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The Barrie Award

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Burcin Becerik is currently a doctoral student at the Harvard University Graduate School of Design in the area of Project Management. Ms. Becerik graduated from Istanbul Technical University with a degree of Bachelors in Architecture in 1999, and a Master in Architecture in 2001. In 2002, she attended the University of California, Berkeley where she received her degree of Master of Science in Civil and Environmental Engineering with a special concentration on "Construction Engineering and Management". Prior to coming to the United States she was awarded with a scholarship from the Higher Education Council of Turkey.

Ms. Becerik's on-going research is in the area of construction project extranets. Her research examines the enhancement possibilities of implementation and operation of extranets in the AEC industry. In addition, it explores the proposed opportunities that the new technology can provide to architects and their collaborators during the life cycle of the construction projects. Ms. Becerik is expecting to complete her studies and graduate in 2005 with a Doctor of Design (DDes) degree from Harvard University.

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CRITICAL ENHANCEMENTS FOR IMPROVING THE ADOPTION OF ONLINE PROJECT MANAGEMENT TECHNOLOGY

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This research focuses on current problems and inefficiencies of implementation and operation of online collaboration and project management technology in the US Architecture, Engineering and Construction (AEC) industry. Despite the enormous number of the solutions and claims about their advanced technology and benefits, the adoption of these tools by the industry stakeholders has been very slow. Unfortunately, the huge amount of technology is presented without targeting the evolving communication & collaboration necessities of the industry. In an attempt to fill the need of research to explore how these tools actually interact with the organizational context, what the needs of the users are, and how this technology can be improved and commonly adopted by the industry, three active construction projects were studied and a user survey was conducted. This paper outlines the findings of a year of research (surveys and interviews) and concludes with “Critical Enhancement Areas” that would hasten the adoption and successful implementation of these tools by the AEC industry. The study enforces that success is less about adding more advanced technology to the tools but it is more about using the available technology in a more reinforcing way to solve business problems and obstacles regarding the adoption of these tools.

Keywords: AEC Industry, Collaboration, Communication, Extranets, and Project Management.

INTRODUCTION

The real estate and construction industry is the largest industry in the world² with distinctive characteristics such as fragmented organizations³, the uniqueness of each project, relatively short period of production, outdoor and unstructured working conditions, and labor-intensive activities. Successful completion of construction projects requires communication and collaboration of numerous multidisciplinary and sometimes geographically separated team members. Continuous and accurate formal/informal communication among project participants is key to resolve conflicts, keep the project on time, on budget, speed up solutions, and to share knowledge for coordinating these efforts.

The rapid advances of online project management (OPM) technology offer new opportunities to improve existing construction project communication and enhance the collaboration. However, despite many benefits of these technologies and all the efforts that have been put into facilitating the communication among the participants in AEC projects (much less effort has been put into having shared understanding) [3], utilization of OPM technology hasn't progressed beyond simple document

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² Representing over \$4 trillion value of construction input in place about 10% of global economic production. In US, about \$480 billion of construction was put into place in 2001, just under 25% of worldwide construction and about 4.8% of US GDP [1]

³ An estimated 720,000 establishments in the US [2]

storage, exchange and management. There is a strong resistance from the industry participants to adopt these new technologies in their full capacity and change how work has traditionally been done⁴.

The huge amount of technology is presented without targeting the evolving necessities of the industry. There are serious doubts whether these products will provide the level of flexibility that teams demand. Moreover, there is no clear understanding of what the communication and collaboration needs and desires are in the AEC industry. Many improvements are needed for the OPM tools themselves and how they are implemented in order to move the industry beyond the functionality of current working methods, and provide a real breakthrough in communication and collaboration effectiveness.

OPM TECHNOLOGY

The term “*OPM technology*” in this research refers to any number of web-based and web-enabled technologies⁵, which offer communication platforms, project management functionalities and hosted collaboration spaces for capital construction projects. Unlike a web-based application, a web-enabled application is not based on the HTML language, but is instead a special software application that is distributed across the Internet much like standard network programs that are accessed over a Local Area Network (LAN). In both of these configurations, team members can reach the project information through their Internet browsers with permission-based access requiring user names and passwords. Although business models vary among OPM providers, these services are typically leased for either a periodic and/or per-user fee.

OPM technology is being used for facilitating team communication, managing and storing documents, controlling workflows and automating construction processes. These tools enable project participants to send, record, store, share, receive, monitor, and manage correspondence, Request for Information (RFI), drawings, specifications and other documents involved in the design and construction processes.

RESEARCH GOAL AND METHODOLOGY

This research has been supported by General Services Administration’s (GSA) Public Buildings Service (PBS), which is the world’s largest landlord of the civilian federal government, [5] and by Harvard University. The aim of the research is to explore:

- How these tools actually interact with organizational context,
- What the needs of the industry are,
- How this technology can be improved and commonly adopted by the industry.

Typical questions answered in this paper are: *How are OPM tools used? What are there benefits from implementations of these tools? What are the barriers to widespread adoption? Which and how technical questions need to be solved?* To accomplish these goals, three GSA construction projects have been studied. Using case studies has been important as an empirical investigation of OPM technology within its real life context. The case studies in this research focus on details and descriptions to examine the conditions, why and how the decisions were made, and what the obstacles and their consequences were. In addition to the case studies an online user-survey has been conducted to identify the factors associated with successful implementation of these tools and to get user opinions on the impact of these tools on team performance and project outcomes.

CASE STUDIES

The research required observing and then evaluating the benefits and the shortcomings of OPM tools and also learning from users’ experiences. GSA helped to identify three construction projects to get in-depth analysis of implementation and usage of OPM technologies. In addition, GSA provided access

⁴ By late 2001, only 40% of General Contractors had tried project collaboration software, according to the Construction Financial Management Association’s “2002 Information Technology Survey for the AEC industry”. [4]

⁵ Web-based: Information generated by project team members is automatically saved to the OPM on the web, Web-enabled: The Internet is used to connect directly to remote applications and self hosted client databases

to the project information and helped to contact the projects' participants. Each case study focuses on new construction with traditional project delivery method (design-bid-build) and has different scopes. All projects were managed by Construction Management agencies acting as GSA's representatives. The cases are ten to fifteen pages long and are structured with the following sections: Project Overview, OPM Technology, Selection Process, Realized Benefits, Improvement Areas, and Conclusions. A common challenge for the project teams was working with a number of team members from different disciplines that are geographically distributed. The OPM solutions utilized in the construction phases of Miami Federal Courthouse Project and World War II Memorial Project were both web-enabled whereas the rest of the OPM tools were web-based. A brief outline of the case studies' statistics is provided in Table 1.

Table 1: Case Study Statistics

Statistics	World War II Memorial Project	NOAA Satellite Operations Facility	Miami Federal Courthouse
Client	American Battle Monuments Commission	National Oceanic and Atmospheric Administration	General Services Administration
Project Manager	GSA	GSA	GSA
Building use	Memorial	Computer Facility	Courthouse
Size	322,345 SF	208,271 SF	577, 784 SF
Construction cost	\$71,677,602	\$53,757,000	\$129,254,000
Project cost	\$101,039,255	\$61,198,000	\$163,022,000
Design period:	06/08/98–11/21/02	02/05/01–09/28/02	08/10/98-12/18/02
Constr. period:	08/27/01–03/05/04	04/30/03–05/18/05	07/16/02–05/16/05
Constr. status:	97% complete	20% complete	51% complete
Design OPM	Citadon, Inc	Citadon, Inc	Framework Technologies
Constr. OPM	Prolog, MPS	Constructware	EdgeBuilder

SURVEY

In addition to the case studies, a more qualitative research was required to explore the needs of the users and also to learn more about the impact of these tools on team performance and project outcomes. The aim of this survey was helping the author to evaluate the strengths, weaknesses and benefits of OPM tools, areas of improvements, and implementation inefficiencies from the end users perspectives.

The first section of the survey was “General Information & Implementation” in which the respondents were asked to provide information about the tool implemented, the project, their background and roles, their experience level with OPM tools and other Communication and Collaboration Technologies. (CCT) The second section of the survey was called “Effectiveness of the Tool”. It examined the perceived benefits of the tool in the specific implementation, user opinions regarding the importance of the OPM tool compared to other means of CCT, evaluation of various aspects of the tool to be effectively used, and suggested improvement areas.

DATA COLLECTION METHODS

A series of interviews and an online survey were conducted to gather data for deeper analysis of implementation and operation of OPM tools in construction projects. The main aim of collecting this data was to find out what can enhance/improve the adoption of this technology by the industry stakeholders.

Interviews

Structured phone interviews, which each lasted approximately one hour, were conducted with the projects' team members. The information requested was straightforward and didn't involve sensitive material, so potential bias was low. Prior to the interviews, requests were sent to the Project Managers and the administrators of the OPM tools to find the most suitable people as respondents. The author was careful to interview at least one team member from major participant stakeholders with various

roles such as Construction Manager, General Contractor, Project Manager, Architect, Engineer, and the Owner. The interviews deepened the author’s understanding of the step-by-step logic of a situation as it occurred, the interviewee’s experience with the tools, the lessons learned in the project and the users’ opinions for improvements areas.

Table 2: Short Interview Questions

#	Questions
Q1	How did the team decide to implement OPM tools in this project?
Q2	How was this tool selected?
Q3	What kind of training, for how long, and by who was it provided?
Q4	What were the attitudes of your colleagues & management towards OPM technology?
Q5	How did the project & your firm benefit by implementing this technology?
Q6	What were the problems with the implementation and usage of the tool?
Q7	How did the management and the technology provider address these problems?
Q8	What should have been done differently?
Q9	What would you recommend for improving the implementation and usage?
Q10	How would you rate the overall effect of the OPM tool on project performance?

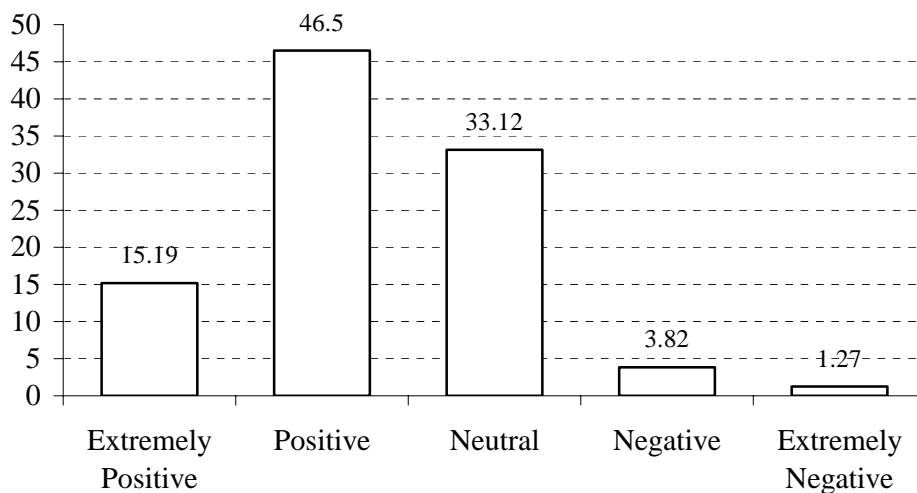
Survey

Many OPM technology users at GSA, including all of the project participants of these three particular projects, were invited to respond to a voluntary online survey of twenty questions. The contact information was requested from the system administrators by online “*administrator survey*” and the invitation to the survey, including the Internet link of the user survey, was sent directly to 400 users via email in mid-February 2004. The answers were collected between February 2004 and May 2004. The answers provided are kept confidential and have been used for statistical purposes in aggregate form only. Not all of the OPM users of the projects were able to complete the survey due to other commitments and time constraints. However, sufficient users completed the survey such that the author was able to identify certain common problems, issues and limitations experienced during the implementation and use of OPM tools.

CRITICAL ENHANCEMENT AREAS

OPM technology holds a great promise. The overall effect of OPM tools on project performance is positive according to 46.5%, extremely positive according to 15.19%, of the users. (Fig 1.) 81.17% of the users indicated in the survey that their company anticipates using an OPM tool for upcoming projects, however most of them also indicated the technology needs improvements and the implementation has to be rethought. This technology is surely bound to replace “old economy ways”, but only if the tools can adequately fulfill the specific needs of building designers, constructors, owners, managers, and suppliers.

Figure 1: Overall effect of OPM tool on project performance



The future is inevitable, but slow at the same time. The question is: are we going to wait for the next generation to overcome obstacles eventually or try to hasten the process and eliminate the inefficiencies as soon as possible? In an attempt to hasten the process, the following enhancements have been identified as critical for the adoption of these tools by the AEC industry based on the formal and informal interviews with the end users; the lessons learned from the case studies, and analysis of the user survey.

Robust Tools Should Fit the Nature of Construction Projects

Design and construction are inherently different processes, shaped by reality. Design is decision intensive, encouraging study and redesign. Construction is production intensive, with defined needs for labour and materials in fixed timeframes. Construction projects are subject to the influence of highly variable and sometimes unpredictable factors. During specific phases, coordination and collaboration may be required in different levels. Participating organizations and the tasks they perform may vary during the project phases while the shared information should be kept stable throughout the life cycle of the project. Managing construction projects is an interdisciplinary art requiring professional skills to achieve the maximum performance. Therefore, OPM tools should be developed to satisfy needs and desires of the project participants.

It has been observed from all of the case studies that there are no tools that would fulfil all stages of the construction projects. Today there are some OPM tools that focus efficiently on workflow and process automation during the construction phase, and there are other OPCM tools that are very good at enabling team communication and document management. Therefore, the project teams have to shift products during the different stages of the construction project, which results in knowledge, time and money lost due to data re-entry, learning curves, and productivity loss. These tools should support the project team during all phases of projects with variable and flexible modules.

Flexible Tools with Customisable Modules

Construction projects are usually unique, complex, custom-built responses to specific clients' interests. AEC organization is based on "temporary networks" of architects, engineers and contractors forming and reforming into corporative groups for each project. [6] Therefore, OPM tools should be flexible enough to align with differing structures of project teams, project types and delivery methods.

For example, in all of the case studies GSA hired a Construction Manager to act as the owner's representative, supervise/inspect the General Contractor, oversee several consultants, etc. In this team structure, almost all communication and document flow goes through the Construction Manager. However, most of the available tools are built according to a traditional delivery system where the Architect and General Contractor communicate directly. Moreover, the tools are very rigid and don't allow the team to modify the modules to accommodate their needs. In the end, either the teams find a custom-built solution, which is unpractical, difficult to use, and the cause of many delays and frustrations, or they stop using the modules.

Another common problem among the current solutions is that most of them were not built by people with construction knowledge and experience. As a result, some of the modules and processes observed in the case studies were reported to be poorly designed and insufficient. The tools should be developed in conjunction with construction experts rather than solely by computer scientists, so that their understanding of the way work needs to be done in this industry can be built into the tools.

Intelligent Workflows

As the world moves towards intelligent data structures, the technology providers should also move towards intelligent tools those will deliver rich, dynamic information rather than today's passive solutions that deliver static reports. Current OPM solutions are very document-oriented, which leads the industry to move towards shuffling electronic paper rather than encouraging truly electronic processes. In fact, even having electronic paper process has clearly demonstrated the industry could gain efficiencies, however the tools need more *intelligent workflow* to survive in the future.

Design and construction processes have unique workflow issues that are not found in other industries, such as extensive and lengthy RFI cycles, multi-stage building code performance checking, etc. Workflows unique to construction projects have to be modeled and built into the tools carefully. The tools should be intelligent enough to manage the processes without any manual help or data re-entry. They should have automated management systems with decision making, data gathering and

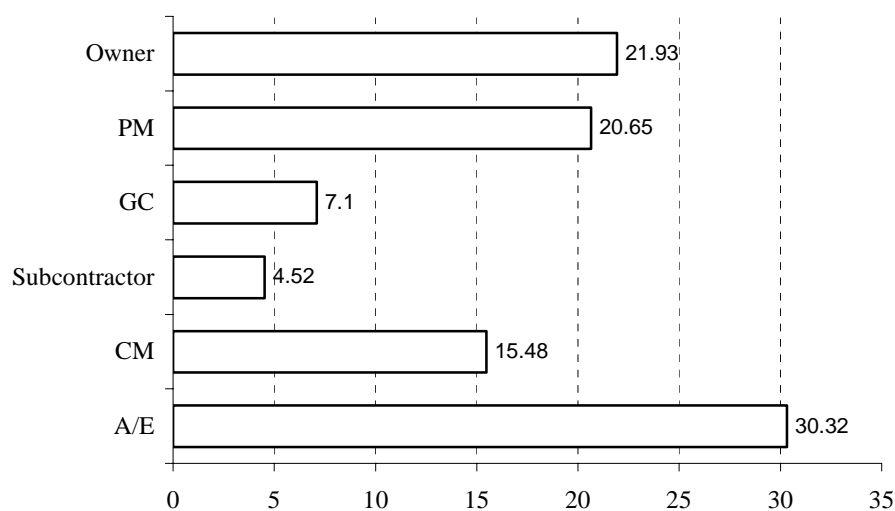
implementation capabilities. Intelligent workflows should have the ability of explicitly describing and understanding the current real-time status of the project, and the purpose of the planned processes, then determine what activities to undertake and in what sequence according to its experience, also adjusting and modifying its actions in response to any changes. [7]

Future OPM tools also should automate tasks between business partners. For example invoices or purchase orders can be exchanged automatically and fed into back-end systems to track shipments, all from within the corporate portal without having to log on to several information sites. As such relationships extend across more companies in the supply chain, this technology will become part of an industry-wide supply chain integration solution. By linking more companies in the value chain and providing better integration of the information shared by each company, these intelligent OPM tools will enhance the reach and integration of the supply chain.

Client/Server with Internet Capabilities

Despite all the developments in information systems, the AEC industry is still in the paper world. The predictions were that the industry would move towards web-based models, however one of the difficulties observed in all of the case studies is that connectivity is still a problem. Often the bandwidth is slow due to the number of the users or/and amount of information in the system, rather than the problem being Internet speed itself. Most of the contractors, subcontractors, suppliers, and construction sites are completely disconnected. This can also be observed from the respondents' profiles of the survey in Figure 2. General contractors and subcontractors replied to the survey are 11.73% in total, which shows that the usage of the tools drop down dramatically down the value chain. All of this creates a situation where paper-based processes have to line up with OPM (if implemented) in construction projects. On contrary, the reason for up to 65% of contractor rework is related to insufficient, inappropriate or conflicting information. [8]

Figure 2: Respondent profiles



However, OPM tools are designed to benefit all project participants. The maximum benefits are achieved only if all the actors involved in the project exercise their options simultaneously by investing the required resources in the system. If this is not the case, the full potential of the investment is not reached. In an industry that is characterized by both decentralized decision-making and conservatism, it is not clear that the end-users will adopt a new technology as enthusiastically as the corporate IT department. [9]

Therefore, solutions should be able to work on client server databases to avoid connectivity problems. The tools also should have Internet capabilities as the technology spreads out and keeps developing. As many of the team members who were interviewed mentioned, the tools should be set up for a wide area network with an Internet component, so that everybody could share and there is no need to upload the files to internal servers for a second time. (E.g. for printing construction documents)

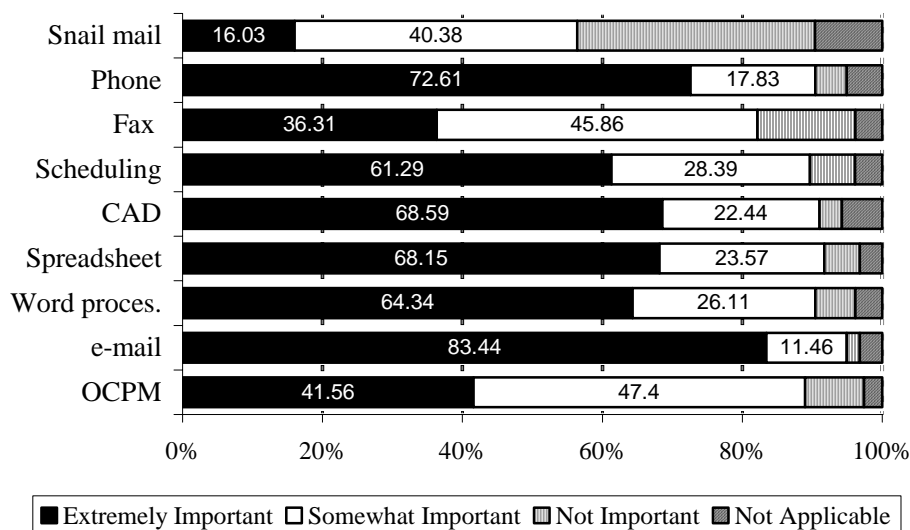
Capturing Paper Documents

The inability to share and interact with information easily and effectively is one of the biggest bottlenecks in using electronic information for collaborative decision-making in the AEC industry. [10] The current situation in the construction industry is that a mixture of different generation methods is used for managing documents. [11] Today hard copy, telephone and fax dominate the exchange of project-specific requirements with suppliers and between the different project participants.

Telephone and email are the major communication tools that were identified in this research as being extremely important for project success, and the fax has lost some of its traditional importance. (Fig 3.) However, before arriving at any conclusions, the respondent profiles should also be considered. According to the case study observations fax is still a major way for transferring documents among downstream team members, especially among subcontractors, suppliers and contractors. Therefore all the information received by fax would have to be scanned either by the general contractor or the construction manager in order to make it electronic. So in most of cases, the two processes operate in parallel, making OPM tools less effective.

Therefore, OPM tools should have a system for all the documents faxed or emailed to be automatically added to the database. Actually this advancement is already being offered by some of the technology providers, as observed on the Miami Federal Courthouse. In this case a project email address is added to an email, which automatically adds the correspondence to the database. There is also an 800-fax number that assists the system in recognizing the document and saves it to the database as a PDF document.

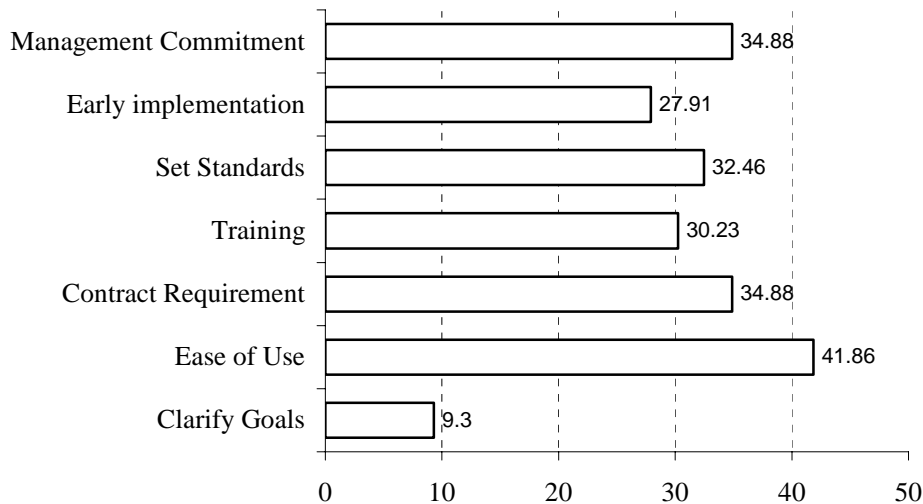
Figure 3: Importance of different applications for the project success



Ease of Use

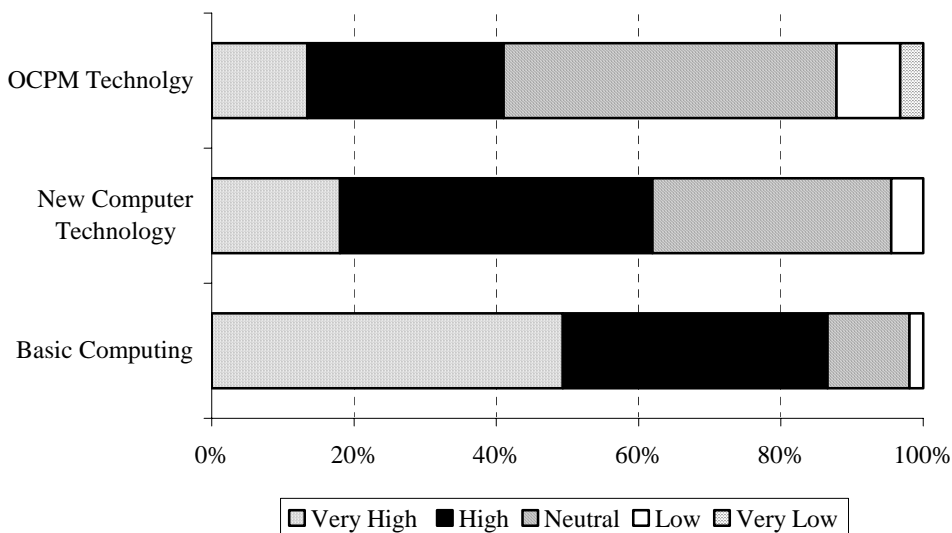
The respondents suggested (Fig 4.), and most of the project, members who were interviewed, agreed that the OPM tools need to be re-designed to make the interface more intuitive and less complex. 70% of the respondents indicated that they believe they received adequate training. However it can be seen from Figure 5 that the comfort level of the users is still very low when compared to basic computing such as Windows, MS Office, and Internet and new computer technology.

Figure 4: Suggestions for improving the implementation of OPM tools (multiple choice)



These show that OPM tools should be more self explanatory, intuitive and quick to learn like a Web search engine. The capability to search documents should also as far as possible resemble current practice, thus relatively simple hierarchical folder structures are popular with end users. [12] Tools should dynamically adapt to the user's skill level and expose as much functionality as the users are ready to use, and not more than they can handle. As a result, the tools can serve both casual and sophisticated users. The tools also should be adjustable to the user's needs and display information relevant to the each user based on their position, role and responsibilities inside the project team.

Figure 5: Evaluation of user comfort level with basic computing (MS Windows, MS Office, Internet), new computer technology and OPM tools



In addition, integration with other applications should be improved. For example, there should be email interaction within the functionalities of these tools. A notification email is usually sent automatically to the responsible party/parties when an RFI is issued. The respondent has to connect to the OPM system, find the RFI and answer it. However, it would be more effective for the system to have email integration, where email is encrypted for security reasons but there is no need to connect to another system. Similar to email integration, the tools should also have integration with Microsoft Office. For example, to see a Word document, there shouldn't be any reason to download it to a local machine for editing. The tools should have Windows Explorer integration so that when the users click on the document, the tool presents a view in Word, and the users can edit/modify the document. Meanwhile, the tool should automatically check the document out, and when the user saves it, the tool automatically sends that document to the database and creates a new version.

Desktop Integration

Today, a significant proportion of all computer applications provide some form of collaborative access even if only through interfaces to other applications. For example, Microsoft has already added collaboration features to Microsoft Project, and launched Office 2003 with inherent collaboration functionality to connect people, information and business processes. These developments indicate that collaboration is rapidly becoming an integrated part of operating system infrastructure. Microsoft SharePoint, which provides a server to allow teams to create web sites for information sharing and document collaboration, and aims to increase individual and team productivity, is free with Windows 2003. SharePoint supplies web sites with document storage and retrieval check in and check out functionality, version history, and flexible, customisable views.

It appears that collaboration is a dominant trend across the technology industry and most of the software vendors see the value of providing collaboration functionality to improve the workflows among project teams. There shouldn't be a need for another software for sharing, storing and managing. There is a strong resistance from the users to have to learn and use another system. In order for OPM tools to be adopted by AEC industry stakeholders more easily, they should be a part of or well integrated with the operating systems.

Interoperability

As of May 2004, there were a total of 270 extranet service providers operating in the US market according. Of these, 82 only focus on the AEC industry. [13] The user companies, which are intended to realize the benefits of these tools, usually find themselves having to use many tools to accomplish their work, and would prefer to utilize just one. For example, architecture firms are almost always obliged to use different products according to the different teams on which they participate.

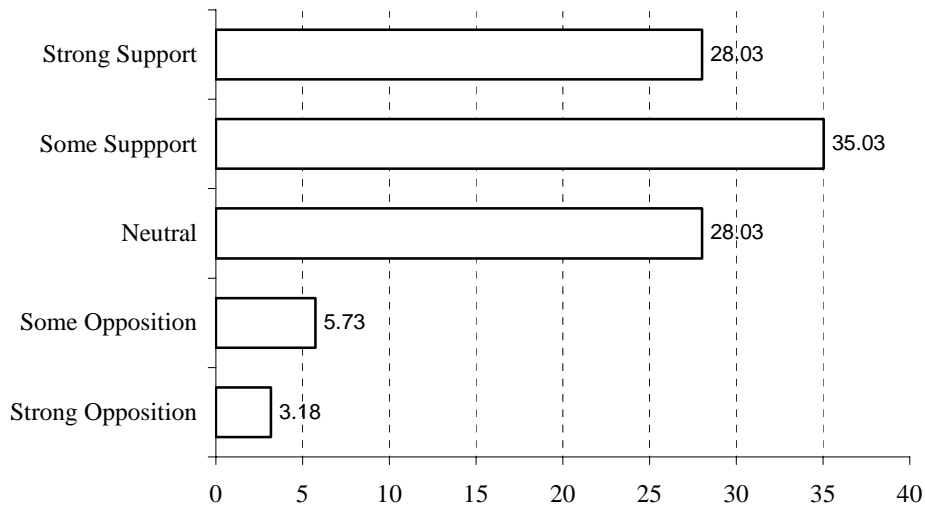
If the systems were interoperable, companies could use their preferred tool in any project. However, interoperability is a huge challenge. Vendor companies have little desire to become interoperable. If OPM tools were designed to allow use of information in corporations' knowledge management systems, those individuals who didn't work on a particular project could benefit from the knowledge gained. However, the vendor companies will resist interoperability because they are focused on a battle for market dominance, both in the US and in the overseas markets in which many also operate. The value to the customers is obvious but the value proposition for the vendors remains undefined.

Strong Management Support & Contractual Requirement

The user survey shows that management-support is satisfactory for the projects in which the respondents participated. (Fig 6.) Management commitment and making OPM tools a requirement of contracts appear as the second suggestion of the users. (Fig 4.) It has been observed from the cases that the presence of a champion along with the power of the owner to mandate is the most important factor contributing to the successful implementation and usage of OPM tools.

The champions have to be technology savvy, understand the necessity to use this tool, the technology, and what it is offering for the job. Champions should be proactive and connected to the team. Success starts from the top and there should be a top-down buy-in by the project team. The project teams should not be only willing to use an OPCM tool but also understand its necessity. The team has to be willing to pay extra attention to making the tool work, because processes will be somewhat different than they have become used to in the all-paper world. Incentives must be in place in order to reward project managers for acting promptly as failure to benefit from platform investments is often due to deficiencies in the design of information flows and managerial incentives. [14]

Figure 6: Evaluation of management support/buy-in for OPM technology

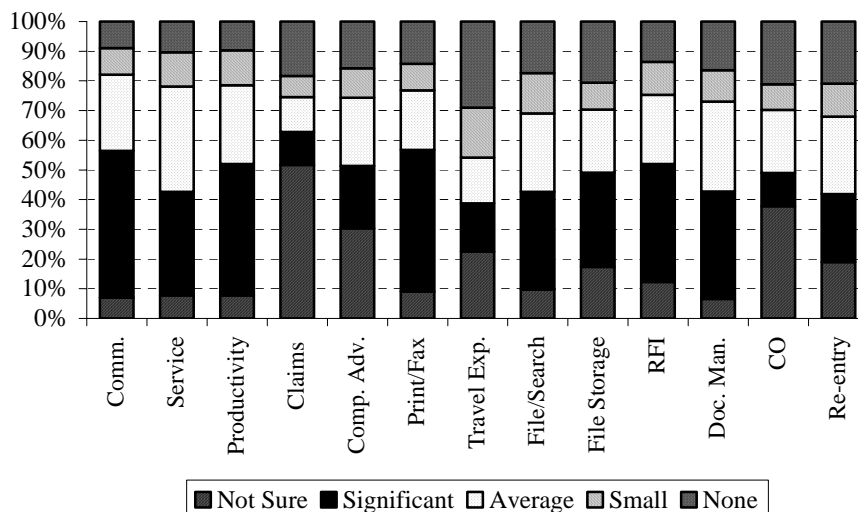


Proved OPM Technology Value Proposition

Unproven price-to-performance is another issue that prevents OPM technology adoption. The primary motivator for actors in the AEC industry to adapt new technology innovations will always be the opportunity for direct gains and benefits in their own operations. In order for the actors involved to realize these benefits there must be a framework in place to measure the relevant cost and benefits associated with the investment. [15] The lack of any quantitative study by an objective party on Return on Investment (ROI) has made it difficult to justify cost/benefit.

Although there have been some initial efforts to study ROI, there are no valid results available today to spur industry stakeholders towards faster adoption. As it can be also observed from Figure 7, there are some benefits that are obvious such as improved communication, reduced printing, mailing, faxing costs, and reduced RFI and submittal turnaround time. However, the users are less confident that they will enjoy benefits of reduced claims and litigation costs, increased competitive advantage or reduced change order costs.

Figure 7: Realized benefits of OPM tools according to the users



There is a need to complete an analysis on cost/benefit of this technology to measure and prove the value of these tools. A rigorous benchmarking exercise is needed to prove that these tools bring increased efficiency to the entire process of making buildings to hasten the adoption of OPM tools.