

## Experiences from implementation of ICT for resource management in small construction companies

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### Abstract

This paper summarizes experiences from the process of implementation of ICT-based systems for resource management in small construction companies. The initial decision process, system requirements specification and integration, education and staff training, and end user experiences were followed in a number of small and medium sized enterprises in Denmark. The findings are derived from the Danish project 'IT at the Construction site' started in 2003 and ended in may 2005. The project has involved a number of small to medium sized construction enterprises organizations and institutions within the building domain as well as ICT tools providers. The Danish Ministry of Science Technology and Innovation financed the project.

The involved construction companies originally used paper based communication between the project management office and the craftsmen on the construction sites. The companies found that this traditional procedure often resulted in ineffective and inefficient communication. Some of the problems identified were:

- difficult to keep craftsmen up to date on changes in projects and tasks
- difficult to give craftsmen access to other internal and external information sources
- time delay after activities were actually performed until they were registered in the management system since paper based notes from the craftsmen should first be collected at the office and then be keyed in by a secretary
- difficult to follow existing procedures to ensure that all consumptions of time, materials and equipment were actually accounted to the correct project

To reduce these problems, the companies implemented new time and resource management systems with some of the following features

- online connection to mobile devices carried by all craftsmen or team leaders at the construction sites
- web access so craftsmen could check and update registered data from any computer, e.g. at home
- real-time connection to the company's general management systems
- bar code readers integrated with mobile phones for easy data input of e.g. materials and equipment

Experiences from the field studies showed that there could be technological problems in integration of systems from different suppliers. The integration problems were often underestimated and the agreements on responsibilities and deadlines for each partner in the implementation process were not sufficient to ensure a smooth implementation in the construction companies. The project experiences enforced the importance of active end user participation in requirements formulation and implementation of new ICT tools and also that communication between software developers and construction workers is a challenge. In some cases, there were cultural barriers to take the new technology into use, technical problems were also reported on the use of the equipment in the construction site environment, e.g. unreadable bar codes on equipment used at the construction site or equipment not suitable for use in the actual work situations.

## 1. Introduction

Many small and medium sized construction companies in Denmark have experienced problems with effectiveness and efficiency of their workflows. An international investigation (Erhvervsfremmestyrelsen, 2000) pointed out that there is a need to strengthen the industry's innovation e.g. by increased use of information technology and increased collaboration with education and research institutes.

With this background, the project 'IT at the construction site' was started to initiate activities to better utilise and develop Information and Communication Technology, ICT, tools at the construction site. The project was launched in 2003 and ended in May 2005. It is now followed up by the newly started 'IT and resource management at the construction site' project. The project has involved several small to medium sized construction enterprises, organizations and institutions within the building domain as well ICT tools providers. The Danish Ministry of Science Technology and Innovation financed the project.

The project included more than 20 partners representing different roles in relation to the construction industry:

- University and engineering school.
- A number of small construction companies and their industry organisation.
- Software and hardware system suppliers and service providers.
- Suppliers of building materials and equipment.
- Local authorities.

With this broad representation, the project covered many different ICT domains:

- Construction web portal.
- Digital document handling.
- Mobile telephone technology for registration.
- Education activities.
- Collaboration between industry and research institutions.
- Evaluation of construction site ICT tools.
- Knowledge transfer.

This paper focuses on the implementation of new systems based on mobile devices for the resource management and information sharing in the participating construction companies. Further documentation from the project is given by Heldgaard et.al. (2005), Carlsen (2003), and Nielsen et.al. (2004).

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In the paper based system, it is time consuming to transfer information on time consumption on working tasks, material use and equipment use from the individual worker at the construction site to the administration of economic follow-up, invoicing the customers and paying wages to the workers. It is also experienced that some workers often waited until Friday to fill in reports of the week and thus had problems to remember details on e.g. equipment use on different projects. This could result in errors or missing records on invoices to the customers. The companies see many advantages in a better control of these procedures. In an attempt to reduce the problems, the companies implemented new time and resource management systems with some of the following features

- online connection to mobile devices carried by all craftsmen or team leaders at the construction sites
- web access so craftsmen could check and update registered data from any computer, e.g. at home
- real-time connection to the company's general management systems

- barcode readers integrated with mobile phones for easy data input of e.g. used materials and equipment.

The tested systems require that data are immediately reported at the beginning and end of a task and in some cases also that the use of equipment and materials is continuously recorded. This significantly improves the possibilities for project management and makes the invoicing and payment procedures more efficient and effective. The faster and more correct invoicing improves both the earnings and liquidity of the company.

## 2. Method

In order to capture experiences from the implementation process of the new systems, we monitored the activities of the companies in different ways:

- Interviews with the managers and implementation responsible persons in the companies.
- Interviews with end users in the production.
- Interviews with suppliers of the implemented systems.
- Assisting companies and suppliers in the implementation process.
- Assisting companies in the education of end users.

Structured notes were kept in a project journal for each participating company. The notes were supplemented by sketches of workflows, physical and cultural environment and artifact descriptions based on the Contextual Design methodology which was introduced by Beyer & Holzblatt (1998). Examples are given in fig 2 and 3.

## 3. Results

We followed the implementation process of three different systems, based on mobile devices, which were tested in three different companies. Company 1 tested a system based on mobile phones with barcode readers. Company 2 tested a system based on PDA's and company 3 tested a system based on ordinary mobile phones. See fig. 1. Experiences from the three companies are described below.



Fig 1 The three systems in test: PDA, mobile phone with barcode reader and ordinary mobile phone.

The participating companies used a number of computer based and paper based systems to assist them in different tasks in their business processes. The systems were more or less integrated, and it was a goal for all companies to have a better integration between the systems. All companies had

- a calculation system used for cost analysis and bidding
- planning and resource management systems
- a financial system to handle all payments, invoicing etc

The systems' relation to a typical project timeline is shown in figure 2.

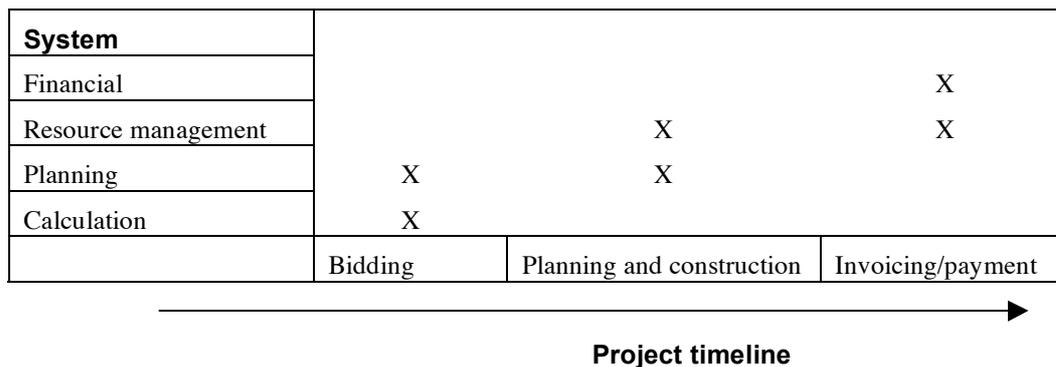


Figure 2 Systems used in the project processes

### 3.1. Company 1

The company had 20 – 30 employees in the production and the administration and project management was run by 4 persons including the owner, his wife and his son. Different IT-systems were used for project management, calculation, manpower management etc. The communication with suppliers and subcontractors was mainly carried out by email. Thus the company already had some experiences with information technology, and the owner was now ready to take a step further to achieve a more efficient workflow in the information handling. It was essential to the company that the same data should not be keyed-in in a number of different systems. With this ambition a test project was started based on mobile phones with barcode readers to capture the use of time and materials on projects.

After a 4 week test period, it was realised that further software development was necessary to make a better integration between at least three software systems from different suppliers. Five coherent development projects were identified and several hundreds of man hours were used for development at the suppliers and testing at the company. The developers and the company faced a lot of challenges during this system development process

- some software components were not as ready as expected for implementation in practice
- software systems integration problems due to poor documentation
- none of the stakeholders had realised the scale of the project when they started
- it was difficult to coordinate system development and not clear who was in charge
- indistinct agreements on responsibility and deadlines in the system development process
- long response times when connecting from mobile devices confused the end users
- in some cases barcodes can easily be damaged in the construction site environment

It was concluded that the barcode readers on mobile phones had a great potential for recording data on time consumption as well as use of materials and equipment and a lot of valuable experience was achieved by all participants. However the participants didn't manage to complete the very ambitious implementation/development project within the time of this research project. The construction company decided to wait for the systems to be more mature before they would start a more extensive implementation.

### 3.2. Company 2

The company had 50 – 60 employees in the production. A worker would typically work on a number of different projects each day, and he could use different types of equipment on each individual project. The existing system was based on weekly paper based reporting from the workers. The goal for the new system was to have a daily efficient reporting of time, material and equipment use on each project. The system should be able to communicate with the company's existing calculation system and financial system as well as a major supplier's database of materials. The company believed that the investment would pay back in better project management and faster invoicing ensuring that all services are invoiced, as well as better view of status of equipment and other resources and fast access to reliable project status.

The company management decided to introduce a resource management system based on PDA's in the company. The system was implemented quite successfully regarding the use of mobile devices for recording of activities. The system was introduced for the employees in a series of short courses of 3 - 4 hours with 4 - 5 participants on each course. The courses were targeted towards specific categories of employees. During the

courses, the employees and the system suppliers had valuable discussions about the data structure, workflow and specific procedures for performing different tasks with the system. The feedback from the employees resulted in a number of adaptations before the final implementation of the system. From the beginning, the system was used in parallel to the existing system and data were compared for quality control.

However, regarding the integration with the financial system and the calculation system, there were problems similar to those in company 1

- several months after implementation of the time recording on PDA's, data on time and equipment use still had to be transferred manually to the financial system
- both suppliers argued that the other part did not do the necessary adaptations of their system
- it was suggested that the company should replace the financial system or the calculation system with other software which could be integrated more easily, but the owner found this too risky since many years of experience was built into the systems

At the end of the research project the system integration was close to be finalised, and the company was generally satisfied with the system due to advantages already achieved with the online time recording, but the owner also emphasised, that it had been a big challenge to introduce the new system. The main experiences were that

- it is very complicated to formulate requirements to a new system consisting of existing and new systems from different suppliers
- the adaptation of systems to work together is very time consuming and requires flexibility from the software developers and patience from the users
- it is assumed that the development process could have gone more smoothly if there had been more focus on project control and more clear agreements on tasks and deadlines between the company and the involved suppliers

### **3.3. Company 3**

The company has up to 100 employees depending on the season. There can be up to 8 workers on the same project and one worker can work on several projects on the same day using different types of equipment. The workers reported use of time and equipment on a weekly basis to a secretary who keyed the data into the financial system. This was very time consuming and it was found that some data were forgotten and never invoiced.

The company decided to use a recording system based on ordinary mobile phones to have a daily reporting on time and equipment use. Figure 3 and 4 show the situation before and after introducing the new resource management system. Equipment is immediately checked out and in to the storage via the mobile phone, and time spent on different projects is in the same manner registered during the workday. Before the implementation, the company had extensive collaboration with the software developers to ensure a satisfactory integration with the existing financial system. When it came to implementation of the new system, it was decided to start with a small group of 10 employees who tested the system for a period before it was further introduced in the organisation.

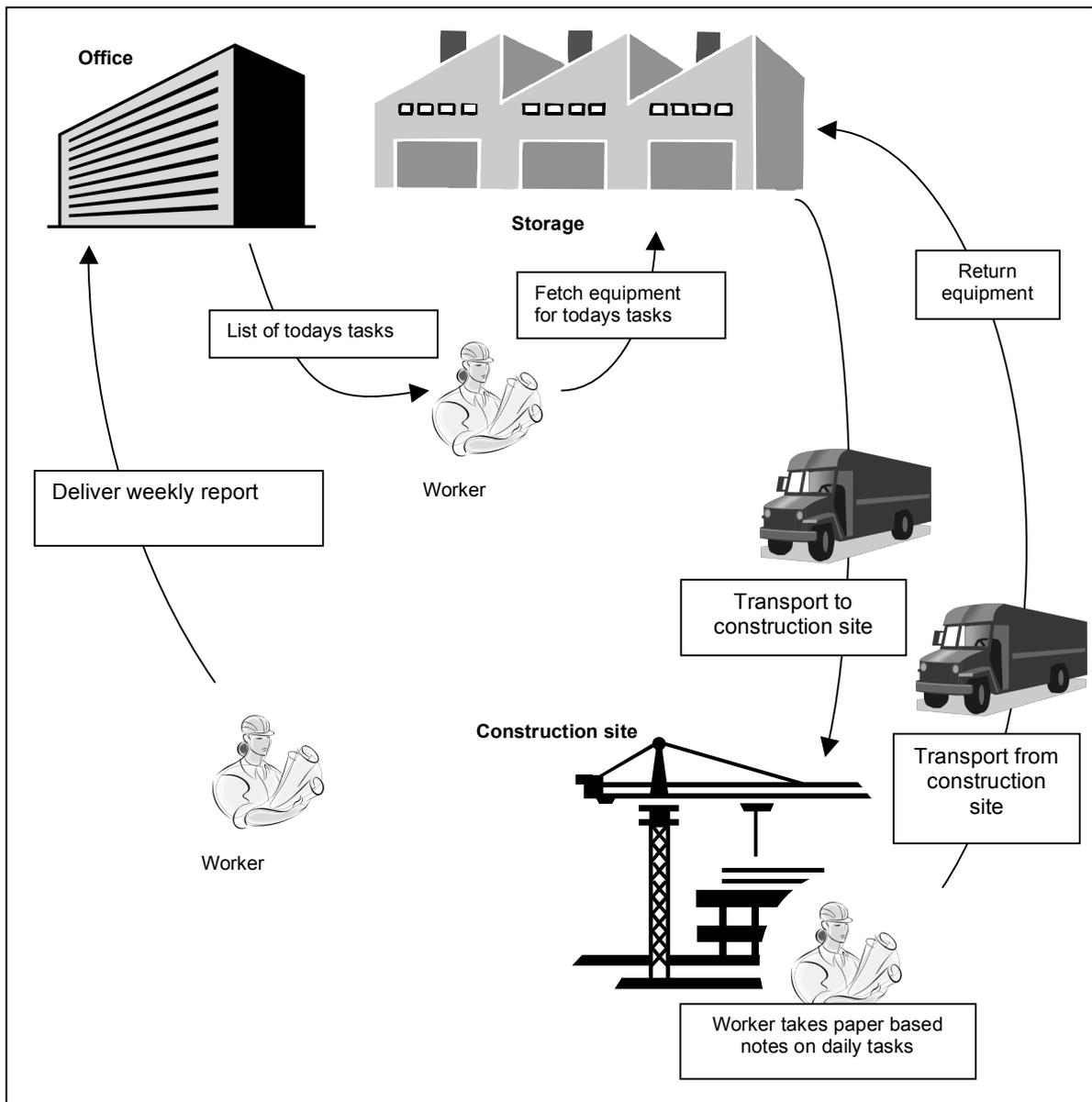


Figure 3 Physical model of the situation *before* introduction of the mobile resource management system at company 3.

From the process of development and implementation the company had the following major experiences and recommendations:

- the supplier told that the new system was able to communicate with our existing accounting system, but it turned out to be a long troublesome process to make it communicate
- the company expected the system supplier to keep the implementation process on track, and it took a long time for us to realise that we had to participate more actively in the project management of the implementation and development process
- it was a challenge to communicate effectively with the software developers since we did not speak the same 'language'

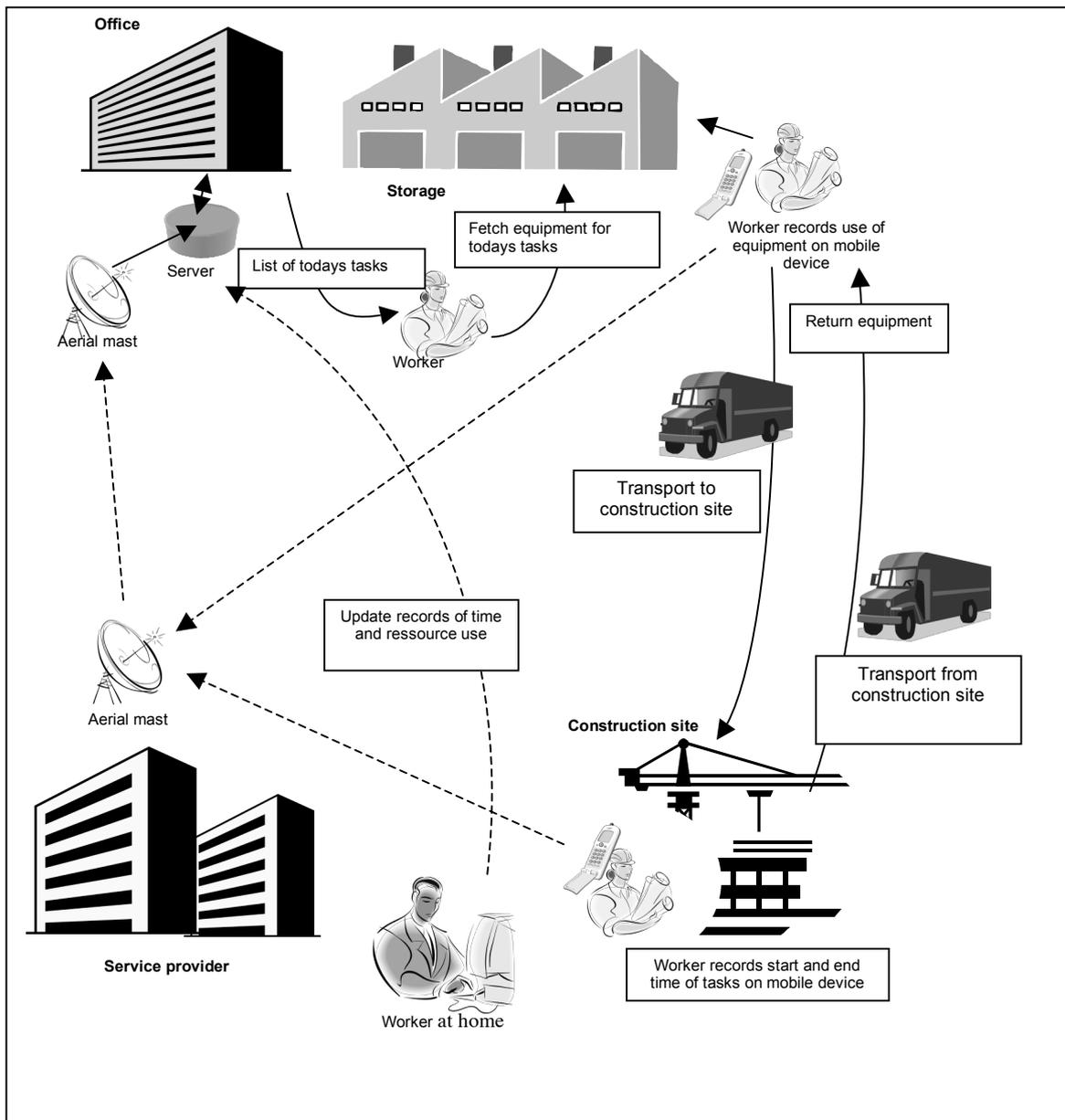


Figure 4 Physical model of the situation *after* introduction of the mobile resource management system at company 3.

- from the beginning we did not pay enough attention on requirements formulation
- in the beginning of a project like this, the company recommends to make a storyboard with detailed descriptions of the business processes, the company's needs, used equipment, working procedures etc. Both people with business knowledge and IT knowledge must contribute to the storyboard
- the employees were generally positive to changes, but it is still important to be aware that the individual employee experiences some benefits, e.g. to have more precise information on projects and tasks or to have a smart new telephone
- the company is always aware of the balance between time, ambitions and resources in system development projects and has a rule of thumb that only 80% of the ambitions for a new system can be fulfilled due to time and resource constraints

## 4. Conclusions

The main findings of the project were:

- The involved companies became aware of possible advantages with the new technology.
- The project initiated valuable sharing of experiences among companies.
- Experiences from the field studies enforced the importance of active end user participation in requirements formulation and implementation of new ICT tools.
- There is a great need for education on several organizational levels in the small and medium sized construction companies.
- There were cultural barriers to take the new technology into use.
- Special effort was necessary to motivate the workers when administrative tasks were partly moved from the office to workers at the construction site.
- Technological problems in integration of systems from different suppliers.
- Problems with ontologies integration on application level.
- The level of ambition for integrating different software systems from different suppliers seems to have been too high in some cases.
- In some cases, the responsibility for management of the systems implementation and integration was not clearly defined in agreements between the construction company and the system suppliers.
- Problems using the equipment in the construction site environment, e.g. unreadable bar codes on equipment used at the construction site or equipment not suitable for use in the actual work situations.

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