PROJECT MANAGEMENT WITH A PROJECT WEB

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SUMMARY: *Using a project web in building now occurs in an increasing number of projects. There is an emphasis, especially in large building projects and by large companies, on using a project web because it is expected to lead to benefits and increased efficiency. A number of Danish case studies, with the aim of investigating three different aspects of the usage of a project web, are presented in this paper. These are: project management, functionalities, and cost/benefit. Based on the data collected and analysed from four case studies using the same lead contractor, this paper contains a summary of the data and a presentation of the conclusions. One of the major findings is that the planning of why and how the project web should be used is often rushed and this results in over hasty usage where the problems begin to exceed the expected efficiency gains. In general the project web service used in the case studies contained the required functionalities, but often it was evident that they were implemented too quickly, resulting in users losing patience and thereafter completing their task using traditional means. Evaluation using the method "Measuring the Benefits of IT Innovation" revealed that a series of projects, led by the same contractor and using the same project web, did not produce a positive payback (in monetary terms), however a significant number of non-economically measurable benefits were identified.*

KEYWORDS: *Project web, Project management, IT evaluation.*

1. INTRODUCTION

It is frequently said that efficiency is poor in the construction industry (ATV 1999;Erhvervsfremme Styrelsen 2000; Construction Task Force 1998; Latham 1994). This point is shown in Figure 1, where productivity in construction is stagnant compared to other industries in Denmark.

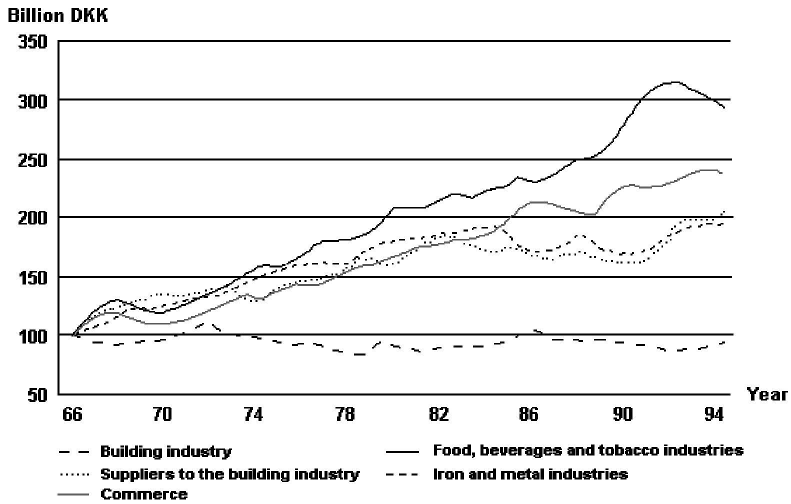


Figure 1: Development in productivity in different industries

This has lead to considerable research on why this is the case and how to change this trend. Several government initiatives in Denmark have, in the past 10 years, been carried out in order to improve the conditions that would enable an increase in the productivity of the construction industry (Dobbelt Op, PPB, Projekt Hus, Det Digitale Byggeri). In one of these initiatives in the mid 90s a number of companies (organised into joint ventures) established extranets with the purpose of exchanging digital information. Even though not all the Extranets were a success it still gave the companies a glimpse of what was to be expected in the future.

Today the development has accelerated to a great degree. The development of network technology has now reached a level where companies, for a relatively low cost, can implement LAN, Intranet, Extranet, WAN or Internet. This development has evidently been taken up, as the number of companies in the construction industry that have access to the Internet is 98% (Howard 2001). The number of suppliers of project webs has likewise increased significantly, however, the Danish supplier Byggeweb is dominant in Denmark.

These two conditions have led to an increasing number of building projects using a project web as a tool to enable and increase the efficiency of the exchange of digital data between the companies in a building project. The usage of the project web has, in earlier research projects, been found to be influenced by a "trial and error" process, from which a need for research into the subject was identified.

Much research in the area of project web has so far been focused on why to use a project web in building projects and which functionalities a project web should or could contain, whereas the actual use of a project web and the impact on different aspects in a building project have not been investigated in great detail. The EU Procure project (Procure 2001) showed that, in large scale engineering projects, clients and contractors are establishing new patterns of working. However it found that the technology was complex and its application was difficult. This is an important research area in which further work is needed.

2. THE RESEARCH PROJECT

A research project was carried out over a period of 10 months starting in September 2001, where the primary objective was to investigate the usage of a project web in a number of building projects. In order to concentrate the effort three research areas were selected based on the interest of the researchers.

- Project management;
- Functionalities in project webs;
- Cost/Benefit of the usage of project webs.

In the research area *Project management* investigations were centred on two themes: (a) how should the project web be used efficiently (project management of the project web) and (b) how can a project web be used as a tool for project management (project management with the project web). The first involves examining the conditions and actions that need to be initiated to ensure a predictable and efficient use. The theme is interesting as most companies still to some degree rely on paper-based data exchange, which means that their working procedures are inefficient and inconvenient when a tool like a project web is being used. Theme 2 involved examining the changes in project management of building projects when a project web is used. A number of aspects in project management could be expected to change when a project web is used, such as how to handle suppliers and sub-contractors taking part in the design process, or how to manage data exchange between design and construction.

The second research area, *Functionalities in project webs*, involved investigations aimed at identifying the users' requirements for functionalities in a project web. A significant number of functionalities can be implemented (Hartvig 2001), but which functionalities are, in the users' opinion, actually necessary and beneficial? The investigation was based on the users' experience gained in building projects rather than speculative considerations about what is possible.

In the last research area, *Cost/Benefit of the usage of project webs*, the cost and benefit of using a project web is investigated. The majority of IT investments are typically justified on the basis of either subjective arguments or acts of faith (Andresen 1999); the same is the case for project webs. What is the cost of using a project web? – or – What kind of benefits are actually achieved when using a project web? These are questions answered by using the IT evaluation method "Measuring the Benefits of IT Innovation". The method is useful when an overview of benefits is needed, but it does not include a cost analysis, so this has been added.

Only data and conclusions from research areas 1 and 3 are in this paper in order to present a suitable level of detail. Further information can be found in (Andresen 2002).

2.1 The process of the research project

Contact with a large contractor was made prior to the project start to establish collaboration where the contractor provided man time (interviews, meetings etc.) and the researchers provided information on increasing the efficiency of project web use. It was agreed that the contractor should select a number of buildings on which to use a project web. These were identified by visits to their sites. Case studies were chosen since the three research areas required a wide range of data with comparable characteristics. Case studies are suitable for this purpose.

To collect data to fulfil the purpose of the research it was decided that, for each of the case studies, a group, working within the building project and a researcher, should gather data and arrange interviews with relevant persons. The group also ensured that the collected data and the conclusions were consistent with reality. A central group of employees from the contractor and researchers from DTU, was also established to coordinate and discuss the findings and to take the initiative on new actions. All interviews, meetings etc. were documented in summaries of the important findings. These were approved by the participants to avoid misinterpretation.

During the data collection and analysis of the case studies a description was written reducing the workload at the end of the research. A final report was written containing a description of the research project, an extract of the case study descriptions, an extract of the data collected and a presentation of the conclusions based on the data analysis. The report is structured so that both students and companies from construction can benefit from it.

3. THE CASE STUDIES

Four case studies were completed, of which three of the building projects used a project web called Byggeweb (Byggeweb). The last case study focused on a building project that did not use a project web. This was used as a comparison enabling an analysis between a traditional building project and those usinga project web.

- **ARTHUR**
  This focused on a traditional building project, implying that the exchange of information by traditional means like meetings, telephone, fax, post and e-mails. It is an office(14,000 m^2 floor area) for a large consultancy company based just north of Copenhagen with a view to the Oresund.
- **FIH**
  This project was one of the first in the company on which a project web was used. It is an office (14,000 m^2 floor area) for an institute that offers finance to companies in the mid to long term. The office has been built near the Little Mermaid, just north of Copenhagen.
- **BRUUNS**
  The third case study is a building project in the centre of Aarhus next to the central railway station. It is a large shopping and cinema centre with a tower designed for offices (65,500 m^2 floor area).

- **PwC**
  The project in focus in the fourth case study is an office for a large accounting consultant. The company already has offices at the location but was expanding by building an extension., Like ARTHUR and FIH it is based just north of Copenhagen.

Common to all four building projects was the same total build contractor. Both design and construction stages were managed by this contractor but, in BRUUNS, daily management was delegated to a number of people.

Table 1. Overview of the four case studies

	Tender sum (mio. DKK)[1]	Project start	Project end	Project web start
ARTHUR	210	November 2000	March 2002	-
FIH	240	June 2000	March 2002	September 2000
BRUUNS	850	August 2000	September 2003	March 2001
PwC	140	Marts 2001	April 2003	July 2001

A number of the characteristics in the case studies are the same: the same total build contractor, the same project web, the same period of completion and this makes the comparison of the data and findings between them more useful. This is enhanced by the fact the three of the building projects are office buildings where the tender sum is in the same range. It is also acknowledged that caution needs to be taken when deriving conclusions, as there are many dissimilar characteristics that can affect an investigated aspect or behaviour.

The fact that it is the same total contractor in all four building projects also has the consequence that some of the project members are active in more than one of the case studies. Therefore some of the experience these project members have gained in one case study might also have an impact on some of the other case studies.

4. ANALYSIS OF THE ACTUAL USAGE OF THE PROJECT WEB

An analysis of the actual usage of the project web was done in order to understand how the project web was used in the three case studies. The data collection and analysis used a method called Social Network Analysis (SNA) (Scott 1991;Walsham 1992;Wasserman & Faust 1994). SNA is a method used for analysing interactions between two or more actors. Examples of output using SNA are sociograms[2], network density and centrality.

Part of the service from the chosen project web supplier is that all actions are recorded and kept. The purpose of this is to provide the possibility of later analysis in case of disagreement between the companies. For research purposes this also makes it possible to analyse the project members' actions to obtain knowledge on the usage of the project web. Data for each of the three projects was handed over by the project web supplier by generating a sorted log-database (in Microsoft Excel). This contained the following information: date, time, person, company affiliation, type of action and filename for each action of a project member on the project web. The entry, 'type of action', was limited to; logon, upload, download, update, delete, preview (using a viewer) and order plot.

The collected data was analysed into two main types to understand how the project web was used, the volume of communication by each user and the type of communication. The volume of communication is analysed by counting the number of each type of action by each user. This analysis provides an understanding of who is using the project web to perform different actions. The analysis can also be used to gain an insight into project web usage during the building process. The type of communication is analysed by (a) identifying the file type on which each action has been performed on, (b) counting the number actions for each type of file and (c) counting the number of actual files of each type. The analysis of these two aspects would, if done manually, be a very time consuming task, which is why a number of small computer programs were developed to do this.

4.1 General data of the project web usage

A number of general characteristics for all three case studies can be seen in Table 2

[1] 100 DKK was worth approximately 8.3£ or 13$ in Nov 2002

[2] A sociogram is a diagram showing the interaction between a number of actors on a certain topic

Table 2. General data on the project web usage

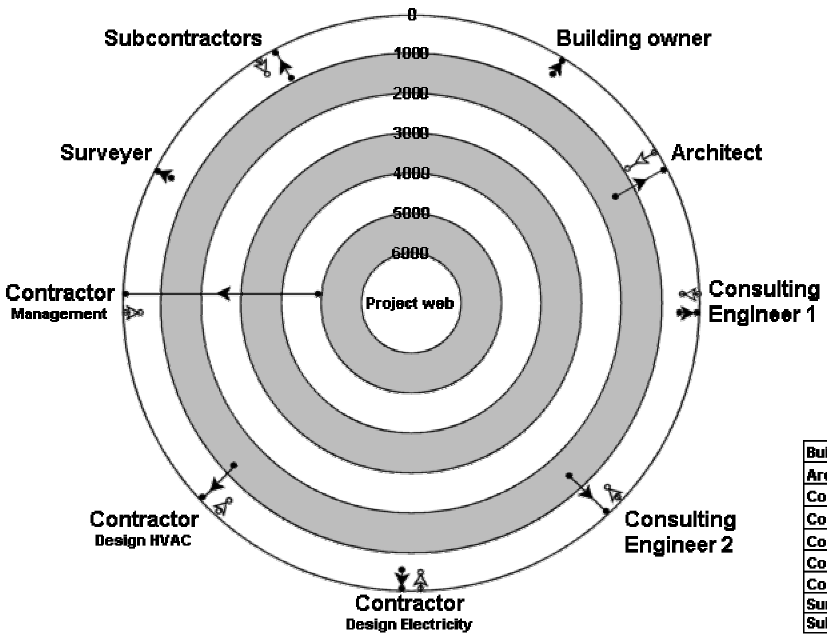
Case study	FIH	BRUUNS	PwC
Period of data collection	Sep. 2000 – Apr. 2002	Mar. 2001 – Jun. 2002	Jul. 2001 – May 2002
Number of active users	35	98	24
Number of company groups	9	11	4
Number of actions	18,336	59,333	5,782
Network density	161.0	292.5	193.6
Average use (month/user)	30.8	40.4	25.6

The data collection period started from the beginning of each project. Only the data from FIH includes the whole project period, whereas the data from both BRUUNS and PwC only covers a part of the building process, as these projects were not finished within the period of the research. This means that some of the data from FIH is related to all the construction stages, whereas the other projects only went to the first construction stages.

BRUUNS is both the largest of the three projects and has the highest use of project web, when measured by number of actions per month per user. This is influenced by the usage decreasing at the construction stage for FIH, resulting in a lower average usage. An interesting point is that the purpose of the project web usage can be seen to influence the measure of average use, as PwC, at one end, decided only to use the project web for CAD-drawings, whereas BRUUNS chose a broader usage, including text documents such as meeting summaries.

4.2 The groups' usage of the project web

For each of the case studies a sociogram was created displaying the total volume of communication using a project web. The sociograms were created by displaying arrows showing the number of the company groups' interactions with the project web. The term interaction relates to the two main actions: "upload of documents" (including upload and update) and "download of documents" (including download and preview).

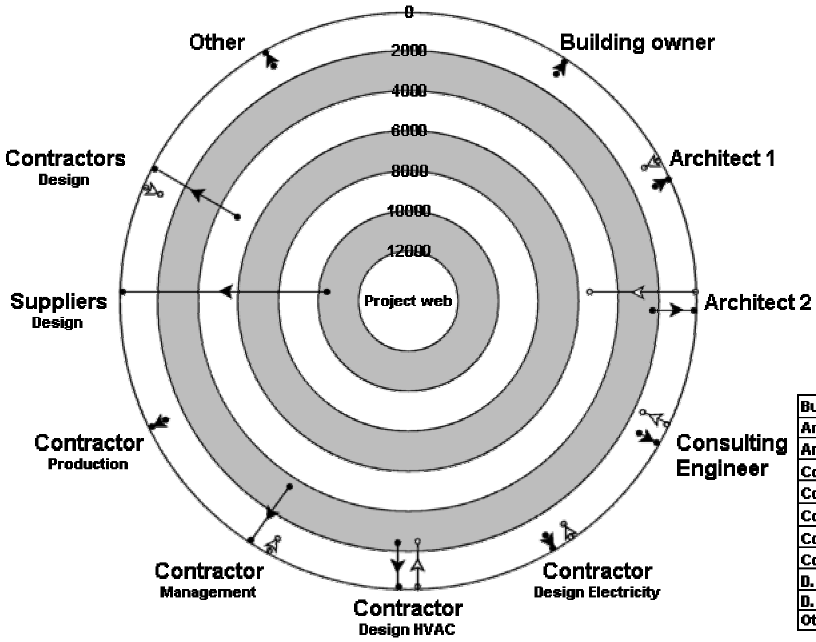


	Up-load	Down-load
Building owner	0	329
Architect	933	1679
Con. Engineer 1	214	326
Con. Engineer 2	503	1440
Contractor, Ele.	361	629
Contractor, HVAC	208	1253
Contractor, Man.	387	4967
Surveyer	0	385
Subcontractors	9	868

Figure 2: Sociogram for FIH

The key characteristics for FIH's usage of the project web are (a) the architect has uploaded most files, (b) the contractor's management group has downloaded most files, (c) the project/design leader has a low usage (both upload and download) and (d) the building owner has downloaded a moderate number of files and no uploads.

Although the expectation for project web use was high, it was quickly revealed that problems of exchanging CAD-drawings demanded so much work that other possibilities were given a lower priority. This is confirmed by about 85% of the actions relating to CAD-drawings and plot-files. The usage is probably also negatively affected by deciding that all summaries and CAD-drawings were plotted and distributed using traditional means. A number of the users therefore had no need to use the project web as they received the information anyway.

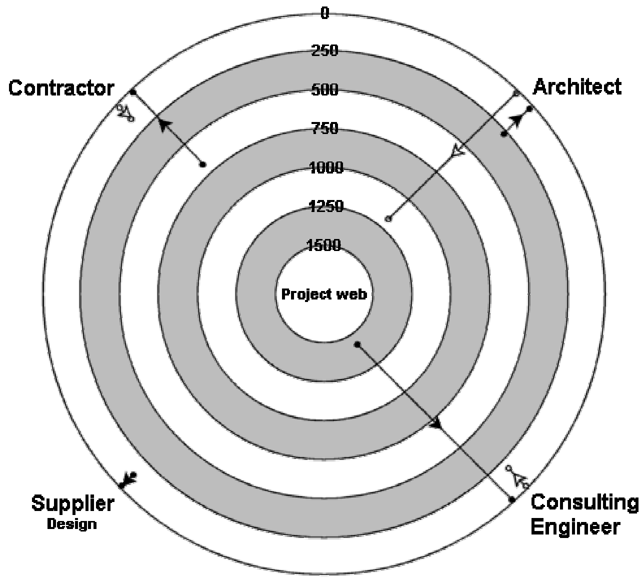


	Up-load	Down-load
Building owner	0	445
Architect 2	147	487
Architect 2	5696	2339
Con. Engineer	1505	1777
Contractor, Ele.	62	391
Contractor, HVAC	2645	2553
Contractor, Man.	943	3324
Contractor, Prod.	0	516
D. Suppliers	0	10369
D. Contractors	19	5166
Other	0	230

Figure 3: Sociogram for BRUUNS

The key characteristics of BRUUNS usage of the project web are (a) the second architect has uploaded most files, (b) the designing suppliers have downloaded most files but made no uploads, (c) the consulting engineer has a moderate upload and download and (d) the building owner has no uploads and a low number of downloads.

In BRUUNS the project web usage focused on several aspects like exchanging CAD-drawings, involving subcontractors and suppliers doing some of the detailed design work, distributing meeting summaries etc. Although the exchange of CAD-drawings in general was satisfactory (there were a few problems with importing other companies' CAD-drawings and plotting them on the project web), it revealed that the standard for CAD-drawing production was often not followed. This resulted in the steel contractor not being able to use the consulting engineer's digital version of the CAD-drawings as background, so that his benefit from the project web was significantly reduced. The percentage of actions related to CAD-drawings and plot-files is about 86%.



	Up-load	Down-load
Architect	1184	264
Con. Engineer	180	1447
D. Supplier	0	81
Contractor	17	698

Figure 4: Sociogram for PwC

In PwC the key characteristics of the project web usage are: (a) the architect has uploaded most files, (b) the consulting engineer has downloaded most files, (c) the building owner is not interested in the project web and (d) very few of the companies involved were connected to the project web.

It was, from the beginning of this project, decided that only CAD-drawings should be exchanged on the project web. This was in order to strengthen the focus of the project web usage. This decision has, however, had a significant influence on the volume of communication through the project web as it was limited to actions related to CAD-drawings. The percentage of actions related to CAD-drawings and plot-files is about 94%.

4.3 Comparing the three case studies

It has been shown that the volume of communication is significantly affected by a number of factors of which one of the more important is the agreed purpose of the project web. Both FIH and BRUUNS expected to use the project web to increase efficiency in several areas, whereas PwC limited this to the exchange of CAD-drawings. This is confirmed by comparing actions on CAD-drawings and plot-files, where PwC is about 10% higher.

Common to all three case studies is that the architect uploads most files, of which a majority are CAD-drawings. This is not unexpected as the architect traditionally produces most CAD-drawings. A common trend cannot be identified regarding who is downloading most files, which means that little can be concluded.

The project management level in the projects (primarily project leaders and design leaders) has, in general, only used the project web to a low degree. In all three building projects the majority of the actions were by those involved in the actual design and construction. This indicates that the project web has mainly been seen and used as a tool to enhance the exchange of information, primarily CAD-drawings. The building owner is only involved, to a limited degree, in using the project web. In PwC the building owner did not use the project web at all. The benefit of the project web to the owner relates to the agreed purpose of the usage, but the building owner's influence on the usage can be beneficial. There is, for example, a large potential to derive FM-data from the project web. In general the three case studies have shown that use of the project web has not been beneficial to the building owner.

5. EVALUATION OF BENEFITS

The usage of the projectweb, in two of the case studies, was evaluated using the framework "Measuring the Benefits of IT Innovation", which is useful for evaluating IT investments (Construct IT 1998). The framework was published in 1998 and has been developed by Construct IT, UK. Although the framework is relatively new and therefore only tested in a limited way, it has proven its value in a number of case studies in both UK and Denmark (Andresen 2001, Carter, Thorpe & Baldwin 1999).

The framework, which only considers the benefits, divides them into three categories:(a) economically measurable, (b) measurable and (c) non-measurable. The three types represent the following: (a) doing things right (efficiency benefits), (b) doing the right thing (effectiveness benefits) and (c) doing better things (performance benefits). Each group of benefits has its characteristics and they are therefore handled differently in separate tables. A useful feature of the framework is the distinction between expected and measured benefits, which only a few IT evaluation methods take into account (Andresen 2001). The evaluated benefits are, as the framework was originally designed, estimated (and/or measured) based on a whole life value.

In the case studies, BRUUNS and PwC, the use of the project web was evaluated using the framework but, since the two building projects were ongoing during the evaluation, two phases of benefit were defined: realised benefits and potential benefits. The realised benefits were estimated in both case studies, whereas the expected benefits were only estimated in PwC. Furthermore the cost of implementing and using the project web was estimated as an enhancement to the framework in order to compare the costs and benefits of using the project web. In both case studies the benefits were identified and estimated from the project's point of view, which means that the benefits relate to the whole project rather than a single company.

5.1 The output of the framework

The cost and benefit data needed to complete the cost analysis and the framework has been gathered through interviews with various key persons from the companies involved in the two case studies, whereas a single key person primarily completed the initial estimations of their "value" in each case study. The accuracy of the estimates might, because of this, not be 100% correct, but it is the most precise given the circumstances. All the cost and benefit data has been publicised to all the companies involved so inconsistent data could be corrected or deleted. This approach also ensures that the collected data represents costs and benefits of the project web usage to the building project and not only to a single company.

5.1.1 The cost of a project web

The first step in the IT evaluation was to analyse the cost of the project web. This was divided into two groups representing; the implementation cost and the usage cost. The implementation cost includes all costs that can be assigned to the project web up to the usage period, whereas the usage cost includes all costs that can be assigned to the project web in the usage period[3]. Only economically measurable costs have been included in the analysis.

Table 3. Cost of the project web in the two case studies

Case study	Implementation cost	Usage cost (realised)	Usage cost (expected)	Average usage cost
BRUUNS	10,000 DKK	463,500 DKK		30,900 DKK/mth.
PwC	93,000 DKK	132,787 DKK	233,870 DKK	11,694 DKK/mth.

Comparing the implementation and usage costs between the two case studies in Table 3 is problematic as some characteristics have a strong influence. Just the fact that there are about four times as many users in BRUUNS as in PwC has a significant influence. Also the length of the usage period is different in the two case studies.

First, when comparing the implementation cost, it was found that the preparation in PwC had been more detailed than in BRUUNS before the actual usage period started. This has the implication that some of the cost in the usage period in BRUUNS might actually correspond to some of the cost in the implementation period in PwC. One of the major differences is the time spent on setting the project web up, so that it meets its purpose. PwC spent about 85,000 DKK (mainly man time) on this task, whereas BRUUNS only spent about 6,000 DKK. In comparison the cost of exchanging the CAD-drawings in ARTHUR was estimated at 130,000 DKK.

Comparing the cost in the usage period, one of the biggest differences is the cost invoiced by the project web supplier, where BRUUNS was significantly higher than PwC. BRUUNS also spent more money on maintaining

[3] In this context the usage period is defined as the period from the time where the project web is used to complete actual work tasks until it either is significantly upgraded or stops being used.

and administering the project web both for general maintenance and CAD-drawing administration. The difference in the projects' average usage costs indicates that, even though the project web in BRUUNS had about four times as many users as PwC, it did not cost four times as much. This is probably because a certain amount is needed to ensure the usability of the project web no matter how many users are attached to the system.

5.1.2 The benefits of a project web

The second step in the IT evaluation was to complete the framework "Measuring the Benefits of IT Innovation". In general the framework has been followed, but two activities in particular were done from the guidelines.

First the stage of IT evaluation was during the usage period, which implies that the estimation part of the framework could not avoid being influenced by the project members' perception of the benefits already achieved. Nor was it possible to complete the second part of the framework, the actual measurement of the identified benefits, because of the lack of time an planning from the building project.

Second, in order to improve the reliability of the output it was decided to focus on the benefits already achieved in the project (meaning that future benefits were not considered). This implies that the estimation of the benefits has not been based on the life-time value described in the framework. The value of the potential benefits for the remaining period of the building project was, however, completed in PwC.

Table 4. Output sheet from MBITI in BRUUNS

Type of benefits	Realised benefits
Efficiency Benefits – *Economically measurable*	Estimated economical value 40,750 DKK
Efficiency Benefits - *Measurable*	Estimated score 54.4 out of 100
Performance Benefits - *Not measurable*	In total there is identified 10 not measurable benefits These are graded in order of significance: 5 * A 5 * B 0 * C 0 * D

19 benefits were identified in BRUUNS through interviews with users from a number of the companies involved. After identification of the benefits it was decided how each should be categorised by its measurability. 6 benefits were categorised as economically measurable, 3 as measurable and 10 benefits as non-measurable.

Although 6 economically measurable benefits were identified, they only provide a total value of about 40,000 DKK. The reason for this is not that the benefits are of little value, but because the likelihood of achieving the benefits was rated as low. The same tendency was found for the measurable benefits where a score of 54.4 indicated that just over half were believed to have been achieved. The last group accounts for more than half of the identified benefits and they are considered as having either a very significant or significant impact.

Table5. Output sheet from MBITI in PwC

Type of benefits	Realised benefits	Potential benefits
Efficiency Benefits – *Economically measurable*	Estimated economic value 82,000 DKK	*Potential economic value 155,250 DKK*
Efficiency Benefits - *Measurable*	Estimated score 60.1 out of 100	*Potential score 45.0 out of 100*

Performance Benefits - *Not measurable*		*In total there are14 non measurable benefits* *These are graded in order of significance:* *4 * A* *5 * B* *5 * C* *0 * D*

23 benefits were identified in PwC: 5 economically measurable, 7 measurable and 11 non-measurable benefits.

Looking at the realised benefits it is seen that the first group has an economic value of about 80,000 DKK (the greatest contribution is from ‘Reduction of time searching for CAD-drawings’). The effectiveness benefits have been assigned a total score of about 60, which indicates that 60% of the measurable benefits are realised. Performance benefits account for almost half and were given equal marks for the three highest ones.

Considering the whole lifetime (in this case the building project’s lifetime) of the project web, the benefits are categorised as: 12 economically measurable, 11 measurable and 14 non measurable. The efficiency benefits equal about 155,000 DKK, whereas the total score of the effectiveness benefits is 45. The total score assigned to the effectiveness benefits has decreased because the likelihood of achieving these benefits has decreased. The performance benefits still account for most benefits and they are all graded in the top three.

5.2 Comparing the two case studies

Both case studies show that the value of the efficiency benefits is significantly lower than the cost of implementing and using the project web. There are many reasons for this but one is especially relevant in this case. In both case studies the likelihood of achieving the efficiency benefits is estimated as low and this indicates that the project web was not implemented well enough.

An important finding is the relatively high number of non-economically measurable benefits (effectiveness and performance benefits) in both case studies. These benefits have a value, although not measurable in economic terms, and should therefore have an influence on deciding whether project web usage is beneficial or not. The difficult task is to balance the three groups’ benefits when concluding on the project web’s success (or failure).

In total the usage of the project web was found to be very costly compared to the estimated efficiency benefits. There are, however, strong indications that, if the project web were implemented better, then this would give a more balanced economic output. This is especially the case if the cost in both the implementation and usage period were better controlled and more emphasis was put on achieving the maximum benefit.

6. IDENTIFIED BARRIERS USING A PROJECT WEB

The last area of findings is focused on project management of, and with, the project web. Much research has addressed the theoretical issues of project management of/with a project web, whereas practical issues are relatively little described. All three case studies have found difficulties achieving the expected potential of a project web. This fact is also evident from the output of MBITI in two of the case studies. A number of reasons were identified as causes of this situation and the most influential ones are presented in the following sections.

A common characteristic in the three case studies was that the usage of the project web was being rushed into. This resulted in the planning and preparation of the project web usage being ill considered and imprecise.

6.1 Objectives

One of the most important issues in using a project web is determining the objectives. It is necessary to decide what the project should gain from a new approach: (a) a faster exchange of digital information, (b) more accurate CAD-drawings or (c) a reduced number of plots? Or is it something else? This was not discussed and reflected on much in the case studies. The attitude was to achieve whatever benefits occur during usage, and this had several drawbacks as usage in all the companies cannot be planned and coordinated without a common objective.

6.2 Agreements

A project web, by definition, involves more than one company and this indicates that an agreement between the companies involved is needed, describing how each should use the project web. In two of the three case studies a project web agreement was made, which included: (a) which application version should be used for each file type, (b) the structure of the project web, (c) the exchange frequency and (d) the responsibilities and rights for uploads and downloads. It was found that the agreements did not have sufficient detail, which resulted in inconsistent usage and problems exchanging files. First, it was a problem that the agreement was not linked to the objectives, which made it difficult to commit the companies to try to achieve targets and coordination. Second, there were difficulties in coordinating usage. This became worse as more companies joined the project.

Even though the structure of the project web was a part of the agreement in two case studies it was a general problem to define and maintain the structure. In one case study the structure was initially defined as company-oriented (each company had its own directory), but during the building process it evolved into three different principles for structuring: file-oriented, company-oriented and building parts-oriented. This diversity was found to be inefficient as users spent much time working out where to download or upload the files. Introducing a new tool should be accompanied by changing working procedures, to provide better and more efficient processes. In the case studies the project web was generally used to carry out existing procedures more efficiently rather than changing them. This led to users, from time to time, discarded the project web as the traditional methods were easier and more efficient. Many of the tasks related to the exchange of data were affected by this problem.

6.3 Legal status

An important constraint was that paper versions were considered as the legally binding documents. This had a significant impact on, not only the usage of the project web, but also other aspects such as the production of CAD-drawings. Several examples, where this was a constraint, were found, for example, when the contractor approved CAD-drawings from the consulting engineer, it was done with paper-based versions, which resulted in bypassing the project web, as it was easier to print/plot the document and then post it. This was also found when the authorities' approval of some documents was needed and they required plans on paper.

In the three case studies use of the project web focused on exchanging CAD-drawings. An old problem with exchanging CAD-drawings has been standardising production and converting their format. This is even more important to solve with a project web, as access to CAD-drawings is improved and used more. Much emphasis was therefore put into applying a common standard and conversion procedures, but it was found that, when even one of the companies involved did not follow the standards fully, this had severe implications for the others. A second problem, highlighted by CAD-drawings, was identifying the need to send them to each company. In one case study it was found that the steel contractor, who designed the details, could not use the consulting engineers' CAD-drawings, as they did not contain enough information. Because of this, the steel contractor's use of the project web provided little or no benefit for this part of the work, even though there is significant potential.

In general the users considered the functionalities of the project web beneficial. Many comments were made on how to redesign these, indicating that the implementation was poor. This is a problem because the users become irritated and lose patience, which effectively leads to decreased usage of the project web.

7. PRACTICAL AND RESEARCH RECOMMENDATIONS

The research has examined a number of aspects of the use of a project web and, through these, several problems have been shown to limit success and efficiency. From the analysis of the collected data, this section contains practical and research recommendations for improving use of a project web in both the short and long term.

7.1 Some practical recommendations

The main recommendation is to put more emphasis on the planning and coordination of project web use. An over hasty planning process, in which the details are not planned and coordinated by the companies involved, causes many of the problems found. This results from a project web being considered as a tool for increased efficiency in existing procedures. Especially important is the identification of objectives for all planning and coordination.

As found in the case studies, there is a need to establish a project web agreement between all the companies involved (also those that join the project at a later stage). The project web agreement should ideally include:

- Targets for the project web usage

- A list of critical success factors
- A list of involved companies
- A description of the companies' duties, responsibilities and rights
- An identification of necessary requirements and usage areas
- The general guidelines for use of the project web

Agreements should be used to establish a common understanding of what to achieve and how to meet objectives. Companies that have signed, but do not follow the agreement, should be forced to do so by an agreed penalty. Establishing a project web agreement is, however, not enough, as it does not help the actual users of the project web. There is a need to develop a project web manual, which includes more detailed descriptions of usage preferably by differentiating between types of users (e.g. architects, engineers, contractors, suppliers etc.)

7.2 Changes in procedures

There is a special need to redesign traditional working procedures for the exchange of data. This is to take advantage of the new possibilities of a project web, so that working procedures are better and more efficient. This is not easy, but needs to be carried out so that the project web is not simply used to repeat existing working procedures. The first task is to plan the changes and the second is to train the users to execute these.

A fundamental change is necessary in what constitutes legal documents, from paper-based to digital versions. Changing this will require amendment of all working procedures based on assumptions that the legal document is paper-based. Digital signatures would help to make project web usage more efficient.

A project web will, in most building projects, probably be used to exchange CAD-drawings, as these files are often central. The success of the project web therefore depends upon the value of exchanging CAD-drawings. It is important that production of CAD-drawings is standardised so that all the companies conform. Also each company should identify, at an early stage, which level of detail they need, so that other companies know this.

The output of MBITI from two case studies, as presented in section 5.2, compared with the cost analysis, gives a negative picture of the project web. From this, the conclusion could be that a project web is not worth its cost, but this would be a hasty conclusion as the analysis only applies to the particular context, whereas improving project web usage according to the recommendations should result in a more positive return on investment.

7.3 Some research recommendations

The findings presented in this paper are based on three case studies in which a project web was used, plus a fourth case study based on a traditional building project. This means that the findings cannot be taken to represent general usage of a project web, and some caution is needed when reading the conclusions. The recommendations are, however, believed to be useful even though not all building projects using a project web experience the same problems. Extending the validation of the findings would therefore be useful if more case studies were completed on the subject of this paper. These would provide a more precise understanding of usage of a project web on building projects and the problems experienced.

One of the important recommendations is to make a digital version the legal document instead of the paper-based version. This is suggested in the knowledge that other countries, such as the UK, already accept this but, in Denmark, there may be a need to examine the consequences.

There is a continuing need to improve the functionalities of project webs, but there is a danger in just implementing new ones without ensuring that the existing ones are actually usable from the users' point of view. It is therefore suggested that more research goes into examining the usability of the existing functionalities.

8. CONCLUSIONS

The research has examined three main aspects of use of a project web: functionalities, cost/benefit and project management. Data was collected on costs and benefits and opinions from interviews. It was found that project webs are primarily used to exchange CAD-drawings, whereas other usage is relatively low. The flow of information through the project web follows traditional communication patterns indicating that the project web is used to increase the efficiency of existing working procedures. The volume of communication found slowly decreases through the building process showing that project webs are mostly used at the design stage.

The cost analysis, and using "Measuring the Benefits of IT Innovation", indicate an effectively negative benefit. This is primarily caused by the likelihood of achieving the benefits being relatively low, but also by the cost in Denmark generally being high. One of the potential benefits is 'Reduced time spent on information searching'. There are strong indications that usage of project webs is immature. Many causes of this have been identified, but a large part of the problem is that the planning and coordination of use is not emphasised enough. A number of fundamental problems are identified such as the fact that legal documents have to be paper-based and the project web is used to execute traditional working procedures.

The case studies generally give a negative picture with many remaining problems. Achieving success with the use of project webs in future requires that these problems are addressed and solved. This will require a significant effort, but it is needed and will, it is believed, in the longer term give a satisfactory payback. Further research in this area should be able to assess whether companies are learning by the experience of using project webs.

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