed from a UTAUT adoption factor perspective.

**Performance expectancy.** While the client of a construction project benefits from reduced costs, fewer errors and tighter schedules, other segments of the project group may see no evident benefits. Consequently performance expectancy, i.e. the end user's belief that using the EDM system will be of benefit in performing his work, depends on how the user participates in the information process of the construction project.

**Effort expectancy.** The end user's position within the information process also affects the efforts involved in learning and using the system. Information providers bear responsibility for maintaining information quality which translates to extra efforts regarding detailed meta-data input etc. Information users, on the other hand, reap the benefits as meta-data allow them to quickly find the documents they are looking for.

**Social influence.** In order to maximize the benefits of EDM, adoption should be mandatory. Presumably the mandate to adopt the EDM system will not be perceived as equally important across the entire project group, and the attitude of management in the participating companies will impact the individual end users' eagerness to adopt project-specific EDM.

**Facilitating conditions.** Although factors such as training, guidelines and support often are provided for by project management or the EDM system provider, the heterogeneous nature of construction project groups causes variance among the participants. The ICT skills, technological infrastructure and support available from colleagues may vary significantly between participating companies.

It should also be noted that the proposed model has not been tested statistically. The quantitative data obtained in the survey was not detailed or broad enough to allow for testing. As such, the model is a synthesis of previous research and qualitative analysis of the empirical findings of this study. Still we hope it can provide a basis for further research.

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