MASTER THESIS

IMPLEMENTING THE ISO/IEC 15288 SYSTEMS ENGINEERING STANDARD IN DUTCH CIVIL AND INFRASTRUCTURE CONSTRUCTION ORGANISATIONS AND THEIR PROJECTS

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Rotterdam, 26-03-2020

UNIVERSITY OF TWENTE.

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Abstract

One of the largest clients in the Dutch civil and infrastructure construction industry, Rijkswaterstaat, is mandating contractors to adopt the ISO/IEC 15288 Systems Engineering standard in construction projects. Theory suggests that Systems Engineering standards should be implemented in the organisational processes of a construction organisation. Projects executed by the construction organisations should consequently tailor these organisational processes to project processes on basis of project-specific needs. This paper examined how the ISO/IEC 15288 was implemented in three construction projects in The Netherlands. Despite the fact that the construction projects investigated succeeded in the implementation of the ISO/IEC 15288, this study found that process managers developed project processes and tailored the ISO/IEC 15288 for each project again. Three major explanations as to why process managers redevelop project processes and tailor the ISO/IEC 15288 for each project were found in this study. They are: i) lack of compliant organisational processes, ii) inward project focus by the process managers and iii) the lack of top management commitment for the implementation of the ISO/IEC 15288. Recommendations for process managers to increase the efficiency of the ISO/IEC 15288 implementation on construction projects are to i) develop compliant organisational processes using a bottom-up approach, ii) implement these compliant processes on construction projects with a social learning approach and iii) ensure top management commitment to develop compliant organisational processes and adopt these on projects. Process managers should first focus on processes that are enacted similar in different construction projects, e.g. risk management and planning. They should introduce the compliant organisational processes with e.g. workshops. Top management commitment can be increased by involving them in the assessments or audits that concentrate on the ISO/IEC 15288.

Key words: Systems Engineering standards, ISO/IEC 15288, Dutch civil and infrastructure construction industry

1. Introduction

The past ten years have shown an increased interest in Systems Engineering in the civil and infrastructural construction industry. This increased interest is reflected in literature too (De Graaf & Loonen, 2018; De Graaf, Voordijk, & Van Den Heuvel, 2016; De Graaf, Vromen, & Boes, 2017; Elliott, O'Neil, Roberts, Schmid, & Shannon, 2012; Locatelli, Mancini, & Romano, 2014). Furthermore, this increased interest is also indicated in practice (Farnham & Aslaksen, 2009; INCOSE, 2012, 2015; ProRail, 2015; ProRail et al., 2013; Rijkswaterstaat, ProRail, Bouwend Nederland, NLingenieurs, & Vereniging van Waterbouwers, 2009). Two large clients, Rijkswaterstaat (the Dutch Highway & Waterway Authority) and ProRail (maintainer of Dutch railways), prescribe the use of Systems Engineering on their projects (Elliott et al., 2012; Rijkswaterstaat et al., 2009). In addition to Rijkswaterstaat and ProRail, many other clients in the Dutch civil and infrastructural construction industry have also embedded Systems Engineering practices in their working methods (ProRail et al., 2013; Rijkswaterstaat et al., 2009).

Rijkswaterstaat goes even further than other clients by mandating contractors to also implement and adhere to a Systems Engineering standard into their construction projects. This standard is the ISO/IEC 15288:2008 system life cycle processes (in short ISO/IEC 15288) (Pfauder, Schweigert, & Hendriks, 2017; Van Loon, 2012). The ISO/IEC 15288 standard provides a framework with which contractors can design their project processes (ProRail et al., 2013). The ISO/IEC 15288 focuses on the whole life cycle of a system (Arnold & Lawson, 2004) and distinguishes four process groups: agreement processes, organisational project-enabling processes, technical management processes and technical processes, containing in total 30 processes (ISO/IEC/IEEE, 2008). Traditionally, Systems Engineering in the Dutch infrastructural and civil construction industry is in line with the technical processes of the ISO/IEC 15288 (Rijkswaterstaat et al., 2009). Therefore, Rijkswaterstaat takes a broader look than only the technical processes of a construction project. The reason behind this, as Van Loon (2012)

argues, follows from Rijkswaterstaat's shift from a construction client expert to a construction client contract manager, a role imposed on them by Dutch government.

The ISO/IEC 15288 makes a distinction between the organisational level and the project level of a business. Theory and guidelines concerning Systems Engineering standards describe that Systems Engineering standards should be implemented in the organisational processes at the organisational level. These organisational processes should then be tailored to project processes, dependent on project specific requirements (INCOSE, 2015; ISO/IEC/IEEE, 2008; Sheard, 2001; Walden, 2007). Accordingly, the intention of the ISO/IEC 15288 is that a business implements the ISO/IEC 15288 into the organisational processes at the organisational level, that is, into the organisational processes. ISO/IEC 15288 defines a process as: "*a set of interrelated or interacting activities that transforms inputs into outputs".* The organisational processes are repeatedly tailored and applied to the projects of the business. Therefore, the projects' processes are derived from the organisational processes (ISO/IEC/IEEE, 2008). Berglund, Böckmann, & Cuklev, (2009) & INCOSE (2015) present advantages of adopting organisational processes compliant to a Systems Engineering standard on different projects of a business. One benefit is that there is less need for reinventing the processes for each separate project of a business. Other benefits include more focus on efficiency gains and organisational learning. So, there are benefits of implementing the ISO/IEC 15288 in the organisational processes and tailor these processes to different projects.

However, Rijkswaterstaat only mandates contractors to implement the ISO/IEC 15288 at the project level, into the project processes. If the ISO/IEC 15288 is only implemented in project processes and these project processes are not derived from organisational processes, aforementioned benefits are not likely to be achieved. Consequently, this leads to efficiency losses for construction organisations. Moreover, theory seems not to be aligned with practice and lacks insight in how these inefficiencies can be managed. Therefore, the aim of this research is to make recommendations to process managers responsible for ISO/IEC 15288 implementation in construction projects to increase their efficiency. More efficiency means that process managers and other project employees have to put less effort in the implementation of the ISO/IEC 15288 into construction projects. This aim is achieved by investigating how process managers of construction organisations implemented the ISO/IEC 15288 into construction projects where Rijkswaterstaat was client. Findings are compared with a conceptual model that was derived from theory and developed for this study. Differences and similarities have been explained and after a comparison with literature, recommendations for process managers have been made.

The topic of this paper is of importance, since the implementation of Systems Engineering standards in civil and infrastructure construction has not been widely investigated before. Particularly the project-oriented focus of the industry versus the organisation-oriented focus of theory are of interest. This research tests and contributes to the enrichment of existing theory and aims to enhance the implementation of Systems Engineering standards on construction projects. The following research question will be answered in this paper: how can process managers implement the ISO/IEC 15288 Systems Engineering standard into their projects in a more efficient manner? To answer this research question, three Design-Built-Finance-Maintenance-(DBFM)-construction projects with Rijkswaterstaat as client served as case studies for this research. The next section of this paper presents the conceptual model that was developed for and used in this study. The third section describes the methodology applied. The fourth section presents the results, after which the fifth and the sixth sections present the discussion and conclusion.

2. Conceptual background

The research of this paper aims to make recommendations to process managers to increase the efficiency of the implementation of the ISO/IEC 15288 in Dutch civil and infrastructure construction projects. Therefore, this section presents a conceptual model illustrating how this can be achieved theoretically. This conceptual model is derived from literature and guidelines in regard of the implementation of Systems Engineering standards. First, Systems Engineering standards are defined. Second, the theory is presented from which as third the conceptual model is developed.

2.1 Systems Engineering standards defined

Systems Engineering can be defined as *"an interdisciplinary approach and means to enable the realisation of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem: operations, cost and schedule, performance, training and support, test, manufacturing, and disposal. Systems Engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs"*

(INCOSE, 2015). Correspondingly, Systems Engineering standards "*define the interdisciplinary tasks that are required throughout a system's life cycle to transform the customer needs into a systems solution"* (Chang, Perng, & Juang, 2008). Systems Engineering standards define "what" should be done, and not "how" certain activities need to be performed. The ISO/IEC 15288 presents its required interdisciplinary tasks as process activities, tasks and process outcomes. For instance, the ISO/IEC 15288 requires for the risk management process as:

- process outcome that *"risks are identified"*,
- process activity to *"analyse risks"*, and
- one of the aforementioned activity's tasks to *"evaluate each risk against its risk thresholds"*.

2.2 Implementing Systems Engineering standards in projects

Theory describes that implementing Systems Engineering standards consists of the incorporation of the Systems Engineering standard into the organisational processes at organisational level, and then tailoring these organisational processes to project processes at project level. The conceptual model aims to concentrate on the effort of the process manager responsible for the ISO/IEC 15288 implementation at project level. As the implementation of the ISO/IEC 15288 at organisational level is crucial from the perspective of theory, steps needed in organisational tailoring have also been also described in the conceptual model. The conceptual model that is presented in this section, derived from Sheard (2001) & Walden (2007), focuses on implementing the Systems Engineering standards into existing organisational processes instead of developing a completely new set of organisational processes. In this way, they aim to maintain more sustainable organisational processes, i.e. they are able to cope with changes in the Systems Engineering standards or other changes better. The next two paragraphs describe the nine steps of the conceptual model, divided in organisational tailoring at organisational level and project tailoring at project level.

2.2.1 Organisational level

Sheard (2001) and Walden (2007) present that a Systems Engineering standard should be implemented in the organisational processes of a business. An important part of implementing the Systems Engineering standard at organisational level is organisational tailoring. In organisational tailoring, a business *"adapts external standards in the context of the organisational processes to meet the needs of the organisation"* (INCOSE, 2015). The first three steps describe organisational tailoring. The first step of organisational tailoring is that a business should have an understanding of the organisational processes and the Systems Engineering standard. With this understanding, a business should define its own needs and select the requirements of a Systems Engineering standard that meet that needs. Accordingly, Walden (2007) emphasizes that organisational tailoring should take place from the standard to the business. So, the second step is that a business should define its needs and the third step to select the elements of the standard that cover that need. When needs from the Systems Engineering standard are determined and selected, businesses can shift their focus to the organisational processes.

After organisational tailoring, the fourth an fifth step concentrate on the implementation of the Systems Engineering standard into the organisational processes. The fourth step is to identify gaps between the Systems Engineering standard and the organisational processes. To identify these gaps, business should make a mapping. Mapping aims at determining where processes and process-activities that are required by the Systems Engineering standard are performed in the organisational processes (Sheard, 2001). If required activities are not described yet in the organisational processes, the mapping results in gaps. The fifth step is that organisations address these gaps. Organisations have multiple ways to address these gaps. Sheard (2001) suggests that gaps should be addressed on a case-by-case basis and presents several ways to handle a gap: i) the activity can be tailored out if (projects of) the business do not need the practice, ii) if an activity is needed, it can be included in one of the existing organisational processes, iii) if the set organisational processes do not contain a whole needed process of the Systems Engineering standard, a new process must be developed. The outcome of the five steps at organisational level is a set of organisational processes compliant to the Systems Engineering standard.

2.2.2 Project level

After the organisational processes are compliant to the Systems Engineering standard, these processes should be adapted to the specific needs of the project. This is project tailoring, which aims at deleting for the project unnecessary activities, while maintaining integrality of the system. Project-specific requirements must be the basis of the project-tailoring, and not merely preferences of project-participants (Walden, 2007). For instance, if a project decides to not execute certain activities of risk management, e.g. to *"evaluate each risk against its risk thresholds",* these activities can be tailored. Accordingly, the sixth step is that process managers on construction projects should determine these project-specific requirements. Factors that influence project-tailoring and result in project-specific requirements are for example stakeholders, project budget, schedule and requirements, risk tolerance and complexity (INCOSE, 2015). For determining the project-specific requirements, process managers should first understand the organisational

processes and the needs of the project. Besides tailoring, that concentrates on eliminating process requirements, process managers should also focus on changes needed beyond tailoring (Sheard, 2001). This is step seven. Step eight is that process managers identify where they have to adapt the organisational processes, on basis of the identified project-specific requirements. The theory suggests that business should put a tailoring policy in place in order to align project tailoring decisions with organisational policies. Tailoring policies prevent that personal preferences of project employees overrule organisational requirements. They also assure that the integrality of the Systems Engineering processes is maintained and that affected parties are consulted (INCOSE, 2015; Walden, 2007). Therefore, step nine is that process managers tailor the activities out following an organisational tailoring policy.

2.2.4 Organisational contextual factors

Other relevant factors or conditions within the context of the business affect a successful implementation of Systems Engineering standards as well. First, Sheard (2001) claims that the biggest issues are to make employees understand what processes are, getting them written down and having management to enforce that processes are executed. Second, Walden (2007) also emphasizes the need for organisational commitment. He claims this should be enforced by (top) management and backed with enough resources (time and people). Defining the processes is just considered as easy first step. Third, the organisation must be willing to change. Important aspects for this are leadership, communication, training, tools, and deployment (Walden, 2007). Fourth, Walden (2007) highlights that the standard must be institutionalized at the "right" level. Figure 1 displays the different levels of the process hierarchy, which are policies, procedures, instructions and supporting materials. Walden (2007) shows that (activities required by) the Systems Engineering standards should be integrated in the procedure level, that describes "what" should be done. This is important, since the standardisation of the Systems Engineering processes should focus on the same level. Fifth, only the process group, and not the whole business, has to understand the new model (Sheard, 2001). The process group are those employees responsible for maintaining and improving the processes of the business. Learning the business' employees all ins and outs of the new Systems Engineering model is not necessary and will probably only lead to confusion. However, process managers require understanding of the standards, including Systems Engineering standards, with which the organisational processes are currently compliant and how the organization's processes relate to them (Sheard, 2001; Walden, 2007). This is important, since different standards often have similar requirements (Sheard, 2001). Sixth, business should use their own terminology as much as possible, instead of copying the terminologies of the Systems Engineering standard (Pfauder et al., 2017; Sheard, 2001; Walden, 2007). Walden suggest that the business' terminology (and culture) should be maintained to prevent confusion and frustration by the employees.

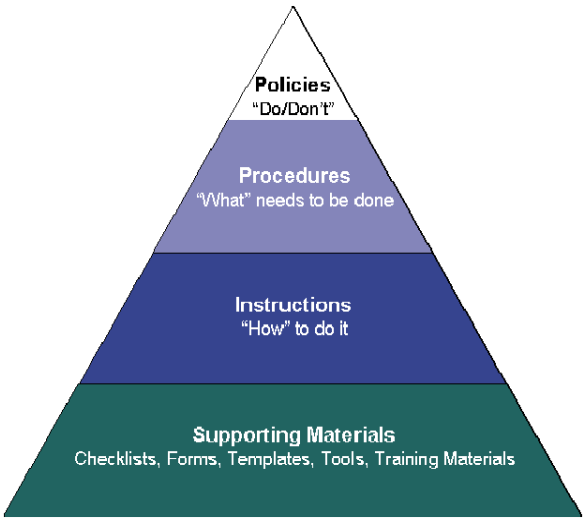

Figure 1: Different levels of the process hierarchy. Adopted from Walden (2007)

2.3 Conceptual model

The conceptual model to implement the ISO/IEC 15288 in projects, derived from theory, consists of the following nine steps (1-9) and six other organisational contextual factors (A-F):

Organisational level

1. Understand the common organisational processes and the ISO/IEC 15288 Systems Engineering standard.
2. Define the needs of the organisation.
3. Select the elements of the ISO/IEC 15288 that meet the needs of the organisation.
4. Identify gaps between the needed ISO/IEC 15288 requirements and the common organisational processes by making a mapping.
5. Address gaps that result from the mapping between needed ISO/IEC 15288 requirements and the common organisational processes on case-by-case basis.

Project level

6. Determine project-specific requirements that influence project tailoring.
7. Identify other changes needed beyond tailoring.
8. Determine in which project processes and process activities tailoring is required by making a mapping.
9. Tailoring activities out of the compliant organisational processes following an organisational tailoring policy. Record tailoring decisions.

Organisational contextual factors

i. Create understanding of processes in general by employees.
ii. Ensure organisational commitment for the implementation of the ISO/IEC 15288 Systems Engineering standard.
iii. Organisations must be willing to change and implement the ISO/IEC 15288 Systems Engineering standard.
iv. Understanding the ISO/IEC 15288 Systems Engineering standard only required for process management group, not for the whole business.
v. Implement the ISO/IEC 15288 Systems Engineering standard at procedure level.
vi. Use own terminology of the business and not that of the ISO/IEC 15288 Systems Engineering standard.

Figure 2 shows the conceptual model. The figure shows that in step 1-5 compliant organisational processes are developed from the ISO/IEC 15288 Systems Engineering standard. In steps 6-8, performed by process managers in projects, the compliant organisational processes are transformed to project processes. These project can be conducted in different periods of times. Lastly, the figure shows the division between the organisational and project level.

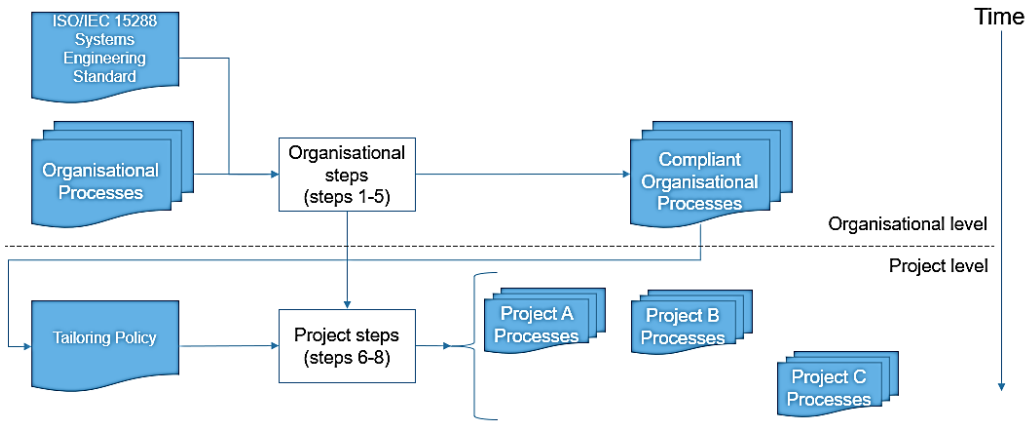

Figure 2: The conceptual model visualized

3. Methodology

The previous section presented a conceptual model that described how the Systems Engineering standard could be implemented at organisational level and how these organisational processes can be adopted in projects. This conceptual model has been compared to practice in order to discover and explain differences and similarities between theory and practice. To investigate the situation in practice, this paper adopted a case study approach.

3.1 Getting started

A case study strategy is suitable for this research since it allows to observe contemporary, real life events in a high level of detail, while still obtaining a holistic perspective (Verschuren & Doorwaard, 2007; Yin, 2014). The implementation of the ISO/IEC 15288 Systems Engineering standard into projects is an examples of such events.

In total, three construction projects have been selected as case studies. Selection criteria were that conformance to ISO/IEC 15288 was contractually required, hence all projects have Rijkswaterstaat as client and a DBFM-contract. Table 1 presents the cases investigated, which are:

1. Case A: The A6 project near Almere. Main contractors of the A6 project are construction organisations Dura Vermeer and BESIX.
2. Case B: The A16 project near Rotterdam, which consists of the combination of construction organisations Dura Vermeer, BESIX, TBI and Van Oord.
3. Case C: The N18 project near Enschede-Groenlo. This project was executed by different subsidiaries of KWS.

The projects of case A and B were in de construction phase at the time of the case studies, but had already implemented the ISO/IEC 15288 Systems Engineering standard. The construction phase of case C was finished in May 2018 and the case project is currently in the maintenance phase. Table 1 shows the cases and the main contractors of the case projects.

Table 1: The three case projects

Case	Project	Main contractors
A	A6 Almere	Dura Vermeer, BESIX
B	A16 Rotterdam	Dura Vermeer, BESIX, TBI, Van Oord
C	N18 Enschede - Groenlo	Different subsidiaries of KWS

3.2 Data collection

Data collection focussed on the period in which projects developed their processes and the ISO/IEC 15288 was implemented. This is the period until the construction projects obtained their commencement certificate. Data were collected via document analysis, expert interviews and observations.

The collected documents were:

- The ISO/IEC 15288 Systems Engineering standard.
- The DBFM contracts of the projects, in which Rijkswaterstaat defined specific project process requirements.
- Project management plans and quality (management) plans, in which projects describe how the ISO/IEC 15288 was implemented.
- ISO/IEC 15288 cross-reference lists and tailoring documents from the projects.
- Other project documents, like guidelines and presentations of workshops. Process managers used these documents to explain the implementation of the ISO/IEC 15288 to the project employees. Reports of assessments were also studied.
- Documents and guidelines of Rijkswaterstaat, e.g. Rijkswaterstaat (2017)
- Organisational documents concerning process standardisation and implementation of the ISO/IEC 15288 at organisational level of Dura Vermeer.

Fourteen interviews were held in total. Two interview rounds were conducted with process managers. First to obtain insight in how the ISO/IEC 15288 was implemented, and second to explain findings of the first interviews and document analysis. The quality managers only participated in one interview round. These interviews were used to further explain findings of the first round of interviews with the process managers and of the document analysis. To sum up, interviews for each case were held with:

- Case A: Process manager and quality coordinator who were responsible for the development of the project management system.
- Case B: Process manager and process coordinator who were responsible for the development of the project management system.
- Case C: Process manager and quality coordinator who were responsible for the development of the project management system.
- Two quality managers of different contractors who were involved with (attempts to) integrating the ISO/IEC 15288 into the organisational processes. These quality managers are not bound to a case.

In addition, meetings and workshops were observed of a team responsible for an attempt to implement the ISO/IEC 15288 at organisational level at one of the contractors. Besides, assessments by an external organisation that focussed on the sufficient implementation of the ISO 15288 in the construction projects were observed. The observations within this study helped clarifying the findings. Lastly, many informal interviews were used to increase understanding and validate findings.

3.3 Data Analysis

The first step in the data analysis was a within-case analysis. Pattern matching and gap analysis aimed to identify the similarities and differences between the Systems Engineering standard implementation within the case projects and theory. To support pattern-matching, the conceptual model has been operationalised in Appendix I. The pattern-matching approach utilizes non-equivalent dependent variables as pattern (Yin, 2014). Gaps resulting from the gap-analysis indicate a mismatch between the theoretical pattern and practice. The second step was a cross-case analysis, that aimed at finding patterns across cases.

4. Results

This section provides the findings of the cross-case analysis and explanations for these findings. Since the cases investigated were similar to a great extent, findings of the within-case analysis are not presented here. The findings of the within-case analysis can be found in Appendix II. The numbers behind sentences in the findings section below refer to steps of the conceptual model as presented in the theory section.

4.1 Findings

The findings are presented in three subsections, which are the organisational level, project level and the contextual organisational factors.

4.1.1 Organisational level

This research focussed on how process managers implemented the ISO/IEC 15288 in construction projects. The findings of the three case studies showed that at organisational level the involved construction organisations did not tailor and implement the ISO/IEC 15288. Observations of meetings at one construction organisation highlighted that understanding of the ISO/IEC 15288 was low (step 1). Furthermore, construction organisations did not determine their needs and select the elements from the ISO/IEC 15288 that fulfil that needs (step 2 and 3). Since the construction organisation had not integrated the ISO/IEC 15288 into the organisational processes, mapping and addressing gaps was not performed at organisational level (step 4 and 5).

4.1.2 Project-level

At the project level, process managers are responsible for the development of the project processes. These process managers all conducted several steps. They began with analysing the contractual requirements, including ISO/IEC 15288 requirements and requirements derived from tender plans. Process managers determined the specific ISO/IEC 15288 requirements by following the Tailoring Process of the ISO/IEC 15288, which is on of the conditions to obtain the commencement certificate. Obtaining the commencement certificate is crucial, since this allows the construction works to start. The cases all had to submit a document in which they explain their tailoring decisions and substantiate why they tailor certain ISO/IEC 15288 elements in their projects. For instance, the cases tailored parts of the Human Resource management process. Some activities of that process are conducted by the construction organisations and not by project employees, and therefore were not taken into consideration. By means of this, process managers determined the project-specific requirements (step 6). However, process managers did not first focus on needs of the project, but directly focussed on the ISO/IEC 15288. None of the projects explicitly derived project-specific requirements from factors presented in INCOSE (2015) and the ISO/IEC 15288. With the only exception being requirements that are part of the tender documents and became contractual requirements when the projects were awarded. This implies that process managers emphasize the contractual requirements and undermine project needs.

Secondly, the process managers designed a process architecture and allocated the contractual requirements to the different project processes included in that process architecture. None of the process managers adopted the processes of the ISO/IEC 15288 directly, but developed a classification of the processes themselves. All process managers developed a cross-reference list for the allocation of the ISO/IEC 15288 requirements to the project processes. One side of the cross-reference list included the requirements of the ISO/IEC 15288 and the other side the project processes. This cross-reference list was, next to the tailoring document, also contractually required to submit for achieving the commencement certificate. The resulting cross-reference list seems like an instance of mapping, as referred to in step 8. However, process managers did not use the mapping to identify what could be tailored out, but to make a checklist what should be included in which project process before the project processes were actually designed.

Thirdly, the process managers made process owners responsible for the content of the project processes. Process owners are in charge of execution of to them attributed processes in the project, e.g. the risk manager for the risk management process. The way in which process owners had to deliver input for the processes differed for each case. In case A and B the process managers provided the process owners with the allocated requirements, templates and guidelines and let them develop their own processes. In case C, the process managers interviewed process owners and wrote the processes themselves. The reason for this was that the process managers of case C wanted to save the process owners the trouble of writing the processes down. Case C was the only case that explicitly used organisational processes as basis for the interviews with the process-owners. The construction organisation of Case C directed the process managers to adopt and adapt these processes. Nonetheless, those organisational processes were not yet compliant to the ISO/IEC 15288. In all cases the process managers encouraged process owner to use existing processes from other projects as inspiration. This was however not obligatory and since process owners have different backgrounds (in projects or organisations), existing processes used as inspiration came from different contexts. Moreover, process owners in all cases had much influence in the content of the project processes. By that means they were able to identify other project-specific needs beyond tailoring (step 7).

Lastly, process managers used the cross-reference list to check whether all ISO/IEC 15288 requirements were described in the project processes. In this way, they used the mapping as control mechanism. To summarize, process managers use contractual requirements and preferences from the process owners to develop project processes for their projects. They did not use a tailoring policy, since this policy was not available (step 9). Tailoring activities were executed before while needs of the project were determined, as already discussed above in step 6.

4.1.3 Organisational contextual factors

In regard to the organisational contextual factors of the conceptual model, the following was found in this research:

i. In case A and B, process owners had to design their own processes and were explained how to do that. Therefore, process owners understood what processes are. However, the process managers of case C wanted to save process owners the trouble of writing their project processes. This could indicate that understanding of processes was low in case C.
ii. Organisational commitment towards the implementation of the ISO/IEC 15288 is non-existent. In none of the three cases, top management enforced to implement the ISO/IEC 15288 on organisational level. In only one organisation, top management initiated the implementation of the ISO/IEC 15288 at organisational level. Nonetheless, this was not backed with enough resources. At project level,

process managers were backed with resources to implement the ISO/IEC 15288. This commitment was probably present since the ISO/IEC 15288 implementation on project level was contractually required.

iii. In the cases investigated, willingness to change and implement the ISO/IEC 15288 at project level was present, since the implementation was contractually required. Process managers pointed out that they have the opinion that the ISO/IEC 15288 should be implemented at the organisational level. However, observations of activities to implement the ISO/IEC 15288 at the organisational level in one of the construction organisations indicated that willingness to change was low.

iv. Process managers probably understand the Systems Engineering standard well, at least enough to have it implemented. However, this is not explicitly measured. Process owners on projects were introduced with the ISO/IEC 15288, because they had to implement requirements in their processes.

v. All cases implemented the ISO/IEC 15288 requirements in the procedure level in the process hierarchy, see Figure 1. Case A and B both had a clear division between plans and procedures, that defined the "what", and work instructions, defining the "how". Project C mainly had procedures that defined the "what".

vi. All contractors remained using their own terminologies.

In conclusion, theory suggest that project processes should be developed starting with compliant organisational processes, using an organisational tailoring strategy, and then execute project-tailoring based on project specific requirements. In practice, process managers do not adopt compliant organisational processes. Instead, process managers develop project processes and tailor and implement the ISO/IEC 15288 to those project processes. They start developing project processes with a process architecture and on basis of the contractual requirements, let process owners mainly decide the content of the project processes and optionally use existing processes as inspiration. Process managers did not use organisational tailoring policies. Nonetheless, all process managers succeeded in the implementation of the ISO/IEC 15288 into the project processes. The next section aims to explain why process managers did not follow the steps of the conceptual model.

4.2 Analysis

The pattern matching and cross-case analysis showed that process managers repeatedly implement the ISO/IEC 15288 for each single project. Therefore, theory and practice differ. This section presents three main explanations why process managers do not follow the steps of the conceptual model.

4.2.1 No sufficient and compliant organisational processes and tailoring policies available

The first explanation is that construction organisations do not obtain appropriate organisational processes and tailoring policies. The construction organisations do obtain organisational processes, which are included in their quality management systems. Quality management systems must be ISO 9001 certified and, among other things, describe the construction organisations' processes (Rijkswaterstaat, 2017). Rijkswaterstaat (2017) even suggests that construction projects should use (parts of) the quality management systems. Nonetheless, none of the contractors integrated the ISO/IEC 15288 into these organisational processes. Moreover, some process managers did not perceive the processes appropriate since they were designed for all types of construction projects of the construction organisations. Different clients, of different magnitudes, have different (contractual) requirements for project processes. The interviews pointed out that even different employees of Rijkswaterstaat seem to have different preferences in how project processes are enacted in construction projects, even though the contractual requirements are largely the same. Besides, the lack of tailoring policies resulted in a lack of direction of the process managers to adopt the organisational processes. In conclusion, process managers did not use the organisational processes since they are not compliant, not regarded sufficient and that there are no tailoring policies defined at organisational level.

4.2.2 Inward project focus

The second explanation for the findings is that process managers and other project employees have an inward project focus. This means that project participants mainly concentrate on matters within the project and seem to hardly look beyond the project boundaries. There are several reasons for this explanation. To start, construction projects are often executed by different combinations of construction organisations. Also, many employees of projects are self-employed and only focus on their jobs within the projects. As result, construction projects seem to be executed by a mixture of different employees with different (organisational) backgrounds each time. This seems to favour an inward project focus. An example to show the diversity of project employees is that even project A and B were executed by different persons, although they were executed by the same construction organisations and almost sequential to each other. Moreover, the process manager of case B, fulfilling a key role in implementing the ISO/IEC 15288, just started her job for one of the construction organisations investigated and came from another construction organisation. In case C, the process manager responsible for the implementation of the ISO/IEC was

self-employed and not a direct employee of the construction organisations that were main contractors of the project. To conclude, project participants focus on project matters and not on matters of the construction organisations.

Moreover, the pressure on implementing the ISO/IEC 15288 requirements into the project processes and creating commitment to the project processes is high. When a construction project is awarded to one or multiple construction organisation, the time pressure to start building as soon as possible is immense. Construction organisations are only allowed to start construction works on a DBFM project if they obtain their Commencement Certificate. One of the conditions to obtain this certificate is the implementation of the demanded ISO/IEC 15288 requirements in the project processes. Besides, Rijkswaterstaat assesses the project processes with the ISO/IEC 15504-6:2013. With the ISO/IEC 15504-6 Rijkswaterstaat assesses to whether the ISO/IEC 15288 is implemented correctly and to which extent the project processes are enacted by the employees of the project (ProRail et al., 2013). By this means, Rijkswaterstaat views construction projects as organisations, which they are actually not in terms of the ISO/IEC 15288. Still, the enactment of the project processes requires commitment from the project employees, since they are the ones that need to perform the project processes. As result, process managers seem to emphasize creating commitment of process owners and employees by letting them develop their own processes. The process managers stated that they considered the commitment towards process owners self-developed processes as more efficient than enforcing project employees to use a defined set of processes. Even when processes were already developed and implemented within a project, project employees had the possibility to change the project processes. For example, the planning manager in case A changed three times during the project. The new planners were allowed to change their project processes, instead of conforming to the current planning process.

4.2.3 Lack of top management commitment for the ISO/IEC 15288 implementation

The third explanation is that the top managements of the construction organisations do not have commitment for the implementation of the ISO 15288 in the organisational processes. Top management of one of the construction organisations involved in case A and B desired to implement the ISO/IEC 15288 at organisational level. However, observations of the team that was responsible for the ISO/IEC 15288 implementation indicated that enough resources were lacking. The lack or organisational commitment is also reflected in the quality management departments of construction organisations. The quality managers that assess ISO/IEC 15288 only concentrate on project compliance, and not on the adoption of organisational processes. One of the reasons behind this could be that Rijkswaterstaat only requires and assesses the implementation of the ISO/IEC 15288 on project level. Therefore, contractors are not triggered to integrate the ISO/IEC15288 at organisational level. Besides, other clients are not requiring the ISO/IEC 15288. As result, the construction organisation's top management are not committed to implement the ISO/IEC 15288 at the organisational level. This explanation might be the result of the focus of construction organisations on short-term profits in separate projects. In projects, process managers also stated they feel little commitment from top management. One of the process managers stated that process management was undervalued by project management. Process managers have to implement the ISO/IEC 15288 at minimal costs, only to fulfil the contractual requirements of the project. This indicates that as long there are contractual requirements, at least some commitment can be identified.

4.3 General Overview

Eventually, process managers succeed in the implementation of the ISO/IEC 15288 in construction projects. Process managers seem to perform the activities that the contract of Rijkswaterstaat requires and by that means also follow some steps of the conceptual model. Nonetheless, the process managers also deviate from the conceptual model. Explanations for the deviations are that there are no appropriate organisational processes available, they have an inward project focus and there is no commitment from top management. As result, process managers define project processes for each project again, starting almost from scratch. Therefore, the deviations from the conceptual model cause inefficiency in the implementation of the ISO/IEC 15288 on construction projects.

Yet, most of the interviewed process managers believe that construction organisations should integrate the ISO/IEC 15288 in the organisational processes and tailor these to projects. This saves process managers the effort to develop project processes for, and implement the ISO/IEC 15288 in each project again. Besides, process managers acknowledge the importance of learning between projects. This importance was also reflected in observations in assessments focused on the capability levels of the project processes. When organisational processes are adopted in different projects, construction organisations are able to learn and improve themselves. Still, the observed project-oriented nature of construction causes a major challenge to achieve this. Moreover, precisely following the contractual requirements as observed in the case studies, can also causes a blind spot. Process managers seem to emphasize what the contract of Rijkswaterstaat

requires and not what the project needs by their perspective.

5. Discussion

The three case studies that were investigated in this study provided insight in how the ISO/IEC 15288 was implemented in the Dutch infrastructure and construction industry. The first part of this section shows the comparison of this understanding with theory in regard of Systems Engineering standard implementation. The results of this study are also compared with literature beyond the scope of Systems Engineering standard implementation to make suggestions for the expansion of current theory. After this comparison, practical implications to increase the efficiency of the implementation of the ISO/IEC 15288 in construction projects for process managers have been made.

5.1 Gap between theory and practice

The results of this study indicate a gap between theory and practice. Sheard (2001) & Walden (2007) both presented that a Systems Engineering standard should first be implemented at organisational level, and that project processes should be derived repeatedly from these organisational processes. Remarkably, the findings of this research do not support this claim. Organisational tailoring was not performed by the construction organisations. Process managers develop project processes for each single project and implement the ISO/IEC 15288 repeatedly. This causes inefficiencies. Furthermore, other benefits as presented in the introduction are not likely to achieved as well, such as organisational learning. The upside of developing new project processes is that it might create commitment towards the project processes. However, it is questionable if commitment towards the rushed processes is ensured in the huge time pressure these project processes are made. Approaches to minimize the inefficiencies caused by the lack of coupling between the organisation and projects need to be found to increase the efficiency of the ISO/IEC 15288 implementation.

5.2 Increasing efficiency of the ISO/IEC 15288 implementation

The differences between theory and practice most likely find their origin in the project-oriented nature of the construction industry. Construction projects are often considered as unique and an “one size fits all” approach is not likely to succeed (Sauser, 2006; Shenhar, 2001). On the contrary, theory appears to regard organisations top down and therefore assumes that the ISO/IEC 15288 is implemented at organisational level. Nonetheless, within the Dutch civil and infrastructure construction the locus of coordination seems to be in the projects and not in the construction organisations. Correspondingly, Dubois & Gadde (2002) define the construction industry as a loosely coupled system. They particularly consider couplings between construction organisations and construction projects as loose. Construction organisations often have different roles in different, unique projects, and operate in different combinations for different clients. Within these projects, couplings are tight, even between different construction organisations. Dubois & Gadde (2002) claim that a result project efficiency is preferred over organisational innovation and learning. The cases investigated also showed this in regard of the ISO/IEC 15288 implementation, where organisational processes were not appropriate, projects had an inward focus on short-term efficiency and top management had little commitment or the ISO/IEC 15288 implementation. As solution, Dubois & Gadde (2002) suggest that the tight couplings between different contractors on projects should be loosened. In this way, couplings between projects and organisations are able to be tightened, following a zero-sum logic, and projects can learn from other projects and efficiency within construction projects can be increased. In contrast, Dorée & Holmen (2004) claim that loosening coupling within projects is not realistic, due to the focus on project objectives and short-term efficiency. Instead, construction organisations should focus on linking subsequent projects, so that tight coupling in projects can be remained and sequential projects can learn from each other (Dorée & Holmen, 2004).

Construction organisations could link sequential projects by developing organisational processes. The cases investigated pointed out that process managers currently do not consider the organisational processes sufficient for the DBFM-projects. Defining sufficient organisational processes requires business process standardisation: *“the unification of business processes and the underlying actions within a company”* (Schäfermeyer, Rosenkranz, & Holten, 2012). Standardising processes between subsequent projects could be achieved through process documentation and reduces variety of the same processes in different projects of the same organisation (Ungan, 2006). The implementation of the ISO/IEC 15288 at the organisational level at one of the construction organisations of the cases investigated was part of organisation wide standardisation program. The standardisation program was delegated to the a standardisation team on middle-management level. As already presented, this team faced a lack of resources. Additionally, they had no bargaining power over the projects of the construction organisations. Polesie (2013) had similar findings and showed that standardisation in construction organisations is often advocated by top management. This task is then delegated to middle management. Rather, Polesie (2013) advocates to use a bottom-up approach when standardising processes. Therefore, these compliant

organisational processes need to be developed within the projects, and not on organisational level. These organisational processes should be complemented with an organisational tailoring policy (Walden, 2007). As organisation that operates in a project-based industry, NASA obtains well defined tailoring strategies (Cox & Thomas, 2014; Horan & Belvin, 2013; NASA, 2016; Van Blankenship, 2016). Nonetheless, it is unsure if the space industry is comparable to construction, particularly whether the locus of coordination lies in projects or the organisation.

However, merely documenting organisational processes that are appropriate is not enough. The project processes of Case A were properly documented, however not adopted in Case B (while having the same main contractors). ProRail et al. (2013) advocate that employees should be stimulated to share their experiences and that lessons learned should be incorporated in new projects. Learning between project can be enhanced by, in terms of Hartmann & Dorée (2015), moving from a sender/receiver approach to a social learning approach. In other words, they claim that *"learning from projects takes place within projects"*. This implies that attention should not only be paid to documenting the compliant organisational processes. It should be ensured that process-owners of the previous project are involved with the definition of the project processes during the initial phase of the new project.

Other studies also highlighted the importance of top management towards the implementation of Systems Engineering standards (Berglund, Böckmann, & Cuklev, 2009; ProRail et al., 2013; Sheard, 2001; Sheard, Lykins, & Armstrong, 2000; Walden, 2007). The lack of commitment often results in a shortage of resources. Literature concerning ISO/IEC 9001 or Quality Management Systems implementation also showed that top management is a major factor for successful implementation. (Garza-Reyes, Rocha-Lona, & Kumar, 2015; Ingason, 2015; Leong, Zakuan, & Saman, 2014). Theory concerning the implementation of ISO/IEC 9001 and/or quality management systems is relevant here, since the ISO/IEC 15288 is implemented in the quality management system that is based on the ISO/IEC 9001. Both describe organisational processes. The commitment of top management was already included in the conceptual model. In conclusion, the implementation of the ISO/IEC 15288 could be more efficient for process managers in a project-based industry like construction. A possible approach to expand existing theory for the construction organisations and their projects is to link subsequent projects by developing sufficient and compliant organisational processes using a bottom-up approach. These organisational processes could be introduced in projects by a social learning approach. Lastly, top management commitment for the implementation of the ISO/IEC 15288 in both the organisational processes and consequently in project processes can be increased.

5.3 Practical implications

This research has three main practical implications for process managers to make the implementation of the ISO/IEC 15288 in construction projects more efficient. The first is that process managers should define and adopt a set of compliant organisational processes that can be used in sequential projects. Particularly, if two projects are executed with similar contractual requirements, for instance two DBFM-projects, and by the same construction organisations, process managers should look beyond the boundaries of their own projects. Process managers should first define organisational processes that are similarly executed over different projects. Suggestions for this are the process of risk management, planning management, the verification process and the validation process. Adopting already compliant organisational processes saves the effort of developing new project processes and implementing the ISO/IEC 15288 in these project processes. However, project employees still need to commit themselves to these processes. Therefore, a second implication is that process managers should focus on a social learning approach, in which the compliant organisational processes including knowledge are transferred from the a previous project to a next project. Process managers should bring process-owners and teams together in e.g. workshops or just one-to-one meetings. Third, process managers should ensure commitment of top management for the development and adoption of compliant organisational processes at both project and organisational level. This can be achieved by setting this topic on the agenda of top management meetings. Also, top management should be involved in the assessments on projects. To conclude, process managers are able to implement the ISO/IEC more efficiently on projects anymore, since they adopt compliant organisational processes and commitment towards these processes is created by connecting process-owners and their knowledge.

Figure 3 displays these recommendations. It shows that from the already defined project processes of project A, organisational processes are developed (1). These organisational processes are introduced in and tailored for subsequent project N with a social learning approach (2). Top management commitment is also presented as crucial factor for all the shown activities (3).

5.4 Limitations and further research

This research had three limitations and suggestions for further research. The first limitation is that this study did not investigate a construction organisation that did

integrated the ISO/IEC 15288 at organisational level. The cases of this study were selected based on whether they had to comply to the ISO/IEC 15288 on project level. The researcher did had the opportunity to observe an attempt to implement the ISO/IEC 15288 at organisational level. During the research, the researcher found out that other construction organisations did integrate the ISO/IEC 15288 in the organisational processes. Further research could focus on these organisations and specifically investigate how these processes are enacted on projects that are executed in combination with other contractors. Second, this study did not investigated a failure case, in which a project did not succeed to integrate the ISO/IEC 15288. Due to the high stakes, i.e. obtaining the commencement certificate, contractors seem to always have success in implementing the ISO/IEC 15288. If present, further research could investigate this failure case. A third limitation is that this study only investigated the integration of the ISO/IEC 15288 until the commencement date, and did not compare this with eventual project success. For further research the relation between how the ISO/IEC 15288 is implemented among the different contractors of a combination and project success would be of interest. Lastly, literature concentrating on the implementation of Systems Engineering standards is scarce and not recent. More research in this area would enlarge this body of knowledge, in which a focus on project-based industries should have priority.

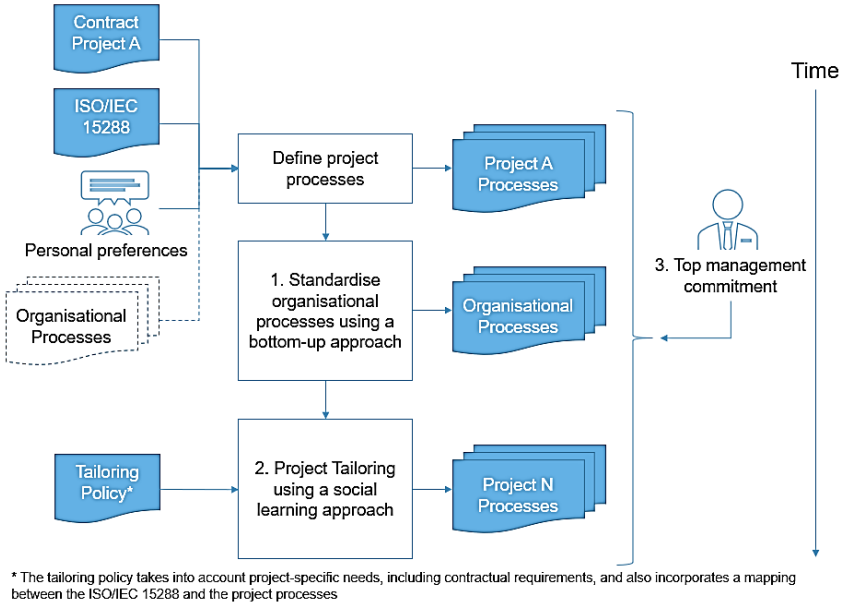

Figure 3: Practical implications visualized

6. Conclusion

This paper discussed the implementation of Systems Engineering standards, particularly the ISO/IEC 15288, in the Dutch civil and infrastructure construction industry. This topic is relevant, since the largest client in this industry, Rijkswaterstaat, is mandating contractors to adopt this standard on project-level in their construction projects processes. However, the current theory was found not to describe how Systems Engineering standards should be implemented a project-based industry like the construction industry. Accordingly, this study showed a discrepancy between theory and practice. The conceptual model that was developed for this study implied that first the ISO/IEC 15288 should be implemented in the organisational processes and that these organisational processes should to be tailored to meet project-specific needs. However, three investigated cases demonstrated that process managers of construction projects in the Netherlands implement the ISO/IEC 15288 only at project level. Process managers develop project processes and tailor the ISO/IEC 15288 for each single project. The result is that process managers implement the ISO/IEC 15288 inefficiently. Reflecting on the project-based character of the construction industry, this study provided three recommendations to process managers to increase efficiency of the ISO/IEC 15288 implementation in construction projects. The first is that organisational processes should be standardised in projects, using a bottom up approach. The resulting compliant organisational processes should be implemented in similar construction projects using a social learning approach. The last recommendation is that construction organisations should ensure commitment for the development of compliant organisational processes (including ISO/IEC 15288 implementation) and the adoption of these processes in subsequent projects. On a final note, it is top management that should promote the project overarching perspective and it could use the ISO/IEC 15288 implementation as means to enhance the coupling between different construction projects.

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Appendix I

Steps of the conceptual model	**Operationalisation**
1. Understand the common organisational processes and the ISO/IEC 15288 Systems Engineering standard (Sheard, 2001; Walden, 2007)	Observe in meetings if the ISO/IEC 15288 is well understood by notifying if employees understand what is meant, if discussing about the ISO/IEC 15288. Also, ask in interviews to what extent process managers have the idea that the ISO/IEC 15288 is understood at organisational level.
2. Define the needs of the organisation (Sheard, 2001; Walden, 2007)	Analyse documents and check whether there is a record of this identification. Verify this in interviews.
3. Select the elements of the ISO/IEC 15288 that meet the needs of the organisation. (Sheard, 2001; Walden 2007)	Analyse documents and check whether there is a record of the selection of the ISO/IEC 15288, for instance a checklist or organisational tailoring document. Verify this in interviews.
4. Identify gaps between the needed ISO/IEC 15288 requirements and the organisational processes by making a mapping.(Sheard, 2001; Walden, 2007)	Analyse documents and check whether there is a record of the selection of the ISO/IEC 15288, for instance an organisational mapping. Verify this in the interviews.
5. Address gaps that result from the mapping between the needed ISO/IEC 15288 requirements and the common organisational processes on case-by-case basis (Sheard, 2001)	Analyse documents and check whether there is a record of the selection of the ISO/IEC 15288, for instance a cross-reference list. Verify this in the interviews.
6. Determine project-specific requirements that influence project tailoring (Sheard, 2001; Walden, 2007)	Analyse documents and check whether there is a record of the selection of the ISO/IEC 15288, for instance project tailoring document. Verify this in interviews.
7. Identify other changes needed beyond tailoring.	Analyse documents and check whether there is a record of the identification of needs beyond tailoring. Verify this in interviews.
8. Determine in which project processes and process activities tailoring is required by making a mapping (Sheard, 2000; Walden, 2007).	Analyse documents and check whether there is a record of the selection of the ISO/IEC 15288, for instance a project mapping. Verify this in the interviews.
9. Tailoring activities out of the compliant organisational processes following an organisational tailoring policy. Record tailoring decisions.	Analyse documents and check whether there is a record of the selection of the ISO/IEC 15288, for instance project tailoring document or cross-reference list. Verify this in interviews.
Organisational contextual factors	
A. General understanding of processes by employees is required (Sheard, 2000)	Analyse documents to what extent attention is given to explaining employees what processes are, e.g. in activities like workshops . Verify in interviews.
B. Ensure organisational commitment for the implementation of the ISO/IEC 15288 Systems Engineering standard (Walden, 2007)	Ask in interviews to what extent organisational commitment was perceived.
C. Organisations must be willing to change and implement the ISO?IEC 15288 Systems Engineering standard (Walden, 2007)	Ask in interviews to what extent organisational willingness to change was perceived.
D. Understanding the Systems Engineering standard only required for process management group, not for the whole business. (Sheard, 2000)	Ask in interviews, to what extent have process managers focused on explaining the standard to the employees. Also, analyse documents, like by the process management developed guidelines and work instructions for the development of project processes.
E. Implement the ISO/IEC 15288 Systems Engineering standard at procedure level of the process hierarchy (Walden, 2007).	Analyse process documents. Validate in interviews.
F. Use own terminology of the business and not that of the ISO/IEC 15288 Systems Engineering standard (Walden, 2007).	Analyse process documents. Validate in interviews.

Appendix II

Steps of the conceptual model	Case A	Case B	Case C
1. Understand the common organisational processes and the ISO/IEC 15288 Systems Engineering standard (Sheard, 2001; Walden, 2007)	**Mismatch.** No organisational tailoring took place. No understanding of the ISO/IEC 15288 at organisational level noticed.	**Mismatch.** No organisational tailoring took place. No understanding of the ISO/IEC 15288 at organisational level noticed.	**Mismatch.** No organisational tailoring took place. No understanding of the ISO/IEC 15288 at organisational level noticed.
2. Define the needs of the organisation (Sheard, 2001; Walden, 2007)	**Mismatch.** No organisational tailoring took place.	**Mismatch.** No organisational tailoring took place.	**Mismatch.** No organisational tailoring took place.
3. Select the elements of the ISO/IEC 15288 that meet the needs of the organisation. (Sheard, 2001; Walden 2007)	**Mismatch.** No organisational tailoring took place.	**Mismatch.** No organisational tailoring took place.	**Mismatch.** No organisational tailoring took place.
4. Identify gaps between the needed ISO/IEC 15288 requirements and the organisational processes by making a mapping.(Sheard, 2001; Walden, 2007)	**Mismatch.** No organisational tailoring took place.	**Mismatch.** No organisational tailoring took place.	**Mismatch.** No organisational tailoring took place.
5. Address gaps that result from the mapping between the needed ISO/IEC 15288 requirements and the common organisational processes on case-by-case basis (Sheard, 2001)	**Mismatch.** No organisational tailoring took place.	**Mismatch.** No organisational tailoring took place.	**Mismatch.** No organisational tailoring took place.
6. Determine project-specific requirements that influence project tailoring (Sheard, 2001; Walden, 2007)	**Match**: Mainly requirements from the stakeholders and customers that are included in the contract are taken into account. This included the ISO/IEC 15288 requirements. Also included in the contract are plans from the tender. Besides, preferences of process owners determine content of the processes to a large extent.	**Match**: Mainly requirements from the stakeholders and customers that are included in the contract are taken into account. This included the ISO/IEC 15288 requirements. Also included in the contract are plans from the tender. Also process owners preferences played important role.	**Match**: Mainly requirements from the stakeholders and customers that are included in the contract are taken into account. This included the ISO/IEC 15288 requirements. Also included in the contract are plans from the tender. Also process owners preferences played important role.
7. Identify other changes needed beyond tailoring.	**Match**. Other changes beyond tailoring were identified implicitly. Since process owners were required to develop their own processes, they were able to identify these other changes and write them down in their plans.	**Match.** Process owners preferences could easily be integrated into the processes, since they were responsible for designing them. These *other changes* were implicitly identified in this way.	**Match** Interviews with process owners had them identifying other changes than the project-specific requirements for tailoring.
8. Determine in which project processes and process activities tailoring is required by making a mapping (Sheard, 2000; Walden, 2007).	**Partial match.** Process managers developed a cross-reference list to allocate the ISO/IEC 15288 requirements to processes. They used this list also as control mechanism, to check if all requirements were met by the processes. However, this mapping was not used to make the transformation from organisational processes to project processes.	**Partial match.** Process managers developed a cross-reference list to allocate the ISO/IEC 15288 requirements to processes. They used this list also as control mechanism, to check if all requirements were met by the processes. However, this mapping was not used to make the transformation from organisational processes to project processes.	**Partial match.** Process managers developed a cross-reference list to allocate the ISO/IEC 15288 requirements to processes. They used this list also as control mechanism, to check if all requirements were met by the processes. However, this mapping was not used to make the transformation from organisational processes to project processes.
9. Tailoring activities out of the compliant organisational processes following an organisational tailoring policy. Record tailoring decisions.	**Mismatch.** No project-tailoring strategy available. Gaps were addressed by adding activities in the processes.	**Mismatch.** No tailoring policy available.	**Mismatch.** No tailoring policy available.

Organisational contextual factors			
A. General understanding of processes by employees is required (Sheard, 2000)	**Match**. Process managers helped the process owners writing the processes and explained what they are to them during.	**Match.** Process managers provided a guideline for the development of the processes and had workshop.	**Match.** Process managers explained what processes were during interviews, if the process owners were not aware of that.
B. Ensure organisational commitment for the implementation of the ISO/IEC 15288 Systems Engineering standard (Walden, 2007)	**Mismatch (same contractors).** Top management declares it wants standardisation, however they leave the standardisation team (middle management) with low amount of resources and power to realize this. Board of the project directs on what they think is important, which is not standardisation. Project managers focus on getting their start certificate and project efficiency and not on standardisation. Also no leadership for standardisation, however some communication as part of standardisation program (neglectable). No training, no tools, no deployment.		**Mismatch:** No commitment from organisation observed. Process managers were self-employed, so they had almost nothing to do with the organisation. It is not likely that they completely follow the desires of the main contractors.
C. Organisations must be willing to change and implement the ISO?IEC 15288 Systems Engineering standard (Walden, 2007)	**Mismatch (same contractors).** Process managers experienced much difficulties with employees to adopt the ISO 15288. Furthermore, the standardisation program team had to deal with lot of resistance from the employees.		Not observed.
D. Understanding the Systems Engineering standard only required for process management group, not for the whole business. (Sheard, 2000)	**Partial match.** Process owners were also educated in how the ISO/IEC 15288 works. However, it is not explicitly measured to what extent the other employees understood the ISO/IEC 15288.	**Partial match.** Process management organised a workshop with an external consultant to explain the ISO/IEC 15288. However, it is not explicitly measured to what extent the other employees understood the ISO/IEC 15288.	**Match.** During interview the Systems Engineering standard was used to develop the processes, so it was explained to the process owners. However, this does not mean the process owners and other employees gained understanding.
E. Implement the ISO/IEC 15288 Systems Engineering standard at procedure level of the process hierarchy (Walden, 2007).	**Match.** Described levels are strategic, tactical and operational. Tactical and operational processes are in line with Walden's (2007) "procedure-level", since they describe what should be done. The A6 project also included work instructions and templates in the operational level, however these do not describe ISO/IEC 15288 requirements.	**Match.** Described levels are strategic, tactical, operational and specialistic. Tactical and operational processes are in line with Walden's (2007) "procedure-level", since they describe what should be done. The A16 project also included work instructions in the operational and specialistic level, however these do not describe ISO/IEC 15288 requirements.	**Match**: in process schemes, that are part of the sub management plans. Level is similar with that of Walden (2007).
F. Use own terminology of the business and not that of the ISO/IEC 15288 Systems Engineering standard (Walden, 2007).	**Match.** Process owners determined processes and also terminology.	**Match.** Process owners determined processes and also terminology.	**Match.** Process managers developed processes from input interviews, and used terminology used by process owners.