Design team communication and performance using a project website

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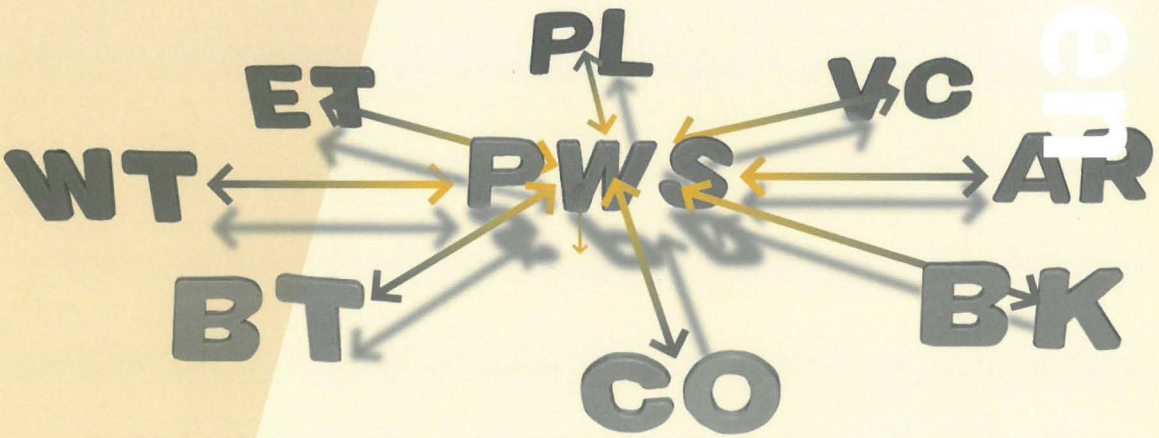

Ad den Otter

Design Team Communication and Performance using a Project Website

/ faculteit bouwkunde

98

Design Team Communication and Performance using a Project Website

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de
Technische Universiteit Eindhoven, op gezag van de
Rector Magnificus, prof.dr.ir. C.J. van Duijn, voor een
commissie aangewezen door het College voor
Promoties in het openbaar te verdedigen
op donderdag 17 november 2005 om 16.00 uur

door

Adrianus Franciscus Hendricus Johannes den Otter

geboren te Schijndel

Dit proefschrift is goedgekeurd door de promotoren:

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Doctoral Thesis
Den Otter, Ad
ISBN: 903861716X
NUR: 957
Keywords: project website, second-order change, change promotors, technological frames, rivalry of tools.

Printed by PrintPartners Ipskamp, Enschede, The Netherlands.

Published as issue 98 in the *Bouwstenen* series of the Faculty of Architecture, Building and Planning of the Eindhoven University of Technology.

Preface

The drive to investigate the use of a new technology for use in communication in design teams started with the promising features of a Project Website that might solve important barriers in team communication. However, because of my own experiences some twenty years ago with the introduction and use of CAD-systems, which promised design teams features for three-dimensional designing, but are still in their infancy in terms of use by architectural design teams today, I wondered whether the IT Productivity Paradox could also be observed for Project Websites used by these teams. Consequently, I set out to investigate essential problems concerning the adoption and use of the tool. I had ambiguous thoughts about the practical profits. On the one hand, things looked promising considering the results in an experimental pilot project, solving coordination problems in the realization phase of a construction project. On the other hand, often new tools are not used for the purpose they were designed for, as the use of CAD-systems shows. I therefore hope, that the results of this research project will be beneficial to the building industry and for architectural design teams in particular.

I could not have done this research project without the willingness of the organizations interviewed and observed, especially the organization we called REA, and my colleagues, friends, ADMS-students and graduates who helped me in collecting data, analyzing the communication and the use of PWS, and improving my English language skills. I started writing down names, but I feared to omit someone. Therefore I only mention my wife for her support and the love always given, even in times when things did not go as easy as expected, my daughter helping me by using her typographic skills, Henk Trum for his wise advices, Joan van Aken for his eternally enthusiastic comments and for challenging me to do further research, and Harry Timmermans for coaching me on the route to quality in thought and writing. Thank you all very much.

When I got the opportunity to start this research project the first person I called was my English acquaintance at the University of the West of England in Bristol, John Edge. I was hesitating a bit about starting the research project, but he said very convincingly: Go for it! And I did! John became a good friend afterwards. However, last year July he died of cancer. I am very sorry that I cannot show and discuss the results with him. For that reason I dedicate this work to John.

Ad den Otter
Eindhoven, September 2005

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Introduction

In the past decade, more than one hundred different Project Website (PWS) packages have become available in the market (http://www.extranetnews.com/the_list/TheList.htm). These packages differ in terms of their interface and marketing focus, but are very similar in terms of underlying functionality. Over 10 different packages are targeted at the AEC (Architectural, Engineering and Construction) market.

The rapid increase in this Information Technology (IT) reflects the fact that Project Websites (PWS) have been advocated for design teams of construction projects, because these websites are supposed to greatly enhance team communication for integral design. This, finally, should result in improved team performance in terms of time, cost and quality (Meredith, 2000). This expected improved performance is based on expected better communication of members of a design team, who share and update their electronically generated and collected design information using a PWS together. This type of communication can be defined as asynchronous because the communication between senders and receivers takes place at different times and mostly at different places. Synchronous communication can be defined as the communication between senders and receivers at the same time, whether or not it is in the same place (Robbins, 2001). Specifically in design teams that are organized for integral design, asynchronous communication is of great importance because of the designer's dependency on each other's generated and updated design information for personal progress (Kvan, 1997; Latour, 1987).

The growing use of IT tools by members of a design team for electronically generating, collecting and updating design information increases the need for IT tools that allow fast and easy access and overview of the status of the latest electronically generated and updated, design information of all team members. This particularly applies to design teams organized for integral design. PWS packages should be able to fulfill these needs because of their very nature: Internet functionality, speed and easy access, overview, transparency, status and version control, track on data sources and data owners as well as database functionality to search for stored information.

Unfortunately, there is a fundamental lack of empirical research supporting such expectations. There is general literature on the IT productivity paradox, which shows that investments in IT do not always result in higher productivity (Brynjolfsson, 1993 & 1998; Mckinsey, 2002). Moreover, the effective use of IT tools has been shown to vary according to 1) Management of information and technology (Brynjolfsson, 1993 & 1998); 2) Lags due to learning and adjustment effects (Brynjolfsson, 1993); 3) Senior management and resistance to change (Dos Santos, 2000); 4) Organizational slack (Dehning, 2004); 5) Drivers of technology change (Hauschildt, 1998); 6) Diffusion delay (David, 1990); and 7) Insufficient changes in workflow to use IT effectively (Martinsons, 2002).

These studies, however, do not focus on the actual use of Project Websites by teams in general or by multi-disciplinary design teams.

Moreover, they are not concerned with the improvement of productivity as a result of better communication and information sharing by using a Project Website collectively. In addition, unlike other IT tools that have been studied in the above-listed literature, Project Website packages might face competition from other easy-to-use tools like MS-Outlook email, MS-calendar and computer networks file management facilitated by MS-explorer that have already proven their effectiveness and are well-established in the market.

To be effective, a Project Website need to be used collectively by a design team in corresponding time intervals in daily work for storing documents for team sharing, changing status of files when appropriate and adding database functionality for quick search activities. For these reasons Project Website use needs additional file handling compared to the above-mentioned IT-tools, that otherwise might be frustrating to Project Website users. If instead, easy file handling is used by dragging and dropping files into a Project Website without appropriate file handling, the tool can easily become a badly functioning information archive, raising information redundancy, instead of functioning as a team communication and sharing tool and attaining the promised goals. Effective use of a Project Website might also cause changes in the present communication of teams and might affect team dynamics (Sproull, e.o., 1991; Webster, e.o., 1995; Stevens e.o. 2000).

Thus, the question is whether the IT productivity paradox observed in other IT domains, might also be observed for design teams in architecture, construction and engineering using Project Website packages, and whether the paradox should be further qualified according to insufficient changes in workflow to use IT effectively, rivalry between IT-tools, management of information and technology, and drivers of technology change.

These aspects are important because the use of a Project Website mainly concerns changes in information handling of design team members in daily work in projects being mostly limited in time. The aspects concerning organizational slack, learning and adjustment effects and diffusion delay have to be taken into consideration, but are not leading drivers of changes that design teams have to make to become more productive. To gather sufficient and reliable information about these aspects, more time for fact-finding is needed than the duration of a design team's life cycle, because design project time usually is limited.

The *goal* of this research project, therefore, is to generate additional knowledge about adoption, use and effects of Project Website packages on team communication and team performance. To that particular end, a multiple case studies was conducted among design teams in the construction industry. This multiple case studies was designed along the principles underlying quasi-experimental designs. That is, use of a project Website and its effects on team communication and performance was analyzed and compared for pairs of design teams that execute comparable construction projects in terms of volume and money, but differ in the amount of training for a specific Project website package. One of the design teams of each pair (the experimental team) received extensive training for stimulating the collective use of the Project Website. The other design team of the pair (the control team) did not receive any major training.

Three rounds of observations were used: 1st) before the introduction/ intervention of the PWS), 2nd) during the use of the PWS, and 3rd) when the intervention effect had decreased, which was expected to be 12 months after starting with the PWS.

This approach allows us to identify any differences between the experimental and control teams, and provide the basis for ruling out or at least reduce the plausibility of alternative explanations of any differences between the design teams. Moreover, to investigate whether major findings could be generalized to other design teams, additional data were collected for other design teams in the AEC industry.

In line with this approach, this dissertation is organized as follows: First, in Chapter 1, we briefly review the relevant literature to define the concept of effective use of IT tools for team communication. In particular, findings in the literature on effective, synchronous and asynchronous team communication as well as on how such effective use can be accomplished are described.

Next, in chapter 2, based on the knowledge about how effective use of a Project Website might be reached, the research problem is defined and the research methodology is described in detail, in particular how measurement of actual Project Website use, team communication and team performance is operationalized and congruent data triangulation is used.

In Chapter 3 the findings of the research project in design teams using a specific Project Website package are described and facts are extracted concerning actual Project Website use, discrepancies between actual and prescribed use and effects on team communication and team productivity. By comparing extracted facts between experimental and control design teams, conclusions are drawn about design teams' communication and productivity change caused by using this specific Project Website package.

Based on the findings reported in Chapter 3, Chapter 4 then identifies similarities and differences between units, and identifies causes underlying differential use of the Project Website, focusing on rivalry between IT tools, management of information and technology, changes in workflow to use IT tools effectively and drivers of technology change.

Chapter 5 addresses the question whether the conclusions described and discussed in Chapter 4 are specific to the organization where the multiple case studies was conducted. By executing a number of mini cases, experiences with the same and with other Project Website packages in other industries are compared with the major research findings of the multiple case studies, to put these findings into a broader perspective.

Finally, in Chapter 6, the final conclusions are formulated and we reflect on the strengths and weaknesses of this research project indicating possible avenues of future research.

Chapter 1: Team communication using a Project Website

1.1 Introduction

As described in the introduction of this thesis, Project Website (PWS) packages have entered the market to support asynchronous communication, which is a promising feature for design teams of construction projects, because it is assumed to improve team performance in terms of quality and productivity. To further qualify this assumption, we will briefly review the relevant literature on synchronous and asynchronous team communication in design teams in this chapter and analyze various means of communication to define the concept of effective team communication by means of a PWS.

To that effect, first the concepts data, information, information exchange, information sharing, information handling and communication are defined in terms of common definitions found in the literature. In addition, formal definitions of synchronous communication and asynchronous communication are given. Based on modifications of Shannon & Weaver's model of communication (Shannon & Weaver, 1949), three concepts of communication are discussed.

Then, synchronous and asynchronous communications in design teams and for integral design in particular are discussed and the importance of easy access, overview, status and version, and track on data sources for a design team are articulated. Available means for team communication are identified. Following that, the available communication means are discussed in terms of strengths and weaknesses for effective team communication in a design team. In addition, the promised strengths, expected opportunities and threats of PWS use are outlined and the expected rivalry of other asynchronous communication means are discussed.

Based on these aspects, we explain the concept of effective team communication of a design team using a PWS to improve quality and productivity with respect to its functioning and its threats to effective use. In addition, we will argue that unlike other IT means for asynchronous communication, PWS's might face competition from other easy-to-use tools such as MS-Outlook calendar, email and computer networks' file management systems facilitated by MS-Explorer that have already proven their effectiveness for asynchronous communication and are well-established in the market. *Finally,* conclusions are drawn about knowledge lacking for the effective use of PWS for team communication and improvement of team productivity.

1.2 Data, information and communication

Although various models of communication have been developed since 1949, Shannon & Weaver's (1949) communication concepts and definitions are still highly relevant. They defined a mathematical theory of communication, based on scientific research in the U.S.A., conducted at the Bell Telephone Laboratories.

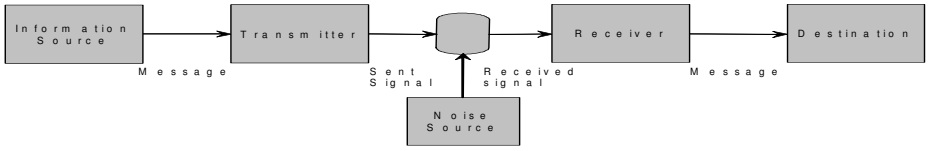

Figure 1.1: Communication model of Shannon & Weaver

Their theory focuses on a linear process between an information source and a receiver. The information source selects a desired message out of a set of possible messages. The selected one may consist of written or spoken words, pictures, music, or any other format. The transmitter changes the message into the signal, which is actually sent over the communication channel from the transmitter to the receiver (Figure 1.1).

Shannon & Weaver (1949) stated that: "The receiver is a sort of inverse transmitter, changing the transmitted signal back into a message, and handling this message onto the destination. When I talk to you, my brain is the information source, yours the destination; my vocal system is the transmitter, and your ear and the associated eight nerve is the receiver"…..…"During the process of transmitting a message, unfortunately certain things are typically added to the signal which were not intended by the information source. These unwanted additions might be distortions of sound (telephony, for example), or static (in radio), or distortions in shape or shading of picture (television), or errors in transmission (telegraphy or facsimile), etc. All of these changes in the transmitted signal are called noise".

Thus, Shannon & Weaver defined communication as a transmitting process of information between a sender and a receiver and attached less meaning to the message transmitted. Based on their mathematical model of communication, a definition of information and communication is provided in the next section.

1.2.1 Information

Because a generally accepted definition of information is lacking, five connected terms that often are used, are described. These terms are: 1) data; 2) information; 3) information exchange; 4) information sharing and 5) information handling.

1. *Data:* abstract, formal, sometimes symbolic entities like elementary facts, letters and -binary- numbers.
2. *Information:* According to Drucker; 'information is a string of data endowed with relevance and purpose' (Drucker, 1988). Data becomes information when the aspect of personal and thus subjective, meaning and interpretation arises. Drucker argues that the sender, explicit or implicit, adds relevance and purpose based on the sender's knowledge and assumptions, implicit or explicit, about missing receivers' knowledge.

3. *Information exchange:* a process of transmitting selected information, defined by the sender, to a receiver or group of receivers through a specific medium and channel. Exchange can be defined as information generation and transmission (the sender's activity), information receiving and interpreting (the receiver's activity) and information storage. These activities might be distinguished as coherent steps.
4. *Information sharing:* Information sharing is defined as a process of making one's own stored and updated information accessible for other members of a group. Sharing presupposes consensus of a group about the interaction and is a necessary condition to be effective (Newcombe, 1965). Sharing needs the trust of group members to be effective (Sproull & Kiesler, 1991).
5. *Information handling:* Information handling is defined as the compilation of all activities of a person or team for collecting, generating, storing, maintaining and exchange of information of a team for certain purposes, via the available means of communication.

1.2.2 Communication

Schramm (1957) modified Shannon & Weavers communication model by adding overlapping fields of experiences of the sender and receiver and introduced a feedback loop from receiver to sender (Figure 1.2). Schramm's adaptation of the model emphasizes that only where the sender's and receiver's fields of experience overlap, there is communication (Heinrich, et al. 1996). Communication is initiated by the sender to challenge and extend the knowledge of the receiver. By doing this, Schramm introduced meaning to Shannon & Weaver's communication model.

Feedback is a type of message that the receiver transmits to the sender in response to having received a message (Wiener, 1948; Fiske 1990). Thus, it is meaningful information to the sender. In fact, by adding a feedback loop to the communication model, the roles of sender and receiver become interchangeable. Based on this modified communication model, Robbins (2001) defined communication as the transference and understanding of meaning between sender and receiver at the same time at the same or different place. Feedback is an essential part of the communication process and determines whether or not understanding has been achieved. Ruler (1996) analyzed the literature on communication to define three concepts of communication for analyzing communication management:

1. The interactive concept: an interactive, back and forth process between sender and receiver(s) with changing roles (Figure 1.2). In this process, feedback is essential for communication (for example: in a dialogue, telephone conversation or group meetings).
2. The effective concept: a one-way process with an active sender and passive receiver(s) with a predictable re-action. In this process feedback is possible but not expected (for example: postal mail, facsimile, paper project dossiers).

3. The active concept: an active one-way process of a sender, for broadcasting or publishing of information to receivers. In this process, the same channel of communication usually cannot give feedback (for example: the Queen's Christmas message on television).

Ruler's concepts of communication are mainly based on differences in communication processes regarding feedback (expected by the sender) of a receiver or group receivers. Thus, a sender might use specific means and media of communication to send a message to receiver(s) depending on the sender's need for feedback. For that reason, it is useful to categorize communication into different types of communication: synchronous and asynchronous. For each type, different means are used depending on the sender's preference of mean of communication to use, the feedback wanted and team appointments.

In addition to Robbins' definition of communication, *asynchronous* communication can be specified as the transference and understanding of meaning between sender and receiver *at a different time* and usually in a different place, whereas *synchronous* communication can be defined as the transference and understanding of meaning between sender and receivers at *the same time*, whether or not they are in the same place. Feedback sent within very short time intervals, for instance seconds or minutes, can be defined as semi-synchronous communication. Examples of semi-synchronous communication are instant messaging and chat boxes. However, in this thesis, semi-synchronous communication is considered to be a form of synchronous communication, because sender and receiver are connected on-line for example by telephone, although there might be a time delay in giving feedback caused by the medium or channel itself by the noise source of the medium or by the receiver.

1.3 Communication in design teams of construction projects

Design teams for construction projects have been defined as temporary, multi-disciplinary and network based organizations of collaborating specialist designers.

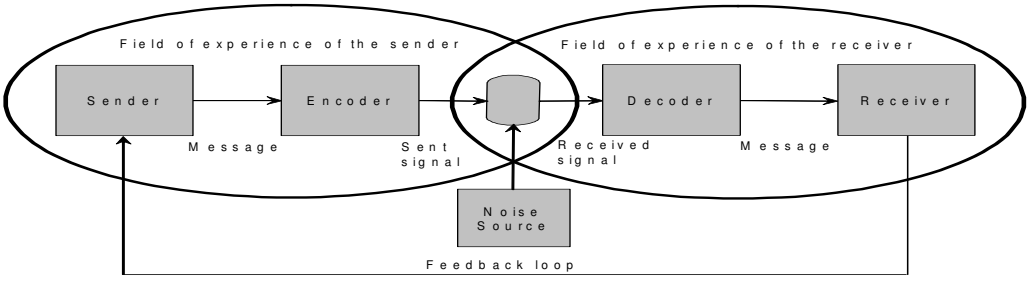

Figure 1.2: Schramm's modified model of communication

A specialist designer is the representative of a collaborating design organization, contracted by the client to produce part(s) of the design. Specialist designers usually are designers with a management task and can be characterized as creative, visionary, spatially aware and abstract thinking practitioners with a high level of technical knowledge and experience (Schön, 1987). In today's design teams of construction projects, a growing number of specialist designers is required to execute equivocal and uncertain tasks in accomplishing the necessary performance of the design (Loon, 1998). Knowledge about the design exists on a cognitive level of design team members (Lawson, 1994, Wiegeraad, 1999; Reymen, 2001), on the level of collaborating design organizations (Heintz, 1999; Friedl, 2000) and on design team's external level via the client, users and other stakeholders (Donker, 1999; Emmitt, 2003). Design team members generate new knowledge by collecting, sharing and transforming information about the design to be produced. Communication is necessary to facilitate these processes.

To distribute generated design knowledge among design team members for the progress of design, they communicate both synchronously and asynchronously using the available means of communication (e.g., Davenport, 1997; Donker, 1999). They need to process their own specialist data before useful information can be delivered to others. Not all designers participate in the same way at the same time. There are many who participate as individuals, working alone for crucial periods and then return to the network process (Latour, 1987). Moreover, design team members greatly depend on the most current design information to work out their own design tasks (Kvan, 1997; Wiegeraad, 1999). Thus team communication of a design team might be defined as the compilation of all processes for sending and receiving messages between team members individually and collectively using the available means of communication (Stohl, 1987).

The design process of this kind of projects can usually be characterized as a continuous process of change that has to be well documented and updated because typically many stakeholders are involved in these processes. Specifically for team communication in integral design processes with a high level of concurrency, design information needs to be well structured. All recently generated and changed information needs to have the right status, version and information about creators and updaters to get overview and transparency on the current design process and progress. In this kind of design teams, members need information updates and feedback from other design team members within hours instead of days.

A design team's communication environment can be characterized as a holistic environment because the key information carriers for team members to communicate are sketches, schemes, images, drawings, and written descriptions together with explanatory stories. In this environment of a design team we can discern an internal and external environment. The design to be made is mainly visualized and discussed by design team members. The internal environment is the design team environment in which collaborating design team members communicate to produce the design. In the external environment, design teams communicate with their client, users and other stakeholders (Figure 1.3).

This communication usually takes place more formally, compared to the internal environment, through team meetings, paper design publication and negotiation, judgment and contracting activities. This kind of communication can also be both synchronous and asynchronous. Generally, design team's management only partly formally organizes both synchronous and asynchronous communications. Part of the internal and external communication takes place in an informal not organized way (Krackhardt, 1993; Robbins, 2001; Kraut, 2002). In this thesis, the internal communication of a design team is considered team communication.

Design team communication processes may be divided into communication between individuals (design team members) and between individuals and different groups of people (design team meetings, with client and users, with other project partners and design team management with client and users, other project partners and stakeholders). Ruler's three concepts of communication (section 1.2.2) fit these communication processes because communication initiated often depends on the feedback wanted by design team management and the client. For that reason, the three concepts of communication will be used in this thesis to analyze communication processes of design teams on feedback given and feedback wanted for reasons of communication management.

1.4 Means of synchronous and asynchronous communication

The most commonly available means in design teams for synchronous communication are face-to-face contact by using dialogues, informal- and team meetings, and at a distance by using telephone, tele- and video-conferencing, and instant messaging (Kvan, 1998). Likewise, the most commonly available means in design teams for asynchronous communication are (in different places) by postal and inter-office mail, facsimile, computer network, email, and MS-Outlook calendar for communication between different places, or (in the same place) by file management, bulletin board and project dossier (paper) for communication at the same place.

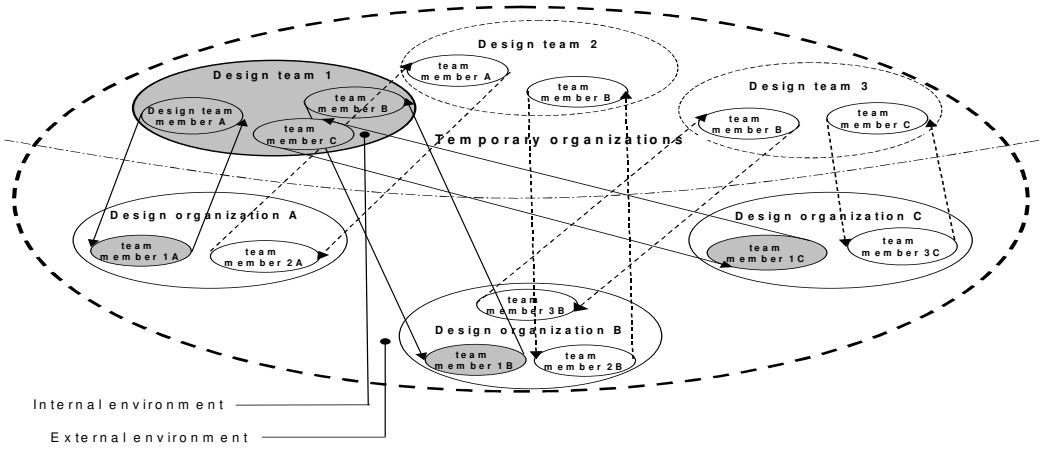

Figure 1.3: The information environment of design teams

Figure 1.4 shows an overview of commonly available means for synchronous and asynchronous communication, structured by their time and place relation. In the sections below, these communication means will be discussed in terms of their strengths and weaknesses for fast and easy access, feedback, structuring, status, version control and track of changes, and overview and transparency of all generated and changed design information.

1.4.1 Strengths and weaknesses using dialogues and team meetings

Dialogues and team meetings are the most commonly used synchronous communication means by design teams. Dialogues are commonly used by team members during the design process to discuss the design in detail, i.e. the parts of the design one is working on, and to fine-tune each other's design tasks. Team meetings are commonly used for several reasons. First, these meetings are used for understanding and discussing the designers' interpretation of the object to be designed and for reaching consensus about the design. Second, they are organized for tuning of design parts and for exchange of experiences Schön argues. Thirdly, team meetings serve planning, discussing, and evaluating progress and finally team meetings are organized to advise the client about the design progress and the latest insights in particular design problems. For these reasons team meetings are mostly formally organized using an agenda and writing minutes of meetings. Usually, a kick-off meeting is planned at the start of the design process to discuss the design, exchange experiences, tune design tasks, in addition to social reasons, such as becoming acquainted with each other. Also brainstorm sessions and discussions of design teams might be organized for these reasons.

Daft & Lengel (1984) introduced the media-richness theory for processing ambiguous information in an organization, based on equivocality and uncertainty of tasks and the use of a variety of media commonly available. Their theory is based on a hierarchy of information richness of the commonly available media using four criteria for ranking: 1) availability of instant feedback; 2) capacity of the medium to transmit multiple cues such as body language, voice tone, and inflection; 3) use of natural language and 4) personal focus of the medium.

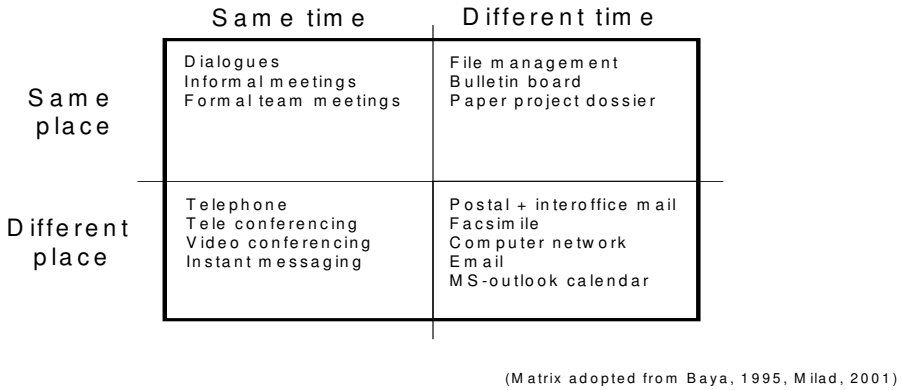

Figure 1.4: Time / space matrix of commonly available communication means for design teams

They argued that team performance improves when team members use media with higher information richness for equivocal and uncertain tasks. Using the four criteria of ranking, means for synchronous communication are ranked higher than means of asynchronous communication. A dialogue should offer the best option for transferring meaning and availability of instant feedback.

According to this theory, the availability for instant feedback is lower in group meetings; here, group members might have different preferences for communication because of group dynamics. Use of the telephone is lower in the hierarchy because there is no capacity of the medium to transmit multiple cues such as body language, voice tone, and inflection, and because the telephone is not everybody's favorite medium. Email is ranked above the facsimile and postal mail because of the opportunity for instant feedback. Facsimile and postal mail are ranked lowest because of the lack of instant feedback, the lack of transmitting multiple cues and the lack of a natural language.

Although the media-richness theory argues that 'richer' media improve team performance more than 'poorer' media, this hypothesis is based on the media choice of managers leading teams with high equivocal and uncertain tasks and has not been confirmed by empirical research on media use. Dennis & Kinney (1998) concluded "the results found no support for the central proposition of media-richness theory; matching media-richness to task equivocality did not improve performance". This finding however was not supposed in other research. Sproull and Kiesler (1991) for example, concluded in their studies, based on experiments and empirical research, that synchronous communication is more effective for reaching consensus in a team than asynchronous communication. Thus, it might be concluded that dialogues and team meetings, both being synchronous means of communication commonly used in design teams, should be used when reaching consensus is necessary.

As described before, formal meetings of teams are commonly used for more reasons than reaching consensus only. So it might be that other means of communication are more effective if there is no need to reach consensus, e.g. if information is needed about progress of design, and/or overview to status of all, actual, electronically generated and updated, design information.

Weaknesses of a dialogue might be their informal nature and time aspects: to meet, for traveling and time for information handling concerning scheduling of appointment and producing approved minutes of the meeting agreed to by sender and receiver.

Weaknesses of a formal meeting of a team might be: 1) time aspects: duration of a meeting (depending on skills of the chair person of the meeting and the participants for debate and interaction, and the chair's leadership), the decisions to make, time for traveling and information-handling aspects concerning scheduling of the appointments to be made; and 2) setting up a meeting with design team members coming from different places. Traveling time might extend to beyond that of the time for the meeting. If time is very limited, design team members might not be prepared for a team meeting and may not have time to read the minutes of the last meeting.

However, a team leader might take time during the meeting to inform those members to prevent failures as a result of not updating information for all members and reasons of tuning tasks.

As a part of synchronous team communication *Informal meetings* can be defined as informal, face to face communication between team members concerning their work during office time. These meetings usually happen at random at workplaces, in corridors, during tea and coffee breaks or lunch hours. Informal meetings in this sense are not part of the informal networks that Robbins defines and in which the organization is discussed: the grapevine. Strength of informal meetings is the interaction between team members in a social context, mostly happening spontaneously when needed, with direct feedback. The weakness of this type of communication is that information mostly has to be stored in the receiver's memory and might be interpreted differently or even forgotten after a while. Controlling the interpretation accuracy of the message is usually not part of it.

1.4.2 Strength and weaknesses using telephone, tele-conferencing and video-conferencing

The telephone, and more specifically mobile phone, is an important means of synchronous communication for design team members. They can be reached almost globally and if contact fails, voice mail and short message service (sms) are provided to inform a receiver about a call from the sender. Feedback can be given on line, by voice mail or by sms.

A weakness of telephone communication might be the need for attention of receivers at unwanted moments. Unwanted phone calls are more disturbing than with emails (Bälter, 1998). Use of tele-conferencing and video-conferencing for team communication is mostly a matter of urgency if face-to-face meetings cannot be realized within certain time limits. People prefer to use tele-conferencing instead of video-conferencing because of it is easy to use nowadays and the fact that less technical equipment and preparations are necessary.

1.4.3 Strengths and weaknesses using postal mail & inter-office mail

In many current design processes, regardless of IT tools, asynchronous communication by exchanging information on paper is necessary to get design information to clients, users, and stakeholders. Paper documents still have a more formal status than electronic documents. Although electronic signatures are accepted by law, electronic documents are not. These are still not in common use. A high volume of electronic information is still typically printed and send by inter-office mail, postal or courier mail. Most of the incoming paper information, necessary for the design process, is not scanned to become electronic information.

Consequently, today's asynchronous communication of design teams often is a mixture of paper and electronic information exchange. This may change in the future, but it is not expected to change very fast in coming years. For example, although electronic CAD drawings have been available for many years and electronic signatures are accepted by law for years, still paper drawings with written signatures are commonly used.

Because of the time needed for giving feedback by post, one will usually use another means of communication for that purpose, like facsimile, email or telephone.

1.4.4 Strengths and weaknesses using facsimile

The use of facsimile might come to the end of its lifecycle, because of the use of Internet and email. Nevertheless, designers still like to use it for exchanging sketches and written information, because it is easy to use and wider used in society (compared to the number of external partners that use email). However, Internet and email require a computer and a scanner at the sender's location and a computer and printer at the receiver's location to produce the same output as a facsimile machine. If an electronic facsimile is used, information can be stored electronically instead of in a paper dossier. Feedback is provided by sending a message back to the facsimile number of the sender. Formal documents can be sent by facsimile if speed is necessary, because facsimile documents are accepted as legal documents, while Emails with or without attachment are not.

1.4.5 Strengths and weaknesses using email

Email is an easy to use IT tool because of its MS-Windows interface. Moreover, it can be used with no, or a minimum of training. The response of the receiver for feedback usually is fast if the receiver uses email on a daily basis. Email can be both an informal and a formal tool. It can be informal because it is experienced as talking by telephone instead of sending a letter. Moreover, spelling mistakes are widely accepted. However, it can also be a formal tool because the message can be printed by the receiver, and stored and re-used for specific purposes afterwards. In fact, the flow of information between a sender and receiver can be recorded in this way. For example, sent information about specific appointments can be stored and printed as evidence to show at meetings that appointments were made. Used in this way by receivers, email becomes a very formal tool, which can be disliked by the sender. Senders who have experienced this might not use email again to communicate with receivers who print their email messages as evidence.

An important feature of email is the option to attach files to a message. Email provides an overview during transmission, because files are attached to messages with information about the sender, version, date and time of sending and status.

If files, however, are stored after transmission, the message with the information about the sender, version, date and time of sending and status disappears, unless special action is taken. Email also provides the option of generating and using distribution lists. Using a distribution list, a message and file attached will be sent to all receivers listed in a distribution list. By sending updated versions of information originally sent to a list of receivers, it can happen that not all receivers update their files. Thus, it may be concluded that overview, status, version and transparency are weak when using email and, moreover, that redundancy of information can easily increase.

1.4.6 Strengths and weaknesses using a computer network

A design team members' design organization which uses a computer network usually prefer communication through the computer network for the sharing of electronic design information, because MS-Explorer and its equivalents are easy to use and the MS-windows interface, the speed, the ease of storing and updating of documents and the search of documents are convenient and do not need any proof of effectiveness. However, a computer network typically connects people within an organization and not people from different organizations. In a computer network, folder-structures and virtual disks are usually present. These include personal folders for design team members, department folders or virtual disks, and shared project folders or virtual disks that are used across departments. A computer network is in part formally organized: use and sharing of folders and virtual disks is restricted to specific users who have specific user rights to use specified parts of the network. Access to folders and files is not registered automatically for users in terms of updater and status of the stored files. Design team members usually store project information in project folders or a shared project disk to share information between members working on the same project in the same organization. Shared project disks may differ in use because of differences in user rights compared to the use of personal folders. In most cases, a shared project disk is as easy to use as a personal folder and does not need a protocol for use. It might thus be concluded that the strength of using a computer network for information storage are ease of use and fast access to the information stored.

Weaknesses of a computer network and MS-Explorer might be that no control of the updaters of information is provided. Everyone who has access to shared folders might change information or even destroy information without being registered for those actions. In addition, there is a lack of status of information and version control. Outdated and double information as well as ambiguous information can easily be stored without notification. Another potential weakness is that computer networks often have poor database functions for structuring and searching stored information. Because of these reasons users of a computer network will never be sure to have the latest information from another team member or colleague. File management of the computer network usually does not facilitate feedback. Feedback of users is frequently given by email or by telephone, because these means are easy to use and there is immediate feedback.

1.4.7 Strengths and weaknesses using MS-Outlook calendar

Collective use of an electronic calendar like MS-Outlook calendar benefits team communication and improves collaboration by providing fast and easy insight into the design team members' appointments and possible dates and time slots for new appointments. The tool is easy to use because of its MS-Windows interface. The status of the information can be changed from normal to highly important and alarms can be installed. As a result, it becomes more transparent when design team members are busy or if they can meet each other.

This functionality is especially effective for the planning of meetings and dialogues or other forms of synchronous communication. With respect to weaknesses, a transparent MS-Outlook calendar might be considered frightening in terms of a "big brother effect", such as management using the information to check whether personnel or staff is present in the office. The calendar is most effective if all team members use it. If it is used by less than 80 percent of the members, it becomes less effective.

If calendar is used to plan meetings of different design team members, typically a secretary of a design team organization is needed to look into the organization's MS-Outlook calendar to prevent unwanted windows into the organization and too much transparency concerning each other's activities. Feedback is a feature of the tool. All participants invited to a meeting receive a message to agree to or to reject the proposed meeting.

1.4.8 Strengths and weaknesses using project dossiers (paper)

In a paper project dossier, all important formal documents of the project are usually stored: contracts and agreements like program of demands, decisions made, financial documents, documents about capacity and time, and schemes and drawings and sketches of the designed object. Strength is: all formal documents are stored in this dossier. The information owner, however, might have changed without notification.

A weakness of the paper project dossier might be the lack of automated registration and slow updating of information compared to time frequency of changes made in the design. For that reason, it is also hard to know the status of stored information. design team members need to go to a specific physical location to get access to the dossier and view the documents. If someone else is using the same dossier, one has to wait or has to experience that certain documents are temporarily out of the dossier, with or without notification. It is not expected that feedback is given to owners of design information stored in the paper dossier.

1.4.9 Evaluation

In section 1.4.1 it has been concluded that synchronous communication by means of dialogues and team meetings, should be used in a design team when reaching consensus is necessary. It has not been concluded however that synchronous communication is effective when general information has to be provided, progress and overview on activities is needed, for exchange of actual information between design team members needed to execute own tasks and progress and for reasons of status, version, overview and transparency. Based on the analyses of the strengths and weaknesses, specific means of asynchronous communication might be considered more effective for these activities. However, as can be observed in the matrix of Table 1.1, a lack of overview, status and version control can be observed in the available means of asynchronous communication and no control on info about the updater. Info about the updater is needed to examine which design team member is responsible for changes in parts of the design.

Table 1.1: Attributes of asynchronous means of communication

Means of communication	Fast	Ease of use	Feed-back	Struc-tured	Over-view	Infor-mal	Formal	Contract docs	Info owner	Info updater	Status	Version
Postal mail	-	-	-	-	-	-	xx	xx	x	-	xx	-
Facsimile	-	x	x	-	-	-	xx	x	xx	-	xx	-
Project dossier	-	-	-	x	-	-	xx	xx	x	-	-	-
Email message	xx	x	xx	-	-	xx	xx	-	xx	xx	-	-
Email attachment	xx	x	-	-	-	xx	xx	-	x	-	-	-
Outlook calendar	xx	x	xx	xx	-	-	xx	-	xx	xx	-	-
Computer network	xx	x	-	x	-	-	x	-	-	-	-	-

Thus, the threat for design teams using the commonly available asynchronous means is an ill-structured information storage and updating process that might slow down design progress and productivity caused by badly or not registered changes, outdated and double information, raising the redundancy of information. In addition, it may easily increase the number of failures, including costs. Because the use of different IT tools for design tasks is increasing, the threat of decreasing progress and increasing failure costs is increasing too, especially for design teams configured for integral design with a high degree of changes in design information. For these reasons, it is important that an IT tool is used that allows fast and easy access and overview of status of all actual generated, updated and collected design information.

1.5 Project Websites

1.5.1 Functionality of Project Websites

A PWS should be able to fulfill the needs described in the above section because of its very nature: Internet functionality, overview, viewing, changing, status and version control, track of data sources and data owners as well as database functionality for searching of stored information. By using the tool collectively, team members can easily get an overview of status of the latest information electronically generated and updated by the team.

PWS can be classified as an asynchronous means of communication involving different times and different places. Internet functionality of a PWS allows easy access for all team members to the PWS, through password and identity codes that are linked to specific user rights. A PWS can be defined as a protected Internet environment: an extranet, accessible for registered users, with information vaults controlled by a central database. To control user rights and maintenance of the PWS, a PWS-administrator is needed. By documenting one's own information stored and updated in PWS according the appointed database structure, with the right status and version, a design team member being the sender of information, facilitates the possibility of viewing or reading, updating and re-using by other design team members being the receivers, whenever needed. Feedback of the receiver is possible by updating the stored information of the sender and by sending a PWS-message to the creator of the stored information.

The system of PWS-storing, maintaining, updating and viewing information and feedback given to team members is defined in this thesis as team communication using a PWS. Re-use of information is defined as finalized information of one project that might be used in another project. To use PWS in the same way and with the same frequency by a group of users, agreements for use are needed.

PWS packages offer different features, ranging from basic features for storage, viewing or reading, and updating through features for status and version control, with virtual office functions overtaking MS-Outlook functionality to advanced features such as for instance management information, automated procedures for information handling of the users in the form of recording, assembling, sorting and classifying the meta-data of the PWS. Four levels of features of a PWS may be distinguished: certain levels are more suitable than others to use PWS for effective design team communication and team performance. These features are not ranked by the producers of the tools. In this thesis, we ranked the features according to less or more features: defined as basic features and automated procedures for information management purposes, defined as advanced features. Both levels are divided in sublevels 1 and 2. Specific packages might have a mix of both kind of features as well. At basic-feature level 1, a PWS package has tools for controlled user access and identification, for viewing and updating of published information, and tools for downloading published information. These PWS-features show similarities with electronic document management systems (EDMS) having comparable features, although EDMS packages are not designed to be accessible through the internet and for use in multi-disciplinary teams (Sutton, 1996). At basic-feature level 2, a PWS package contains tools of feature level 1 and also has tools for status and version management, and might have integrated MS-Outlook -email, -calendar and -contact functionality. At advanced level 1, a PWS package contains tools of feature level 2 plus some tools for semi-automatically or automatically storing of all electronically generated output of software packages in PWS and adding pre-defined attributes. Finally, at advanced level 2, a PWS package contains tools of advanced level 1 with tools for all procedures that can be automated for information handling of the users in form of recording, assembling, sorting and classifying the meta-data of the PWS. This feature, for instance, provides management information concerning time spent between retrieval of a document, changing it and updating and registration of creators and updaters.

A PWS can be implemented centrally at design team level or distributed in each collaborating design organization at the design team organizations level. If a PWS is used as a central tool, the IT facilitating organization has to manage and supervise the use of the PWS. A PWS might be used for storage of actual information with a high or low time frequency of storing and updating. High frequency of storing and uploading means per hour, per 4 hours or per day depending on the level of concurrency of the design process, team members agree to. A low time frequency means time periods of several days to a week for storage and updating.

Based on time frequency and the three concepts of communication of Ruler (1996), four modes of team communication using a PWS might be identified.

These communication modes show that time frequency of information sharing using PWS is important for effectiveness of team communication and improvement of team performance. A re-use mode is added for use of PWS as an electronic library (Figure 1.5).

First, in the *Interactive* mode, a high frequency of updating of actual information is needed. In this mode, information is stored and uploaded every hour to register all changes in information and maximize tuning between design team members. Frequent feedback is expected by team members by updating the information or by sending messages It is expected that a PWS, used in this mode, may be highly effective for team communication and improves team performance substantially because of the up-to-hour status and overview of stored information. Secondly, in the *Effective* mode, the PWS is used to store and update actual information within a time frequency of every 4 hours to a maximum of one day (24 hours). It is expected that used in this mode, a PWS will be effective for team communication and will improve team performance because of the up-to-date status and overview of stored information. Thirdly, in the *Active* mode, storage of provisional or semi-final information takes place with a time frequency longer than one day and mostly without updating. In this mode of communication, the information is semi-final or provisional. Feedback is not expected because most likely the actual process of storing and updating of information took place in the shared project disk (section 1.4.6). It is therefore expected that PWS use in this mode, which also can be defined as Publication mode because mostly these documents are printed for publication purposes, will no longer be effective for team performance. Finally, in the *Re-use* mode the finalized information of a design process or parts of it to be used in other phases of the design project or future design projects are stored. A PWS used in this mode as an electronic or digital library might improve team performance of future projects.

1.5.2 Expected strengths of Project Websites for design teams of construction projects

According to their producers and vendors a PWS offers a more or less virtual office space to a design team with members collaborating at a distance.

Interactive mode	Effective mode	Active mode	Re-use mode
Use of PWS In workflow of integral design, in every days work with a high frequency of generating and changing information	Use of PWS in workflow, in every days work or in integral design processes	Use of PWS for sharing of information between design partners, for publication of information to client and stakeholders.	Use of PWS as information archive with final information for re-use of design information in other design projects
Storage and updating per hour or less	Storage and updating per day or per 1/2 day	Storage and updating when files are printed for publication to client / stakeholders	Storage of information when the design phase is finished

Figure 1.5: Modes of communication using a Project Website

For that purpose, first PWS's offer particular features to get a quick overview of generated and updated information and of the status of information. In that way, PWS's provide insight into the status of design progress and work still to be done. Depending on the rights of a design team-member to use a PWS, one is allowed to view or to comment on drawings, documents and proposals for changes and updates.

Second, because of the improved overview, insight and track of document owners and updaters, team members are able to work more concurrently than before. Because of the increased overview and control of content, conflicting and redundant information can be noticed more easily and actions can be taken to prevent failures. Indirect effects that can be expected are related to information assimilation, decreased search time for design information, and re-use of design solutions. Vendors claim that these aspects increase team communication that finally results in improved performance.

Third, design teams using PWS have the opportunity to reflect on the actual design process by analyzing the meta-data of PWS (Reymen, 2001). Meta-data are data about a stored document: data, time, owner, status and version, attributes of the stored information. The meta-data show the exchange and sharing of files by design team members within a selected time range. By reflecting on a structural base, design team management is able to make visible inefficiencies in the design process and measure performance improvement in terms of time and quality. This might challenge the team to enhance concurrency of design actions and offers opportunities for integral design. A design team using PWS is able to monitor if one is still on track, who contributes in which way on which moment and what information is added, stimulating continuous reflection of practitioners-in-action (Schön, 1987). In doing so, collaboration within the design team might be enhanced (Paashuis, 1998), stimulating action learning and self-management of team members (Argyris, 1999), especially if members experience benefits from using the PWS (Capron, 1999). The use of the PWS and its meta-data for structural reflection and learning purposes might strongly support the development of a collective mind within a design team (Kelly, 1994) because design team's organizations develop collective information behavior and create knowledge about the design and the design process (Nonaka, 1995).

1.5.3 Expected weaknesses of Project Websites use in design teams of construction projects

Weaknesses of using a PWS in design teams may be the need of new skills of users to communicate using a PWS, higher organizational dependency and rivalry between IT tools available. Teams members need to develop specific skills because a PWS is different in handling electronic information. To be used collectively the tool needs more and specific training and procedures for use compared to other IT tools such as MS-Outlook MS-explorer. In particular, team members have to be trained in vault-storing of files and attaching attributes with key words to files, change of status and usage of specific document formats. In that sense, the aspects of change to collective use of a PWS might show similarities with the adoption and use of electronic document management systems (Sutton, 1996).

However, these packages are not an alternative because of the limited possibilities for team communication in multi-disciplinary teams. EDMS packages are focused on one organization instead of project focused with several different organizations involved.

To allocate stored files, team members have to get acquainted with the use of queries that search for attributes attached to the stored files and the use and construction of key words to appoint attributes. Finally, if a register of key words is lacking, members have to define their own key words. If status of files is not changed properly, double and outdated files might occur that increase the chance of making mistakes. These requirements are obviously more demanding than simpler IT tools.

As for high organizational dependency, the effective use of PWS depends on the collective use by design teams members, who all have to use the PWS in the same way and the same frquency. PWS can be used by design teams members in one of the four described modes in section 1.5.2. Therefore, agreements is needed for collective use both at design team level by team members and at the design organizations level because information generated in each of the partner organizations has to be stored in the PWS. Design team management needs to manage PWS use, administration and responsibilities for using the PWS for several reasons. First, procedures for updating and maintaining files, adding attributes, changing the status of stored files, etc. have to be developed and controlled. Secondly, bad use of PWS needs to be controlled and corrected. Thirdly, administrative tasks concerning user rights of design team partners and clients for viewing and reviewing collective knowledge about the design and the design process stored in files in the PWS database have to be executed. Finally, ownership of stored information and protection of ownership needs to be addressed and managed.

Organizations may also have to face objections related to social control and “big brother effects” because a PWS allows management to track and see who is updating a drawing or document at what time and how much time it takes to update. This effect might induce design teams members to reluctantly use PWS or non-adopting or even rejecting use (Rogers, 1962), which may have adverse effects on team communication and team performance. This relatively high level of vulnerability due to organizational dependency may lead to frustrations in its own right (Sutton, 1996). Trust is needed to reduce the degree of vulnerability (Handy, 1995, Dickson, 1996; Jarvenpaa & Leidner, 1999).

Rivalry between IT tools available may be a weakness for a variety of reasons. First, because design teams members are creative and visionary persons with uncertain and equivocal non-routine tasks, the use of PWS at advanced level 1 or 2 (section 1.5.1) might be too prescriptive to use effectively for team communication in the design phase of a construction project. For that reason, design teams members might not use PWS for storing actual information but will continue using the easier to use shared project disk facilitating the computer network for storing actual information and will use the PWS afterwards to store information for publication or archive reasons by dragging and dropping of files. Such behavior will jeopardize the optimal use of a PWS.

Secondly, there may also be rivalry between a PWS and other IT tools supporting central file management because a PWS package will be used most likely as a jacket for use of all software implemented already in an organizations computer network. Such networks often have already implemented a jacket software package such as for instance MS-Outlook. Users are acquainted with the functionality of the present package and interface, which might cause frustrations and conflicts if PWS has to be used instead MS-Outlook or both PWS and MS-Outlook have to be used.

Thirdly, use of a mail messenger facilitated by the PWS package to sent messages about updated and stored files to other design teams members obliges users to maintain a second email box next to the commonly used mailbox in MS-Outlook. Discussions and conflicts may therefore arise about the gains of using a PWS.

Rivalry between PWS packages available might appear if distributed PWS packages are used by design team members in multidisciplinary teams. One can imagine that, because of the market situation in which different PWS packages are bought or hired per project it may be difficult to organize effective use of a specific PWS for a specific project. In this situation, similar to the use of available CAD-packages with differences in features for libraries, layers, appointments and procedures, design teams partners will all like to use their own PWS package which they are most familiar with (Spekkink, 2001).

1.5.4 Implementation of a Project Website package

Regarding the issues discussed it might be concluded that the implementation of a PWS is not the migration of using one software package to another one, but in fact is the change from a manually method of information handling to an automated method (Aken, v. 2002). When these kind of changes occur specific care has to be taken for: 1) training to use the new tool and training the changes in workflow; 2) the planning of change and management of changes; 3) adequate handling of problems occurring during use; 4) slow and non adoption of the PWS due to incongruent technological frames (Orlikowski, 1994). Because a PWS is not an easy to use tool like email, the efforts to get used to work with the new tool might easily take more effort in the beginning than users benefit directly for their own tasks to fulfill. A PWS by nature, is an open, empty database structure accessible by internet tools that needs group document storage to become attractive to users. Such a tool might become effective for team communication that affects performance, if used collectively by all team members who use the tool in the same way with comparable frequencies of use. In that regard, a PWS needs collective use by a group to change from a push to a pulling setting in contrast to email that easily changes into a pulling setting if only one member of a group use the tool for answering another team members message.

1.5.5 Empirical evidence

To ground the expectations about weaknesses of PWS a broad literature search on empirical evidence was done but unfortunately without success.

Castle (1999) did empirical research about the potential of PWS for use in multi-disciplinary construction projects towards a better understanding of PWS, but did not investigate the effects of PWS use on team communication and team performance. Soibelman (2001) investigated possibilities of using PWS for improving logistic procedures in AEC projects, but did not investigate whether the use of PWS affects team performance.

There is a general literature on the so-called IT productivity paradox, which shows that investments in IT do not always result in higher productivity (Brynjolfsson, 1993, 1998; Bakos, 1998; Santos dos, 2000; Mckinsey, 2002). Moreover, the effective use of IT tools has been shown to vary according to mismanagement of information and technology (Brynjolfsson, 1993), drivers of technology change (Hauschildt, 1998), and insufficient changes in workflow to use IT effectively (Martinsons, 2002). These studies, however, do not focus on the actual use of PWS's by teams in general or by multi-disciplinary design teams in particular. Moreover, they are not concerned with the improvement of productivity as a result of better communication by using a PWS. The only exception that we are aware of is a study on PWS use for performance improvement in a Dutch construction project (Groosman, 1999). However, it involved technical engineers instead of specialist designers in the design phase, and hence no conclusions can be formulated with respect to design teams.

The results obtained in the realization phase of a construction project do not necessarily generalize to design teams of construction projects. The tasks executed in the realization phase of a construction project are directly related to work that needs to be conducted. Moreover, users mostly benefit directly from the information stored in the system about their own tasks to fulfill, changing the PWS easily to a pull setting.

1.6 Conclusions and discussion

The goal of this chapter has been to provide a context for assessing the potential of PWS, as vendors claim, in improving team communication and therefore team productivity . Based on a basic concept, developed in communication theory and media-richness theory, we have systematically identified the potential strengths and weakness of alternative communication modes, specifically for integral design processes. This evaluation leads to the conclusion that a PWS potentially is the most effective means of communication because it has some features that allow both synchronous and asynchronous communication and unlike other means of communication supports the various means of communication.

This is not say that PWS do not exhibit particular potential weaknesses. The required skills that are relatively more difficult to achieve, require stricter compliance with procedures and protocols by all team members and a clear and consistent role of management to be fully effective for team communication. Moreover, PWS is not an easy to use tool like email and has to be used collectively first to become a pull system for its users.

The question becomes whether working habits, culture and role of management are sufficient to harvest the potential of a PWS. Unfortunately, there is a fundamental lack of empirical research. To provide some answers to this question and contribute to the existing literature, a research project, designed to examine the influence of PWS use on team communication and team performance of design teams, is reported in the next chapters.

Chapter 2: Research design and methodology

2.1 Introduction

As described in Chapter 1, we can conclude that there is a fundamental lack of knowledge about the effective use of a Project Website (PWS) by design teams for construction projects in the context of team communication and improvement of team performance. Based on expected weaknesses of a PWS and the general literature about the IT productivity paradox, which shows that investments in IT do not always result in higher productivity, the main question addressed in this study is whether the IT productivity paradox observed in other IT domains can also be observed for design teams in architecture, construction and engineering using PWS's or whether this paradox should be further qualified according to an organizational and management context.

Before discussing the results of this study, in this chapter, the research problem is defined and the general research design is outlined. First, we describe how the main research questions were developed. Next, we outline a multiple case study that was designed to answer the research questions. Specific case study questions are discussed. Then, the issues of operationalization are motivated. Finally, we describe how measurements were executed; the principle of triangulation was applied to extract evidence and how conclusions were derived.

2.2 Problem definition, research questions and research design

2.2.1 Problem definition, objectives and research questions

Based on the findings of the literature review, it can be concluded that there is a fundamental lack of knowledge about use of a PWS and its effects on team communication and team performance in design teams. Moreover, we do not know whether the IT productivity paradox observed in other IT domains can also be observed in design teams in architecture, construction and engineering. The present PhD study represents an attempt to fill this gap and contribute to the literature on the use of this IT tool in different organizations. In particular, we wish to generate additional knowledge about the use and effects of a PWS in design teams.

To that purpose, the following main research questions guided our study:

1) How do design teams actually use a PWS compared to the prescribed use in a construction design project?
2) What are the reasons for discrepancy, if any, between actually and prescribed use of a PWS?
3) What are the effects of using a PWS on team communication?

4) What are the effects of using a PWS on team performance in terms of efficiency and effectiveness and added value for the consumer?
5) To what extent are the findings related to the above questions specific to the industry of architecture, construction and engineering?

From the outset, It should be articulated that the outcomes of this study can only start providing answers to these questions. Replication research will be necessary to enhance knowledge in this area, as not much is known yet.

2.2.2 Research design

A so-called quasi-experimental design was chosen as the underlying research design because it is very appropriate to provide answers to these main research questions (Campbell e.o. 1971). A quasi-experimental design differentiates between an experimental group, which is stimulated, by means of extensive training, to use a PWS in this case, and a control group, which is very similar to the experimental group but did not get extensive training. In an organizational context, a strict implementation of this principle is rather problematic, as management cannot easily deny access to new technology.

Differences in the present study therefore were related to differences in the amount of stimulation of groups. By controlling certain other potentially influencing factors, any differences between the experimental and control group can undoubtedly be uniquely attributed to the experimentally manipulated factor; in this case the use of a specific PWS. This thinking guided the design of the present research project, but it should be noted in advance that quasi-experimental designs usually involved large samples so that statistical inference theory can be used to draw statistical conclusions. As we will see later, the number of observation units was small in this project, implying that we cannot draw any statistical inferences. In other words, in this study, the principles underlying quasi-experimental designs were only used as a systematic means of interpreting results and for avoiding obvious alternative interpretations, not under the control of the researcher, as much as possible.

To that particular end, a multiple case studies was conducted involving design teams in the construction industry. A case study design was selected as the research strategy because the type of questions raised are so-called *how* and *why* questions (Yin, 1994). That gave us the opportunity to study and compare the use of a PWS in pairs of teams of different regional organized units of analysis.

Changes in team communication and team performance were measured. This measurement was repeated three times: 1) before the introduction/ intervention before the use of a PWS), 2) during the use of the PWS, and 3) when the intervention effect had decreased, which was expected to be 12 months after the introduction of the PWS in the organization (Figure 2.1). It should be noted that the timing of the measurements is critical to the findings of these types of studies. Acceptance and diffusion of new technology in organizations may be expected to conform to an S-shaped curve (Rogers, 1962).

If this is true, it means that observed differences may be smaller than they really can be when the second measurement takes place before the acceptance of the new technology has reached its saturation point. Repeated measurements reduce this possible caveat.

By repeating this case study several times with comparable design teams executing comparable projects, differences in the use of the PWS and its effects on team communication and team performance were measured and major findings were generated. As indicated, this approach allows one to compare the performance of pairs of design teams and provide the basis for ruling out or at least reduce the plausibility of alternative explanations of any differences between the design teams. In addition, the external validity is expected to increase.

Because design teams are temporary organizations by their very nature and often differ because of the uniqueness of design projects, a permanent organization had to be selected in which comparable design teams, executing similar projects, operate in different organizational units. The fact that experimental and control groups were selected within the same organization means that many variables operational at the level of the organization could be assumed constant. The fact that organizational units were involved means that unobtrusive measurement had to be attempted.

To address the question whether the major findings generated were specific to the organization used in the case studies, experiences of similar and different Project Website packages (PWS) in different organizations in the Dutch Construction Industry are reported to put the major research findings in a broader perspective. Based on reflections on the major findings and experiences of the same and similar PWS in different organizations, the research questions were answered by deriving conclusions on the use of a PWS by a design team for a construction project, and its effect on team communication and team performance. Figure 2.2 summarizes the case study method used in the research project.

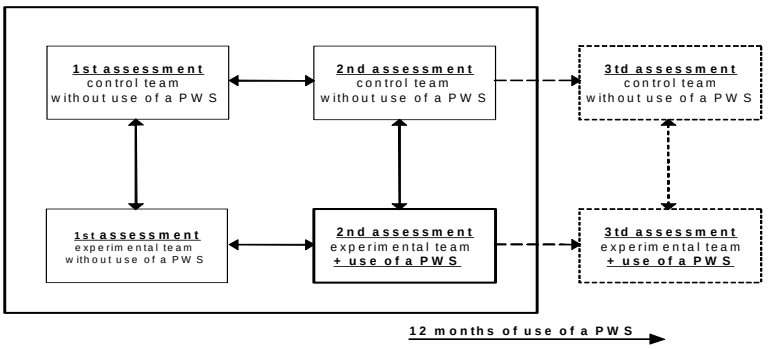

Figure 2.1: Research strategy of the multiple case studies

2.3 Description of the multiple case studies

2.3.1 Introduction

In this section the multiple case studies are described in detail for different organizational units of a specific organization. In addition, the case study questions are discussed that underlie the three measurements. Finally, data sources and specific aspects of the case studies in the organization studied are reported on.

2.3.2 The case study organization

The multiple case studies were conducted at the Real Estate Agency (REA), which is a pseudonym for a Dutch governmental organization located centrally, that handles the building and construction of facilities for governmental departments regional through organizational units. In 2001 REA implemented the project Website package ProjectWise (PW) in the organizational units for use by design teams to improve team communication and team performance in terms of efficiency and effectiveness (Appendix A).

Data were collected in three organizational units. For reasons of confidentiality, these units will be called unit A, B and C respectively. Within each organizational unit we selected, an experimental team that had extensive training and a control group that used PW without extensive training. The experimental teams in the various units are denoted respectively by AE, BE, and CE. Similarly, the control teams in the various units are represented by AC, BC and CC respectively. Within each unit, a pair of design teams was chosen based on comparable technical complexity and volume of the design object as well as the number of design team members. In units A and B, teams were composed per project; a project leader supervises the team, but a team member's functional leader is the sector leader.

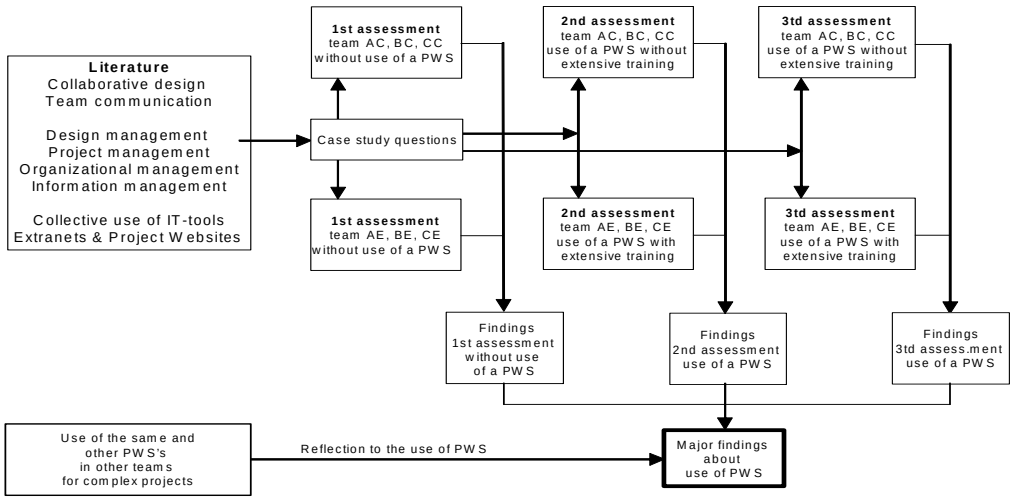

Figure 2.2: Multiple case studies method

There are sector leaders for architecture, framework, air-central heating installations and electro-technical installations. The project leader in unit A and B, without any intervention of researchers, chose team members. In unit C, team members do not change by project, but as in units A and B a project leader supervises the teams.

Subjects in this research project are architects, advisors, engineers and managers in their role of members of design teams, and support staff such as secretarial staff, system managers and administrative staff of the three organizational units (Appendix B1A). Each team selected consists of 8 members, the secretarial staff excluded, executing design tasks for a construction project: for example, an office building with lunchroom facilities or a comparable project regarding volume and money. The research was organized in such a way as to exclude, as much as possible, external influences. To protect the integrity of the investigation, researchers did not indicate to REA what would be subjected to scrutiny and assessment. Also, team management and team members did not know this, to reduce the risk that the conduct of this study will affect their daily behavior.

2.3.3 Multiple case studies questions

The questions of interest are the same for all three measurements. The purpose of the first measurement before the introduction and implementation of PW in the organization was to collect data about team communication and performance without the use of PW. This would serve as a benchmark and establish any possible differences between the experimental and the control groups. In particular, the following research questions were relevant:

1) How do REA's design teams communicate using the various, available means of communication?

2) How do REA's design teams actually use PW compared to the prescribed use?

3) What are reasons for discrepancy, if any, between observed and prescribed use of PW?

4) What are the effects of using a PWS on team communication?

5) What are the effects of using a PWS on team performance in terms of efficiency and effectiveness and added value for the costumer?

The purpose of the first, second and third measurement was to collect data about team communication and performance, before, during and after the introduction of ProjectWise (PW) and between the experimental and control groups. By comparing data between the second and third measurements and the first measurement, each experimental group could be examined for effects on communication and performance.

To rule out that any improvement could be attributed to any other factor than PW, performance was compared between experimental and control groups in the same organizational unit. Any differences between organizational units can be used to qualify the effects of PW use on performance according to management style, culture, changes made by team members and preferences for team communication.

2.3.4 Operationalization

The general question that is addressed in this PhD thesis concerns the hypothesis that the *use* of a Project Website (PWS) will increase team *communication* and therefore affects team *performance* positively. These theoretical concepts however can be defined in different ways. Hence, these concepts must be operationalized into measurable variables. Our general conceptual framework guides this operationalization.

Measuring the actual use of a PWS is relatively straightforward. Actual use of a PWS is defined as the daily use of the tool for all design tasks generating electronic output. This use was investigated by measuring the frequency of activities for storing, reading and changing the status and version of documents for all members of the experimental and control group as registered in PW's history log and by comparison of the outcomes. In detail this concerns analyzes of: the number of stored files per user per month, the number of ProjectWise users per month, the number of files dragged & dropped by which frequency per month, the number of types of documents stored per month, the number of files changed of status to final per month, the number of attributes attached to stored files per month. A grade pointing system was developed for the number of files stored to weight the PW-use of each team member, which is described in detail in Section 2.3.6.

Measuring team communication offers more of a challenge. According to the general definitions of communication and team communication (Sections 1.2.2 and 1.3), team communication concerns flows of information between members of a group through specific channels by using the available means of communication. Team communication is not restricted to transfer of information, but concerns all activities of information handling needed for the exchange and storing of information through specific channels to members of a group, individually and collectively. Discrimination between synchronous and asynchronous communication is necessary because of substantial differences in synchronous information flows using voice, ears and brains for generating, transmitting and storing information compared to asynchronous flows by a) paper using postal mail channels and paper dossiers for storage and b) electronically using electronic means for storage (Section 1.4.1). According to our conceptual framework, the mixed use of these means of communication is required to improve team communication. Thus, team communication of design teams in organizational units of REA was investigated by measuring the frequency of using available *different* means of communication and the information handling activities for collecting, storing, reading, and maintaining information.

Moreover, team communication and preferences for using specific means of communication were identified by asking questions about use, information handling and preferences for using particular means of communication. Finally, effectiveness of the use of PW for team communication was operationalized by measuring changes in the frequency of using means of communication, caused by PW-use as a new means for team communication.

Based on Ruler's concepts of communication (Ruler, 1996), the use of PW for team communication was classified into interactive, effective, active and re-use. Classification depends on the possibility of indirect or direct feedback and the frequency of interaction between senders and receivers. In integral design processes, PW is expected to be highly effective in *interactive* mode, when information is updated every hour, which is not the case in REA's design teams. In these teams, PW was expected to be effective in *effective* mode for team communication because of daily storing and the maintenance frequency. Feedback in PW refers to those situations where another team member reads the stored PW information with a certain frequency. In *active* mode, when PW is used less than on a daily basis, substantial effects on team communication are not expected because of the lack of feedback and use of other communication means in effective communication mode. REA's client and stakeholders were not allowed to use PW, but feedback could be given by other means of communication. In *re-use* mode is feedback not relevant because documents are considered to be finalized. In this mode, PW is used as an electronic or digital library for all design teams of REA. Thus, by measuring the frequency of storing and maintaining of files using PW by each team member and reading of files by other members of the same team, the degree of effectiveness of PW as a means of team communication was operationalized.

Synchronous team communication was measured by observing team meetings specifically with respect to discussions and appointments about the use of PW, problems with PW and the storage and distribution of minutes of meetings and other relevant documents for team sharing. It was expected that minutes of meetings and other documents that are highly important for all team members were stored and viewed in PW. Also change of status of documents to Final might be discussed in team meetings.

To get an indication about time spent on informal meetings by design teams, estimations of team members about daily time spent on informal and formal team meetings, were gathered by structured interviews and an average figure value for the experimental and control team in each unit was generated. By comparing the outcomes of validations of both teams it was investigated whether differences between teams were discriminating enough in order to decide that they essentially diverged from each other. Outcomes of less than half or double time were marked as non-substantial because of the inaccurate way of measuring. Accurate measurements about informal meetings need specific measurements and equipment for observing and recording. These measurements are time intensive because of the spontaneous and informal nature and the randomly frequency of this kind of communication (section 1.4.1).

Because of these aspects, time spent typically differs from day-to-day and different team members might not spend their lunch hours on verbal, informal, face-to-face communication concerning their work. Because most electronic means of communication are generally considered to be easy–to-use tools, the frequency of use and storage of information through these means were measured. Changes in frequencies of using Email and Outlook were also investigated because the use of these means started almost at the beginning of the research project, together with the introduction of PW.

Measuring *team performance* by using PW needs another set of indicators. Based on REA's success criteria for implementing a PWS (Appendix C), team performance of the experimental team is expected to increase in terms of efficiency and effectiveness. According to Brynjolfsson (1998) *"productivity is simple to define but it is notoriously difficult to measure. Output measure should include the value created for consumers"*. The contribution of ProjectWise (PW) to productivity increase might be because of the increased efficiency reflected in decreased search time for stored information and increased quality reflected in a database-structured, electronic information vault with the complete, valid and latest generated design information. Increased efficiency is expected because daily PW use by a design team as prescribed, results in a well database-structured, electronic information vault with actual and finalized information that is directly and rapidly accessible at each team member's workplace for reading, feedback, updating and re-using. In addition, the quality of output of the design phase is expected to improve because of the electronic information vault containing all electronic generated files with the right status and the appointed attributes for quick searching activities by using queries. Although attaching attributes to files stored in PW might need more time compared to storage in a separate part of the network disks, PW's quick search options finding valid information are expected to be more efficient. For that reason it can be expected that the number of readings of a team's PW content by its team members' increases. Also the readings by members of other teams in the same unit using PWS and searching for re-use of information are increasing the consumer's value.

Based on these claims, efficiency improvement was first measured by comparing the number of members of the experimental team reading each others stored files with that of the control team and reflected to readings of a reference or ideal team. Efficiency is expected to increase if the number of team members, reading each others PW-files, increases above six per month. This number is the average of the number of team readings by team members (Table B2A5). Time saved per PW reading in PW is expected to be at least ten minutes because otherwise a team member has to visit the centrally located project dossier (on paper) at another workplace for making photocopies or writing notes. Thus by electronic searching in PW at least six times, one hour of office time might be saved for executing other design activities. Most team members indicated that they visit the project dossier more than 3 times a week. Because of the change to electronic reading using PW, the number of visits might decrease although it cannot drop to 0 because the project dossiers contains incoming paper files which cannot be read electronically at the workplace.

If a PW-user read only once during the period of measurement it is regarded as curiosity for the new tool and not for professional interest. For that reason, reading only once is omitted in the results of analyses. Efficiency decreases if only an arbitrary part of the files can be found using queries in PW. *Next*, by comparing the number of readers of other teams in the unit, to the number of team readers, it was investigated whether members of other design teams in a unit show interest in a team's PW-content for reasons of gathering design knowledge and re-use purposes. It might be that a substantial increase of these readings also might contribute to team performance.

Quality improvement was measured first by comparing the electronic generated information in PW to the paper dossier documents stored, in terms of completeness and status of the electronic stored information. PW-files, which were not finalized when the design phase was finished and still could be changed, were regarded as redundant information. Redundancy increases if the number of paper documents in the paper project dossier is larger compared to the number of PW files. It can be expected that missing PW documents are stored in the shared project disk or another part of network disks. For that reason file updating in PW should not be older than 5 months because usually a design phase is finished within this period and paper copies were already sent and stored in the paper project dossier. Files stored and not updated or/and not finalized in the last 5 months of measurement was regarded as redundant information and decreasing quality of design information.

2.3.5 Data sources and data collection

Eight different data sources were used for the analyses. These data sources were: 1, interviews with all team members and secretaries; 2, a tick list for use of means of communication; 3, observations at team meetings; 4, check of archived project files on paper and electronically; 5, history log of PW concerning use of PW by subjects; 6, interviews with deputy unit managers and project leaders of the experimental teams about efficiency indicators; 7, documentation about prescribed use of PW; and 8, data of "on-the-spot-check" of actual use of PW by subjects. To show the relation between the case study questions and the various data sources a matrix was developed (Table 2.1). The data sources and method of data collection are described in detail below.

1) Interviews with subjects by using a structured questionnaire with both qualitative and quantitative questions about the kind and frequency of using PW and other available means of communications. In addition, questions were asked about the team members' preferences and irritations related to various communication means for information handling (Appendix B). Specific detailed questions provided data about a) easy-to-use IT-tools like Email and MS-outlook agenda and use of PW; b) preferences of team members and management for the use of these means of communication; c) Problems occurring when using specific means of communication; d) vision of the subjects on the effectiveness and knowledge and apprehension of applied means of communication;

Continuation of 1) Interviews: e) capacity and time planning for the design phase and the planning of the design information handling; f) open questions about the subject's opinion on problems and ways to improve information handling in design teams for construction projects.

Moreover, quantitative and qualitative questions about planning, control and management of information were formulated in the structured questionnaire. All interviews took place face-to-face at the subject's workplace. The subject received the questionnaire at the start of the interview. Following this, the interviewer read every question and asked the subject to write down the answers to the quantitative questions. The interviewer himself wrote down the answers related to qualitative questions. The interviews were executed by the researcher and experienced assistants who were instructed before the interviews took place. The researcher and assistants decided on the coding of the data. The questionnaire and answers were retracted at the end of the interview to prevent copying and distribution, and most importantly to remember the responses in the measurements that followed. The answers were processed by the researcher and assistants in Excel and Word files and afterwards verified by the subject. All approved interviews were signed by the subject and archived by the researcher. If changes had to be made they were changed by the subject and signed for verification.

2) A tick list about the frequency with which subjects used various means of communication in their daily work. This source provided quantitative data for the verification of answers to questions in the structured questionnaires. The data were registered in Excel files.

3) Observations of team meetings by qualified observers. It supplied qualitative data on face-to-face team communication in design teams. A protocol for observations was developed for observers to focus on (Appendix A3). All handling of information was observed during a meeting on the use of means: verbal, or paper or electronic means. Time needed for information exchange was measured as well as time for discussions and decision-making. If a design team used PW it was noted whether discussions about PW use took place and which appointments about use were made.

Table 2.1: Data sources related to case study questions

Nr	Case study questions	Data sources							
		1	2	3	4	5	6	7	8
1a	How do design teams communicate and with what means?	X	X	X	X				
1b	How does a design team actually use PW compared to its prescribed use?	X				X		X	X
1c	What are reasons for discrepancy, if any, between actual and prescribed use of PW?	X		X		X			
1d	What is the effect of PW on the team communication?	X	X	X		X			
1e	What is the effect of PW on the team performance in terms of time and quality?	X			X		X		

Continuation of 3) Observations: The handling of minutes of meetings was investigated regarding the means of information used. In addition, we observed how a team meeting was structured: who chairs the meeting and in which way and why, who takes minutes, how is it done, how does the information exchange with the client takes place, which information is exchanged and discussed face-to-face and how much time is required for the exchange of information and discussion to reach consensus? Observations of team meetings were executed by at least two different observers eliminating personal interpretations as much as possible. Before the observations, instruction took place by means of a meeting with the observers to discuss the observation procedure. At least four team meetings of every project leader involved in the research were observed. An observer visit a sequence of two meetings. Experiences were exchanged afterwards and a written report was made.

4) Checks of archived files of the realized design phase of a construction project in paper and electronic form. This source provided quantitative data on differences in storage and structure of stored files. It also provided data on the generated design information: medium (paper or electronically), efficiency and quality of information handling, and finalized files of a past design phase. The data were registered in Excel files. All documents were categorized to sort and kind, and counted. For the experimental teams, we examined whether all stored paper documents were the same as the electronic ones, stored in PW having the right status.

5) The history log of PW provided quantitative data on daily PW-use by subjects, information handling by adding attributes or by dragging and dropping files in PW and updating and finalizing files in PW. These data were forwarded as Excel files, once a week to the researcher by the application manager of REA during the research project.

6) Interviews with the deputy unit managers of the organizational units through registered Word text files, provides qualitative data on management of planning and capacity.

7) REA's ProjectWise manual provided quantitative and qualitative data on prescribed use of PW and responsibilities for PW use by team members and team management. The manual was developed by the application manager of REA, together with ProjectWise coordinators of each regional unit of REA and was available for use as a Word file and as an html-document that was direct accessible on REA's Intranet.

8) An "on the Spot check" on PW's actual use provided quantitative data on the actual use of PW by subject. The researcher's assistant visited each organizational unit in December 2003 with the consent of the PW-coordinator of the related organizational unit. The actual use of PW was observed by monitoring PW activities for one day and more, in particular observations were made with the expert, who used PW for which task and whether subjects used PW as prescribed. An Excel report was made of each observation with data about that used PW, at what time and for what purpose it was used. These data were compared with the history log of PW for the same period of time.

Continuation of 8) “on the Spot check”: In this way, the output of the history log was verified and deviations from the history log, received by the application manager of REA, were examined.

2.3.6 Measuring ProjectWise activities

PW activities were measured between February 2003 and March 2004 using PW’s history log that registers storage, updating, reading and finalizing of files for each individual team member. A grade point system was developed to measure the extent by which each team member and the team as a whole use the system and how the system is used in the context of team communication. Ideally, the development of such a measurement instrument involves extensive pre-testing, estimation and validity testing to find the set of items and scores that would discriminate best between different levels of communication. Because that would constitute a Ph-D thesis in its own right, a simpler approach was adopted in this study. Rather than developing and applying a validated measurement instrument, a decision calculus approach was used. This means that we developed a normative instrument, founded on theory-driven reasoning. It should be stated from the outset that such instruments, by definition, are normative and subjective and that consequently the results depend on the instrument and, in particular, on the assumptions made. The measurement instrument is based on two dimensions: intensity and kind of use, and the extent of using media other than PWS.

As for intensity and kind of use, the average number of files stored per month per team member is equal to 4 (Table B2A1). For every four additional files stored per month by a team member, an extra point is given. To support team communication, it is paramount that various team members use the system. To measure the extent this happens, one additional point per month was given if the following combinations of team members used the PWS in that particular month: project leader – team coordinator; project leader – architect, and architect – team coordinator. The underlying reasoning, as discussed in the theoretical part of this thesis, is that the project leader and team coordinator are the key persons, responsible for PW use as prescribed and team communication, while the architect is the key person in the team, responsible for the quality of the design, on which other team members depend. Thus, if all eight members of a design team collectively use PW in any given month, and each member stores four files during that month, the total number of points in that month for the team is equal to 11 (8 team members receive 1 point; in addition, the team receives 3 extra points because the project leader, team coordinator and architect use PW during that month).

Based on the scores of individual members, the number of points for a best scoring team (consisting of the best scoring members) can be derived. We call this a ‘reference or ideal team’. Table B2A2 shows that the highest number of points of this ‘ideal team’ in a single month is 35 (column ‘Highest score’). Note that it reflects the habits of REA design teams and their members. It is not the absolute maximum that can be reached, because the best scoring members did not exclusively use the PWS for storing their output.

Figure 2.3 visualizes the increase in the number of points for an ideal team due to a gradual increase of PW-use. It constitutes a normative curve, derived from the following set of assumptions and considerations. First, REA's central management expected that full PW-adoption would be realized within six months. Thus, the curve should reach its asymptotic maximum after six months. Secondly, the maximum number of points is 40, which is obtained if all team members exclusively use the PWS (Table B2A2). This implies that no file dragging is used and structural engineers use the Pdf. format for PW file storage. Thirdly, we assume that the adoption process follows a traditional S-shape curve. This fixes the general functional form between the number of points and time. Fourthly, we assume that the curve is symmetric around an inflection point halfway the 6 month time period. Finally, we assume that the marginal rate of increase of the number of points is approximately constant in the 5 months period, embedded in the 6 months that we consider. That is, only 2 weeks before and 2 weeks after this period are used for respectively starting the adoption and dampening of the increase to reach asymptotically the maximum number of points.

Because not all activities involving PW necessarily contribute to team communication, some storing activities were not given any points. In particular, team members may use the shared project disk or part of the computer network disks for daily file storage, and copy these files less frequently to PW. These copying activities result in the presence of files in both systems, increasing information redundancy, risk of failure, and therefore less focus on PW. For this reason, copying (dragging and dropping) activities was not given any points. Dragged PW-files were identified in the PW's history log if a group of files (at least two) were stored at approximately the same time (within five minutes apart). This choice of time interval was based on the assumption that we expect that a new file cannot be made and stored faster.

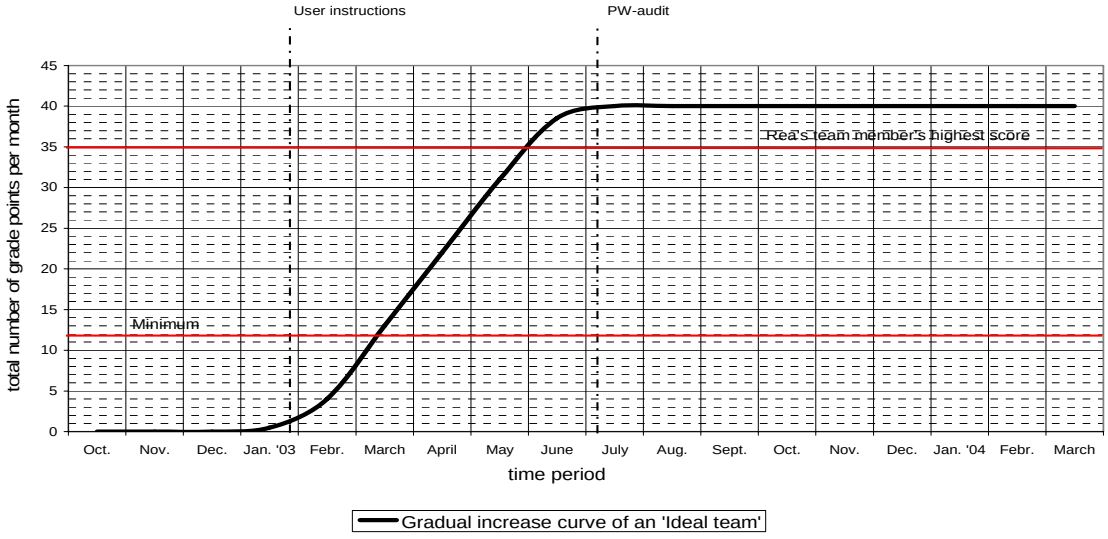

Figure 2.3: Number of points of the reference or ideal team as a function of time

2.4. Measurements and triangulation of data

Prior to the 0-assessment of the design teams in REA's organizational units A, B and C, the next procedure was followed to include the subject in the research project. First, it was discussed with the unit mangers and their deputy's that the assessment and comparison should concern similar design projects. The deputy managers identified such projects and the concerned project leaders were informed about the interviews. Next, contact was made with these project leaders to verify that the project indeed complies with the stated requirements and to make further arrangements.

To avoid undesired influences of management during the data collection, all appointments were made directly with subjects and no official letters and questionnaires were sent by postal mail. Official letters and content might have been registered and opened and might have caused undesired reactions of subjects. After these preparations, the interviews and observations took place during several rounds of measurement.

2.4.1 Measurements

The data were collected as follows. The 1st measurement (result 1) took place in 2001/early 2002 prior to the introduction of PW. The technical implementation of PW within the organization took place in 2002 and was completed by the end of 2002. For each unit, a PW coordinator was appointed by the unit manager to stimulate PW adoption. Regular meetings of PW-coordinators of all units were arranged to discuss conflicts and solve problems related to PW-use. The 2nd measurement (result 2) took place in September 2003, eight months after the start of using PW for new projects and 3 months after regionally organized workshops were held for the experimental teams teaching them how to use this new technology. We expected that by this time, skills for using the software were sufficiently developed and appointments about PW use had been. The 3rd measurement (result 3) took place in March 2004, 14 months after the start of PW and six months after the 2nd measurement. We expected that by this time, the acceptance and diffusion of the new technology would be at a matured stage. This was also expected because in December 2003 project leaders agreed on a modified protocol for PW use based on the experiences with PW between February 2003 and December 2003. Because of the research design chosen, deviations in the organizational units related to change in management in units B and C and the move of units A and B to other locations, could be eliminated because both teams in the unit experienced the same organizational changes during the research project.

2.4.2 Data triangulation

Data triangulation through convergence of data of multiple data sources was used to formulate valid answers to the case study questions. By comparing the answers generated for each organizational unit, final answers on the case study questions were formulated, corroborating fact extraction (Yin, 1994).

The data of different data sources as related in table 2.1 were compared for each organizational unit to verify outcomes, eliminate differences and finally to derive valid and robust answers as Figure 2.4 shows.

The answer to case study question 1, *How do REA's design teams communicate using the available means of communication*, is the result of the triangulation of quantitative and qualitative outcomes of data source 1 compared to quantitative data of data source 2, qualitative data of data source 3, and quantitative data of data source 4. Any differences were discussed with the subjects for explanation. Based on the outcomes, conclusions were formulated about how REA's design teams communicate using the available means of communication.

The answer to case study question 2, *how do design teams actually use a PWS compared to the prescribed use in a construction project?*, is the result of triangulation of quantitative outcomes of data sources 1, 5, 7 and 8. Data based on an analysis of the PW Meta-data of PW (source 5), were verified with "on the spot check" data (source 8) and quantitative data from data source 1. Any differences were discussed with the subjects for explanation, and a new file of Meta data was extracted from the PW system to verify the reliability of the system. Based on the outcomes, conclusions were formulated about actual use of the PW. Finally, these facts were compared with REA's manual on PW-use, in particular with the protocol for PW use and responsibilities (data source 7).

The answer to case study question 3, *What are reasons for discrepancy, if any, between observed and prescribed use of a PWS?*, is the result of triangulation of the qualitative outcomes of data sources 1, 3 and 5. The main data concerned qualitative data of the structured questionnaires (data source 1a) and observations of team meetings (data source 2). These data were compared in terms of similarities and differences.

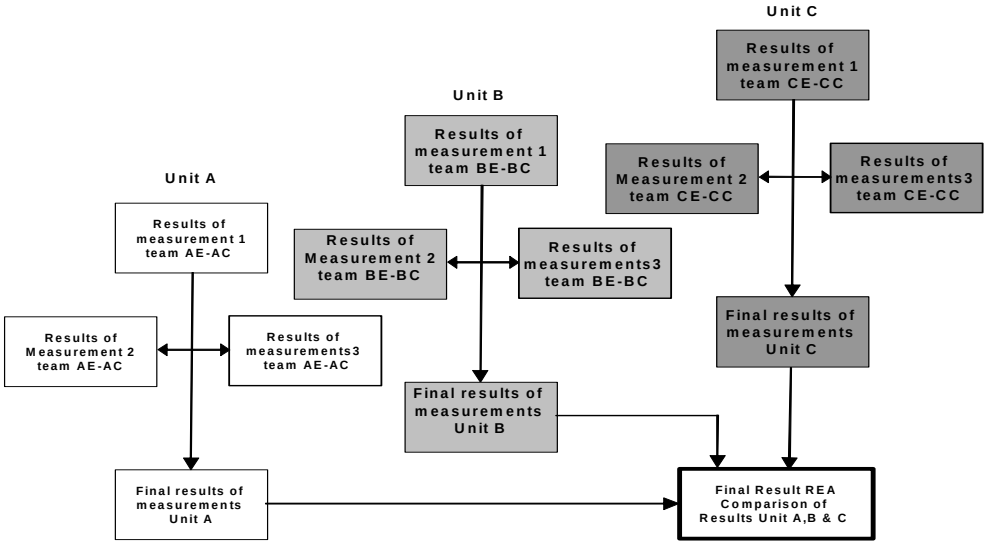

Figure 2.4: Comparison of results of units A-B-C

Any differences were verified with observed, actual PW use (source 5). Differences that still existed after verification were discussed at the end of the research project with the concerned project leader.

The answer to case study question 4: *What are the effects of using a PWS on team communication?*, is the result of triangulation of the quantitative outcomes of data sources 1, 2 and 3. Quantitative data of the structured questionnaires were compared with data of the tick lists (source 2) and observations of team meetings (source 3) to verify outcomes and eliminate differences. By comparing the outcomes of measurement 1, the starting point of measurements, with the measurements 2 and 3, changes in communication due to use of a PWS were measured.

Similarly, the answer to case study question 5: *What are the effects of using a PWS on team performance and added value for the consumer?*, is the result of triangulation of the quantitative outcomes of data sources 1, 4, 5 and 6.

Finally, discussions about differences in outcomes were organized (data source 1b). To derive facts about changes in quality due to the use of PW, quantitative data sources 5 and 4 were compared for both the experimental and control team over the three periods of measurements.

2.4.3 ProjectWise implementation in REA's organizational units

ProjectWise was chosen out of several other Project website packages after tests executed by a workgroup in REA which was organized for that purpose and which advised REA's management (Appendix A1). PW has integrated linking facilities for Microstation and Outlook Office software. User-friendly linking facilities between PW and the saving of files of different software packages are important for the daily use of PW (Appendix B2C). For users a specific REA's user manual was developed with the prescribed use of PW in daily work and responsibilities for team members and project leader. User instructions were given in the beginning of 2003 to all members in small groups in all units.

In unit A also management got these instructions. Users had to practice themselves at their own workstation. In June 2003 an extensive training ProjectWise was given, by means of a PW-team workshop per unit to project leaders of the experimental team and team members. In this extensive team training the use of the package for which purpose, tasks and responsibilities to fulfill and problems occurring during use were discussed and solutions to problems were given.

2.5 Conclusions

In this chapter, based on the problem definition and the research design, the various aspects of operationalization were discussed. In particular, the operationalization was described by the concepts of team communication and team performance.

By defining indicators for measuring communication and performance the measurement was described. In addition, the principle of triangulation of outcomes using multiple data sources was discussed. Based on these operational decisions, the specific analyses and their findings will be presented in the next chapter.

Chapter 3: Results of REA's multiple case studies

3.0 Introduction

In the previous chapter, we have described in detail the general methodology and specific operational decisions underlying this study, which aims at analyzing whether the technology paradox observed in many domains can be found as well in the context of design in the building industry. The specific area of research concerns Project websites (PWS), which have been promoted to improve team communication and hence team performance. A central decision underlying this study has been to use the principle of quasi-experimental design. That is, to test for any differences in PWS use, an experimental team and a control team have been identified within the same organization, executing comparable projects in terms of volume, technical complexity and money.

In this chapter we will report the results of comparative analyses that were performed, along the line of triangulation of data as described in section 2.4.2, to answer case study question 1, 3 and 4 (Section 2.2.1). It should be emphasized from the outset that the analyses reported in this chapter should be viewed as descriptive statistical analyses, and not be interpreted as inferential statistical analyses. Because we have used a quasi-experimental design, involving three rounds of measurements, we will first compare the experimental and control teams based on the first measurement, before the PWS package: ProjectWise (PW) was used in REA's organizational units. It was expected that no substantial differences in the use of communication means exist between these teams at this stage, because the pair of teams function in the same organizational environment using the commonly available communication means for executing comparable tasks. This lack of any differences is important, because any differences later on can then in principle be attributed to technology. Next, we will report the results of the second and third round of measurements to examine whether differences in use of PW that might affect team communication and team performance can be observed between the experimental and control team in each unit.

3.1 Team communication before ProjectWise use

Team communication in design teams of organizational units of REA was investigated in 2001- 2002 before PW was used, as described in section 2.3.4. First the quantitative data obtained through structured interviews with subjects about the frequency of use of the available means of communication were compared with data of tick lists. Next, these outcomes were elaborated using the qualitative data obtained through structured interviews with subjects, observations during team meetings and archive checks. The overview of collected data is assembled in Appendix B.

3.1.1 Team communication in teams AE and AC

Table 3.1 displays the results of quantitative analyses on the actual and preferred use of the available communication means in the experimental team (AE) and the control team (AC). By and large, it shows that differences in the use of communication means between the experimental and control team were small. *Formal meetings* of teams were organized with a frequency of 3-week intervals. In these meetings, the client or a delegated consultant was often present. According to the opinion of 6 members of team AE and 7 of AC, formal team meetings can be organized more efficiently and shortened in time. Subjects made suggestions for improvement. Team meetings of AC were organized more formal than those of AE because of formal procedures of the client of the project who chaired the meetings. Mostly, procedures and checklists fill were on the agenda of the meetings. Team meetings of AE were chaired by the project leader, were less formal and more focused on the contents of the project and the client was not present in all meetings. According to 7 members of team AE and 5 members of AC, email can be used to better inform team members on team meetings (Appendix B1A). For *dialogues*, Table 3.1 shows that this means of communication was used frequently. Whenever team members needed to discuss design problems related to each other's design tasks, an appointment was made to meet the same day. Most team members of both teams (7 of team AE and 6 of team AC) preferred the use of dialogues. For *Informal meetings*, subjects were asked to indicate the percentage of time spent daily on all verbal communication excluding formal meetings and telephone communication as showed in Table 3.1. Team AE's percentage of estimated daily office time spent on informal meetings is 12 percent, which represents 1 hour. In team AC, the outcome is approximately 1.5 hour. The difference of approximately half an hour for informal meetings between both teams is less than half, supporting the conclusion that differences are small.

Table 3.1: Overview of the use of communication means by teams AE and AC in 2001-2002

Type of communication means	Preferred means score		Number of team users		Percentage of time used		Frequency per day		Frequency per week		Frequency per month	
	AE	AC	AE	AC	AE	AC	AE	AC	AE	AC	AE	AC
Formal meetings	1	0	8	8	12	9			1x 3wk	1x 3wk		
Dialogues	7	6	8	8					<5, all	<5, all		
Informal meetings	1	6	8	8	12	20	<5, all	<5, all				
Discussions, brain-storm sessions	0	0	8	8							1x 3 month	1x3 month
Postal mail	0	1	8	8			<5, all	<5, 7p >5, 1p				
Telephone			8	8			<5, 7p >10,1p	<5 3p >5, 5p				
Facsimile	0	1	8	8			<5, 7p >5, 1p	<5, all				
Outlook email	5	3	8	8	6	8	<5, 7p >5, 1p	<5, 5p >5, 3p				
Outlook calendar	2	0	6	3			<5, all	0				
Shared project disk	0	0	8	8			<5, all	<5, all				
Project dossier	0	0	8	8					<5, all	<5, all		

For *discussions and brainstorm sessions*, Table 3.1 shows an average frequency of 1 per quarter of a year. Mostly, these interactive team meetings are held when a new design project starts to discuss design aspects and concepts with the client. Most team members are involved in 4 or more projects per year. For *Postal mail*, Table 3.1 shows this means is used with a low daily frequency of <5 documents. It can be divided into external and inter-office mail. Inter-office mail is organized formally. Before a letter is accepted for sending by postal mail it need a specific leaflet, signed by the project leader or unit leader. External postal mail is mostly used to send documents and drawings to the client and stakeholders of the project or to send information to other units of REA. For *Telephone* use, the table shows that all team members of both teams use it with a higher daily frequency than facsimile and mostly for making appointments and for exchanging information with team members and external parties. According to 6 members of both teams, the use of telephone decreases because of the use of email. For *Facsimile* use, this means is used with all members of both teams but with a low daily frequency (<5). It is mostly used to make appointments and send documents.

As for *Outlook email* use Table 3.1 shows that all team members of both teams used email with a higher daily frequency than facsimile. The average daily use in team AE is 6 to 8 percent of daily office hours in team AC. It is used mostly for sending short messages and documents attached to the message. Team members indicated that the use increased from the start in 2000 until 2002, by 30 percent in team AE and 20 percent in team AC (Appendix B1A). In team AE, email is one of the preferred used means of communication according to the opinion of 5 team members. Email messages are stored electronically in personal folders or printed and stored in members own paper dossier. Storage of important messages in the project dossier sometimes happens with a formal leaflet attached and signed by the project leader. To the opinion of 7 members of AE and 5 of AC, email can be used to better inform members as preparation for team meetings. Although in team AE more members prefer the use of email (5 team members in contrast to 3 of team AC), more members of AC use Email with a higher daily frequency. It can be concluded that both teams adopted this asynchronous means of communication rapidly. For *Outlook calendar* use, the table shows that 6 team members of AE used it in contrast to 3 of AC. This means still cannot be used effectively for team communication because it will only be effective when all team members and the secretary use this means. The use of this means did not start so rapidly as Email when MS-Outlook was implemented in 2000. For *Shared project disk* use, all members of both teams commonly used this disk for project documents storing and sharing. This was organized by IT System management of unit A to decrease file distribution by email attachments that slowed down the computer network. For *Project dossier* use, all members of both teams use this means. It contains mostly all incoming and outgoing paper documents and is maintained by the concerned project leader. It is the most important storage of information for the team because of all the signed contracts about the project stored. Structure and maintenance should be improved according to team members and management.

The use of IT tools for re-use of design information, like a PWS, should be an improvement according to the opinion of 6 team members of both teams (Appendix B1A). Thus it can also be concluded that most team members of both teams are positive about the effectiveness of re-use of information by means of IT.

Overall then, the comparison of analyses of using different means of communication between the experimental AE and control team AC are small and non-substantial. Most team members prefer the use of dialogues. No aversion against use of new IT tools for team communication was observed in both groups. Because teams were not specifically selected we assume that the findings about team communication for teams AE and AC are relevant for all design teams in unit A.

3.1.2 Team communication in teams BE and BC

Table 3.2 displays the results of quantitative analyses of the use frequency and preferred use of the available communication means in the experimental team (BE) and the control team (BC). It shows that *teams mostly organized Formal meetings* with a frequency of 3 weeks interval. In team BE the project leader chaired team meetings and the coordinator writes minutes of meetings. Team meetings of team BC were chaired by a delegated client and not by the project leader. According to the opinion of 6 members of both teams, formal team meetings can be organized more efficiently and shorter in time. Subjects made suggestions for improvement. A total of 8 team members of BE and 7 members of BC argued that email can be used to inform members in preparations on team meetings (Appendix B1B). The table shows that *Dialogues* were used almost daily. Five members of BE and 6 of team BC prefer using dialogues to discuss design issues directly related to their own activities face-to-face. Time spent on *Informal meetings* indicated by subjects are showed in Table 3.2 as a percentage of time spent daily.

Table 3.2: Overview of the use of communication means by teams BE and BC in 2001-2002

Type of communication means	Preferred means score		Number of team users		Percentage of time used		Frequency per day		Frequency per week		Frequency per month	
	BE	BC	BE	BC	BE	BC	BE	BC	BE	BC	BE	BC
Formal meetings	3	0	8	8	14	9			1x 3wk	1x 3wk		
Dialogues	5	6	8	8					<5, all	<5, all		
Informal meetings	4	5	6	6	14	14	<5, all	<5, all				
Discussions, brain-storm sessions	1	0	8	8							1x 3 month	1x3 month
Postal mail	0	0	8	8			<5 all	<5 all				
Telephone	3	2	8	8			<5, 5p >5, 3p	<5, 4p >5, 4p				
Facsimile	0	1	8	8			<5 all	<5, 7p >5, 1p				
Outlook email	2	0	8	8	8	4	<5, 6p >5, 2p	<5, 6p >5, 2p				
Outlook calendar	0	0	2	2								
Shared project disk	0	0	8	8			>5, all	>5, all				
Project dossier	0	0	8	8					<5, all	<5, all		

Team BE's percentage of estimated daily office time spent on informal meetings is equal to that of team BC: 14 percent, which is approximately 1 hour. Table 3.2 shows an average frequency of 1 per 3 months for *Discussions and brainstorm sessions*. These inter-active team meetings mostly are held at the start of a design process to discuss the design with the client to accelerate progress. Most members are involved in 4 or more projects per year. *Postal mail* is used with a low daily frequency (<5 per day). It can be divided into interoffice mail and external mail. Interoffice mail is organized formally. Before a letter is accepted for sending by postal mail it need a specific leaflet, signed by the project leader or unit manager. External mail is mostly used to send documents and drawings to the client and stakeholders of the project or to send information to other units of REA. The table shows that the *Telephone* is mostly used with a higher frequency for daily use than facsimile. It is mostly used for making appointments and exchanging information with team members and external parties. To the opinion of 6 members of team BE and 4 of BC the use of telephone decreased due to the use of email. *Facsimile* is used with a low daily frequency (<5 per day). The architect, a part-timer, mostly used facsimile to sent images and sketches to team members and stakeholders.

Table 3.2 shows that *Outlook email* is used with a higher frequency than facsimile. The use of email started when MS-Outlook was implemented in 2000. It is mostly used for sending short messages and documents attached to the message. According to the opinion of team members, the use of email increased in 2001-2002 by 30 percent in team BE and 25 percent in BC (Appendix B1B). In team BE, 2 members prefer the use of email for communication. Email messages were stored electronically in personal folders or printed and stored in team members own paper dossier. Some important messages are stored in the project dossier. To the opinion of 8 members of BE and 7 of BC, email can be used to better inform members for preparations of team meetings. The estimated time spent on email daily is according estimations of team members: 8 percent by team BE and 4 percent by BC. The difference between the time spent might be that some team members of BE are located at an other office and more information was exchanged. However both teams used email with the same frequency per day. Thus it can be concluded that both teams rapidly adopted this electronic means of communication. *Outlook calendar* use started much later regarding the implementation of MS-Outlook in 2000. In team BE only 2 team members are using the tool, which is not effective in a team of 8 members, the secretary excluded. The table shows that *Shared project disk* is commonly used daily by all team members. The *Project dossier* is used commonly for storage of all incoming and outgoing paper documents in the same way as in unit A. The use of IT tools for re-use of design information, like a Project Website, should be an improvement according to 7 members of both teams (Appendix B1B).

Overall then, the comparison of opinions of various means of communication between the experimental and control team of unit B suggest that differences are small and non-substantial. Most team members prefer the use of dialogues. Both teams are positive about the effectiveness in re-using information electronically and no aversion in teams was observed against the use of new IT tools for team communication.

3.1.3 Team communication in teams CE and CC

Table 3.3 shows the results of the quantitative analyses of use frequency and preferred use of available communication means in the experimental team CE and the control team CC. The overall table of use of communication means shows with respect to *Formal meetings* of the teams that these are organized with a frequency of 3 weeks. According to the opinion of 7 team members of both teams, formal team meetings can be organized more efficiently and shortened in time. Mostly, procedures and checklists are the agenda of the meetings. To the opinion of 8 members of both teams, email can be used to better inform members on team meetings (Appendix B1C). *Dialogues* were used almost daily according to six members of both teams to discuss design issues face-to-face. To get an indication about time spent on *Informal meetings* subjects were asked to their estimation of the percentage of time spent daily on verbal communication without formal meetings and telephone communication as showed in Table 3.3. Team CE's percentage of estimated daily office time spent on informal meetings is 23 percent, which is approximately 1 hour and 45 minutes of daily office time. In team CC the outcome is approximately 1 hour (13%). The difference of approximately 45 minutes of daily office time for informal meetings between both teams is less than half, thus was regarded as being small and non substantial. *Discussions and brainstorm sessions* were held with an average frequency of 1 per 3 months (Table 3.3). Mostly these interactive team meetings are held when a new design project starts to discuss design aspects and concepts with the client. Most team members are involved in 4 or more projects per year. The table shows that *Postal mail* was used mostly with a low daily frequency of <5 documents. The handling of documents is organized formally in the same way as in unit A and B. *Facsimile*, was used with a low frequency per day. It was used to make appointments, and sending information: documents as well as images and sketches.

Table 3.3: Overview of the use of communication means by teams CE and CC in 200 -2002

Type of communication means	Preferred means score		Number of team users		Percentage of time used		Frequency per day		Frequency per week		Frequency per month	
	CE	CC	CE	CC	CE	CC	CE	CC	CE	CC	CE	CC
Formal meetings	2	3	8	8	11	19			1x 3wk	1x 3wk		
Dialogues	6	6	8	8					<5, all	<5, all		
Informal meetings	2	4	8	8	23	13	<5, all	<5, all				
Discussions, brain-storm sessions	0	0	8	8							1x 3 month	1x3 month
Postal mail	0	0	8	8			<5, 6p >5, 2p	<5, all				
Telephone	0	0	8	8			<5, 4p >5, 4p	<5, 1p >5, 7p				
Facsimile	0	0	8	8			<5, all	<5, 7p >5, 1p				
Outlook email	2	1	8	8	10	11	<5, 2p >5, 6p	<5, 7p >5, 1p				
Outlook calendar	0	0	4	2								
Shared project disk	0	0	8	8			<5, all	<5, all				
Project dossier	0	0	8	8					<5, all	<5, all		

Outlook email was used with a higher frequency than facsimile (Table 3.3). The use started when MS-Outlook was implemented in 2000. It is mostly used for sending short messages and documents attached to the message. The use of email increased in 2001-2002 with 10 percent in team CE and 25 percent in team CC according opinions of team members (Appendix B1C). Both team used email. Although in team CE, 2 team members prefer the use of email, daily use of email of team CC is 11 percent in contrast to 10 percent in team CE. To the opinion of 6 members of team CE and 6 of CC the use of telephone decreases because of the use of email. Email messages are stored electronically in a personal folder or printed and stored in one's personal paper dossier, and important messages are sometimes stored in the project dossier. To the opinion of all team member's email can be used to inform members better as preparations for team meetings. *Outlook calendar* use did not start so rapidly as Email when MS-Outlook was implemented in 2000. In team CE, 4 team members are using the tool which is too less to be effective for team communication in a team of 8. Table 3.3 shows that all team members used *Shared project disk* commonly. This use was initiated in this unit in 2001 by IT System management because email attachments slowed down the computer network too much. The other units adapted this idea afterwards. The *Project dossier* was used for storage of all incoming and outgoing paper documents and also signed contracts are stored. It is the most important storage medium for the team. The project leader maintains the project dossier. Sometimes important email messages are stored without the prescribed signed leaflet of the project leader. The use of IT tools for re-use of design information, like a PWS should be an improvement according the opinion of 7 team members of both teams (Appendix B1C). Thus both teams were positive about the effectiveness of re-use of information electronically.

Overall then, the comparison of using the various communication means between the experimental and the control group in unit C show small and non-substantial differences. The comparative analyses on team communication do not show aversion against use of new IT tools for team communication and for re-use of information.

3.2 Project Website use in units A, B and C

The units discussed in the previous sections suggests that no major differences between the experimental and control teams in their use of available communication tools existed before the introduction of ProjectWise (PW). In the next sections we will examine whether there is evidence of any different trajectories between the experimental and control teams as results of extensive training how to use PW.

3.2.1 Results for teams AC and AE

3.2.1.1 Observed use of ProjectWise

The results of comparative analyses in unit A between experimental team (AE) and control team (AC) to determine whether actual PW-use differed are shown in Figure 3.1. In addition, the Figure shows the graph of PW-use of an ideal team and a minimum and maximum line as explained in Section A.2.3 to reflect on the team's actual use. The figure shows that PW use in team AE is substantial higher than in team AC. However, the figure also shows that the usage levels do not reach the defined maximum level. Team AE's curve finally reached 21 points (which is less or more than half of the maximum number of points). This point level might expected be sufficient for effective team communication because it is twice as high as the defined minimum level, while AC's curve finally reached only 5 points, which is approximately half of the minimum. However, AE's point level is the result of an increased frequency of PW-use by only 4 members, out of a team of 8 and because the fifth user, the architect, adopted PW in the last month of measurement (Figure 3.2). This number might be insufficient because arguably a team of 8 members needs 8 members for effective team communication, the project leader included. Only in July 2003, this minimum number of users was reached. Team AC never reached AE's level because at most only 3 members used PW. The steeper gradient of AE's curve compared to AC's curve, starting in June 2003, is the result of the PW-team workshop held in early June in which most AE's team members participated, with the exception of the architect and structural engineer. Of team AC, only the coordinator participated. The dip in AE's and AC's curve in August is caused by the summer holiday when few team members used PW.

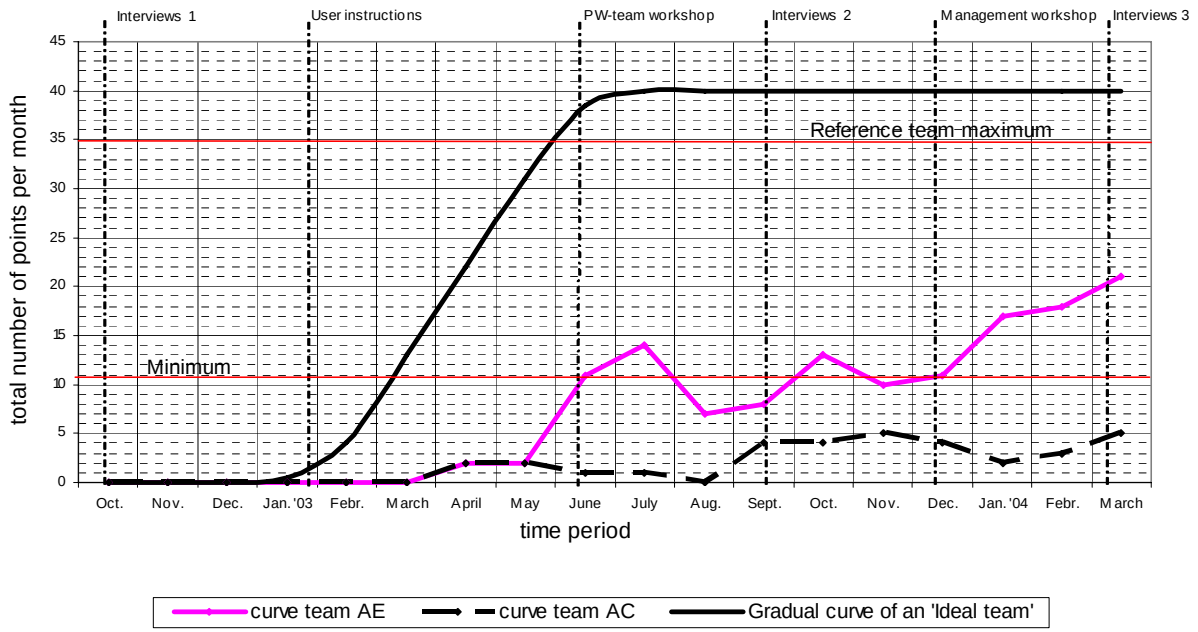

Figure 3.1: Curves of ProjectWise grade points per month for teams AE, AC and for an ideal team

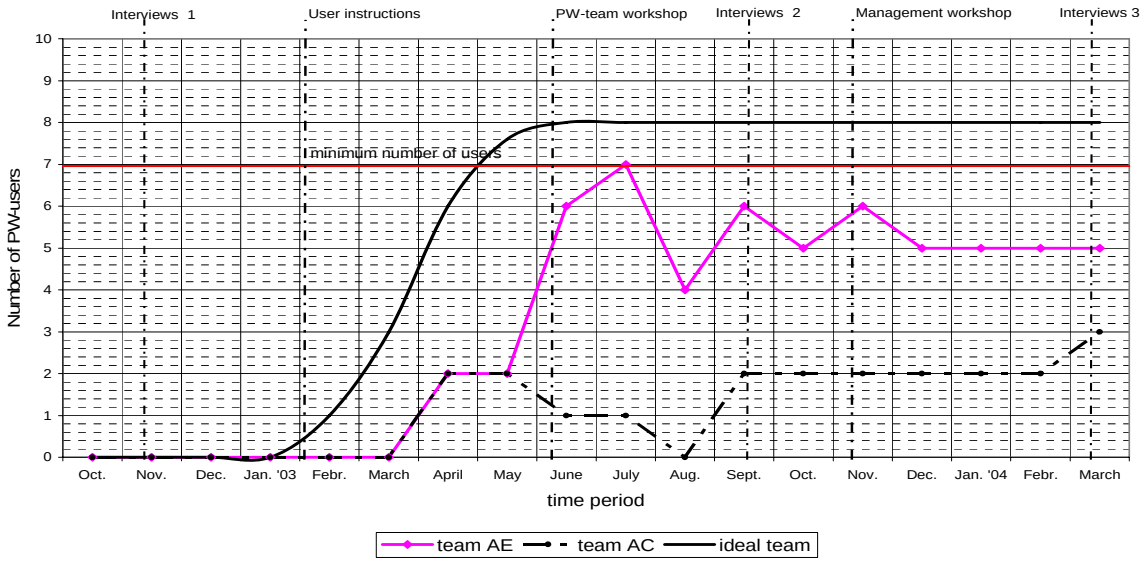

Figure 3.2: Curves of the increase of the number of ProjectWise users in team AE, AC and of an ideal team

In the experimental team AE, 5 adopters and 3 non-adopters (of which 2 are rejecters) were identified (Appendix B2C). Rejecters use the tool for a few months and then discontinue the use. In team AC 3 adopters and 5 non-adopters were identified. The number of PW-adopters in team AE decreased after increasing first. AE's project leader can be identified as an early PW-adopter, while the one of team AC was a laggard that started PW-use late mostly using the shared project disk. The coordinators of both teams were PW-adopters. The architect of team AE was a laggard mostly using the shared project disk, while the one in AC was a non-adopter. The quantity surveyor of team AE was an early adopter while the one in AC was a non-adopter. The detail construction designer adopted PW while the one in AC did not.

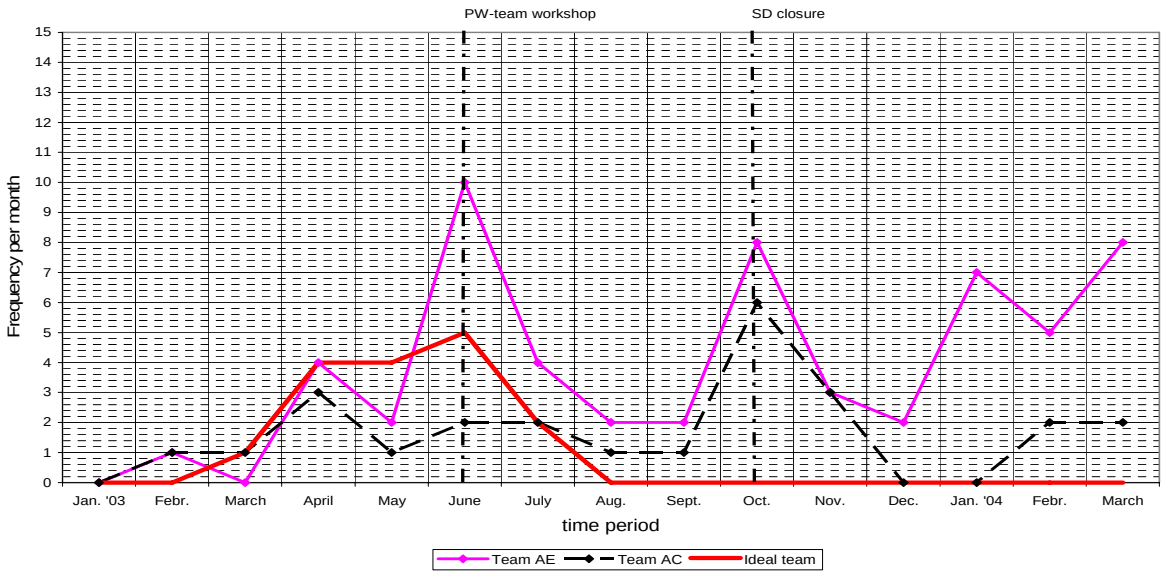

Figure 3.3: Curves of the frequency of dragged & dropped ProjectWise files by teams AE, AC and of an ideal team

The E-installation designer of both teams and the HC-installation designer of the experimental team were rejecters. The E-installation designer of AC and the structural engineers of both teams were non-adopters. AE's team members involved the secretary staff in PW-use for outgoing postal mail for the finalizing of letters stored in PW. Team management themselves changed the postal mail procedure for outgoing mail from paper to electronic in September 2003. Instead of a concept paper document confirmed and registered by the postal chamber of the unit, the secretary before printing finalized the electronic copy in PW.

The control team AC did not change to the new electronic procedure and continued the old one. All members of the group of structural engineers argued repeatedly during the measurement, that PW was not beneficial to their daily work. These designers, being PW non-adopters and the E-designer and HC-designer of team AE, being PW rejecters, use specialist software packages in daily work which are more difficult to use in PW than in shared project disk or network disks. For that reason, it might not be expected that the number of PW-users of the experimental team AE increase again to a sufficient level of team communication. Thus, although AE's curve gradient in Figure 3.1 looks promising, the increase will probably not continue and the curve is not expected to reach the maximum line.

Dragging and dropping of files. The number of files dragged and dropped in PW should decrease during use when users get familiar to daily PW storage, as shown in Figure 3.3 by the curve of an ideal team. However, comparison of the curves of teams AE and AC show an increase in both teams after closure of the shared project disk by the end of the measurement. Unit management closed the shared project disk advised by PW-users during the PW-team workshop to force non-adopters to PW-use. The increase of dragged and dropped files in PW after closure of the shared project disk shows that, in spite of closure, members of both teams continued using another part of the network disks (the department or personal disk) for sharing. Team AE 's curve shows a higher increase because all 5 PW-users used dragging and dropping in contrast to the 2 PW-users of team AC. The peaks in the curves can be explained by the PW team workshop in June 2003 and the closure of the shared project disk in October when many files had to be transferred to PW. Users were helped by system management to drag and drop files in time because after closure of the shared project disk all remaining files were deleted. The percentage of dragged files compared to the total of files stored in PW by team members of AE was 39 percent and for team AC 56 percent (Appendix B2C). Because 6 members of AE indicated that they still used a part of the network disks for sharing and 4 out of 8 team members can be marked as regular file-draggers, it might be concluded that 50 percent of actual information was stored in network disks instead of PW.

Stored documents for team sharing. The results of analyses whether members of team AE and AC stored documents for team sharing are displayed in Figure 3.4.

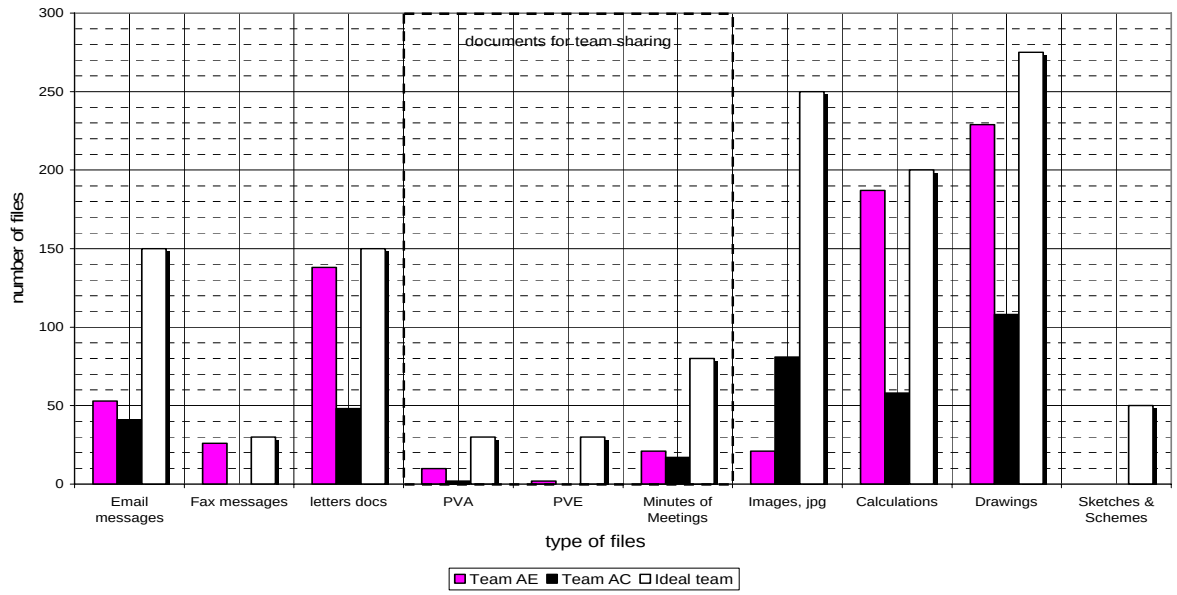

Figure 3.4: Graphs of the type of stored ProjectWise files of teams AE, AC and of an ideal team

Although team AE stored more than twice the number of drawings, calculations and letters compared to AC's storage, this number is less than half the expected number of document storage for team sharing of an ideal team. Minutes of meetings were mostly dragged files, stored in PW as finalized information. Instead of an increase in storing of minutes that might be expected by the end of measurements when team members got familiar to team sharing, this storage decreased (Appendix B2C).

Change of status to Final. The result of the analyses, to determine whether team members changed the status of files to 'Final' are displayed in Figure 3.5. It shows that except in the final month, the experimental team changed a higher number of file status than the control team. However, the figure also illustrates a lack of substantial awareness of changing to final. The overall pattern is rather erratic, and peaks can be explained by specific events. Compared to the number of finalized files of an ideal team, the experimental team changed less than 30 percent of this number. The peak in January 2004 can be explained by the decision of unit management in that month that file-status should be changed to final every time when PW-files were printed instead of by ending the design phase.

Adding of attributes. The comparative analyses of manually attaching attributes to files between teams AE and AC is shown in Figure 3.6, and compared to the same activity by an ideal team. This comparison determines whether team members added attributes to all PW-files as prescribed. Attaching attributes to stored PW files should be perfect and accurate to be effective for using queries for quick files searching, which may be showed by and ideal team's graph. However, the Figure shows that teams AE and AC never perfectly added attributes to PW-files and this activity decreased in time.

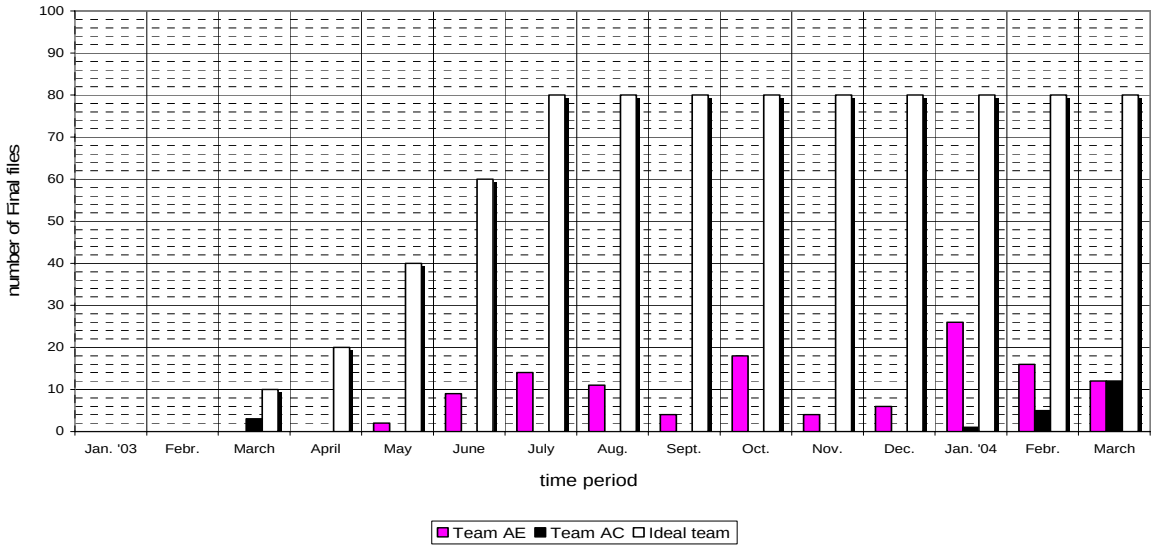

Figure 3.5: Graphs of the number of finalized ProjectWise files by teams AE, AC and of an ideal team

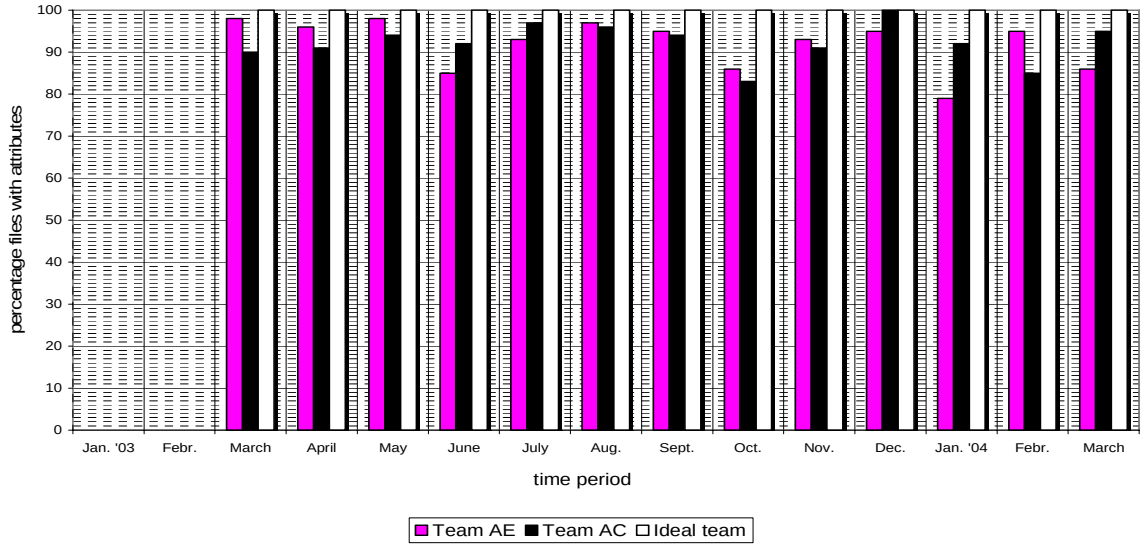

Figure 3.6: Graphs of the number of manually adding of attributes by teams AE, AC and of an ideal team

Table 3.4: Overview of the percentage of type of file storage by teams AE and AC and prescribed storage

Team	Actual file storage ProjectWise	Actual file storage shared project disk	Re-use storage ProjectWise
Team AC	25%	75%	5%
Team AE	50%	50%	12%
Prescribed storage	100%	0%	100%

Almost 30 percent of team AE's stored PW-files does not have attributes attached against 27 percent of that in team AC (Appendix B2C). These files and files stored in shared project disk or network disks cannot be found by using queries in PW (Table 3.4).

Findings about observed ProjectWise use. Overall then, the results of comparative analyses between the experimental (AE) and the control (AC) team show that a higher number of members of team AE used ProjectWise with a higher intensity of use compared to team AC. However, AE's actual use shows that effects of extensive training decreased. Instead of a growing number of users, this number decreased. Reflecting on these results to prescribed PW-use suggests that AE's ProjectWise use differs substantially. In spite of efforts for stopping use of network disks this was still continued and only 50% of the generated electronic files were stored in PW. Too less PW-files were finalized for re-use (Table 3.4). Thus, quick file searching in team's AE PW-content might not be effective to contribute to team performance. Because files are stored in PW and on the network disks without the right status the risk to costs of failures might increase due to redundancy of information. The results also show that ProjectWise communication in the effective mode of communication was restricted to the AE's project leader and 4 members which number may be too low for effective team communication in a team of 8 members.

3.2.1.2 Effects on team communication

Effects of PW use on team communication were measured to identify whether PW-use caused changes in use of the other available means of communication. Table 3.5 shows the comparison of use of team communication means in the experimental team (AE) and the control team (AC) by the end of the measurement in 2004.

Table 3.5: Overview of the use of communication means by teams AE and AC in 2004

Type of communication means	Preferred means score		Number of team users		Percentage of time used		Frequency per day		Frequency per week		Frequency per month	
	AE	AC	AE	AC	AE	AC	AE	AC	AE	AC	AE	AC
Formal meetings	0	0	8	8	11	11			1x 3wk	1x 3wk		
Dialogues	6	6	8	8					<5, all	<5, all		
Informal meetings	2	2	8	8	18	19	<3, all	<3, all				
Discussions, brain-storm sessions	0	0	8	8							1x 3 month	1x3 month
Postal mail	0	0	8	8			<5 all	<5 all				
Telephone	0	0	8	8			<5, 4p >5, 4p	<5, 5p >5, 3p				
Facsimile	0	0	8	8			<5 all	<5 all				
Outlook email	0	0	8	8	11	11	<5, 3p >5, 5p	<5, 4p >5, 4p				
Outlook calendar	0	0	8	7			<5, all	<5, all				
Shared project disk	0	0	6	7			<5, all	<5, all				
Project dossier	0	0	8	8					<3, 3p >3, 5p	<3, 4p >3, 4p		

The findings show that no noteworthy changes in team communication can be observed. Only the use of Outlook email and calendar showed some changes.

Outlook email use increased in team AE from 6 to 11 percent and in team AC from 8 to 11 percent. Team members indicated that Email was mostly used instead of telephone and postal mail (Appendix B3A). For most members of team AE, Outlook email became the best-used asynchronous communication means, as was the case for most team members of AC. It was used mainly for short messages and appointments. Important messages usually were printed. When put in the project dossier the message needs to be formalized by putting it in a leaflet that was confirmed by team management. Table 3.5 shows, *Outlook calendar use* increased during 2003-2004 in team AE to collective use by all team members, while 7 out of 8 of AC's members used it.

Next, some small, non-substantial changes in the use of synchronous communication means appeared. Team's use of *Formal meetings* changed from 10 percent to 11 percent in team AE and from 9 percent to 11 percent in team AC. Observations during team meetings before the PW-teamwork shop took place, showed discussions in team AE about difficulties with PW-use and the easy use of SD. Also electronic sharing using PW for minutes of meetings and other documents instead of paper distribution was discussed. After the PW-team workshop, these kinds of discussions were no longer observed in AE's team meetings. *Dialogues* remain the most preferred means. Time use for *Informal meetings* by team AE changed from 12 to 18 percent and in team AC from 20 to 19 percent. A reason for team AE's increase of 6 percent might be the move to another location in the beginning of 2003, when two sub-units were joint. Less informal communication could take place before, because of co-location of some AE's team members. Team members did not give any indication that the increase observed was related to PW-use. Also through the other data sources no relation between this change in synchronous communication and PW use was observed. *Shared project disk* use was closed. However, another part of the network disks was used for sharing according to the opinions of team members decreasing from 8 to 6 members in team AE and from 8 to 7 in AC. Finally, no changes in frequency of use of communication means occurred with respect to *Discussions, Facsimile, the Project dossier* and *Postal mail*.

Findings of effects on team communication. Overall results of comparisons show that no effects on team communication by the use of ProjectWise were observed in the experimental (AE) and in the control team (AC). This outcome strengthens the outcome of the comparative analyses on PW-use that team AE's PW-use did not affect team communication.

The secretary got involved in ProjectWise use of team BE because of finalizing PW-files for outgoing postal mail. The control team continued the old paper procedure using the postal chamber. Comparison of the various use of means showed a substantial increase in the use of Email and change to collective use Outlook calendar. Comparative analyses also show the continuation of network disks after closure of the shared project disk by 6 team members of the experimental team and 7 of the control team (Appendix B3A).

It might be observed that the non-adopters being structural engineers and the architect being a laggard, mostly communicate through dialogues, using paper sketches and schemes.

3.2.1.3 Effects on team performance

Effects on team performance were measured first by analyzing each team member's number of file readings of the teams' PW content (Appendix B, Table B2C7). Although the Table shows that the number of team readings by members of team AE was higher than that of team AC, only 3 team members read files at maximum instead of collective readings. In team AE 5 team members out of 8 did read other team members PW-content in contrast to 2 members of AC. Figure 3.7 shows that the curve of the number of readings per month of team AE is higher compared to AC's curve. The Figure also shows a peak in AE's readers curve, one month after the PW-team workshop took place. After decreasing, the curve increases by the end of measurement to the peak level of July 2003. The minimum level of file reading by team members that might contribute to team performance was not reached. This might also be caused by the fact that only 50% of electronic files were stored in PW and team members might also search electronically for files in the network disks in which the other 50% of files were stored. Second, the comparison whether members of other design teams in the same unit read PW-files stored by teams AE and AC for reasons of re-use as displayed in Figure 3.8. The figure show, that AE's content was repeatedly read by a higher number of readers of other teams to more than 10 times in contrast to the number of readers of AC's- PW content, which was read only to a maximum of 4 times by 1 member of another team during measurements. Next, comparison of readings by members of other teams and team members of AE's content, as displayed in Figure 3.9, shows an increase to 25 readings by members of other teams reading AE's PW content in February 2004.

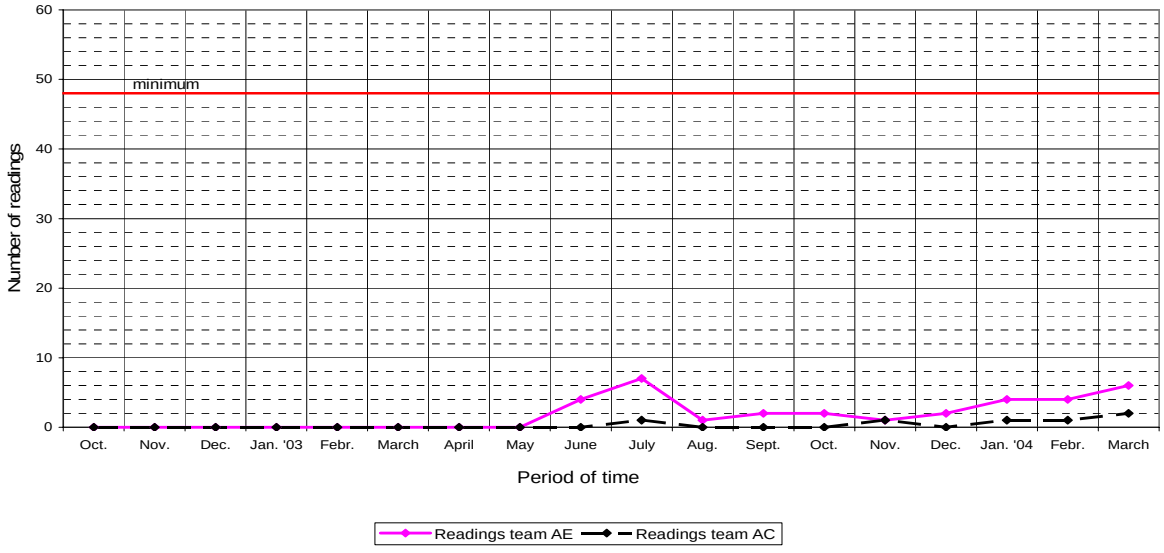

Figure 3.7: Curves of the number of team readings per month by members of team AE and team AC

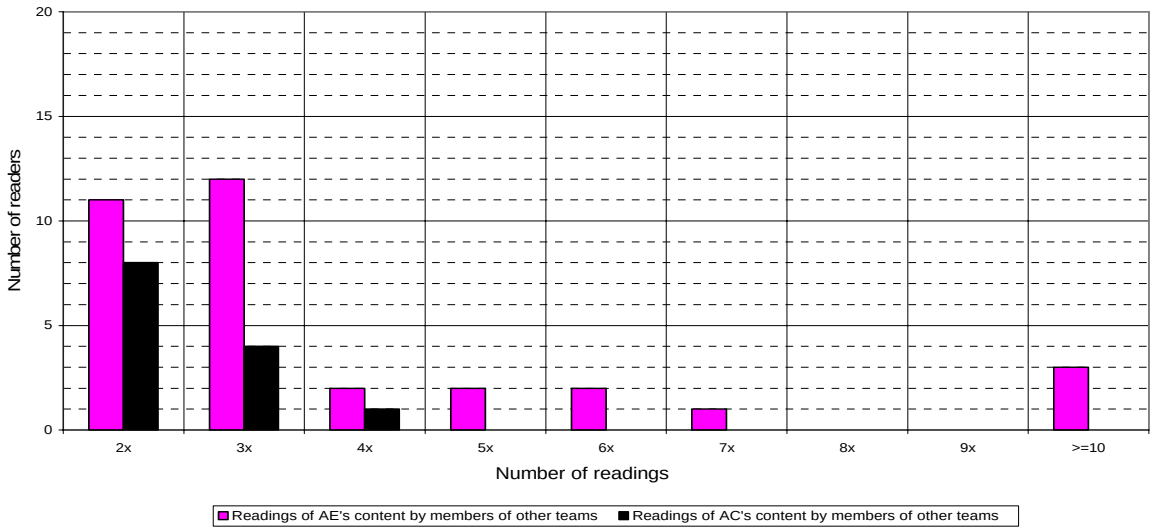

Figure 3.8: Graphs of the number of readers and readings of PW content of teams AE and AC by members of other teams

Although these readings reached a substantial higher level and increased rather steeply than that of team members of AE, the minimum level that might contribute to team performance was not reached. File reading was not restricted to a specific file type but all types of documents were read. It might be that the increase was caused by re-using AE's files at the start of a new project and file reading was promoted by the user platform that was organized in this unit after the PW-team workshop took place.

Finally, the comparison between PW-content and the content of the project dossier show that this dossier contains incoming paper documents concerning official correspondence with the client about client's wishes, finances and changes in design. The quantity concerns about 25% of the total of stored documents, the resting 75 percent concerns design related documents generated by the design team and sent to the client and stakeholders.

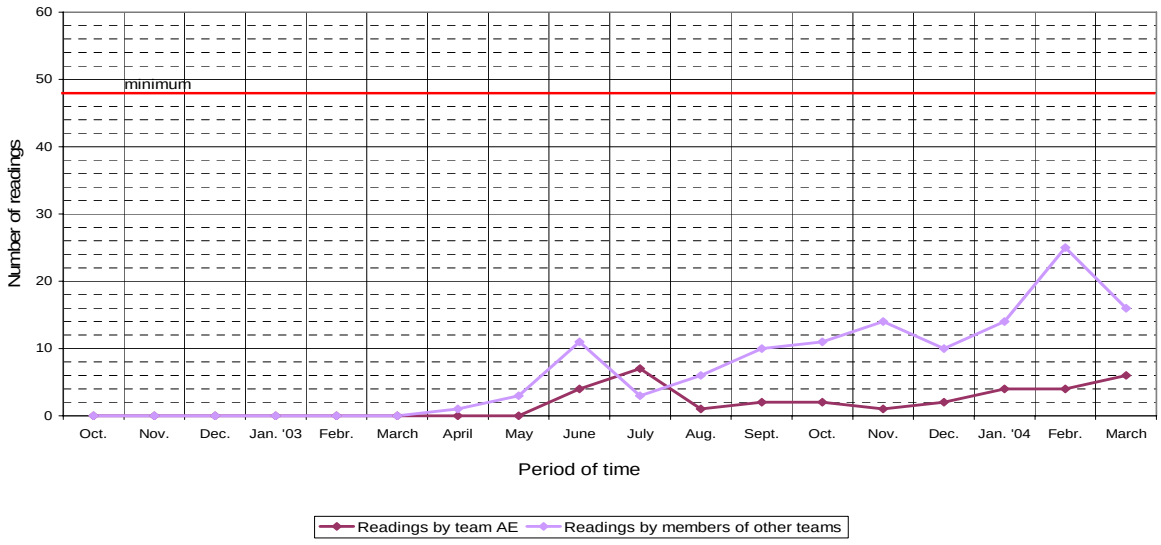

Figure 3.9: Curves of the readings of AE's PW-content per month by members of the same team and of other teams

In the project dossier, copies of electronic documents are grouped in reports, for instance copies of MS-excel sheets, MS-word documents and drawing files in a report of the results of the preliminary design. Compared to the electronically stored files in PW, differences are showed in storing because the electronic files were not grouped and most of the files stored were not finalized. Paper design sketches of the architect, framework drawings and part of drawings of air-central heating installations and electro-technical installations were not stored in PW.

Findings of effects on team performance. Overall then, the results of the comparative analyzes on team performance between the experimental team (AE) and the control team (AC) show, that although team AE's performed better in using PW due to intensive training it was on a substantial lower level than expected that might not contribute to team performance. This fact is strengthening by the finding of actual PW-use that only 50% of the generated files were stored in PW. Because of the existence of other electronic dossiers in the network disks and the project dossier in which all files are present as paper copies, having the right status, and grouped, it can not be expected that AE's, not collective, use of PW contributed to team performance. Team members probably might try first to find files in PW and afterwards, because file searching is not effective if less than 50% of stored files can be found, have to search in other electronic dossiers or have to visit the project dossier to find the information they need.

Rivalry between working in PW and shared project disk / network disks was observed by a high number of team members storing 50 percent of generated files not in PW. The increase in readings of files by other members of the unit for re-use in other projects might be promising to contribute to team performance in these projects.

3.2.2 Results for teams BC and BE

3.2.2.1 Observed use of ProjectWise

Figure 3.10 shows the results of comparative analysis between the experimental team (BE) and the control team (BC) to determine differences in their daily PW-use. The PW-use curve of team BE is rather irregular showing many peaks and valleys that finally decreased. The curve of BC is rather similar although on a lower level. Team BE's curve passed the minimum level defined for effective team communication, only in July 2003, one month after the PW-team workshop took place, when the team gained 15 points.

However, only an average number of 4 out of 8 members used ProjectWise (Figure 3.10), which may be an insufficient number for effective team communication. In team BC, the maximum number of PW users observed was 2. The dips in the curves are caused by specific events: the move of the organization, summer holidays and Christmas-new year holidays when few team members used PW. In the experimental team BE, 4 adopters and 4 non-adopters were identified, of which the project leader was a rejecter, against 2 adopters and 6 non-adopters in the control team BC, of which 2 were rejecters (Appendix B2D).

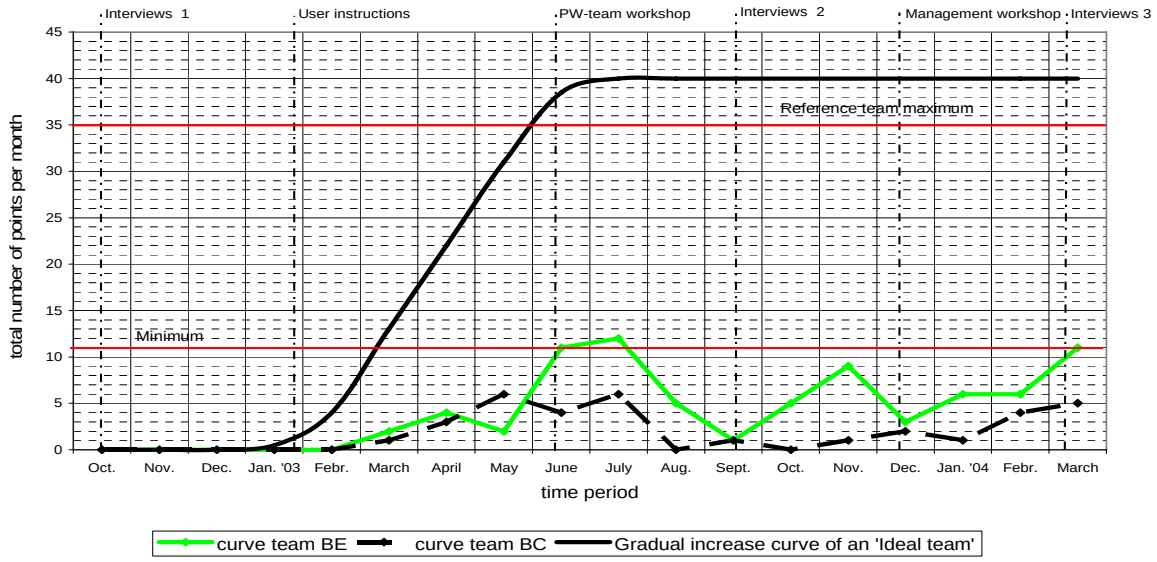

Figure 3.10: Curves of ProjectWise grade points per month for teams BE, BC and for an ideal team

In team BE, the project leader rejected PW in September 2003 after 3 months using the tool. In his opinion PW is a tool mainly meant for designers who store and maintain drawing files. Both the HC-installation designer and the E-installation designer were early PW-adopters. The HC-installation designer is also the PW-coordinator of unit B. Also the team coordinator was a PW-adopter. The unit B's secretarial staff got involved in PW-use of team BE by registration and finalizing of the outgoing postal letters before printing these for sending by postal mail. Letters were stored in PW by team members, instead of sending a paper document by inter office mail for confirmation and registered by the unit's Postal chamber. The structural engineer, quantity surveyor and architect can be identified as non-adopters. In team BC, the HC-installation designer and the E-installation designer adopted PW.

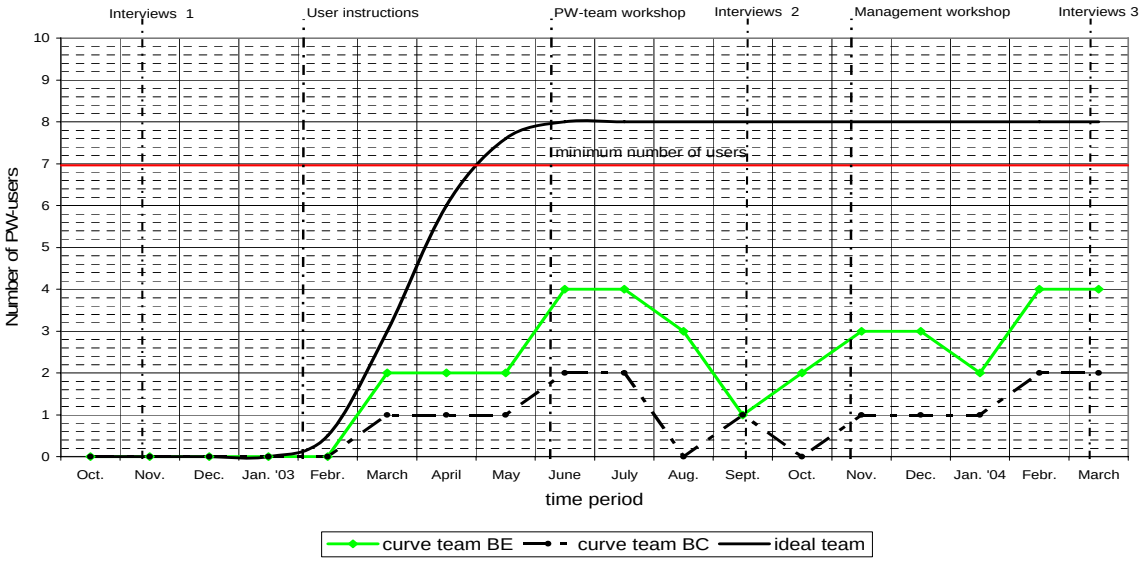

Figure 3.11: Curves of the increase of the number of ProjectWise users in team BE, BC and of an ideal team

Team BC's project leader and the other 6 team members were non-adopters. The quantity surveyor and detail construction designer, which both attended the PW-team workshop, used PW for at least 2 months and then rejected use. Team BC did not use PW for outgoing postal mail and continued to old paper procedure. The structural engineer of both teams mostly used paper and pencil for calculations and sketches as concepts for CAD drawings to be made by the detail construction designer. Because the PW-coordinator of unit B was also a team member of the experimental team, he had less hierarchical power to force prescribed use to team members who rejected PW-use, especially not to the project leader.

Dragging and dropping of files. Figure 3.12 shows that the frequency of dragging and dropping reached some high peaks in team BE and finally increases again, compared to the decreasing curve of an ideal team. Peaks occurred in July 2003, one month after the PW- team workshop an in November. The increase at the end of measurement might be caused by an extra PW-training in the unit at the end of measurement to change shared project disk use to PW-use. Over 50 percent of PW-content of team BE (52 percent) and BC (57 percent) was dragged and dropped (Appendix B2D). Because files are copied by these activities and usually not deleted afterwards in shared project disk, the same files are present in both vaults. Six members of both teams indicated that both shared project disk and PW were used regular.

Stored documents for team sharing. Comparison of PW content of teams BE and BC (Figure 3.13) show that members of team BE stored both drawings and other documents in contrast to team BC whose members mainly stored drawings. Some email messages and no fax messages were stored. Team BE stored more documents for team sharing than team AC although this number still may be low compared to the storage of an ideal team. Minutes of meetings were stored as finalized information ready for re-use.

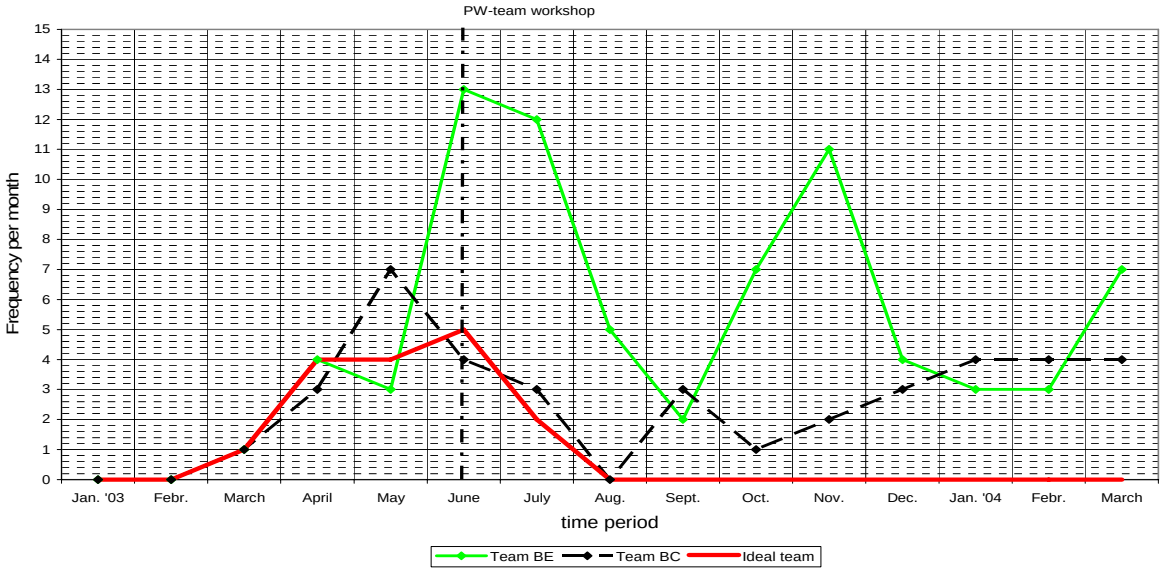

Figure 3.12: Curves of the frequency of dragged & dropped ProjectWise files by teams BE, BC and of an ideal team

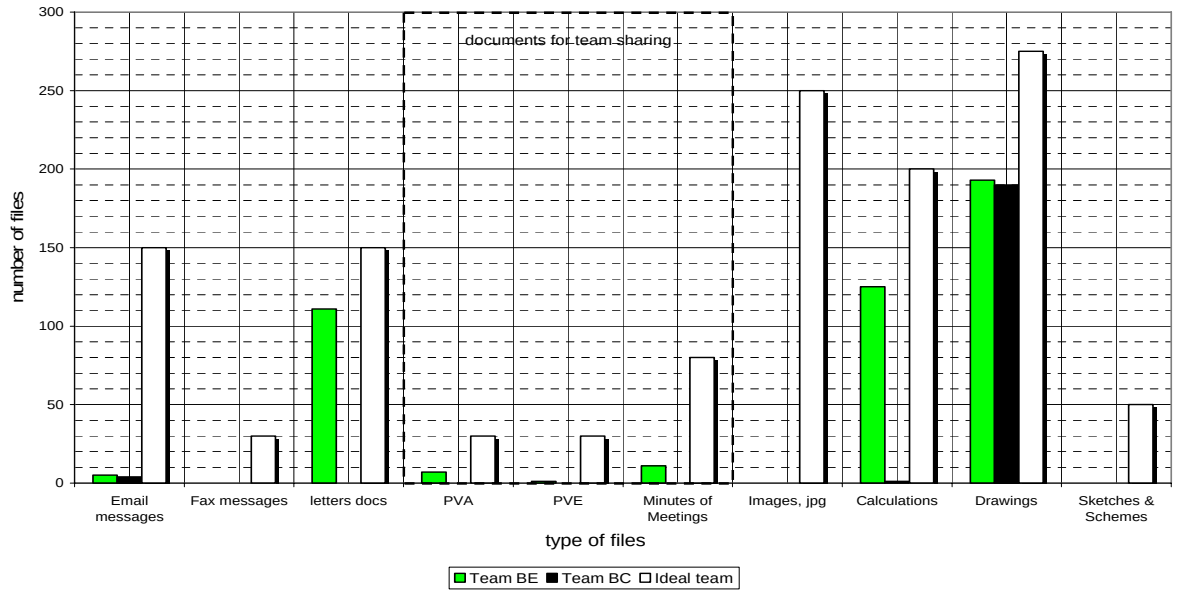

Figure 3.13: Graphs of the type of stored ProjectWise files of teams BE, BC and of an ideal team

These documents mostly were stored in PW by using dragging and dropping. In the last 3 months of the measurements, no minutes of meetings were stored anymore. The fact that in team BC, as many drawings were stored as in team BE strengths the opinion that teams PW-use mainly focused on storing drawings. The use of PW-messenger was stimulated for a short while by the project leader of team BE after the workshop took place. However, because of the lack of functionality for making distribution lists of users, a limited number of persons that could be reached and the fact that Outlook Email had to be used also, team BE stopped using PW-messenger. In this unit, no PW-user platform was organized to discuss PW related problems to improve PW-use for daily work.

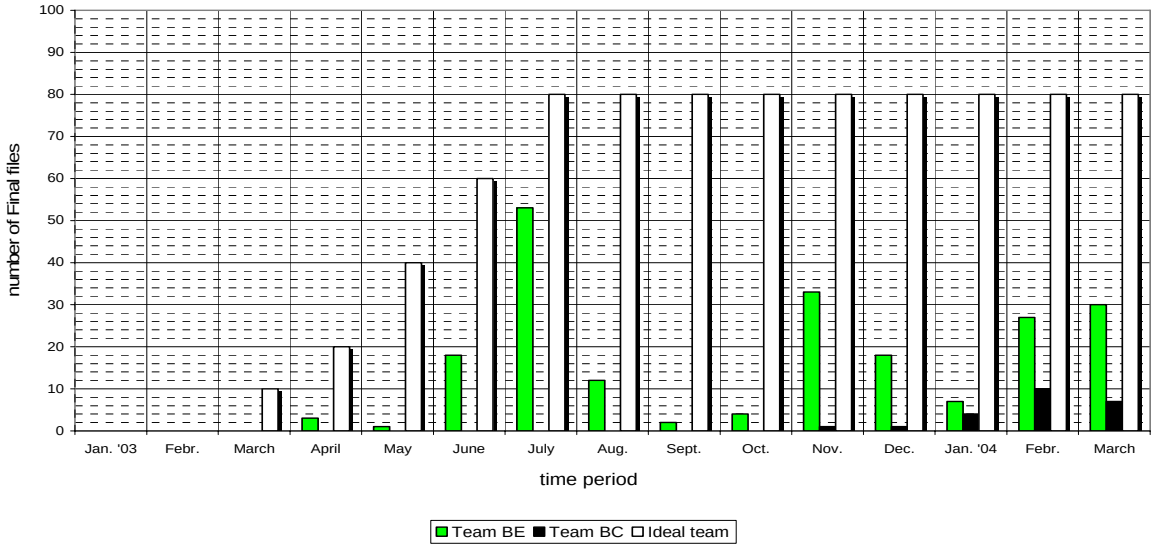

Figure 3.14: Graphs of the number of finalized ProjectWise files by teams BE, BC and of an ideal team

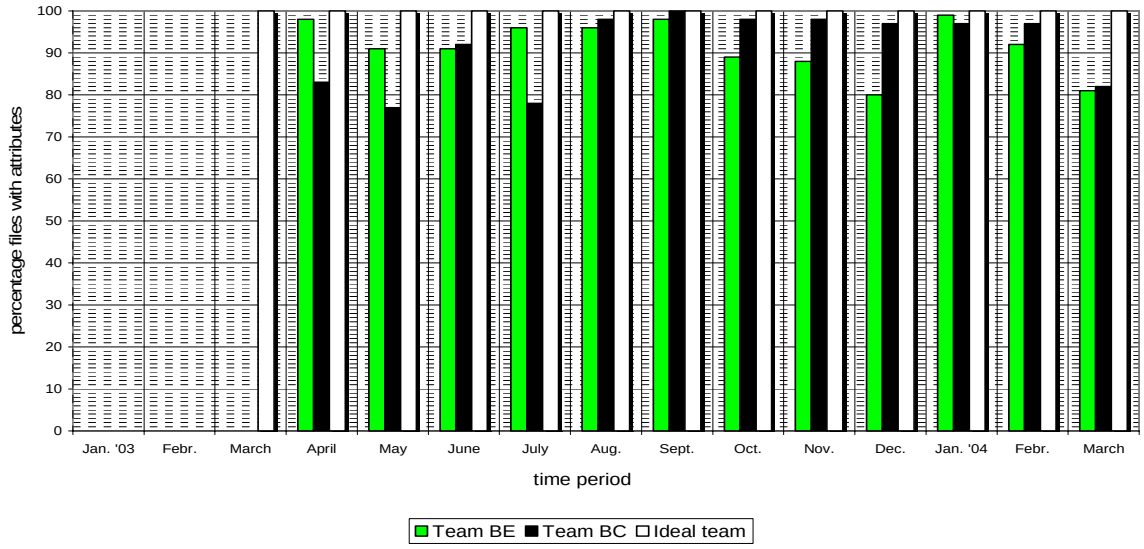

Figure 3.15: Graphs of the number of manually adding of attributes by teams BE, BC and of an ideal team

The project leader and coordinator of team BE used PW mainly for outgoing postal mail. He stored concept letters, which afterwards were finalized by the secretarial staff, printed and signed by the project leader to be sent by postal mail

Change of status to Final. The results of comparative analyses, to determine whether team members changed the status of files to 'Final', are shown in Figure 3.14. It shows that team BE performed better than team BC, which members who made CAD-drawings, only stored few files in the last three months of measurement. This might be due to an extra PW training organized in February 2004 to stimulate PW-use. The overall pattern does not show a regular use of 'change of status' as the graph of an ideal team might show. Dips appear when the organization moved and during summer holidays and Christmas-New year when most team members were not in the office. However compared to the graph of an ideal team, the manually attaching attributes to files decreased at the end of the measurement period. Attaching attributes to stored files should be perfect and accurate because files without attributes cannot be found by using quick file searching in PW (Appendix B2D). Analyzes show that more than 20 percent of PW-files stored do not have attached attributes which easily might make quick file searching not effective, specifically if most generated files were not stored in PW as table 3.21 shows.

Findings about observed ProjectWise use. The results of the comparisons between the experimental team BE and the control team BC show that more members of team BE used ProjectWise more intensively than members of team BC did. However, compared to the level of PW usage of an ideal team, PW use of team BE is much lower than the prescribed PW use with respect to the continued daily use of shared network disk and the change to Final (Table 3.6).

Table 3.6: Overview of the percentage of type of file storage by teams BE and BC and prescribed storage

Team	Actual file storage ProjectWise	Actual file storage shared project disk	Re-use storage ProjectWise
Team BC	15%	85%	1%
Team BE	25%	75%	29%
Prescribed storage	100%	0%	100%

It was observed also that PW was used less for team sharing of documents, and adding of attributes was at a low level. Compared to the high use of shared project disk instead of PW team members might not start searching files in PW. Rivalry between IT tools was observed between Outlook-Email and PW-messenger, and between PW and shared project disk. PW was not used collectively by team BE and its project leader rejected PW-use. The comparative analyses show that only 4 members of team BE used PW in the effective mode of communication, which might be too less for team communication in a team of 8 members and without involvement of the project leader.

3.2.2.2 Effects on team communication

Table 3.7 shows the results of a comparative analyze of the use of communication means in the experimental team (BE) and the control team (BC) in the beginning of 2004. The results of comparison of analyses before and after PW introduction (Section 3.1.2) show that no changes in team communication occurred that were caused by the use of PW. *Outlook email* became one of the preferred communication means. The frequency of use increased in team BE from 7 to 12 percent and in team BC from 5 to 7 percent (Appendix B2D). The comparisons showed non-substantial changes with respect to the use of *Formal meetings* by the teams.

Table 3.7: Overview of the use of communication means by teams BE and BC in 2004

Type of communication means	Preferred means score		Number of team users		Percentage of time used		Frequency per day		Frequency per week		Frequency per month	
	BE	BC	BE	BC	BE	BC	BE	BC	BE	BC	BE	BC
Formal meetings	2	0	8	8	11	13			1x 3wk	1x 3wk		
Dialogues	5	4	8	8					<5, all	<5, all		
Informal meetings	5	3	6	6	15	10	<3, all	<3, all				
Discussions, brain-storm sessions	0	0	8	8							1x 3 month	1x3 month
Postal mail	1	0	8	8			<5, 7p >5, 1p	<5, 7p >5, 2p				
Telephone	4	2	8	8			<5, 2p >5, 6p	<5, 6p >5, 2p				
Facsimile	1	0	8	8			<5 all	<5 all				
Outlook email	5	4	8	8	12	8	<5, 3p >5, 5p	<5, 6p >5, 2p				
Outlook calendar	1	0	5	5			<5, all	<5, all				
Shared project disk	0	0	6	6			<5,all	<5, all				
Project dossier	0	0	8	8					<5, all	<5, all		

Time used changed from 12 to 11 percent in team BE and from 9 to 13 percent in BC. Based on results of observations of team meetings, the increase of 4 percent in team BC was not related to PW use. The changes of 2 percent in team BE and 4 percent in team BC is considered as a rather normal deviation in duration of a meeting of 1,5 hour. The use of *dialogues* (Table 3.7) is no longer the only most preferred means of communication.

Changes in time used for *informal meetings* show a decrease to 1 percent difference in time used by team BE, from 14 to 15 percent, and from 14 to 10 percent in BC. The decrease of 4 percent in team BC, which is less than half an hour of daily office time, is non-substantial as argued in section 3.11. Team members did not indicate this change was related to PW use. *Postal mail* was used more to the opinion of some team members, which increase was not related to PW-use. *Outlook calendar* was used by 5 members of both teams, which number is too low to function as a collective communication tool in a team of 8 members.

Shared project disk was still used as the table shows, by 6 members of team BE and 5 members of team BC according to the opinion of team members. The use of *Discussions, Facsimile and the Project dossier* also did not show changes. The paper procedure of *outgoing Postal mail* was changed to an electronic process using PW for registration and finalizing of letters by the secretarial staff in July 2003.

Findings of effects on team communication. Effects on team communication due to the use of ProjectWise were not observed in the experimental team BE nor in the control team BC. This result might be expected because only 4 members out of a team of 8 used at ProjectWise highest. Only the frequency of Outlook Email use showed an increase and this means became one the preferred means of communication. According to the opinion of 6 members of the experimental team the use of shared project disk was continued (Appendix B3C). The non-adopters being architects and structural engineers, mostly communicated face-to-face using paper sketches and schemes.

3.2.2.3 Effects on team performance

First, analyzing of effects on team performance by comparisons whether team members read stored files in PW of other team members show that zero members of team BC read files of colleagues and 6 members of team BE read files from more than 1 time up to more than 10 times (Appendix B3D, Table B2D7). Although the level of readers of team BE was considerably higher than that of BC, BE's team members did not read collectively other team members stored files. Figure 3.16 shows that in the curve of team BE a peak in team readers can be observed in the period directly after the PW-team workshop took place, and afterwards showing a slow decrease although some peaks can be observed (Figure 3.16) never reaching the first peak. The minimum number of file readings that might contribute to team performance was never reached. In contrast to the team readings of BE, the curve of team readings of team BC show zero activities except for one reading in February 2004.

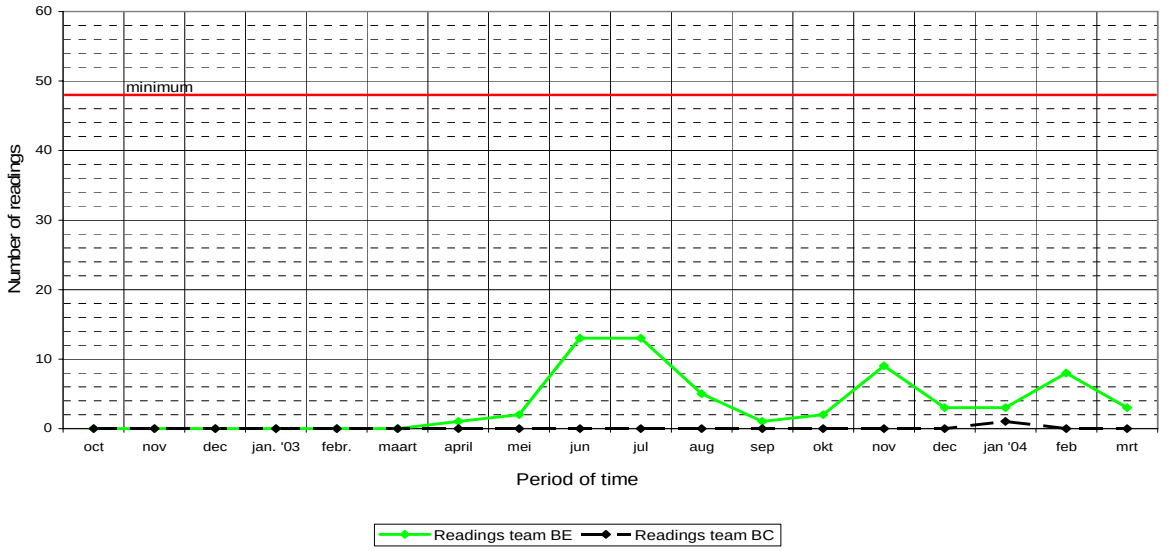

Figure 3.16: Curves of the number of readings of PW-content per month of teams BE and BC

Second, the comparison of readers of other teams in the unit, reading PW-content of team BE and BC show that more members of the unit read team's BE content (Figure 3.17). If we compare the number of readings of BC's content by members of the unit with that of members of BE, which team had the highest number of readers, comparable peaks and valleys can be observed although readings of BC's content is lower than that of BE. Shared project disk was continued in use for actual file storage instead of PW as Table 3.7 shows. Next, the comparison of readers of other teams in the unit and team readers of BE's PW-content (Figure 3.18) show that the curve of unit readers did not increase but decreased in time, while the curve does not pass the minimum line for the numbers of readings that might contribute to team performance.

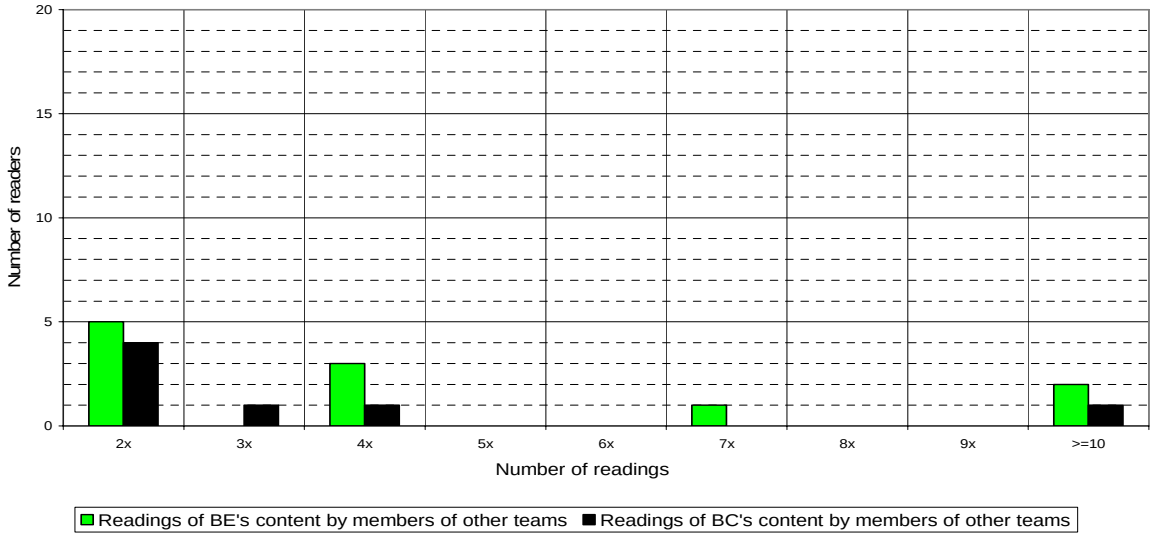

Figure 3.17: Graphs of the number of readers and readings of PW content of teams BE and BC by members of other teams

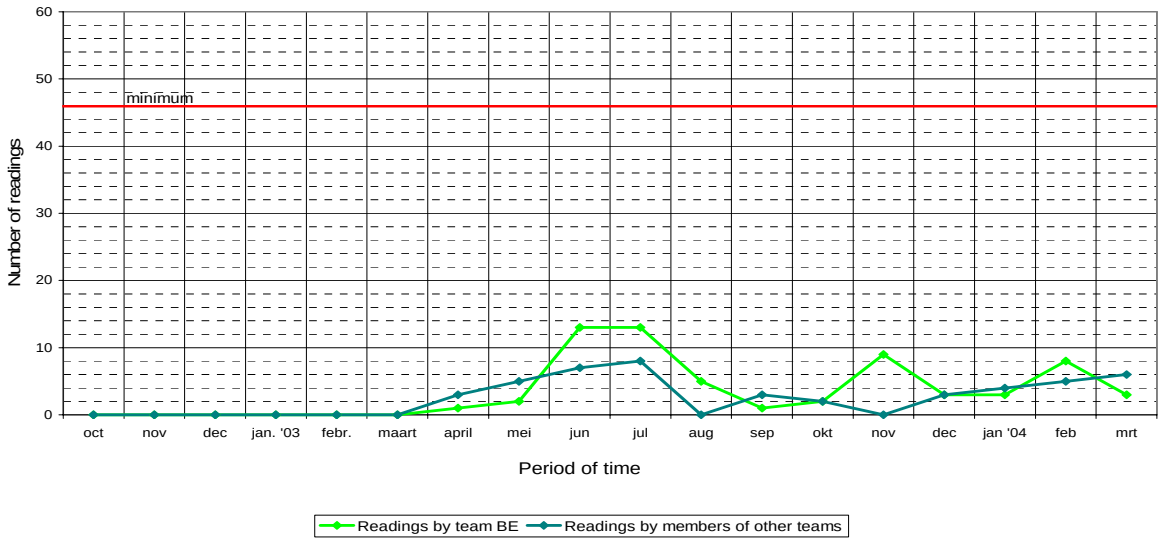

Figure 3.18: Curves of the readings of BE's PW-content per month by members of the same team and of other teams

Comparison of both curves show a similarity in peaks that might be related to a specific event; the PW-team workshop taking place in June 2003. The curve of readers of other teams in the unit increases at the end in contrast to the team readers decreasing curve.

Finally, the content of the project dossier was compared to PW-content. In the project dossier, one fourth of the total content concerns incoming files showing correspondence with the client about client's wishes, finances and changes in design. The remaining 80 to 70 percent concerns generated documents of the design teams. These documents are mostly grouped in reports instead of being separated word- excel and other type of documents as is the case in PW. Its users additionally can group PW-files.

Findings of effects on team performance. Overall then, the results of comparative analyses of ProjectWise use between the experimental (BE) and the control (BC) team did not show a contribution to team performance although team BE's intensive training show a substantial increase in use and reading of PW-content. It was also observed that team BE's reluctant use of PW by too few team members, differs highly from prescribed use to be effective for team communication using PW. The continuous use of shared project disk by most team members and the storage of 60 percent of electronic generated files in this medium show the rivalry between PW and shared project disk.

3.2.3 Results for teams CC and CE

3.2.3.1 Observed use of ProjectWise

The result of comparative analyses between experimental (CE) and control team (CC) to determine any differences in their daily PW-use is displayed in Figure 3.26. Team CE's irregular curve is quite different from the curve of team CC that stayed at a very low level.

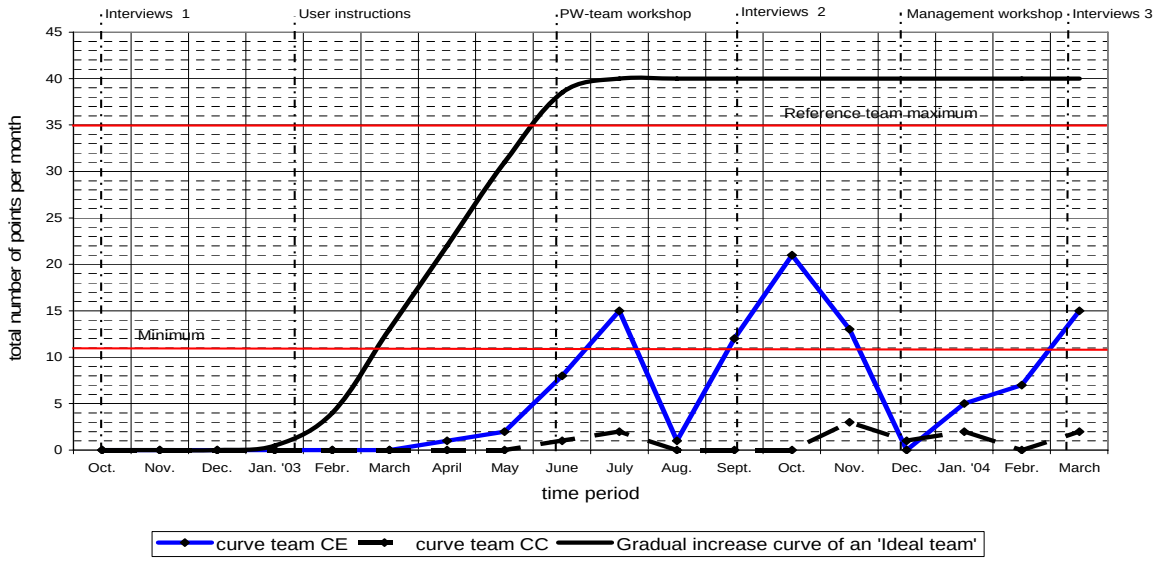

Figure 3.19: Curves of ProjectWise grade points per month for teams CE, CC and for an ideal team

Figure 3.19 also shows that although CE's curve is higher it did not reach the defined level of the curve of an ideal team. Team CE could only reach the highest point level of 21 points in November 2003 when the design had to be finished. Later it dropped back finally to 15 points. The PW-team workshop enhanced team CE's curve that much that it passed the minimum level for effective team communication in June-July 2003. In team CE finally 4 adopters and 4 non-adopters were identified, three of which were laggards (Figure 3.20). In team CC one adopter and 7 non-adopters were identified of which one is a laggard (Appendix B2E). The PW-team workshop was the start of PW-use for the project leader, architect and detail construction designer. The structural engineer, the detail construction designer and E-installation designer can be identified as laggards who seemingly random use both PW and shared project disk.

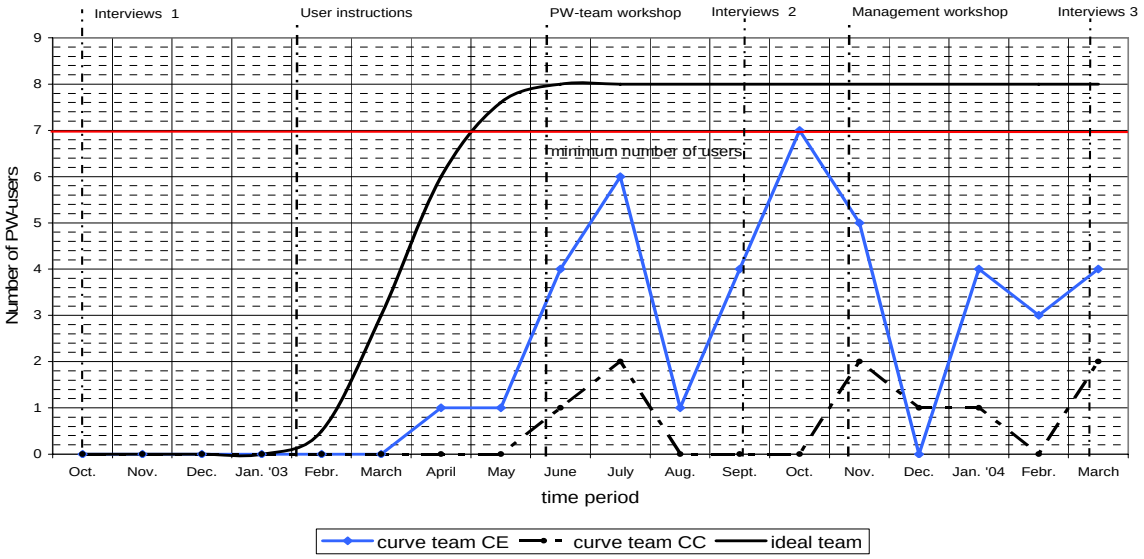

Figure 3.20: Curves of the increase of the number of ProjectWise users in team CE, CC and of an ideal team

In team CC only the HC-installation designer used PW. The project leader and all other team members used the shared project disk instead of PW. The dips in CE's curve are caused by specific events: the summer holidays and Christmas-New year holiday when few team members used PW. Five team members of tem CE and 7 of team CC indicated that they continued the use of shared project disk after the PW-team workshops took place (Appendix B2E).

Dragging and dropping of files. In Figure 3.21 the comparison of frequency of file dragging and dropping in PW is displayed. The figure shows that CE's curve most increased after dips due to the summer holiday and Christmas-New year. However, the frequency of dragging and dropping of files should decrease during use when users get more familiar with daily ProjectWise storage as shown in the Figure. 3.21 by the curve of an ideal team. Almost sixty percent of the total of files stored by team CE were dragged and dropped out of shared project disk, in team CC this percentage is 85 percent (Appendix B2E). An extra PW-training provided in the unit in February 2004 might have caused the increase of dragging and dropping in March. Although the team coordinator, the detail construction designer and E-installation designer used PW regular, they also used shared project disk.

Stored documents for team sharing. The results of comparison of document storing for team sharing between the experimental and the control team are showed in Figure 3.22. It demonstrates that team BE's documents storage for team sharing is higher than that of team BC, although still much lower than that of an ideal team. Facsimile messages were not stored.

Change of status to Final. Figure 3.23 shows the comparison of the degree of status change of documents to final in teams CE and CC. It shows that team CE changed more documents to final than team CC did.

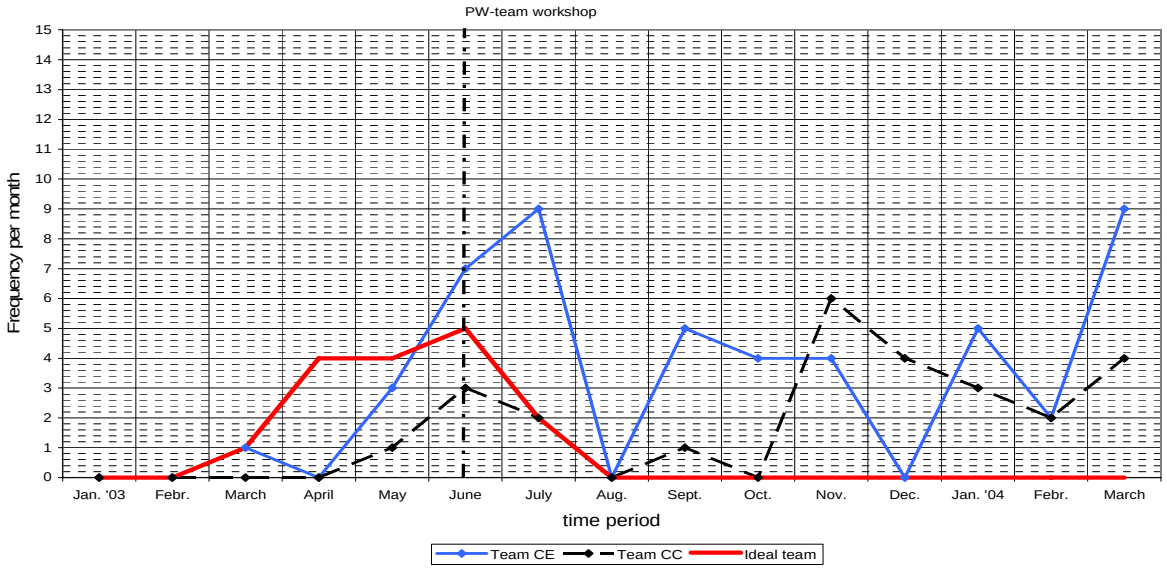

Figure 3.21: Curves of the frequency of dragged & dropped ProjectWise files by teams CE, CC and of an ideal team

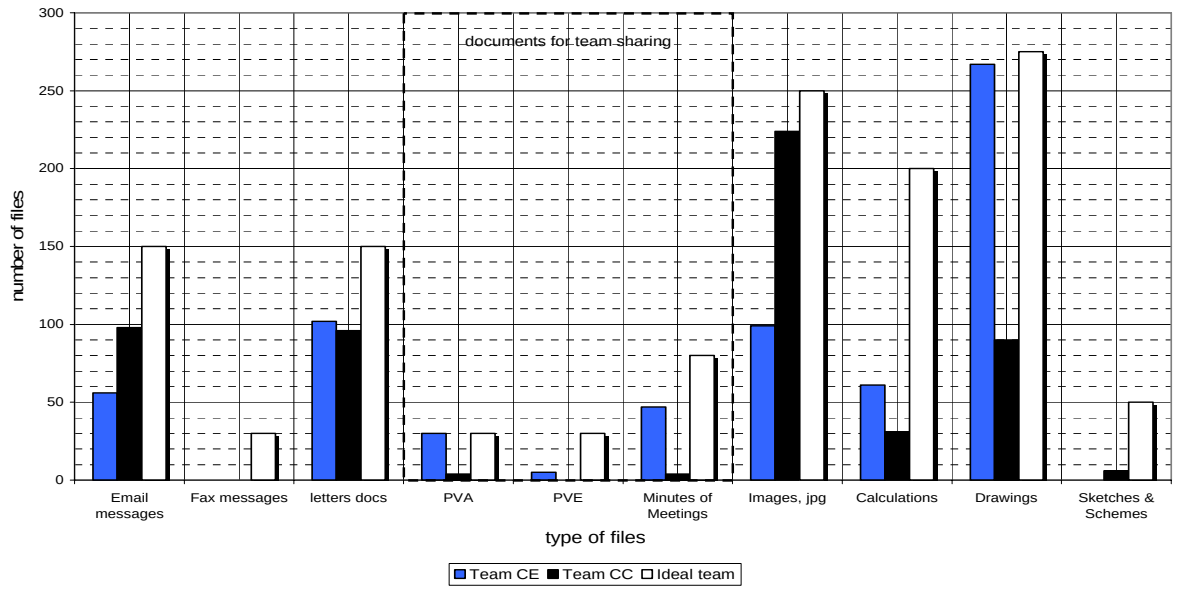

Figure 3.22: Graphs of the type of stored ProjectWise files of teams CE, CC and of an ideal team

The figure also shows that no regular activities for change to final took place in experimental or control team. However, the degree of finalizing by team CE is still small compared to the degree of finalizing of an ideal team. Finalizing only took place after specific events; peaks occurred in July 2003, after the PW-team workshop that was held a month before, and in February 2004 when extra PW-training was organized. We observed that all PW-adopters of team CE used the change to Final option only once during the 15 months of measurement. In team CC, files were finalized only once by one person; the detail construction designer.

Adding of attributes. The degree of the manually adding of attributes to files by teams CE and CC is shown in Figure 3.24. The graphs show differences between both teams, finally decreasing instead of increasing in time. The adding of attributes was never perfect.

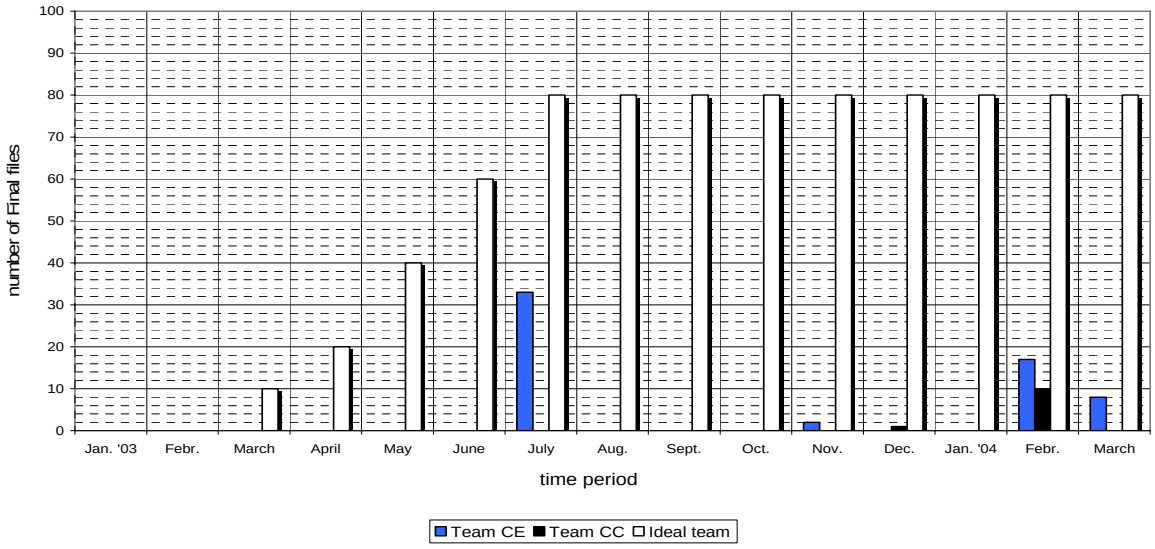

Figure 3.23: Graphs of the number of finalized ProjectWise files by teams AE, AC and of an ideal team

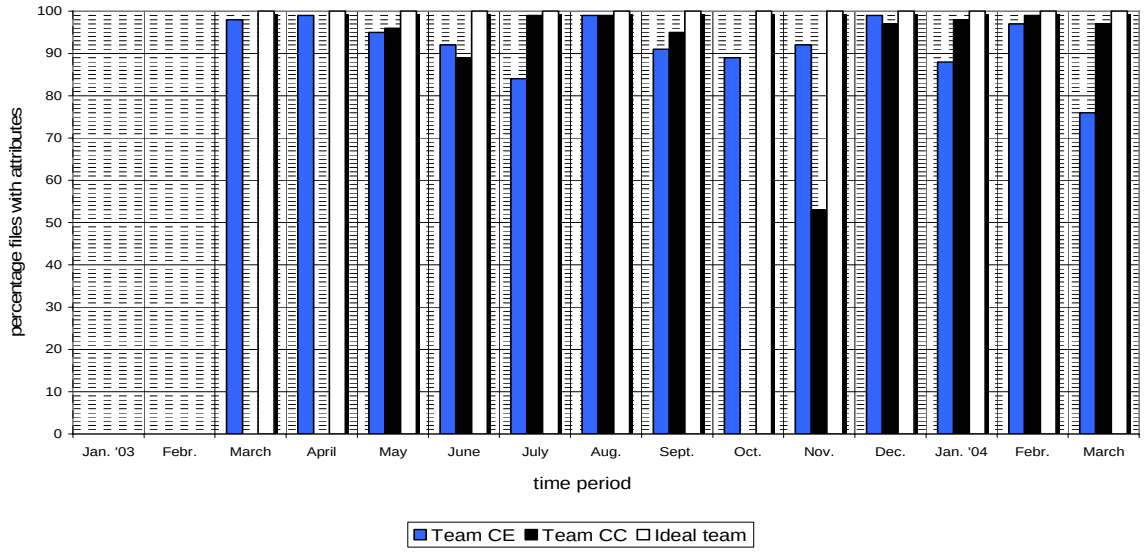

Figure 3.24: Graphs of the number of manually adding of attributes by teams CE, CC and of an ideal team

Reflected to the manual adding of attributes of an ideal team, it shows that this activity was inaccurate and never perfect. Over 35 percent of stored PW-files of team CE does not have attributes attached which makes quick file searching problematic (Appendix B2E).

Findings about observed ProjectWise use. Overall than, the results of comparisons of analyses between the experimental team (CE) and the control team (CC) show that ProjectWise was not used collectively by team CE although its number of users and the frequency of use was higher compared to use by team members of CC. Reflection of these findings to prescribed use as illustrated by the outcomes of an ideal team show that team CE's PW use is at a substantial lower level. Discrepancies of prescribed use are illustrated by: the continued use of Shared project disk, the low change of file-status to Final (Table 3.8), the low degree of attaching attributes to files and the storage of documents for team sharing and reading of PW-content. The comparative analyses show that effective mode of PW-communication was restricted to the project leader and 3 other members of team CE which is expected to be too less to be effective for team communication in a team of 8 members.

3.2.3.2 Effects on team communication

The results of comparative analyses of the use of communication means by members of team CE and CC at the end of the measurement period is displayed in the matrices of Table 3.9.

Table 3.8: Overview of the percentage of type of file storage by teams CE and CC and prescribed storage

Team	Actual file storage ProjectWise	Actual file storage shared project disk	Re-use storage ProjectWise
Team CC	5%	95%	1%
Team CE	40%	60%	10%
Prescribed storage	100%	0%	100%

Table 3.9: Overview of the use of communication means by teams CE and CC in 2004

Type of communication means	Preferred means score		Number of team users		Percentage of time used		Frequency per day		Frequency per week		Frequency per month	
	CE	CC	CE	CC	CE	CC	CE	CC	CE	CC	CE	CC
Formal meetings	3	5	8	8	14	11			1x 3wk	1x 3wk		
Dialogues	7	5	8	8					<5, all	<5, all		
Informal meetings	6	5	8	8	18	23	<5, all	<5, all				
Discussions, brain-storm sessions	0	0	8	8							1x 3 month	1x3 month
Postal mail	0	0	8	8			<5, all	<5, all				
Telephone	4	7	8	8			<5, 4p >5, 4p	<5, 2p >5, 6p				
Facsimile	1	1	8	8			<5, all	<5, all				
Outlook email	4	6	8	8	10	11	<5, 2p >5, 6p	<5, 2p >5, 6p				
Outlook calendar	0	2	7	7			<5, all	<5, all				
Shared project disk	0	0	7	8			<5, all	<5, all				
Project dossier	0	0	8	8					<5, all	<5, all		

Comparison of these results with the results of the analyses before PW was introduced, show no noteworthy changes can be observed which might be caused by ProjectWise use. A substantial change in *Outlook calendar* use was observed. Although 7 members out of 8 of both teams used this means, to be effective for team communication all members need to participate. Also a noteworthy change was observed in the use of *Dialogues.* This communication means remains the preferred means of team CE but in team CC, team member's opinion changed to telephone use. Time used for *Formal meetings* changed from 11 to 14 percent in team CE and from 19 to 11 percent in team CC (Appendix B2E). The 8 percent decrease for team CC's formal meetings was caused by less use of formal checklists in meetings. No member of team CC indicated any relation of this decrease to PW-use.

Findings of effects on team communication. Overall, the comparative analyses suggest that the introduction of ProjectWise does not cause any effect on team communication in the experimental team CE and in the control team CC. This is likely caused by the fact that only half the team (4 members out of a team of 8) used PW. Shared project disk was continued in use by team CE according to the opinions of 7 team members. It was observed that the non-adopters being quantity surveyors and laggards being architects both used the shared project disk and MS-email for team communication instead of PW (Appendix B3D).

3.2.3.3 Effects on team performance

First, the analyses on the effects on team performance by using PW concerning whether team members read files stored files by other team members show that the number of team members of team CE was substantial higher than those of team CC, reading a higher number of files. In team CC, most team members (5) did not read files of other team members (Appendix B2F).

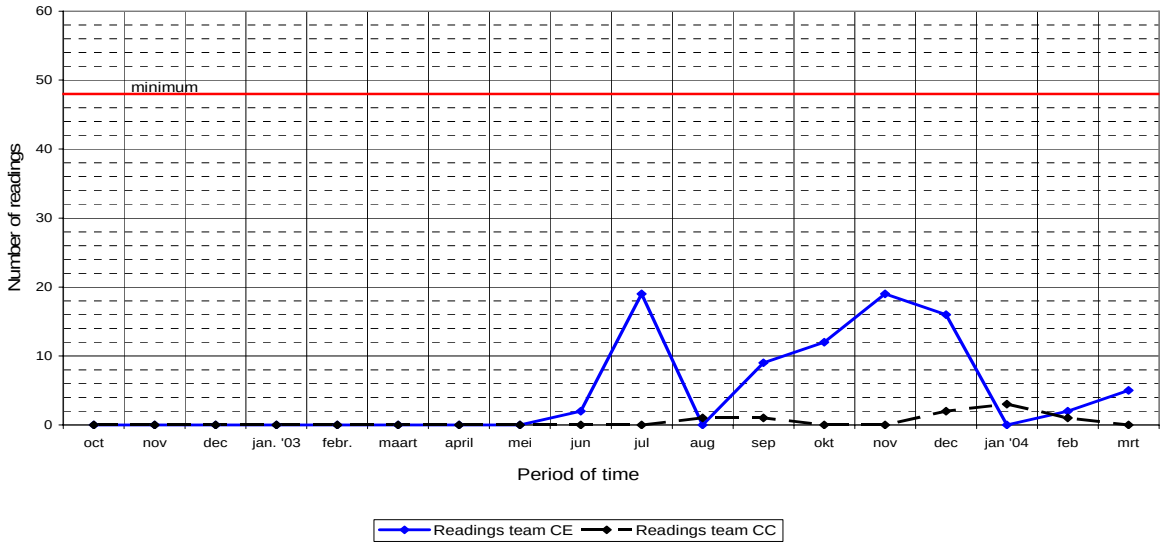

Figure 3.25: Curves of the number of readers of PW-content per month of teams CE and CC

The curve of readings of members of team CE per month is considerably higher than that of team CC that almost shows no activities. However, compared to the readings by an ideal team, team reading of CE is substantial lower (Figure 3.25). Three to 4 team members mostly executed team readings. Only in November 2003 when a design had to be finished the number of readings increased to 7. The Figure shows that the minimum level of team readings that might contribute to team performance was not reached. Because only 40 percent of all generated files can be read in PW, team members most likely will also search in shared project disk in which 60 percent of design files were stored. *Second*, the comparison whether members of other teams in the unit show interest in ProjectWise-content by readings of CE's PW-content show that CE's content was substantially read more than CC's content to more than 10 times by 2 members of other teams against 4 times as a maximum of CC's content (Figure 3.26). Next, the comparison between the number of readers of the own team and other teams, reading CE's content (Figure 3.27) show that the curve of readers of other teams decreases in time instead of increases. The curve also does not reach the minimum level for readers to contribute to team performance. The team readers curve and the curve of readers of other teams show irregular patterns with similar dips during holidays and because of the readings of project documents at the end of a design phase in November and December 2003.

Finally, the comparison between the content of the project dossier and PW-content shows that 30 percent of the project dossier concerns incoming files about correspondence with the client about client's wishes, finances and changes in design. The rest of the content concerns generated and grouped files in reports by the design teams. Only a small percent of separated documents were observed as stored in PW concerning word, excel and other documents. Mostly these types of documents were grouped in reports for advising the client in design decisions. In unit C no user platform was organized to discuss PW-use and adoption.

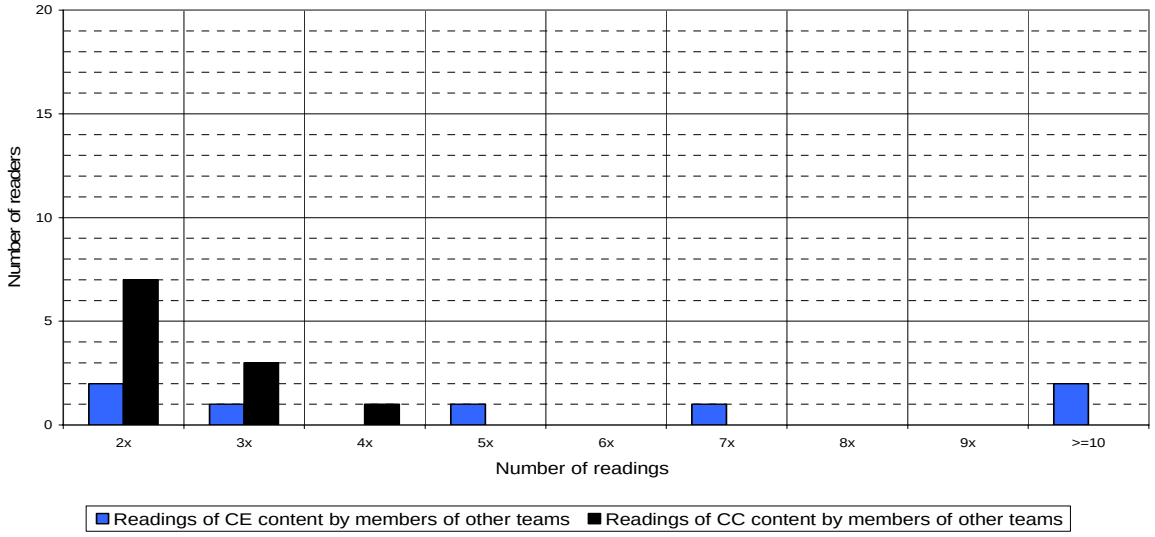

Figure 3.26: Graphs of the number of readers and readings of PW content of teams CE and CC by members of other teams

Findings of effects on team performance. Overall, the findings of the comparative analyzes between the experimental (CE) and the control (CC) team show, that although team CE showed better results in use of the tool and readings of PW-content by team members, due to intensive training, too small effects were observed that might contribute to team performance.

3.3 Conclusions

ProjectWise (PW) use was investigated by using a quasi-experimental design for a multiple case study in three organizational units of a national operating Real Estate Agency (REA).

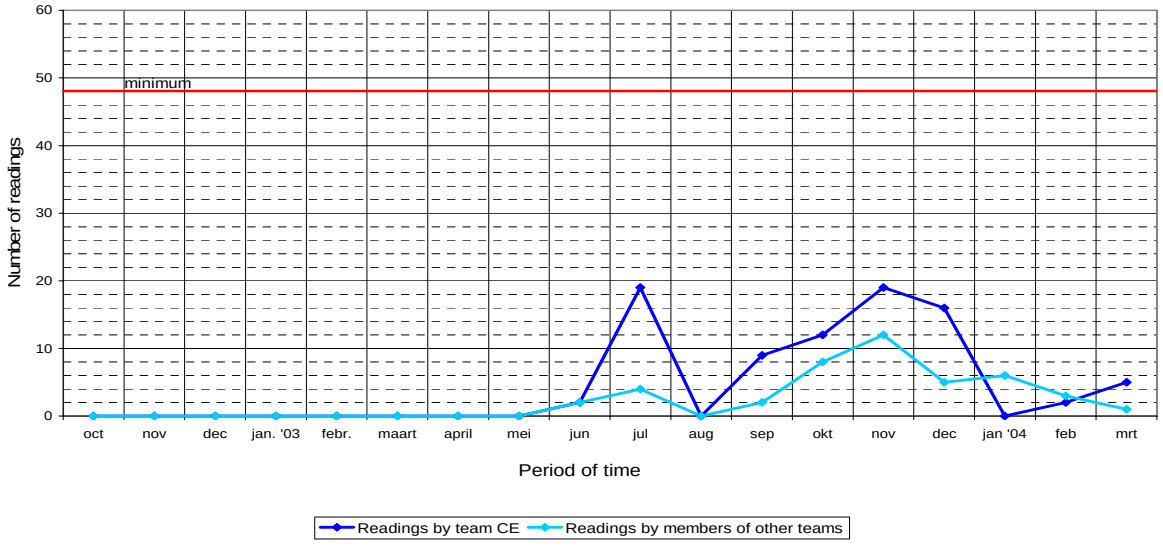

Figure 3.27: Curves of the readings of CE's PW-content per month by members of the same team and of other teams

The tool was introduced in all units in the same way, but the experimental teams viewed, got an extensive training. The results of the multiple case studies as described in Section 3.2.1, 2 and 3., show that PW was used more by team members of the experimental teams but not used collectively by all members and non-adopters mostly concerns the architects and structural engineers mostly using face-to-face communication and paper. No effects on team communication and some small effects on team performance were detected.

The findings also show that the frequency of use of the tool of the best performing experimental team, team AE, was still substantially lower than expected by management and reflected in the use of an ideal team.

The comparison of electronic generated files to the content of the project dossier showed that less electronic files were stored in PW compared to the paper copies in the dossier and no electronic files were grouped and not showing that they are related to each other as the paper copies do which often were put together in a report and in that form of appearance were sent to the client and stakeholders.

The risk of costs of failures easily might increase, due to the increased redundancy of information caused by the storage of electronic generated files in ProjectWise and in shared project disk or another part of network disks. Thus, it can be concluded finally that the productivity paradox, observed in use of other types of IT tools, can be observed corresponding for the use of ProjectWise.

Although overall the impact of ProjectWise use on the changing use of the available synchronous and asynchronous communication means was less than anticipated, some differences between the units were observed. In the next chapter, we will analyze whether these differences can be attributed to differences in office culture/ structure and management style.

In chapter 5 the results of the multiple case studies will be reflected to experiences of use of the same and different Project Website packages in other organizations to generalize conclusions whether the productivity paradox observed in the multiple case studies, is specific to this organization or can be observed also for the use of different Project Website packages in other organizations in the Dutch construction and offshore industry.

Chapter 4: Possible causes of differential ProjectWise adoption

4.1 Introduction

In the previous chapter, we have reported on similarities and differences between experimental and control design teams in terms of ProjectWise (PW) use, means of communication and productivity for three units separately. The findings of these analyses suggested that the productivity paradox observed for the diffusion of many examples of technology also is relevant for the use of Project Websites (PWS) in design teams. The findings, however, also provided evidence of differential adoption of PW between units, which may reflect differences in management style and culture. In this chapter, therefore, we will identify possible causes of such differential adoption of PW. To detect whether differences in PW-use can be related to differences in management style, management interventions that stimulated team members to adopt PW were compared across units. Moreover, the outcomes of these comparative analyses will be evaluated against the literature to identify possible causes of differential PW-adoption.

4.2 Possible causes

To discuss differences in management style and culture in units comparative analyses were executed, first of management interventions to stimulate PW-adoption on all REA's management levels, and next to changes in user involvement observed in teams and units regarding use of IT tools for team communication, to identify change agents.

4.2.1 REA's management style

It was observed that PW was implemented using a top-down approach, first introduced by REA's central management and then by the managers of the units. REA's central management decided to implement PW based on the report of a workgroup concerning returns on investment of PW-use in design teams (Appendix A.1). PW-use instructions were only given to small groups (5 persons) at the start of PW-use in January 2003, because management expected that after this instruction, team members would easily learn how to use the tool. Team members were expected to use PW at their own workplace by using the manual in which all functions and users' responsibilities were listed and explained. Only after almost three months after the start of PW-use, in April 2003, each unit manager, pushed by REA's central management, appointed a PW-coordinator. The unit managers were pushed to appoint a coordinator because users in all units complained about problems related to the use of the tool and because of analyses by the PW-application manager showed that very few team members used PW. The PW-coordinators tasks were not defined clearly at the start and focused on problem solving.

Their main task was to facilitate team members' acquaintance with PW-use and to assist them when problems occurred. The PW-coordinators also had other tasks in the unit. The one in unit A was a senior staff member of the business department, who kept direct contact with unit and team management and organized the PW-user platform. The PW-coordinator of unit B was an IT-system manager and also a member of the experimental team. Being a team member made it more difficult for him to operate independently for all teams and staying in direct contact with unit management compared to the one in unit A. The PW-coordinator in unit C had an assistant manager background and mostly stayed in contact with unit management. He generated an additional PW-manual specifically tuned at unit C.

Central management initiated the PW-team workshops organized in June 2003 in each unit to get team members more involved in the change to PW-use and to solve the continuous flow of reported use-problems. The workshops were organized in joint cooperation between central management, unit management and PW-management (PW-application manager, PW-coordinators and IT-system management). The project leader and team coordinator of the experimental teams and members of all units' design task groups were trained in using the tool collectively for specific tasks and in solving user problems that occurred during the training. During these workshops, for the first time, unit and team management and team members had the opportunity to discuss collective PW-use and targets of use. The workshops also had to demonstrate to team members that PW could be used for all tasks without problems. We did, however, observe differences in these workshops between unit management and workshop management concerning communication and PW-commitment.

Unit A's manager showed commitment in changing work habits by opening the workshop, participating in PW-use discussions and evaluating the outcomes. Afterwards, he initiated the closure of the shared project disk, a suggestion made by PW-users during the workshop. This action and organizing a PW-user platform in the unit reflects a bottom-up approach, involving users in the change process, which we did not observe in units B and C. The deputy manager of unit A was not only actively involved in the change by executing the closure of the shared project disk, but he also used a computer in his daily work and was able to use PW. The user platform however was not led by the PW-coordinator but by a team coordinator whose opinion was that PW-features were not beneficial in daily work.

Unit B's manager and deputy were less committed compared to unit A's management and showed more indifferent behavior towards PW-adoption. Most PW-activities were delegated to the PW-coordinator in this unit. The unit manager only opened the PW-team workshop and did not participate in PW-use discussions and evaluation of outcomes, which was done by the PW-coordinator. Unit B's deputy was not present at the workshop either. In contrast to the deputy in unit A, this deputy hardly ever used a computer and was not familiar with PW-use. He showed concerns for a growing lack of face-to-face communication due to the use of IT tools.

He was also very interested in concepts for integral design and team member's change in attitude towards design, but he doubted that ProjectWise could be used for this purpose. The rejection of PW-use by the project leader of the experimental team in this unit shows a lack of awareness at team management level about PW-use affecting team performance.

The manager of unit C also showed less commitment to PW-adoption, although he was present at the PW-team workshop, which he opened. The PW-coordinator led the workshop and its evaluation afterwards. Only in this unit, all members of all design disciplines were present. In the PW-team workshop in unit A the structural engineer and architect were not present; in the one in unit B none of the architects joined. Unit C's manager left the organization two months after the PW-team workshop took place and unit C's deputy manager was much less involved in the change of using PW. This deputy expressed concerns about other changes in the organization. The deputy became the new unit manager at the end of 2003. He ordered new PW-trainings to enhance PW-use in the beginning of 2004.

The PW-team workshops were the real start of PW-adoption, as demonstrated by the substantial increase in use by team members of the experimental teams, and also were the start of the bottom-up approach in unit A, whose experimental team adopted PW better. The higher increase in PW-use and higher adoption level in unit A by both teams compared to the ones in unit B and C might also demonstrate the importance of a bottom-up approach and the active involvement of unit management. At a team management level, in all units, the team leaders who were made responsible for the prescribed use of PW argued that they lacked the managerial authority to enforce prescribed PW-use to non-adopters or rejecting team members.

4.2.2 Management interventions

Comparison of management interventions at the unit level shows that prescribed PW-use was scheduled to start in all units and all teams in January-February 2003 (Table 4.1).

Table 4.1: Overview of differences in management interventions between units and teams

REA's management interventions	Unit A		Unit B		Unit C	
	AE	AC	BE	BC	CE	CC
Prescribed use of PW in projects	Yes	Yes	Yes	Yes	Yes	Yes
Appointment of independent PW-coordinator	Yes	Yes	No	No	Yes	Yes
Closure of shared project disk	Yes	Yes	No	No	No	No
PW-user platform	Yes	Yes	No	No	No	No
PW-team workshop	Yes	Yes	Yes	Yes	Yes	Yes
Unit manager participation in workshop	Yes	Yes	No	No	Yes	Yes
Deputy unit manager involved in PW-use	Yes	Yes	No	No	No	No
Use of PW for outgoing letters by the team's secretary	Yes	No	Yes	No	No	No
At the team level:						
Project leader stimulated PW-use	Yes	Yes	No	No	Yes	No
Extra PW-training materials	No	No	No	No	Yes	Yes

Table 4.2: Overview of changes at workflow level in use of communication means

Type of change	Unit A		Unit B		Unit C	
	AE	AC	BE	BC	CE	CC
Collective use of Outlook-Calendar	Yes	Yes	No	No	Yes	Yes
Collective use of PW-messenger	No	No	No	No	No	No
Collectively instructed not to use PW-messenger	Yes	Yes	No	No	No	No
Increase of readings by team members	No	No	No	No	No	No
Increase of readings of PW-content by unit members	Yes	Yes	No	No	No	No

The use of shared project disks was not discontinued in units B and C and no user-platform was organized as was done by the management of unit A. The unit managers of units A and C participated in the PW-team workshop in contrast to unit B's manager. Only the deputy manager of unit A was involved in PW-use. Comparison across units of PW-adoption at the team level showed that in the experimental teams the project leader team BE did not adopt PW in contrast to teams AE and CE. The project leader of team BE was reluctant to adopt PW. Comparison of the same management interventions between the control teams shows that the project leaders of teams BC and CC did not adopt PW in contrast to the project leader of team AC who used PW on a low level by the end of measurements. The use of PW by the secretarial staff for finalizing of letters electronically also differed between units. Both teams of unit C and the control teams in units A and B did not use this new option but continued their old paper routine with verification by the postal chamber.

Thus, Unit A's management assisted by team management showed the highest number of management interventions for stimulating PW-use and also showed a bottom-up management approach. Both units B and C showed a top-down management approach. Fewest management interventions were detected in unit B, specifically at the team level by the non-adoption of PW by project leaders.

4.2.3 User involvement in units

Comparative analysis of bottom-up initiated changes with respect to the use particular means for team communication by team members and teams shows that most changes were observed in unit A, one in unit C and none in unit B (Table 4.2). Outlook Calendar was used collectively by teams in units A and C in contrast to the teams in unit B. Collective use of PW-messenger was not observed. In unit A PW-users instructed colleagues collectively not to use PW-messenger because of rivalry between the use of PW-messenger and Outlook-email. Comparison of non-adopters and laggards between units shows that architects and structural engineers in units A and B and structural engineers and quantity surveyors in unit C were the laggards and non-adopters. These groups were very less involved in change to PW-use. The comparison of readings of PW-content by members of other teams in the unit shows a substantial increase in this type of readings in unit A that was not detected in units B and C. This increase is also in contrast with the non-increase in the number of readings of PW-content by team members. REA's organizational units provide a varying number of tools for communication. Team members mostly make their own choices independently.

Table 4.3: Number of members of a team of 8 persons who prefer particular communication means

Type of communication means	Unit A				Unit B				Unit C			
	Preferred means 2001		Preferred means 2004		Preferred means 2001		Preferred means 2004		Preferred means 2001		Preferred means 2004	
	AE	AC	AE	AC	BE	BC	BE	BC	CE	CC	CE	CC
Formal meetings	1	0	0	0	3	0	2	0	2	3	3	5
Dialogues	7	6	6	6	5	6	5	4	6	6	7	5
Informal meetings	1	6	2	2	4	5	5	3	2	4	6	5
Discussions, brain-storm sessions	0	0	0	0	1	0	0	0	0	0	0	0
Postal mail	0	1	0	0	0	0	1	0	0	0	0	0
Telephone			0	0	3	2	4	2	0	0	4	7
Facsimile	0	1	0	0	0	1	1	0	0	0	1	1
Outlook email	5	3	0	0	2	0	5	4	2	1	4	6
Outlook calendar	2	0	0	0	0	0	1	0	0	0	0	2
Shared project disk	0	0	0	0	0	0	0	0	0	0	0	0
Project dossier	0	0	0	0	0	0	0	0	0	0	0	0

However, for effective team communication, a team needs to choose collectively which specific media to use and how often to use it. Comparative analysis of the preferred use of communication means between units in 2004 shows that only team members of teams BE and CC selected an IT-tool (Outlook-email) as one of their preferred means of communication (Table 4.3). Dialogues were chosen as the only preferred communication means by most members of both teams in unit A in contrast to unit B's teams, which both chose two preferred communication means. In unit C, teams CE and CC, which were permanent teams, had a different choice of preferred means of communication. Comparison of bottom-up changes in team communication and preferences for use of communication means show that in unit A only one preferred communication means was chosen and most bottom-up changes took place. The low preference for a communication means may influence PW-adoption positively. Unit B showed the choice of two preferred means and no bottom-up changes. Table 4.3 shows that the preference for using a communication means differed per team in unit C that did not occur in the other units. This might be due to the permanent teams functioning in unit C, which team members do not change.

4.2.4 Rivalry between IT-tools

PW-use faced competition from the more easy-to-use shared project disk and parts of network disks of which file management was facilitated by MS-Explorer. The highest level of this type of rivalry, reflected in the percentage of file storage (60 percent and higher) in shared project disk was shown in units B and C. Unit A showed a lower level of rivalry although this was still 50 percent of the number of files stored, keeping in mind that the shared project disk was closed. Increased rivalry was specifically reported when specialist software was used because of increased and annoying information handling procedures using PW.

Rivalry might be eliminated if MS-Explorer was closed for use in daily work. This is however difficult to realize because of the linkage between the Windows operating system and MS-Office modules for file storage and updating.

Rivalry between MS-email and PW-messenger as shown in unit A was observed in all units. The use of parts of network disks obviously became a strong habit in daily work that cannot be changed easily. Because it may be difficult avoiding this type of rivalry by changes in the IT-environment, management interventions are needed. Because of the rivalry, PW-adoption for re-use instead of daily use was promoted by unit A's user platform. Also, the collective instruction by PW-users in unit A not to use PW-messenger may be indicative of re-use promotion and influences the substantial increase in the number of readers in the unit reading PW-content of the experimental team. It might be that management in unit A lost some control on user adoption by not leading the user platform and not stimulating collective PW-use in daily use. In the next section, therefore, the aspect of planning of change and change management will be discussed.

4.3 Planning of change and change management

In this section, we will try to interpret the outcomes of the comparative analyses in terms of theoretical frameworks emanating from the literature about planned change (e.g., Bennis, 1961; Levy, 1986; Robbins, 2001) and managed change (e.g., Kanter, 1983; Tichy, 1983; Hauschildt, 1998; Aken, v. 2002).

4.3.1 Planning of change

It was observed that REA's central- and unit management planned the change involving collective PW-use at the strategic level and handled the workflow level by short user instructions and the user manual instead of planning the process of change. REA's team members were supposed to change existing paper and electronic processes for information handling themselves when they started using PW. This change may be identified as an automation problem (from project dossier's paper documents to electronic PW documents). However, because the change also involved a change from using the shared project disk to PWS-use, the change may also be conceptualized as a migration problem. Because rejecters of PW-use were detected in units A and B, a more specific technology acceptance problem (Davis, 1993; Venkatesh, 2000) may have caused a barrier for migration. Such type of individual barriers can easily prevent collective PW-use. However, it was observed before the change to PW-use (Section 3.1) that team members used all kinds of IT-tools for different tasks for more than 5 years, that team members in all units easily adopted MS-email and no aversion was observed against using new IT-tools. Thus, it seems unlikely that a fundamental negative attitude towards using IT-tools was a major barrier.

Project Websites packages (by nature) have to be used by a group collectively in the same way in their daily work to be effective.

Therefore, important factors influencing change and adoption are the groups' opinion and the change in groups' attitude regarding the collective use and usefulness of the tool (Orlikowski, 1994; Andriessen, 2003).

Using the 7S-framework of Peters & Waterman (1982), we can see that the introduction of PW is not only a change of systems but also involves changes in the other aspects of the framework; changes in the structure and strategy of the organization, team members requiring additional user skills, changes in staff to manage and support the change of systems, changes in management style and finally, collective PWS-use in daily work needs to become a part of the shared values of the organization.

Levy (1986) argued that discrimination in planning of change between so-called first-order and second-order changes is important to identify the nature of the change. First-order changes concern changes that do not change the system's core. "First-order changes are linear and continuous. It implies no fundamental shifts in the assumptions that organizational members hold about the world or how the organization can improve it's functioning". Robbins (2001) argued. "Second-order change in contrast, is a multidimensional, multilevel, discontinuous, radical change involving reframing of assumptions about the organization and the world in which it operates". For these reasons it might be suggested that the collective change to PW-use by REA's design teams cannot be identified as a first order, linear change but is better regarded as a second-order change. The use of the new technology imply more radical and dramatic changes in information handling processes and working habits of users, who have to choose together to use PW for team communication and who need to stop or change the use of other IT tools for that purpose.

4.3.2 Top-down and bottom-up approach

REA's unit managers of unit B and C showed a top-down approach (Lawler, 1989; Kanter, 1992) in the planning of change to PW-adoption based on the hierarchy of the organization and delegating tasks for prescribed PW-use finally to the level of the project leader of teams. Leavitt (2004) describes the need for transparency in hierarchical, top-down organizations and also describes the tasks to perform by middle management because responsibilities may be easily intertwined and not be transparent as the functioning of REA's project leaders show. High unit management involvement in design processes, in which professional practitioners participate, might easily kill motivation (Schön, 1987; Reymen, 2001). This might also influence the progress of design and might increase the risk of tool rejection. Burns (1961) concluded, based on detailed empirical research, that for changing conditions in organizations an organic management system is more appropriate instead of a mechanistic system. Mintzberg (1983) and Robbins (2001) also argued that in this type of organizations, in which small groups are doing their work for market oriented projects, management should support and facilitate these groups of high educated experts in achieving a higher task performance instead of prescribing tasks. By using a bottom-up approach, management is able to involve team members and groups actively in the change process and could become more committed to PW-use as shown in unit A.

Although results show that this type of management intervention was still insufficient to achieve collective PW-adoption, the bottom-up approach seems to be the best intervention strategy as suggested by Figure 4.1. Involving team members collectively in the change process and making them aware that the tool's features are beneficial in daily work stops high professionals from feeling forced to use a specific technology. Rather, regularly promoting tool features that are beneficial in their daily work may constitute a pull factor and make them wish to adopt and use the new tool. The continued use of a part of the network disk in unit A, after the closure of the shared project disk, rather than using PW suggests that PW did not change from a push to a pull-setting for users. Obviously, PW's features convinced only a part of the team that it would be beneficial in their daily work.

4.3.3 Management of change

Team members in all REA's units expressed a low but stubborn type of resistance to change in using PW. This resistance mainly concerned the following items: lack of understanding why this change in technology has to be executed because the shared project disk already functioned for the same purpose, differences in insights in the use of PW, lack of trust regarding collective change using PW by other members of the team belonging to other design groups, a low willingness to change because of habits in information handling and, finally, time pressure on the production of the design and the fear of loosing time by using a new, unknown tool (Appendix B, Section B2F). Tichy (1983) argues that changes concerning the technical-economic aspect system of an organization have side effects on the organization's cultural and political aspect system because these are intertwined like a rope. Thus, a change in one of these aspect systems needs management of all systems and should not be limited to the system that is changed. Levy (1986) claims that a second-order change in an organization, such as a change from normal routines and habits to the effective use of new routines and tools, needs both planning and management of change. With respect to the management of the change process, Lewin (1951) states that change agents are needed to 'unfreeze' the organization.

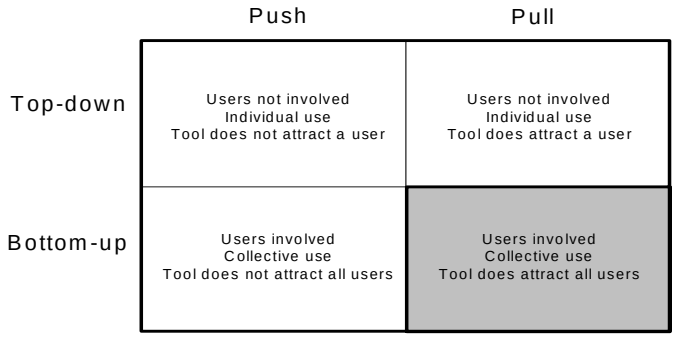

Figure 4.1: Management approaches and push-pull settings

Similarly, Tichy (1986) argues that the organization needs to awake by mobilizing driving forces of change, promoting the benefits of change, trainings to get the required user skills and the benefits in daily work (Kanter, 1992), removing restraining forces to change and making the change operational in the organization.

After execution of the change, 'refreezing' the organization is necessary to establish the new routines as part of the organizational routines. It is also important to choose which tactics to use for change management: fast or slow change, changing a part of the organization or the organization in total, and focusing on change by individuals or by groups (Kanter, 1992; Lawler, 1989).

In REA, only some of these aspects were explicitly and fully managed: the PW-coordinator can be seen as a change agent for cultural aspects, the PW-administrator and PW-application manager as a change agent for technological aspects and finally the unit manager, deputy unit manager and project leader as change agents for the political aspects. In addition, the user platform in unit A may be identified in principle as a driving force for change.

4.3.4 Troika of innovation

The differences between the interventions of change agents observed in units show that in unit A the combined efforts of change agents were more successful in stimulating PW-adoption and increase use. According to Kanter (1992), change implementers are needed at the workflow level to make change happen. These persons have to lead the daily change in the organization being aware of habits of team members. The appointed PW-coordinators can be seen as such change implementers. Hauschildt (1998), investigated technological change in organizations that changed successfully to identify drivers of this change, and introduced the Troika of innovation (Figure 4.2). They emphasize the important role of a process promotor as a change implementer for successful change management besides the power promotor and the technology promotor which were already identified before by Witte (1973) and the need for interaction between promotors. The process promotor, they stated, is the champion of the innovation and is needed because the power and technology promotor are not able in their positions to discuss changes on the workflow level.

The Power promotor is needed for formulating the goals underlying the innovation, in this case the effective use of PW: what performance improvement is desired/expected by using PW and how can this be achieved? In terms of management of conflicts, this person needs to manage conflicts resulting from incompatible demands for resources and from incompatible power of positions. *The Process promotor* is needed for project- and interface management tasks regarding the innovation, networking, providing information about human and financial resources. His or hers main task is to solve and/or dismiss resistances in the team and between the team and the organization against the innovation. This person is the man at the helm of the innovation. The process promotor manages change effectively by knowing the organization very well and connecting persons who are pro innovation (driving forces) as well as debates and negotiates with persons who have antagonistic motives (restraining forces).

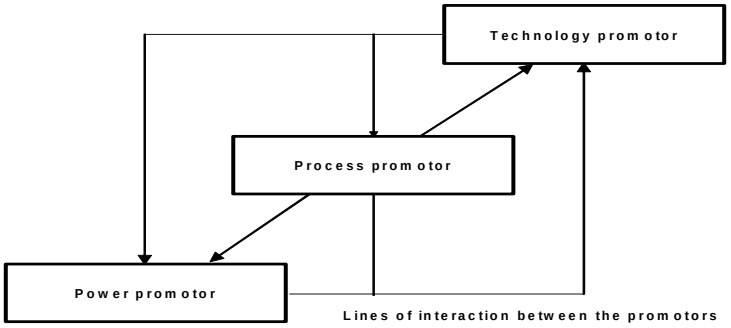

Figure 4.2: The troika of promotors and their interaction

He indicates conflicts on the organizational-, department-, or personal level. The Process promotor tries to solve these conflicts himself or involves the power promotor to solve these. The promotor by organizational know-how and the champion of the innovation, which in case of PW might be identified as the PW- coordinator and might also be labeled as the transformational leader of PW-use (Tichy, 1986).

The Technology promotor is the expert of the IT possibilities, databases, integration of systems and technological problems involved. This person, the IT system manager of a unit and in case of PW; the PW-application manager and PW-administrators, knows all about the use of PW and the best way to use PWS effectively. This person assesses existing solutions and generates new alternatives if problems occur to use PW for specific tasks. The technology promotor is necessary in the management of conflicts due to contradictory perceptions and information.

Kirchmann (1994) showed some evidence that the Troika structure might achieve better economic results than any other structure. Lechler (1997) was able to confirm the assumption that the probability of the occurrence of a process promotor and his positive influence on a project's outcome increases with problem complexity.

Thus, with respect to REA, change management in unit A has most aspects of this Troika model. The PW-coordinator was someone, well known in the organization both on the workflow and management level and not a team member, whose position limits his power because of a hierarchical relation with project leaders. However, it seems that management might have been more effective if it would have been shown to all team members that the tool is beneficial in their daily work and aspects of second-order change were managed concerning team members' assumptions and expectations about the organization and the world in which it operates. Repeated discussions about different opinions concerning the usefulness of the tool between team members, project leaders and PW-coordinators suggest that the design teams at large were not convinced about PW being beneficial in daily work.

4.3.5 Technological frames

PW-use needs the collective adoption by a team to become effective for team communication. Collective adoption needs shared values about PW-use by a group. In REA's units, conflicts were observed in rivalry between IT tools but also with respect to the goals underlying collective use in daily work.

Orlikowski (1994) states, "Where the technological frames of key groups in the organizations, such as managers, technologists, and users are significantly different, difficulties and conflict around the development, use, and change of technology may result". She uses the term technological frame to identify the assumptions, expectations and knowledge that members use to understand technology. This includes not only the nature and role of technology itself, but also the specific conditions, applications and consequences of that technology in particular contexts. To analyze and discuss whether such technological frames between groups in an organization are incongruent, she distinguished three aspects: nature of technology, technology strategy and technology in use.

Nature of technology refers to members' images of the technology and their understanding of its capabilities and functionality. Interviews, meeting reports and member checks indicate that in REA the dominant image of design team members and unit management of PW was that of an advanced tool for re-use of electronically stored information. This in contrast to REA's technologists (the PW-application manager and PW-coordinators) who expressed in their meeting reports much more the image of an electronic communication tool for sharing documents by using effectively PW's advanced database capabilities. The main image of REA's central management was that of an instrument, beneficial for integral design in the longer run. They explicitly promoted PW at the start of the PW-team workshops as a tool for team communication that allows integral design.

Technology strategy refers to views of the various groups in an organization why the organization acquired and implemented the technology. It includes team members understanding of the motivation or vision behind the adoption decision and its likely value to the organization. REA's central management had the objective of stimulating in the longer run integral design. In contrast, it seems that unit management became primarily convinced of the benefits of the tool for re-use of information. Other groups (team managers, team members and design group leaders) developed thoughts of PW being a handy tool for the business department and unit management to get a better overview of workflow and design progress. Thus, there were conflicting views why the organization needed the new technology.

Technology in use refers to user's understanding of how the PW technology should be used on a daily basis and the actual conditions and consequences associated with such use. Findings in the multiple case studies show that user's understanding of PW-use differs from the management view. This might be due to differences in interest between members in using PW as shown by the non-adopters and laggards in units A and B (mainly architects and structural engineers) who continuously argued that PW was not beneficial to their daily work.

Team members in unit B and C indicated during the PW-team workshop that PW and Outlook-explorer for the shared project disk were highly comparable, a view which was enhanced by the look-a-like interface. The same view was expressed by unit C's project leaders. In unit B, the project leader of the experimental team expressed his idea that PW should be used as a package for storing CAD-drawings and not for all types of documents.

Thus, the data reveal the existence of incongruent technological frames within and between units that may contribute to the explanation of the technology paradox. Specifically in units B and C, the frequent discussions between team members and project leaders about the ambiguous use of IT-tools without a clear goal support this conclusion.

4.3.6 Re-design of communication flows

REA's change in the outgoing Postal mail processes using PW, as shown in units A and B, might be the start of a re-design of communication flows. However, this change in workflow only started during the change and not earlier, immediately after the introduction and was not sufficiently changed because the old process was not removed. By leaving the old manual process open for use it was ambiguous for teams to change trusted work habits.

Hammer (1993) argues that re-designing means much more reshaping of processes by differently organizing the work done. In planning second-order change, the radical re-design of existing information processes to effectively and efficiently use new tools should be a part of it. Re-designing should concern both the re-design of manual processes concerning tasks and responsibilities, and re-design of communication flows. The move towards integral design suggested by central management was supposed to be a first order change. However, observations indicate that such a change process did not start spontaneously and that non-adopters and laggards communicated mainly verbally and on paper. Unit B's management did not even consider PW to be a part of an integral design concept. By defining and implementing the new processes as part of second order planned change and by indicating how and for which purposes to use these efficiently, designers (specifically architects and structural engineers) may easier discover the advantages of collective PW-use in their daily work. This may also help avoiding the development of incongruent technological frames.

4.4 Conclusions

In an attempt to identify possible causes of differential adoption of ProjectWise, and explain differences in the observed productivity paradox, we have discussed relevant concepts that may be useful for theoretically interpreting the observed differences. The comparisons between units in terms of differential PW-adoption suggest that a team training and a bottom-up management approach actively involving users in the change better stimulate PW-adoption. However, the user platform organized for this purpose, and not managed by change agents, showed a focus on the re-use mode instead of collective use in daily work.

The rivalry between IT-tools, specifically between PW-use and use of parts of network disks proves to be an important cause for the non-collective PW-adoption in daily work.

In particular, the results suggest that the introduction of PW was implemented as a first order instead of a second-order change. Ideally management style should show the key aspects of a Troika model using change agents and stimulating more interaction with ultimate users.

Clear goals, tasks and responsibilities need to be defined for change promotors, in particular for the PW-coordinator as process implementer of collective PW-adoption by the design teams, involving team members and more specifically architects and structural engineers. In addition, where possible, change should be managed from a pull as opposed to a push setting. Rivalry of tools combined with insufficient user insight into the use of the tool in their daily work and insufficient changes in workflow leave opportunities open for the development of incongruent technological frames between individuals and groups.

It can be concluded, therefore, that the productivity paradox comes about because of insufficient awareness on a unit and central management level about organizing the change as a second order change process, managing the process of change on a unit level instead of a team level, the lack of a bottom-up approach. Moreover, re-design options to optimize PW-use for integral design, avoiding inefficiency and showing benefits in daily work were not sufficiently explored, leaving open ambiguous choices to team members. Also, change agents functioned on too low a level to be successful and lacked the necessary authority to correct discrepancies, differences between units in terms of re-active instead of pro-active behavior and promoting the benefits of change to unit members. These factors may be seen as important possible causes for explaining differences in the technology paradox between the units.

Chapter 5: Experiences of PWS-use in other industries

5.1 Introduction

In the previous chapter, we identified some possible causes that might at least partially explain the observed differences in the use and effects of ProjectWise (PW) in REA. In particular, the major findings of REA's multiple case studies seem to suggest that planning change management as a second-order change is important. In addition, a bottom-up approach is likely to be effective in the sense that it will involve users in the process of change, with a better chance of alleviating or avoiding possible incongruent technological frames and perhaps implementing change in a pull rather than in a push setting.

To examine whether this identification of possible causes for the existence of the technology paradox in professional design teams and the apparent differences in implementation can be triangulated in other organizations, we conducted a series of small mini cases, involving different organizations in the Dutch construction and offshore industry that use the same or different Project Websites (PWS). Based on this comparison, involving quite different organizations that are using the same or different PWS packages for design and engineering purposes, similarities and differences are identified in collective PWS-adoption affecting team communication and performance. Similarities in outcomes would suggest that our findings are more general and do not depend on a single organizational setting, management style or culture.

The results of this study are reported in this chapter. First, we will discuss the selection of the mini cases, and briefly describe their nature and the software used. Next, we will discuss similarities and differences in the adoption of the PWS and its effects on communication, performance and productivity. Finally, we will draw some conclusions to put REA's major findings in a broader perspective.

5.2 Methodology for executing the mini-cases

Providers of various, well-known PWS packages were asked to select which organizations in different industries, having this experience, should be interviewed. After this selection the process- and IT-managers of the chosen organizations were interviewed. These persons are experienced the implementation and management of PWS-adoption by teams that execute design and engineering plans for construction projects in architecture, construction and engineering. Because of the scope of these mini cases, the interviews were limited to these managers. As these managers were responsible for the success of implementation, there could be some bias in their answers, which has to be kept in mind when assessing the findings.

Table 5.1 shows an overview of the organizations interviewed and the various PWS packages used in these organizations.

Semi-structured interviews were held with respondents in these organizations asking about (I) collective PWS-adoption and the effects on team communication, performance and productivity to detect whether the Productivity Paradox can be observed; (II) the planning of change including implementation and training provided; (III) the management of change and the change agents used; (IV) driving forces and resistances, and (V) which other effects appeared due to PWS use (Appendix A4). If rivalry between PWS and other tools occurred, it was asked how this was managed. At the end of the interview (to avoid iteration in answering the questionnaire of interviewer), findings of REA's multiple case studies were compared with experiences in their organization.

The semi-structured questionnaire consisted of closed and open questions. The respondents verified all data afterwards to avoid erroneous interpretations as much as possible. Respondents gave their opinion about team performance improvement, and increase in productivity. None of the respondents reported systematic measurements of performance and productivity. The organizations interviewed were classified as design firms producing designs for a material artifact in architecture, construction and engineering and design & construction firms producing designs and the material artifact designed.

5.3 Experiences of Project Website use in other organizations

5.3.1 PWS packages and organizations interviewed

Table 5.1 gives an overview of the PWS packages and organizations included in the mini cases. These concern the following:

ProjectWise (PW): Design firm A, which is a department of a municipality responsible for urban design, only uses PW for the storage of generated CAD-drawings. Table 5.2 shows user aspects, training and period of use. No process manager was appointed; the IT system manager fulfilled this task. Design & construction firm A is a company that produces offshore production platforms and pre-assembled units. PW is used for the storage, maintenance and facilities management of all project-related documents.

Table 5.1: Overview of consulted organizations concerning experiences of PWS-use

Project website package	Organization	
ProjectWise (PW)	Design firm A	Design & construction firm A Design& construction firm B Design & construction firm C
File2Share (F2S)	Design firm B Design firm C	
AddView (@View)	Design firm D Design firm E	
Meridian		Design & construction firm D Design & construction firm E

The client gains access to the generated documents during the life-cycle of the product. It is used for calculating the extra work and cost implications of changes in specifications during design and construction. Their design teams mostly are multi-disciplinary teams that partly consist of members of the organization and partly of external members of partnering organizations. Design & construction firm B uses PW for designing and engineering of automated telephone centers in The Netherlands for almost six years. All generated CAD-files and related reports are stored in PW. The unit manager functions as a process manager mediated by an IT-system manager. Design & construction firm C is an international firm operating in 13 countries across the world, producing high-tech equipment for hospitals, which uses PW for the installation of this equipment. All CAD-files and other project-related documents are stored and maintained in PW. The main headquarters are located in The Netherlands and operated by a unit manager and a process manager who manages the application.

File to Share (F2S): Design firm B uses F2S for the storage of all finalized project-related documents of design projects (Table 5.2). Generated documents are stored in parts [?] of network disks. A project coordinator is appointed as a process manager for multi-disciplinary teams each consisting of 4 members of different design organizations, which all use F2S. No contractual and confidential information is stored in F2S. Design firm C uses F2S for the storage of all finalized project related documents of design projects. Generated documents are stored in parts of network disks. A project coordinator was appointed as process manager for multi-disciplinary teams each consisting of 6 members of different design organizations, which all use F2S. No contractual and confidential information is stored in F2S.

AddView (@view) is used by design firm D for the storage of all finalized project documents by multidisciplinary teams consisting of 4 members (Table 5.2). This PWS is mostly used by a smaller number of members in design teams for construction projects. A project architect was appointed as the process manager. Design firm E is a framework design organization that uses this PWS for storage of all finalized project documents as an alternative for postal mail. No process manager was appointed.

Meridian is used by design & construction firm D, which is an offshore company building production platforms for the offshore. The PWS is used for storage and maintenance of all generated electronic documents, mostly CAD-drawings (Table 5.2). A process manager was appointed to manage the application for teams consisting of 6 people. The design & construction firm E, which is an offshore company producing vessels and production platforms uses Meridian as an electronic library, in which all finalized, electronic CAD-drawings of design & construction projects are stored and all scanned archived drawings of old projects for consultancy of files and re-use in new projects.

Table 5.2: Overview of Project Website user's aspects in organizations

Package /Organization	Users		Training			File type		Use period
ProjectWise	Team	Total	Instructions	Internal	External	Written documents	Drawings	Year
REA	8	80	X	X		X	X	1,3
Design firm A	6	70	X				X	2
Design & construction firm A	6	120		X	X	X	X	2
Design & construction firm B	10	150		X	X		X	6
Design & construction firm C	3	40		X	X	X	X	3
Meridian								
Design & construction firm D	6	46		X	X	X	X	1,5
Design & construction firm E	5	35	X				X	1,5
File2Share								
Design firm B	4	16	X		X	X	X	5
Design firm C	6	12	X			X	X	3
AddView								
Design firm D	4	4	X				X	1
Design firm E	4	4	X				X	2

Table 5.3: Overview of PWS-adoption aspects reflected in other organizations

PWS use aspects	Collective daily use	Performance improvement	1st-order change	2nd-order change	Process re-design	PWS process manager	Rivalry	PWS exam
ProjectWise								
REA			X			X	X	
Design firm A			X				X	
Design & construction firm A	X	X		X	X	X	X	
Design & construction firm B	X	X		X	X	X	X	
Design & construction firm C	X	X		X	X	X		X
Meridian								
Design & construction firm D	X	X		X	X	X	X	
Design & construction firm E	X	X	X				X	
File2Share								
Design firm B			X				X	
Design firm C			X				X	
AddView								
Design firm D			X				X	
Design firm E			X				X	

5.3.2 Comparing experiences

As shown in Table 5.3, similarities in outcomes between these organizations and REA were detected, although also differences were observed too. As for *collective daily use,* teams in design & construction firm A, B, C, D and E use the PWS collectively and daily as a tool for storing files in contrast to the design firms that use PWS for file storage with a lower frequency. At design & construction firm E the PWS is used for daily consultation of all finalized files and the electronic library files of archived projects.

Improvement of team performance, in terms of a higher productivity, was reported by the design & construction firms B and C. In these firms change was planned as a second-order change and information handling processes were re-designed. The other firms did not report any improved team performance by using the PWS. Although the reported improvement of team performance might be distrusted because of respondent's interests to answering such questions positively, the results suggest that performance improvements were obtained by shorter production time. Design & construction firm A reported increased profits by using PWS for the more exact recording of changes in specifications made by the client during the design & construction process, that were priced and paid afterwards.

In contrast to our expectations but similar to the results obtained for REA, there was no substantial change in team communication. However, design & construction firm A did report more contacts between the contracted design- and engineering firms. Design & construction firm B announced plans to integrate the PWS with an Enterprise Resource Planning system involving the sales department.

Change agents were reported in the design & construction firms A, B, C and D. The respondents of these firms can be identified as the PWS-process manager who can be viewed as the process promotor, being pro-active, well-known in the organization, understanding technology and who functions at the organization's management level. These persons cooperated closely with the IT-manager of the firm. Respondents in designs firms B, C and D who reported to be the process managers, functioned much more as coordinators and only reported facilitating tasks and not stimulating, instructing or training users on how to use the PWS collectively to be beneficial in their daily work. This was mainly done by the provider of the PWS packages.

A bottom-up approach of management interventions involving organizing user meetings was reported by 7 firms. Design & construction firms C, D and E stopped organizing user meetings because it was only necessary when PWS-use started. In four design firms the platform still existed. One design firm and two design & construction firms reported that no user meetings were organized. Re-design of workflow processes and information handling processes (IT-component and organizational component) was detected in design & construction firms A, B, C, D and E.

In A, B, C and D additional software was used to simplify PWS-use for users, providing direct gates to PWS instead of using MS-Office for starting applications, and routines for saving files directly in the PWS adding the attributes automatically.

In that way annoying procedures for PWS-users were eliminated or reduced to a minimum level. Design & construction firm B showed the highest level of re-design by integrating PWS with the applications used that made it very difficult for team members to use applications without PWS-storage. Also the entire process of generating drawings electronically by using the PWS was automated by using advanced electronic libraries.

Design & construction firm A automated a part of the information handling processes for postal and incoming electronic mail for automatic PWS-storage. A new electronic information handling process was developed for facility management purposes, using the PWS-database produced in the design & construction project, during the whole lifecycle of the object (> 25 years). The client was offered a new electronic service for electronic viewing of the PWS-database of the object to search for the number and specifications and drawing of every part if a client liked a revision or a part to be repaired. Design & construction firm C automated the entrances to the PWS package and made direct links with all international co-located offices for daily overview of the local vaults. Design & construction firm D made links for all entrances of software packages used together with the PWS and automated a part of the information handling processes for postal and incoming electronic mail for automatic PWS storage. Design & construction firm E changed the complete paper archive into an electronic one. Adding actual information, however, was not automated.

Rivalry between PWS-use and part of network disk was reported by almost all respondents who used the PWS collectively for daily use. This rivalry also occurred in organizations which had an active process promoter. Respondents of design & construction firms reported that this needs to be checked on a regular basis (after one to three months). At most, a few members need to be corrected for using parts of network disks again, instead of using the PWS. The respondent of the design & construction firm B reported the lowest level of rivalry. This might be caused by the fact that it was very difficult for users to work outside the application without PWS storage, support of the electronic library and having the right attributes attached, and also because team members were well trained. It was company' rule that one can only use the PWS if one passed the PWS exam successfully.

The respondents of the design firms, who use the PWS with a lower frequency (mostly weekly or once over a longer period of time) reported that the PWS only contained files that were copies of network disks without any updating for storage in the PWS. This might be identified as a form of rivalry because no difference in content of the PWS and the network disk exists, and the PWS is used mainly for electronic distribution of files. Redundancy of information and the chance of mistakes may easily appear with such low updating frequencies.

PWS training and instructions differed between organizations. Team members of all design firms and design & construction firm E had to train themselves in PW-use. Collective PW-training in teams was provided by design & construction firms A, B, C and D. Design & construction firm B showed the highest level of training. Each team member had to pass a PWS exam after finishing a PWS training program before PWS use.

This firm had used the PWS for almost 6 years, which is the longest period found in this investigation. The respondents of design & construction firm C argued that the most important change for team members using a PWS is to become acquainted with database features. A two-day training course was provided for new users in which all aspects of the PWS and the use of a database were explained, trained and examined by doing pilots. Every 4 to 6 months the firm organizes a meeting at the Dutch headquarters for users from 13 countries worldwide to discuss PWS use and new features in updates and upgrades of the package.

Technological frames of groups and organizations using a PWS were different. Comparison of the design & construction firms' perspective to that of the design firms shows that the design & construction firms thought of technology as an instrument for concurrent design in design and engineering in contrast to the design firms which view PWS as an instrument for electronic publishing to external parties as a substitute for postal mail or for electronic archiving and re-use in other projects instead for collective daily use.

Reports on change to a pull-setting were reported by respondents of the design & construction firms. The closure of the user platform was an indication that the change process was finished and users reported effectiveness of the tool. These firms made specific entries to the PWS package to avoid rivalry and made it more difficult for users to work without the PWS. Consequently, most users became acquainted with daily PW-use. Because no users were interviewed in the mini-cases, data on a team level about user satisfaction cannot be reported.

5.3.3 First order and second-order changes

All design firms and design & construction firm E planned change as a first-order change without re-designing workflow- and information handling processes. They only give user instructions to team members for using the tool and few explanations regarding the purpose of use. All electronic information was handled by the computer network and by Outlook-email, which was believed to be much safer compared to physical storage in a PWS. They believed they would lose control of their generated products and lose valuable data and information in case of accidents.

The design & construction firms A, B, C and D planned change as a second-order change by re-designing information handling processes, training users in teams and appointing a pro-active process promotor.

5.3.4 Other effects of Project Website use

For reasons of confidentiality, contracts and financial information usually were not stored in a PWS used by design firms. This reflects a lack of trust in the technology and fear of hacking, viewing and even of downloading protected information by non-authorized persons. Thus, mostly, only documents directly related to projects and necessary in the current design process were stored. Concerning the re-use of stored PWS-files, the managers of most design firms indicated that for reasons of copyright, re-use of documents collected in the PWS is problematic.

They like to be professionally involved in such maintenance projects and be paid for re-use activities. For these reasons, after project closure, the stored files were typically removed if no new agreements with the client were made.

5.4 Conclusions

By comparing the findings of the multiple case studies executed in REA with the experiences in the other industries we searched for similarities and differences to see to what extent it is possible to formulate more general conclusions that strengthen our knowledge about collective daily PWS-use and successful adoption of PWS, independent of any organizational setting, management style or culture.

The findings of these mini cases lead to the conclusion that the IT productivity paradox as observed in REA's multiple case studies, is not unique and can also be observed in other firms using the same and different Project Website packages. On the other hand, there also are differences. Especially design & construction firms appear to have better results with the adoption of a PWS, that planned change as a second-order change, redesigned workflow processes to optimize PWS-use and avoided rivalry of tools, tested PWS-users on their PWS-competences, pro-actively used change agents, and reported a bottom-up approach by organizing user meetings to stimulate PWS-use. However, a direct relation between improvement of team performance and team communication was not reported or shown.

Chapter 6: Conclusions and recommendations for future research

The motivation for this research project was to reduce the gap in our knowledge about the effective use of a Project Website (PWS) by design teams. PWS has been advocated as an important tool for design teams of construction projects, because these websites are supposed to greatly enhance team communication. PWS vendors claim these results in improved team performance in terms of time, cost and quality. PWS may increase efficiency because of a decreased search time for all generated information. Improved quality may be expected in the sense that complete, valid and currently generated design information will be easily accessible to all members of the design team. In fact this means working smarter by effectively using IT tools in daily work.

For that reason, the main question to be answered in this project was whether this IT Productivity Paradox also can be observed in design teams using a PWS in architecture, construction and engineering and to what extent the use of a PWS (and resulting team communication and performance) differs in different organizational and management settings. To the best of our knowledge, no empirical research in the building industry has been or is being performed to support the often claimed, effects nor to support or deny the IT technology paradox in this field. The goal of this dissertation, therefore, was to gain further insight into the use and effects on communication (and thus on the claimed team performance) of a PWS in architecture, engineering and construction design teams. To that end, the following research questions guided the research project: (1) How do design teams actually use a PWS compared to the prescribed use in a construction design project? (2) What are the reasons for discrepancies, if any, between observed and prescribed use of a PWS? (3) What are the effects on team communication of using a PWS? (4) What are the effects on team performance of using a PWS in terms of efficiency and effectiveness and added value for the consumer? (5) To what extent are the findings related to the above questions specific for architecture, construction and engineering? Because there is no parallel research available for comparison, it should be emphasized from the beginning, that the outcomes of this study can only be a start in providing answers to these questions. For the same reason replication research will be necessary to enhance knowledge in this area.

The research project involved the comparison of three pairs of design teams in three organizational units within in one large organization, which we called REA. The teams were supposed to use a PWS as prescribed. All teams were given basic instructions on how to use the PWS and were then supposed to further train and educate themselves in the workplace using the help function of the user manual. One group of these teams, the so-called experimental teams, received extensive training to stimulate PWS-use, the other group of teams, the so-called control teams, did not receive this training. By comparing the frequency and nature of use of the available communication tools before and during the use of the PWS, we were able to detect variations in the use of the PWS and in its effects on team communication.

The design of this research was inspired by the principles underlying quasi-experimental designs in the sense that experimental and control teams were as similar as possible on as many variables as possible that potentially influence PWS use. The principles underlying quasi-experimental designs were used as a systematic means to interpret results and to avoid as much as possible obvious alternative interpretations outside the control of the researcher. It should be emphasized however, that the number of pairs of teams was small, and hence no statistical analyses could be conducted. In addition, the fact that all teams received a basic amount of instruction is not ideal, but could not be avoided.

By executing multiple case studies using a quasi-experimental design we generated knowledge about the use of a specific PWS package and its effects on team communication. The results suggest that there is indeed some evidence of occurrence of the IT Productivity Paradox in the design teams investigated using the PWS. None of the experimental teams, while using the PWS better than the control teams, fully adopted the PWS in daily use nor used it collectively in the same way. The degree of adoption and the size of effects varied between teams. To identify possible causes for such differences, the three units were compared in terms of management style and culture. It turned out that the unit for which the positive effects of the PWS were highest, although still lower than anticipated and without full collective adoption by the team, was characterized by a pro-active behavior and a bottom-up management approach that increased user involvement in the change process. Management showed more signs of pro-active change than observed in other units and the organizing of a user platform stimulated PWS-use. However, one can observe change agents did not manage the user platform and the PWS-use was promoted for information re-use purposes instead of daily use as prescribed. No re-design options were explored or planned towards concepts of integral design, although REA's central management suggested this option. Because of rivalry between PWS-use and the use of network disks, and of difficulties in information handling using specialist software packages, incongruent technological frames developed, which made the prescribed collective adoption more difficult.

Thus, it can be concluded that in the multiple case studies in REA the Productivity Paradox can be observed because of insufficient awareness at a unit and central management level of managing the process of change as a second order instead of a first-order change. Other reasons that can be detected concern not using a bottom-up approach for management interventions and insufficient introduction of the tool providing sufficient training for PWS-use. Moreover, re-design options to optimize PWS-use for integral design, avoiding inefficiency of and rivalry between tools, were not explored or poorly started while existing processes of information communication were not closed, leaving ambiguous choices open to team members. Also, change agents functioned on too low a level to be successful and lacked the necessary authority to correct discrepancies, differences between units in terms of re-active instead of pro-active behavior and promoting the benefits of change to unit members. These factors may be seen as important possible causes for explaining differences in the technology paradox observed between the units.

To examine whether similar findings could be obtained in other organizations using the same and different Project Websites, a series of mini cases were conducted in different industries that use various PWS packages. These mini cases were performed by means of interviews with process- and IT managers of design and design & construction firms. Keeping in mind that interviews may be biased because the respondents interviewed may be inclined to give more positive answers than the actual situation permits, the results of the mini cases suggest that the change to collective daily PWS-use needs a second-order planning of change and a bottom-up approach of management interventions using pro-active change agents and team training through which PWS use is ideally changed into a pull-setting for users.

If the results of the mini cases can be generalized to similar organizations, they suggest that the following conditions are probably to improve the acceptance of the new technology in general and PWS's in particular: (i) competition between tools should be avoided from the start; (ii) a team should have sufficient skills to use the technology as good as the competing tools; (iii) both workflow- and information handling processes should be redesigned for efficient and effective PWS-use; and (iv) pro-active change and implementing agents are made responsible for the successful change of PWS-use to a pull-setting for users.

Thus, it can be concluded that the IT Productivity Paradox was observed in design teams in architecture, construction and engineering using a PWS, but differing in intensity as a function of how change management is implemented. Successful adoption and implementation of PWS and technology in general requires management of a second order change process. In any case, the ultimate adoption and impact of new technology depends on the extent to which it is perceived as beneficial to design team members in integral design processes on a daily basis.

When interpreting the results of this study, the following potential limitations should be kept in mind: First, as indicated before, the findings are based on a small number of pairs of teams. Hence we cannot make any statistical inferences to draw generalizable conclusions. Second, the organizational environments observed are dynamic by nature and moved in a different direction during the time of observation, which is less beneficial to the research project as exemplified by the introduction of the PWS to all REA's teams, because management could not easily deny access to the new technology. This means that we cannot perfectly adhere to the chosen principles underlying the research design. Third, assuming that the introduction and dissemination of new technology can be described in terms of an S-shaped curve, the fact that we had a limited number of observation periods may imply that we did not detect the full extent of the use of this technology. This would only be the case if the adoption had already reached its maximum. This is likely to be the case, though, as there was no evidence of further intensified use.

Some of these limitations can be avoided or can be relaxed by conducting additional research. In particular, the following lines of research seem important. First, by executing new case studies in the same and in different types of design teams, further validation, also in statistical terms, would be possible, allowing one to draw more generalizable conclusions.

Second, we could not draw any firm conclusion that even in the ideal case of full adoption, there would still be evidence of the technology paradox in design teams, or that under such circumstances there would be a positive effect on team communication and performance.

It is therefore recommended to focus future research on design teams that have fully adopted PWS and only then analyze its effects. The results of such a study would enable one to judge whether sub optimal change management primarily causes the paradox or that more fundamental factors, related to working attitudes and habits of design teams in architecture, are the major obstacle to improved performance and productivity. Third, the conceptual framework underlying our study, based on literature, suggested an indirect relationship between PWS use and performance/productivity, mediated by team communication. However, both the multiple case studies and the mini cases did not show any substantial change in using synchronous and asynchronous means of team communication. This implies that if there is any impact of PWS use on performance, it may not be mediated by a change in team performance. A further elaboration of this issue thus is critical for a better understanding of the mechanisms underlying change in team performance.

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Appendix A: Formats for data collection

A1. Format interview with deputy unit manager

Date:

According to the function description there are three main tasks for deputy unit managers.

What is your vision on executing the main (primary) tasks:

1. Responsibility for the effectiveness and efficiency of executing projects ?
2. Responsibility for development and realization of the firms' strategy?
3. Your own competences with respect to changes in work?

According to central management another task is the monitoring and management of the project leaders. Can you describe how you do this in practice?

According to central management you are responsible for the improvement of information handling in the unit with special attention to the business department and secretarial staff. Can you describe how you do this in practice?

4. How can the efficiency and effectiveness of projects be improved?

5. Which problems can be detected and how can they be handled?

6. Integral design? What are your thoughts about this concept?

7. What is the driver for the change to Integral design?

8. Are projects evaluated? Is feedback given?

9. Is use of means of IT important for the effectiveness and efficiency of projects?

10. Are you familiar with ProjectWise? Can you use the tool in daily work?

Additional questions: the structured questionnaire.

Name of interviewer.

Date.

Verified by respondent.

A2. Tick list

Name respondent.
Project number.

Week number.
Monday / Tuesday / Wednesday / Thursday / Friday
Please, record the number of all new E-mail messages, Postal mail letters,
Facsimile messages, Telephone calls in-out en meetings per day

	Number	Total
Received E-mail messages		
Received postal mail letters		
Incoming telephone calls		
Received facsimile messages		
Sent E-mail messages		
Sent postal mail letters		
Outgoing telephone calls		
Sent facsimile messages		
Outlook agenda, to do list		
Project Website use		
Search in database		
Dialogues		
Informal meetings		
Formal meetings		
Interactive work sessions		

A3. Check list for Archived files

Archived files check
Date.
Project number.
Project leader.

Sketch design	Description	Number
Email messages		
Fax messages		
Letters		
Contract		
Sketches		
Drawings		
Budget		
Capacity and time planning		
Tender documents		
Others:		

Preliminary design	
Email messages	
Fax messages	
Letters	
Contract	
Sketches	
Drawings	
Budget	
Capacity and time planning	
Changed tender documents	
Others:	

Detailed design	
Email messages	
Fax messages	
Letters	
Contract	
Sketches	
Drawings	
Budget	
Capacity and time planning	
Presentation	
Others:	

A4. Report observation of team meeting

Design team:…….. Location:……..
Meeting date:..... Duration:.....

Name of observer:

Meeting participant's	**presence**
A: Client	yes/no
B: Project leader	yes/no
C: Team coordinator	yes/no
D: Architect	yes/no
E: Framework designer	yes/no
F: Quantity surveyor	yes/no
G: Detailed construction designer	yes/no
H: AC-installation designer	yes/no
I: E-installation designer	yes/no

Mark the person that led the meeting with '0' /
Mark the person who makes notes with '+' /
Mark the person(s) dominant in the meeting with ' * '

Time	Activity (checklist / discussion / agreement / information given on subject / problem / task)	Type of information	Information carrier (paper, face-to-face, electronic, sketch, image, scheme)

Instructions for observation
- Two observers.
- Two meetings per observer (after each other), total of four meetings.

Questions for observers to be answered in the observation report:
How is design information exchanged in the meeting?
- By means of: face –to – face, photocopies of documents, drawings, sketches, images, schemes
- Sketches during the meeting + story by which designer?
- Presentation means used in the meeting (beamer, overhead projector, drawings, face-to-face)?
- Which indication was given of ProjectWise use? Discussion about use of ProjectWise?
- How is information distributed (on paper, by Email attachment, computer network, ProjectWise)?
- How is the minute of the meeting distributed (on paper, by Email attachment, computer network, ProjectWise)?
- How is information generated, stored (face-to-face / on paper/electronic)?
- How can the meeting be characterized?
    - Formal, informal meeting.
    - Type of meeting: introduction, agreements – contracts, problem solving, discussion, checklist-procedure for actions and progress, plan of work, tuning of tasks, reporting progress and planning).
    - Pleasant meeting?
- Setting date for meeting by organizer / email / Outlook calendar / other.
- Duration of meeting: short <1 hour, normal = 1,5 hour, long >=2 hours.

Date of next meeting:

A5. Format semi-structured questionnaire REA

	Interviews Design teams Real Estate Services (REA)			
	Version 1.3	Answers measurement 1	Answers measurement 2	Answers measurement 3
1.1	**Introduction**			
1.1.1	Discipline:			
1.1.1.1	For how long have you been working in this position?			
1.1.2	Name: id-code			
1.1.3	Age:			
1.1.4	Team coordinator:			
1.1.5	Education:			
1.1.6	Additional education:			
	Technical:			
	Social:			
	Management:			
1.1.7	Name of project:			
	Name Project leader:			
1.1.7.1	How many projects parallel?:			
1.1.7.2	Assignment responsibility:			
1.1.8.	Kind of teams: exchangeable / fixed teams			
1.1.8.1	Capacity of work:			
1.2	**Effectiveness of methods and means**			
1.2.1	**Generation**			
1.2.1.1	What kind of documents do you produce, for what purpose?			
	Reports:			
	Minutes:			
	Letters:			
	Drawings:			
	Sketches:			
	Budgets:			
	Calculations:			
	Planning's:			
	Records:			
	Specifications:			
	Other:			
1.2.1.2	Until which moment in the design process do you make schemes and sketches (or other documents) on paper?			
1.2.1.3	In your opinion would it be preferable to use software earlier in the design process, e.g. to make sketches using the computer?			
1.2.1.4	Please elaborate			
1.2.1.4.1	What percentage of your work is done on paper, not by computer?			

1.2.1.4.2	Will this remain stationary? Or will it increase or decrease?			
	Information Collection			
1.2.1.5	Where do you get your information?			
	Web:			
	Publications:			
	Magazines:			
	Books:			
	Own database/archives:			
	Project file:			
	ProjectWise:			
	Own brains:			
	Other:			
1.2.1.6	Which information source is the most important to you?			
	Web:			
	Publications:			
	Magazines:			
	Books:			
	Own database/archives:			
	Project file:			
	ProjectWise:			
	Own brains:			
	Other:			
1.2.1.7	And which takes the least time?			
	Web:			
	Publications:			
	Magazines:			
	Books:			
	Own database/archives:			
	Project file:			
	ProjectWise:			
	Own brains:			
	Other:			
1.2.1.8	Which leads to the most effective result?			
	Web:			
	Publications:			
	Magazines:			
	Books:			
	Own database/archives:			
	Project file:			
	ProjectWise:			
	Own brains:			
	Other:			
1.2.1.9	For which reason?			
1.2.1.10	Do you make a focused search for the information you require?			
1.2.1.11	Do you collect for a project all that you consider relevant?			
1.2.1.12	Do you keep all you consider relevant?			

	Information Processing			
1.2.1.13	How do you process information?			
	paper collection / photocopying			
	scanning			
	ICT cut & paste			
	Other			
	ICT as support			
1.2.1.14	Do you use ICT in processing the collected information?			
1.2.1.14.1	For how long have you been using ICT?			
1.2.1.15	Does it bother you that new ICT means are being used for information handling?			
1.2.1.16	Can you elaborate?			
	Disturbances in the Information Processing			
1.2.1.17	Do you find changing software (apart from updating) disturbs the process?			
1.2.1.18	Can you elaborate?			
1.2.1.19	What should be the minimum period between changes of software?			
1.2.1.20	Do you consider it difficult to convert to new software?			
1.2.1.21	And what if this involves a special training?			
1.2.2	**Exchange**			
1.2.2.1	What means of communication are used?			
	Postal mail:			
	Telephone:			
	Facsimile:			
	E-mail:			
	Project file:			
	ProjectWise:			
	Paper project file			
1.2.2.1.1	Do you think project files are useful?			
1.2.2.1.2	Why would you think so?			
1.2.2.1.3	Do you often look in the project file for design information?			
1.2.2.1.4	Do you often check information in the project file?			
1.2.2.1.5	Do you often add information to the project file?			
1.2.2.1.6	Could you always find what you're looking for in the project file?			
1.2.2.1.7	Could the use of the project files be improved?			
1.2.2.1.8	Why do you think so?			
1.2.2.1.9	Who is responsible for the project file?			
	Telephone			
1.2.2.2	What do you use the telephone for?			
	Appointments:			
	Information acquisition:			
	Clarification:			
	Discussion:			
	Supplements:			
	Other:			
1.2.2.3	How often daily do you use the telephone for incoming calls?			

	How often daily do you use the telephone for outgoing calls?			
	Postal and interoffice mail			
1.2.2.3.1	What do you use the mail for? (Internal and external mail)			
	Sending documents:			
	Passing on appointments:			
	Sending graphical data (sketches, images, e.g.) on paper:			
	Supplements:			
	Other:			
1.2.2.3.2	How many postal items do you receive daily?			
	How many postal items do you send daily?			
	Facsimile			
1.2.2.4	What do you use a fax machine for?			
	Sending documents:			
	Passing on appointments:			
	Sending graphical data (sketches, images, e.g.) on paper:			
	Supplements:			
	Other:			
1.2.2.5	How many fax messages do you receive daily?			
	How many fax messages do you send daily?			
	Outlook email			
1.2.2.6	For what **internal** purposes do you use e-mail? (Intranet, within the project team)			
	None:			
	Short messages:			
	Memo's:			
	Making appointments:			
	To do list:			
	Sending documents (attachments):			
	Other:			
1.2.2.7	For what **external** purposes do you use e-mail? (Internet, outside the project team)			
	None:			
	Short messages:			
	Memo's:			
	Making appointments:			
	To do list:			
	Sending documents (attachments):			
	Other:			
1.2.2.8	Do you use e-mail messages within ProjectWise?			
1.2.2.8.1	If you indicated using PW messages sometimes, please explain why			
1.2.2.9	Do you use common address files?			
1.2.2.10	Do you also have a personal address file?			
1.2.2.11	How many e-mail messages daily do you receive (excl. PW messages)?			
	How many e-mail messages daily do you send (excl. PW messages)?			

1.2.2.11.1	How many PW messages a day do you receive?			
	How many PW messages a day do you send?			
1.2.2.11.2	Do you think PW messages are better than normal e-mail?			
1.2.2.11.3	Please explain why:			
1.2.2.12	Do you make less use of the telephone due to the use of e-mail?			
1.2.2.13	If yes, how much less?			
1.2.2.14	Do you make less use of the facsimile due to the use of e-mail?			
1.2.2.15	If yes, how much less?			
1.2.2.16	Do you think e-mail has taken over any other forms of communication (other than telephone or fax)?			
1.2.2.17	If yes, which ones?			
	Dialogues:			
	Informal meetings:			
	formal meetings:			
	Interactive work sessions:			
	Postal mail:			
	Outlook–agenda, to do list:			
	ProjectWise:			
1.2.2.18	What do you think e-mail is most suitable for?			
	For what reason?			
	ProjectWise			
1.2.2.18.1	What do you use PW for?			
	Sending documents:			
	Storing documents:			
	Setting appointments:			
	Sending graphical data (sketches, images e.g.):			
	Supplementations:			
	Exchange within the project team:			
	Other:			
1.2.2.18.2	How many times do you put new documents in PW daily?			
1.2.2.18.3	How many times do you open a document in PW daily?			
1.2.2.18.4	How many times do you change documents in PW daily?			
1.2.2.18.5	How many times do you take a look at documents of other team members in PW daily?			
1.2.2.18.6	How many times do you make changes in documents of other team members in PW daily?			
1.2.2.18.7	How many times do you use [Copy to server] in PW daily in order to save a document?			
1.2.2.18.8	Do you consider PW to be a means of communication or a central file storage system?			
1.2.2.18.9	Please explain why:			
	Communication aspects			
1.2.2.19	Which means of communication do you use in the design team?			
	Dialogues:			
	Informal meetings:			
	formal meetings:			

	Interactive work sessions:			
	Postal mail:			
	Telephone:			
	Facsimile:			
	E-mail:			
	Outlook–agenda, to do list:			
	ProjectWise:			
	Other:			
1.2.2.20	Which means of communication do you use most?			
	Dialogues:			
	Informal meetings:			
	formal meetings:			
	Interactive work sessions:			
	Postal mail:			
	Telephone:			
	Facsimile:			
	E-mail:			
	Outlook–agenda, to do list:			
	ProjectWise:			
	Other:			
1.2.2.21	Why?			
1.2.2.22	Do you sense an information overload within your team?			
1.2.2.23	In case this occurs, through which communication mode?			
	Dialogues:			
	Informal meetings:			
	formal meetings:			
	Interactive work sessions:			
	Postal mail:			
	Telephone:			
	Facsimile:			
	E-mail:			
	Outlook–agenda, to do list:			
	ProjectWise:			
	Other:			
1.2.2.24	What are the likely causes of this?			
	Meetings			
1.2.2.25	Do you think that instead of formal meetings there is another way, other than described above, which is more effective to exchange information?			
1.2.2.26	Please elaborate:			
1.2.2.27	Do you think that instead of face to face (physical) conversations there is a better way to exchange information effectively?			
1.2.2.28	Please elaborate:			
	Information sharing - distribution			

1.2.2.29	What arrangements have been made for the distribution of information in your project team?			
1.2.2.30	In what way is that information recorded?			
	Strategic plan:			
	Protocol for distribution of information Distribution:			
	Other			
1.2.2.31	Who co-ordinates these arrangements?			
1.2.3	**Publishing**			
	Publishing information			
	What/who for do you publish documents?			
1.2.3.1	Internally for the project team:			
1.2.3.2	Internally for the Regional Directorate:			
1.2.3.3	Documents to the client:			
1.2.3.4	For government bodies:			
1.2.3.5	Documents for the network:			
	Information storage / Dossiers			
1.2.3.6	Which methods of information storage do you apply?			
	ProjectWise:			
	Documents on the Netwerk:			
	Shared paper dossier:			
1.2.3.7	To which information do you have access?			
	ProjectWise:			
	Documents on the network:			
	Shared paper dossier:			
1.2.3.8	Do you electronically archive the information?			
1.2.3.9	If not, do you find it desirable to do so?			
1.2.3.10	Do you have a personal dossier?			
	Yes, on paper:			
	Yes, electronic:			
	No:			
1.2.3.11	Is there an increase or a decrease of digital storage?			
1.2.3.12	Is there an increase or decrease of paper storage?			
	Management of shared information			
1.2.3.13	Who manages this stored information?			
	You:			
	Project leader:			
	Secretariat:			
	Other			
1.2.3.14	Is that based on formal arrangements?			
1.2.3.15	If yes: what are these arrangements?			
	Information status / validating of design information within the project team			
1.2.3.16	Are all documents checked before being centrally stored?			
1.2.3.17	Who defines the status of documents?			
	You:			
	Project leader:			
	Secretariat:			

	Other			
	Change Procedures			
1.2.3.18	Can you describe the change procedures?			
1.2.3.19	Who manages this?			
	anyone providing information			
	the project leader			
	other			
1.2.3.20	Is that based on formal arrangements?			
1.2.3.21	Or are the arrangements depending on the project?			
	Information reuse			
1.2.3.22	Do you have access to data of your past projects?			
1.2.3.23	If yes: how?			
1.2.3.23.1	Approximately how often weekly/monthly do you consult this source?			
1.2.3.24	Do you have access to data of past projects of others?			
1.2.3.24.1	Approximately how often weekly/monthly do you consult this source?			
1.2.3.25	If yes: how?			
1.2.3.26	Do you have access to data of current projects of colleagues?			
1.2.3.26.1	Approximately how often weekly/monthly do you consult this source?			
1.2.3.27	If yes: how?			
1.3	**Time and activity**			
1.3.1	**Generating**			
	How do you generate documents?			
1.3.1.1	Do you make drafts of letters that are word processed by the secretary?			
1.3.1.2	Do you process letters yourself and sent them to the secretary for checking and printing?			
1.3.1.3	Do you process letters yourself and sent them of?			
1.3.1.4	Does your secretary send the letters?			
1.3.1.5	Who is signing your letters? (name and function)			
	You:			
	Project leader:			
	Head of department:			
	Other:.....			
1.3.1.6	Would you always follow the described procedure or will that depend on the conditions?			
1.3.1.7	If yes, please describe the procedure:			
1.3.1.8	What will you do if the person to sign is out of office?			
1.3.1.9	Will this give a delay?			
	Sketches (questions for architect)			
1.3.1.10	Do you make sketches?			
1.3.1.11	What type of sketches?			
	Concepts:			
	Impressions:			
	Detail sketches:			
	Presentation sketches:			

	Other:			
1.3.1.12	In which design phase do you make sketches?			
1.3.1.13	How do you make sketches?			
1.3.1.14	Do you prefer to sketch on paper or on the computer?			
1.3.1.15	Are the sketches further elaborated on the computer?			
1.3.1.16	If yes: by you?			
1.3.1.17	If no: how is the information transfer taking place?			
1.3.1.18	Do you have formal arrangements for this?			
	Visualizations (questions for architect)			
1.3.1.19	Do you make computer visualizations yourself?			
1.3.1.20	If no: does anyone else make these on computer?			
1.3.1.21	How do you present the information and how is the information transfer conducted?			
1.3.1.22	With which software are the visualizations made?			
1.3.1.23	In which phase of the design?			
1.3.1.24	Do you miss such software to make visualizations?			
	Sketches and schemes			
1.3.1.25	Do you make schemes on paper?			
1.3.1.26	Sketching them?			
1.3.1.27	Do others elaborate these on the computer?			
1.3.1.28	Do you make schemes yourself using computer software?			
1.3.1.29	If yes: with which software are the schemes made?			
	Planning of information processes (questions for the project leader / preparation co-coordinator)			
1.3.1.30	Do you make an information process planning on paper or with the computer?			
1.3.1.31	If on paper: does someone else elaborate this on computer?			
1.3.1.32	How do you present the information for this planning?			
1.3.1.33	In general: does the team well observe the agreed planning for the information exchange?			
1.3.1.34	What do you do in case a team member exceeds the time planning?			
1.3.1.35	Can such a time planning excess be foreseen?			
1.3.1.36	Can time planning excesses be controlled easy?			
1.3.1.37	If no: what is the reason?			
	Time registration			
1.3.1.38	Does time registration take place using paper or electronically?			
1.3.1.39	Do you use time registration for your own project feedback?			
1.3.1.40	Does feedback on time registration take place from the project team?			
1.3.1.41	Who deals with this feedback?			
1.3.2	**Exchange**			
1.3.2.2	Do you print e-mail:			
	Received:			
	Send:			

1.3.2.3	Why do you do this?			
1.3.2.4	How do you keep these printed received e-mail messages?			
	Project dossier:			
	Own archive:			
	Other:			
	Not kept:			
	How do you keep these printed send e-mail messages?			
	Project dossier:			
	Own archive:			
	Other:			
	Not kept:			
1.3.2.5	Do you keep received e-mail messages (digitally)?			
	All:			
	Important ones:			
	Archive:			
	No:			
	Do you keep send e-mail messages (digitally)?			
	All:			
	Important ones:			
	Archive:			
	No:			
1.3.2.6	Do you delete received messages after printing them?			
	Do you delete send messages after printing them?			
1.3.2.7	Do you respond to a received message?			
1.3.2.8	Would you also like to work without e-mail?			
1.3.2.9	Would you also like to work without paper?			
1.3.2.10	Do you consider e-mail a useful aid?			
1.3.2.11	Do you have the skill to store e-mail addresses of received messages in your own address file?			
1.3.2.12	Do you receive documents of other team members by e-mail?			
1.3.2.13	Do you use distribution or mailing lists? (E-mailing to multiple known addresses?)			
1.3.2.13.2	How long do you already use e-mail?			
1.3.2.14	Would you prefer using e-mail to to the telephone?			
	Electronic diary			
1.3.2.14.1	Do you use an electronically calendar, such as Outlook?			
1.3.2.14.2	If yes, what purposes do you use that diary for?			
	Calendar:			
	To do list:			
	Memo's:			
	Personal data:			
	Communication aspects			
1.3.2.15	How much time of your daily work do you spend on oral communication, including formal meetings and excluding telephone conversations?			
1.3.2.16	How much time of your daily work do you spend on formal meetings?			

1.3.2.17	How much time of your daily work do you spend on e-mail?			
1.3.2.18	How much did this increase over the past year?			
1.3.2.19	Did you experience there is less telephone contact due to the use of e-mail?			
1.3.2.20	In your opinion: is it possible that e-mail will take over all fax machine tasks?			
1.3.2.21	In your opinion: can e-mail be used for preparing a meeting?			
1.3.2.22	In your opinion: can e-mail be used to replace a meeting?			
	Team meetings			
1.3.2.23	In your opinion: are informal meetings necessary for decision-making?			
1.3.2.24	In your opinion: can in the present situation meetings be conducted more efficiently?			
1.3.2.25	If yes: how?			
1.3.2.26	Could there be fewer meetings?			
1.3.2.26.1	What is the frequency of formal meetings?			
1.3.2.27	Can the duration of a meeting be shortened?			
1.3.3	**Changes in Design Information**			
1.3.3.2	Do you keep track of changes to documents by using a formal Record of Changes?			
1.3.3.3	Do you inform others about changes in sketches, plans and documents?			
1.3.3.4	If yes: how?			
	Orally:			
	E-mail:			
	Telephone:			
	Record of alterations:			
	Note:			
	Via PW:			
	Other:			
1.4	**Discussion Questions**			
1.4.1	What do you think can be improved in the information exchange processes?			
1.4.2	Do you expect re-use of information by digitally stored files to be effective?			
1.4.3	Do you expect this to have positive or negative consequences for the processing speed and use of time and why?			
1.4.4	Do you consider ICT-use to be an improvement or not for the effectiveness and efficiency of the information processes in daily work?			
1.4.4.1	Do you miss certain forms or means of communication that you use in this questionnaire?			
1.4.5	Do you miss certain questions or would you like to make some comments?			
	Supplementary questions about ProjectWise			
1.4.6	For how long have you been working with PW?			
1.4.7.1	Do you consider you have sufficient PW skills?			
1.4.7.2	Would you like to participate in a supplementary training? If yes: for which parts?			

1.4.7.3	Have you participated before in training in the application of PW?			
1.4.7.4	Can you find what you are looking for in the manual of PW when you had questions?			
1.4.7.5	Do you consider PW to be an improvement?			
1.4.7.6	Can you indicate why?			
	PW procedures			
1.4.8	Is PW online when your PC is switched on?			
1.4.9	Do you prepare digital documents in PW?			
1.4.10	Where do you store documents that have been generated outside PW?			
1.4.11	Do you sometimes look for files using PW-Query?			
1.4.12	Do you report questions or problems to the PW co-ordinator?			
1.4.13	What do you think is best in PW?			
1.4.14	What do you think is the most tedious in PW?			
1.4.15	Do you store important e-mail in PW?			
	Why?			
1.4.16	In your opinion: is the recording of capacity planning information in PW advantageous?			
	Why?			
1.4.17	In your opinion: is the recording of time planning information in PW advantageous?			
	Why?			
1.4.18	Do you put documents in FINAL yourself?			
	Why, yes or no?			

A6. Format questionnaire other Firms

Use of a Project Website
by a construction firm
Semi- structured questionnaire. Interview held at
date:

	Yes or no answers, please circle the right answer	answers
1.0	Name of the organization, using the PWS	
1.1	Name of the respondent:	
1.2	Respondent's function regarding the management of PWS:	
	Application manager	yes/no
	Administrator	yes/no
	User + project leader of a team:	yes/no
	User + team coordinator:	yes/no
	User + team members:	yes/no
1.3	Name of the Project Website package:	
1.4	Number of licenses:	
2.0	For which purposes is the PWS used:	
	Letters and reports:	yes/no
	Calculations:	yes/no
	Planning schemes:	yes/no
	Drawing files:	yes/no
	Facsimile messages:	yes/no
	Email messages:	yes/no
	Photographs:	yes/no
	Minutes of meetings:	yes/no
3.0	Who is responsible for prescribed use of PWS?	
	Project leader	yes/no
	Administrator	yes/no
	Other person?	yes/no
3.1	Is prescribed use controlled and if so by whom?	yes/no
	Are there sanctions for discrepancies of prescribed use?	yes/no
3.2	Motivation of the yes/no answer:	
	Are actions for correcting users needed?	
4.0	How long is the PWS in use?	
	< 1 year	
	< 2 year	
	<3 year	
	>= 3 year	
5.0	At which department, group or team is the PWS used?	
	Name of team or department:	
	Task:	
	Task:	
	Task:	
	Are persons allowed to view or to update other files?	yes/no
	Motivation of the answer:	
6.0	In what type of teams is the PWS used?	
	Project teams, multidisciplinary:	yes/no

	Project teams, mono disciplinary:	yes/no
	Vast project teams:	yes/no
7.0	Who is responsible for the team result?	
	Who is responsible for prescribed PWS-use by the team?	
8.0	Purpose of use of the PWS?	
	Daily use for improving team performance:	yes/no
	Publication of files occasionaly:	yes/no
	Electronic library function for re-use of files:	yes/no
9.0	Which agreements have been made for the frequency of storing?	
	Per hour:	yes/no
	Per 3 or 4 hours:	yes/no
	Per day:	yes/no
	Other period:	yes/no
10.0	Which software packages are used:	
	MS-office modules: word, excel	yes/no
	Other modules:	
	CAD-package? Name of the package:	
	Other package:	
	Other package:	
	Other package:	
11.0	Manual for use of the Project Website:	
	Standard manual:	yes/no
	Specific firm manual:	yes/no
	If a firm manual is developed, how is this maintained:	yes/no
	Which extra appointments are made for prescribed use:	
	Change of version and status?	yes/no
	Updating by other team members?	yes/no
	Finalizing of stored files?	yes/no
	Use of attributes?	yes/no
	Number of used attributes?	
	Use of wizards for adding attributes?	yes/no
12.0	How are team members trained?	
	External, extensive training?	yes/no
	Internal, extensive training?	yes/no
	Training in teams or groups?	yes/no
	User instructions?	yes/no
	Extensive training with database functions?	yes/no
	Certificate by the end of the training?	yes/no
	Self training and practicing at the workplace?	yes/no
	Other training?	
13.0	PWS-storage of other documents:	
	Storage of facsimile messages?	yes/no
	Storage of email messages?	yes/no
	Is a Mail messenger used for notification?	yes/no
	If so, for what reason?	
14.0	Is status change of documents used?	yes/no
15.0	Are queries in use?	yes/no

16.0	Is the adding of attributes checked?	
17.0	Is a user platform organized?	yes/no
	If so, who are the members?	
	Who chairs the platform?	
	Purpose of the platform?	
18.0	Which type of improvement is the target of PWS-use?	
	Improvement of time?	
	Does increase of time improvement occur?	
	Improvement of quality?	
	Does increase of quality improvement occur?	
	Improvement of both time and quality?	
	Does increase of time and quality occur?	
19.0	Which new problems occur due to PWS-use?	
20.0	Are there wishes for improvement of the PWS-use?	
21.0	Will PWS-use extend in the firm in the near future?	
22.0	How is the computer network structured?	
	Member's own disk?	Yes/no
	Shared project disk?	Yes/no
	Department or discipline disk?	Yes/no
23.0	Other remarks concerning PWS-use?	

Appendix B: Overview of collected data of REA

B1. Use of communication means before ProjectWise use

B1A. Use of communication means before ProjectWise use in teams AE and AC

Table B1A1: Estimated use by team members of formal and informal meetings in 2001-2002

Team role	Team AE		Team AC	
	Formal	Informal	Formal	Informal
Project leader	10%	30%	10%	30%
Team coordinator	10%	10%	10%	20%
Architect	8%	12%	10%	25%
Structural engineer	10%	10%	5%	30%
Quantity surveyor	5%	5%	<10%	5%
Detail construction designer	10%	10%	10%	10%
HC-installation designer	20%	10%	10%	20%
E-installation designer	20%	10%	10%	20%
Average	12%	12%	9%	20%

Table B1A2: Preference of use of postal mail by team members in 2001- 2002

Team role	Team AE		Team AC	
	Preferred use	Frequency	Preferred use	Frequency
Project leader	No	<5	No	<5
Team coordinator	No	<5	No	<5
Architect	No	<2	No	<5
Structural engineer	No	<5	No	<5
Quantity surveyor	No	<5	No	<5
Detail construction designer	No	<5	No	<5
HC-installation designer	No	<5	No	<5
E-installation designer	No	<5	No	<5
Average percentage	No	<5	No	<5

Table B1A3: Estimated use of MS-email and increase of use in 2001 - 2002

Team role	Team AE		Team AC	
	Outlook email use per day	Increase of email use	Outlook email use per day	Increase of email use
Project leader	5%	0%	5%	0%
Team coordinator	5%	60%	5%	60%
Architect	5%	60%	5%	40%
Structural engineer	5%	20%	10%	0%
Quantity surveyor	5%	20%	5%	20%
Detail construction designer	5%	0%	15%	0%
HC-installation designer	5%	60%	5%	20%
E-installation designer	10%	20%	10%	20%
Average percentage	6%	30%	8%	20%

Table B1A4: Influence of MS-email use on the use of other communication means

Influence of MS-email use on:	Number of team members AE	Number of team members AC
(1.3.2.19) Decrease of telephone use	6	6
(1.3.2.21) Preparations team meetings	7	5
(1.3.2.20) Decrease of facsimile use	6	6

Table B1A5: Number of team members that expect re-use of information to be effective

Measurements 2001-2002, question 1.4.2: Do you expect re-use of information by digitally stored files to be effective?	Team AE		Team AC	
	Yes	No	Yes	No
Project leader	X			X
Team coordinator		X	X	
Architect	X		X	
Structural engineer	X		X	
Quantity surveyor		X		X
Detail construction designer	X		X	
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	6	2	6	2

Table B1A6: Number of team members that consider ICT-use to be an improvement or not

Measurements 2001-2002, question 1.4.4: Do you consider ICT-use to be an improvement in daily work?	Team AE		Team AC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X			X
Architect	X		X	
Structural engineer	X		X	
Quantity surveyor	X		X	
Detail construction designer	X			X
HC-installation designer		X		X
E-installation designer		X	X	
Total number	6	2	5	3

Table B1A7: Number of team members who think that team meetings can be organized more effective

Measurements 2001-2002, question 1.3.2.24: Can team meetings be organized more effective?	Team AE		Team AC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X		X	
Architect	X		X	
Structural engineer	X		X	
Quantity surveyor		X		X
Detail construction designer		X	X	
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	6	2	7	1

B1B. Use of communication means before ProjectWise use in teams BE and BC

Table B1B1: Estimated use by team members of formal and informal meetings in 2001-2002

Team role	Team BE		Team BC	
	Formal	Informal	Formal	Informal
Project leader	30%	25%	10%	0%
Team coordinator	10%	20%	7%	33%
Architect	15%	20%	10%	0%
Structural engineer	10%	10%	7%	3%
Quantity surveyor	20%	10%	10%	10%
Detail construction designer	10%	10%	10%	10%
HC-installation designer	10%	10%	10%	45%
E-installation designer	10%	10%	10%	10%
Average percentage	14%	14%	9%	14%

Table B1B2: Preference of use of postal mail by team members in 2001- 2002

Team role	Team BE		Team BC	
	Preferred use	Frequency	Preferred use	Frequency
Project leader	No	<5	No	>5
Team coordinator	No	<5	No	<10
Architect	No	<5	No	<5
Structural engineer	No	<5	No	<5
Quantity surveyor	No	<5	No	<5
Detail construction designer	No	<5	No	<5
HC-installation designer	No	<5	No	<5
E-installation designer	No	<5	No	<5
Average percentage	No	<5	No	<5

Table B1B3: Estimated use of MS-email and increase of use in 2001 - 2002

Team role	Team BE		Team BC	
	Outlook email use per day	Increase of email use	Outlook email use per day	Increase of email use
Project leader	15%	40%	0%	0
Team coordinator	5%	0%	5%	20%
Architect	5%	40%	5%	40%
Structural engineer	10%	100%	3%	0%
Quantity surveyor	5%	20%	5%	20%
Detail construction designer	5%	0%	5%	20%
HC-installation designer	5%	20%	5%	0%
E-installation designer	15%	20%	5%	100%
Average percentage	8%	30%	4%	25%

Table B1B4: Influence of MS-email use on the use of other communication means

Influence of MS-email use on :	Number of team members BE	Number of team members BC
(1.3.2.19) Decrease of telephone use	6	4
(1.3.2.21) Preparations team meetings	8	7
(1.3.2.20) Decrease of facsimile use	3	5

Table B1B5: Number of team members that expect re-use of information to be effective

Measurements 2001-2002, question 1.4.2 Do you expect re-use of information by digitally stored files to be effective?	Team BE		Team BC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X		X	
Architect	X		X	
Structural engineer	X		X	
Quantity surveyor		X	X	
Detail construction designer	X			X
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	7	1	7	1

Table B1B6: Number of team members that consider ICT-use to be an improvement or not

Measurements 2001-2002, question 1.4.4: Do you consider ICT-use to be an improvement in daily work?	Team BE		Team BC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X			X
Architect		X	X	
Structural engineer	X		X	
Quantity surveyor	X		X	
Detail construction designer	X			X
HC-installation designer	X			X
E-installation designer		X	X	
Total number	6	2	5	3

Table B1B7: Number of team members who think that team meetings can be organized more effective

Measurements 2001-2002, question 1.3.2.24: Can team meetings be organized more effective?	Team BE		Team BC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X		X	
Architect	X			X
Structural engineer	X			X
Quantity surveyor	X		X	
Detail construction designer		X	X	
HC-installation designer	X		X	
E-installation designer		X	X	
Total number	6	2	7	1

B1C. Use of communication means before ProjectWise use in teams CE and CC

Table B1C1: Estimated use by team members of formal and informal meetings in 2001-2002

Team role	Team CE		Team CC	
	Formal	Informal	Formal	Informal
Project leader	10%	45%	20%	20%
Team coordinator	10%	10%	10%	30%
Architect	20%	35%	30%	20%
Structural engineer	10%	45%	30%	0%
Quantity surveyor	10%	0%	10%	0%
Detail construction designer	10%	10%	10%	10%
HC-installation designer	10%	20%	10%	10%
E-installation designer	10%	20%	30%	10%
Average percentage	11%	23%	19%	13%

Table B1C2: Preference of use of postal mail by team members in 2001- 2002

Team role	Team CE		Team CC	
	Preferred use	Frequency	Preferred use	Frequency
Project leader	No	10	No	>5
Team coordinator	No	10	No	<5
Architect	No	<5	No	<5
Structural engineer	No	<5	No	<5
Quantity surveyor	No	<5	No	<5
Detail construction designer	No	<5	No	<5
HC-installation designer	No	<5	No	<5
E-installation designer	No	<5	No	<5
Average percentage	No	<7	No	<5

Table B1C3: Estimated use of MS-email and increase of use in 2001 - 2002

Team role	Team CE		Team CC	
	Outlook email use per day	Increase of email use	Outlook email use per day	Increase of email use
Project leader	20%	0%	15%	40%
Team coordinator	20%	20%	5%	20%
Architect	10%	0%	25%	80%
Structural engineer	5%	0%	5%	0%
Quantity surveyor	5%	20%	5%	0%
Detail construction designer	5%	20%	5%	0%
HC-installation designer	5%	20%	10%	40%
E-installation designer	10%	0%	20%	20%
Average percentage	10%	10%	11%	25%

Table B1C4: Influence of MS- email use on the use of other communication means

Influence of MS-email use on:	Number of team members CE	Number of team members CC
(1.3.2.19) Decrease of telephone use	7	6
(1.3.2.21) Preparations team meetings	8	8
(1.3.2.20) Decrease of facsimile use	7	7

Table B1C5: Number of team members that expect re-use of information to be effective

Measurements 2001-2002, question 1.4.2: Do you expect re-use of information by digitally stored files to be effective?	Team CE		Team CC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X		X	
Architect	X		X	
Structural engineer	X		X	
Quantity surveyor	X		X	
Detail construction designer	X			X
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	8	0	7	1

Table B1C6: Number of team members that consider ICT-use to be an improvement or not

Measurements 2001-2002, question 1.4.4: Do you consider ICT-use to be an improvement in daily work?	Team CE		Team CC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X			X
Architect	X			X
Structural engineer	X		X	
Quantity surveyor	X		X	
Detail construction designer	X			X
HC-installation designer		X		X
E-installation designer	X			X
Total number	7	1	3	5

Table B1C7: Number of team members who think that team meetings can be organized more effective

Measurements 2001-2002, question 1.3.2.24: Can team meetings be organized more effective?	Team CE		Team CC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X		X	
Architect	X		X	
Structural engineer	X		X	
Quantity surveyor	X		X	
Detail construction designer		X		X
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	7	1	7	1

B2. Observed ProjectWise use of REA's experimental and control teams

B2A. Divers tables for measurement of PW activities

Table B2A1: Average number of file storage of REA's experimental teams during 10 months

Team role	File storage team AE	File storage team BE	File storage team CE	Average file number
Project leader	150	29	32	70
Team coordinator	56	37	29	41
Architect	6	0	0	2
Structural engineer	0	0	13	4
Quantity surveyor	127	9	0	45
Detail construction designer	135	70	2	69
HC-installation designer	40	29	14	28
E-installation designer	16	74	71	54
Total number of files in 10 months	530	248	161	313
Team member's average number per month	7	3	2	4

Table B2A2: Grade points of REA's team members that used PW the best and ideal use
* Regular file draggers, ** Structural engineers should use .Pdf format for file storage in PW

Team role	Grade points team AE	Grade point s team BE	Grade points team CE	Highest grade point score	Ideal use
Project leader	5	4	4	5	5
Team coordinator*	3	2	3	3	5
Architect	1	0	2	2	2
Structural engineer**	0	0	1	1	2
Quantity surveyor	5	1	0	5	5
Detail construction designer	5	4	6	6	6
HC-installations designer*	2	3	4	4	6
E-installations designer	2	4	6	6	6
Project leader + coordinator	1	1	1	1	1
Project leader + architect	1	0	1	1	1
Coordinator + architect	1	0	1	1	1
Team total grade points	26	19	29	35	40

Table B2A3: Overview of the average number of actual readings per team member per month

Team role	Team AE readings	Team BE readings	Team CE readings	Average number of readings
Project leader	2	5	8	5
Team coordinator	5	9	19	11
Architect	7	0	3	3
Structural engineer	0	1	15	5
Quantity surveyor	3	8	3	5
Detail construction designer	1	15	10	8
HC-installation designer	0	2	5	3
E-installation designer	0	4	19	8
Team's average number	2	5	10	6

Table B2A4: Overview of the percentage of prescribed storage in PW and finalized for re-use

Percentage of storage of electronically generated files by REA's design teams			
	Actual storage PW	Actual Storage in SD	Storage for re-use
Prescribed use	100%	0%	100%

Table B2A5: Overview of ProjectWise user rights in REA's design teams

Function / Role	Authority for granting user rights	Viewing / reading of files	Create and delete files	Change files of other user	Change of file status to Final	New Version of files	Grouping of files	Download files by other user
PW-management	X	X	X	X	X	X	X	X
Administrator	X	X	X	X	X	X	X	X
Project leader		X	X	X	X	X	X	X
Architect		X	X	X	X	X	X	X
Team coordinator		X	X	X	X	X	X	X
Quantity surveyor		X	X	X	X	X	X	X
Structural engineer		X	X	X	X	X	X	X
Detail construction designer		X	X	X	X	X	X	X
HC-installation designer		X	X	X	X	X	X	X
E-installation designer		X	X	X	X	X	X	X
Secretary staff		X	X	X	X			
Unit member		X						X
Colleague in other unit		X						X

B2B. Software packages used with ProjectWise

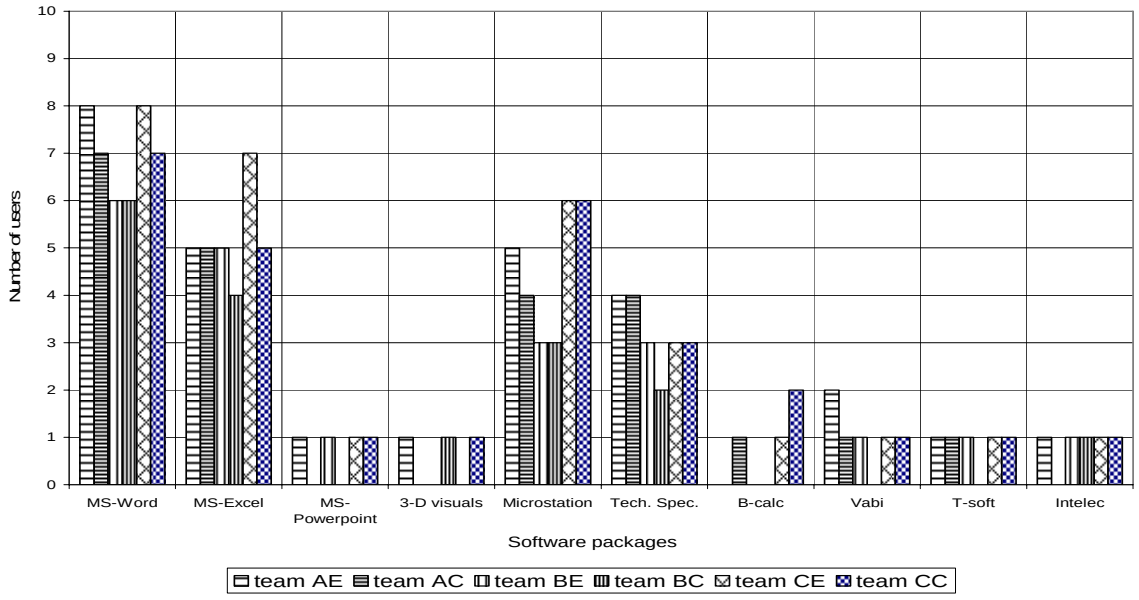

Figure B2B1: Graphs of use of software packages in units A-B-C

B2C. Use of ProjectWise in teams AE and AC

Table B2C1: Number of grade points for ProjectWise use per month per team member of team AE

TEAM AE	2003 Jan.	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb	Mar
Project leader	0	0	0	1	1	2	1	1	1	2	2	5	5	5	5
Team coordinator	0	0	0	0	0	1	4	2	0	1	1	1	4	1	3
Architect	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Structural engineer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quantity surveyor	0	0	0	0	0	2	2	2	3	5	3	2	4	3	5
Detail construction designer	0	0	0	0	0	1	1	0	2	3	2	2	3	5	4
HC-installation designer	0	0	0	0	0	2	1	0	1	1	1	0	0	2	0
I-installation designer	0	0	0	1	1	2	1	1	1	0	0	0	0	1	0
Project leader + coordinator	0	0	0	0	0	1	1	1	0	1	1	1	1	1	1
Project leader + architect	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Coordinator + architect	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Team total:	0	0	0	2	2	11	14	7	8	13	10	11	17	18	22

Table B2C2: Number of grade points for ProjectWise use per month per member of team AC

TEAM AC	2003 Jan.	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb	Mar
Project leader	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1
Team coordinator	0	0	0	1	0	0	0	0	0	0	4	2	0	2	2
Architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Structural engineer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quantity surveyor	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Detail construction designer	0	0	0	0	1	0	1	0	3	3	1	2	0	0	1
HC-installation designer	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
I-installation designer	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0
Project leader + coordinator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Project leader + architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coordinator + architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Team total:	0	0	0	3	2	1	1	0	4	4	5	4	2	3	5

Table B2C3: Frequency of file-dragging per month by team members of team AE
(regular file draggers are marked with *)

TEAM AE	2003 Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb.	Mar
Project leader*		1		2	1	1						1	2	3	3
Team coordinator*						1	1						3		1
Architect															1
Structural engineer											1				
Quantity surveyor*						2		1		3	2		1		
Detail construction designer*						3			1	1			1	2	3
HC-installation designer						2	2		1	1		1			
E-installation designer				2	1	1	1	1		3					

Table B2C4: Frequency of file-dragging per month by team members of team AC (regular file draggers are marked with *)

TEAM AC	2003 Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb.	Mar
Project leader*															
Team coordinator*			1	1		1					2			1	2
Architect															
Structural engineer											1				
Quantity surveyor*															
Detail construction designer*		1					1		1	3				1	
HC-installation designer															
E-installation designer				2	1	1	1	1		3					

Table B2C5: Number of dragged files per month by members of team AE

TEAM AE	2003 Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	2004 Jan.	Feb.	Mar.	Total
Project leader	3	0	3	21	17	35	6	6	6	9	22	30	22	38	43	263
Team coordinator	0	0	0	0	0	38	12	7	2	6	4	4	15	17	47	152
Architect	0	0	0	0	0	0	1	0	0	2	0	0	0	0	4	7
Structural engineer	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	2
Quantity surveyor	1	0	0	0	2	0	5	10	12	27	14	9	23	19	25	147
Detail construction designer	0	0	0	1	1	4	3	3	10	14	17	10	18	35	70	186
HC-installation designer	0	0	0	0	1	13	19	1	6	24	4	14	14	7	8	111
I-installation designer	0	0	0	12	6	9	5	5	4	16	0	5	2	5	3	72
Team total:	4	0	3	40	30	102	55	32	70	99	82	74	105	146	227	986

Table B2C6: Number of dragged files per month by members of team AC

TEAM AC	2003 Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	2004 Jan.	Feb.	Mar.	Total
Project leader	0	0	0	0	0	1	2	2	0	2	6	1	22	8	7	51
Team coordinator	0	0	17	16	1	3	0	2	0	0	15	6	7	19	30	121
Architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Structural engineer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
Quantity surveyor	0	0	0	0	0	0	2	0	0	0	1	0	4	3	2	12
Detailed designer	2	2	0	5	3	0	18	1	1	15	27	10	3	19	15	121
HC-installation designer	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
I-installation designer	0	0	0	11	6	8	5	5	4	0	15	5	0	5	3	67
Team total:	2	2	17	32	10	12	27	10	5	17	64	22	36	55	62	431

Table B2C7: The number of readers of team AE and AC and their number of reading the teams PW content

	Number of Readings								
	2x	3x	4x	5x	6x	7x	8x	9x	>=10x
Number of members of team AC	1	1	0	0	0	0	0	0	0
Number of members of team AE	1	1	0	1	0	1	0	0	1

Table B2C8: Use of ProjectWise type and number of stored ProjectWise-documents team AE

TEAM AE	Email msg.	Fac-similes	Letters docs	PVA	PVE	Minutes of meetings	Images, jpg	Calcula-tions	Drawings	Sketches and schemes
Project leader*	4	26	25	10	2	-	4	26	-	-
Team coordinator*	-	-	25	-	-	12	-	41	-	-
Architect	-	-	3	-	-	-	17	-	2	-
Structural engineer	-	-	4	-	-	-	-	9	-	-
Quantity surveyor*	-	-	25	-	-	-	-	81	-	-
Detailed designer*	-	-	-	-	-	-	-	-	201	-
HC-installation designer	-	-	25	-	-	-	-	26	26	-
I-installation designer	49	-	11	-	-	-	-	4	-	-
Total docs:	53	26	134	12	2	12	21	187	229	-

Table B2C9: Use of ProjectWise type and number of stored ProjectWise-documents team AC

TEAM AC	Email msg.	Fac-similes	Letters docs	PVA	PVE	Minutes of meetings	Images, jpg	Calcula-tions	Drawings	Sketches and schemes
Project leader*	-	-	16	2	-	-	-	6	-	-
Team coordinator*	-	-	16	-	-	13	76	26	6	-
Architect	-	-	-	-	-	-	-	-	-	-
Structural engineer	-	-	4	-	-	-	-	11	-	-
Quantity surveyor*	-	-	-	-	-	-	-	11	-	-
Detailed designer*	-	-	-	-	-	-	5	-	101	-
HC-installation designer	-	-	1	-	-	-	-	-	1	-
I-installation designer	41	-	11	-	-	-	-	4	-	-
Total docs:	41	-	48	2	-	13	81	58	108	-

Table B2C10: Number of members that reported use of ProjectWise, shared disk and project dossier

Means used for document storage:	Number of users team AE		Number of users team AC	
	2001-2002	2004	2001-2002	2004
ProjectWise	1	7	1	7
Shared project disk / part of network disk	7	4	8	4
Project dossier	6	5	7	5
Generation of doc's in PW?	0	4	0	4
Generation of doc's in Shared project disk?	6	6	7	7

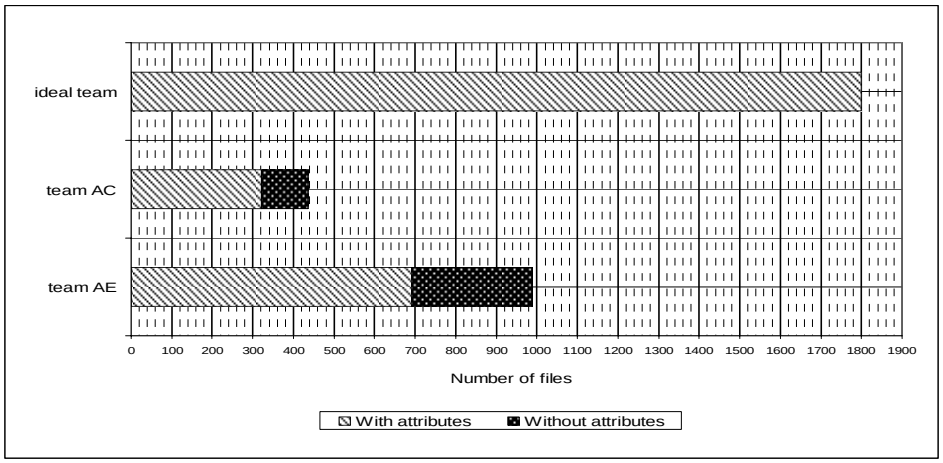

Figure B2C1: Total of the manual adding of attributes by teams AC and AE

B2D. Use of ProjectWise in teams BE and BC

Table B2D1: Number of grade points for ProjectWise use per month per team member of team BE

TEAM BE	2003 Jan.	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb	Mar
Project leader	0	0	0	0	0	4	4	2	0	0	0	0	0	0	0
Team coordinator	0	0	0	0	0	1	2	1	0	0	1	1	0	1	2
Architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Structural engineer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quantity surveyor	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Detail construction designer	0	0	0	0	0	0	0	0	0	4	4	1	2	2	4
HC-installation designer	0	0	1	3	1	3	1	1	0	0	0	1	0	1	2
I-installation designer	0	0	1	1	1	2	4	0	0	1	4	0	4	2	3
Project leader + coordinator	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0
Project leader + architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coordinator + architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Team total:	0	0	2	6	2	13	15	7	2	5	9	4	6	7	11

Table B2D2: Number of grade points for ProjectWise use per month per team member of team BC

TEAM BC	2003 Jan.	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb	Mar
Project leader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Team coordinator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Structural engineer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quantity surveyor	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
Detail construction designer	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0
HC-installation designer	0	0	0	1	6	3	4	0	0	0	0	0	1	3	4
I-installation designer	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1
Project leader + coordinator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project leader + architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coordinator + architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Team total:	0	0	0	1	6	4	6	0	1	0	1	2	1	4	5

Table B2D3: Frequency of file-dragging per month by team members of team BE
(regular file draggers are marked with *)

TEAM BE	2003 Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb.	Mar
Project leader	0	0	0	0	0	1	4	2	0	0	0	0	0	1	0
Team coordinator*	0	0	0	0	0	3	4	1	0	0	1	1	0	0	3
Architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Structural engineer	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Quantity surveyor*	0	0	0	0	1	1	0	0	2	0	1	2	1	0	0
Detail construction designer*	0	0	0	1	1	1	0	0	0	7	6	0	0	1	1
HC-installation designer*	0	0	1	3	0	4	1	2	0	0	0	1	0	0	1
E-installation designer*	0	0	0	0	1	2	3	0	0	0	3	0	2	1	2

Table B2D4: Frequency of file-dragging per month by team members of team BC (regular file draggers are marked with *)

TEAM BC	2003 Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb.	Mar
Project leader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Team coordinator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Structural engineer	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Quantity surveyor	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Detail construction designer*	0	0	0	0	0	0	0	0	1	0	1	1	2	0	0
HC-installation Designer*	0	0	1	3	7	3	3	0	0	1	0	0	2	3	1
E-installation Designer*	0	0	0	0	0	0	0	0	2	0	0	2	0	1	3

Table B2D5: Number of dragged files per month by members of team BE

TEAM BE	2003 Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	2004 Jan.	Feb.	Mar.	Total
Project leader	0	0	0	1	0	17	18	9	0	0	1	0	0	1	0	47
Team coordinator	0	0	0	1	1	6	10	5	2	0	3	4	0	4	9	45
Architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Structural engineer	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Quantity surveyor	0	0	0	0	1	2	2	0	5	1	1	0	0	0	0	12
Detail construction designer	0	0	0	2	2	3	3	1	0	15	16	3	7	10	15	77
HC-installation designer	0	0	4	14	3	13	4	4	2	1	3	4	0	4	7	63
I-installation designer	0	0	3	4	3	9	16	0	0	6	15	2	17	7	11	93
Team total:	0	0	8	30	11	58	65	26	13	23	41	18	24	29	42	388

Table B2D6: Number of dragged files per month by members of team BC

TEAM BC	2003 Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	2004 Jan.	Feb.	Mar.	Total
Project leader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Team coordinator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Structural engineer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quantity surveyor	0	0	0	0	0	0	6	2	0	0	3	1	2	2	2	18
Detail construction designer	0	0	0	0	2	3	5	0	2	1	1	6	3	1	0	24
HC-installation designer	0	0	3	11	23	12	16	1	0	1	1	1	5	12	15	101
I-installation designer	0	0	0	1	0	0	0	0	3	0	1	5	0	6	4	20
Team total:	0	0	3	12	25	15	27	3	5	2	6	13	10	21	21	163

Table B2D7: The number of readers of team BE and BC and their number of reading the teams PW content

	Number of Readings								
	2x	3x	4x	5x	6x	7x	8x	9x	>=10x
Number of members of team BC	0	0	0	0	0	0	0	0	0
Number of members of team BE	1	0	1	1	0	0	1	1	1

Table B2D8: Use of ProjectWise type and number of stored ProjectWise-documents team BE

TEAM BE	Email msg.	Fac-similes	Letters docs	PVA	PVE	Minutes of meetings	Images, jpg	Calcula-tions	Drawings	Sketches and schemes
Project leader	-	-	36	4	1	8	-	17	-	-
Team coordinator	3	-	51	2	-	1	-	29	-	-
Architect	-	-	-	-	-	-	-	-	-	-
Structural engineer	-	-	-	-	-	-	-	-	-	-
Quantity surveyor	-	-	2	-	-	-	-	19	-	-
Detail construction designer	-	-	17	-	-	1	-	-	84	-
HC-installation designer	2	-	25	1	-	1	-	42	5	-
I-installation designer	-	-	16	-	-	-	-	18	104	-
Total docs:	5	-	147	7	1	11	-	125	193	-

Table B2D9: Use of ProjectWise type and number of stored ProjectWise-documents team BC

TEAM BC	Email msg.	Fac-similes	Letters docs	PVA	PVE	Minutes of meetings	Images, jpg	Calcula-tions	Drawings	Sketches and schemes
Project leader	-	-	-	-	-	-	-	-	-	-
Team coordinator	-	-	-	-	-	-	-	-	-	-
Architect	-	-	-	-	-	-	-	-	-	-
Structural engineer	-	-	-	-	-	-	-	18	-	-
Quantity surveyor	-	-	-	-	-	-	-	-	-	-
Detail construction designer	-	-	-	-	-	-	-	-	34	-
HC-installation designer	-	-	-	-	-	-	-	1	120	-
I-installation designer	4	-	-	-	-	-	-	-	70	-
Total docs:	4	-	-	-	-	-	-	1	190	-

Table B2D10: Number of members that reported use of ProjectWise, shared disk and project dossier

Means used for document storage:	Number of users team BE		Number of users team BC	
	2001-2002	2004	2001-2002	2004
ProjectWise	0	6	0	6
Shared project disk / part of network disk	7	6	6	5
Project dossier	7	6	7	5
Generation of doc's in PW?	0	5	0	2
Generation of doc's in Shared project disk?	8	7	4	4

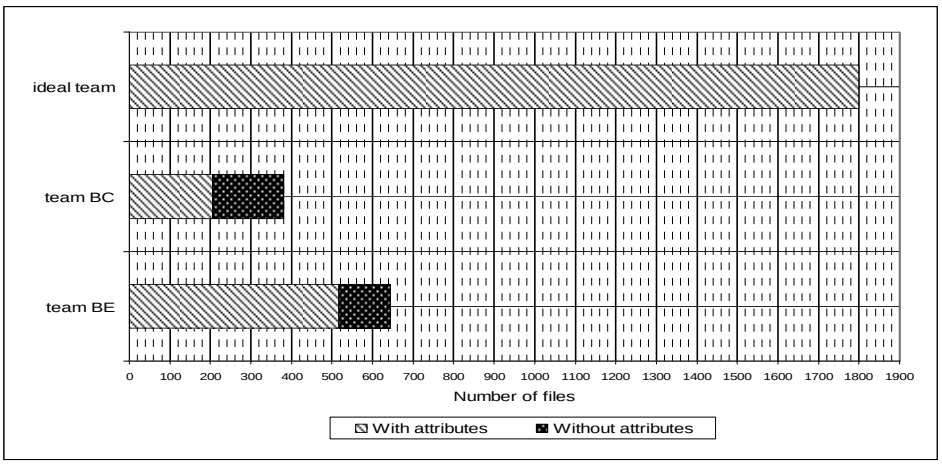

Figure B2D1: Total of the manual adding of attributes by teams BC and BE

B2E. Use of ProjectWise in teams CE and CCC

Table B2E1: Number of grade points for ProjectWise use per month per team member of team CE

TEAM CE	2003 Jan.	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb	Mar
Project leader	0	0	0	0	0	1	1	1	1	2	2	0	1	4	2
Team coordinator	0	0	0	0	2	0	2	0	0	3	1	0	0	0	2
Architect	0	0	0	0	0	2	2	0	0	2	0	0	2	1	0
Structural engineer	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Quantity surveyor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Detail construction designer	0	0	0	0	0	2	4	0	3	4	3	0	0	0	6
HC-installation designer	0	0	0	0	0	0	1	0	2	1	0	0	1	1	4
I-installation designer	0	0	0	1	0	2	2	0	6	5	5	0	1	0	0
Project leader + coordinator	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1
Project leader + architect	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0
Coordinator + architect	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Team total:	0	0	0	1	2	8	15	1	12	21	13	0	5	7	15

Table B2E2: Number of grade points for ProjectWise use per month per team member of team CC

TEAM CC	2003 Jan.	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb	Mar
Project leader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Team coordinator	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Architect	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Structural engineer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quantity surveyor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Detail construction designer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HC-installation designer	0	0	0	0	0	0	0	0	0	0	0	1	2	0	1
I-installation designer	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1
Project leader + coordinator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project leader + architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coordinator + architect	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Team total:	0	0	0	0	0	1	2	0	0	0	0	3	2	0	2

Table B2E3: Frequency of file-dragging per month by team members of team CE
(regular file draggers are marked with *)

TEAM CE	2003 Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb.	Mar
Project leader	0	0	0	0	0	1	0	0	2	0	2	0	0	0	2
Team coordinator*	0	0	0	0	2	0	0	0	0	1	1	0	0	0	0
Architect	0	0	0	0	0	1	2	0	0	0	0	0	4	0	0
Structural engineer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quantity surveyor*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Detail construction designer*	0	0	0	0	0	2	2	0	1	3	1	0	0	1	2
HC-installation designer*	0	0	0	0	0	0	2	0	0	0	0	0	0	1	4
E-installation designer*	0	0	1	0	1	3	3	0	2	0	0	0	1	0	0

Table B2E4: Frequency of file-dragging per month by team members of team CC (regular file draggers are marked with *)

TEAM CC	2003 Jan.	Feb.	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	2004 Jan.	Feb.	Mar
Project leader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Team coordinator	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0
Architect	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0
Structural engineer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quantity surveyor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Detail construction designer*	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0
HC-installation designer*	0	0	0	0	0	0	0	0	1	0	4	3	1	0	0
E-installation designer*	0	0	0	0	0	3	1	0	0	0	0	0	0	0	4

Table B2E5: Number of dragged files per month by members of team CE

TEAM CE	2003 Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	2004 Jan.	Feb.	Mar.	Total
Project leader	0	0	0	0	0	11	0	0	12	0	6	0	0	0	7	36
Team coordinator	0	0	0	0	30	0	0	0	0	2	5	0	0	0	0	37
Architect	0	0	0	0	0	3	15	0	0	0	0	0	27	0	0	0
Structural engineer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Quantity surveyor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10
Detail construction Designer	0	0	0	0	0	16	12	0	4	4	48	0	5	0	10	99
HC-installation Designer	0	0	0	0	0	0	3	0	14	6	0	0	3	6	4	36
I-installation Designer	0	0	4	0	2	6	11	0	3	0	0	0	4	0	0	30
Team total:	0	0	4	0	32	36	41	0	33	12	59	0	39	6	31	249

Table B2E6: Number of dragged files per month by members of team CC

TEAM CC	2003 Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	2004 Jan.	Feb.	Mar.	Total
Project leader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Team coordinator	0	0	0	0	0	3	0	0	0	0	0	3	3	0	0	9
Architect	0	0	0	0	13	0	0	0	0	0	70	0	0	0	0	83
Structural engineer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quantity surveyor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Detail construction designer	0	0	0	0	0	0	0	0	0	0	0	0	10	12	0	22
HC-installation designer	0	0	0	0	0	0	0	0	15	0	210	10	17	0	0	252
I-installation designer	0	0	0	0	0	164	6	0	0	0	0	0	0	0	100	270
Team total:	0	0	0	0	13	167	6	0	15	0	280	13	30	12	100	636

Table B2E7: Number of readers of team CE and CC and their number of reading the teams PW content

	Number of Readings								
	2x	3x	4x	5x	6x	7x	8x	9x	>=10x
Number of members of team CC	2	0	1	0	0	0	0	0	0
Number of members of team CE	0	3	1	0	0	1	1	0	2

Table B2E8: Use of ProjectWise type and number of stored ProjectWise-documents team CE

TEAM CE	Email msg.	Fac-similes	Letters docs	PVA	PVE	Minutes of meetings	Images, jpg	Calcula-tions	Drawings	Sketches and schemes
Project leader*	6	-	53	15	1	38	-	12	4	-
Team coordinator*	-	-	1	1		-	-	14	32	-
Architect	-	-	-	1	-	-	49	-	40	-
Structural engineer	-	-	1	-	-	-	-	-	13	-
Quantity surveyor*	-	-	1	-	-	-	-	8	-	-
Detail construction designer*	-	-	3	3	-	-	50	4	96	-
HC-installation designer	50	-	38	1	4	7	-	17	4	-
I-installation designer	-	-	5	2		2	-	6	78	-
Total docs:	56	0	102	30	5	47	99	61	267	0

Table B2E9: Use of ProjectWise type and number of stored ProjectWise-documents team CC

TEAM CC	Email msg.	Fac-similes	Letters docs	PVA	PVE	Minutes of meetings	Images, jpg	Calcula-tions	Drawings	Sketches and schemes
Project leader*	-	-	2			-	-	-	-	-
Team coordinator*	-	-	8	1	-	-	-	6	-	1
Architect	-	-	-	-	-	-	42	-	-	-
Structural engineer	-	-	2	-	-	-	-	-	13	-
Quantity surveyor*	-	-	2	-	-	-	-	-	13	-
Detail construction designer*	-	-	2	2	-	-	-	-	21	-
HC-installation designer	-	-	21	-	-	1	170	14	21	3
I-installation designer	98	-	41	1	-	3	12	11	22	2
Total docs:	98	0	96	4	0	4	224	31	90	6

Table B2E10: Users indication of ProjectWise, shared project disk and project dossier (paper)

Means used for document storage:	Number of team members CE		Number of team members CC	
	2001-2002	2004	2001-2002	2004
ProjectWise	0	8	0	7
Shared project disk / network disk	6	7	7	8
Project dossier (paper)	5	6	7	5
Generation of doc's in PW?	0	5	0	2
Generation of doc's in Shared project disk?	8	5	8	7

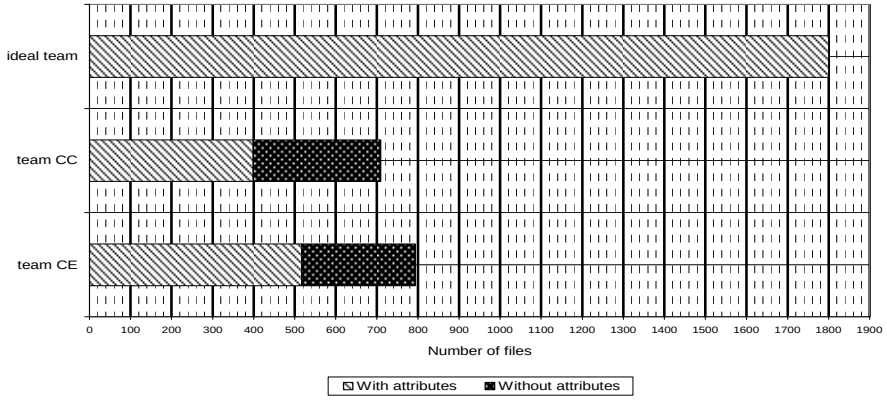

Figure B2E1: Total of attribute adding by teams CC and CE

B2F. User complains about ProjectWise use during measurement in unit A, B and C

Table B2F1: Overview on the number of positive and negative arguments of PW-use

Period of measurement September - October 2003	Unit A		Unit B		Unit C	
	Team AE	Team AC	Team BE	Team BC	Team CE	Team CC
PW use is improvement	5	2	7	6	5	4
PW-use is not an improvement	3	5	3	0	2	2
Positive arguments about PW	12	4	12	16	9	8
Negative arguments about PW	16	15	9	4	6	5
No meaning	0	1	2	2	1	2

B3. Use of communication means during ProjectWise

B3A. Use of communication means during ProjectWise use in teams AE and AC

Table B3A1: Estimated use by team members of formal and informal meetings in 2004

Team role	Team AE		Team AC	
	Formal	Informal	Formal	Informal
Project leader	10%	30%	10%	10%
Team coordinator	10%	30%	10%	20%
Architect	20%	10%	10%	30%
Structural engineer	10%	20%	10%	20%
Quantity surveyor	10%	10%	20%	20%
Detail construction designer	10%	0%	10%	10%
HC-installation designer	10%	10%	10%	10%
E-installation designer	10%	30%	10%	30%
Average percentage	11%	18%	11%	19%

Table B3A2: Preference of use of postal mail by team members in 2004

Team role	Team AE		Team AC	
	Preferred use	Frequency	Preferred use	Frequency
Project leader	No	<5	No	<5
Team coordinator	No	<5	No	<5
Architect	No	<5	No	<5
Structural engineer	No	<5	No	<5
Quantity surveyor	No	<5	No	<5
Detail construction designer	No	<5	No	<5
HC-installation designer	No	<5	No	<5
E-installation designer	No	<2	No	<2
Average percentage	No	<5	No	<5

Table B3A3: Estimated use of MS-email and increase of use in 2004

Team role	Team AE		Team AC	
	Outlook email use per day	Increase of email use	Outlook email use per day	Increase of email use
Project leader	>25%	20%	10%	40%
Team coordinator	15%	40%	5%	0%
Architect	5%	20%	5%	0%
Structural engineer	5%	40%	5%	40%
Quantity surveyor	5%	0%	20%	80%
Detail construction designer	5%	0%	10%	0%
HC-installation designer	5%	20%	10%	0%
E-installation designer	20%	0%	20%	0%
Average percentage	11%	19%	11%	20%

Table B3A4: Influence of MS-email use on the use of other communication means

Influence of MS-email use on :	Number of team members AE	Number of team members AC
(1.3.2.19) Decrease of telephone use	5	6
(1.3.2.21) Preparations team meetings	8	8
(1.3.2.20) Decrease of facsimile use	4	2

Table B3A5: Number of team members that expect re-use of information to be effective

Measurements 2004, question 1.4.2: Do you expect re-use of information by digitally stored files to be effective?	Team AE		Team AC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X		X	
Architect	X		X	
Structural engineer	X		X	
Quantity surveyor	X			X
Detail construction designer	X		X	
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	8	0	7	1

Table B3A6: Number of team members that consider ICT-use to be an improvement or not

Measurements 2004, question 1.4.4: Do you consider ICT-use to be an improvement in daily work?	Team AE		Team AC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X		X	X
Architect	X		X	
Structural engineer	X		X	
Quantity surveyor	X		X	
Detail construction designer	X		X	
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	8	0	7	1

Table B3A7: Number of team members who think that team meetings can be organized more effective

Measurements 2004, question 1.3.2.24: Can team meetings be organized more effective?	Team AE		Team AC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X		X	
Architect	X			X
Structural engineer	X		X	
Quantity surveyor	X		X	
Detail construction designer		X	X	
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	7	1	7	1

B3B. Use of communication means during ProjectWise use in teams BE and BC

Table B3B1: Estimated use by team members of formal and informal meetings in 2004

Team role	Team BE		Team BC	
	Formal	Informal	Formal	Informal
Project leader	20%	>30%	10%	20%
Team coordinator	0%	>50%	20%	20%
Architect	10%	0%	10%	10%
Structural engineer	10%	0%	10%	0%
Quantity surveyor	10%	10%	<10%	0%
Detail construction designer	10%	10%	10%	10%
HC-installation designer	10%	10%	10%	20%
E-installation designer	15%	5%	20%	0%
Average percentage	11%	15%	13%	10%

Table B3B2: Preference of use of postal mail by team members in 2004

Team role	Team BE		Team BC	
	Preferred use	Frequency	Preferred use	Frequency
Project leader	No	<5	No	>5
Team coordinator	No	<5	No	>5
Architect	No	<5	No	<5
Structural engineer	No	<5	No	<5
Quantity surveyor	No	<5	No	<5
Detail construction designer	No	<5	No	<5
HC-installation designer	No	>5	No	<5
E-installation designer	No	<5	No	<5
Average percentage	No	<5	No	<5

Table B3B3: Estimated use of MS-email and increase of use in 2004

Team role	Team BE		Team BC	
	Outlook email use per day	Increase of email use	Outlook email use per day	Increase of email use
Project leader	20%	0%	5%	0
Team coordinator	10%	40%	20%	100%
Architect	5%	0%	5%	20%
Structural engineer	5%	20%	5%	20%
Quantity surveyor	20%	40%	<5%	20%
Detail construction designer	10%	20%	5%	80%
HC-installation designer	15%	20%	5%	0%
E-installation designer	10%	20%	10%	20%
Average percentage	12%	20%	8%	33%

Table B3B4: Influence of MS-email use on the use of other communication means

Influence of MS-email use on :	Number of team members BE	Number of team members BC
(1.3.2.19) Decrease of telephone use	6	6
(1.3.2.21) Preparations team meetings	8	7
(1.3.2.20) Decrease of facsimile use	7	5

Table B3B5: Number of team members that expect re-use of information to be effective

Measurements 2004, question 1.4.2: Do you expect re-use of information by digitally stored files to be effective?	Team BE		Team BC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X		X	
Architect	X		X	
Structural engineer		X	X	
Quantity surveyor	X		X	
Detail construction designer	X			X
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	7	1	7	1

Table B3B6: Number of team members that consider ICT-use to be an improvement or not

Measurements 2004, question 1.4.4: Do you consider ICT-use to be an improvement in daily work?	Team BE		Team BC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator	X		X	
Architect	X		X	
Structural engineer	X		X	
Quantity surveyor	X		X	
Detail construction designer		X		X
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	7	1	7	1

Table B3B7: Number of team members who think that team meetings can be organized more effective

Measurements 2004, question 1.3.2.24: Can team meetings be organized more effective?	Team BE		Team BC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator		X		X
Architect		X	X	
Structural engineer	X		X	
Quantity surveyor	X		X	
Detail construction designer		X	X	
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	5	3	7	1

B3C. Use of communication means during ProjectWise use in teams CE and CC

Table B3C1: Estimated use by team members of formal and informal meetings in 2004

Team role	Team CE		Team CC	
	Formal	Informal	Formal	Informal
Project leader	20%	20%	10%	10%
Team coordinator	10%	20%	10%	>40%
Architect	10%	30%	10%	>40%
Structural engineer	10%	20%	10%	20%
Quantity surveyor	10%	0%	10%	0%
Detail construction designer	10%	10%	10%	0%
HC-installation designer	10%	20%	10%	>40%
E-installation designer	20%	20%	20%	30%
Average percentage	14%	18%	11%	23%

Table B3C2: Preference of use of postal mail by team members in 2004

Team role	Team CE		Team CC	
	Preferred use	Frequency	Preferred use	Frequency
Project leader	No	<5	No	<5
Team coordinator	No	<5	No	<5
Architect	No	>5	No	<5
Structural engineer	No	<5	No	<5
Quantity surveyor	No	<5	No	<5
Detail construction designer	No	<5	No	<5
HC-installation designer	No	<5	No	<5
E-installation designer	No	<5	No	<5
Average percentage	No	<5	No	<5

Table B3C3: Estimated use of MS-email and increase of use in 2004

Team role	Team CE		Team CC	
	Outlook email use per day	Increase of email use	Outlook email use per day	Increase of email use
Project leader	20%	0%	15%	40%
Team coordinator	10%	0%	>25%	50%
Architect	20%	20%	5%	20%
Structural engineer	5%	20%	5%	20%
Quantity surveyor	5%	0%	5%	0%
Detail construction designer	5%	20%	5%	0%
HC-installation designer	5%	20%	10%	40%
E-installation designer	10%	0%	20%	20%
Average percentage	10%	10%	11%	24%

Table B3C4: Influence of MS- email use on the use of other communication means

Influence of MS-email use on :	Number of team members CE	Number of team members CC
(1.3.2.19) Decrease of telephone use	4	6
(1.3.2.21) Preparations team meetings	8	8
(1.3.2.20) Decrease of facsimile use	8	7

Table B3C5: Number of team members that expect re-use of information to be effective

Measurements 2004, question 1.4.2: Do you expect re-use of information by digitally stored files to be effective?	Team CE		Team BC	
	Yes	No	Yes	No
Project leader	X		X	
Team coordinator		X	X	
Architect	X		X	
Structural engineer	X		X	
Quantity surveyor	X		X	
Detail construction designer		X	X	
HC-installation designer		X	X	
E-installation designer	X		X	
Total number	5	3	8	0

Table B3C6: Number of team members that consider ICT-use to be an improvement or not

Measurements 2004, question 1.4.4: Do you consider ICT-use to be an improvement in daily work?	Team CE		Team CC	
	Yes	No	Yes	No
Project leader		X	X	
Team coordinator	X		X	
Architect	X			X
Structural engineer	X		X	
Quantity surveyor	X		X	
Detail construction designer	X		X	
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	7	1	7	1

Table B3C7: Number of team members who think that team meetings can be organized more effective

Measurements 2004, question 1.3.2.24: Can team meetings be organized more effective?	Team CE		Team CC	
	Yes	No	Yes	No
Project leader		X	X	
Team coordinator	X		X	
Architect	X		X	
Structural engineer	X			X
Quantity surveyor	X		X	
Detail construction designer		X		X
HC-installation designer	X		X	
E-installation designer	X		X	
Total number	6	2	6	2

Appendix C: REA's workgroup advice

A.1 Workgroup advice concerning ProjectWise implementation in REA's organizational units

In November 2001, an advice for implementation of a Project Website was made by a special workgroup of REA.

The next criteria for success were described:

1. "By implementing ProjectWise (PW) as a project dossier management system, all documents of all projects of REA- real estate services will be stored structured and digitally, based on the Basic format for Output information (BVO). The improvement for REA in terms of time, money and quality:

2. About euro 500.000, - decreasing of the yearly cost (5% of the yearly cost of personnel for engineering[1]) by decreasing search time necessary for searching, sending, storing, access and copying of design information.

3. About euro 220.000, - decreasing of the yearly cost (2% of the yearly cost of personnel for engineering) by re-use of design information.

4. About euro 100.000,- decreasing of the yearly cost (1% of the yearly cost of personnel for engineering) by improvement of sharing and exchange of information as a result of this, the cost of failures will decrease.

5. A better satisfied customer by delivering a better uniform product because of re-use of design information with an improved price/quality ratio.

6. A contribution to the security of knowledge present in the organization by the explicit, structured digital storage and accessibility of design -information and -knowledge that is embedded in the stored project documents.

[1] Figures based on cost of personnel of REA that are not allowed for publication

Summary

The motivation for this research project was to reduce the lack of knowledge about the effective use by design teams of a Project Website (PWS). Project Websites have been advocated as an important tool for design teams of construction projects, because these websites are supposed to greatly enhance team communication. PWS vendors claim these results in improved team performance in terms of time, cost and quality**.** However, in other domains there was evidence of the so-called IT Productivity Paradox. Literature shows that the use of IT tools does not always result in higher productivity. A Project Website may contribute to productivity improvement because of increased efficiency, reflected in reduced retrieval time, by providing direct access to a database-structured, electronic information vault with the complete, valid and most recently generated design information of all team members. For that reason, the main question to be answered in this project was, whether this IT Productivity Paradox can also be observed in design teams in architecture, construction and engineering using a PWS and to what extent the use of a PWS (and resulting team communication and performance) differs in different organizational and management settings.

To the best of our knowledge, no empirical research in the building industry has been or is being performed to support the often claimed effects nor to support the IT technology paradox in this field. The goal of this dissertation, therefore, was to gain further insight into the use and effects on communication (and thus on the claimed team performance) of a PWS in architecture, engineering and construction design teams.

To that end, the following research questions guided the research project: (1) How do design teams actually use a PWS compared to the prescribed use in a design project? (2) What are the reasons for discrepancies, if any, between observed and prescribed uses of a PWS? (3) What are the effects on team communication of using a PWS? (4) What are the effects on team performance of using a PWS, in terms of efficiency and effectiveness and value for the consumer? (5) To what extent are the findings related to the above questions specific to architecture, construction and engineering?

By executing multiple case studies we generated knowledge about the use of a specific PWS package and its effects on team communication and performance. The multiple case studies involved the comparison of three pairs of design teams in three organizational units within one large organization, which throughout this dissertation we shall call REA. The pair of teams consisted of a so-called experimental and control team that were as similar as possible on as many variables that potentially influence PW use as possible. These teams were supposed to use a PWS as prescribed and got basic instructions for PWS-use and were then supposed to further train and educate themselves in the workplace by means of a user manual. The experimental teams received more extensive training to stimulate PWS-use. By comparing the frequency and nature of use of the available communication tools by the teams before and during the use of the PWS, we were able to detect variations in the adoption and use of the PWS and in its effects on team communication and performance.

The results suggest that, although some minor effects on team performance were observed, there is indeed evidence of the occurrence of the IT Productivity Paradox in the design teams using the PWS. The experimental teams showed better use of the PWS than the control teams. However, none of them fully adopted the PWS and used the tool daily in the same way. Moreover, the degree of adoption and the size of the effects varied between teams.

To identify possible causes for such differences, the three units were compared in terms of management style and culture. It turned out that the unit with the highest positive effects of the PWS (although still lower than anticipated), was characterized by a pro-active behavior and a bottom-up management approach that increased user involvement in the change process. Management showed more signs of pro-active change than observed in other units. However, because of rivalry between PWS-use and the use of network disks, and difficulties in information handling using specialist software packages, incongruent technological frames developed that made the prescribed collective adoption more difficult.

Thus, it can be concluded that in the multiple case studies in REA the Productivity Paradox is observed because of insufficient awareness at unit and central management level of managing the process of change as a second order instead of a first-order change. Other reasons that can be detected concern not using a bottom-up approach for management interventions, and insufficient introduction of the tool and training for PWS-use. Moreover, re-design options to optimize PWS-use for integral design, avoiding inefficiency and rivalry of tools, were not sufficiently explored. Also, change agents functioned on too low a level to be successful and lacked the necessary authority to correct discrepancies, differences between units in terms of re-active instead of pro-active behavior, and to insufficiently promote the benefits of change to unit members. These factors may be seen as important possible causes for explaining differences in the technology paradox observed between the units.

To be able to compare experiences searching for similarities and differences and to derive conclusions about PWS use, a series of mini cases were conducted. These mini cases were performed by means of interviews with process and IT managers of design and design & construction firms in different industries that use various PWS packages. The results of the mini cases suggest that the change to collective daily PWS-use needs a second-order process, involving a bottom-up approach of management interventions using pro-active change agents and team training by which ideally PWS use is changed into a pull-setting for users.

The findings of these mini cases lead to the conclusion that the IT Productivity Paradox as observed in REA's multiple case studies, is not unique and can also be observed in other firms using the same and different Project Website packages. There are also differences. Especially those design & construction firms appear to have better results with the adoption of a PWS that planned change as a second-order change, redesigned workflow and information handling processes to optimize PWS-use and avoid rivalry of tools, tested PWS-users on their PWS-competences, used change agents pro-actively, and reported a bottom up approach by organizing user meetings to stimulate PWS-use. However a direct relation between improvement of team performance and team communication was not reported or shown.

If the results of the mini cases can be generalized to similar organizations, they suggest that the following conditions are probably to improve the acceptance of the new technology in general and PWS's in particular: (i) rivalry of tools should be avoided from the start; (ii) a team should have sufficient skills to use the technology as good as the rival tools; (iii) both workflow and information handling processes should be redesigned for efficient and effective PWS-use; and (iv) pro-active change and implementing agents are made responsible for the successful change of PWS-use to a pull-setting for users.

In summary, can be concluded that the IT Productivity Paradox was also observed in design teams in architecture, construction and engineering using a PWS. It differs however in intensity as a function of how change management is implemented. Successful adoption and implementation of PWS and technology in general requires management of a second-order change process. In any case, the ultimate adoption and impact of new technology depends on the extent to which it is perceived as beneficial to design team members in integral design processes on a daily basis. In that sense it may be a more fundamental limit to the impact in professional architectural design teams.

Summary - Dutch

De motivatie voor dit onderzoeksproject kwam voort uit de behoefte om het gebrek aan kennis te verkleinen over het effectieve gebruik van Project Websites (PWS) door ontwerp teams. PWS pakketten worden vaak aangehaald als belangrijke middelen voor ontwerpteams van bouwprojecten omdat verondersteld wordt dat ze teamcommunicatie in belangrijke mate verbeteren. PWS verkopers claimen dat dit ook resulteert in een verbetering van de teamprestaties in termen van tijd, geld en kwaliteit. Echter, in andere domeinen is er bewijs gevonden voor de zogenoemde IT productiviteitsparadox. De literatuur hierover laat zien dat het gebruik van IT middelen niet altijd resulteert in een hogere productiviteit. Een PWS kan een bijdrage leveren in verbetering van productiviteit door verhoogde efficiëntie en effectiviteit. Dit kan tot uiting komen in terugverdientijd doordat men direct toegang heeft tot een elektronische informatieopslag, met een database structuur, met daarin de complete, geldige en meest recent gegenereerde ontwerp informatie van alle teamleden. Om die reden was de hoofdvraag van het onderzoeksproject of deze IT productiviteitsparadox zich ook voordoet in ontwerpteams voor bouwprojecten welke een PWS gebruiken en tot welk niveau het gebruik van een PWS (die resulteert in verbetering van teamcommunicatie en prestaties) verschilt in verschillende organisatie- en management settings.

Naar ons beste weten is er geen empirisch onderzoek in de bouwwereld uitgevoerd, of wordt er uitgevoerd, die de geclaimde effecten of de effecten van het optreden van de IT technologie paradox op dit gebied ondersteunen. Om die reden is het doel van deze dissertatie om nadere inzicht te krijgen in het gebruik en de effecten van gebruik op communicatie (en daarom ook op de geclaimde teamprestaties) van een PWS in ontwerpteams voor bouwprojecten. Daarvoor zijn de volgende onderzoeksvragen leidend 1: Hoe gebruiken ontwerpteams actueel een PWS in een ontwerpproject vergeleken met het voorgeschreven gebruik? 2: Wat zijn redenen voor afwijkingen, indien deze voorkomen, tussen het geobserveerde en het voorgeschreven gebruik van een PWS?; (3) Wat zijn de effecten van gebruik van een PWS op teamcommunicatie?; (4) Wat zijn de effecten op teamprestaties van gebruik van een PWS in termen van efficiëntie en effectiviteit en de waarde voor de gebruiker?: (5) Tot welk niveau zijn de bevindingen over de vragen 1 t/m 4 specifiek voor ontwerpteams voor bouwprojecten.

Door het uitvoeren van een meervoudige case studie genereren we kennis over het gebruik van een specifieke PWS en de effecten ervan op teamcommunicatie en prestaties. Deze meervoudige case studie omvat de vergelijking van drie paren van ontwerpteams in drie zelfstandig georganiseerde units binnen één grote organisatie die we in deze dissertatie REA zullen noemen. Elk paar bevatte een zogenaamd experimentele- en controle team, welke zoveel mogelijk aan elkaar gelijk waren betreffende alle mogelijke variabelen die van invloed kunnen zijn op het gebruik van de PWS. Alle teams werden verondersteld een PWS te gebruiken zoals voorgeschreven en kregen basisinstructies voor het gebruik ervan.

Ze dienden zichzelf verder te trainen op hun eigen werkplek door gebruik van de helpfunctie en de gebruikershandleiding. De experimentele teams kregen daarnaast een veel uitgebreidere teamtraining om het gebruik van de PWS te stimuleren. Door het vergelijken van de frequentie en het dagelijkse gebruik van de beschikbare communicatie middelen tussen de beide teams, vooraf en tijdens het gebruik van een PWS, waren we in staat om variaties te detecteren in de adoptie en het gebruik van de PWS en de effecten daarvan op teamcommunicatie en prestaties. De resultaten hiervan doen vermoeden dat, alhoewel er enige kleine effecten op team prestaties waargenomen werden, er inderdaad bewijs is voor het optreden van de IT productiviteitsparadox in ontwerpteams die een PWS gebruiken. De experimentele teams lieten een beter gebruik van de PWS zien dan de controle teams. Geen enkel team adopteerde de PWS echter volledig voor dagelijks gebruik en zowel de adoptiegraad en de grootte van de effecten tussen de teams varieerde.

Om de mogelijke oorzaken voor dergelijke verschillen te kunnen verklaren werden de drie units vergeleken in termen van managementstijl en cultuur. Het bleek dat de managementstijl van de unit met de hoogste positieve PWS effecten (alhoewel nog steeds lager dan verwacht), gekarakteriseerd kan worden door een pro-actief gedrag en een bottom-up management benadering die positieve gevolgen had op de betrokkenheid van de gebruikers in het veranderingsproces. Deze managementstijl vertoonde meer tekenen van pro-actieve verandering waarbij de gebruikers in de verandering betrokken werden dan werd waargenomen in de beide andere units. Door de competitie tussen PWS gebruik, het gebruik van gedeelde netwerkdisks en de moeilijkheden bij toepassing van specialistische software in PWS, ontwikkelden zich echter ook zogenaamde ‘incongruent technological frames’ die het voorgeschreven gebruik bemoeilijkten. Daarom kan geconcludeerd worden dat in de meervoudige case studie in REA de productiviteitsparadox werd waargenomen omdat men, zowel op unit niveau en op het niveau van het centrale management, zich onvoldoende bewust was van het managen van een dergelijk veranderingsproces als een tweede orde verandering in plaats van een eerste orde verandering. Andere redenen kunnen zijn het niet gebruiken van een bottom-up management stijl waarbij de gebruikers in de verandering betrokken worden en onvoldoende introductie van een PWS en training in de toepassing ervan. Daarnaast werden herontwerpopties om het gebruik van PWS te optimaliseren voor integraal ontwerpen, het vermijden van inefficiëntie en de competitie tussen communicatiemiddelen niet voldoende geëxploreerd. Ook de veranderaars functioneerden op een te laag niveau en waren teveel re-actief in plaats van pro-actief waardoor onvoldoende de voordelen van de verandering onder de aandacht van de teamleden gebracht werd. Ze hadden ook onvoldoende management verantwoordelijkheid om afwijkingen te corrigeren. Deze factoren kunnen als belangrijke, mogelijke oorzaken gezien worden die de verschillen in het optreden van de productiviteitsparadox tussen de units kunnen verklaren.

Om ervaringen te vergelijken, op zoek naar verschillen en overeenkomsten, en conclusies over het gebruik van PWS te kunnen trekken, werd er een serie van mini-cases uitgevoerd. Ze werden uitgevoerd door middel van interviews met proces- en IT-managers in

ontwerp en ontwerp-uitvoerings organisaties die dezelfde en andere PWS pakketten gebruikten. De resultaten van de mini-cases geven aan dat de verandering naar het collectieve dagelijkse gebruik van een PWS een tweede orde veranderingsproces nodig heeft met een bottum-up managementstijl waarbij de gebruikers in het veranderingsproces betrokken worden, toepassing van pro-actieve veranderaars en team training. Dit zou ertoe moeten leiden dat een PWS gebruikers aantrekt.

De bevindingen uit deze mini-cases leiden tot de conclusie dat de IT productiviteits paradox zoals die binnen de meervoudige case-studie in REA aangetroffen werd niet uniek is en ook in andere organisaties aangetroffen werd die hetzelfde PWS pakket of een ander pakket gebruikten. Er werden ook verschillen aangetroffen. Met name in die ontwerp- en uitvoeringsorganisaties die betere resultaten lieten zien in de adoptie van een PWS en die de verandering als een tweede orde proces gepland hadden, informatie behandelingsprocessen en werkvloer processen herontworpen hadden om het gebruik van de PWS te optimaliseren waarbij competitie tussen middelen vermeden werden, die gebruikers testen op hun PWS competentie, pro-actieve veranderaars ingezet hebben en die vermelden dat ze een bottom-up benadering toegepast hadden door het organiseren van een gebruikers platform om het gebruik van de PWS te stimuleren. Echter, een directe relatie tussen de verbetering van teamprestaties en teamcommunicatie werd niet gemeld en was ook niet zichtbaar.

Als de resultaten van de mini-cases gegeneraliseerd kunnen worden naar overeenkomstige organisaties, dan wijst dat in de richting van de volgende condities die de acceptatie van de nieuwe technologie verbeteren en met name het gebruik van een PWS: (i) competitie tussen beschikbare middelen dient vermeden te worden vanaf het begin; (ii) een team dient over voldoende vaardigheid te beschikken om de technologie even goed toe te passen als concurrerende middelen; (iii) zowel werkvloer als informatie behandelingsprocessen dienen herontworpen te worden voor een efficiënt en effectief PWS gebruik; en (iv) pro-actieve veranderaars en implementeerders dienen verantwoordelijk gemaakt te worden voor de succesvolle verandering waarin een PWS gebruikers aantrekt.

Samengevat kan geconcludeerd worden dat de IT productiviteitsparadox ook aangetroffen werd in ontwerpteams voor bouwprojecten die een PWS gebruiken. Het optreden ervan verschilt echter in de mate van intensiteit op basis van en hoe verandermanagement werd geïmplementeerd en toegepast. Succesvolle adoptie en implementatie van een PWS, en technologie in het algemeen, vereist het managen van een tweede orde veranderproces. De ultieme adoptie en impact van een nieuwe technologie hangen af van de mate waarin verwacht wordt dat deze ondersteunend zal zijn voor ontwerpteamleden in het dagelijks gebruik in integrale ontwerpprocessen. In die zin kan er een meer fundamentele limiet zijn voor de impact hiervan in professionele bouwkundige ontwerpteams.

Subject index

Author index

Curriculum Vitae

The author of this dissertation was born on March, 5th 1951, in Schijndel, The Netherlands. After finishing his Mulo-B degree in Vught in 1967, he started his studies in Building Technologies and Structures in 's-Hertogenbosch at the Hogere Technische School (HTS), graduating in 1977. During this study he worked for several architectural firms, a building contracting firm and fulfilled his military service at the Genie (Corps of Engineers) of the Koninklijke Landmacht.

In the period 1977–1985 he worked at various architectural offices on the restoration of houses, shops and churches, designing and engineering schools, dwellings, town halls, a small theatre, offices, shopping malls, and hospitals. During this period, he studied Architecture as a part-time studies at the Academie voor Architectuur en Stedebouw in Tilburg. He graduated in 1985, together with three colleagues on an urban and architectural design for the renewal of a formal industrial area of Philips in Middelburg. His urban design was nominated in a design contest of the municipality of Middelburg and also earned the public prize of the town. During 1982-1984 he also studied Building Informatics at the Technische Universiteit Eindhoven TU/e with a focus on Computer Aided Architectural Design (CAAD).

After these studies he became partner in an architectural firm and got involved in Computer Aided Design (CAD) through the Vereniging voor Computergebruik Architectenbureaus (VCA) in The Hague. In 1987, together with partners, he started a firm for advice and training in CAD packages (AutoCAD, Microstation, e.o.); third-party software development and the writing of handbooks for the use of CAD in the building industry became part of the office output. In 1993, after dividing the firm into several separate units, he continued with consultancy services, writing handbooks for AutoCAD use in architectural firms, published by Addison Wesley in Amsterdam, and became a part-time lecturer in Building Informatics and Economics at the Hogeschool 's-Hertogenbosch. In this period he developed, in cooperation with Twijnstra Gudde, a two-year part-time course in Construction Project Management at the post-HBO excellence level.

In the Summer of 1998 he became Assistant Professor at the Department of Business Science of the TU/e and core lecturer for the post-graduate technological designers program Architectural Design Management Systems (ADMS) of the TU/e. Since the Autumn of 2000 he has held the position of Assistant Professor at the Department of Architecture, Building and Planning of the TU/e and is head of ADMS.

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BOUWSTENEN zijn verkrijgbaar bij:
Publikatiewinkel 'Legenda'
Gebouw Vertigo
Faculteit Bouwkunde
Technische Universiteit Eindhoven
Postbus 513
5600 MB Eindhoven

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Kernredaktie
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Project Websites (PWS) have been advocated for design teams of construction projects, because these websites are supposed to greatly enhance team communication. This, finally, should result in improved team performance in terms of time, cost and quality. This expected improved performance is based on expected better communication of members of a design team who share and update their electronically generated and collected design information using a PWS together. This particularly applies to design teams organized for integral design.

Unfortunately, there is a fundamental lack of empirical research supporting such expectations. To be effective, a Project Website need to be used collectively by a design team in corresponding time intervals in daily work for storing documents for team sharing, changing status of files when appropriate and adding database functionality for quick search activities. This thesis therefore, generates additional knowledge about adoption, use and effects of Project Website packages on team communication and team performance.

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