The effect of enterprise information system characteristics on task productivity
a production engineering context

Ariëns, G.T.

Award date:
2018

Link to publication
Master Thesis
The effect of Enterprise Information System Characteristics on Task Productivity
A Production Engineering Context

By
G.T. (Guy) Ariëns

Supervisors
Prof.dr. E.J. Nijssen  TU/e
Dr. O. Türetken  TU/e
E. Maira MSc  TU/e
I. Hensen  DAF Trucks N.V.
F. van Verre  DAF Trucks N.V.
Department of Industrial Engineering & Innovation Sciences

Eindhoven, University of Technology

Subject headings: Enterprise Information Systems, IS Success, IS Adoption, Task Productivity, Individual Performance, Ease of Use, Locatability, Data Presentation Quality, Rapid Prototyping
Management Summary

Nowadays companies invest a vast amount of capital on Enterprise Information Systems (EISs) to provide company-wide integration of core processes and information for all functional areas within the company. Part of these investments are meant for analyzing EISs and discovering key improvements that can be made to increase the performance of its users.

This study focuses on the specific context of an EIS within a Production Engineering (PE) environment. The research aims to understand what specific EIS characteristics effect the task productivity of its users. Once the effects of specific EIS characteristics on task productivity were identified, the identified EIS characteristics were analyzed and improved through an improved version of the EIS. This improved version of the EIS was built in the form of a prototype. This prototype was tested to find out if the improvements had an effect on task productivity in terms of time. The test results were positive, thus confirming the findings that specific EIS characteristics had an effect on task productivity.

The research was executed at the PE department of DAF Trucks N.V., which is one of the three biggest truck manufacturers in Europe. The current EIS does not support the processes of the users in an efficient way due to the non-routineness of the tasks it is hard to learn and not easy to use. Also, a general consensus among the users is that localization of data is a difficult task, especially if you haven’t used that data before.

To investigate what kind of effect the EIS characteristics have on task productivity the following research question was formulated:

What is the effect of Enterprise Information System characteristics on task productivity?

Methodology

Literature review

First a literature review was done to find what is already known about this subject. Three models were found that were extensively tested in the literature. They were also extended and adjusted by multiple researchers. The three models were the Technology Acceptance Model (TAM), the DeLone and McLean (D&M) model, and the Technology to Performance Chain (TPC) model. They all identified potential relevant EIS characteristics that influenced constructs related to task productivity. EIS characteristics that were relevant were system quality, information quality, perceived ease of use and task-technology fit (TTF). These characteristics are often constructs of multiple EIS characteristics.

Research model and hypotheses

A research model and hypotheses were constructed to give answer to the research question. This research model was based on the effect between constructs that were found in the literature review and was specified to the context of this study, namely production engineering. Constructs that were found relevant were: locatability, data presentation quality and ease of use (EoU). It was hypothesized that: locatability positively affects task productivity and EoU. Data presentation quality positively affects task productivity and EoU. EoU positively affects task productivity. In the context of PE it was also hypothesized that due to the non-routine nature of the task the effect of locatability on task productivity will be negatively influenced due to the fact that the more non-routine a task is for a user the harder it is to localize the data, since he hasn’t used that data before. Another hypothesis was the effect of experience with the EIS on the connection between locatability and EoU, and data presentation quality and EoU. More experience with the system will make it easier to locate data within the system and users will find the
data presentation quality easier to understand, since they are used to it.

**Questionnaire and Data Analysis**
A questionnaire was used to gather the data for the data analysis. 43 respondents filled in the questionnaire and the data was analyzed with the software package SmartPLS 3 using the partial least squares method for structural equation modeling (PLS-SEM).

**Results**
One item loaded almost identical on two factors so it was dropped. All constructs had good reliability and validity scores. The adjusted r-squared for EoU and task productivity were respectively 0.487 and 0.308.

Locatability had a negative effect on task productivity and a positive effect on EoU. Data presentation quality only had a positive effect on task productivity. EoU positively affected task productivity. Non-routineness did not seem to have an effect. Experience had a positive moderating effect if users had more than 10 years of experience with the EIS, otherwise a negative moderating effect.

These results of locatability reflected the context of the PE department, since for users with a lot of experience the effect of locatability on EoU is amplified, which in turn affects task productivity and therefore may cancel the direct negative effect of locatability on task productivity. Users acknowledge the fact that data is often so hard to find that it is nog easy to use and takes them a long time to accomplish a task at hand.

**An improved EIS to support the work preparation process**
One of the most time consuming and difficult tasks within the PE department of DAF Trucks N.V. is the work preparation process. Production engineers need to translate all new designs of the product development department into production information in order to produce the trucks by production. This time intensive process is called the work preparation process and due to its non-routine nature it’s hard to localize the data and not easy to learn. This corresponds with the outcomes of the research model. The improved EIS was focused on this process.

Therefore, during de analysis of this process we focused on locatability, EoU and also data
presentation quality. A new EIS was made by developing a prototype. A test case was made to evaluate the current system with the new improved EIS.

The results were positive. The new improved EIS was approximately 60 to 68 % faster in terms of time needed to perform a typical work preparation case. This indicated that improving the current system on locatability, EoU and data presentation quality had significant effect in terms of task productivity.

**Academic contribution**

This study yields an academic contribution in several ways.

Firstly, it extends the literature on EIS characteristics that directly influence productivity. This is extended in two ways, through a theoretical model and through a confirmative test case.

Also, most research on EIS success and EIS adoption uses more general and constructs of EIS characteristics, such as system quality and information quality. This research used more specific EIS characteristics to identify the power of these characteristics on productivity.

Besides this, task productivity is used in most literature as an antecedent of overall performance. This study presents the effects between the constructs in a far more detailed manner.

As last, the context of the study also has an academic contribution, since it suggests, provides and proves that certain EIS characteristics are important in a production engineering environment. This extends the understanding in existing literature which EIS characteristics are important for performance and therefor EIS success in a production engineering environment.

**Practical contribution**

These outcomes have practical contributions for DAF N.V. and suggest they develop or improve their current EIS based on these EIS characteristics.

It also has practical contributions for other companies that face task productivity issues in a production engineering context. These companies can try to identify if the users face the same problems in terms of locatability, EoU and presentation.

The prototype that was developed as a new EIS can be used by DAF as a new task supporting system or when they choose not to integrate the prototype they can examine its functionalities to build their own support system for the work preparation process.
Table of Contents

Management Summary ........................................................................................................ II
Methodology ..................................................................................................................... II
   Literature review ........................................................................................................ II
   Research model and hypotheses ................................................................................ II
   Questionnaire and Data Analysis ................................................................................ III
Results ............................................................................................................................. III
An improved EIS to support the work preparation process .............................................. III
Academic contribution ................................................................................................. IV
   Practical contribution ............................................................................................... IV
Table of Contents .......................................................................................................... V
List of Figures ................................................................................................................ VII
List of Tables ................................................................................................................ VIII
1. Introduction ................................................................................................................. 1
   1.1. Research Setting – Production Engineering Department at DAF N.V.................... 1
   1.2. Problem Identification and Research Question .................................................. 2
2. Literature Review ....................................................................................................... 4
   2.1. Introduction ........................................................................................................ 4
   2.2. Brief introduction of TAM, D&M model and TPC model .................................... 4
   2.3. Technology Acceptance Model ........................................................................ 5
   2.4. DeLone & McLean IS Success Model ................................................................ 6
   2.5. Technology-to-Performance Chain Model ........................................................ 8
   2.6. Impact of EISs on Productivity ........................................................................ 9
       2.6.1. Usability of User-Interfaces ...................................................................... 10
3. Model and Hypotheses Development ....................................................................... 11
   3.1. Ease of Use ....................................................................................................... 12
   3.2. Locatability ...................................................................................................... 13
   3.3. Data Presentation Quality ................................................................................ 13
   3.4. Moderation effects: Non-routineness and Experience ...................................... 13
4. Methodology .............................................................................................................. 14
   4.1. Questionnaire .................................................................................................. 14
   4.2. Data Analysis Method .................................................................................... 14
5. Results ....................................................................................................................... 15
6. An Improved EIS: A Prototype and Test .................................................................. 15
6.1. The development process of the prototype .............................................. - 16 -
6.2. Test Case and Results ............................................................................. - 17 -

7. Discussion ........................................................................................................ - 18 -

7.1. Discussion of the research model and the prototype test ......................... - 18 -
7.2. Academic contribution .................................................................................. - 19 -
7.3. Practical contribution ................................................................................... - 19 -
7.4. Limitations and suggestions ....................................................................... - 19 -

8. References ......................................................................................................... - 21 -

9. Appendix ........................................................................................................... - 25 -

9.1. Questionnaire ............................................................................................... - 25 -
List of Figures

Figure 1 Research Model ........................................................................................................... II
Figure 2 Organizational Structure of the Production Engineering Department at DAF N.V. .... - 2 -
Figure 3 The current work process for work preparation .......................................................... - 3 -
Figure 4 TAM and TAM 2 ........................................................................................................ - 5 -
Figure 5 DeLone and McLean original model ........................................................................... - 7 -
Figure 6 DeLone and McLean updated model .......................................................................... - 7 -
Figure 7 Technology-to-Performance Chain model .................................................................. - 8 -
Figure 8 Interrelatedness of the models: D&M, TAM and TPC ............................................... - 9 -
Figure 9 Research Model ........................................................................................................ - 12 -
Figure 10 Results of the research model ................................................................................ - 16 -
List of Tables

Table 1 Variables of TAM 2................................................................................................................. - 4 -
Table 2 Summary of the reliability and validity of the constructs.............................................. - 15 -
Table 3 Path coefficients of the effect between the constructs.................................................. - 16 -
Table 4 Indirect path coefficients................................................................................................ - 16 -
Table 5 Users characteristics for the case ..................................................................................... - 17 -
Table 6 Time of the users performing the case............................................................................. - 18 -
1. Introduction

An Enterprise Information System (EIS) provides enterprise-wide integrated information systems covering all functional areas and performs core corporate activities. Enterprise Information Systems (EISs) are business management systems that seek to combine all aspects of the organization (Olson & Kesharwani, 2010). It facilitates processes for planning, manufacturing, marketing and sales and it is usual that an EIS uses integrated database management systems. This way it reaches its goal to integrate all the data and processes of the organization.

Understanding the impact of EISs characteristics on the productivity of users is essential for organizations, as it can improve the performance of individuals and organization (Petter & McLean, 2009). Researchers acknowledge the fact that EISs have effect on the performance of its users and that it can be measured. Firms also spend substantial sums on EIS and in the last decades it had become a core of almost every business. Last year (2017) the EIS companies made a total revenue of 34 billion dollars showing the enormous amount of investments that are made by other firms (Forbes, 2017).

To assess the impact of EISs on its users researchers investigated and measured a variety of constructs such as, perceived usefulness, net benefits, individual impact and user satisfaction. Researchers also found constructs that have an effect on these constructs for instance, system quality, information quality, service quality and perceived ease of use. These constructs are interrelated and can clarify what EIS characteristics influence users productivity. Most researchers do this in a broader way by investigating user performance with constructs as perceived usefulness or individual impact. While these constitute items for productivity they do not specifically investigate the productivity of users. Also, most researchers collapse EIS characteristics, such as accuracy, relevance, presentation, integration, understandability, into one or two constructs such as system quality and information quality. Not investigating the individual effects of these characteristics on user performance or productivity. It can be relevant to know in different company or department settings to know what and to which extend EIS characteristics influence productivity. In the next paragraph our company setting will be discussed and following the research question will be formulated.

1.1. Research Setting – Production Engineering Department at DAF N.V.

The company setting is the production engineering department of DAF Trucks N.V.. The production engineering (PE) department is responsible for the design of the production process and all the necessary tools that facilitate the production process. The PE department is divided in 5 teams that each have their own specialization. First, there is PE Product. They are responsible for the projects. Projects are new developed trucks by production development and this team has to engineer the production process for these new trucks. Second, two teams are responsible for the daily production design and necessary tooling. These two teams are responsible for a different area of the factory, respectively area 1 and area 2. Third, PE Process is responsible for all the processes of the production design. Finally, PE Non-Standard Orders (NSO) is responsible for non-standard orders. They have to fit and adjust certain parts of the production design to enable the production of vehicles with adjustments that are not listed in the truck catalogue of DAF. This organizational structure is presented below as figure 2.
1.2. Problem Identification and Research Question

DAF developed their own EIS to support the core tasks for the translation of new designs from R&D to production rules. The process is hindered by continuous changes by R&D to designs but also by the fact that data needs to be pulled from several/many sources. The non-routine nature of the task makes automation and system support difficult.

The system runs on a mainframe computer and is also referred to as the Mainframe system, which can be seen as a combination of a Manufacturing Execution System (MES) and Enterprise Resource Planning (ERP) system. The experience of the production engineers with the EIS is characterized as difficult to learn and difficult to use. Locating data within the system can also be challenging depending on the task and familiarity with the data. When the data is localized, the presentation is also important to interpret it and in some cases this can also be difficult for production engineers. The expectation is that these aspects affect the productivity of the production engineers. However, this hasn't been properly assessed. The production engineering department wants to assess the impact of EIS characteristics on task productivity and would like to positively change these characteristics to increase task productivity. Task productivity is the amount of time needed to complete a task.

The department is especially interested in a specific task called work preparation. The production engineers of the team PE Product are responsible for this process, which is processing the new trucks developed by product development (PD) into work instructions. These work instructions are used in production to assemble the trucks.

The task of developing work instructions starts with translating the so called Cross-list ("Kruisjeslijst") into work instructions for the production teams. This is a paper document that contains all the parts of the new developed trucks. There are a lot of variants of trucks and they need to develop work instructions for specific variants or groups of variants. Some components (e.g. fuel tanks) are shared amongst multiple variants of trucks, so that means the same work instruction can be used on a specific workstation (e.g. workstation for mounting fuel tanks). The production engineer needs to extract information from different parts of the Mainframe, different systems and different parts of the Cross-list. Depicted in figure 3 is the current situation of information gathering during the work preparation process. The assembly line is split into multiple assembly areas and translated into four disciplines of production engineering. Each discipline works in their own way for their specific stage of the assembly line, hence the two different production engineers in figure 3. They use multiple parts of the Mainframe and they also use the VOG database, which holds all the drawings of the engineer of PD. They need to combine all this information with the information of the Cross-list. This reflects the problem of localizing the different data within the Mainframe and across systems. Another aspect is that the mainframe can only show you one or two screens at the same time. This limits the amount of information the production engineer can view at one time and this reflects the problem of data presentation.

Taking these aspects into account is what makes the process of work preparation time intensive. Besides these aspects there could be multiple characteristics of information systems that influence the task performance, which need to be explored. So in a more
general sense, the research setting at DAF N.V. is best characterized as complex, since they are responsible for the transition of all relevant information of PD into information that is understandable for the production factory and the supporting departments of the production factory. The non-routine nature of the job makes automation difficult and sets limitations to the system. Non-routine makes for difficult to learn/to use the system and identify/locate the right data. The question is how ease of use can be enhanced and what characteristics affect the task productivity of the users?

Accordingly, we formulated the following research question:

**What is the effect of Enterprise Information System characteristics on task productivity?**

The aim is to identify EIS characteristics which are related to constructs as perceived usefulness, individual impact, net benefits and performance impacts. These constructs encompass task productivity. Therefore, in the next section a literature review is presented to investigate the factors that affect these constructs. The aim is not to investigate an enormous amount of factors that could influence task productivity. Rather focus on aspects that relate to the situation of DAF N.V. and the department of PE. Meaning that we want to know what influences constructs that are related to task productivity. Considering this, we identified three factors of EISs that were found relevant, namely locatability, presentation, ease of use and two factors that influence the impact of these three characteristics, namely non-routineness and experience. A research model was developed to investigate how these factors are related to task productivity. These are presented after the literature review together with the methodology.
2. Literature Review

2.1. Introduction

The impact of EIS characteristics on constructs such as perceived usefulness, individual impact, net benefits and performance impacts has been part of the literature that aims to conceptualize and identify EISs success and EISs adoption. Researchers have tried to identify EISs success and EISs adoption since the 1970’s/1980’s and are still concepts that are used today to identify the potential of EISs (Daradkeh & Moh’d Al-Dwairi, 2018; Jewer, Compeau, & Besworth, 2017; Tam, Tam, Oliveira, & Oliveira, 2017; L. Wu & Chiu, 2018).

EIS success is an attempt to understanding the value and efficacy of EISs on individuals, organizations, strategies, productivity, work design and tasks (Abugabah, Sanzogno, & Poropat, 2009; Delone & McLean, 2003).

EIS adoption is about the acceptance of new EISs by individuals. More specifically, what are the factors affecting users’ acceptance and utilization of the technology (Marangunić & Granić, 2015).

There are three models that are most commonly used for studying EIS adoption and EIS impact on end users (Abugabah et al., 2009). Therefore these three models will be briefly presented and are discussed in separate sections to identify the links from EISs to performance and productivity. This will be followed by a review of studies that empirically researched the identified links in order to get an understanding of the impact of EISs on end user performance and productivity.

2.2. Brief introduction of TAM, D&M model and TPC model

In the beginning there was a lot of individual research, which was noticed by other researchers that lead to the first models of EISs Success and EIS adoption. It started with the technology acceptance model (TAM) of Davis (1985) which showed the effect of EIS characteristics and other factors, such as perceived ease of use and perceived usefulness on user acceptance of EISs. Followed by DeLone & McLean (1992) with their DeLone & McLean (D&M) information systems success model which tries to answer the question “what is the dependent variable of EIS success?”. The D&M model defines six dimensions of EISs success: system quality, information quality, use, user satisfaction, individual impact and organization impact. In 1995, Goodhue & Thompson (1995) presented the Technology-to-Performance Chain (TPC) model, the essence of the model

<table>
<thead>
<tr>
<th>Process</th>
<th>Variable</th>
<th>Definition of variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social influence</td>
<td>Subjective norm</td>
<td>“A person’s perception that most people who are important to him/her think he/she should or should not perform the behavior in questions”</td>
</tr>
<tr>
<td></td>
<td>Voluntariness</td>
<td>“Extent to which potential adopters perceive the adoption decision to be non-mandatory”</td>
</tr>
<tr>
<td></td>
<td>Image</td>
<td>“The degree to which use of an innovation perceived to enhance one’s status in one’s social system”</td>
</tr>
<tr>
<td></td>
<td>Experience</td>
<td>“The direct effect of subjective norm on intentions may subside over time with increase system experience”</td>
</tr>
<tr>
<td>Cognitive instrumental</td>
<td>Job Relevance</td>
<td>“An individual’s perception regarding the degree to which the target system is applicable to the individual’s job. Job relevance is a function of the important within one’s job of the set of tasks the system is capable of supporting”</td>
</tr>
<tr>
<td></td>
<td>Output Quality</td>
<td>“In perceptions of output quality, users will take into consideration how well the system performs the tasks that match their job relevance”</td>
</tr>
<tr>
<td></td>
<td>Result demonstrability</td>
<td>“Tangibility of the results of using the innovation will directly influence perceived usefulness”</td>
</tr>
</tbody>
</table>

Table 1 Variables of TAM
is that in order for an information technology to have a positive impact on individual performance, the technology must be utilized and the technology must be a good fit with the tasks it supports.

2.3. Technology Acceptance Model

TAM is specifically tailored to model user acceptance of EISs and the goal of TAM is to provide an explanation of the determinants of user acceptance. It theorizes that perceived usefulness and perceived ease of use are the primary drivers of TAM (Marangunić & Granić, 2015). Davis (1985) defined these constructs as follows:

Perceived usefulness (PU): “the degree to which an individual believes that using a particular system would enhance his or her job performance”

Perceived ease of use (EoU): “the degree to which an individual believes that using a particular system would be free of physical and mental effort.”

TAM postulates that PU and EoU impact usage of a system, through intention to use. Utilization of a system in turn positively effects user performance (Goodhue & Thompson, 1995; Staples & Seddon, 2004). Venkatesh & Davis (2000) extended the TAM model, referred to as TAM 2 (see figure 4), to understand the determinants of perceived usefulness and usage intentions in terms of social influence and cognitive instrumental processes. They state that PU is affected by EoU, subjective norm, image, job relevance, output quality, result demonstrability (See table 1 for definitions). They conducted a longitudinal research which included two voluntary settings and two involuntary settings of EIS use. The results across the studies indicated that subjective norm, image, job relevance and result demonstrability were significant determinants of PU. Results also showed that subjective norm, PU and EoU were direct determinants of intention to use.

Researchers modified and extended TAM & TAM 2 and also applied them in different settings (Marangunić & Granić, 2015). For example, Lee & Kim (2009) used TAM to investigate the usage of an intranet and tested new external factors. They introduced external factors such as technical support, web experience, task equivocality and task interdependence. These factors were

![Figure 4 TAM and TAM 2](image-url)
theorized to affect PU, EoU and usage. Their results indicate that PU is influenced by EoU, technical support, web experience and task equivocality. EoU is influenced by technical support and web experience. They find that PU directly affects the usage of the intranet and EoU does not. Interesting is that the external factors, technical support, web experience and task interdependence, also directly influence usage. Just as Lee & Kim (2009), researchers extended the models with more external predictors for the variables PU and EU such as prior usage and experience (Burton-Jones & Hubona, 2006; Oh, Ahn, & Kim, 2003), self-efficiency (Davis & Venkatesh, 1996) and confidence in technology (Amoako-Gyampah & Salam, 2004).

Other modification or extensions that were made can be characterized as follows:

1. **Factors from other theories of technology acceptance** for increasing predictive validity of the TAM, such as expectations (Venkatesh, Morris, Davis, & Davis, 2003), risk (Featherman & Pavlou, 2003; Pavlou, 2003), trust (Gefen, 2004; Gefen, Karahanna, & Straub, 2003; K. Wu, Zhao, Zhu, Tan, & Zheng, 2011) and user participation (Amoako-Gyampah, 2007).

2. **Contextual factors** that have an moderating effect, like gender and cultural diversity (L. Huang, Lu, & Wong, 2003; Padilla-MeléNdez, Del Aguila-Obra, & Garrido-Moreno, 2013; Straub, Keil, & Brenner, 1997); and technology characteristics (Plouffe, Hulland, & Vandenbosch, 2001).

3. **Different usage measures** were used to study actual system usage, such as usage perception (Horton, Buck, Waterson, & Clegg, 2001; Moon & Kim, 2001; Szajna, 1996) and actual usage of technology (Davis & Venkatesh, 2004).

2.4. **DeLone & McLean IS Success Model**

The primary purpose of the D&M model was to develop a taxonomy of EIS success (DeLone & McLean, 1992) In the D&M model, *systems quality* measures technical success, *information quality* measures semantic success, *use, user satisfaction, individual impacts and organizational impacts* measure effectiveness success. D&M suggested that these measures were independent, but that there was interdependency among them (see figure 5).

The years after the proposed D&M model, researchers tested, modified or extended the model and applied it to specific applications. These potential improvements were recognized by D&M and as a reaction they revised their original model in 2003 (Delone & McLean, 2003).

A prominent addition to the model was the introduction of the construct service quality as another dimension of EIS success. The construct was added because of the changes in the role of information systems over the last two decades. With the introduction of this construct D&M recommend to use different weights for system quality, information quality and service quality depending upon the level of analysis.

A second modification was replacing individual impact and organizational impact with one dimension, which they called *net benefits*. The goal of this change was to tackle the criticism that EIS can affect other levels than individuals and organizations. Therefore, the updated model accounted for benefits at any level of analysis. Researchers could now determine which level of analyses is appropriate for their research goal.

Seddon (1997) proposed a respecification of the original model, since he was concerned that the model had elements of both process and variance models, which from his point of view, making it hard to interpret and understand. His respecification separated
the process and variance components. D&M found this to be making the model too complicated and lacked parsimony. D&M stated that their original model is composed out of three process steps: creation and utilization of an information system; and the effects of its utilization. They supported the variance component of their model by reviewing many empirical studies that fully or partially tested the model. However, D&M did take the concerns seriously and enhanced the original model by clarifying the use construct and modified it slightly. They say that use must precede user satisfaction in a process sense, but positive experience with use will lead to greater user satisfaction in a causal sense. Also, given the variability of EISs and the settings their used in, it can be appropriate to measure intention to use rather than use. When using intention to use as a measure, user satisfaction would lead to a higher intention to use, which affect use. This is included in the updated D&M model (see figure 6).

A considerable amount of research had been dedicated to fully or partially test the D&M model. This was further confirmed when they reviewed their model with a meta-analysis at individual level (Petter & McLean, 2009). They found 150 studies between 1992 (introduction of the original model) and mid-2007, which examined one or more of the hypotheses of their model. After applying an extra set of criteria they used 53 data samples from 52 studies. They found strong support for the relations: from system quality and information quality to user satisfaction, as well as their relation to intention to use; from net benefits and user satisfaction to intention to use; between user satisfaction and net benefits. For instance, Wu & Wang (2006) applied the D&M model to evaluate the success of knowledge management systems (KMS). Their results indicated that system quality and information quality significantly affected user satisfaction in a positive manner. The same held for the relation from perceived net benefits of KMS to user satisfaction and use. Interesting to see was direct significant effect of information quality on perceived KMS benefits, whereas D&M assumes this effect is moderated through user satisfaction or use.

Moderate support was found for the relations: from information quality and system quality to use; between use and individual impact. D&M found 7 and 15 studies for that tested the link between,
respectively, information quality and use, system quality and use. This shows the support for these relations. For instance, (Bergeron, Raymond, Rivard, & Gara, 1995) found that the user satisfaction of information quality and system quality positively affected the frequency of use. They tested these effects with users perceptions of: information content, system accessibility and sophistication of the system. Another example is the study of Pituch & Lee (2006) who found that system functionality, system interactivity directly affected the use of e-learning systems. Regarding the relation between use and individual impact, D&M found 26 studies that confirmed this relation. For example, Raymond & Bergeron (2008) found that when project managers made greater use of project management software their productivity, effectiveness and efficiency increased.

Although 26 studies reported a relation between use and user satisfaction the link was found to weak. The only links that were not tested or not significant were the links from service quality to intention to use, use and user satisfaction.

2.5. Technology-to-Performance Chain Model

In 1995 (Goodhue & Thompson, 1995) proposed the Technology-to-Performance Chain (TPC) model. It states that for information technology to have a positive impact on individual performance, the technology must be utilized, and the technology must be a good fit with the tasks it supports. This last argument makes use of the concept of Task-Technology Fit (TTF) construct, which is the degree to which a technology assists an individual in performing his or her portfolio of tasks (Goodhue, 1995). User evaluations of TTF are affected by task characteristics, such as the non-routineness of a task; individual characteristics and of course the specific system in question. Thus, the TPC model asserts that individual performance is impacted by TTF and utilization, where TTF is influenced by three other antecedents. The model is visualized in figure 7. The model also proposes a link between TTF and antecedents of utilization, which hints on a model that integrates TAM and TTF. This has also been done by a number of researchers (Isaac, Abdullah, Ramayah, & Mutahar, 2017; McGill & Klobas, 2009; Yen, Wu, Cheng, & Huang, 2010).

Figure 7 Technology-to-Performance Chain model
(Goodhue & Thompson, 1995) tested the TPC model and found that TTF and utilization together predict the most variance of performance impact. Confirming their proposition that individual performance is impacted by TTF and Utilization.

Other studies also confirm these findings (D'Ambra & Wilson, 2004; Isaac et al., 2017; Staples & Seddon, 2004). For instance, (McGill & Klobas, 2009) applied the TPC model to evaluate the performance impact of learning management systems, which support the teaching and learning process of students. Their results showed that TTF had a positive impact on learning and some effect on the student’s grades. Utilization was also found to have an impact on individual performance. They also found that TTF strongly affects two constructs that were antecedents of utilization, namely expected consequences of use and attitude towards use, which is also proposed by the TPC model.

2.6. Impact of EISs on Productivity

All three models include antecedents of individual performance, such as TTF, EoU, usage and user satisfaction. These models were tested, applied, extended and modified by other researchers, which led to more antecedents of individual performance.

Most researchers find that EISs characteristics influence individual performance of users through user satisfaction and use (Petter & McLean, 2009), following the D&M model.

A smaller group of researchers confirmed that EISs also has an direct effect on individual performance, these researchers often followed the models of TPC and TAM.

However, some researchers that followed the D&M model also found a direct link from information quality and system quality to individual performance (Etezadi-Amoli & Farhoomand, 1996; P. Seddon & Kiew, 1996; Teo & Wong, 1998; Wixom & Watson, 2001; J.-H. Wu & Wang, 2006).

![Figure 8 Interrelatedness of the models: D&M, TAM and TPC](image)
To conclude, the three models that were discussed are interrelated. A representation of the interrelatedness between constructs of the different models is shown in figure 8. The updated D&M model is the basis and TPC and TAM constructs are added in respectively blue and green. Hence, Net Benefits is replaced by individual impact and individual impact is represented in the same construct as perceived usefulness, since they are often interchanged.

2.6.1. Usability of User-Interfaces
Besides the literature that studied the effect of EIS on performance. There is also a literature stream that studied the effect of usability problems of EISs on user performance. However these studies are limited.

Examples of usability problems are complexity of visual layout, difficulty of navigation, appearance of user interfaces, output of systems that are difficult to interpret and user interfaces, which aren’t intuitive (Singh & Wesson, 2009).

Parks (2012) tested if the complexity of a user interface (UI) affected the time needed to complete a task and the success rate of a task. The default UI of the EIS was rather complex and required almost twice as many steps to navigate seven times the number of on-screen elements. They tested the task time and task success with the complex UI and a simplified version. Complexity of the UI significantly influenced task time, task success was not.

Sonderegger & Sauer (2010) tested two functionally identical UI’s of mobile phones and manipulated their visual appearance (highly appealing vs not appealing). They found that participants using the highly appealing rated it as more usable. Also, participants using the highly appealing version needed less time to complete their task. They also made less errors and needed less clicks to complete their task.

Scholtz, Cilliers, & Calitz (2010) also investigated the usability of EISs and found usability issues with navigation, inadequate support for users task, information overload and complexity of the presentation.

The studies that are discussed here usually use usability testing techniques, such as case studies, ethnography, interviews and time diaries. The goal is to identify usability problems for that specific EIS, however as Turetken, Ondracek, & IJsselsteijn (2017) also point out, these are instances and do not claim generalizability. They do give concrete examples of usability problems effecting user performance and task productivity.

There are few studies that, in a more generalizable manner, studied the effect of usability characteristics on perceived usefulness and ease of use. Turetken et al. (2017) made a contribution to generalizing the effects of usability characteristics on user performance and ease of use. They conceptualized user performance with performance expectancy, which is defined as the degree to which an individual believes that using the system will help him or her attain gains in job performance. Ease of use was conceptualized with effort expectancy, which is defined as the degree of ease associated with the use of the system.

They specified three constructs to have an effect on performance expectancy and effort expectancy, namely information overload (IO), control familiarity (CF) and user interface fit (UIF). CF is the extent to which an end user perceives the UI of the EIS, regarding control, navigation, orientation and labeling, as familiar. When talking about IO of an UI it relates to the degree in which unnecessary, task-irrelevant information is placed on the interface. UIF is the extent to which an end user of an EIS perceives that the UI matches the demands of his/her tasks. UIF has its origin from the literature on TTF (Turetken et al, 2017), therefore acknowledging the need for the right fit between an UI of an EIS and the users task requirements, as proposed by Goodhue (1995).
Their results indicated that IO and UIF affected performance expectancy, in such a way that the more IO elements an UI contains the lower the performance; and the better the fit between the UI and user needs the higher the performance. Also, IO, CF and UIF affected effort expectancy. Too much elements of IO have a negative effect on the degree of ease of use that is associated with an EIS. CF and UIF positively affects effort expectancy. Meaning the more familiar the EIS is for a user the easier it is perceived and the better the fit between UI and the needs of the user, the easier the system is perceived by the user.

Other researchers that also studied the effects of usability characteristics in a more generalizable manner were Joo, Lee, & Ham (2014). They investigated, amongst other variables, the effect of visual design and found an direct effect of UI design on perceived usefulness. The UI design was evaluated with readability, font style, color, layout and overall satisfaction.

These studies on usability characteristics show the effect of EIS characteristics, in the context of the usability field, on EoU and PU. This is gives more detail in EIS characteristics that can influence task productivity in comparison to more general constructs such as system quality and information quality.

To conclude, this study focusses on EIS characteristics and their effect on task productivity. This literature review is relevant, since productivity is one of the main underlying factors of the constructs of individual impact, individual performance and PU. Almost all the studies discussed in this review have used productivity, whether it was task productivity or end-user productivity, as an underlying factor for one of these constructs of individual performance. Also a well-cited measurement tool for measuring the perceived impact of EIS on work by Torkzadeh & Doll (1999) includes task productivity as one of the four underlying factors that measure individual performance.

3. Model and Hypotheses Development

This report started with the company setting of DAF N.V. and focused on the department of production engineering. The research question was as follows:

*What is the effect of Enterprise Information System characteristics on task productivity?*

The literature review tried to address this by reviewing the literature according to the three most accepted models and identifying the factors that influence constructs that encompass task productivity.

The TPC model of Goodhue & Thompson (1995) is the one that gives the best answer to the research question, since it directly links EIS characteristics to individual performance. Their dependent variable, performance impact, is defined as the accomplishment of a portfolio of tasks by an individual. According to them, performance impact means that higher performance indicates some mix of improved efficiency, improved effectiveness, and/or higher quality.

In the context of the PE department of DAF N.V. we are interested in a more detailed and simple dependent variable, namely task productivity. We want to know what impacts the productivity of a user when performing a task that is supported by their EIS, simply said the time needed to perform a task. So, we chose to adopt the construct of task productivity of Torkzadeh & Doll (1999): *The extent that an application improves the user's output per unit of time.*

Therefore, we constructed our own model which has similarities with the TPC model. Only our model is in the context of a
production engineering environment and has a different or more specified dependent variable. Also, the task-technology fit construct of the TPC model is a broad conceptualization of multiple EIS characteristics, such as lack of confusion, level of detail, locatability, meaning, meaning, accessibility, assistance, EoU, system reliability, accuracy, compatibility, currency and presentation (Goodhue, 1998).

To put our model even more in context of a production engineering environment we used three EIS characteristics, which are part of TTF, that seem to reflect the context at DAF the most: locatability, presentation and EoU. Also, the effect of non-routineness of tasks is taken into account due to the non-routine nature of tasks within the PE department. This non-routineness is caused by the fact that the PE department needs to translate complex and a large amount of product variations to production information. Last, the effect of users’ experience with the EIS is also taken into account, since the current EIS is characterized as difficult system to learn. So overtime experience may play a role with the users.

To avoid a discussion on the relevance of the TPC model and its TTF construct, the model and TTF is still used to explain the performance impacts and use of information systems in different contexts: ERP systems (Glowalla & Sunyaev, 2014), mobile banking (Tam & Oliveira, 2016), job search websites (K.-Y. Huang & Chuang, 2016), e-learning (Larsen, Sørebø, & Sørebø, 2009) and online platforms (Chang, 2010).

In the next paragraphs we will discuss the hypotheses and present our research model (see figure 9) that is used to investigate the research question. The background of the factors locatability, presentation, EoU, non-routineness and experience and their hypothesized effect on task productivity is explained.

3.1. Ease of Use

The models discussed in the literature review do not link EoU with PU, except the TPC model where EoU is one of the factors of TTF. However, Goodhue & Thompson (1995) do not find a significant relation
between EoU and individual performance. In contrast, there are studies that link EoU to PU (Mao & Palvia, 2008; Yen et al., 2010). These researchers believed and verified that increased EoU is contributes to improved PU. We therefore hypothesize:

H1 The ease of use of the EIS positively influences task productivity

3.2. Locatability

Locatability is the ease of determining what data is available and where to find it. The easier users can find the data they need the faster they can accomplish their task. Klopping & McKinney (2004) used locatability as one of their factors in the construct TTF and found that TTF positively affected PU. Their construct of PU includes elements of task productivity. In our context of DAF N.V. we therefore expect that locatability will directly affect task productivity.

H2 Locatability of the EIS will have a positive effect on task productivity

Klopping & McKinney (2004) also found TTF to affect EoU, but did not test if there was a relation between PU and EoU. In contrast, TTF has been also been found to effect PU, but fully mediated through EoU (Dishaw & Strong, 1999). We therefore also hypothesize:

H3 The effect of locatability on task productivity is partially mediated through ease of use

3.3. Data Presentation Quality

As mentioned earlier, researchers found links between information quality and individual performance (Ahn, Ryu, & Han, 2007; Teo & Wong, 1998; Wixom & Watson, 2001; Wu & Wang, 2006). Wu & Wang (2006) investigated, amongst other effects, the effect of information quality on perceived usefulness of a knowledge management system. In their context, information quality is the quality of the content and the link between the context of a task and the information provided. Their measurement items reflect factors like format, understandability and if it is right detail.

Also, the presentation of data in terms of format, right level of detail and understandability are factors that are found in predicting the construct of information quality for EISs (Gable, Sederer, & Chan, 2008).

In our context, the quality of data presentation is also most likely seen as a combination of factors like format, right level of detail and if the meaning is understandable. We use these factors as our predictors of the construct data presentation quality. We therefore hypothesize:

H4 Data presentation quality positively influences task productivity.

Ahn et al. (2007) found that the construct information quality which uses items such as format and right level of detail, has a direct effect on EoU. We also suspect the presentation of data to have an effect on EoU. Therefore, we hypothesize:

H5 The effect of presentation on task productivity is partially mediated through ease of use

3.4. Moderation effects: Non-routineness and Experience

When the task portfolio of a user forces them to engage in more non-routine tasks they perceive the locatability of a EIS to be lower (Goodhue & Thompson, 1995). The reasoning is that these users are constantly testing the boundaries of the system due to these non-routine tasks and are therefore encountering more problems with routine tasks. Therefore, we expect that the degree of non-routineness of tasks negatively moderates the effect of locatability on task productivity. That is; the more non-routine the tasks are, the lower the effect of locatability on task productivity.
H6 The effect of locatability on task productivity is negatively moderated by non-routineness

Users with more experience with the EIS are more capable of exploiting information that is available, since they are more experienced with the system (Chang & Chen, 2008). Users with more experience also have a stronger sense of perceived self-efficacy which positively effects their perceived ease of use of a system (Hernández, Jiménez, & Martín, 2010). In the context of this research the effect of locatability on EoU is expected to be moderated by experience, since users with more experience are expected to be more acquainted with the required data for a specific task. So, the more experienced users are with the data the higher they perceive their self-efficacy with the EIS and the EoU with the system. We therefore hypothesize the following:

H7 The effect of locatability on ease of use will be stronger for more experienced users

Also, Ahn et al. (2007) found a direct effect of information quality on EoU and Hackbart, Grover, & Mun (2003) reported a positive direct effect of experience on EoU. This direct effect of experience can be explained by the fact that the more experience an user has with the characteristics of the EIS, the higher they perceive the EoU of the system (Chang, 2010; D’Ambra & Wilson, 2004). We expect that an user that is more experienced with the presentation of the data the more likely they perceive the system as easier to use, instead of a direct effect of experience on EoU. We hypothesize the following:

H8 The effect of data presentation quality on ease of use will be stronger for more experienced users

4. Methodology

4.1. Questionnaire

The respondents were the production engineers of the engineering department of DAF N.V. and a total of 46 responses were collected. They filled in the questionnaire for their overall perception of the EIS, in this case the Mainframe, for their task portfolio's.

We used the measurement tool of Goodhue (1998) to measure the different constructs of locatability and EoU. For presentation we used their construct together with two other constructs of their tool, namely meaning and right level of detail. We used this as the construct of presentation. They developed this tool and tested it with 357 users. They found excellent reliability and discriminant validity for the dimensions. The questionnaire items are rated on a seven-point Likert scale, where 1 stand for strongly disagree; 4 stands for neither disagree nor agree; and 7 stands for strongly agree.

The item for evaluating the degree of non-routineness of a task was adopted from Goodhue (1995) and adjusted to simplify the item.

In order to measure our dependent variable task productivity we used the items of Torkzadeh & Doll (1999). Task productivity is measured through three items:

- This application saves me time
- This application increases my productivity
- This application allows me to accomplish more work than would otherwise be possible

“This application” is replaced by the term “the Mainframe” to put it in context of DAF.

All questionnaire items were discussed with two production engineers of the department. Both working there for more than 15 years. Some little adjustments were made to ensure the right understanding of the questionnaire items.

4.2. Data Analysis Method

We used partial least squares method for structural equation modeling (PLS-SEM) to assess our constructs and structural model. This method has been a widely accepted
multivariate analysis method in management information systems research (Gefen, Straub, & Rigdon, 2011). PLS-SEM has been used to overcome problematic model identifications issues and is a powerful method to analyze complex models using smaller samples (Ringle, Sarstedt, & Straub, 2012). Since our sample size is rather small (43 respondents) this was a major consideration to use PLS-SEM. For our constructs we performed a confirmatory factor analysis through PLS using SmartPLS, version 3.2.7. Constructs internal consistency was analyzed through Cronbach’s alpha; discriminant validity and convergent validity was tested with AVE. At first we investigated the indicators of the constructs and the number of factors that are explained through a factor analysis. The test showed good indications for the indicators of presentation, task productivity and EoU. For locatability one of the indicators was removed since it loaded to heavily on two different factors. Due to that reason locatability became a one indicator construct.

The constructs of EoU, presentation and task productivity had good convergent validity (see table 2), since their average variance scores (AVE) were above 0.5 respectively 0.84, 0.68 and 0.83. Their Cronbach’s alpha coefficients indicated good internal consistency (>0.7), respectively 0.81, 0.89, 0.90. Their discriminant validity was also evaluated and all indicated good discriminant validity based on the fact that the square roots of AVE were higher than all the correlations between constructs. The indicators were also checked for multicollinearity. No abnormal values were found (almost all <2.6), only an indicator of the construct productivity and an indicator of presentation had a value of 3.5 which is close to the maximum VIF value of 4 as suggested by Fan & Jackson (2008). We chose to not delete the variable since it is below the recommended threshold value of 4.

5. Results

The research model has two adjusted r-square values for ease of use and task productivity are respectively 0.487 and 0.308.

The model fit of the research model is also evaluated on two other fit indices. First, the standardized root mean square residual (SRMR) is evaluated and a value of less than 0.10 is considered a good fit (Henseler et al., 2014) and the model has a SRMR of 0.095. Second, the normed fit index (NFI) is evaluated and a value of more than 0.90 is considered a good fit (Bentler & Bonett, 1980). The model has a NFI value of 0.673. This is rather low, however NFI is not a good indicator for evaluating model fit when N is small (Hu & Bentler, 1995). This is the case with our sample size of 43.

Table 3 and 4 show the results of structural model. The path coefficient from EoU to task productivity was significant (p-value=0.016) and was positive (β=0.358). This confirms H1 which states that EoU positively affects task productivity.

H2 says that locatability has a positive effect on task productivity, however the results indicate a negative effect (β=−0.353;p-value=0.019). So, H2 is not supported.

The direct effect of locatability on EoU is positive and significant (β=0.395;p-value=0.006), however the indirect effect of locatability on task productivity through EoU is not significant (p-value=0.068). Therefore, H3 is not supported.
H4 is supported, since the path coefficient from Data Presentation Quality to Task Productivity is found to be positive ($\beta=0.268$) and significant (p-value=0.043), which states that the quality of the data presentation positively affects task productivity.

Presentation does not directly affect EoU in a positive way, since the path coefficient is not significant (p-value=0.066). The indirect effect of presentation on task productivity mediated by EoU is also not significant. Therefore, H5 is not supported.

Non-routineness turns out not to moderate the relation between locatability and task productivity (p-value>0.05; Table 4 moderating effect 2), so H6 was not supported.

H7 was supported, experience moderated the effect of locatability on EoU ($\beta=0.358$; p-value=0.004). The results of users who had 0 to 10 years of experience with the system showed a negative moderating effect and the users with more than 10 years' experience showed a positive moderating effect.

The moderating effect of experience on the effect of presentation on EoU, was not found (p-value>0.05, see table 4 moderating effect 3). So, H8 was not supported.

6. An Improved EIS: A Prototype and Test

6.1. The development process of the prototype

The results of the research model indicated that the presentation of data influences the task productivity of its users. Also, EoU influences the productivity and EoU was affected by locatability. The interesting finding was that locatability has a negative effect on task productivity, however users with more than 10 years' experience, apparently know the Mainframe well enough that the ease of finding data could have such a positive effect on the relation between locatability and EoU that the negative effect of locatability on task productivity is countered. This could mean that in order to counter for the negative effect of locatability an user must have 10 years of experience, which is an enormous amount of learning time.

To address the problem of locatability of data within the Mainframe system, we made a prototype of a new EIS with a focus on better locatability and therefore increasing the EoU. We also paid attention to the presentation of data since this also affect task productivity.
To build the prototype we first had to analyze the task of the work preparation process and we did this through an ethnographic study. Ethnography is the process of gathering information about users and tasks directly from users in their normal work environment (Hughes, King, Rodden, & Andersen, 1995). This way of gathering information creates a deep understanding of the way of working regarding the work preparation process.

Using that analysis we developed our prototype in an iterative manner together with the user. The approach is called rapid prototyping, which allows to build functionalities in iterative cycles together with the user. For the actual development of the prototype we used the software tool Mendix, which allows to produce and test the prototype during these iterative cycles.

After several weeks the prototype was finished. The main focus was combining data from multiple fields of different user interfaces into a representative way. With the current system data was hard to locate since it could be in different parts of the system or different ‘screens’. The ethnographic analysis found the data necessary for the work preparation case and this was used in the prototype. The prototype reduced the number of screens to 2 or 3, which are needed to complete the process. Extra care was taken to present this data according to the requirements of the users, since it meant more information in one format. The interaction with the system was also improved since it could be handle by normal mouse clicks instead of keyboard combination, which should increase the EoU the users experience.

### 6.2. Test Case and Results

In order to test the prototype a representative case was developed together with an experienced user and four users were selected to execute the test. Two with more than 10 years’ experience and two with less than 10 years’ experience. We coded the users as followed:

<table>
<thead>
<tr>
<th>Table 5 Users characteristics for the case</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EIS</strong></td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Mainframe (current system)</td>
</tr>
<tr>
<td>User 1</td>
</tr>
<tr>
<td>Prototype</td>
</tr>
</tbody>
</table>

Two users performed the case using the current EIS, one with more than 10 years’ experience and one with less than 10 years’ experience. The other two users performed the case using the prototype. It was expected that in of the users who executed the case using the current system, the one with more than 10 years’ experience, would outperform the other user. However, due to the fact that the user 1 had an extra excel tool he needed less time to finish the case. The tool let him find a specific set of data way faster. User 1 recorded a time of 28 minutes and user 2 recorded a time of 36 minutes. User 3 and 4 were explained how the system worked and could navigate for a couple of minutes. They recorded times of respectively 11 minutes and 20 seconds and 8 minutes. This provides strong evidence that by improving the locatability of the EIS and EoU, while taking the presentation of data into account, one can drastically improve the time needed to perform a work preparation case at DAF N.V.

One would expect the two users that used the prototype would come fairly close to each other, however it turned out that user 4 had some preliminary knowledge due to earlier experience with some of the data. So the most realistic and honest comparison is by comparing the time of user 3 with the times of user 1 and user 2. This would mean a time reduction of respectively 59.5% and 68.5%.
Table 6 Time of the users performing the case

<table>
<thead>
<tr>
<th>EIS</th>
<th>Experience</th>
<th>Mainframe (current system)</th>
<th>Prototype</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-10 years</td>
<td>User 1: 28 minutes</td>
<td>User 3: 11 minutes 20 seconds</td>
</tr>
<tr>
<td></td>
<td>&gt;10 years</td>
<td>User 2: 36 minutes</td>
<td>User 4: 8 minutes</td>
</tr>
</tbody>
</table>

7. Discussion

7.1. Discussion of the research model and the prototype test

The main goal of our study was to identify EIS characteristics in the context of the production engineering setting at DAF N.V. and determine how these influence the task productivity of users. We identified three EIS characteristics that directly influence task productivity, namely EoU, locatability and data presentation quality. The factor of users’ experience with an EIS moderated the effect of locatability on EoU. To address our research question, we proposed a theoretical model that relates these constructs. We then validated our theoretical modal through a survey. The findings were used to develop a solution and also test this solution to see if it had the desired effect of increasing the task productivity. Some hypotheses were supported and the test results confirmed the findings of our theoretical model.

Our findings indicated that EoU had a positive and significant effect on task productivity. This supports that EISs that are perceived as easier to use are also perceived to result into better task productivity.

Locatability was found to have a negative effect on task productivity. This was not as hypothesized (H2) and could be due to the fact the current system at DAF is perceived as not productive that even though users who rate the system with good locatability still have an overall perception of bad task productivity. This speculation is reasonable when looking at the average score of task productivity, which is 2.9 on a scale of 5, where 3 means that the users perceive the current EIS to moderately ensure their task productivity and 2 means it only is responsible for a little of their task productivity.

Also the non-routineness of task does not seem to influence the effect of locatability on task productivity. However the interesting effect is that non-routineness does have a direct negative effect on task productivity. Meaning that the more non-routine a task portfolio of the user is the worse they perceive their task productivity with the EIS.

A positive result was the fact that locatability had a positive effect on EoU, this supports our hypothesis (H3). This implicates that when users describe the localization of data within an EIS as easy to find they perceive to have a higher task productivity.

Data presentation quality had a positive effect on task productivity, meaning that the right format, right level of detail and a clear meaning of data will have a positive impact on the way users perceive the an EIS to facilitate their task productivity.

On the other hand, data presentation quality did not affect EoU according to our findings. Also, experience did not influence this effect.

An interesting fact in this study was the fact that only users with more than ten years’ experience had a positive moderating effect on the positive influence of locatability on EoU. Meaning that, despite the fact locatability had a negative effect on task productivity, locatability could influence EoU in such a strong way that the negative effect could be overcome or seriously reduced. This
is quite absurd to realize that users need to have more than ten years of experience to properly find data within the current EIS. These findings were used to construct a new EIS and test it with a prototype. The focus was of course on locatability, since this negative effect on task productivity had to be tackled. Also, development efforts were made to improve the data presentation quality and EoU compared with the current EIS. A test case of the work preparation process was made to evaluate the prototype and the results were positive. The users that executed the case with the new EIS (prototype) realized significant faster times. The most honest comparison is to compare the user with more than 10 years of experience, who needed 36 minutes with the current EIS, with the user with less than 10 years of experience and who needed 11 minutes and 22 seconds with the new EIS. Meaning a time reduction of approximately 59%.

The test results of the new EIS (prototype) confirm the findings of our research model, that it useful to focus on the EIS characteristics of locatability, data presentation quality and EoU of an EIS in the context of production engineering to improve task productivity.

7.2. Academic contribution

This study yields an academic contribution in several ways.

Firstly, it extends the literature on EIS characteristics that directly influence productivity. This is extended in two ways, through a theoretical model and through a confirmative test case.

Also, most research on EIS success and EIS adoption uses more general and constructs of EIS characteristics, such as system quality and information quality. This research used more specific EIS characteristics to identify the power of these characteristics on productivity.

Besides this, task productivity is used in most literature as an antecedent of overall performance. This study presents the effects between the constructs in a far more detailed manner.

As last, the context of the study also has an academic contribution, since it suggests, provides and proves that certain EIS characteristics are important in a production engineering environment. This extends the understanding in existing literature which EIS characteristics are important for performance and therefore EIS success in a production engineering environment.

7.3. Practical contribution

These outcomes have practical contributions for DAF N.V. and suggest they develop or improve their current EIS based on these EIS characteristics.

It also has practical contributions for other companies that face task productivity issues in a production engineering context. These companies can try to identify if the users face the same problems in terms of locatability, EoU and data presentation quality.

The prototype that was developed as a new EIS can be used by DAF as a new task supporting system or when they choose not to integrate the prototype they can examine its functionalities to build their own support system for the work preparation process.

7.4. Limitations and suggestions

Although this research has its limitations, it also opens directions for future research.

First, the scope of the EIS characteristics that are used to explain task productivity is limited and based on three factors. There are more EIS characteristics found in the literature who are related to constructs that use productivity as an indicator. This can be interesting to investigate further in order to better understand the direct effects of EIS characteristics on productivity.

Second, the research showed that some hypotheses were not significant. This study
has a very limited amount of respondents (43) and some hypotheses were close to being significant (H3 & H5). This rather small sample size could explain for the non-significance.

Third, the context of production engineering can be investigated in multiple companies to establish more confirmation of the research model. Also, other context can be investigated using this model where data localization and data presentation quality is seen or thought of as critical.

Last, due to the fact that the production engineers weren’t all well-educated enough we had to resort to a single item construct of non-routineness. This can drastically limit the exploratory power of the construct. Therefore, it can be interesting to use a more well founded construct of non-routineness and do this study again or use non-routineness in another setting but related to EIS characteristics and performance or productivity.
8. References


model. *Journal of the Association for Information Systems, 9*(7), 377.


9. Appendix

9.1. Questionnaire

Research model constructs

Locatability [adopted from Goodhue (1998)]
- It is easy to find out what data DAF maintains on a given subject.
- It is easy to locate data even if I haven’t used that data before. (dropped)

Ease of Use [adopted from Goodhue (1998)]
- It is easy to learn how to use the Mainframe
- The Mainframe is convenient and easy to use.

Data Presentation Quality [adopted from Goodhue (1998)]
- The data that I need is displayed in a readable and understandable form.
- The data is presented in a readable and useful format.
- DAF maintains data at an appropriate level of detail for my purposes.
- Sufficiently detailed data is maintained by DAF.
- The exact definition of data fields relating to my tasks is easy to find out.

Task Productivity [adopted from Torkzadeh & Doll (1999)]
- The mainframe saves me time.
- The mainframe increases my productivity.
- The mainframe allows me to accomplish more work than would otherwise be possible.
What is your current function?
- Senior Production Engineer
- Production Engineer
- Other

What is your age?

Which PE group do you belong to?
- PE Process
- PE Product
- PE Area 1
- PE Area 2
- PE NSO

For how long have you been working in the PE department?
- <1 year
- 1-2 years
- 2-3 years
- 3-5 years
- 5-10 years
- 10+ years

For how long have you been using the Mainframe?
- <1 year
- 1-2 years
- 2-3 years
- 3-5 years
- 5-10 years
- 10+ years

As a Production Engineer, you have a certain portfolio of tasks that you execute. Whenever you perform a task and you use the Mainframe in the process, overall how non-routine are those tasks for you personally? Non-routine means how NOT routine a task is for you or in simpler terms: the task is not familiar for you.

Please rate this on a scale from 1 to 7. 1 means that whenever you use the Mainframe, the task is routine (familiar) for you. 7 means that your tasks, when you use the Mainframe, are non-routine (not familiar).

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

My tasks are non-routine
The next questions are ALL about the Mainframe. So when there are words like system or sources it means the mainframe and parts of the mainframe. There will be a statement about the Mainframe and you have to rate it on a scale from 1 to 7. 1 meaning I strongly disagree with the statement and 7 meaning I strongly agree with the statement.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- It is easy to learn how to use the Mainframe
- It is easy to find out what data DAF maintains on a given subject
- The Mainframe is convenient and easy to use.
- Sufficiently detailed data is maintained by DAF.
- The exact definition of data fields relating to my tasks is easy to find out.
- The data that I need is displayed in a readable and understandable form.
- The data is presented in a readable and useful format.
- DAF maintains data at an appropriate level of detail for my purposes.
- It is easy to locate data even if I haven’t used that data before.

The next questions are about the Mainframe and the productivity you experience. There will be a statement about the Mainframe and you have to rate it on a scale from 1 to 5.

<table>
<thead>
<tr>
<th>Not at all</th>
<th>A little</th>
<th>Moderate</th>
<th>Much</th>
<th>A great deal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

- T1: The mainframe saves me time
- T2: The mainframe increases my productivity
- T3: The mainframe allows me to accomplish more work than would otherwise be possible

This is the end of the survey. Please press the button “submit form” in the top right corner of the screen. You will be asked to fill in your email address. Please use your DAF email address. Thank you for spending time on this survey!