The added value of simulation in increasing maturity levels of customer service processes

Msc thesis Report
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Preface

This report is the result of my master thesis project, carried out to complete the two-year Master of Science program System Engineering, Policy Analysis and Management (SEPAM) with the specialisation Modelling, Simulation and Gaming at Delft University of Technology. The aim of this project was to demonstrate the added value of discrete simulation on different maturity levels of customer service processes. For this, three case studies have been performed at the ING Domestic Bank Netherlands. The project made clear that discrete simulation is a tool that can be valuable for the ING; it can help the ING cut costs, make better decisions and accelerate change processes.

During this research great support has been provided by the ING Domestic Bank Netherlands and the System Engineering section of the faculty Technology, Policy and Management, Delft University of Technology. Therefore I would like to thank all the people at ING that helped me, especially the Black Belts at the department Operational Excellence Consulting. Above all I want to thank my supervisor Jessica Sun for her effort, feedback and enthusiasm and the other Black Belts who have worked with me in the case studies: Stella Bakkes, Wouter Albers and Elles Roeleveld. From the Delft University of Technology I want to thank my first supervisor Joseph Barjis, for his comments and positive criticism. Furthermore I want to thank my second supervisor Marijn Janssen and my graduation professor Alexander Verbraeck.

Last but not least I would like to thank my family and friends for their moral support during the last half year.

I hope you all enjoy reading this report!

Delft, April 2012

Robbert Weijers

This is a public version of the report, please contact Robbert for more information about the confidential parts of the report:
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Executive Summary

During the past decades, the financial sector has become increasingly competitive. To survive in this competitive sector, it is important for retail banks to retain existing and obtain new customers (Visalli, Roxburgh, Daruvala, Dietz, Lund, & Marrs, 2011). Retail banks have therefore shifted their focus in recent years to customers; customer satisfaction has become an important Key Performance Indicator (KPI) for retail banks. ING Domestic Bank Netherlands is improving its processes with Operational Excellence in order to decrease the costs and increase the maturity level of the processes. The department Operational Excellence Consulting (OEC) of ING helps the bank with achieving operational excellence in her processes.

Research context
A review of scientific research showed that high-quality simulation can be of added value when improving processes and increasing operational excellence. However, simulation is currently not yet commonly adopted by commercial organisations. One reason for this is that the added value of simulation is often unknown.

The department OEC of ING Domestic Bank Netherlands uses a maturity model, the Process Measurement & Improve (PM&I) model, to increase the maturity level of customer service processes. This PM&I model consists of several methods and tools that are used to increase the maturity levels. In the current situation, OEC does not yet use the tool simulation. An exploratory study on the added value of simulation can help the department OEC to improve its way of working.

Objective of the research
The purpose of this research is thus to investigate the added value of simulation within the projects of OEC. Using three case studies, the added value within 3 projects will be made clear. Processes with different maturity levels will be addressed in the projects. We will look at the substantive added value of simulation and the added value of simulation in change management.

Research question
The following research question is answered for the purpose of the research objective:
Where and how can discrete simulation add value to the way of working of the internal consultant department OEC in increasing maturity levels of the PM&I model?

The research method
To answer the above stated research question, a literature review was conducted on maturity models and change management within organizations. Interviews and internal documentation were consulted to describe how OEC improves processes and guides changes in ING. In consultation with OEC, criteria were defined to determine the added value of their projects. These criteria are applied to three different case studies of projects of OEC:

- Case study 1: Operational Management project. The aim of this project was to reduce the throughput time at the logistics department
- Case study 2: Lean Six Sigma project. The aim of this project was to increase the 'straight through process' rate in the mortgage application process.

- Case study 3: Value Chain Steering project. The aim of this third project was to decrease the costs and failure rate in the process to reverse a wrong direct debit payment.

In the three case studies a discrete simulation model was designed to analyse the problems and test possible solutions. Once completed, the added value of simulation was evaluated with the use of interviews. Both Black Belts of the projects, as the management in the value chains were interviewed. After positive results of the case studies, an analysis was conducted on the steps to be taken by ING to implement simulation in a sustainable way to ensure its added value to their projects

Added value of simulation in increasing maturity levels

In all three case studies, simulation has shown benefits for OEC in increasing the maturity level of the process. The maturity of a process can be viewed in different process areas. The case studies showed that simulation had added value within the process areas Capacity Management, Continuous Improvement and Transparency. The case studies made clear that the level of added value of simulation is dependent on the level of maturity of the process.

In the process area Capacity Management simulation adds value to processes with a low maturity level. In the first case study -the Operational Management project at the logistics department- simulation was used to optimize the schedules of the employees. The simulation model has also added value by visualizing the impact and influence of re-allocating employees during the day. Capacity Management was outside of the scope in case study 2, therefore there are no insights of added value of simulation at maturity level 2. In the third case there was not data yet available and therefore the simulation model could not help in the process area Capacity Management.

In the process area of Continuous Improvement, the first case study showed that simulation had limited added value in improving a process with a low maturity level. Processes with a low maturity level are simple and organized on an individual level, limiting the amount of complex interactions. The OEC consultants can improve these simple processes in an efficient manner with their current tools. Processes with a higher maturity level are more complex. The tools currently used by the OEC consultants are not always capable to solve such complex problems in an efficient manner. In the second case study a simulation model was designed that identified which business rules of the mortgage application process should be improved to meet the objectives of the project. The OEC consultants were with their current tools unable to efficiently determine these business rules; the simulation was thus of high added value to that project.

Within the process area Transparency simulation provides- regardless of the maturity level- much value. A simulation model makes static process descriptions more dynamic. With that, process descriptions became significantly more transparent, and it became possible to make feedback loops and dependencies visible within the processes.

Added value of simulation in change management

Next to the added value of simulation in increasing maturity levels, the added value in change management is determined. Processes were changed in the case studies to achieve shorter throughput times. A change of a process can result in resistance from employees. There are different phases in a change process, ranging from the contact with a change to understanding a change to adopting the change. The case studies showed that simulation especially contributes to create a better

understanding for a process. Due to the simulation model stakeholders believed in the outcomes of a change, this has contributed positively to the implementation of the changes.

Research conclusions

In the first two case studies, simulation is applied in the latter phase of the project. In this phase, a significant amount of data is available on the processes under analysis. In the last case study, simulation was applied at the start of the project. This case study showed that the added value of simulation in the starting phases of a project is low. The reason for this is that at the beginning of a project, little data is available as input for the simulation model. As a result, the simulation model cannot be used to perform quantitative analysis, it can only be used for qualitative analysis.

Designing of a simulation model costs time and money. In consultation with Black Belts of OEC, the contribution of simulation in the projects is judged and compared with the costs. In the first two case studies simulation was of added value for OEC. The qualitative benefits of the third case study, like better insights in the process, did not outweigh the costs of the analysis- and therefore the simulation is not of added value.

Simulation has benefits in both change management in projects and in substantive aspects in projects. The contribution of simulation is not only gained by the simulation model itself, simulation requires a structured way of working. This structured way of working contributes also to a better project.

The research demonstrated that simulation can be of high added value for the department OEC. The specific area where simulation contributed is dependent on the maturity level of the process. In higher maturity levels, processes are more complex. In the process area continuous improvements, simulation is more of added value in these complex processes.

Because of the high added value in the projects, OEC is recommended to analyse further the best way how simulation can be implemented in the organisation. Extra investments in simulation packages, high-quality trainings in simulation, and the specific role of OEC in designing simulation models should be analysed in order to implement simulation at ING.

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List of Abbreviations

Abbreviation	*In full*
A&O	Analyse en Ontwerp
BKR	Bureau Krediet Registratie
BPM	Business Process Management
BPMM	Business Process Maturity Model
CCC	Controle Correctheid en Compleetheid
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
CMO	Commercial Mid Office
CO	Commercial Office
COO	Chief Operating Officer
CPR	Change Proces Regie
E2E	End-to-End
FAT	Functionele Acceptatie Test
GAT	Gebruikers Acceptatie Test
HDN	Hypotheken Data Netwerk
HIP	Hypotheken in Progress
ING	Internationale Nederlanden Groep
KKS	Klant Keten Sturing
LSS	Lean Six Sigma
ML	Maturity Level
MOT	Model Office Test
NAT	Niet Annuitaire Toets
NHG	Nationale Hypotheek Garantie
NPS	Net Promoter Score
O&CI	Operational & Change Intelligence
OEC	Operational Excellence Consulting
OKO	Operarioneel Keten Overleg
OM	Operationeel Management
ROI	Return on Investment
PM	Product Management
PM&I	Process Management and Improvement
SEI	Software Engineering Institute at the Carnegie Mellon University
SFH	Stichting Fraudebestrijding Hypotheken
VC	Value Chain
A&O	Analyse en Ontwerp

1 Introduction

ING Domestic Bank Netherlands is the number 2 retail bank in the Netherlands. The bank is a full universal bank for 8.9 mln customers and has 14.762 employees. More background information about the bank is given in appendix 1.

One of the departments of ING Domestic Bank Netherlands is the department Operational Excellence Consulting (OEC) that focuses on improving operational excellence. Operational excellence is defined as the design and management of the maximization of operating profit through the continuous operation of an excellent production and/or delivery system that offers customers the right value (Assen, 2008). Operational excellence in one of the three pillars of the strategy of ING Group, see appendix 1.

According to different reports (Visalli, Roxburgh, Daruvala, Dietz, Lund, & Marrs, 2011), (Maguire, et al., 2010) (Duthoit, Grebe, Kastoun, & Sims, 2011) high customer satisfaction is becoming more and more important in the banking sector. In this chapter the importance of customer satisfaction and the role of the OEC department will be introduced.

After this a short introduction in simulation of customer service processes is given. Simulation is a tool that can help companies to become more operational excellent (Olhager & Persson, 2007). OEC is currently not using simulation and wonder if they can improve their way of working with simulation.

1.1 Customer services within the banking sector

In the Netherlands the retail-banking revenue pool was relative stable during the financial crisis, however the market has undergone significant turmoil (Duthoit, Grebe, Kastoun, & Sims, 2011). A comprehensive research by McKinsey on global banking showed that global banking recovered strongly in 2010 and 2011. In order to secure a sustainable future, banks have to transform their business models in ways more radical than many have contemplated to date (Visalli, Roxburgh, Daruvala, Dietz, Lund, & Marrs, 2011). Basel III regulations required banks to increase their capital and liquidity. This will result in a systematic reduction of banking profits (Leach, Ott, Hall, & Kelly, 2011). To overcome these problems retail banks will have to deliver superior customer experience to a generation that has much greater choice and is likely to be more price-sensitive (Visalli, Roxburgh, Daruvala, Dietz, Lund, & Marrs, 2011). Banks should combine sales and service excellence with low costs and take multichannel excellence to the next state. These initiatives and the superior customer experience are critical to showing customers that they need only one bank to meet their financial-services needs (Duthoit, Grebe, Kastoun, & Sims, 2011).

Like many other banks, ING Domestic Bank Netherlands is aware of the need for a renewed focus. ING Domestic Bank Netherlands is the retail bank of the ING Group in the Netherlands. This retail bank is subsidiary of ING Group NV that is listed on several stock exchanges. Where in this report ING is used, ING Domestic Bank Netherlands is mentioned.

On the 3rd of November 2011 ING presented measures to decrease costs and increase their services to the customers. One of the most important aspects in this '2015 strategy' is the program 'Enthousiaste Klanten' (in English: 'Enthusiastic Customers'). This program consists of five pillars (ING, 2011) that are aimed to increase the customer satisfaction:

- Customer Suitability
  - Products that fit the financial needs, situation, knowledge and investment purpose of customers
- Easier
  - Customer oriented processes that fit the expectations and wishes of customers
- NPS & Customer panels
  - Rollout of Net Promoter Score as key performance indicator and starting the dialogue with customers to determine their wishes
- Customer-oriented channels
  - Improving the quality and uniformity in customer communication from the channels. Helping customers in one time and improving the complaints process.
- Customer-oriented communication
  - Communicating from a customer's perspective

Almost 30% of people's purchases (services or products) are done by recommendations from others (ING, 2011). Due to internet and social media it becomes easier to make recommendations of a product or service and this percentage is rising. Websites with recommendation for products are getting more and more popular. In the banking sector there are already sites as www.bankenvergelijken.nl on which you can compare the products and services of the banks in the Netherlands.

ING uses the Net Promoter Score (NPS) to measure the customer satisfaction. An explanation about the NPS and how this NPS is measured is described in appendix 5.

In order to increase the NPS, ING introduced service guarantees (in Dutch: 'service beloften' or 'leveringsgaranties'). An example of such a service guarantee is the guarantee that ING will deliver a new credit card within 6 working days after this card is requested (ING, 2011). Like this example, ING is making service guarantees for the 100 most important services and processes. Improvements in processes and systems in retail banking are necessary to survive in the strong competitive market (The Boston Consulting Group, 2009). The improvements in processes and systems will among else ensure that ING can set high service guarantees and increase the customer satisfaction.

1.2 ING and the department OEC

In order to meet the service guarantees, ING has to change their current business processes: ING should have smart, quick and reliable business processes. For this reason ING started to implement operational excellence in their business processes on different management levels.

The Operational and Change Intelligence (O&CI) department[1] is responsible for making and keeping ING Domestic Bank Netherlands Operational Excellent in both banking activities as project-based/changing activities.

A sub department of O&CI is Operational Excellence Consulting (OEC). OEC consists of certified Lean Six Sigma consultants (called Black Belts) who are responsible for the improvement of operational performance to customers in cooperation with the value chains in ING. Examples of value chains in ING are

[1] this department was called Change & Proces Regie until 1 January 2012

savings, payments, mortgages and private banking. See appendix 2 for an organizational chart where O&CI and OEC are shown in the hierarchy of ING.

Black Belts work for a short time (3-6 months) at a department of ING and help managers with improving their business processes. They are doing this in three different types of projects:

- Operational Management project: Improving Operational Management at one single department, grey in Figure 1
- Lean Six Sigma project: Improving a sub process in the value chain, blue in Figure 1
- Value Chain Steering project ("Klant Keten Sturing" in Dutch): Improving a total end-to-end process in a value chain, orange in Figure 1

OEC has developed different tools and techniques that they use for the three types of projects. Most of these tools belong to the Lean and Six Sigma methodologies.

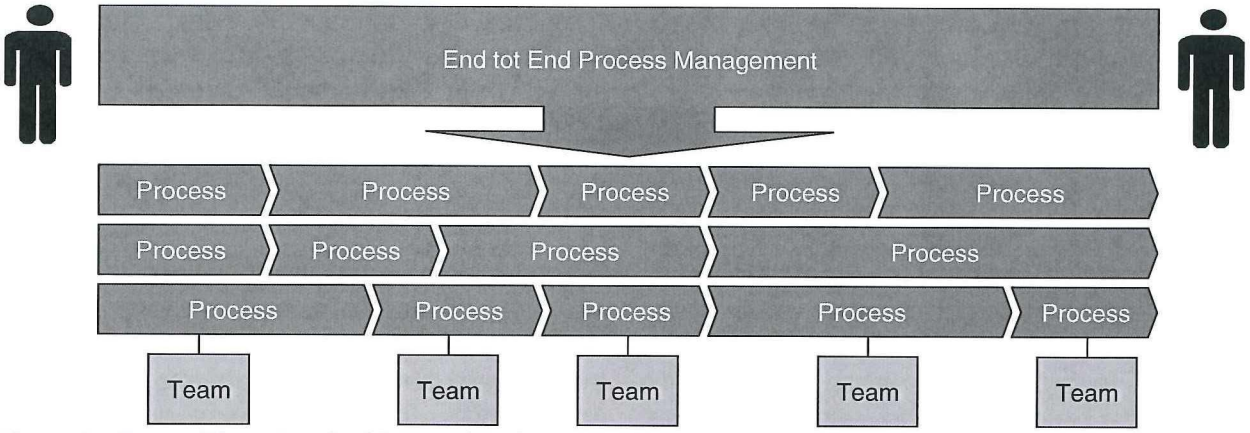


Figure 1 - Three different project types of OEC

Processes in ING have a maturity level. This maturity level is determined by the current status of process management in the value chain. There are five maturity levels (ING, 2012):

Level 1: Success in these processes is usually more the result of individual heroics and not the result of sustainable processes. No process awareness.

Level 2: Each department/team within the process is in control by using Operational Management. No active process management.

Level 3: The process is standardised, effective and efficient. The outcome is not yet reliable or predictable. Process management is in place.

Level 4: Variation in the process is reduced within the customer and business requirements. Process management is able to achieve a predictable and reliable outcome.

Level 5: By being pro-active and using continuous improvement the process manager is able to continuously meet the changing customer and business requirements.

In chapter 3 the three types of projects, the different maturity levels and their relation will be explained.

1.3 Customer service based processes and simulation

According to (Tumay K. , 1995) customer service based processes are complicated because:

- Humans have complex and unpredictable behaviour
- There are many interactions between entities and resources
- Service activities times are highly variable and customer arrivals are random

There are situations conceivable in which the statements above are not applicable. See for examples processes at which customer arrivals are not random (customers that have an appointment) and customer processes where human behaviour is of little/negligible influence in the process (an IT-bases process such as a payment on Internet). Although Tumay's statements are not suitable for all customer processes, most customer service based processes are complicated because only one of Tumay's statements can already make a process complicated. This complicatedness results in, among else, the fact that the total waiting time for a customer is more than 95% of the total processing time in an average customer service based process (Tumay K. , 1995), experts at ING estimate that the total waiting time for customers at ING is more than 99% of the total process time (ING, 2012).

Simulation is a tool that imitates the operation of a real-world process or system over time (Banks, Introduction to Simulation, 1999)and is a tool that is often used in customer service based processes. Simulation is often used in this area because it is a powerful tool in making analyses, tests and visualisations of complicated processes such as a customer service based processes (Carson, 2005). Complicated is here defined as "composed of many elaborate interconnecting parts" (Maylor, Vidgen, & Carver, 2008).

The characteristics of a customer service process (complicated, interactive, dynamic) are according to Pidd (1996) and Cassandras & Lafortune (2008) typical characteristics of a discrete-event simulation (DES). A DES model is defined as one in which the state variables change only at those discrete points in time at which events occur (Banks, Introduction to Simulation, 1999).

OEC uses different tools and methodologies for improving customer processes, these will be discussed in chapter 3. OEC does not yet use the tool simulation. Although it can be challenging to simulate a customer service-based process (Kokkinoul & Cranage, 2011), proven results of simulation models in customer service based processes (Kim & Kim, 2001) make clear that OEC has a big opportunity to improve their way of working by including simulation in their set of tools. This research will examine when, where and how OEC can use simulation to get the most added value of this tool.

1.4 Structure of the report

In the next chapter the research problem will be described. Research questions will be given that lead to an answer for the research problem. Furthermore methods and methodologies are presented that will be used in answering the research question. Chapter 3 will exist of a literature review on maturity models such as the well-known CMM and ING's adapted version PM&I (including the three projects types of OEC). In this chapter there will also be a review on the current literature about simulation in banking and the combination between maturity models and simulation. The chapter will finish with the steps that have been taken to determine the added value of simulation. Chapter 4, 5 and 6 will be used to describe three case studies that are done in order to answer the research questions. The conclusions about these case studies will be discussed in chapter 7. Chapter 8 will be used to propose a plan how

business processes (Jeston & Nelis, 2006). Definitions that follow this movement are from Paul Harmon: 'BPM is a management discipline focused on improving corporate performance by managing a company's business processes' (Harmon, 2005) and from Jeston and Nelis: 'The achievement of organisation's objectives through the improvement, management and control of essential business processes' (Jeston & Nelis, 2006). This definition is also used in the different BPM maturity models that currently exist. BPM becomes more and more important in companies; Gartner even stated that BPM has been identified as a number one business priority by many CEO's (Gartner, 2005). Business process maturity models are a framework to improve end-to-end business processes. With BPMM, improvements are done at the right place when the organization is ready for them (Curtis, 2004).

There is no scarcity of process maturity models in literature. According to Brett Champlin there are more than 150 (variations of) process maturity models around (Spanyi, 2004). Harmon created in 2003 a BPMM model for organizations. This model was based on the Capability Maturity Model as described in the previous paragraph. A year later Fisher (2004) created a BPMM and combined 'five levers of change' with five states of maturity. Another BPMM that is often used is the model from TeraQuest/Borland Software (Curtis, 2004). This model was the foundation of the BPMM made by the Object Management Group (OMG). OMG's BPMM is nowadays the standard BPMM in scientific literature.

Most of the BPMM are based on the proven maturity model, CMMI. In the comparison (appendix 3) you can see that the mentioned models are all quite similar. Different names are used for maturity levels but the descriptions of levels are the same. A comparison between the BPMM of TeraQuest and CMMI showed that both models have many similarities (see Figure 3).

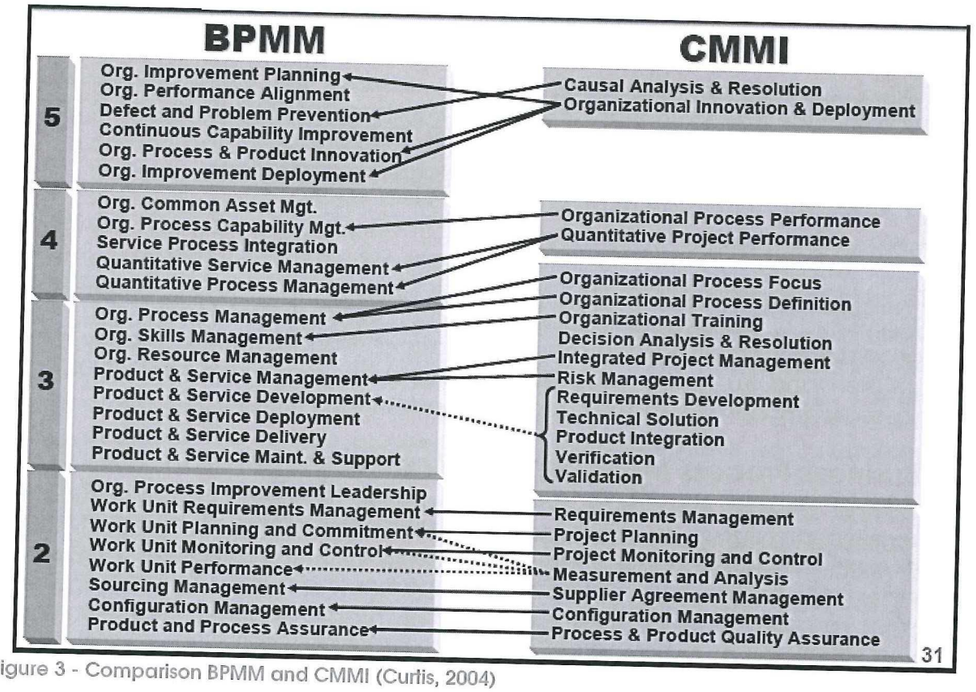


Figure 3 - Comparison BPMM and CMMI (Curtis, 2004)

3.3 The PM&I approach

ING designed their own Business Process Maturity Model: the Process Measurement & Improvements (PM&I) approach (ING, 2012). ING's PM&I approach consists, like other maturity models, of five different maturity levels. ING did not only describe the different maturity levels, they also defined methodologies and tools to increase the maturity level in their organization. First the different maturity levels are elaborated, and then the different project types that are used to increase a maturity level are given.

3.3.1 Maturity Levels

In Figure 3 you can see ING's maturity model with the following five maturity levels:

Level 1: Success in these processes is usually more the result of individual heroics and not the result of sustainable processes. No process awareness.
Level 2: Each department/team within the process is in control by using Operational Management. No active process management.
Level 3: The process is standardised, effective and efficient. The outcome is not yet reliable or predictable. Process management is in place.
Level 4: Variation in the process is reduced within the customer and business requirements. Process management is able to achieve a predictable and reliable outcome.
Level 5: By being pro-active and using continuous improvement the process manager is able to continuously meet the changing customer and business requirements.

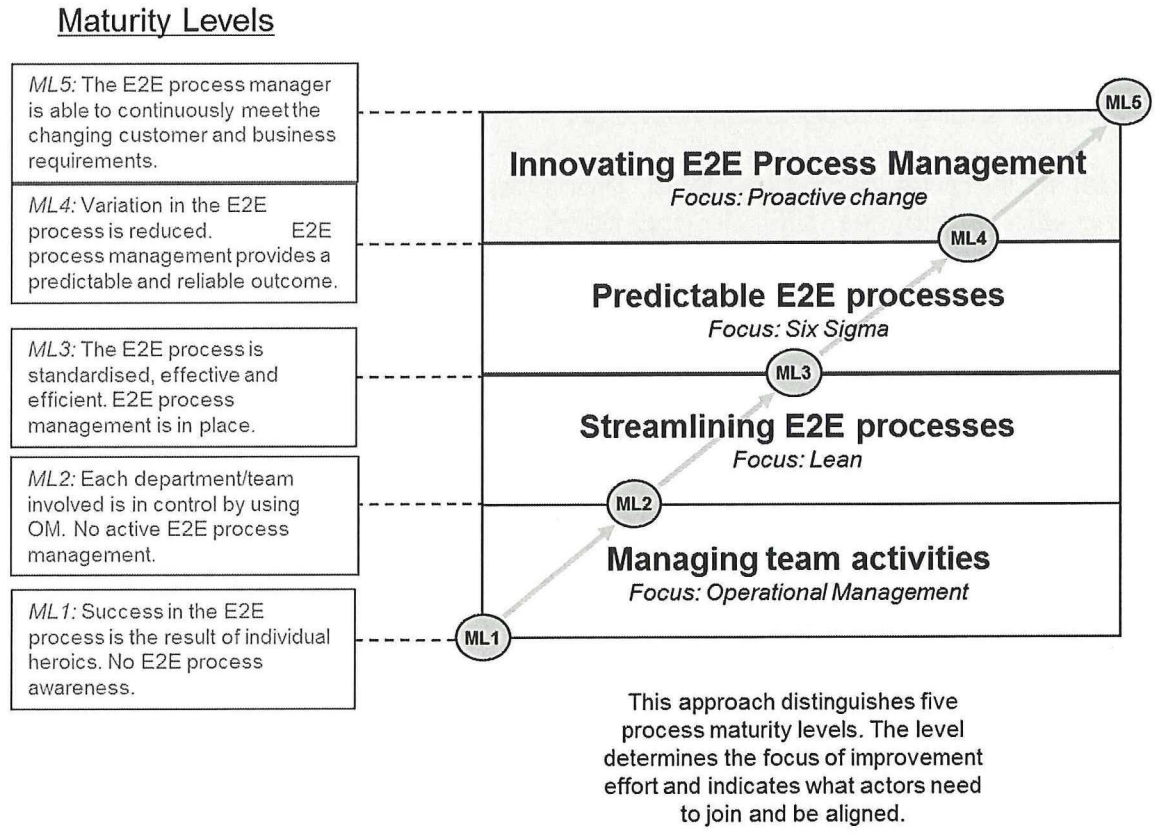


Figure 4 - PM&I Maturity levels (ING, 2012)

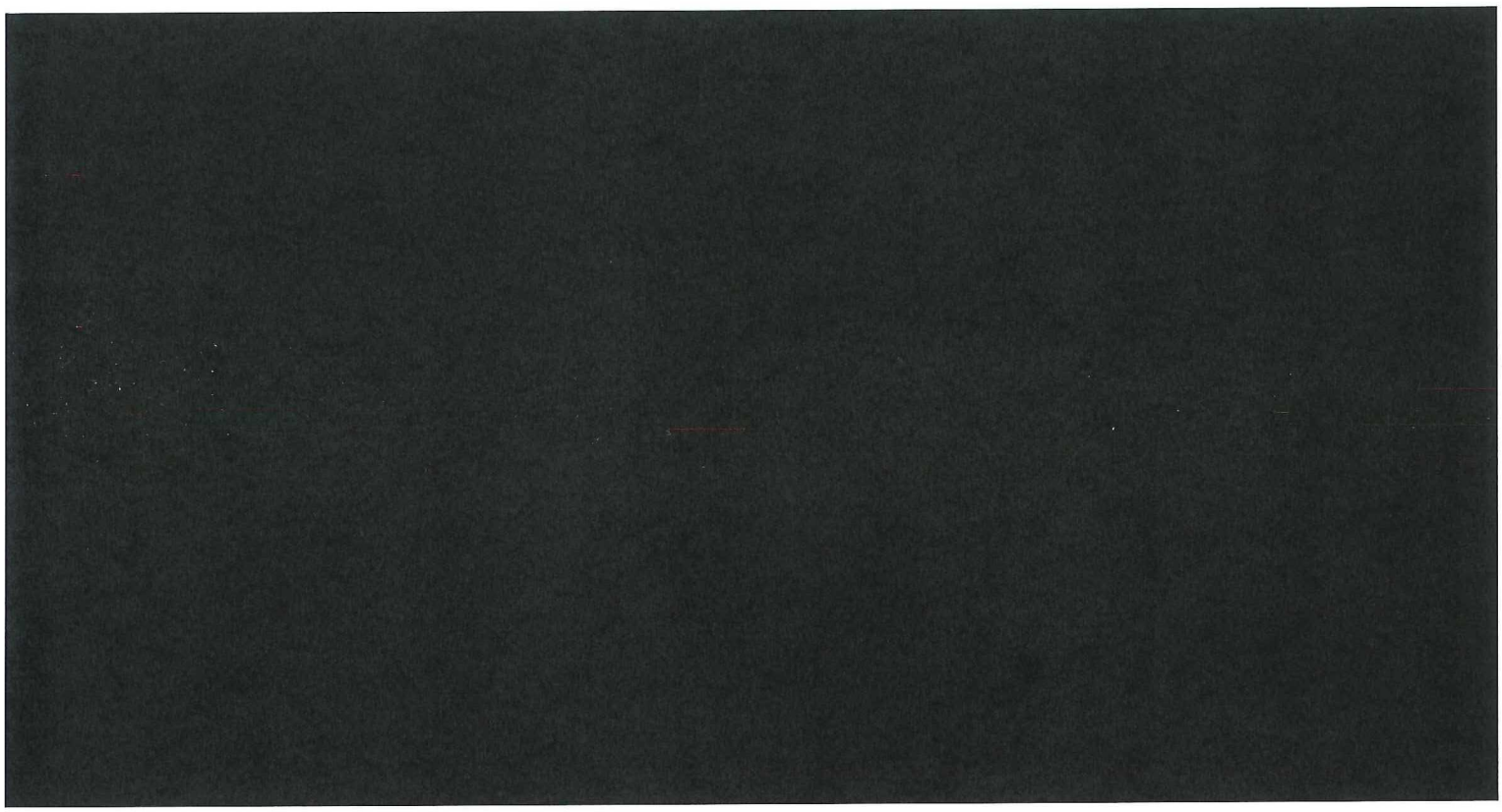
The Black Belts of OEC are helping ING by increasing maturity levels. The transition between maturity level 1 and 2 requires another approach than the transition between maturity level 3 and 4. The different transitions (ING, 2012) are:

- In the first transition, from maturity level 1 to maturity level 2, Operational Management (OM) is implemented for all activities within every team involved in the processes in scope. "Operational Management deals with the design and management of products, processes, and services and considers the acquisition, development, and utilization of resources that firms need to deliver the services their clients want" (MIT SLOAN School of Management, 2012). OM provides the means to optimally match workload and team capacity, insight in individual team performance and a culture of continuous improvement.
- After implementation of Operational Management within all the teams, the performance of all processes and teams can be measured. Processes are however not yet standardized, effective and efficient. The processes are made more effective and efficient by using Lean techniques. Lean is a management methodology aimed at removing waste in a process (Hicks, 2007). After successful implementation of Lean techniques processes are standardized and effective and the maturity level is increased to 3.
- The standardized and effective processes have variation that can be eliminated with Six Sigma tools. This result in more reliable and predictable processes that match better the customer and business requirements. The focus area of this approach is the same as in the previous approach. This approach will increase the maturity level from level 3 to level 4.
- The last approach that is used by the Black Belts is 'proactive change'. In this approach Black Belt are aligning/streamlining several departments of one value chain so these departments can handle proactive to upcoming changes. Aligning the departments increases the communication between the departments. This communication will lead to proactive management in the value chain and the end-to-end customer processes will be better (less errors, shorter throughput time etc.).

In order to increase a maturity level, processes and people should be changed; dealing with employees' attitude and behaviour is essential in these situations. The change process in the transition between two maturity levels is very important. Without a good change process people can block the transition (wittingly or unwittingly). Change management is needed to guide a transition between two maturity levels. Change management is a systematic approach to deal with change, both from the perspective of an organization and on the individual level (Song, 2009). Each project of OEC has a substantive part and an change management part. The substantive part will be explained in paragraph 3.5, an elaboration on the change management is given in paragraph 3.6.

3.3.2 Process Areas in the PM&I model

Like other maturity models such as the CMMI, each maturity level of the PM&I model has several process areas. The different process areas of the PM&I are showed in Figure 5 and described below.



Performance Management

Performance management is an activity to continually manage the activities based on facts and figures and focuses on the customer and business requirements. At a low maturity level, process management takes place in a single department (middle management), at higher maturity levels Performance Management takes place at a more end-to-end process. The detail of the facts and figures is higher at a higher maturity level. In maturity level 4 statistical analyses are done at the performance figures.

Capacity Management

Capacity management is the activity to plan and monitor the required capacity for all actual and forecasted inflow for the department. At a low maturity level, capacity is managed in small teams or departments. At a higher maturity level capacity is managed on a total value chain. Furthermore the prediction of the inflow is more accurate and management is better able to adjust capacity to changes. Communication between teams, better measurement systems and dispersion of inflow can lead to better predictions of inflow.

Continuous Improvement

Continuous improvement is an activity to continuously improve the activities and management, based on facts and figures, in light of the customer and business requirements. At low maturity levels continuous improvement is not well structured,

and the improvements are very small with a limited scope. At higher maturity levels the improvements are more at E2E-base, and the improvements have more impact on the customer.

Transparency
Transparency is an activity to have an actual (up-to-date) description of the activities and processes to achieve a shared insight & understanding of the activities. Higher maturity levels have a more transparent process description than lower maturity levels.

Visual Management
Visual management is an activity to visualize the performance of processes. At a low maturity level this is the departmental performance, at higher maturity level the visualized performance is more E2E oriented. Performance can be visualized in reports, but also on the work floor with notice boards.

3.3.3 PM&I compared to CMMI

In Table 6 the PM&I approach is compared with the CMMI model. There are many similarities between both models, however there are also some differences. In the PM&I approach Visual Management is initialized on the first two maturity levels. Visual management is a tool that utilizes visual aids such as signs, charts and visual queues to focus organizations on targets and objectives. The CMMI model does not have any form of Visual Management explicit described.

The CMMI model does not only focus on the processes but they have also included personal aspects in their model. These personal aspects, such as Organizational Training, are not included in the process areas of the PM&I approach. This does not mean that ING does not take personal aspects into account, ING has only not added these specific aspects in the PM&I model, the PM&I model is only about the maturity of the process, regardless of the (skills of) people working in the processes.

The main conclusions from comparing ING's PM&I model and the CMMI model is that the CMMI is more detailed. Multiple process areas of the CMMI model can correspond with one process area of the PM&I approach. The PM&I model is a maturity model that exists for just a few years and is used only by the ING. The CMMI model is used for many years and by many organisations. It is not surprising that there is much more data exists about projects done with the CMMI model and therefore the detailedness of this model is far more accurate. Earlier versions of the CMMI model had also a fewer amount of process areas (see CMMI version 0.2) (SEI, 1997). The two maturity models are not exactly the same, but the models do look like a lot. It cannot be said that the exact conclusions and recommendations of this research are true for the CMMI, but what can be said is that many insights of this research are also true for the CMMI.

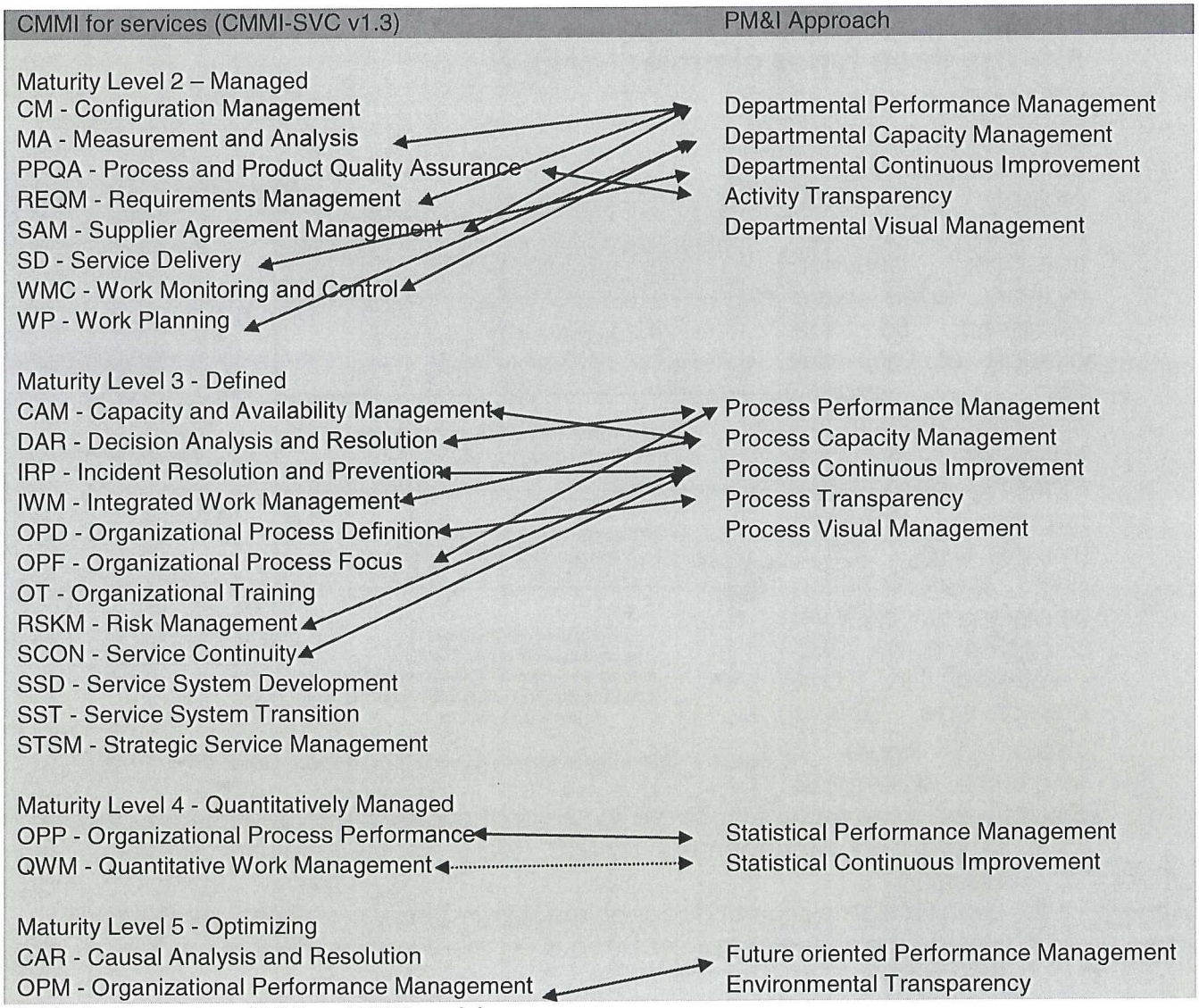


Table 6 - Comparison CMMI and PM&I model

3.4 The three types of project of OEC

In the introduction was stated that OEC uses three different types of projects and in paragraph 3.3 four transitions between maturity levels were explained. So the projects of OEC are not exactly corresponding with the transitions of the maturity levels. The transition between maturity level 2 and 3, and the transition between maturity level 3 and 4 is by OEC combined in one project type. This is visible in Figure 7 where the three focus areas for the three project types are shown on the right. The three project types are:

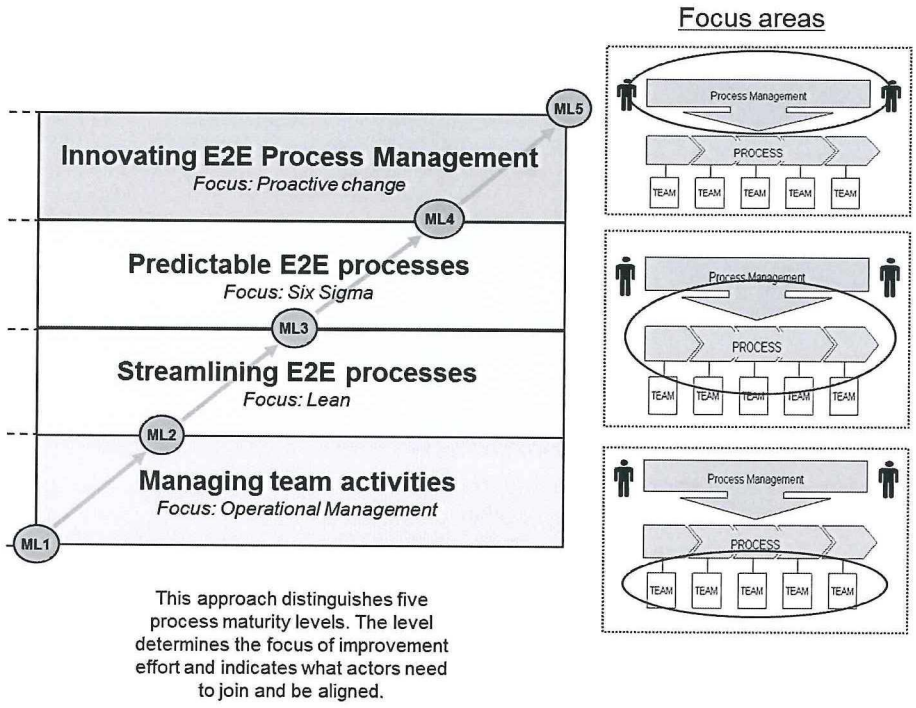


Figure 7 - Maturity levels PM&I model with focus areas (ING, 2012)

1. Operational Management project (focus on low maturity processes, see Figure 7)
2. Lean Six Sigma project (focus on medium maturity processes, see Figure 7)
3. Value Chain Steering project (focus on medium/high maturity processes, see Figure 7)

These project types will be clarified on the next pages.

The customer oriented performance on ING's services and product increases by increasing the maturity levels. In scientific literature (Thomas & McGarry, 1994) and also within ING there are two views on the way how processes can be improved. Some say that improving processes has to be done with the bottom-up approach, so first establishing Operational Management, then starting with Lean and Six Sigma and after all aligning processes with Value Chain Steering. Others say that process improving is better by starting at the top. By doing a Value Chain Steering project, sub processes became visible that need Operational Management and/or Lean Six Sigma. Both approaches have their own advantages and disadvantages. In this paper the bottom-up approach is used and described. An process is improved by first organising the activities (Operational Management), then removing the parts that do not add value to customers (lean), decreasing the variation and defect (Six Sigma) and after all aligning the several departments in a process (Value Chain Steering).

3.4.2 Lean Six Sigma

Lean Six Sigma projects are focused on processes where OM is established, so these processes have in general maturity level 2. Lean and Six Sigma are management philosophies that are focused on improving business processes. Lean management is based on Henry Ford's philosophy of low cost, fast lead time and high quality. This management philosophy was widely adopted by manufacturing companies in the 1990's and is increasingly being used by financial organisations. Lean management aims at removing waste in processes. Waste is hereby defined as 'anything that does not add value for the customer' (Aldous, 2012). Six Sigma was also adopted in the 1990's and is increasingly being used by financial organisations nowadays. Six Sigma is aimed at removing anything that does not conform to customer requirements and focuses on variation reduction and improving quality (Aldous, 2012). Lean Six Sigma is the integration of these two management philosophies.

There are two major critiques against the lean approach. The lean approach cannot good deal with low volume processes. A more responsive approach is needed in these processes because they are often highly volatile and the customer requirements are often unpredictable. The other point of critique to lean is that lean cannot deal with just-in-time production (Cox & Chicksand, 2005). The lean approach would not be useful for all the processes within ING, especially in low volume processes another management philosophy should be used.

The goal of a Lean Six Sigma (LSS) project is not per se increasing the maturity level of a process. Often a LSS project is aimed at a single aspect of a process such as decreasing the failure rate, decreasing throughput time or increasing quality. Because (most times) not all the aspects of a process are improved in a Lean Six Sigma project, the process does not always increase in maturity on all the process areas.

A Lean Six Sigma project is performed with the DMAIC method (see Figure 9). The DMAIC method if often used in enterprises and stands for Define, Measure, Analyse, Improve and Control. All these steps are done in a LSS project and they always proceed in the DMAIC order.

Define

- Review project charter
- Validate problem statement and goals
- Validate Voice of the Customer and Voice of the Business
- Validate financial benefits
- Validate high-level Value Stream Map and scope
- Create communication plan
- Select and launch team
- Develop project schedule
- Complete Define Gate

Measure

- Value Stream Map for deeper understanding and focus
- Identify key input, process, and output metrics
- Develop operational definitions
- Develop data collection plan
- Validate measurement system
- Collect baseline data
- Determine process capability
- Complete Measure Gate

Analyze

- Identify potential root causes
- Reduce list of potential root causes
- Confirm root cause effect on output
- Estimate impact of root causes on key outputs
- Prioritize root causes
- Complete Analyze Gate

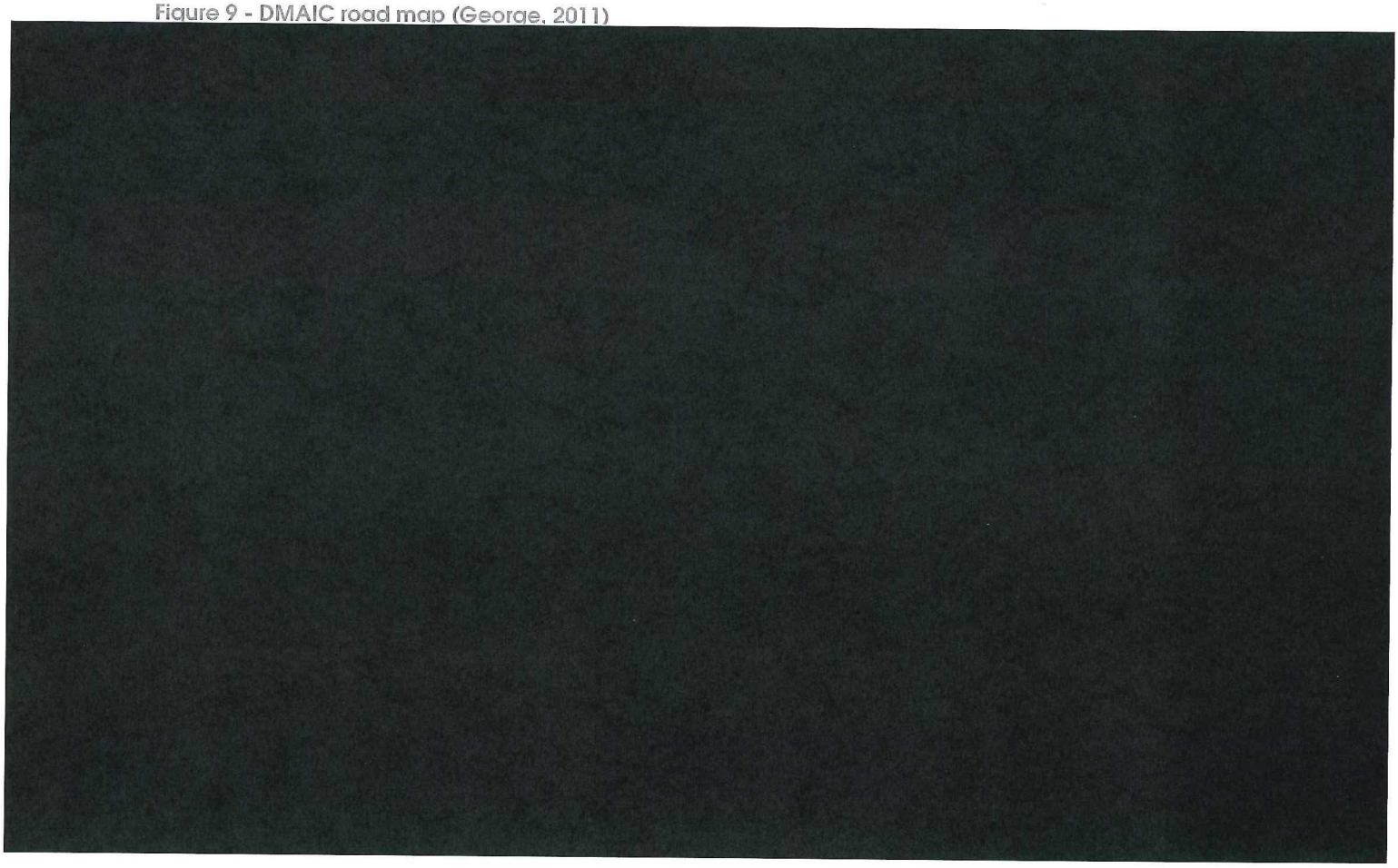
Improve

- Develop potential solutions
- Evaluate, select, and optimize Best solutions
- Develop "To-Be" Value Stream Map(s)
- Develop and implement pilot solution
- Confirm attainment of project goals
- Develop full-scale implementation plan
- Complete Improve Gate

Control

- Implement mistake proofing
- Develop SOPs, training plan, and process controls
- Implement solution and ongoing process measurements
- Identify opportunities to apply project lessons
- Complete Control Gate
- Transition monitoring/ control to process owner

Figure 9 - DMAIC road map (George, 2011)



3.4.4 Summary of the three types of projects

An Operational Management project is focused on improving the maturity on one department. For this purpose OEC uses the OM-in-a-box method. This method consists of hard and soft elements, but the major activities in an Operational Management project are soft based. This is the opposite of a Lean Six Sigma project. Lean Six Sigma projects are more fact based and here the hard elements are more important. In a Lean Six Sigma project a Black Belt optimizes a total process, the scope is often broader than one department. The last project type is Value Chain Steering, in these projects chain partners are broad together and an improvement structure is settled. In Value Chain Steering projects soft elements are more important; the chain partners should get a shared understanding about the process and the performance of the process. In Figure 11 a total overview of the maturity levels, the belonging types of projects and the focus areas in the organisation is given.

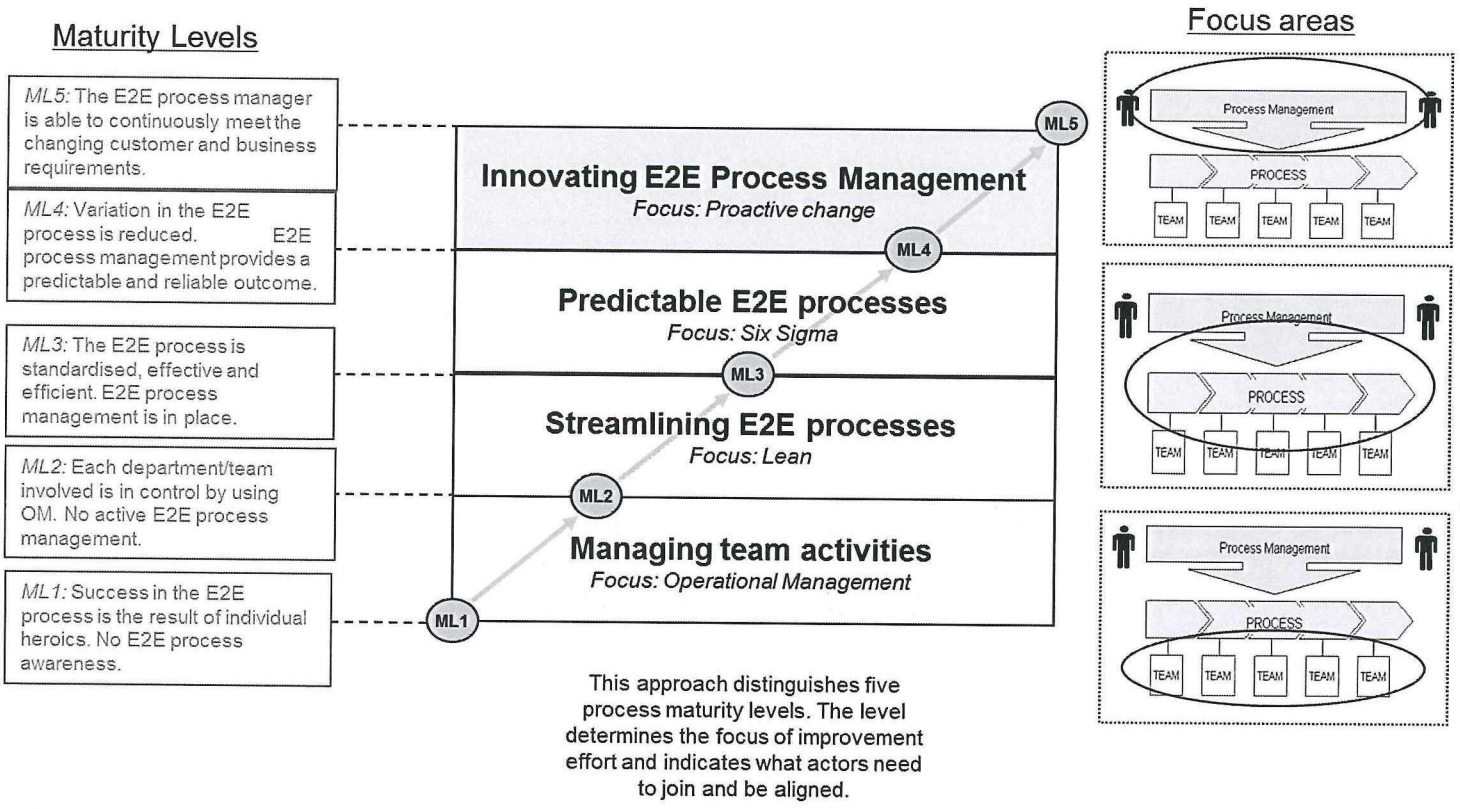


Figure 11 - Maturity levels and focus areas of the PM&I model (ING, 2010)

3.5 Change Management

In normal organisations, about 70% of the organizational transformations fail because many crucial elements in the change process are skipped (Blanchard, 2010). Often companies wrongly assume that change is all about improving financial results and they forget 'soft' benefits such as trust or emotional commitment among employees. An often used formula in management is Maier's law: E = Q x A (David & Pelt, 2010). This formula means that Effectiveness (E) is determined by two elements: the Quality (Q) of an improvement or advice and the Acceptance (A) of the improvement or advice. The Acceptance is also called the Cultural and is the soft part of an improvement. The formula can be seen in Figure 12, the left circle of the figure is about the acceptance and the right part is about the quality. These two parts together determine the performance.

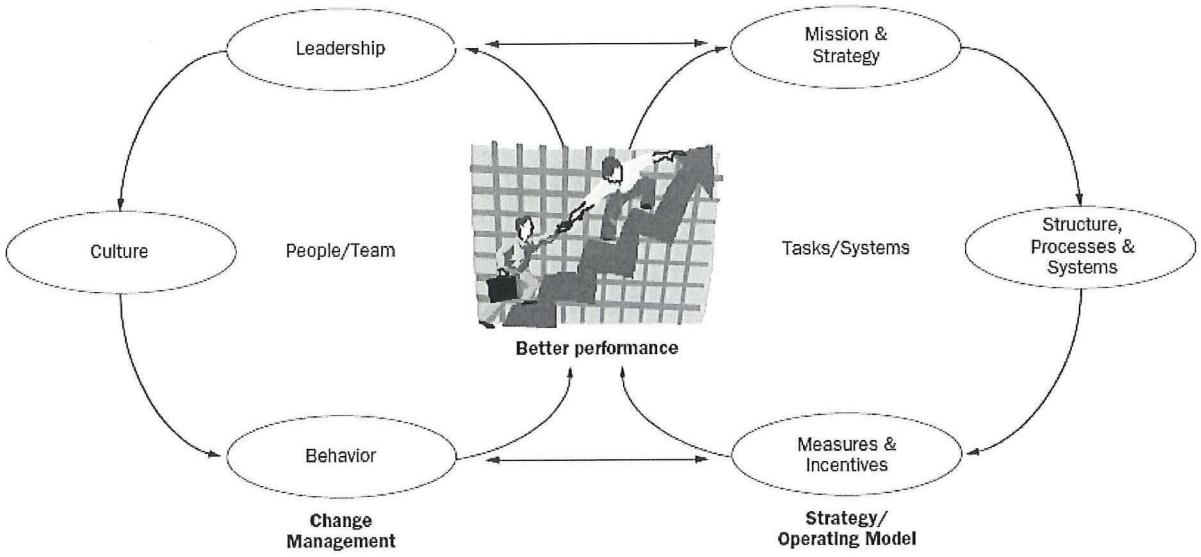


Figure 12 - Change Management vs Strategy/Operating Model (Booz Allen Hamilton, 2004)

According the theory of Green and Kreuter (1999) there are more than 100 variables that can influence behaviour of people. Green and Kreuter categorised these variables in three main determinants:

1. Predisposing determinants. These are factors that motivate people in a desired behaviour.
2. Enabling determinants. These are factors that make it possible for people to have a specific behaviour. Examples of these factors are trainings, technology or money needed for a specific change. Rules and regulation can also be needed as an enabling factor.
3. Reinforcing determinants. These are factors that include rewards and feedback reviews from others. An important factor is this determinant is the feedback (power) of higher management.

Behaviour of people is caused by many factors and determinants. Behaviour cannot be changed by a single factor. Changing behaviour should involve predisposing, enabling and reinforcing determinants. This means that Black Belts have to deal with all the three main determinants.

Management that imposes a specific behaviour is the most important reinforcing determinant for the Black Belts. Black Belts and the middle management have to commit higher management of their problems and solutions. Furthermore middle management should impose desired behaviour to their employees.

The enabling determinants are the trainings and methods that Black Belts use in their projects. Management is trained by Black Belts in specific activities and get through these training more skills to perform changes. Furthermore tools are often developed in projects (for example dashboards with performance data) that are used by management in changes. With these enabling factors, management is able to perform changes in processes and is able to create enabling determinants for the employees.

The predisposing determinants are factors that motivate people for a specific change. Examples of these factors are awareness, attitude or social influence. These factors are the soft factors in the projects of Black Belts. Especially in the Operational Management project (to motivate employees) and in the Value Chain Steering project (to motivate chain partners) these factors are important.

Maier's law that was introduced in the beginning of this paragraph is sometimes expanded with the letter M: E = Q x A x M. In this formula the Effectiveness is not only determined by Quality and Acceptance, but also by the Management. The Q, A and M can then be seen as the three main determinants in Green and Kreuter's theory. The Quality is about what is possible (the Enabling determinants), the Acceptance is about the motivation of people (the Predisposing determinants) and Management is about the tasks that management imposes to the employees (the Reinforcing determinants).

Dealing with the different determinants and increasing the efficiency in changing processes is described in literature of change management. Change management has many definitions. Sometimes it is defined as the process of changing: 'change management is the process of continually renewing an organisation's direction, structure and capabilities to serve the ever-changing needs of external and internal customers' (Moran & Brightman, 2001). Others define change management as a method that can help by changing a process: "Change management is a systematic approach to dealing with change, both from the perspective of an organization and on the individual level" (Song, 2009). In this research the second definition is used. Many articles and reports are written about required change strategies for process changes.

Scientists and consulting firms often come up with a list of recommendations that should be followed in order to succeed a process change or organisational change. Five lists with recommendations are found in Table 13.

Communication

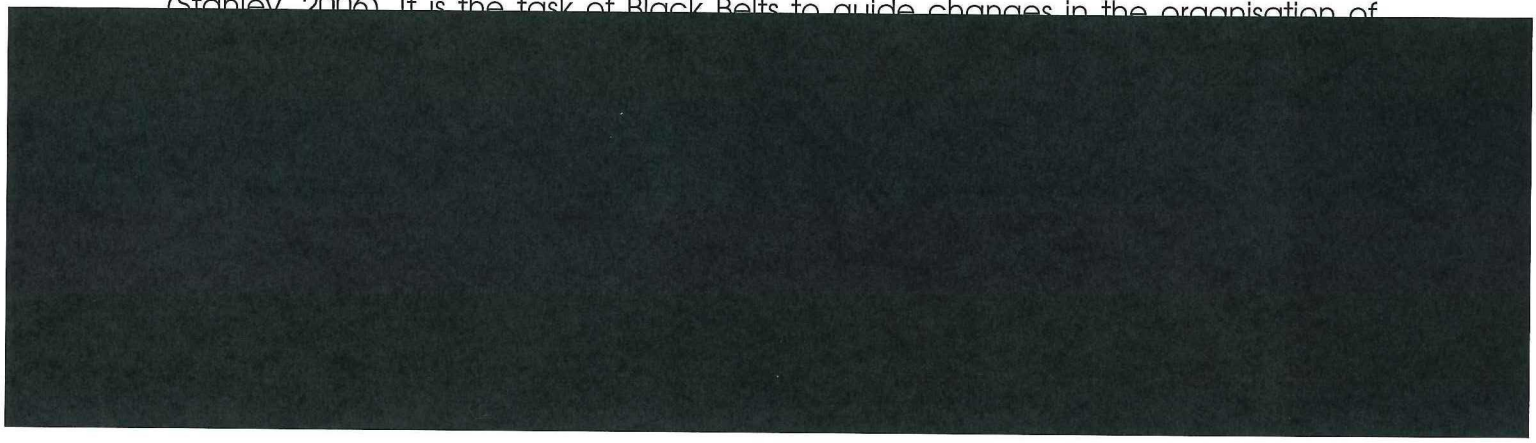
Communication is an element that if often coming back in the lists (recognisable with the, among others, the words 'share', 'communicate', 'address', 'dialog', 'speak' and 'feedback') and is one of the most important aspects in change management (Kotter, 2002) (Heathfield, 2012) (Rick, 2012).Communication is about informing people with the aim to persuade, convince or tempt them. The more specific communication is, the higher the probability is that people will change their behaviour. The effect of a generic mass media campaign is for example 2 to 3% and a customized campaign will already get effects of 20% (Egmond, 2010).

Torben Rick (2012)	***John P. Kotter*** (2002)	***Gordon Stanley*** (2006)	***Booz&co*** (2004)	***Susan Heatfield*** (2012)
Create a sense of urgency based on the company's financial performance, competitive situation, market position, technological trends	Increase urgency - inspire people to move, make objectives real and relevant.	Plan for change from a solid base	Address the human side of change systematically	Demonstrate That You Value People
Communicate information broadly and dramatically. To successfully implement change initiatives, organizational leaders must identify the need for change and communicate it throughout the organization.	Build the guiding team - get the right people in place with the right emotional commitment, and the right mix of skills and levels.	Identify discrepancies between formal and informal practice in the organization.	Change starts at the top and begins on day one	Share Leadership Vision
When dealing with change management it is often required to have a closer look at the current strategy	Get the vision right - get the team to establish a simple vision and strategy, focus on emotional and creative aspects necessary to drive service and efficiency.	Control expectations about the proposed changes.	Real change happens at the bottom	Share Goals and Direction
Create a shared vision, values and common directions. Make sure to address culture	Communicate for buy-in - Involve as many people as possible, communicate the essentials, simply, and to appeal and respond to people's needs.	Select change agents carefully.	Confront reality, demonstrate faith, and craft a vision	Trust People
Visualize the "journey"	Empower action - Remove obstacles, enable constructive feedback and lots of support from leaders - reward and recognise progress and achievements.	Build support among like-minded people however they are recruited	Create ownership, not just buy-in	Provide Information for Decision Making
Communicate the goals/targets in a simple way – a surprisingly simple image can express more ideas than a thousand complex words.	Create short-term wins - Set aims that are easy to achieve - in bite-size chunks. Manageable numbers of initiatives. Finish current stages before starting new ones.	Identify those opposed to change and try to neutralize them.	Practice targeted over-communication	Delegate Authority and Impact Opportunities, Not Just More Work
Create a dialog – Involve the whole organization.	Don't let up - Foster and encourage determination and persistence - ongoing change - encourage ongoing progress reporting - highlight achieved and future milestones.	Avoid future shock	Explicitly address culture and attack the cultural center	Provide Frequent Feedback
Measure early and often ..... and tell about it	Make change stick - Reinforce the value of successful change via recruitment, promotion		Assess the cultural landscape early	Solve Problems: Don't Pinpoint Problem People
If you want something to grow, pour champagne on it: Create wins			Prepare for the unexpected	Listen to Learn and Ask Questions to Provide Guidance
Continuously lookout for inconsistencies - Deal proactively with resistance			Speak to the individual as well as to the institution	Help Employees Feel Rewarded and Recognized for Empowered Behavior

Table 13 - Lists with recommendations in Change Management

Facilitating team for change

Next to the communication, people involved in the change are important. A guiding team with the right people, the right emotional commitment and the right mix of skills and levels is needed for a successful change in the organisations (Kotter, 2002) (Stanley, 2006). It is the task of Black Belts to guide changes in the organisation of



3.6 Business Process Simulation

Business process simulation is a tool to analyse business processes over time and to experiment with scenarios (like for instance redesigning business processes) before implementing them into an organization (Rust, Cetinkaya, Seck, & Wenzler, 2011). Business process simulation is considered as relevant and highly applicable in organizations according to Aalst et al. (2010). Aalst et al. didn't look to the maturity levels of the business processes they simulated, this can however be important: There can be other needs for a simulation with a low maturity level business process compared to a process with a high maturity level. A business process with a low maturity level has for example less data available, business processes are not well documented and data is not measured. A business process that if totally in control and with a high maturity level has on the other hand much data available. Building a simulation model of a business process with a high maturity level demands therefore a different approach.

There is limited literature available that handle maturity levels of business processes combined with simulation. In the software industry Raffo et al. (1999) did a research to maturity levels and the CMM in software industry. He concluded that simulation is useful at all the maturity levels, but the area of the added value is different at the different maturity levels. At the lower maturity levels (2 and 3) the graphical capabilities of the simulation gave a good overview of the process. At the higher maturity levels the simulation gave good quantitative results that they could use to improve their system and process. In 1999 Cristie did a similar research as Raffo and draw the same conclusions (Christie, 1999). In 2008 Raffo and Wakeland did an extensive research at the Carnegie Mellon University (founder of the CMMI) with a focus of Process Simulation Modelling and CMMI capabilities. For each capability they described how simulation could add value. In 2002 Miller et al did a research to simulation with the CMMI model. He determined the Process Areas where simulation could give most added value. Maturity level 2 was not applicable for simulation according Miller. In the higher maturity levels simulation could add value but not at all the different Process Areas of the CMMI (Miller, Pulgar-Vidal, & Ferrin, 2002)

3.6.1 Simulation within the transition between maturity levels

Figure 12 visualises the relation between change management and changes in the strategy or operating model of an organisation. This research is about the added value of simulation in increasing maturity levels. The formula E = Q x A makes clear that optimizing processes will not directly lead to a better performance. Behaviour of people (Acceptance) is just as important (or maybe more important) as the structure and processes in an organisation. Simulation can add value in both improving the structure/process as in change management.

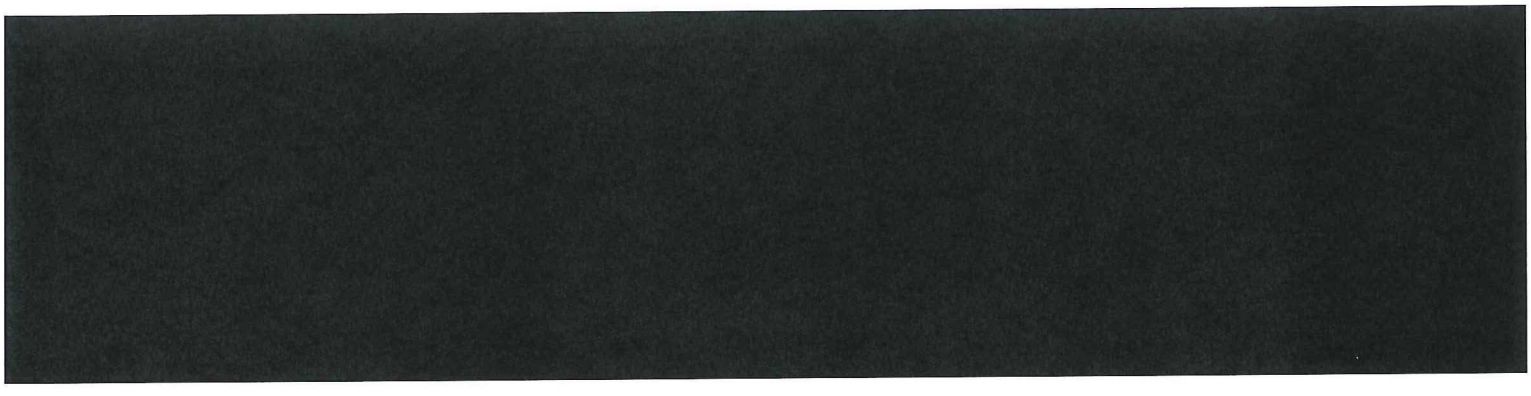
With simulation, processes can be optimized so that a higher level of maturity can be accomplished. Almost all literature about simulation is about optimising processes or systems. Especially in manufacturing, simulation is often used, see Table 14 (Hlupic, 2000). In manufacturing the change process if less important because many processes or systems are automated and changes to the process do not require many changes in people's behaviour.

APPLICATION AREAS OF SIMULATION	*PERCENTAGE OF USERS (%)*
Manufacturing	33.3%
Communications	22.2%
Distribution	22.2%
Trading	11.1%
Analysis of statistical sampling problems in surveys of industry	11.1%
Stock control of stocks of cash for a multi-branch bank	11.1%
Packing halls	11.1%
Customer service	11.1%
Compiler networks	11.1%
Business processes	11.1%
Repair	11.1%

Table 14 - Application Areas of simulation from a group simulation experts (Hlupic, 2000)

Next to optimisation of processes, simulation can also add value on the Acceptance of a change process (the A in Maier's law). A simulation model can for example help a manager by making a problem clearer to his employees and so motivate employees for a desired change. This advantage of simulation (good in communication) is given by many lists of advantages/disadvantages of simulation (see for example (Hommen, 2009)). However there is almost nothing written about this specific advantage. In the paper of (Aguilar, Rautert, & Pater, 1999)there is stated that simulation can help in communication and creating acceptance for a solution, but this is not the main goal of simulation. Simulation has main impact on analysing according Aguilar.

Next to communication, simulation can also help in another way in the change process. Mayer, Blockstael and Valentin (2004) described a building block approach to simulation. A simulation building block approach is a general way of thinking, modelling, and working that is based on object-oriented concepts and reusability of small model parts (Valentin & Verbraeck, 2002). Simulation tools based on building blocks support the making of simulation models and these tools make the models suitable for effective and efficient communication between simulation experts, decision makers, and stakeholders (Verbraeck & Valentin, 2002) (Valentin & Verbraeck, 2002). In this research a standard simulation method (Banks, Introduction to Simulation, 1999) is used (see appendix 6), other simulation approaches, including the simulation building block approach, are out of scope.



The second simulation model at ING was made for a Msc. Graduation Project (Rutte, 2011). Rutte made a simulation model to improve the closing procedure of bank accounts and to determine the added value of discrete simulation to Lean Six Sigma. Rutte concluded his research by stating that Lean Six Sigma does not provide proper techniques to improve dynamic, interactive and complicated processes. Discrete Event Simulation should be used in combination with Lean Six Sigma to improve these kind of processes. Next to these two models, simulation of business processes is completely new to ING.

There are a few other banks that use simulation, but most of this information is confidential. System Navigators has made different models for ABN Amro, including a simulation of a new banking front-office concept. In other sectors such as transportation, manufacturing, construction, telecommunications, military and health care process simulation is far more established (Cetinkaya, 2011). Aalst et al. (2010) give several reasons for the lack of adoption of business process simulation. Among else lack of training, limitations of existing tools and the fact that model development is time consuming and costly are reasons that lead to the little use of simulation. Rust et al. (2011) did a research among management consultants and came up with a business process simulation method to support management consultants to model, simulate and analyse business processes in a well-defined manner. Because of the recent publication of this method it is too early to draw conclusions of increased adoption of simulation in business due to this new method.

3.7 Criteria for defining the added value of simulation.

Simulation can have added value in the acceptance of an improvement and in the quality of an improvement (or substantive added value). Both aspects of added value will be investigated in this research. In literature there are no clear criteria that can be used to determine the added value of the tool simulation for a consultancy department like OEC. When in literature is spoken about added value of simulation, often the added value of total project is mentioned (in which simulation is used) and not the added value of the specific tool simulation. In order to determine the added value of simulation for OEC, it is important to make a clear distinction between the added value of a project and the added value of the specific tool simulation. OEC want to know how they can work more efficiently and so they want to know if the tool simulation has added value for them.

Some articles in literature have defined criteria for simulation models, but most times these criteria are not aimed at determining the added value of a model. Criteria in these articles are aimed at determining the quality of a simulation model. Frischherz and Schonborn did for example define criteria for good animations of simulation models (Frischherz & Schonborn, 2004) A simulation model that scores high at all the criteria of Frischherz and Schonborn is an excellent simulation model but it can still have no or limited added value for a company. For example the tool simulation can be very good and deliver good results, but it can be too costly to build a simulation model.

In this paragraph the process of creating criteria to determine the added value of simulation is described and these criteria are presented. First the substantive added value of simulation models and then the criteria for added value in change management will be discussed.

3.7.1 Criteria for the substantive added value of simulation

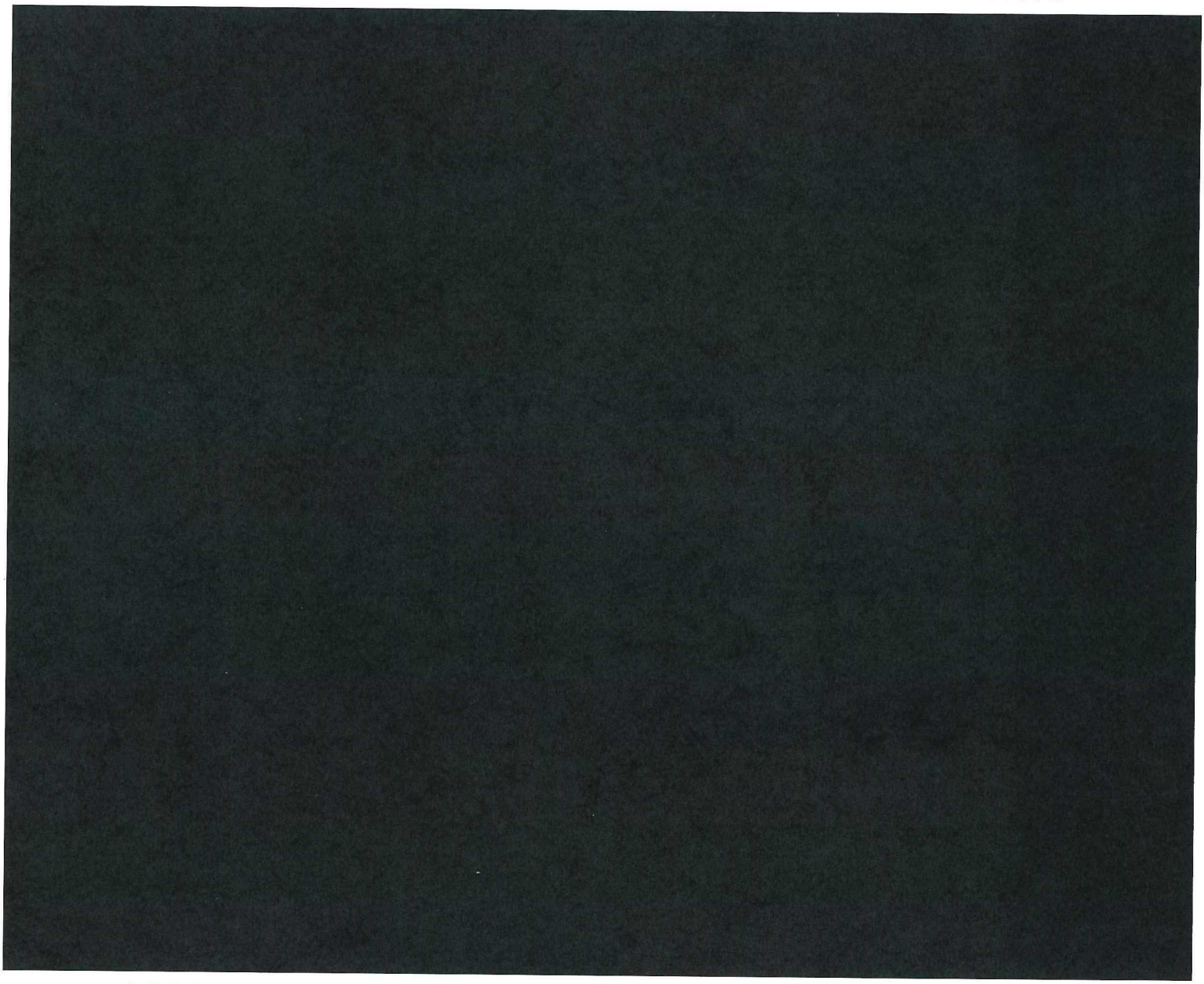
As said before it is important to make the distinction between the added value of a project of OEC and the added value of simulation in that project. By knowing the added value of a project of OEC it can be said which part of this added value can be allocated to the tool simulation. Therefore first the added value of a project should be defined. In this research the added value of a project is defined as the increase in maturity level of the PM&I model. The increase in maturity level is examined by comparing the maturity level at the start of a project with the maturity level at the end of a project.

Choosing the maturity level for a process is difficult. A process can have maturity level 1 and also contain some aspects of maturity level 2 or even 3. An objective judgment of the maturity level of a process is essential to come up with an objective conclusion about the added value of simulation. Therefore criteria are formulated for each process area at each maturity level of the PM&I model.

Internal documentation and assessments for OEC's project are the basis for these criteria (ING, 2012). Multiple meetings took place with several Black Belts to discuss and optimize the criteria (ING, 2012). The final list of criteria for maturity levels is given in appendix 4.

To illustrate how these criteria look like, the list of criteria for the process area 'Transparency' is given in Table 15. In this list you can see that there are multiple criteria in which simulation cannot add any value. For example, simulation cannot help in making work instructions more accessible. But there are also criteria in which simulation can, potentially, add value, see for example the criteria "The influence of variation on the process is clear". The criteria clearly visualize that the tool simulation

is not sufficient in increasing the maturity level of a process. Simulation can be a tool that helps in increasing maturity levels, but other methods and tools are still needed.



3.7.1.2 Scores on the criteria

The scores of the criteria before and after the project showed the increase in maturity level during the project. It did however not show the added value of simulation. This added value is determined in interviews with the Black Belt of the project and with middle management where the project took place. The criteria were used as guidance in these interviews. The Black Belt and middle management gave their view on the added value of simulation on each criteria of the model. These views are, in cooperation with the Black Belt and middle management, translated is a score on a five point scale:

1. Simulation has no added value
2. Simulation has limited added value
3. Simulation has medium added value
4. Simulation has high added value
5. Simulation has indispensable added value

3.7.2 Criteria for the added value of simulation in the change process

The Patterson-Connor Commitment Curve is a model that described the stages in a change process. The model shows how and when people become committed to major new organizational requirements. A process typically passes eight stages when facing a change (Connor, 2011):

1. Contact
2. Awareness
3. Understanding
4. Positive Perception
5. Experimentation
6. Individual Adoption
7. Institutionalisation
8. Internalisation

A change can fail on different phases in the commitment curve. Figure 16 shows the different stages and the possible points of failure in a change process. The stages are grouped in three phases: the preparation phase, the acceptance phase and the commitment phase. In the preparation phase the foundation for later development of support to the change is formed. The acceptance phase is an important phase, people shift from seeing the change as something "out there", to seeing it as having personal relevance. In the commitment phase, the perceptions that have been created in the acceptance phase result in actual commitment for the change.

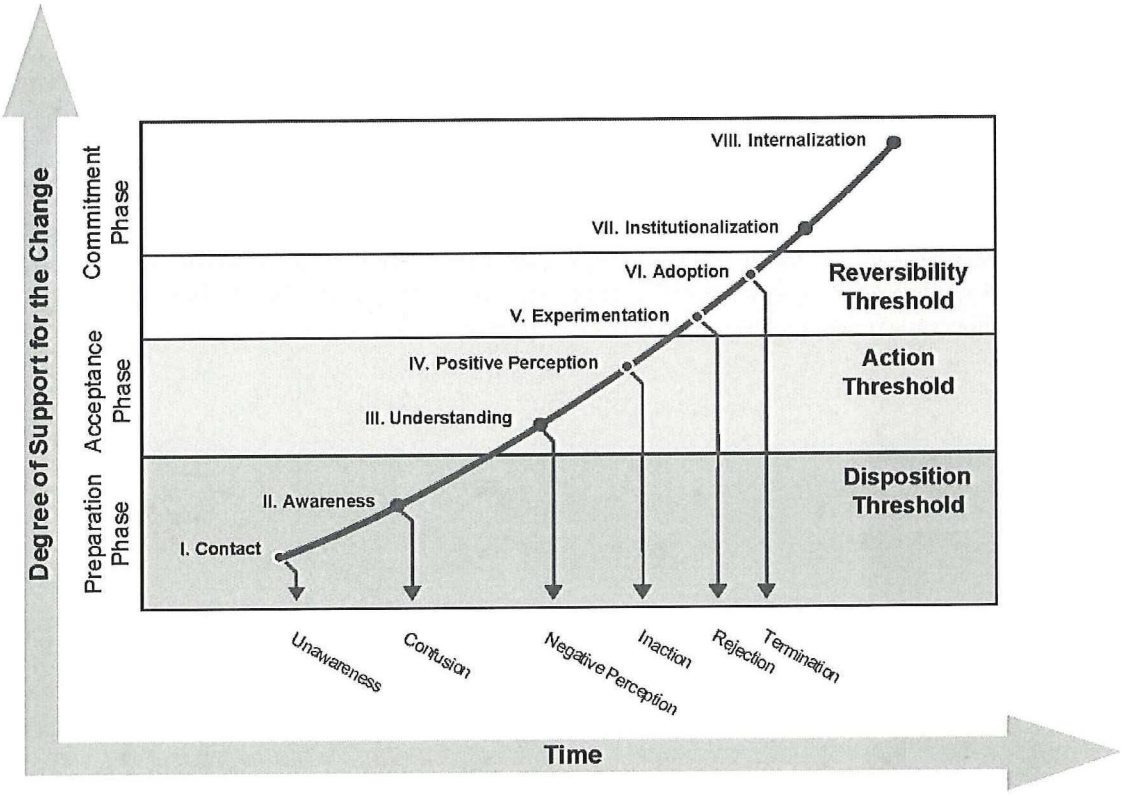


Figure 16 - Patterson-Connor Commitment Curve (Connor, 2011)

Different actors in a change process can go faster or slower through the commitment curve. Higher management will for example react different to a change than the employees on the work floor.

The added value of simulation to the change process is measured with a short survey/interview in which the different stages of the commitment curve are addressed. These interviews took place with the involved Black Belts and employees.

An example of a question used in determining the added value of simulation is: "Did simulation have added value (compared with the normal way of working) in creating understanding about the improvement among higher management?". This question (and the others, see next pages) is answered on a five-point scale:

1. Simulation has no added value
2. Simulation has limited added value
3. Simulation has medium added value
4. Simulation has high added value
5. Simulation has indispensable added value

3.8 Conclusion

Enterprises are using Business Process Maturity Models to analyse and improve their processes. Many variants of BPMM exists, most of them are quite similar and are based on the Capability Maturity Model Integration. ING has also developed a Maturity model: the PM&I model. OEC is helping value chains by increasing the maturity level, there are three different types of projects that they perform. Each project type corresponds to another transition of maturity level in the PM&I model.

Simulation is a powerful tool to increase performance of processes. Simulation can add both substantive value and value in the change process of improvements. Enterprises, especial in the financial world, have not yet widely accepted simulation. The current literature about simulation and business process maturity models is limited. This research will expand this literature and demonstrate the added value of simulation at different maturity levels.

Criteria are set up to determine the added value of simulation. In order to determine the substantive added value of simulation, the increase in maturity level of a project is discussed with middle management and Black Belts. In these discussions each process area is judged on the added value of simulation on a five-point scale. The added value of simulation in the change process is determined with a commitment curve. With middle management and Black Belts the added value of simulation in the eights stages of commitment on the Patterson-Connor Commitment Curve is discussed on, again, a five-point scale.

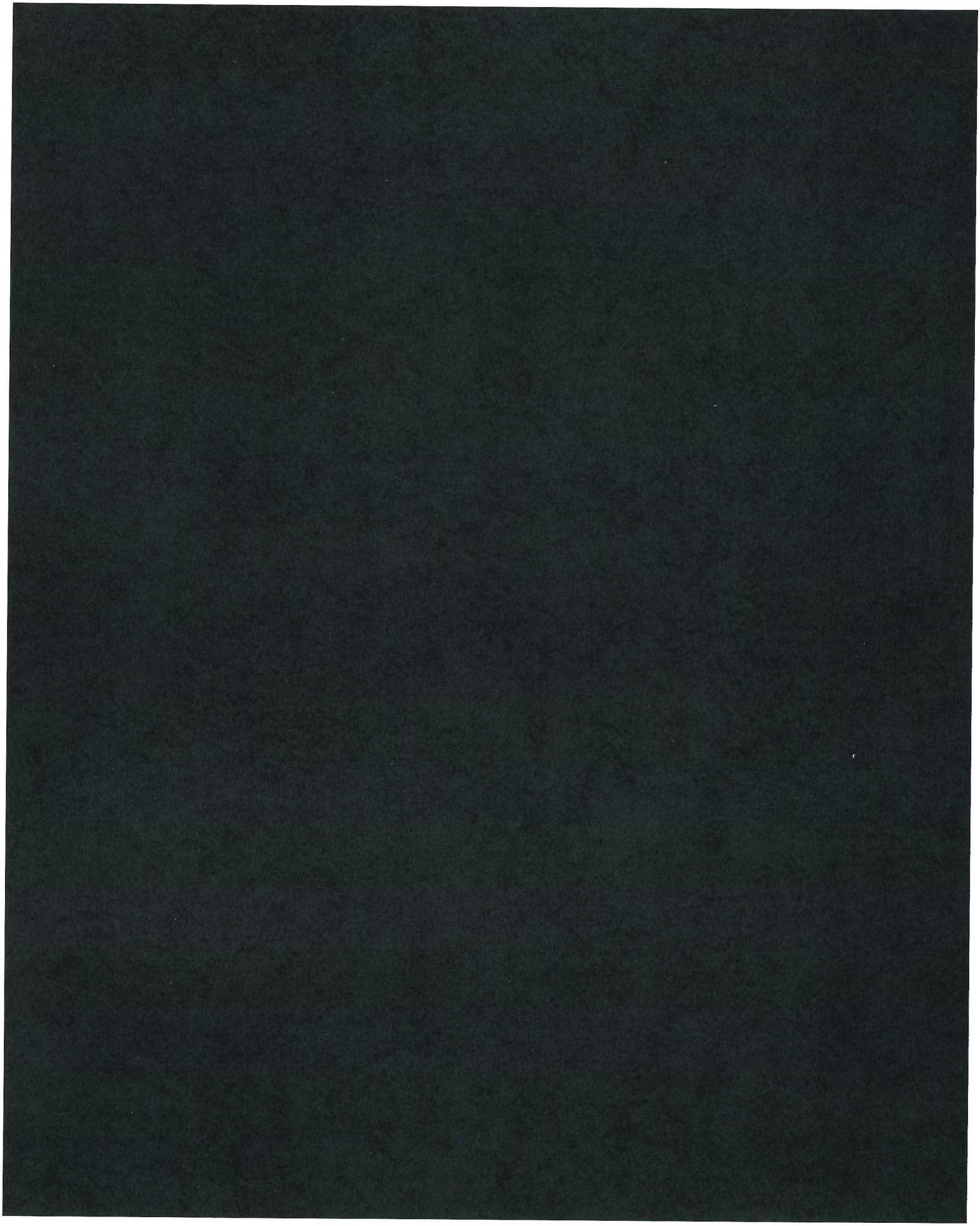
4 Case 1: Operational Management project

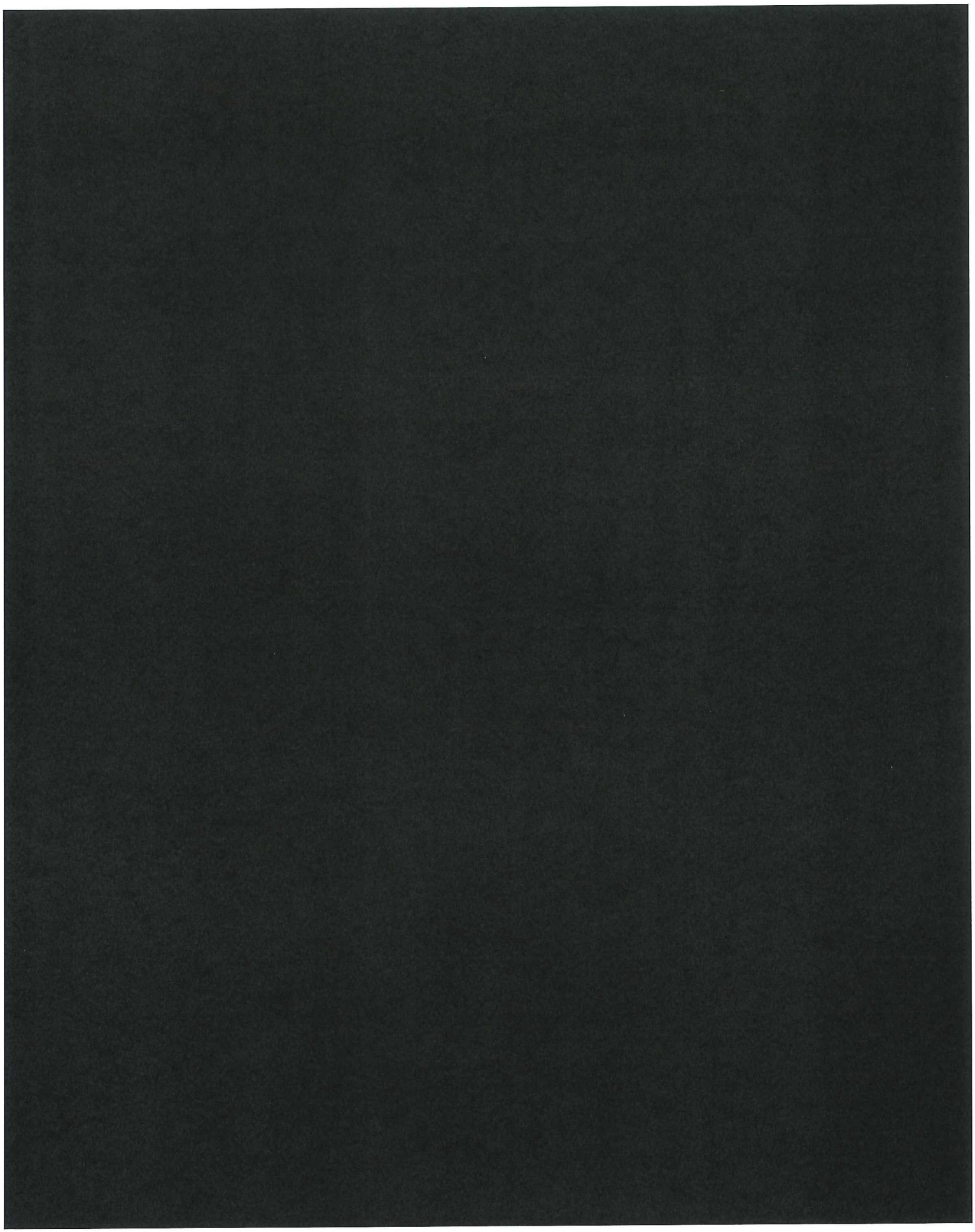
4.1 Introduction

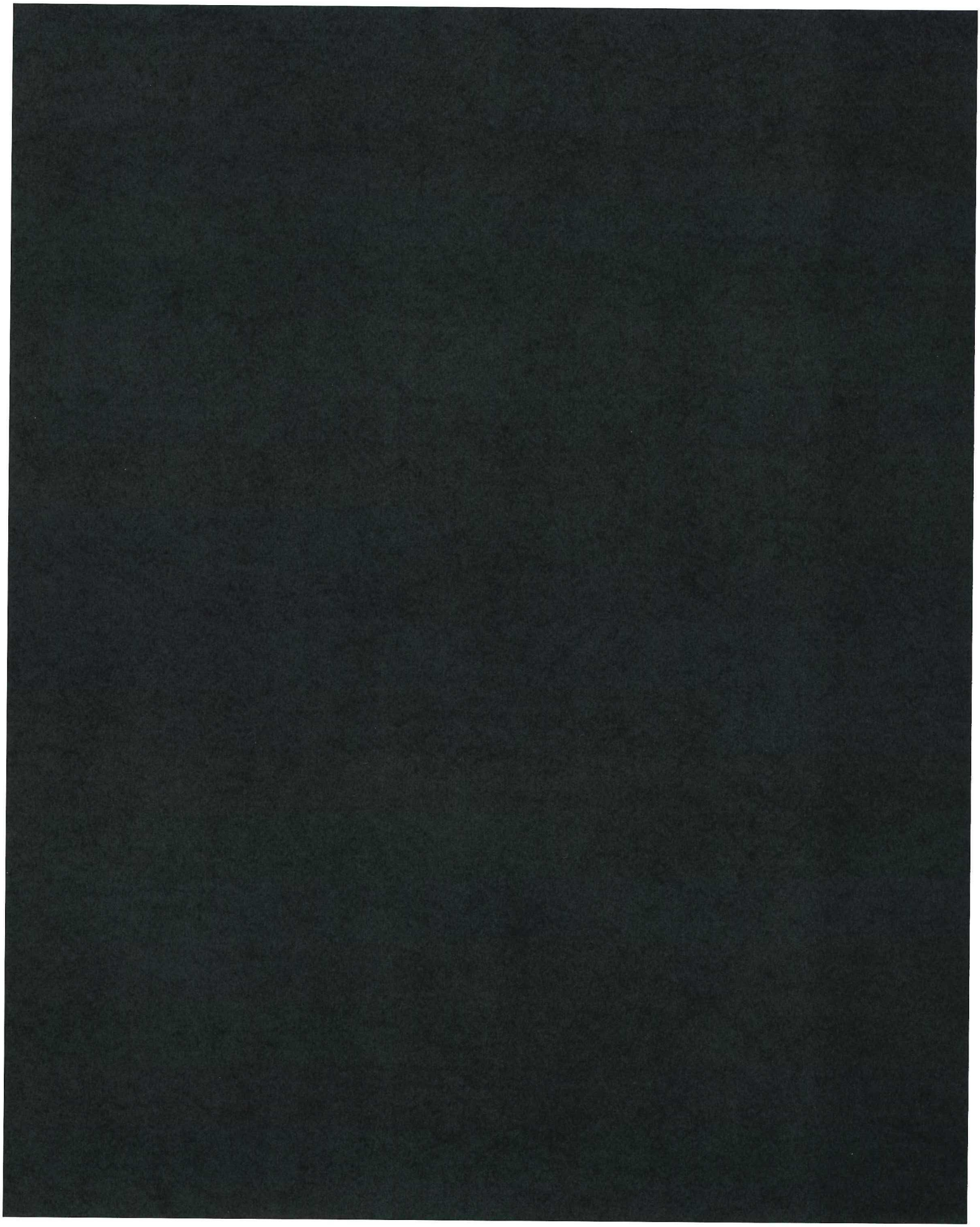
The department Logistics ('Logistiek') in ING's office in Leeuwarden receives [redacted] customers' mail of the ING, [redacted]. Logistics sorts all these incoming customer requests and sends them to the corresponding back office department.

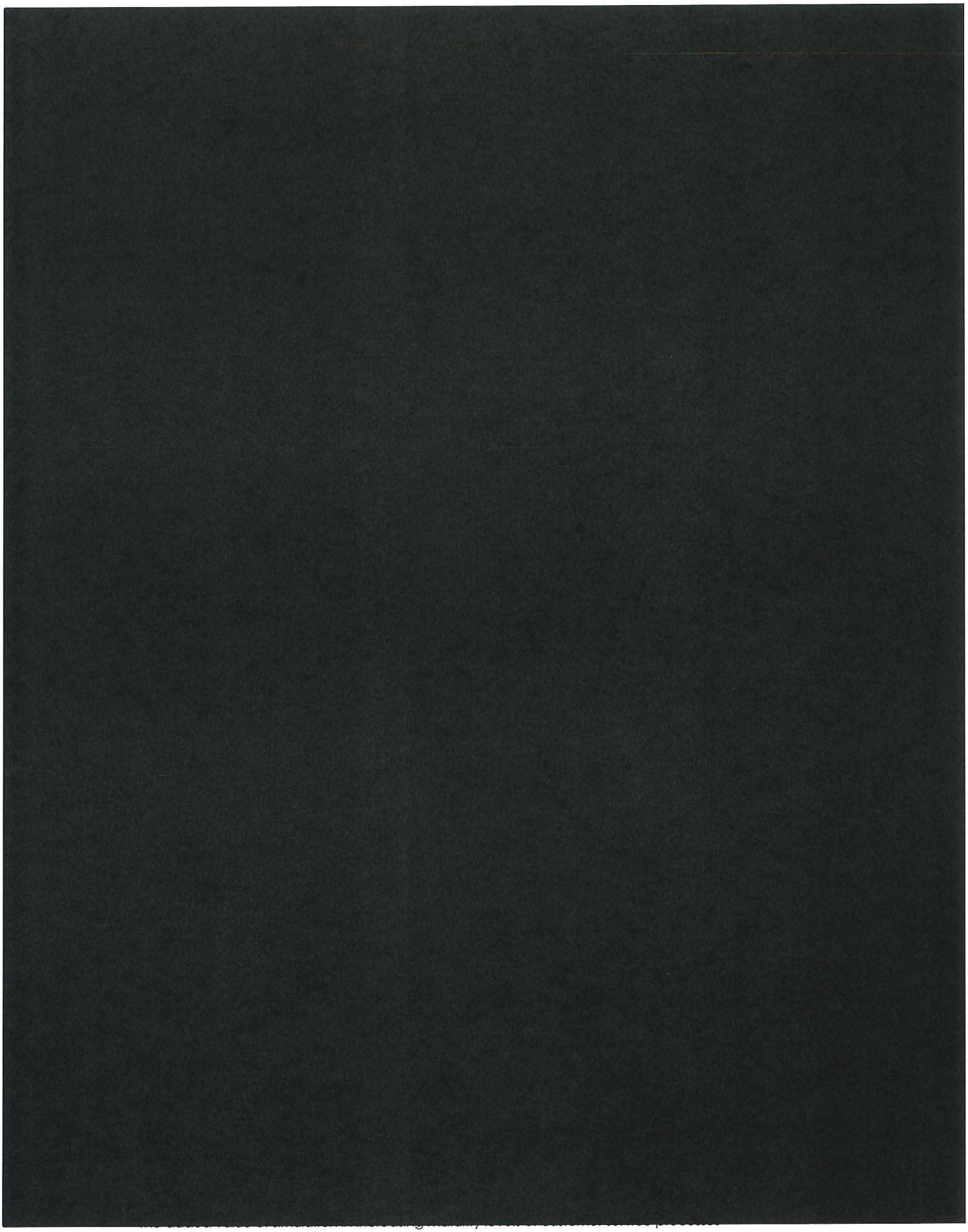
[redacted]. Due to the service guarantees the process had to be accelerated.

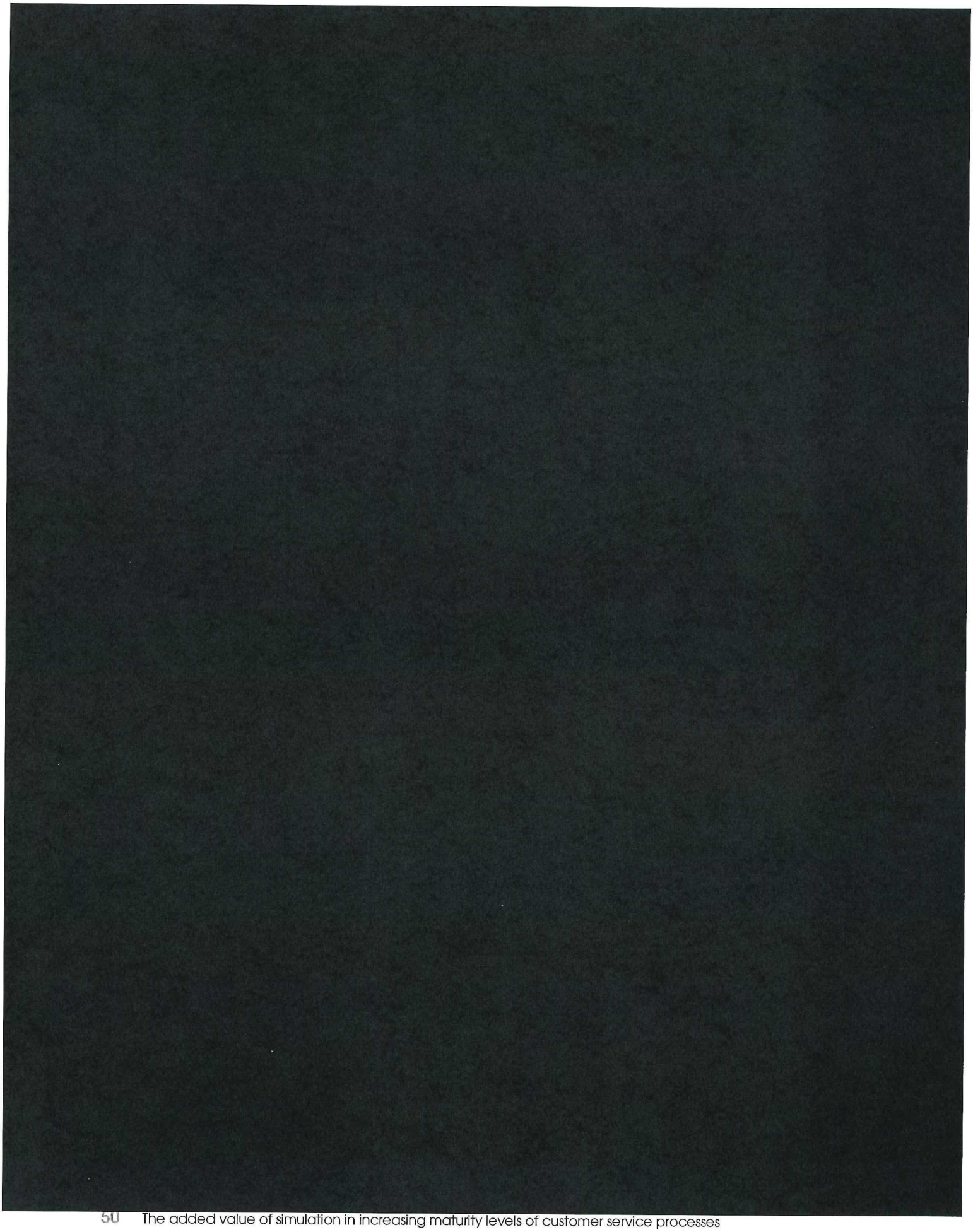
[redacted]

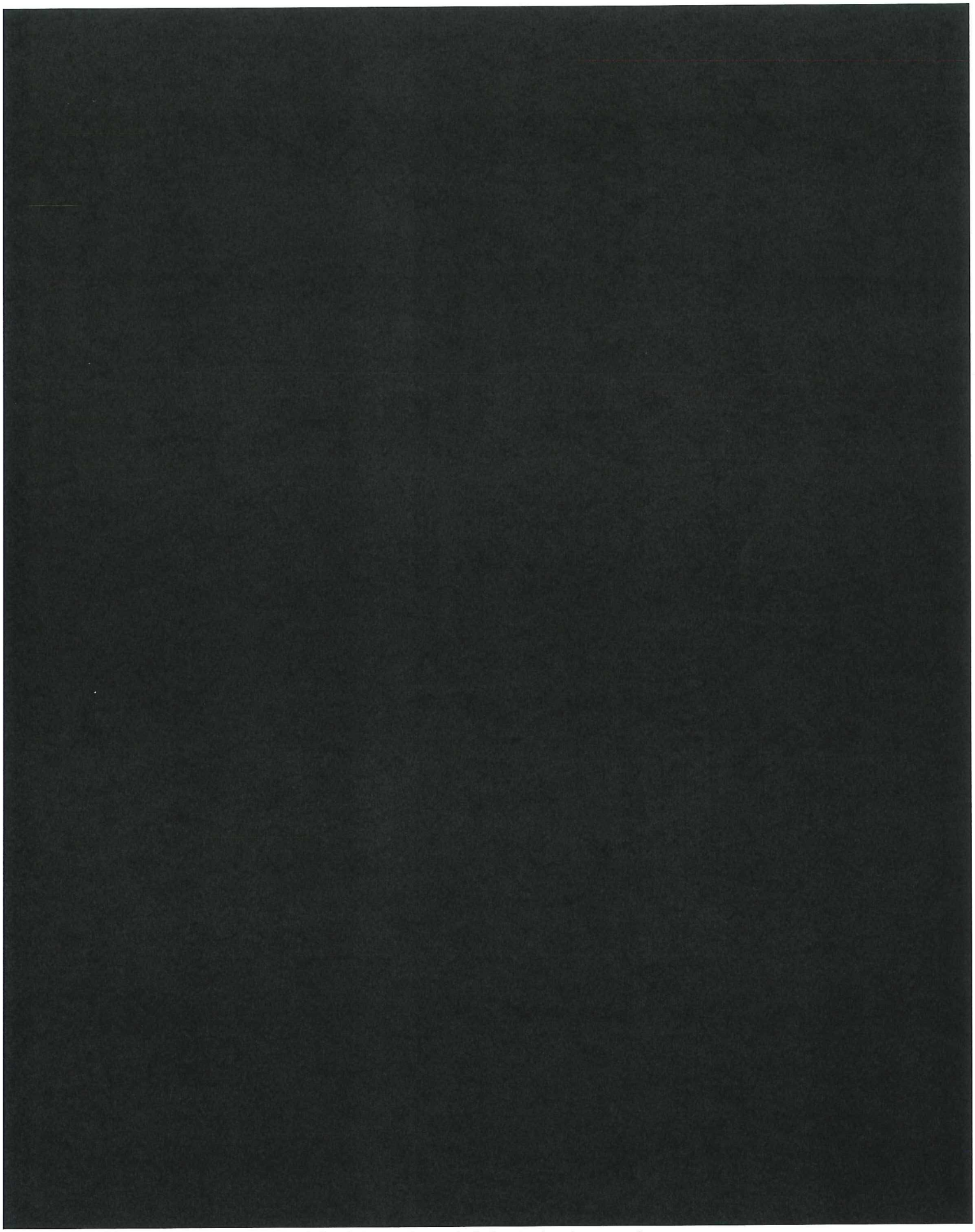












case the simulation expert was new in the organisation ING, time that has been spent on learning the organisation is not applicable with ING simulation experts.

4.6 Conclusion

Figure 21 visualizes the increase of maturity level during the case study. Before the project started (left part of the picture) maturity level 2 was not met, just a few elements of maturity level 2 were visible in the process. This is shown in the picture with the circles that are just filled for a quarter. After the case study (right side of the picture) maturity level 2 was still not reached. The project was however not ended when the case study ended, simulation might have more added value in the remainder of the project. The current contribution of simulation on the increase in maturity level is determined in interviews. Based on these interviews it could be concluded that it was worthwhile to build a simulation model in this Operational Management project.

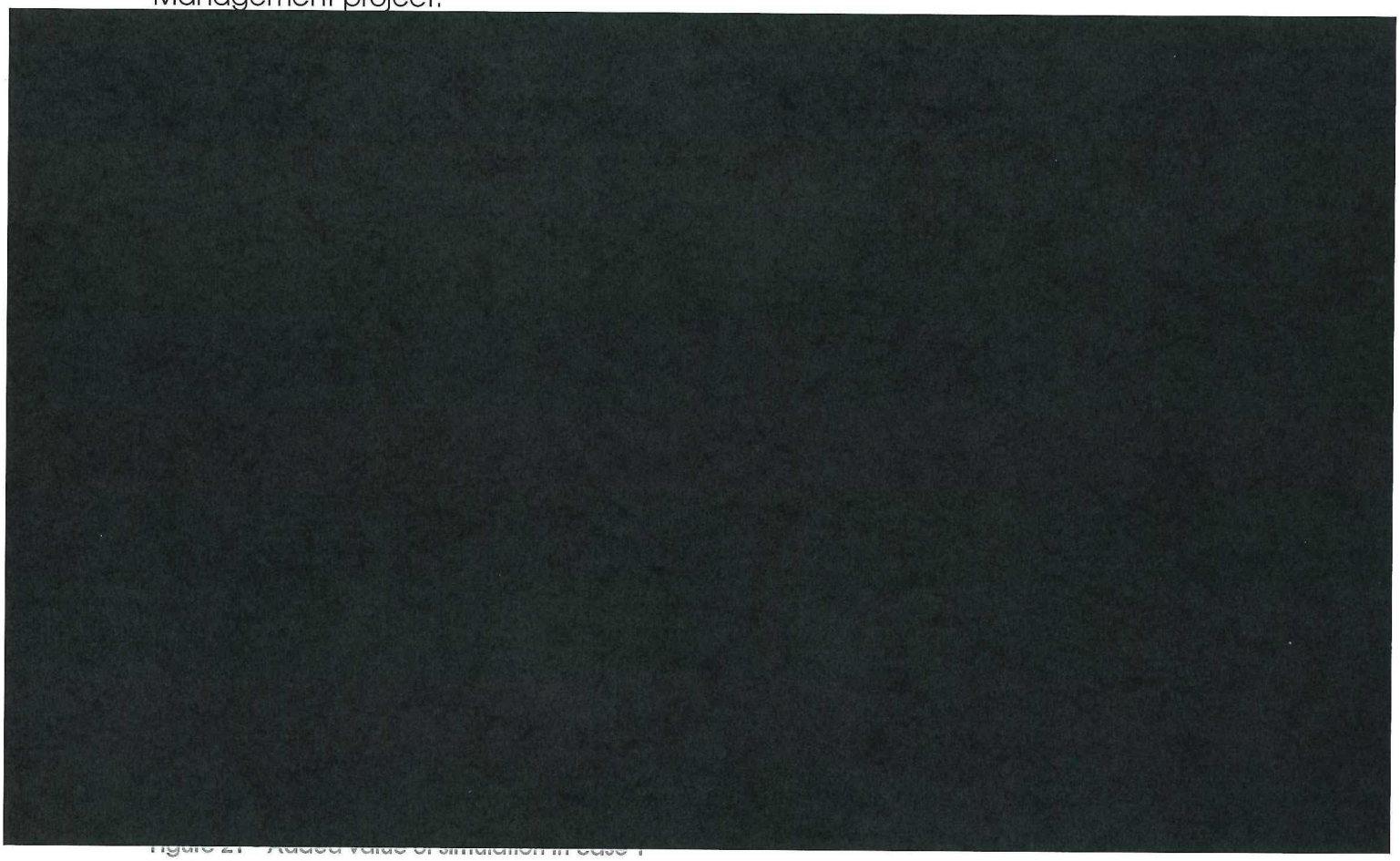


Figure 21 - Added value of simulation in case 1

In the interviews the contribution of simulation on the increase of maturity level of the process areas is discussed. Simulation did not contribute in the increase of the process area 'Performance Management'. In the process area Capacity Management simulation contributed much. The simulation model showed what resources were needed at what time. This information led to more detailed and better schedules for the employees. The simulation did also help management by understanding Capacity Management and re-scheduling capacity during the day. Simulation had medium added value in the continuous improvement. The simulation model showed waste in the process and was used to test some scenarios, the process was so simple that this could also be done with other tools (such as value stream mapping) therefore the added value of simulation is only medium. The

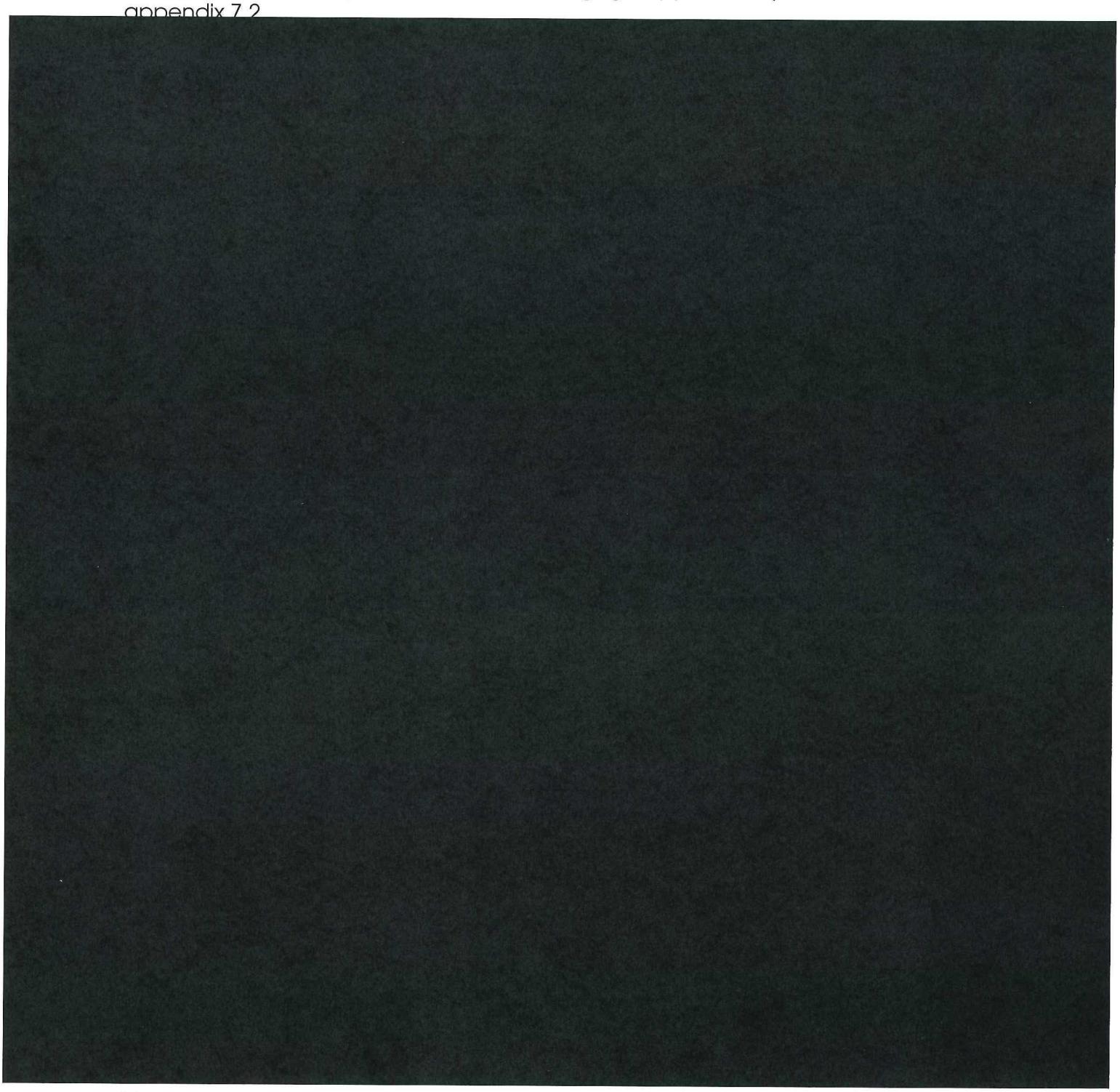
second process area with high added value of simulation is Transparency. Due to the simulation the processes and activities became very transparent at the department Logistics.

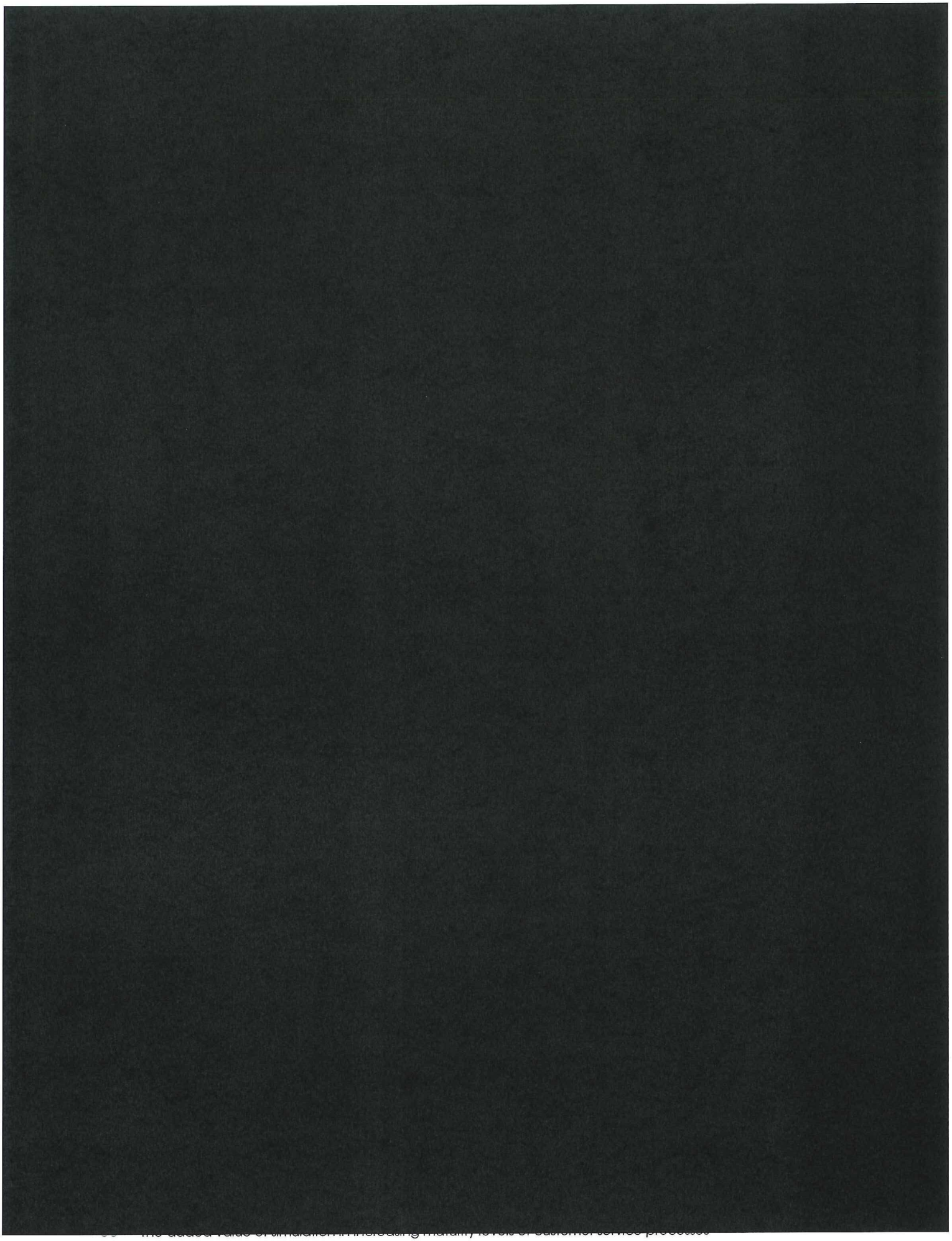
The contribution of simulation in the change from the old situation to the new situation is visualized with the orange arrow. Simulation had high added value in the change process. Middle management was convinced with the simulation that the new situation was feasible. The simulation model had high added value in communicating the new way of working to the employees, because of the simulation model the understanding of the change and new situation was much higher.

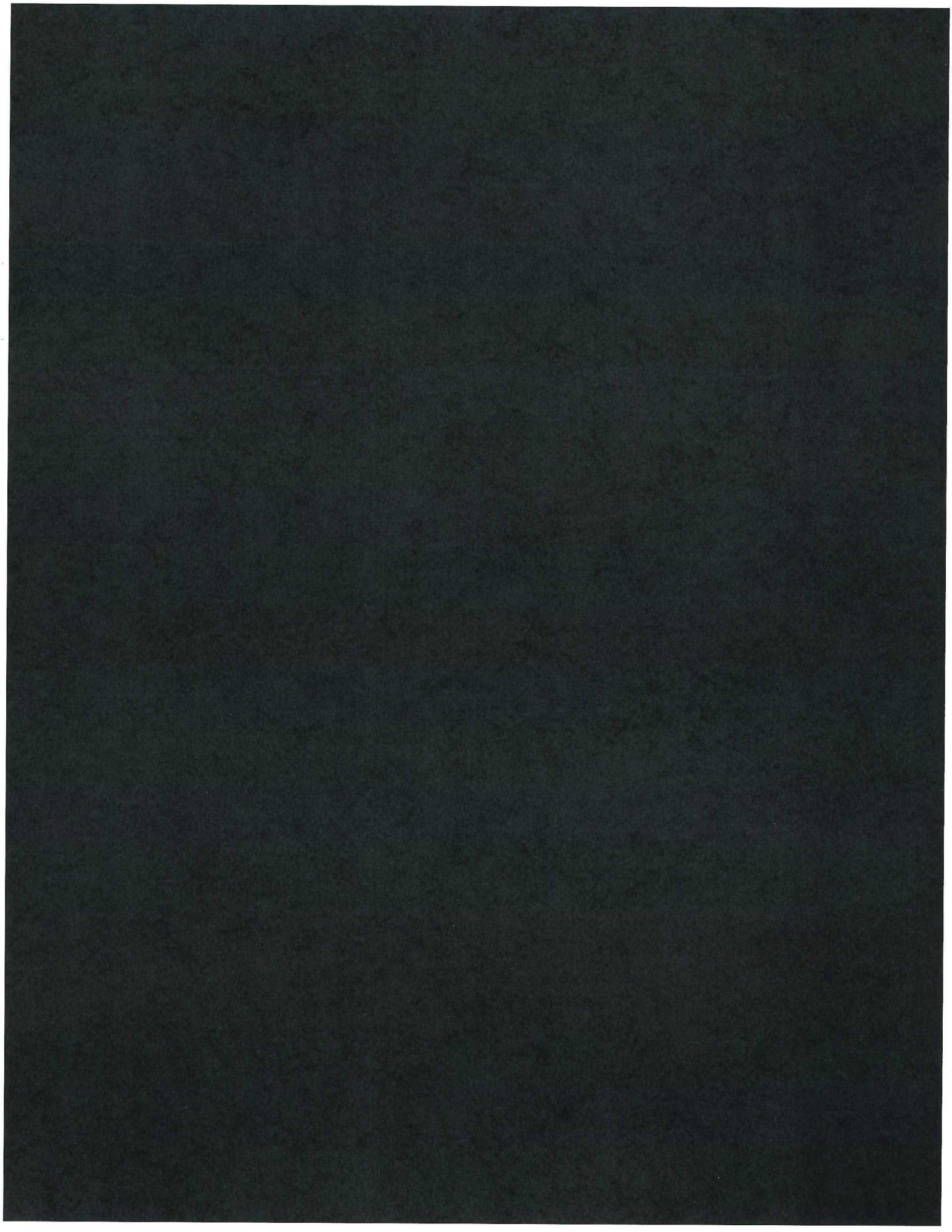
5 Case 2: Lean Six Sigma project

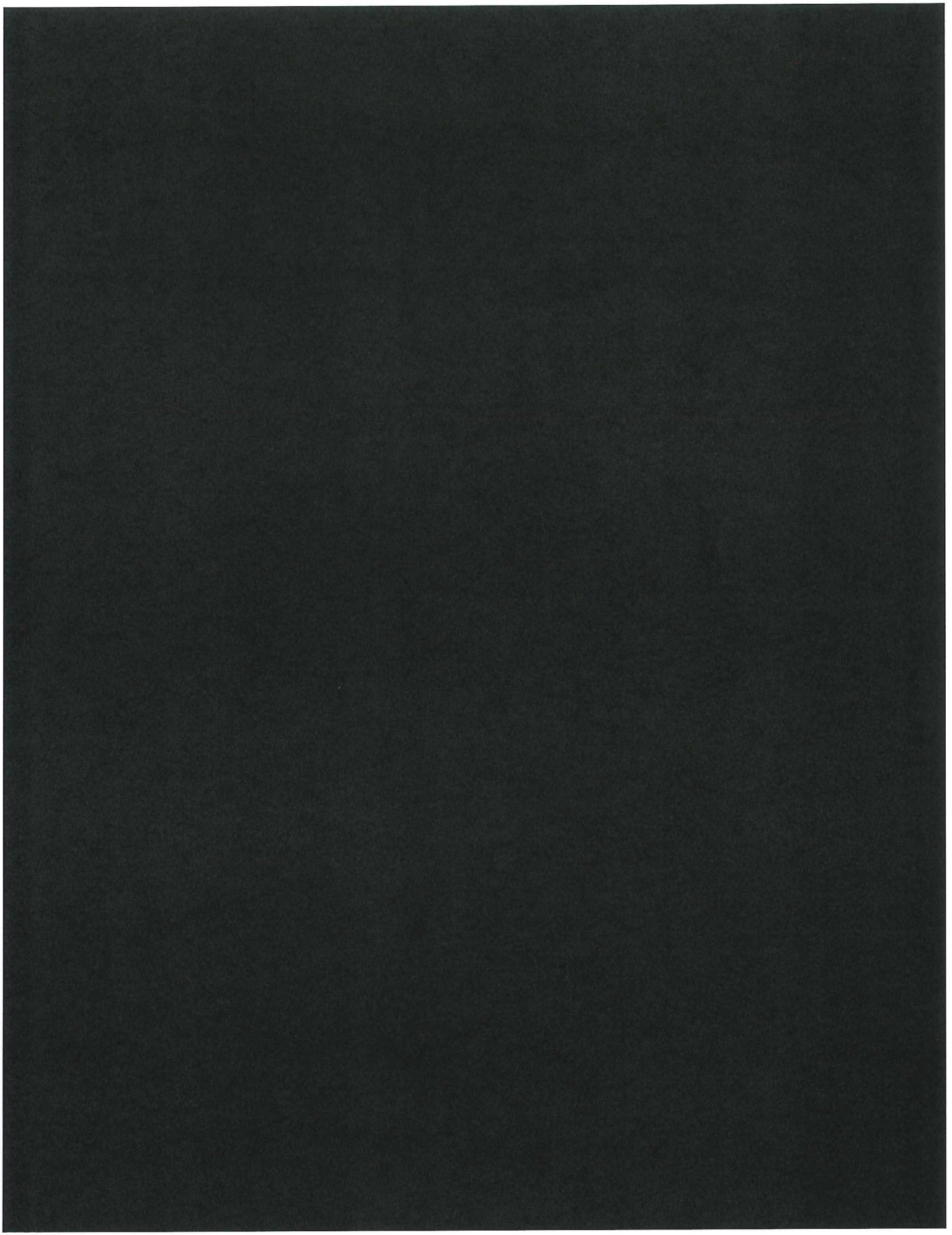
5.1 Introduction

ING is one of the biggest mortgage lenders in the Netherlands. In 2010 more than 41.000 households closed a mortgage by ING and there are in total more than 500.000 people in the Netherlands who have a mortgage by ING (ING, 2011). In December 2011 ING implemented a new system to process the application of new mortgages. With this new system, Force, it is possible to create a quote for a new mortgage completely automatic. The mortgage application process is visualized in appendix 7.2









5.5 Conclusion

Figure 24 visualizes the increase in maturity levels and the added value on the different process areas. The left part of the picture shows that the maturity level was between 2 and 3 before the project started. Each process area has different criteria, these criteria are used to determine the maturity level. In the Lean Six Sigma project the mortgage application process increased from maturity level 2 to maturity level 3. Interviews made clear that simulation added value at different process areas in this transition. This is presented below the process areas in Figure 24.

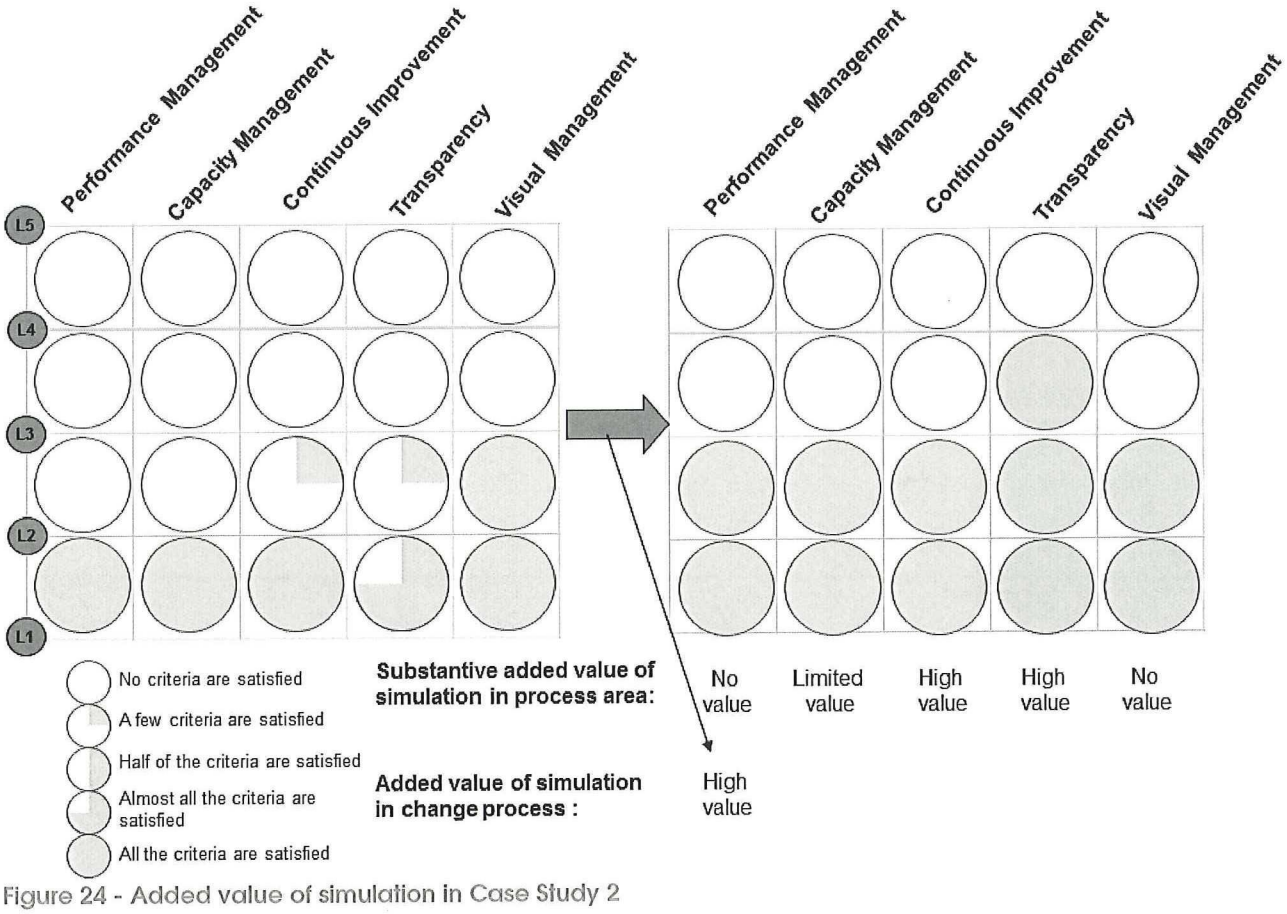


Figure 24 - Added value of simulation in Case Study 2

At the process area Continuous Improvement the simulation model gave indispensable information for designing improvements. The process was visualized dynamic what increased the Transparency enormously. In rising awareness in ING about STP handling of mortgage application, the simulation model had essential added value. Thanks to the simulation model, middle management understand the improvements that contributed to the change process.

Next to the added value on the different criteria in the transition to maturity level 3 this case did also show that simulation models can be used to replace (parts of) a test team. In this case the simulation model could replace 7 people of the MOT, this would save about € 200.000, the total costs of making the simulation model were €8.000 so by only looking to this aspect the use of simulation would already have a positive result of €192.000.

6 Case 3: Value Chain Steering Project

6.1 Introduction

In 1969 the first direct debit payment ("automatische incasso" in Dutch) was performed in the Netherlands. Direct debit is also called pre-authorized debit (PAD) or pre-authorized payment (PAP). A direct debit is an instruction that a bank account holder (with direct debit contract) gives to his or her bank to collect an amount directly from another account. The payer had given the direct debit contract holder the right to collect the money of his account.

Direct debit is an important payment product in the Netherlands. In 2011 more than 1.3 billion direct debit transactions took place (see Figure 25), this is more than 10% of all the payment transactions in the Netherlands (Currence, 2012A) (Equens, 2012). There are four different direct debit variants in the Netherlands (Currence, 2012B):

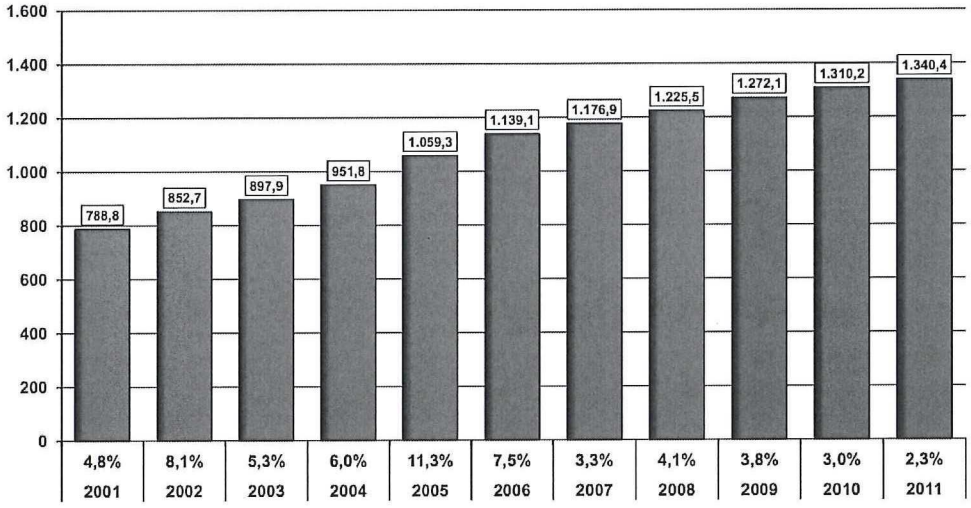


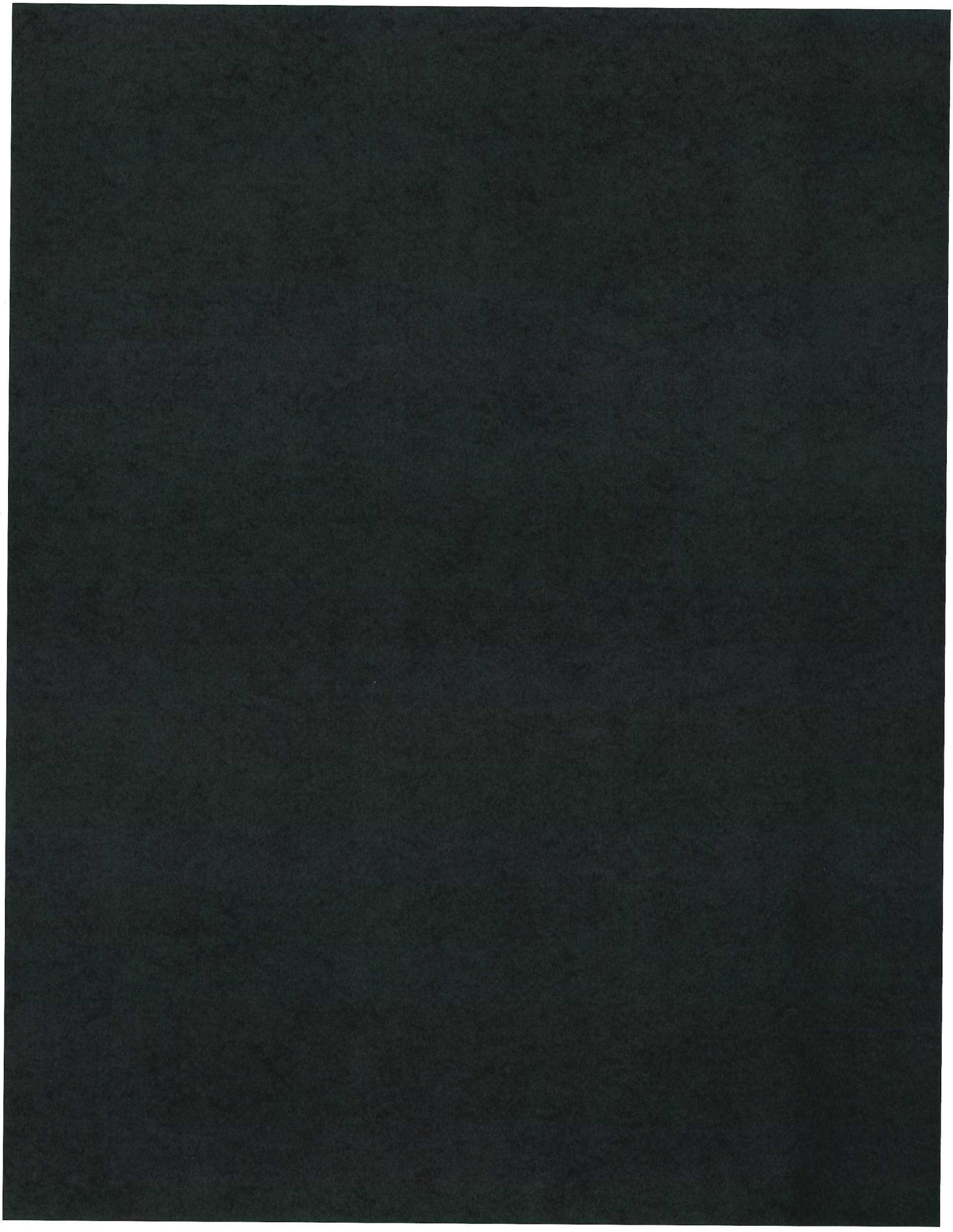
Figure 25 - Amount of direct debit payments in the Netherlands (Equens, 2012)

- One - Off ("eenmalige machtiging" in Dutch)
- Recurrent General ("doorlopende machtiging algemeen" in Dutch)
- Recurrent Business ("doorlopende machtiging bedrijven" in Dutch)
- Recurrent Games of Chance ("doorlopende machtiging kansspelen" in Dutch)

The variants differ in costs for the collecting organisation, refund period for payer, refund period for bank and the required method for notifications to the payer. For all the types a collecting organization must have a direct debit contract with their bank. The collecting organization can then collect from any account by providing the name and account number of the account holder, if there is enough money on the account.

Legally, the collecting organization must have a signed and dated authorization card (Incasso mandate) specifying the amount (to be) debited. Currence Incasso BV is the owner of the payment formula Direct Debit and has defined rules and regulations for the products Direct Debet. These rules include (Currence, 2012C):

1. an Incasso mandate is received in writing or by telephone;
2. only the agreed amount can be collected, with the agreed frequency, on the agreed dates;
3. only the amounts for the agreed products and/or services can be collected, following delivery;
4. collection is discontinued as soon as you receive cancellation of an Incasso mandate



An important lesson learned in this case study is that by the start of a project data is not widely available and gathering data takes much time, especially if data is scattered on different chain partners. Simulation will therefore not have added value to OEC at the start of a value chain project; the benefits are not higher than the costs for making a simulation model in the first period of such a project. However, the simulation model showed already useful benefits. If simulation would be used later in the project it is recommended to start designing the simulation at the start of the project as is done in this case study. Otherwise the benefits that helped in this first phase of the project would be missed.

7 Conclusions on the case studies

To be able to determine the added value of discrete simulation for the OEC department three case studies have been performed. It was the intention that these case studies would start at maturity levels 1, 2 and 3-4. However, the third case study -the Value Chain Steering project- did not have the envisioned maturity level 3 or 4. It's maturity level was between 1 and 2, and so we cannot draw conclusions about maturity level 3 or 4.

An additional issue of the third case study was that it was conducted at the start of an OEC project, while the first two case studies were performed near the end of the projects.

In this section, we will first consider the possibility for generalisation of results of the case studies. This will give the answer to the sub question *"To what extent is it possible to generalize the results of the case studies to other projects?"*. Paragraph 7.2 answers the sub question *"What are the differences of added value of discrete simulation at the different transitions of maturity levels?"* by comparing the case studies with each other. Finally, the possibility to generalize the simulation models will be discussed.

7.1 Generalisation of case studies to other projects

As opposed to a comparative research, a case study research can by definition not result in scientific conclusions that are generically applicable (Florusse & Wouters, 1991). With a case study research, only one or a few elements are the subject of research, which makes it not viable to draw general conclusions. In this paragraph the specificity of the case studies is discussed. If a case study has many specific elements that are only applicable for that case study, the results and insights are less valuable for other problems or projects.

Case study 1 was an example of an Operational Management Project in OEC. Other Operational Management projects have been analysed to find similarities and differences with the project under study. In 2010 an Operational Management project had been performed at the Mortgage Operations Support department. This department registers all the mortgage mail. The project showed several similarities with Case study 1; the maturity level of both projects were almost the same at the beginning and at the end of the projects. Furthermore the same approach, tools and instruments were used in both projects. One distinction between both projects was that in case study 1 people became redundant because of the improvements. This made the 'change management' part more important than in the Operational Management project at the Operations Support department. In interviews with Black Belts some other specific elements of the project were discovered. The process in the case study was a process that only took 2 hours in a day, and then all the mail was opened and sorted. Most processes within ING are done for entire days. At logistics it is more important to take the peak moments into account, these activities cannot be done later on in the day.

Case study 2 was an example of a Lean Six Sigma project. In most Lean Six Sigma projects a clear structure is used with the DMAIC steps (Define-Measure-Analyze-Improve-Control, see paragraph 3.4.2). Each phase is ended with a tollgate where a tollgate document is presented before the next phase starts. In this project no real tollgate documents were made. Although there were no tollgate documents, the project went through all the different phases and these phases adequately represent the phases of a typical Lean Six Sigma (LSS) project. In the

project a process was simulated that was not yet implemented. Black Belts mostly improve an existing process instead of improving a process that is going to be implemented. On this point the project is different to other LSS projects. In a LSS project where a current process is improved, simulation can probably be of more added value because testing improvements in an existing process is more risky than testing improvements in a process that is not yet implemented.

Case study 3 was a Value Chain Steering project. There are other Value Chain Steering projects done at the department Payments. By comparing this project with the projects that are already performed, there are many similarities. The involved actors, the complexity of the process and the inflow of the process are comparable with other processes in Value Chain Steering projects. Resistance to change, often does not materialize until the final phase of the project. As this project is only in its beginning phase, it is not yet possible to see if there is more or less resistance to changes.

The three case studies were three typical OEC projects. Problems in ING are unique, so there is a very small chance that the results of one of the case studies can be copied completely to another problem.

Comparing the three case studies, one case study is more complex than another case study. The complexity of a process has a relation with the maturity level. The organization and management of a process with a low maturity level is minor compared to higher level maturity processes: there are not many relations with other processes. Processes with a higher maturity level are broader managed, and therefore more dependencies arise and the process becomes more complex. The amount of involved actors is also higher in higher maturity levels.

7.2 The added value of simulation in the case studies related to the transition of maturity levels

In this paragraph the differences of the contribution of simulation in the case studies will be discussed. These differences will be related to the maturity levels of the processed.

Designing simulation models requires a structured way of working. We argue that many benefits of simulation models area are the results of designing a simulation and not of the result of the simulation model itself. For example, a benefit of simulation that is named by Oakshot (1997) is: "simulation often gives people a better understanding of the system." The case studies showed that a better understanding of the system is mostly created by designing the model. By desiging a simulation model each step or activity in a process is analysed and discussed. Such a structural way of working gives many insights, illustrated by an example from the third case study. In the third case study the input sources for the process "melding onterechte incasso" were discussed. By discussing these sources it seemed that some input sources were not used anymore, while the process manager thought that these sources were still in use. It is quenstionable if insights like these can be completely contributed to the simulation. Black Belts are also analysing processes for making flow-diagrams, however most times they do not strive for the same level of detail as one would when performing a simulation study of a process. We argue that many benefits of simulation are not purely contributable to simulation, these benefits can also be gained with other tools. But the tool simulation askes for a specific structured way of thinking that results in many benefits.

The following table summarizes the contribution of the simulation models and gives the process areas where simulation is of most added value. Below the table

these results will be discussed with the characteristics of the corresponding maturity levels.

Case study	Maturity Level (start)	Maturity Level (end)	Added value of simulation	Process Area where simulation had the biggest impact
Case study 1	1	2	- Simulation model optimized the schedules - Management was trained in Capacity Management with the simulation model - The simulation made the process transparent - The simulation model helped in obtaining commitment of management Logistics - Employees understood the changes due to the simulation model	Capacity management Transparency Change management
Case study 2	2	3	- the simulation identified the ´wrong´ business rules - new business rules could be tested with the simulation model - predictions about the STP% could be made with the simulation model - the simulation model made the process in Force transparent - the simulation model increased the understanding about the process and business rules	Continuous Improvement Transparency Change management
Case study 3	2	2	- the simulation model made the process more transparent, dependencies and involved actors in sub processes became clear - the simulation model specified which data was needed to manage the process -the simulation model helped in creating understanding about the problems	Transparency Change management

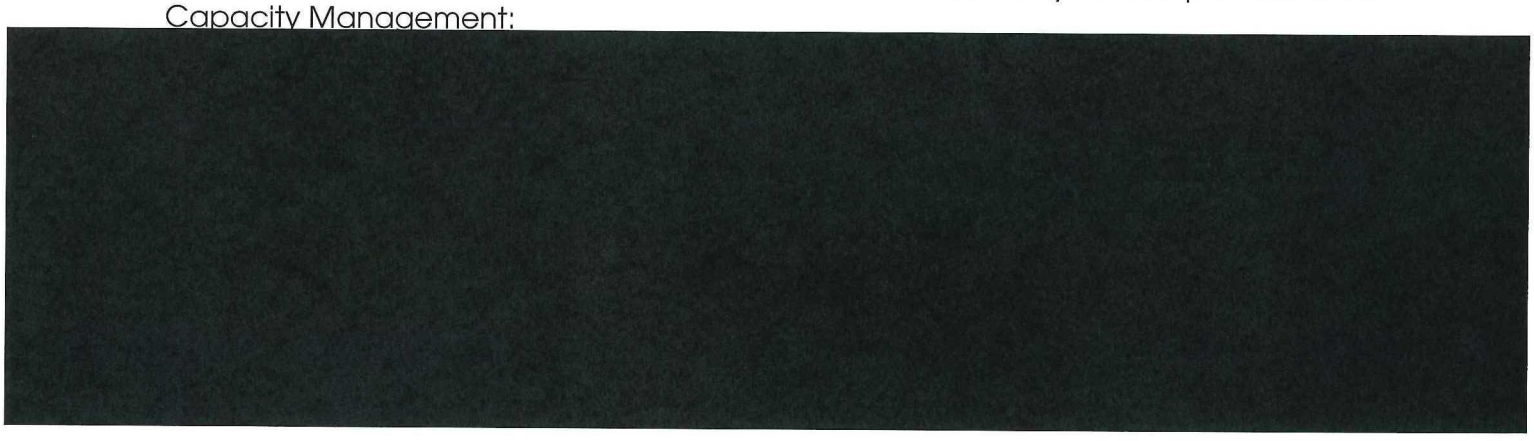
Table 27 - Added value of simulation in different maturity levels

7.2.1 Performance Management

In the case studies simulation was not considered as highly valuable for the process area Performance Management. Performance Management concerns the figures of the day-to-day activities of a department. The case studies showed that simulation did not add any value at this process area. Literature also states that discrete event simulation is considered as a tool that is more suitable to predict or test scenarios than managing day-to-day activities. However there are some authors that argue that simulation can be used in day-to-day activities, but they concern other simulation tools than were used in this research. For example Pfahl & Lebsanft (1999) and Powell et al. (1999) have written papers on simulation models that help in modifying planned work.

7.2.2 Capacity Management

The simulation model contributed a lot in the first case study to the process area Capacity Management:



- Management was trained in re-allocating employees during the day. The simulation model led to useful insights for the management about queues and idle employees. With these insights they could be trained in effective re-allocating capacity. Without these insights management would not re-allocate employees in the right way and the required throughput time would probably not be met.

Capacity Management was outside of the scope of the second case study. Capacity Management was inside the scope of the third case study, but in the first two months there were no improvements in Capacity Management. There was no data available in the first two months, and therefore no quantitative simulation experiments could be conducted for Capacity Management. We therefore argue that if there is no data available (schedules of employees, input for the process), simulation cannot add value to a project of OEC in the process area Capacity Management. This statement is however not limited for the tool simulation, interviews made clear that the same counts for the current way of working of OEC. The big improvements on Capacity Management are done in the last phases of a project, once the required data is available.

The contribution of simulation to Capacity Management is often discussed in literature about simulation in the health care sector; see Jacobson, Hall, & Swisher, (2006).

7.2.3 Continuous Improvement

Continuous Improvement is the activity to continuously improve activities or processes. A condition for high-quality continuous improvement is that management can identify waste in a process and analyse problems that results to this waste.

In the first case study, simulation contributed to continuous improvement by identifying the queues in the process. With these insights, management could make better changes in the process and so accelerate the process. Furthermore the simulation model resulted in added value by being able to test improvements. However, the level of added value of simulation was limited. An interview with a Black Belt made clear that the same results could have been obtained with the current methods and tools used by the Black Belts. The process has maturity level 1, the process is locally managed and there are no big dependencies with other processes. We argue that simulation is not needed to optimise a process with this level of simplicity. The department OEC has easier tools (such as Value Stream Mapping) that can be used to analyse and improve these simple processes. Simple pilots can also easily take place at this maturity level to improve the processes.

At higher maturity levels optimization takes place at broader processes (or combinations of activities from maturity level 1). These processes are more complex and therefore simple tools are not always sufficient to improve the processes. Case study 2 demonstrates a process where the current tools of OEC are not sufficient for efficient analysis and improvement of the process. Before the case study started, analytical analyses took place on data that was gathered from 10 employees who were testing a system. The simulation model made the 10 employees redundant and made better analyses on the causes of the problem. The simulation model was the main source and test instrument for continuous improvement of the process. In the second case study simulation was therefore of high added value.

The third case study did not yet have continuous improvement activities. As already stated before, this project was still in the beginning phase. There was no data yet available of the process, so the problems could not yet be analysed. In this

phase the simulation model did not contribute to the process area Continuous Improvement.

We argue that simulation has high added value in analysing problems and testing scenarios in processes with maturity level 2 or higher. The first case study showed that simulation did not add value on lower maturity levels because of the simplicity of the process. The last case study showed that without relevant data there is no added value; therefore we argue that simulation only contributes in the later phase of a project.

7.2.4 Transparency

Transparency is about having a shared description and understanding about activities of processes. All the case studies demonstrated added value of simulation to this process area Transparency. ING often uses flow diagrams to describe and discuss processes. These flow diagrams are static diagrams. The simulation models made the static process descriptions dynamic, which had a positive impact on the shared understanding about the processes in all the maturity levels. These more transparent process descriptions led to important insights in the case studies.

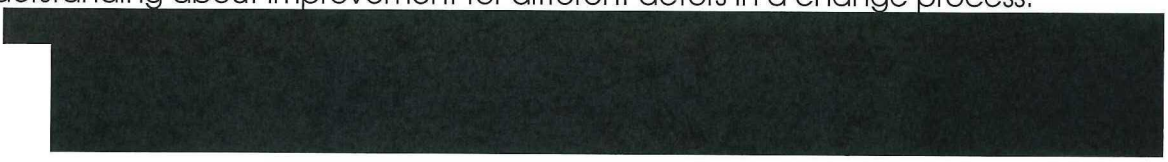
7.2.5 Visual Management

The process area Visual Management should not be confused with the visual representation of a process. The process area Visual Management is about visualising performances to employees on the work floor to make them more motivated. In none of the case studies simulation resulted in added value in the process area Visual Management. The impact of Visual Management was not made clear with simulation and simulation could not help to improve on this process area.

In the change process it is very important to visualise expected performances and new processes. This is however something else then Visual Management; this process area is about displaying the real performance on the work floor. Visualising expected performances in new processes will be discussed in the next paragraph.

7.2.6 Change Management

In all the projects simulation had high added value in change management. In this research change management was more important in the transition between maturity level 1 and 2 than in the transition between maturity level 2 and 3. This had to do with the changes and the involved actors. The step between maturity level 1 and 2 required a new way of working for many employees. The impact of the changes at this transition level was therefore much bigger than at the transition between maturity level 2 and 3. It is however also possible that a transition between maturity level 2 and 3 requires a total new way of working. We therefore argue that the importance of change management does not depend on the maturity level, but on the type of change. The contribution of simulation on change management did also not depend on the maturity level. In all the case studies simulation was used and contributed to change management in the acceptance phase of the commitment curve. The three different case studies showed that simulation creates more understanding about improvement for different actors in a change process.



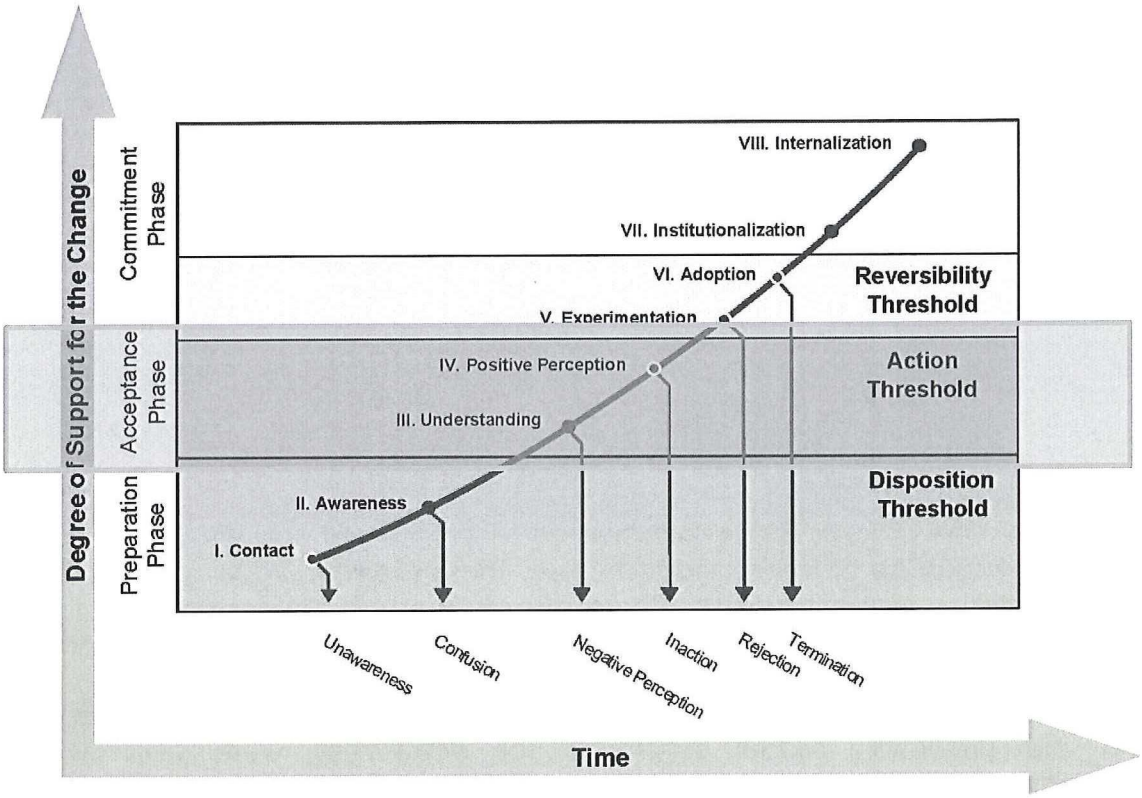


Figure 28 - Commitment curve, added value of simulation is on the acceptance phase

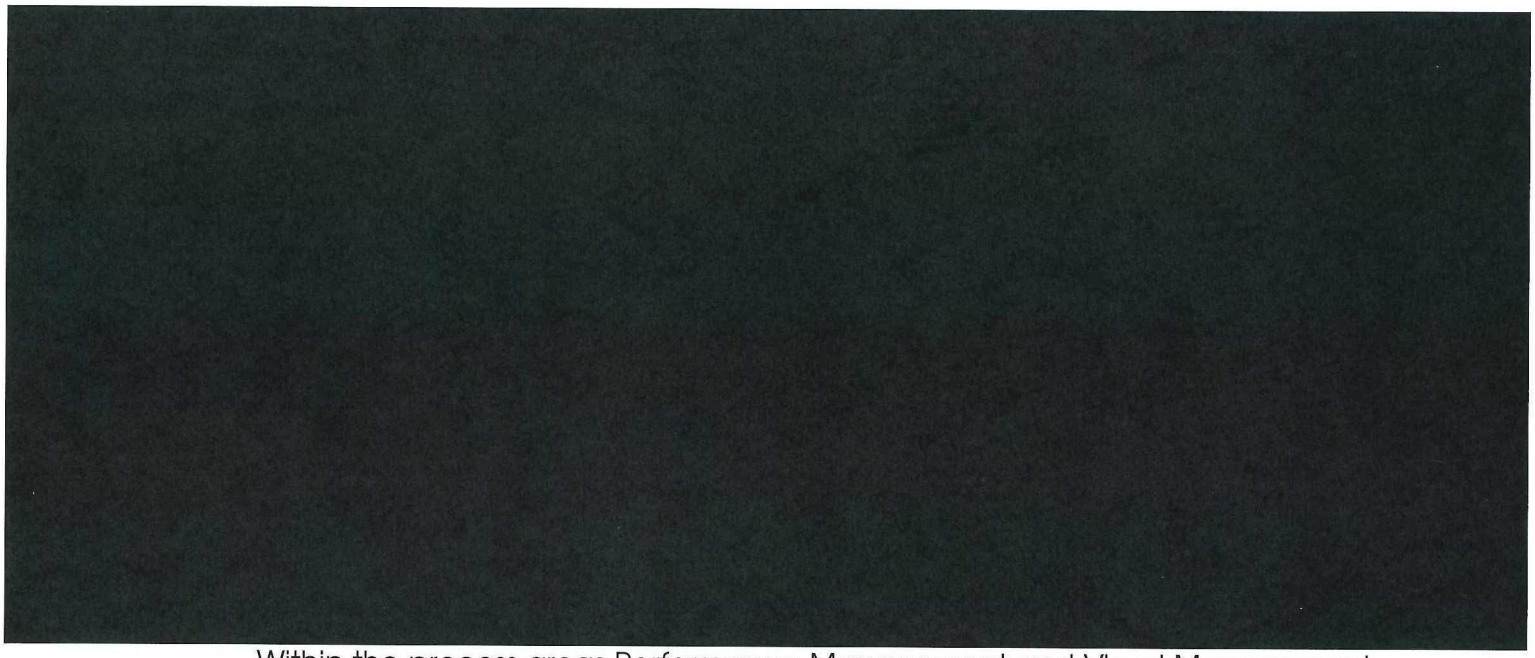
The case studies showed high added value of simulation in the acceptance phase of a change, see the orange block in Figure 28. A simulation models increases the understanding of process, Manuj, Mentzer, & Bowers (2009) and Hommen (2009) mentioned also this benefit of simulation in their articles. But they did not test the benefit in a case study. Based on the case studies we argue that simulation creates better understanding of a change in both higher management (those who should implement the change) as on the work floor, those who undergo the change. Both

aspects are important in a project, without commitment from higher management the change may not start and without commitment from the employees a change can easily fail.

7.3 Conclusion

Simulation did have added value for the department OEC in improving customer service processes of ING. The added value differed between the case studies. Case study 3 made clear that simulation is less useful in the start of a project. In the start of a project there is no or less data available which makes it not possible to conduct quantitative experiments with the simulation model. Without these quantitative experiments simulation can still be useful in terms of making processes more transparent and creating understanding for the changes. In the third case study these benefits of simulation were however not higher than the costs according to interviews with Black Belts.

If there is data available, simulation can have substantive added value in the different process areas of the PM&I model. The added value of simulation in the different process areas is gathered in interviews and visualized in Figure 29.



Within the process areas Performance Management and Visual Management simulation was of no or limited added value. These process areas concern the day-to-day activities of the processes, there are other simulation approaches that can contribute to the improvement of day-to-day activities (Pfahl & Lebsanft, 1999) (Powell, Mander, & Brown, 1999).

We argue that simulation is of high added value in Capacity Management. With the simulation model schedules for employees were optimized and management could be trained in Capacity Management. Without the simulation model less optimal schedules would be used and it would have taken much more effort to give management insights in the importance of Capacity Management. In the second case study Capacity Management was out of scope, so we cannot make conclusions on the contribution of simulation at this maturity level.

In the process area Continuous Improvement there is a difference in added value of simulation between a process with maturity level 1 and maturity level 2. Processes organised at maturity level 1 are significantly less complex. Case study 1 demonstrated that common sense and analytical tools are suitable to improve the

process design of a simple process. Simulation resulted in the same process design as made with the analytical tools, but making the simulation model took much more time. In the second case study the simulation model was of high added value in continuous improvement. Without the simulation model it would not have been possible to efficiently determine improvements in business rules. The simulation model could replace the activities of 7 persons who were testing different business rules.

The processes became much more transparent due to the simulation models. The simulation model resulted in insights in dependencies between different activities, business rules and people that were not known before.

Next to the substantive added value of simulation, the simulation models resulted also in added value in the process of implementing changes. People are going through a commitment curve in important changes. This commitment curve consists of different stages were the acceptance for a change is increased in each stage. The simulation models helped in all the case studies in the most important stage on the commitment curve: creating understanding about the change. Without the simulation model it would have taken much more effort for management and Black Belts to create a shared understanding about the changes in the projects.

Based on the conclusions from the case studies, simulation is not recommended for OEC to use in the following situations:

- Simulation should not be used if no data is available
- Simulation should not be used if a problem can be solved analytically, using common sense or if it is easier to perform direct experiments.
- Simulation software is expensive. Simulation should not be used if the costs exceed savings.

In this research system behaviour was not too complex to model and management did not have unreasonable expectation of the simulation model but based on literature (Ncetianz, 2012) two recommendations are added two the list to make the list more complete:

- If managers have unreasonable expectation or the power of simulation is over estimated, simulation may not be appropriate.
- If system behaviour is too complex or cannot be defined, simulation is not appropriate

8 Implementing simulation at OEC

In chapter 7 the conclusion is drawn that simulation is of added value for the department OEC. At this moment, simulation is not used at the department and employees are not trained to use simulation. This chapter will give some insights how OEC can implement simulation in order to benefit from the positive results of the simulation tool.

According Williams (2002) (1996) simulation should get the status "norm" in organisations and the exploitation of simulation power should be a standard step during the operation, design or revision of a process. Williams is a consultant who promotes business process simulation. According to Melão (2001), consultants and software companies saw big opportunities to extend their market share by using simulation and promoted simulation extensively. Melão states that the 'promoting articles' are not founded on critical analysis of the simulation phenomenon and its practice, but are based on 'success stories'.

Hommen (2009) agrees with Williams and states that using simulation as a 'norm' can lead to on-going, long-term benefits for the organisation.
Williams (2002) formulated 7 interrelated techniques that are highly useful to increase the ease and frequency with which a company gains productivity improvements through simulation. These techniques, which are listed in Table 30, will be addressed in this chapter. Williams explicit states that the techniques work best synergistically, in concurrency and co-operation.

1. constructing a support infrastructure within the company for simulation
2. disseminating awareness of simulation and its benefits throughout an organization
3. documentation of successful applications of simulation and the benefits accruing from them
4. organizing training classes and seminars in simulation
5. evaluation, choice, and support of appropriate software tools
6. evaluation and choice of simulation consultants and model builder
7. maintaining knowledge of and enthusiasm for simulation within the organization

Table 30 - Seven steps to make simulation norm (Williams, 2002)

8.1 Implementation of simulation during this master research

In this [redacted] OEC. The simulation model was presented to several employees within ING (from the lowest level in the organisation to the highest level) to make them aware of the added value and possibilities of simulation. All the presentations of the simulation model were successful and made people enthusiastic about simulation.

In a meeting of the OEC department with all the Black Belts (40 persons) a more extensive presentation was held about discrete simulation. In this meeting the Black Belts were enthusiastic about simulation as well. During the presentation, questions as 'When can I start using simulation in my project? This is very valuable for me!' already raised.

After a successful meeting with the Chief Operating Officer (Board of Directors), possibilities to buy a licence for simulation software were investigated and send to the Management Team of O&CI.

The Operational Management case study did also show the added value of simulation on a short term. In December 2011 the model of the second case study was presented to the manager of the Back Offices of ING. After this successful meeting, a presentation was set up for the manager of O&CI where the advantages of simulation were presented. In this presentation the first two case studies were treated and questions about the simulation models were answered. This presentation led to purchase of laptop with a single license for Rockwell's Arena (total investment: €34750).

Next to the simulation software OEC has hired two simulation consultants who can work with the simulation package. One of these simulation consultants started in February 2012. In the past this person performed a research within ING (Rutte, 2011) of combining simulation with Lean Six Sigma (not by OEC). The other simulation expert who is hired is the author of this research and will start in May 2012 at OEC. These simulation consultants will however not work full-time on simulation and modelling, they will also have other consulting activities. Next to the two simulation experts, OEC has also hired a graduate student who will do a graduating project on the added value of the combination between discrete event simulation and gaming. This graduate student starts in May 2012.

8.2 Next steps implementation of simulation at OEC

In the previous paragraph you could read that simulation is presented to several employees. OEC has bought a laptop with a simulation package and OEC hired two simulation consultants. With a simulation package and only two persons who can work with this package, simulation is not sustainable implemented at the department according to the seven techniques of Williams.

With the activities of the previous paragraph only 3 of the 7 techniques of Williams did get attentions (number 2, 5 and 6). To upgrade the use of simulation to the status of "norm", the other techniques should get attention as well.

8.2.1 Training

In this case study a simulation consultant (also called a simulation specialist or simulation expert) at OEC made the simulation models. This has several advantages and disadvantages. A simulation consultant can make better models then a person that makes simulation models occasionally. On the other hand, a simulation consultant leaves when a project is finished, which has the result that important knowledge about the simulation model is not available anymore for the users. If a person from a value chain makes a simulation model, the knowledge will stay (with the person) at the value chain, however the simulation model will probably have less quality.

Igor Rust (2011) did a research to the use of business process simulation by management consultants. Rust concluded that most management consultants cannot work with the current simulation tools and he designed a supporting tool that helps management consultants in modelling and simulating business processes.

Furthermore, Rust recommended to set up a permanent team of consultants that are specialized in simulation.

A lot has been discussed about what skills you need to use simulation. Some people say that almost no skills are needed for simulation. See for example Jim Sinur (2009), the leading BPM analyst at Gartner: "Most people think that simulation is hard and is for those gifted with deep math skills. Today, nothing could be farther from the truth. Simulation is nicely embedded in process modelling and BPM engines and pretty easy to use even for business folks". Many others say, including the author of this research, that many skills are needed to make a good simulation model (Khan, 2009) (PNMsoft, 2012).

The required computer and programming skills become less important in the last years due to better simulation packages. But for more complex systems, programming skills are still necessary. Having knowledge about a simulation package is however not sufficient to be a good simulation analyst. Data collection skills and statistical skills are maybe more important for a simulation consultant. Without correct input data or without a good interpretation of output data, a simulation model can give wrong conclusions. In the last place, good communication skills are also important for a simulation consultant to communicate outcomes to other actors. Simulation is often seen as a skill that can only be learned by doing many times. Shannon (1998) and Carson (2005) mention both that simulation is an art and a science. A science because of the data analytical skills that are needed. And they mention it an art because, like any art, you learn it by practising and mentoring. The tools or skills are not enough to be a good simulation consultant.

The skills needed for a simulation consultant have many similarities with the skills of a Black Belt. According to the iSixSigma organization, a top ten skill for a Black Belt is to have a technical aptitude. This technical aptitude is explained by having good computer/software literacy and analytical skills (iSixSigma, 2012). A master degree in engineering or statistics is not required for a Black Belt, but it will be beneficial in many cases. Next to the technical aptitude, a Black Belt should also have strong communication skills. Black Belts at OEC had an extensive training to get the required skills.

Because of the similarities on skills between a Black Belt and a simulation consultant (technical aptitude, communication), Black Belts seems to be a logical group to train in simulation skills. There is already a group Black Belts who showed their interests in learning simulation. By training a group Black Belts in simulation, a specialized team of simulation consultants can be set up as is recommended by Rust (2011). However, extra analysis is recommended on this field. It might be better to train both Black Belts as employees from the value chains, so they can make together the simulation models and keep the knowledge in the value chain.

A training of at least 3 days is needed before a person can make a standard simulation model (Systems Navigator, 2012). For more advanced models (as holds for the case studies) more days of training are needed. Training can be given in different ways:

- Training from an external company such as Systems Navigator (in-house or at a training centre)
- Online training, for example http://www.systemsnavigator.com/courses/
- Training from OEC's simulation consultants, who work at OEC

[redacted]

An analysis on the best training methods is recommended. After training, a simulation specialist should be able to build a simulation model by him-/herself. However, like stated above, simulation is an art and is best learned by practising. ING should make an analysis how they can support and mentor simulation consultants in their projects.

[redacted]

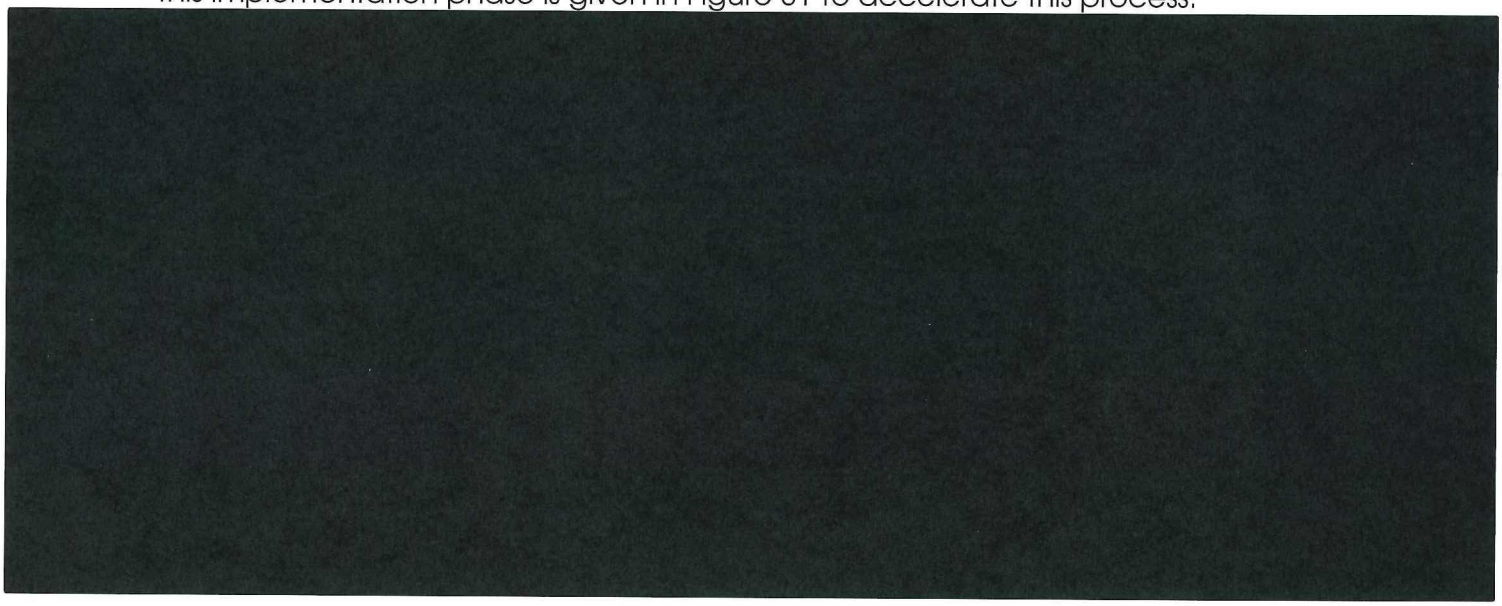
8.2.3 Creating awareness at ING

The steps discussed so far are aimed at implementing simulation at OEC. OEC is doing projects at value chains within ING to improve processes. These value chains should also understand the power of simulation models. If value chains don't trust simulation, it will not work. At this moment simulation is unknown at value chains, except at the departments of the case studies. Therefore, a showcase is needed to communicate the power of simulation to show value chains will better accept the tool simulation.

[redacted]

8.2.4 Planning

At this moment there is much enthusiasm for simulation within the ING. It is recommended to use this momentum and start soon with analysing the best training methods and implement simulation on a sustainable way within ING. A planning for this implementation phase is given in Figure 31 to accelerate this process.



9 Conclusion and Recommendations

This chapter starts by answering the research questions as defined in chapter 1. The several sub questions will be answered, resulting in the answer to the main research question. Paragraph 9.2 contains the recommendations for the department OEC and recommendation for further research.

9.1 Answers to the research questions

The first research question *'What are the maturity levels of the PM&I model?'* is answered in chapter 3 where an extensive explanation of the PM&I model is given. Many organisations use business process maturity models to improve processes. The PM&I model is a business process maturity model developed by the ING, and it consists of 5 maturity levels:

- Within level 1, the lowest maturity level, success of processes is the result of individual heroics, processes are simple and there are limited dependencies with other departments.
- At maturity level 2, activities and processes of a single department are in control by the department managers.
- One maturity level higher- level 3-, process management takes place at end-to-end level and processes are end-to-end in control.
- In maturity level 4, variation in processes is reduced and processes give a predictable and reliable outcome that matches the customer and business requirements.
- In level 5- the highest maturity level- there is proactive process management and continuous improvement established to ensure that processes meet the changing customer and business requirements. Within ING, and in other financial organizations, there are almost no processes with maturity level 5.

The second research question is about the tools that OEC currently use to improve processes and increase maturity levels *"How is OEC currently increasing the maturity levels of the PM&I model?"*. Chapter 3 answers this question by giving the three different types of projects that are done by the Black Belts. Operational Management is used to organise single departments (transition maturity level 1 – 2), Lean Six Sigma is used to improve a process on a specific element (transition maturity level 2 – 3) and Value Chain Steering is used to improve an end-to-end process by helping the chain to be more in control (transition maturity level 3/4 – 5). Case study 3 showed that Value Chain Steering projects are also performed on processes with lower maturity levels.

Criteria have been defined to answer the third sub question *"How can the added value of discrete simulation be evaluated?"*. Although some consultants and simulation software suppliers give the ROI of simulation, no objective criteria to determine the added value of simulation exist. When literature discusses the added value of simulation, most times the added value of a simulation project is mentioned. However, the added value of the *specific* simulation tool compared to other tools is limited discussed in literature. With internal documentation and in cooperation with Black Belts, criteria are set up to determine the added value such a specific simulation tool for a project of OEC. First, after the case studies these criteria are discussed in interviews with Black Belts and management to determine the added value of the specific simulation tool. Next to the substantive added value, criteria are also set up to determine the added value of simulation in creating commitment to

change. The Patterson-Cordon commitment curve (see paragraph 3.7) is used to get more insight in the specific area of the contribution of simulation.

The fourth sub question was *"What are the differences of added value of discrete simulation at the different maturity levels?"*. Three case studies have been performed to determine differences of DES at different maturity levels. In chapter 7 the results of these case studies are discussed. Simulation has contributed on the following elements:

- Simulation was of high added value in improving Capacity Management at a process with a low maturity level. A simulation model has been used to determine the optimal schedules for employees. Furthermore the simulation model helped in demonstrating the importance and impact of Capacity Management to managers.
- Simulation is of high added value in the process area 'Continuous Improvement' on maturity level 2. The simulation model identified dependencies between business rules and replaced the activities of 7 people of a test team. Simulation contributes in answering what-if questions about new business rules. On maturity level 1 processes were simple, and therefore an extensive simulation study was not needed to optimize the process.
- Simulation helped in making processes more transparent for managers and employees. ING used static flow diagrams to show how processes are controlled. The simulation models made the static flow diagrams dynamic, the dynamic diagrams gave more insights and were more easy to communicate.
- Simulation helped in both maturity level 1 as in maturity level 2 to accelerate a change process. An important phase in getting acceptance for a change is getting a shared understanding for the change. Simulation was of high added value in creating a better understanding for a change. Simulation models showed exactly the impact of a change, both to individual employees, as to the performance of a process.

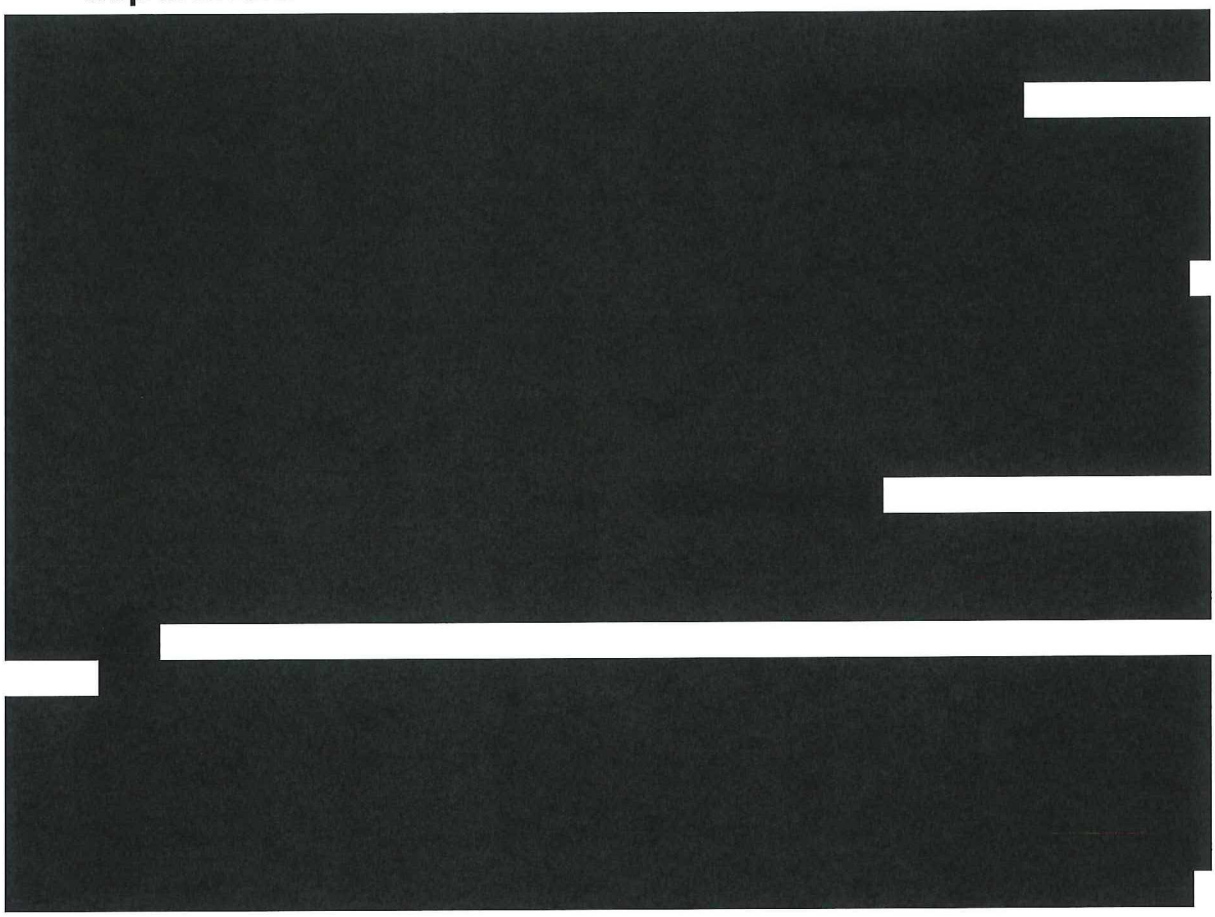
"To what extent is it possible to generalize the results of the case studies to other projects?" No general solid conclusions can be made based on only three case studies. Discussions with Black Belts made clear that the performed case studies were typical examples of OM, LSS and KKS projects of OEC. The lessons learned in the case study can be used in next projects.

The last chapter contained an analysis of the activities that are needed to sustainably implement simulation within ING and the department OEC. This analysis gives an answer to the sub question *"How can discrete simulation be implemented and ensured at OEC?"*. With the use of Williams' techniques (see paragraph 8.1), the important aspects for implementation of simulation have been addressed. Important aspects in this plan are:

- Purchasing simulation hard and software
- Creating awareness on simulation and demonstrating benefits of simulation
- Training employees at OEC in simulation

Where and how can discrete simulation add value to the way of working of the internal consultant department OEC in increasing maturity levels of the PM&I model?
In the transition to maturity level 2 and 3, discrete simulation adds value in both the change process in projects and in substantive aspects in projects. Simulation makes processes at each maturity level in the PM&I approach more transparent than the current tools of OEC. This adds value by communicating process improvements and by creating a higher sense of urgency. Furthermore simulation can add value at a low maturity level for Capacity Management and at a higher maturity level for Continuous Improvement. Extra simulation software and training of simulations consultants is needed to ensure the added value of simulation within OEC.

9.2 Recommendations for the Operational Excellence Consulting department



9.3 Recommendations for further research

Business process simulation has been dominated by the propaganda of software companies and consultants according to Meloã (2001). He states that this is one of the reasons that simulation has suffered from a lack of serious research. This research has given insights into the benefits of simulation at different processes and different maturity levels. This research made also clear that many questions on business process simulation are still unanswered:

- Besides discrete-event simulation, there are many other simulation techniques such as system dynamics or agent-based modelling. It would be interesting to determine the added value of other simulation techniques or combinations between simulation techniques. Successes of processes with maturity level 1 are for example mostly based on individual heroics. The actions and behaviour of actors are therefore very important in this maturity level. Agent-based modelling might be better in predicting and improving processes with maturity level 1 than discrete-event simulation (Siebers, Macal, Garnett, Buxton, & Pidd, 2010).
- In this research we used Bank's approach for building the simulation models. This is a traditional standard approach. In the last years many new promising simulation approaches have arisen, such as for example a simulation building block approach (Valentin & Verbraeck, 2002), gaming (Mclean, Jain, Lee, & Riddick, 2005) or a collaborative modelling and simulation approach (Barjis,

2011). Research to the added value of other simulation approaches can help in improving the quality of simulation.

- Next to the simulation technique and simulation approach there are also many simulation tools. Lots of knowledge about simulation is necessary to build the simulation models of this research. Further research is recommended in improving simulation tools so people with no background in simulation can make and use simulation models effectively and efficiently.
- The simulation models in the research were so called 'one-shot' simulation models, that were used in one project to improve a process. The models are not used for the day-to-day activities. Simulation models that are daily used to improve the process can probably be of high added value. Further research to the added value of simulation models for day-to-day management is recommended.

10 Reflection

In this chapter I will reflect on the research that is conducted for this master thesis project. I will reflect on the used methodology and research methods in paragraph 10.1. The case studies and the results of these case studies will be reflected in paragraph 10.2. In the last paragraph (10.3) I will reflect on the planning of this research project.

10.1 Research process and methodology

10.1.1 Case study research

The choice for doing a case study research was clear and logically from the first moment. OEC had especially asked to perform a research to the added value of simulation in their three types of projects. After almost 1 week I started already with modelling a process in the simulation package Arena to calculate throughput times. When I started to write my research proposal (1 week later) I realized that I had not used any research methodology and I did not know what the scientific relevance of my project should be. I discussed my problem with other graduate students and colleagues at ING. At that moment I discovered the models that are used by ING, and I found the PM&I maturity model. I dived into literature about the relations between maturity models and simulation and discovered that there was limited research on these aspects. Therefore I decided to investigate the added value and relation between maturity models and simulation.

Because I was going to perform a case study research, it was already clear for me that I should use a case study framework to set up and evaluate the case studies. During the first case study I read much literature about case studies and realized that it is very important to plan the process and evaluation methods in advance. So during the first case study I set up the process to compare and evaluate the case studies, and in the second and third case study I reaped the benefits of this. In the last phase of this project I discovered that it is not only important to make a process and evaluation method in advance, it is also important to describe this process and evaluation method extensively in your report. Without a good description how a case study is performed, the results are less useful for readers of the report.

10.1.2 Discrete event simulation

There are many different simulation methods and even more approaches to build a simulation model. I had already much experience in discrete event simulation and the problems at ING seemed suitable for discrete event simulation. Therefore, I made the decision to use discrete event simulation in my research. This decision was, at that moment, not well founded and quickly made. Looking back, discrete event simulation was a good and useful simulation method. The problems had typical characteristics that belong to discrete-event problems. There are many approaches to build a discrete-event simulation model. I had used a traditional approach that consists of setting up the goals, making a process map, collecting data and performing the experiments.

When there are more actors involved, other simulation methods or other approaches to build a simulation model can probably be of more added value. In the last case study I was going to simulate a process with many involved participants, who all did not understand the process completely. Because data was

not widely available, it took me much effort to have a good view on the process and to build the simulation model. Another simulation approach, for example collaborative modelling, could be more suitable for this case study. With collaborative modelling the simulation model would be made in a session with all the involved actors. Other simulation methods, such as a simulation game can also be very useful when there are many actors involved and strategic questions should be answered. In this thesis I only looked to discrete-event systems modelling with a traditional way of building the model, but during the case studies I realized that there are many other simulation approaches that can be useful. Especially in higher maturity levels (4 or 5) soft skills are becoming more important, other simulation are than probably better.

10.1.3 Evaluation method of the added value

I used interviews to determine the added value of the tool simulation in the projects. A simulation model can contribute by improving a process. The qualitative benefits of such a contribution can often not be determined, because the situation without the tool simulation model is most times not known. Without simulation model a process would be less efficient or more risky. The simulation model helped in improving the process so it became more efficient.

In the most optimal situation you would compare two projects where you improve the same process twice: with and without simulation. In this way you can objective compare the end-results of the two projects and determine the added value of the tool simulation. However, it is for a commercial company not interesting to perform a project twice. This would double the costs of the project.

The consultants at OEC are experienced Black Belts who are doing many projects and so they can make good predictions about the results of projects. The experience of these Black Belts is used in interviews to determine the contribution of simulation to a project. In cooperation with Black Belts criteria are set up to determine the added value of a project. Many discussions took place to make these criteria suitable for all processes.

The interviews gave good insights in the added value of simulation. For the Black Belts and the managers it was clear that simulation contributed highly to the end results of the projects. For this reason, ING had already invested in a simulation package and starts using simulation in other projects. Qualitative benefits are however still less convincing than quantitative benefits. Most managers think in costs and in that respect it would be interested to have a return of investment of the tool simulation. As mentioned earlier, the qualitative benefits could not be measured in this research because the situation without a simulation model was not known. The Model Office Team in the second case study is an exception on this. At the moment that the Model Office Team started with testing Force, it was unknown that a simulation model would be build. The simulation model made clear that 7 (of the 10) people of the Model Office Team were redundant because of the simulation model, this could be translated in costs.

10.1.4 Case studies

Three projects were chosen for a case study in this master thesis project. Choosing the case studies was a difficult process, the project should be suitable for the research but ING had also their preferences about the projects. Looking back to the case studies there were some elements of the case studies that made the research less satisfying. In the second case study, Capacity Management was out of scope. Therefore no conclusions could be drawn about the contribution of simulation to

Capacity Management on maturity level 2. Case study three was started together with the project itself, it was better for the research if all the case studies were performed in the same moment of the project. In that way the comparison between the case studies would be fairer. On the other, case study 3 has now given insights in the contribution of simulation in other phases of an OEC project. This insight is also important for OEC. Case study 3 did also not have the maturity level as what was intended. The intention was to perform a case study at maturity level 1, 2 and 3 or 4. The last case study should have been a case study on maturity level 3 or 4, however when the case study was started it seemed that the maturity level was not even 2. Reflecting on the case studies, the research could have more general conclusions if clear requirements were defined and used for the case studies.

10.2 Reflection on the planning

I started my research at the 19th of September 2011. To stay focused, I made a planning with different deadlines to work to. My first intention was to finish my project in 5 months, at the end of February 2012. The first weeks of my graduation project proceeded smoothly. In the fourth week of my project I held my kick-off meeting with my graduation committee.

My mid-term meeting was planned in the end of December. I did not take holidays into account in my planning and therefore the project took somewhat longer than was planned in December. Therefore, I had to schedule my mid-term meeting in January. Planning a meeting with the full graduation committee seemed difficult due to busy agendas. The result was that separate mid-term meetings took place with the different super visors.

The useful comments of the mid-term meeting were taken into account and I proceeded with the graduation project. Because it was difficult to schedule a mid-term meeting with all the supervisors, I started soon after the mid-term meeting with planning my green light meeting and with my graduation date. Unfortunately it was not possible to plan the graduation date in the end of March as was planned in my mid-term meeting.

During the project I followed my planning quite well. Only in December there were some delays (2 weeks) due to the holidays that were not taken into account in the planning. In 2012 the project did also take some weeks longer due to difficulties in planning the green light meeting and the graduation date. Looking back, it is probably positive for this paper that the green light meeting and graduation date were delayed for a few weeks. If the planning has been followed, the schedule would have been really tight what probably had a negative influence on the quality of this report.

In the planning there were two months scheduled for each case study. The master thesis project was however not only about the case studies, also this report should be written. Many graduate students advised me to start as soon as possible with writing the report, so not all the work has to be done in the last weeks. Although I started with writing my report early in the project, the most part of writing and improving the report took place in the last months before the green light meeting. Therefore, my workload was higher in the last months and there was less time for the third case study compared with the other two.

I would recommend fellow students to schedule all the meetings with the graduation committee (mid-term, green light and graduation date) already before the kick-off. In the first place, these meetings are hard deadlines that make you more motivated in the project. In the second place, agendas can be very busy and this can results in unnecessary delays.

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12 Appendices

The appendices of this report are confidential. Please contact Robbert Weijers for more information about the appendices: robbert.weijers@ing.nl

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