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A SIMULATION TOOL FOR RADIO FREQUENCY IDENTIFICATION CONSTRUCTION SUPPLY CHAINS

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ABSTRACT

Radio Frequency IDentification (RFID) technology is being used more and more in the construction industry. RFID tags and peripheral equipment are becoming cheaper and more suitable for application in the supply chain. However, it is difficult for contractors to estimate the costs and benefits of using RFID technology in their production processes. Based on a case study and simulations, the aim of this study is to develop a simulation tool for contractors that would help them to decide how to use RFID technology in specific supply chains. In the case that was studied, the simulation tool provided insight into what errors in the supply chain resulted in unnecessary processes but gave hardly any idea of the cost reduction of the production process by using RFID technology.

KEYWORDS
RFID, construction supply chain, failure costs

1. INTRODUCTION

RFID is a technology used to identify and monitor objects and people. An RFID system consists of RFID tags, RFID tag readers, output devices and software. The price of the RFID tags will fall considerably in the next few years, which continues to prompt a study of whether an RFID system in the supply chain can generate benefits and how the pros and cons should be assessed.

Use of RFID technology in the management of the material and information flows in the supply chain can cut unnecessary costs. Ren et al. [1] describe the management of the material and information flows as a 'process of planning inventory control, receiving and storing, material handling, physical distribution and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements'.

In the supply chain, unnecessary costs are incurred because building elements are produced using the wrong drawings, the wrong building elements are delivered or the products were wrongly identified during processing. In the Netherlands, these unnecessary costs have been estimated at approximately 10% at a turnover of 50 billion euros [2].

Use of RFID technology in the supply chain has already been the subject of a number of studies. Furlani [3] looked at the automated tracking of structural steel members at the construction site with the aid of an RFID system. Jaselski [4] conducted pilot tests to establish that data was downloaded faster into the company's materials tracking system. Yagi [5] developed a material parts and information packets unified architecture. J. Song [6] automated 'the task of tracking the delivery and receipt of fabricated pipe spools in industrial projects'. Kaneko [7] found that carbon dioxide emissions were reduced by using RFID technology. Gajamani [8] investigated the use of an RFID system for automated schedule and inventory monitoring in real time, and Wang [9] enhanced construction inspection and management by using RFID technology.

A master study [10] conducted at Eindhoven University of Technology in the Netherlands compared a supply chain with and without an RFID system. For contractors, it is difficult to estimate the costs and benefits of using RFID technology in their production processes. This is why the study looked at how the supply chain with and without an RFID system is structured and how the technology can help reduce unnecessary costs. This paper contains a brief summary of the study results. The aim of the master study is to develop a simulation tool for using RFID technology in the supply chain by means of a case study and simulations.

2. QUESTIONS AND METHODS

To develop a simulation tool, the following questions had to be answered:

How can the work processes with and without RFID technology in the supply chain be compared?

What is the structure of a cost calculation by implementing RFID technology?

These questions will be answered by studying a case and carrying out simulations.

2.1. Case study

The case in question is the 'Dommelbergen' construction project, where an existing bridge was replaced by four new bridges. The project duration was nine months and it was budgeted at two million euros. During the case study, the supply chain of piles between production and placement was analysed by interviewing the work planner and the site foreman, which created an insight into how the work processes are supposed to proceed and how they actually did.

The study also looked at the administrative work processes, such as processing waybills, drawing up delivery reports, keeping track of building products in place, drawing up pouring releases, keeping a log, filling in hours worked by employees and subcontractors, etc. Eight different project document folders and the content of A4 file trays were also studied.

2.2. Simulations

To gain insight into the performance of the supply chain processes using an RFID system, these processes are simulated with the aid of software. Boersma [11] describes simulation as a cyclical process, in which a model of the actual system is developed and used to conduct experiments. The aim is to be able to describe and explain the behaviour of the system, after which the performance of various alternative strategies that influence the behaviour of the system can be tested. The ARENA program was the software used.

The model not only consists of direct work processes, but also of indirect work processes such as inspection and registration. The model also comprises alternative work processes required to correct irregularities such as returning the wrong piles and performing extra inspections. See Figure 1.

The model input is the number of orders and call-offs each day. The chance of an unnecessary process having to be performed has been entered in the model on the basis of interviews with experts. The simulation consists of a scenario that takes up a production year in which 60,000 piles are driven. The output is a percentage that shows the extent to which unnecessary processes are performed.

Three possible scenarios of a supply chain for piles are calculated.

Of the existing process as it occurred during the case study.

RFID used in the existing process.

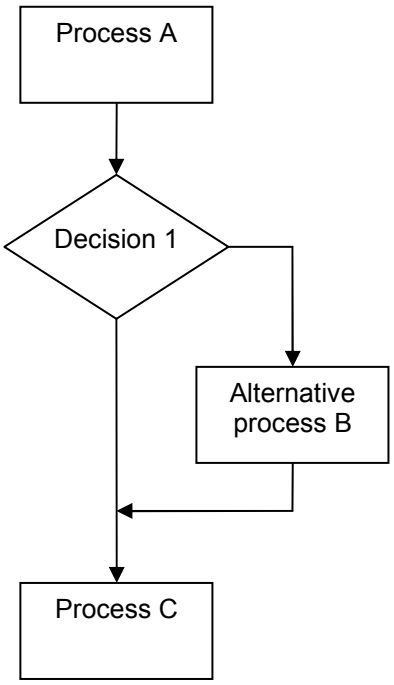

Figure 1. A typical part of the model, where a particular decision results in an unnecessary process and therefore additional costs.

RFID pessimistic. This includes a number of errors such as the attachment of the wrong RFID tags, illegible RFID tags caused by bad stacking or the wrong RFID tag is read out.

2.3. Cost estimations

On the basis of the scenario, the costs will be calculated for an RFID system comprising an RF network, hand terminals, readers, docking stations, RFID tags, network rental and programming costs of both the producer and the contractor.

3. RESULTS

3.1. Case Study

The case study produced the following results:

The site foreman is not always available to run the necessary processes in the case of irregularities. He may not be on the site, may be in a meeting or may be walking around somewhere on the site.

The collected information does not provide sufficient insight to draw a comparison between existing work processes and work processes that could be supported by RFID.

The work processes have been visualised in six models:

1. A general overview model of the material and information flows between the factory and the construction site.

2. A table with a description of the key words, such as people, locations, variables, activities, administrative objects, ICT and other key words. [10, p. 27]

3. An organisation chart that establishes the connection between the key words in the table referred to above and a number of extra positions such as management, buyer and administrator. The connecting lines are the information flows.

4. A DataFlow diagram, which shows the activities and the relationships between them. The activity procedure of the piles includes the award of the contract, ordering, producing, delivering, driving and paying. A total of 27 supply chain activities are described in the model.

5. An activities diagram. This diagram describes the activities in more detail.

6. A class diagram. To examine the use of an RFID system, a specific diagram is used to provide insight into what information should be on the RFID tag. This model comprises 17 objects or activities.

3.2. Simulation results

The model used for the simulations consists of 79 execution and optional processes.

Three simulations were performed:

The existing situation

The actual RFID situation

The pessimistic RFID situation.

Use of an RFID system results in 1.18% fewer irregularities in the supply chain for the pile manufacturer and 10.58% for the contractor. In the pessimistic scenario, these figures are 2.64% and 6.76% more irregularities, respectively. See Table 1.

The simulations show that use of an RFID system can have a positive influence on the business process:

- The number of processes falls
- The number of errors falls.

Table 1. Percentage of irregularities in various scenarios.

Simulation	Manufacturer irregularities [%]	Contractor irregularities [%]
Existing situation	3.80	13.46
RFID	2.62	2.88
Pessimistic RFID scenario	6.54	19.22

3.3. Cost estimation results

An RFID tag costs 2% of the average price of a pile and the RFID system infrastructure costs 1%, which amounts to a total of 3%. The costs of the RFID tags look to be the biggest expenditure at approximately 76%.

4. DISCUSSION

The study aimed to answer two questions: how can working processes be modelled to simulate them and what is the structure of a cost calculation by implementing RFID technology?

The values established for the simulations only apply to the pile supply chain in the case study.

The cost of the tags will fall in the next few years. For the construction industry, the use of RFID technology could generate benefits such as fewer unnecessary production process costs, as well as a better final product. A precondition for putting in an RFID system is that the costs of the system should pay for themselves from the unnecessary costs. The system becomes even cheaper when several building elements are monitored with RFID technology.

The aim of the master study is to develop a simulation tool for implementing RFID technology in the supply chain by a case study and simulations. The result of the study is a model of a building element that can provide insight into all necessary and unnecessary work processes in the supply chain. The latter is certainly a means to improve processes and to produce a more reliable process.

5. CONCLUSIONS

The resulting simulation model gives stakeholders a decision tool with which to study whether the introduction of an RFID system creates benefits. When using an RFID system for the supply chain, (i) fewer errors may be made, leading to fewer irregular and incidental processes, (ii) the information becomes available faster and (iii) work is more efficient. Stakeholders can use the model to decide for themselves whether the extra costs outweigh the unnecessary costs incurred if an RFID system is not used.

When incorporating an RFID system into the supply chain, account must be taken of the fact that data may be accessed wrongfully and that communication may be disrupted by other devices such as cordless phones. To keep this vulnerability to a minimum, the RFID system should meet a certain standard of quality.

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