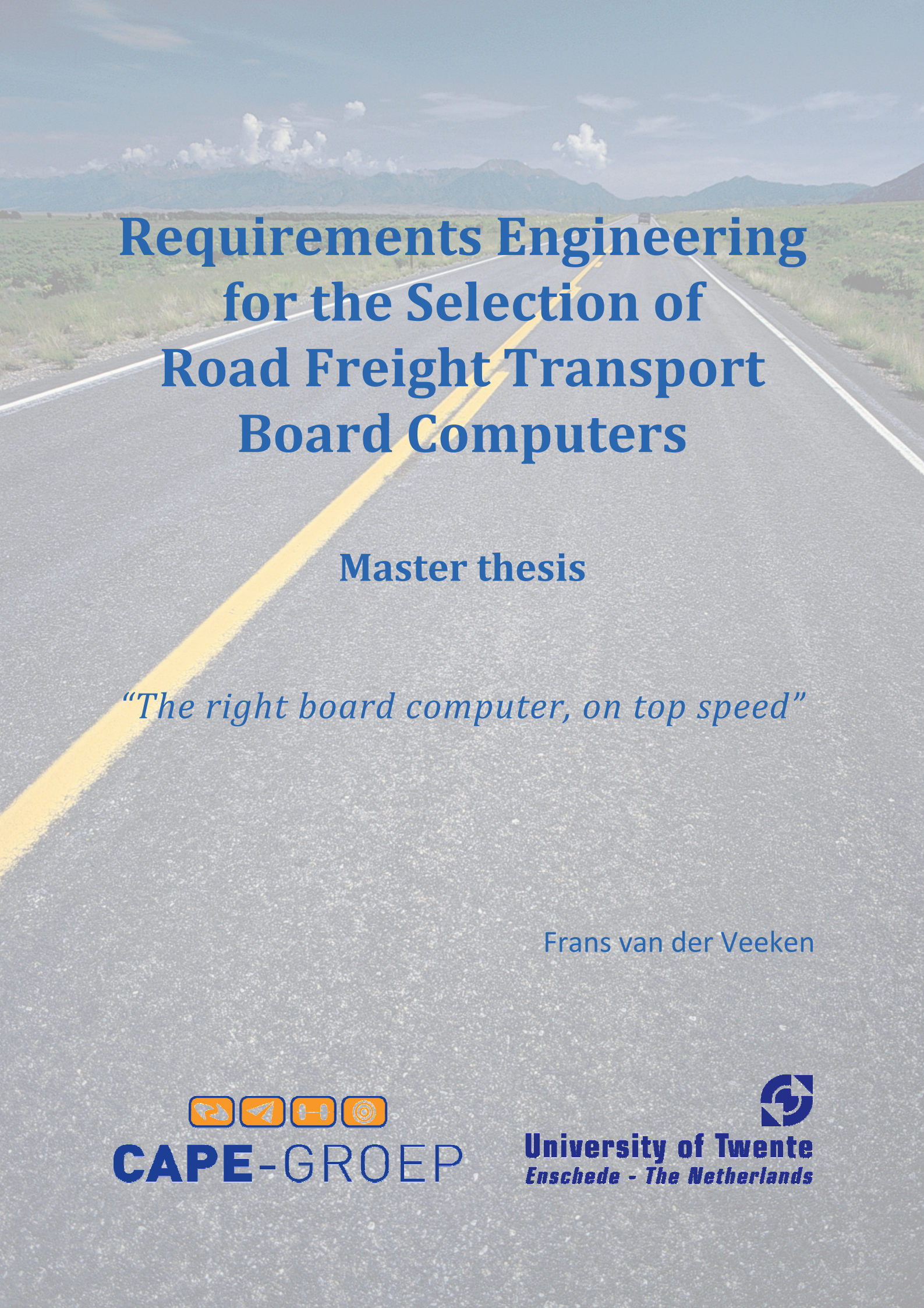


Requirements Engineering for the Selection of Road Freight Transport Board Computers

Master thesis

"The right board computer, on top speed"

Frans van der Veeken

CAPE-GROEP

University of Twente
Enschede - The Netherlands

Requirements Engineering for the Selection of Road Freight Transport Board Computers

Master thesis

"The right board computer, on top speed"

Public version

Place and date
Enschede; August 16, 2009

Author
F.D. (Frans) van der Veeken
Master student Business Information Technology

First Supervisor
Dr. N. (Klaas) Sikkel

Second Supervisor
Dr. M.E. (Maria) Iacob

Company Supervisors
D. (Dennis) Brugging
Drs. R. (Rob) ter Brugge

Management Summary

We performed a research for CAPE Groep, a small and fast growing Dutch IT and management consultancy organization active in mainly the transport and logistics industry. The main deliverable of this research was a method which CAPE Groep can use to effectively advise its clients, Dutch transport companies, on the selection of board computers for road freight transport.

The last years in the Dutch transport industry we can see decreasing margins, rising environmental and security regulations, and a growing demand for additional and fast services. These tendencies create a demand to improve the efficiency of the business processes and create better and quick insight in statuses and reports of the execution progress of transport companies. Board computers can be useful means to increase efficiency and gain better and faster information and indeed the number of board computers in use increased a lot the past years.

The consultants from CAPE Groep advice transport companies on the selection of the most appropriate board computer system, from which many Commercial Off The Shelf systems are available, and want to do this more efficient. The consultants do have a lot of experience in the field, and do have some standard steps in the advice process but missed an explicit step-by-step approach and list of possible requirements. Therefore we developed a validated method for CAPE to support the effective advice of road freight transport companies on the selection of Board Computer systems. This method combines the found theoretical insights and practical experiences on the topics of COTS package selection, requirements engineering, business process analysis, enterprise architecture and the road freight transport industry. This thesis describes the mentioned topics and prescribes specific methods for the various steps in the advice process.

CAPE Groep uses a standard approach to come from the list of all known vendors to the eventual selection of one vendor, in which the specification of business goals, the analysis of business processes and the specification and prioritization of requirements play an important role and are supported by the developed method. The developed steps of the method treat the succeeding topics of general motivation, maturity level, transport type, company characteristics, business strategies, business goals, scope and willingness, business requirements, enterprise architecture, general nonfunctional requirements, other functional requirements and eventually the processes and related overall list of requirements.

The method is translated into a collection of Microsoft Excel sheets which guide the CAPE Groep consultant and the transport company representative through the process, by providing specific questions, scenario's and opportunities to insert the answers in a convenient arranged way and see the results in a well presented way. Also, very extensive reference business process models and reference enterprise architectures are designed which can be used to create the models for specific companies.

The performed validation proved the usefulness of the method, which is already (partially) in use by CAPE Groep. The validation also showed the use of the method to create explicit insight in the company, its goals, processes, and architecture and the possibilities and choices of board computers, next to its main use of specifying requirements to use for the selection of a board computer system.

We recommend CAPE Groep to gradually implement the developed method in all board computer selection projects, and continuously evaluate and improve it. Improvements of the method can mainly be made by creating a (partly) automated way of walking through the process, but we also recommend not trying to completely automate the framework since it is very useful for both parties to scan the complete list. Also, the prioritization of requirements; the relation between characteristics and requirements; the implementation of vendor, project and financial requirements; and the verification of requirements for known products can be improved and added to increase the success of the framework. Also, we recommend the adoption of the method for other IT projects CAPE Groep is involved in, selection but possibly also development projects at transport companies.

Preface

In October 2008, I took the very first step to the end product of my master thesis by meeting Rob ter Brugge and his colleagues from CAPE Groep during the break of a guest lecture of the course Business Process Integration. Rob told me about the research project and back home I directly sent an email. Within a few days the agreement was made and mid November I started my research. At the start it was hard to formulate a good research proposal, but I felt directly comfortable within the company and as soon as the research design was made the first results of my efforts became visible.

Now, about 10 months after my first acquaintance with CAPE Groep, my research is finished. I am very content with the results of my efforts and hope and expect that the research product will support CAPE Groep in their advice work for transport companies looking for a new board computer system. Also, I hope that CAPE Groep will further develop the framework to get the most out of it.

The first months at CAPE my office days were spare but after the move to the new office I was much more at the office where both the people and the very nice coffee motivated me a lot. My working period at CAPE was an enjoyable and very valuable experience in an inspiring, pleasant environment from which the project management workshops and the New Year event are perfect examples.

Many people helped me during this final phase of my study, which I will try to thank one by one. At first, I want to thank my UT supervisors Maria Iacob and Klaas Sikkel, who gave very useful feedback during our many sessions, and directed me into the eventual project goal. Then, I want to thank my supervisors from CAPE Groep. Dennis Brugging, thanks a lot for helping me to find the input for my research, getting me into contact with people, giving feedback on my work, participating in the validation, and for all your other efforts during the many meetings we had. Rob ter Brugge, many thanks for giving me the opportunity to do my research at CAPE Groep, and for all your efforts during the project. Pieter Verkoost, thank you for participating in the validation case studies. And off course, thanks to all other colleagues from CAPE Groep, who accompanied me during my days at CAPE Groep and the team activities: Sebastian, Bart, Bas, Alexander, Mustafa, Rene, Pieter and Jos.

I also thank the people from Tielbeke who provided very useful input and gave a good impression of the transport world. Marco Hollenberg and Henk Zanting, the truck drivers who gave me the opportunity to see me the truck driver work by accompanying them through the country; Gerrit Horstman, planner of the DHB department and John Marsch, planner of the TeamTrans department, for showing me the planning process and the planner job in general; Harry Kamtjes, dock coordinator, for showing me all processes at the dock; Marius Verschuren, for showing the warehouse processes. Thank you very much. Thanks a lot also to the two consultants from Centric Logistic Solutions, Rodney Bode and Bernd Wilms, who showed, explained and motivated the use of the Roady board computer. Thanks to Hayley Bakker for proofreading my thesis.

Furthermore, I thank some people who supported me during my master project, but also during other periods of my life. Many thanks to my parents for supporting me during my research project time, during my study in general and in fact during my complete life. My father also gave very useful feedback on my thesis, thanks a lot for that! And last, but certainly not least, I want to thank my girlfriend Martenique a lot for her endless motivational power, and her loving support in general. Finally, to any person who did help me but who I forgot to mention: thanks a lot too!

In spite of the fact that one should keep continuously learning to get the most out of life, the finishing of my Master feels like the finishing of a period in my life. A very important and pleasant period, which I nevertheless am very happy to finish. From this moment, I look forward to the new phase of my life, my working career, and when this will be as pleasant as my study period, I will be very content.

Frans van der Veeken
Enschede, August 2009

Brief Table of Contents

Table of contents

List of Figures

1 Introduction

This document describes a research on the requirements for board computers used in the road freight transport industry, which is performed at CAPE Groep in Enschede. The project is the final assignment for the master Business Information Technology at the University of Twente.

In this chapter the background of this project will be described. First, a short descriptions of CAPE Groep will be given, then the key concepts board computer, transport type, board computer selection, and enterprise architecture are described and finally the research goal and thesis structure will be explained.

1.1 CAPE Groep

CAPE Groep in Enschede is a small and fast growing IT and management consultancy organization, active in the transport, logistics, and shipbuilding industry. In these markets efficient operations are essential so the companies need constant tuning between processes and systems. The experience in these markets is the basis of the services of CAPE Groep and its consultants, which support the clients with the process optimization, project management and the selection and implementation of IT-systems.

1.2 Board computer

For a successful execution of orders in a road freight transport company, effective information exchange between the driver and office of the company is essential. The last years, transport companies tend to implement board computers for this reason. In general, a board computer is a device which registers all kind of information (like location data by means of GPS and truck information by communication with the CANbus (Controlled Area Network)) and communicates two-ways with various systems in a transport organization by means of wireless communication techniques such as GSM, GPRS, satellite or UMTS. This communication takes place on different levels and for different purposes, e.g. track and trace, hour registration and planning. The device is build-in in the truck or is mobile so that the driver can take it out of the truck to the customers. See section 3.2 for an extensive definition of a board computer.

1.3 Transport types

Which functionality is expected from a board computer and what communication takes place between the (planning) office and the driver mainly depends on the business processes within a company. Therefore, in this research the modeling of business processes was one of the first steps. The industry can be segmented in four types of transport, for which the business processes on the level of job preparation, execution and finishing differ significantly. These types are: trailer trucking, full truck load, less than truckload and dense distribution. (CAPE, 2008) (TWNA, 2009) (UMTRI, 2009) See section 3.7.3 for an extensive explanation of this segmentation.

1.4 Board computer selection

CAPE Groep advises transport companies on the selection of board computer systems, and wants to accelerate and improve this advice process. For this reason, CAPE needs good insight on both the demand and supply side of board computer systems. This research gives insight on the first part, the demand for board computers, by showing the process reference models and requirements and by presenting a tool for the elicitation of requirements for individual companies. See section 3.3 for an extensive explanation of the chosen package selection method and section 3.4 for an explanation on requirements engineering specific.

1.5 Enterprise architecture

Board Computers have to fit into the business and have to communicate with various systems, and by various ways, within a transport organization. Therefore, the enterprise architecture will be an

important basis for the requirements. In this research the main existing enterprise architectures will be specified and modeled. See section 3.6 for a detailed explanation of enterprise architecture.

1.6 Research goal

CAPE Groep advises transport companies on the selection of board computer systems, and wants to accelerate and improve this advice process. For this reason, CAPE needs good insight on both the demand and supply side of board computer systems. This research will help CAPE with the first part, and therefore the goal of this research is:

To develop a validated method for CAPE to effectively advise road freight transport companies on the selection of Board Computer systems.

1.7 Thesis structure

This chapter describes the background of this research. After that, the research design is presented in chapter 2 and then the research material and literature that is relevant for this project are reviewed in chapter 3. The developed framework will be presented in chapter 4, and the validation and the validation results are described in chapter 5. The conclusion, reflection and recommendations in are given in chapter 6. The appendices contain explanations of the most important definitions, various pictures, overviews of the process models and requirements and an impression of the method to be used by CAPE Groep in practice.

1.8 Conclusion

CAPE Groep needs an efficient tool for the elicitation and specification of requirements for board computers for individual companies, in order to effectively advice road freight transport companies on the selection of the best board computer system. This tool is developed and validated during this research.

2 Research design

This chapter describes the design of this research, by successively presenting the problem statement, the research questions, the research model and the research strategy. (Verschuren and Doorewaard, 2007) (Cooper, 2006) (Geurts, 1999) (Kuypers, 2003) At the end of this chapter its clear what the problem is and how it is solved by this research project.

2.1 Problem statement

Based on the research goal the following problem statement is formulated:

How can we develop a method for CAPE to effectively advise to road freight transport companies on the selection of Board Computer systems?

2.2 Research questions

The goal of this research can be accomplished by answering the following sub-questions:

1) What does the road freight transport industry look like and how can it be segmented?

2) What are the non-specific frequently used requirements for Board Computers that hold for all road freight transport companies?

3a) What do the business processes look like for the road freight transport segments?

3b) Which requirements for Board Computers result from these processes?

4a) Which main enterprise architectures can be distinguished in the road freight transport industry?

4b) Which requirements for Board Computers result from these architectures?

5) Are there other important discriminating business characteristics relevant for the Board Computers requirements and which new requirements may result from these characteristics?

6) Which questions have to be asked by CAPE during the requirements specification process, to select the relevant requirements for Board Computers for specific road freight transport companies, in order to narrow the range of possible solutions?

2.3 Research model

The design of this research is schematically represented in Figure 1. This research model shows the different steps of this assignment, and their relations, which eventually will lead to the end goal of this project: a validated method to advise road freight transport companies on the efficient requirements specification for the selection of Board Computers.

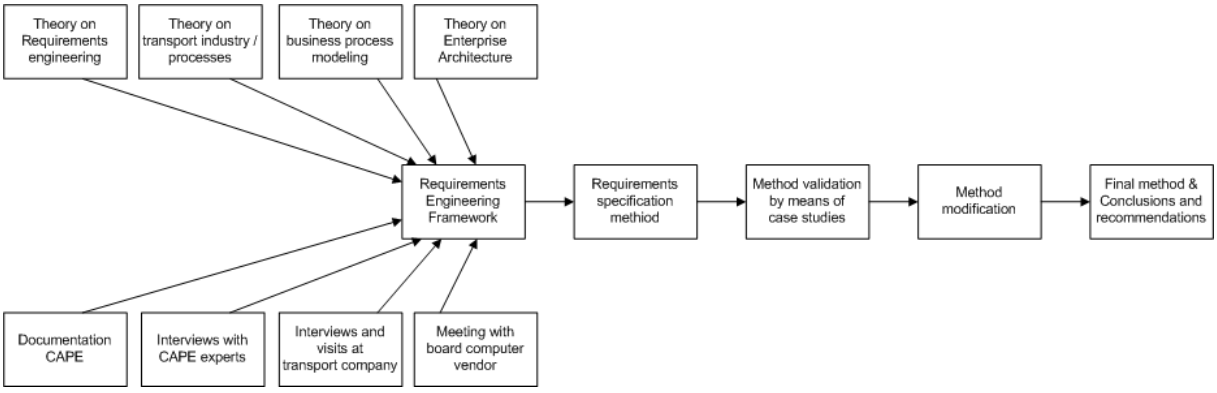


Figure 1 Research model

The research starts with a study of literature on the relevant topics. Then the road freight transport sector will be quickly analyzed and divided into segments of transport types, which have different (execution of) processes and thus different requirements for board computers. This analysis will be executed by a study of literature, asking CAPE experts and studying documentation of CAPE. Also, a

transport company will be visited, and a driver will be accompanied for one day, to get an impression of the daily practice.

A list of possible, frequently used, requirements for board computers for use in road freight transport will be made. This list will be based on the requirements that can be found in the documentation from about five previous projects CAPE was involved in. After this list has been consolidated, it will be checked by the experts from CAPE and completed where necessary. Also, documentation from Board Computer vendors will be used to make sure there are no important requirements missing, without writing down requirements for functionality that has been developed by a vendor but will never be used. It has to be noticed that the requirements that will be specified are mostly domain requirements, which tell *what* the system should support. This in opposite to system requirements, which tell *how* the system should function. (Lauesen, 2002)

For the various transport types, what the business processes look like will be explained and business process models will be made. There is very little literature available on this topic, but there is documentation which can be used as a basis. The extensive documentation on road freight transport companies from CAPE will be used as the most important basis for the creation of the business process models. When it is clear what the business processes look like for the various segments, we will match the requirements to the business processes.

The enterprise architectures of road freight transport companies will also be studied, since the architecture has an important influence on the requirements too. Description and models of the main enterprise architectures found at road freight transport companies will be given, based on the documentation of previous projects, CAPE knowledge and documentation from board computer vendors. After the architectures are described and modeled, requirements will be matched to the possible architectures.

During the research, it might be possible that additional discriminating characteristics will be found which have an important influence on the requirements. If that will be the case, these characteristics and their influence will be described.

Finally, one big questionnaire or various smaller sub questionnaires will be made which CAPE can use to interview transport companies, and get information on all relevant topics such as business processes, architecture and other issues. With the answers CAPE can easily select, from the board computers available on the market, a reduced number (shortlist) of feasible Board Computer solutions for their client.

The developed method will be validated by briefly testing it at four different companies, which represent the various segments, and which will be selected with the help of CAPE experts. With the questionnaires the transport companies' representatives will be interviewed, and the answers will be worked out into the relevant requirements. Then CAPE experts will evaluate the results and thereby the performance of the method.

2.4 Scope

During this research a method will be developed which CAPE can use to effectively advise to road freight transport companies on the selection of Board Computer systems. The deliverables of this research will be: an analysis and segmentation of the industry, an analysis and description of the main company characteristics; an analysis and description of the main company strategies and goals; descriptions and models of the main possible enterprise architectures; descriptions and models of the business processes; a list of frequently found requirements, general and following on the various characteristics; and finally questionnaires which can be used to efficiently get insight in the characteristics and the following relevant requirements of a specific company.

The research will focus on the analysis and description of the mentioned characteristics and the requirements following on those characteristics, and on the development of questionnaires to efficiently gather information on those characteristics. Together these will make up a requirements specification framework which will support the board computer selection process.

One should notice that it is not the goal of this research to describe the researched topics for transport companies completely into detail, but to get insight in the discriminative characteristics. With those discriminators CAPE will be able to easily specify the relevant requirements for specific companies.

The main data source will be the documentation of about five previous projects CAPE was involved in. Secondly, information and insight CAPE experts give during the research will be very important. Also, various departments of one transport company will be visited and two truck drivers will be accompanied for one day to get insight in the daily practice. Documentation from board computer vendors will be studied and one vendor will give a demonstration and explanation on their product. One transport company looking for a board computer will be used as a case to validate the framework.

During this research, documentation of Board Computer systems will be studied and during the company visit Board Computers will be seen in action, but besides that the analysis of the solutions is out of scope. Lauesen (2002) distinguishes three succeeding main phases in the specification and use of requirements:

1. Elicitation and analysis: finding and structuring requirements
2. Validation: the customer's check that requirements match demands
3. Verification: checking that the product fulfills the requirements

The to-be developed method will cover only the first two steps and keeps verification out of scope. In the case of system selection verification means the comparison of existing systems by checking which systems fulfill the requirements the best. This division will be the same during the execution of the research: requirements will be found and structured, and checked if they match the demands. But which product fulfills which requirements the best will not be studied.

The research will mention important characteristics of the board computer vendors, implementation issues, and project issues such as risk and costs but they are not really covered in the framework and therefore are out of scope.

2.5 Research strategy

Verschuren and Doorewaard (2007) distinguish five research strategies. This project will use a grounded theoretical approach for the creation of the method, which combines the practical situation with theoretical principles and existing methods. For the validation of the method we will hold two role playing case studies in which situations in which CAPE Groep consultants use the developed framework to advise transport companies are simulated.

2.6 Research material

One can distinguish five different types of sources, which are people, documents, literature, media and reality. (Verschuren and Doorewaard, 2007) In this research only the first three will be used since media do not give very useful information and it is not doable to get information from reality in this case:

- People: The empirical part of this research will use people as an important data source. For the development of the method interviews will be conducted with mostly CAPE experts to get information on the real life situation. Transport company representatives and vendor representatives will be approached to complete and validate the method. A truck driver will be accompanied for one day and a transport company will be visited to get insight in the daily routine in which board computers are implemented. For the validation part the developed method will be tested by briefly testing the questionnaires with interviews at companies, and CAPE experts will evaluate the performance.
- Documents: CAPE has many documents on current and previous projects on board computers and related topics. Also, on the internet documentation is available on relevant subjects. The

documentation from the internet will be mainly used as background information for the creation of the method. The documents from CAPE on previous (board computer) projects will be used as the main basis for the specification of requirements, and the description and modeling of business processes and enterprise architectures.

- Literature: Scientific literature will be an important part of the research input. For the creation of the framework literature on (methods for) requirements engineering for COTS-selection, business process modeling, enterprise architecture and the transport industry will be used.

2.7 Conclusion

This chapter showed what will be researched and how the research will be carried out. The next chapter will describe the relevant literature.

3 Theory

This section describes the theory that has been studied and the results from this on the main topics of this research. These topics are: board computers, package selection, requirements engineering, business process analysis, enterprise architecture and the road freight transport industry. The sources are both literature study and empirical research.

This chapter starts with a short description of the empirical research that has been done. In this chapter only the main conclusions from the empirical research are given and then the specific research topics are discussed.

3.1 Empirical research

Empirical research has been performed by interviewing, accompanying and discussing (with) people from the practical world, and by studying documentation from previous board computer related projects and documentation from board computer systems.

Two employees from CAPE Groep, have been interviewed several times on their experiences during board computer projects and on their wishes for the method that will be developed during this research. Also, they were asked on their general experiences end knowledge in and from the transport industry: business processes, enterprise architecture, atmosphere, and so on.

Visits at the planning department, dock, garage and warehouse of the transport company Tielbeke, and the accompanying of two drivers from this company gave insight in the practical situation. What are their experiences with their Board Computer? How is it used and what do the employees like or like not from it? This research was also used to get insight in the business processes at a transport companies.

The documentation of five of CAPE's projects related to board computers have been studied, giving insight on the way these projects are carried out, on the business processes, on the most important issues and drivers, and on requirements for board computers.

Also, documentation from about fifteen board computer vendors was studied and a meeting with a vendor was held. Appendix Appendix D describes the empirical research in detail, and the main conclusions are written below:

3.1.1 CAPE Experts

According to the CAPE experts the main reasons of clients for implementing board computers are the ability to decrease communication costs and to follow the trend, a vision with which a lot of chances and possibilities are unseen. CAPE is asked to assist in the selection and implementation process because of its extensive experience, contacts in the market and technical knowledge. CAPE wants to improve the speed of requirements specification, and therefore wanted to start this research. It would help them a lot if they have a more structured and predefined way to clear up the processes in a transport company, the demands for the board computer following from those processes, and the necessary interaction with other systems. An important issue is the border between Board Computer, TMS and APS which is very vague in some cases because the functions of these systems overlap.

3.1.2 Tielbeke visits

The visits at the planning department of the transport company Tielbeke gave insight in the practical situation. The planners like the Board Computer system because it saves a lot of work and works simple and effective. It is easy to communicate with the drivers with "SMS-like" messages. It is also easy to monitor the status of the drivers, although the board computer sends back a lot of data which is not used. Also, it is very useful that job instructions can be changed during the day. It is a problem that it takes a lot of time to send the instructions to the board computer because the drivers have to wait for it when they start working. The digital registration of names (given by the persons

that received or handed over shipments) instead of signatures is a good alternative for digital signatures, since it gives a quick proof until the paper signature returned at the office and is scanned. The hour report which is printed and signed by the driver at the end of the day is a good way to validate and finalize the registered hours.

The accompanying of two drivers from Tielbeke gave clear insight in the practical use of Board Computers. Some drivers were resisting the system in the first period after the implementation but nowadays everyone is used to the system and realizes the benefits of it. The truck drivers think the board computer is slow, which is specially a big issue in distribution because then a lot of shipments have to be registered. Also they mention some issues with the navigation, since it is not really appropriate for truck navigation. The drivers also dislike the way traffic queues have to be registered and the fact that the board computer time registration differs with the tachograph time. They do think the board computer is easy to use and are glad the hour registration, essential for their salary, is done in a good way now. Also the function which changes the registered GPS coordinates after a location was three times found to be different than registered was perceived very useful.

The (cross)docking process was found to be very complicated, since a lot of shipments have to be distributed cross the dock. It is not very easy for the driver to make sure he has all shipments that are planned for his trip. A scanning or RFID device could makes this last process much easier, giving opportunities for a new board computer.

3.1.3 Board Computer projects

The documentation of five of CAPE's projects related to board computers have been studied, giving insight in the way these projects are carried out, transport organizations in general, business processes and activities, used definitions, the most important issues and drivers and last but not least on requirements for board computers. Since these documents gave such a pile of information, they were the main input for the process and architecture descriptions and requirements specified in this research.

3.1.4 Board computer vendor documentation

The documentation from about fifteen board computer vendors was studied and a meeting with a board computer vendor was held. These results were used to check no requirements or project drivers were missing. But requirements were not copied when they could not be derived from the business processes or architecture. The meeting with the board computer vendor gave insight in the transport industry in general, and "how things work" in this sector.

3.2 Board Computers

In general, a board computer is a device which registers all kind of information (like location data by means of GPS and truck information by communication with the CANbus) and communicates two-ways with various systems in a transport organization by means of wireless communication techniques such as GSM, GPRS or UMTS. This communication takes place on different levels and for different purposes, e.g. track and trace, hour registration and planning. The device is build-in in the truck or is mobile so that the driver can take it out of the truck to the customers.

3.2.1 Functionality

A board computer mainly replaces processes which previously were performed on paper and replaces communication which previously took place by phone. These replacements can cause a decrease/eliminate of administrative efforts and accompanying delay, cost and possibility of errors. Board computers also bring new functionality, because they register and communicate information which previously was not saved. General spoken: a board computer real-time registers all data from a truck, its driver and the load: what is the driver doing when and where and what is the status of the truck and the load? With this information analyses and checks can take place which were impossible without the board computer.

A board computer mainly supports the execution process, but also is used for easier billing, settling, controlling and planning. In general, the main functionalities of a board computer are communication, registration and location determination.

Registration

The board computer records data on the execution of jobs, like driving, loading and waiting times and other billing data. These registrations take place both manual and automatic. Manual by typing in numbers by following the question path, and automatic by a connection with the tachograph, GPS, and a connection with the CANbus. The registrations can be read at the office realtime thanks to a mobile communication network. This data can also be used to inform customers with track and trace information, and send to the salary system and transport management system. The status updates can also be used to adjust the estimated time of arrival (ETA) and planning based on deviations from the original schedule.

Communication

With a board computer the communication no longer takes place by speech, but with text messages which are exchanged over a data network. This decreases costs and gives rest on the planning department, decreasing the chance on errors. There are various mobile communication networks available such as GSM, GPRS, UMTS and satellite, differing in geographic reach, costs, speed and reliability. GSM is still popular but GPRS is GPRS is quickly winning market share.

Location determination

GPS (Global Positioning System) is used in almost all board computers to determine the location of the trucks. This position data can be used for tracking and tracing and to update the actual planning. Also, GPS is used to support the driver with navigation support.

More detailed functionalities

In more detail, the main functionalities of board computers are the support of:

- Communication of orders, statuses and other messages
- Navigation
- Hour registration; for billing and settling
- Expense registration; for billing and settling
- Proving, of mainly deliveries and pickups
- Status updating; track and tracing
- Performance analysis; management information

Charter drivers: Points of attention

An important point of attention for the implementation of board computers is how to cope with charter drivers. When the charter driver used its own board computer a connection with the charter board computer has to be made. And when the charter will use the board computer of the company hiring the charter, one has to determine which data is needed from the charter. (TLN, 2005)

3.2.2 Integration maturity

We can distinguish four levels of integration maturity to classify bard computers. With level one the Board Computer brings the less, and also costs the less, and with level four the board computer will bring the most benefits but also will costs the most. This is not on the last place because of the efforts to integrate it. The Dutch transport organization TLN specifies three maturity levels (TLN, 2005) but CAPE Groep distinguishes a fourth level (CAPE Groep, 2009, see Figure 16 in Appendix Appendix A). Based on these two sources together, we have specified the following four maturity levels:

Level 1: The trucks can be followed on a map, and simple text messages can be exchanged.

Level 2: Functionality of level 1 plus administration of worked hours.

Level 3: Functionality of level 2 plus: controlling of drivers, feedback, and modification of controlling based on feedback.

Level 4: Functionality of level 3 plus: fleet management.

The requirements on the board computer depend a lot on which level of integration maturity is strived for, and therefore this has to be made explicit in an early phase.

3.2.3 Implementation drivers

The previous section showed the main functionalities a board computer can offer, but before selecting a system most transport companies do not see all those advantages. The main reasons for many transport companies to implement a board computer is just to decrease communication costs because the companies see the board computers mainly as a useful device for the effective exchange of messages. This, and the fact that they simply want to follow the "trend" of implementing a board computer are the main reasons to implement such a system. The communication costs indeed can decrease dramatically, so this is a valid argument to implement a board computer, but with this vision a lot of chances and possibilities are unseen. (See section D.1.1)

Better and more complete implementation drivers are:

- Improve customer satisfaction
- Improve driving behavior
- More efficient and effective execution and controlling
- Get management information and improve profitability and negotiation position
- Decrease work pressure of administration and planning (TLN, 2008)

3.2.4 Trends

Board Computers in their simplest form are in use for more than fifteen years, but in these years a lot has changed. The communication networks are improving and the costs of it are decreasing and therefore more data is send real-time. Also, more and more board computers are having a connection with the CANbus, for which good standards are developed, so more truck performance data is offered from the truck to the office.

In 2008 25 percent of the Dutch road freight transport companies used a board computer. From the companies with less than 10 vehicles this was less then 10 percent, and from the companies with more than 50 vehicles it was more than 90 percent. So, bigger companies are much more used to use board computers than smaller companies. In the distribution and intermodal transport board computers are more popular than in the other transport types. (TLN, 2008)

3.2.5 Experiences at Tielbeke

A visit at the planning department of the transport company Tielbeke, and the accompanying of two drivers from this company showed that the planner likes the Board Computer system mainly because it saves a lot of work and works simple and effective. Some drivers were resisting the system in the first period after the implementation but nowadays everyone is used to the system and realizes the benefits of it. The truck drivers think the board computer is slow, mention some issues with the navigation, dislike the way traffic queues have to be registered and the fact that the board computer time registration differs with the tachograph time. They do think the board computer is easy to use and are glad the hour registration, essential for their salary, is done in a good way now. So, in this single case there was some resistance against the board computer in the first period, and there are some issues with the use of it. But in general the Board Computer brings important benefits for this company. See section D.2 for an extensive description of the Tielbeke case.

3.3 Package selection

The process of Commercial Off The Shelf (COTS) system package selection contains various steps, from which the analysis of the business processes and the specification of requirements are two very important ones. Little (1998) and TTM (2009) explain how these two steps fit in the complete process of package selection. Jacobs et al. (2004) give another approach for package selection, but leave the process analysis out of scope. After an explanation of these three theories the experiences from CAPE are described and the sources are combined into a package selection approach which will be supported by the method developed in this research.

3.3.1 Defining sectors and reference models

Little (1998) describes a method for package selection meant for small and medium sized enterprises (SME) which is depicted in Figure 2. The context of Little's work is a little different than this research, but the basic idea with the three steps - the identification of the industrial sector and it's reference model, then the specification of requirements and then the selection of the right package - is very useful and is adopted in this research by the approach: identify the relevant transport type(s), specify model by means of reference model, specify requirements and eventually select the right package .

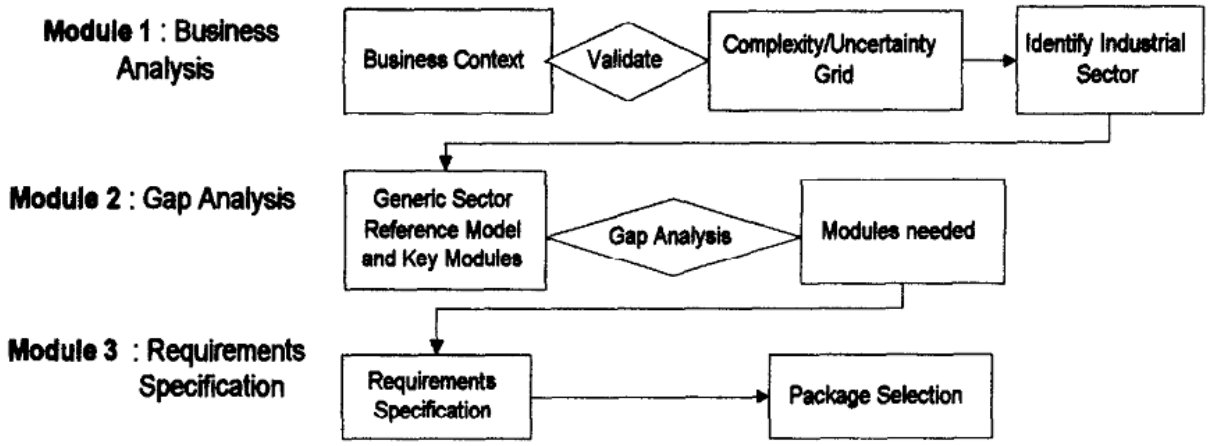


Figure 2 Package selection model for SME's (Little, 1998)

3.3.2 Tool selection

Jacobs et al. (2004) defined a clear approach for the selection of a business process modeling tool, which is depicted in Figure 3. With this approach several available tools are screened based on a list of requirements and wishes of the organization and eventually one is chosen.

A good thing of this approach is that the exploration of the tool market is specified explicitly and that the iterative character of certain steps is mentioned. Also, the specification of knock-out criteria fits well with the context of this research. A weak point is that because this approach focuses on the selection of a tool for modeling and not for the support of a process it misses the process analysis.

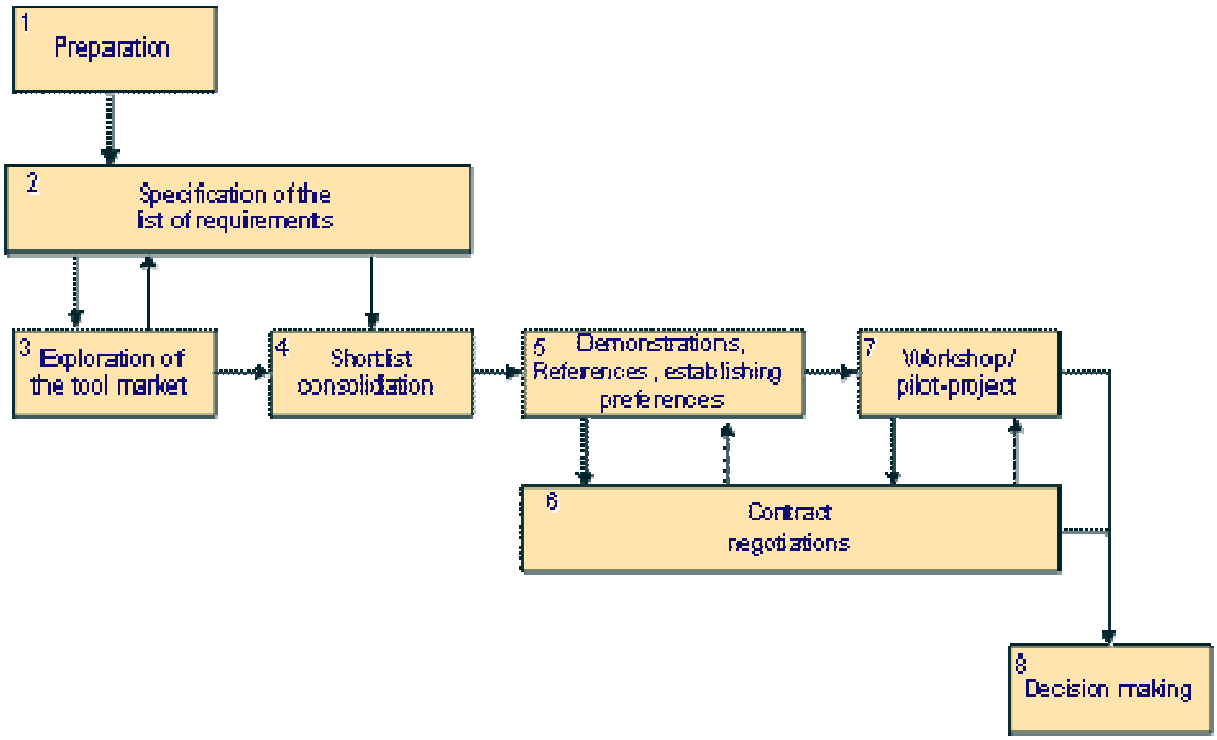


Figure 3 Tool selection process (Jacobs et al., 2004)

The selection process described by Jacobs et al. (2004) starts with an analysis of the current situation. After that the requirements are specified and prioritized. The most important ones are ranked with a 1 and are called Knock-out criteria. Then the market is explored to produce a longlist of possible suppliers. All suppliers on this list will be asked to answer a standard questionnaire concerning the product they offer, known as the Request for Information (RFI). In the next phase the information received in the previous phase is evaluated, and a first sorting of the suppliers on the long list will be made based on the KO criteria. Then a thorough evaluation of the remaining candidates must be carried out to produce a short list of three to four names. Then, with the suppliers on the short list appointments should be made for demonstration and presentation of their products, such that a better understanding of the tool features and capabilities can be achieved rapidly. In order to effectively benefit from the contact with the suppliers it is recommendable to steer the presentations towards the demonstration of the tool in situations that mimic the daily practice of the organization. Often it is also possible to get in contact with other users of the tool, and ask them to give references regarding the tool and the supplier. Visiting these clients may also bring some light on the abilities and inabilities of the tool and also on the relationships of the supplier with its current clients. After this and the contract negotiations it should become possible to come to a conclusion regarding the preference for a certain supplier. After the selection, the tool must undergo a validation in a practical setting. It is sensible to select an organization-specific case that requires the usage of all the required essential functionality. At the end of the selection process a final recommendation report must be delivered, possibly accompanied by an implementation plan.

3.3.3 Board Computer Specific

The Dutch transport website TTM (2009) recommends the process as depicted in Figure 4 for the complete process of selecting and implementing a Board Computer system, stating that the implementation of a board computer system is not just “the choice for a nice display but the change of business processes”. This advice is adopted, and the steps are used as a basis for the approach developed in this research.

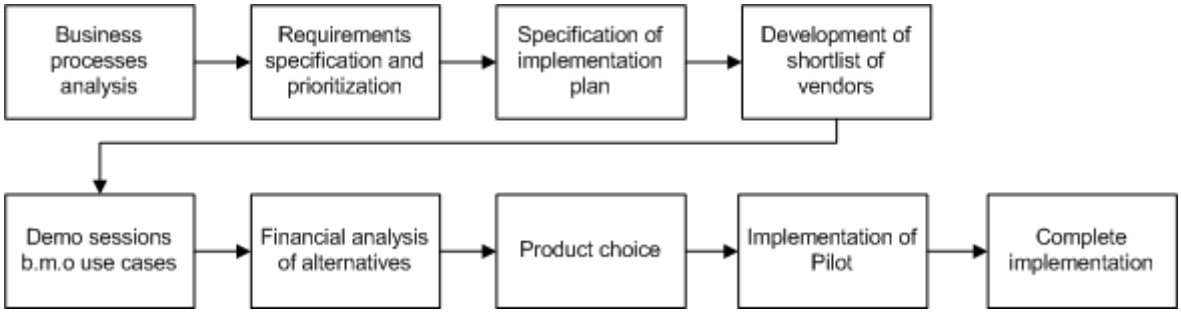


Figure 4 Board computer selection and implementation process (TTM, 2009)

3.3.4 CAPE's experiences

Two employees from the CAPE Groep were interviewed and asked how they are used to do Board Computer package selection for transport companies, and how they want it to be.

CAPE Groep has much experience in the transport industry in general, and with board computer specific. Transport companies heard about this extensive experience and want help from CAPE Groep. CAPE Groep can assist with the management of the project, with advice with respect to the context and by using their contacts in the industry. They can use previous projects as best practice examples, and know the vendors active in the market. CAPE Groep can give a fresh objective vision on the company and provide the company with the necessary technical knowledge which most companies miss.

The people from CAPE Groep guided several Board Computer projects, and are confident about how they did this and will do it in the future. They know quite well what the important issues are that a board computer can solve, and know quite some details on the most used board computers. Still, it would help them a lot if they have a more structured and predefined way to clear up the processes in a transport company, the demands for the board computer following from those processes, and the wished interaction with other systems.

CAPE does not have a strictly fixed approach for this nor is the approach captured on paper. Nevertheless, the results from the interview showed that CAPE does have an order of steps which they normally follow more or less. The way of working from CAPE looks like the approach from TTM, but CAPE has more steps and a slightly different order and the approach is a little more detailed and pragmatic. The biggest differences with TTM are that CAPE makes the implementation plan as one of the last steps and that it uses a longlist based on knock-out criteria before the shortlist.

3.3.5 Package selection approaches combined

Based on the discussed literature and the experience of CAPE, an approach is developed which CAPE Groep can use for the efficient selection of Board Computer systems for their customers. The approach is mainly based on the experiences from CAPE, since that is the case on which this research focuses. But the approach is also supported by the approaches TTM, Little and Jacobs suggest.

The developed approach, which is supported by the method delivered during this research, is depicted in Figure 5. The sections after the figure explain the various steps.

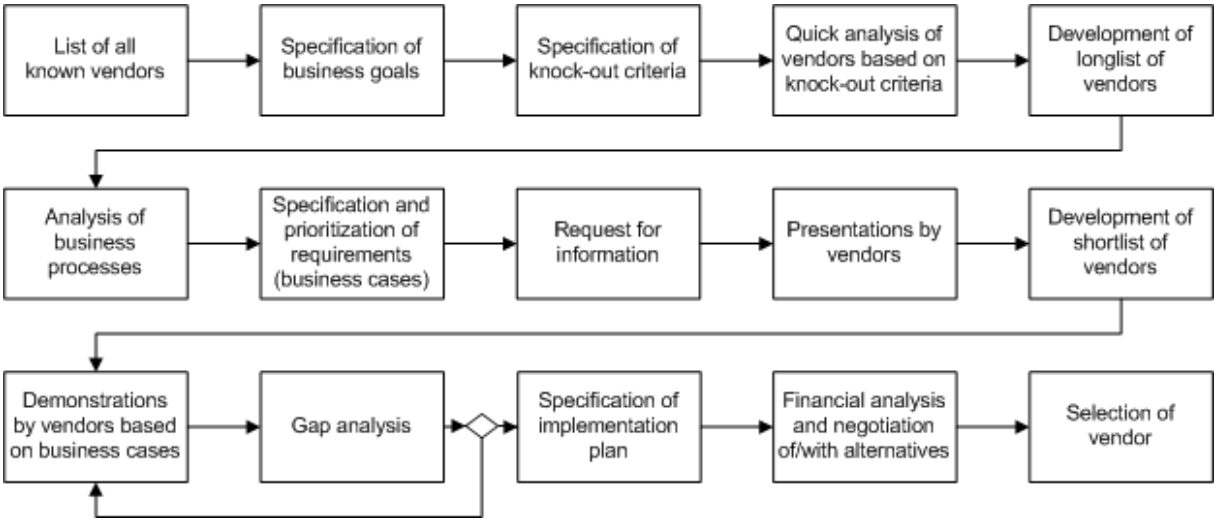


Figure 5 Developed package selection process

3.3.5.1 List of all known vendors

CAPE starts with a list of all companies they know that provide board computers. In practice, this list contains about 30 to 50 vendors.

3.3.5.2 Specification of business goals

Together with the transport company looking for a board computer CAPE formulates the business goals, the drivers for the project related to the business strategy. CAPE's role in this is mainly to ask questions like: what do you want to achieve with the system? Example of an answer: "We want to decrease the communication costs with 20 percent." During this phase CAPE also determines which transport type(s) the transport company performs.

For many transport companies, the motivation to implement a board computer is just that the competitors have a board computer too and that the company wants to decrease the communication costs. But a board computer can help a transport company in reaching much more goals. In many cases these kind of goals are formulated by the company on a high level, but maybe are not thought of by the people involved in the choice for a board computer. CAPE should help the company by presenting the representatives possible goals from which the company can select the relevant ones.

The problem with this approach is that the transport companies are likely to select all goals, because they off course prefer to get all benefits. Because of this, a prioritization technique is selected which forces the company to chose, and which results show the relative prioritization very precise, but which is very easy to use. The technique selected for this is the 100-dollar test, see section for an explanation of this technique. (Berander and Andrews, 2005)

In this context CAPE considers their client, the transport company, as one stakeholder having one prioritized list of goals, and therefore the support of conflicting goals and requirements of various stakeholders is out of scope. (Berander and Andrews, 2005)

3.3.5.3 Specification of knock-out criteria

Based on the business case and project drivers the knock-out criteria are formulated. This is a list of about twenty criteria the vendor and its system must fulfill. So, not only the product is evaluated but also the vendor providing it. Because of the knowledge and great experience of the CAPE employees, they can easily formulate these knock-outs. Examples: "The vendor must have delivered their product to at least three companies with more than 50 vehicles before." or "The Board Computer device should be mobile."

The mentioned sources do not advise to use knock-out criteria, but CAPE does. This is the case because at this early stage it would cost too much effort to evaluate the vendors with a complete list

of requirements. This way, the list of 30 to 50 vendors can relatively easy be reduced to about 10 to 15.

3.3.5.4 Quick analysis of vendors based on knock-out criteria

The alternatives are analyzed based on the knock-out criteria. If an alternatives does not match all knock-out criteria, it is dropped. Off course, when none of the alternatives can fulfill all criteria it is possible that the ones which fulfill the most are chosen.

3.3.5.5 Development of longlist of vendors

When an elimination has been made based on the knock-out criteria, about 10 to 15 vendors are left.

3.3.5.6 Analysis of business processes

After the longlist is made, the business processes of the transport company are analyzed. Off course to speed up the selection process this analysis can be done parallel with the previous steps. Analyzing the business processes means that the consultants specify which kinds of transport are executed, how this is done and how the process is supported. For this, one needs to know the business context and business sector.

3.3.5.7 Specification and prioritization of requirements (business case)

With the use of the business process analysis and the previous described business case and knock-out's prioritized requirements are specified. The consultants from CAPE are used to formulate these requirements as business cases. In the business case the processes are described and the vendors are asked to show *that* (and not *how*) these processes are supported. With this approach CAPE can test both whether the vendor *understands* the business and process and whether the product *supports* this.

3.3.5.8 Request for information

The vendors from the longlist are contacted with a request for information. They are asked to give a presentation on their company and their product. Usually ten to twenty percent of the vendors do not even respond to the request, and are dropped.

3.3.5.9 Presentations by vendors

The vendors from the longlist give a presentation and answer questions, responding on the request for information. During this presentation the vendor representatives have to show that their company: understands the business, is financial healthy, has enough experience and has good references, without going into details on the product. CAPE uses this meeting to get a feeling about the vendor.

Most approaches suggest only the vendors from the shortlist give presentations, because that saves time. Nevertheless, CAPE wants presentations from the vendors from the longlist, because it is very important how the feeling between the transport company and the vendor is. The transport company does not just buy a system from the vendor but starts a long time relation with the vendor and values the feeling and relationship with that vendor very much. When the feeling with a vendor is not right, the vendor can be dropped and the demonstration can be skipped, which saves time.

3.3.5.10 Development of shortlist of vendors

Based on the vendor presentations a shortlist of about three to five vendors is developed.

3.3.5.11 Demonstrations by vendors based on business case

The vendors from the short list demonstrate their product based on the business case. They have to show in what way their package supports and handles these case.

3.3.5.12 Gap analysis

After the demonstrations are given, for each alternative it is analyzed what the gap is between the requirements from the transport company and the fulfillment of these requirements by the vendor's

product. When CAPE or the transport company wants to see additional or modified functionality, wants to have additional information from the vendor, or wants to see more demonstrations then the vendor is asked to come back. This combination of the demonstration and gap analysis steps is iterative and can be repeated until the gap analysis is completed and time and investments are specified.

3.3.5.13 Specification of implementation plan

When only a few vendors are left the implementation plan is specified by CAPE and the individual vendors. This is done in this phase, and not earlier like TTM suggests, because at this moment it is known what has to be done for the implementation and how much time this will take: how easy is it to connect systems, what has to be added custom-made, and so on.

3.3.5.14 Financial analysis and negotiation of/with alternatives

In this phase the financial characteristics of the alternatives are analyzed and the negotiations take place with the vendors.

3.3.5.15 Selection of vendor

Based on the previous steps, one vendor and its product is selected. Then this product is implemented by a pilot, but from that point the process is out of scope of this research.

3.3.5.16 Package selection support by this research

The package selection approach explained above works step by step from a list with all existing Board Computer vendors, known by CAPE, to the selection of one final vendor. In the model, the definition vendor is chosen, but the term package could be used also. Vendor is used because CAPE and its client chose not for just a package but intentionally select a vendor, taking into account also the characteristics of the company providing the system. Furthermore, not just the package is selected, but also other (for example custom-made) parts needed for optimal usage of the system. The approach is developed to be used for the selection of Board Computers, but is suitable for the selection of other comparable systems (in the transport industry) too.

The method developed in this research will support the package selection approach on the subjects of business goals specification, requirements specification (on various levels) and business process analysis. How these various steps should be performed will be explained in the next sections. Section 4.1 further explains the relation between the package selection process and the method delivered with this research.

3.4 Requirements engineering for COTS selection

The specification of requirements is one, very important, step in the process of package selection, as explained in section 3.3.5. This step is supported by this research's product and this chapter will describe how this should be done.

Various authors such as Lauesen (2002) and Engelsman (2008) acknowledge that the purpose of requirements differs a lot between the situation in which they are specified for the design of a custom-made system, and the situation in which they are specified for selecting the right Commercial-off-the-shelf (COTS) system. In the former scenario, the requirements are design-oriented, in the latter scenario - which fits the situation of CAPE advising a transport company - they are more solution-oriented. Therefore, in this research requirements engineering is defined as "the process of determining the needs and conditions to meet a certain result" and a requirement is defined as "a feature of the system or a description of something the system is capable of doing in order to fulfill the system's purpose". (Pfleeger, 1998) Although most literature focuses on the design-oriented requirements, the last decade some good methods for solution-oriented requirements engineering have been developed too.

An important problem with requirements engineering, according to (The Standish Group, 2001) one of the top 10 problems for an IT-product success, is the fact that there is no basic set of

requirements. In this research this problem is solved by creating a basis set of requirements for Board Computers from which the relevant ones for specific transport companies can be selected.

The following paragraphs describe various requirements types and levels that are defined by different authors, and eventually defines and explains the definitions and criteria that are used in this research.

3.4.1 Requirement types and levels

When a specific transport company is looking for the most suitable COTS board computer system, it is the best to start the requirements specification at a high level and distinguish different kind of requirements. Lauesen (2002), Robertson and Robertson (2007) and Engelsman (2008) designed very useful divisions for this.

Lauesen (2002) distinguishes domain and product requirements. The former tell *what* (which process/task/function) the system should support and the latter *how* the system should function and which functions it should provide. Lauesen also distinguishes goal-level requirements, which explain why the customer wants to spend money on the product.

Robertson and Robertson (2007) made another division in the Volere template for the specification of requirements. Their four types of requirements relevant for this research are:

- *Project drivers* are the business-related forces. These are the high-level goals a company wants to achieve with the implementation of a board computer system.
- *Functional requirements* are the fundamental or essential subject matter of the product. They describe what the product has to do or what processing actions it is to take.
- *Nonfunctional requirements* are the properties that the functions must have, such as performance and usability. These requirements are also called Quality Requirements.
- *Design constraints* impose restrictions on how the product must be designed. For example, it might have to be implemented in the hand-held device a company is already using, or it might have to cooperate with other existing hardware and software.

The Volere template also distinguishes project constraints and project issues, but these requirement types are out of the scope of this project since we decided to focus on the functionality of the products and not study project and vendor issues into detail.

Engelsman (2008) developed a method for requirements management and modeling, in which he clearly distinguishes requirements engineering for bespoke systems and for COTS selection. He acknowledges the big influence of enterprise architecture (requirements) on the eventual requirements and the chosen solution. His method is worked out concrete and combines the best aspects of literature (e.g. PORE from Ncube and Maiden (1999) and CRE from Alves and Castro (2001)).

Engelsman distinguishes requirements in the problem domain and requirements in the solution domain. Requirements in the problem domain are requirements that the stakeholders want to achieve through use of the system (the objectives), with no reference at all to a possible solution, which are also called business requirements. Strategic choices of transport companies will be reflected in these requirements. System requirements in the solution domain state how the system will meet the stakeholder requirements (the behavior), without any reference to a design.

The Wexlog white paper (Wexlog, 2006), an example from the practice in the transport industry, distinguishes *Features* which *Provide* functions which on their turn bring *Business Benefits*. In fact Features fulfill Functional and Non-functional requirements, Provide stands for Business Requirements, and Business Benefits are Business Goals. See Figure 6 for an example of this distinction for Transport Management Systems.

Feature	Provide	Business Benefits
Automated workflow in complex organization	Support multi country and multi-lingual complex organizations	Standardized processes
Real Time transaction	Operational data are updated in RT, financial data accordingly	Reduce operational and financial errors
Real Time scanning (Barcodes, RFID) and labelling	See above, support multiple labels and identifiers	Improve operational and administrative productivity
Real Time visibility of shipments statuses	Track and Trace, data and physical flow reconciliation	Improve Customer Service and operational quality
Seamless process support from order booking to delivery	Reduce work overhead, errors (new data entry), standardize processes	Improve productivity and quality
Timely assembly of great variety of document formats	Automated document assembly and generation	Fast and timely document generation
Automated financial settlement, linked with operational execution.	Improve : customer and supplier invoicing, COD management	Reduce errors and useless work overhead
Built in cost/revenue on shipment level, trip level, organization level	Solid cost monitoring	Allow yield mgt, supplier cost reduction, internal cost reduction
Built in operational KPI	Solid quality monitoring	Allow operational quality management

Figure 6 Alternative disctinction of demands on different levels (Wexlog, 2006)

In COTS selection the focus is less on specifying a complete requirements specification, but the goal is more to derive an initial set of requirements which can be used to reduce the number of appropriate alternatives. The second step is to prioritize the requirements because not all requirements are just as important and offered products will not always provide a complete match. The iterative character of Engelsman's approach – updating the requirements specification while analyzing products - is implemented in this research by studying vendor documentation on the characteristics of their product.

3.4.2 Requirement types and levels combined

In this research the divisions from Lauesen, Robertson and Robertson and Engelsman will be combined, and Wexlog is used as a "proof from practice". The terms business requirements and system requirements from Engelsman are used, since they will sound the most logic to laymen at transport companies. The system requirements are divided into functional requirements, nonfunctional requirements and design constraints (like Robertson and Robertson proposed) because those three types very well match the aim of this research since the architectural and "device" requirements can be put under the design constraints. The high-level definition Business goals is used for the specification of the reasons why a company wants to spend money on the products. The terms Goal-level requirements (Lauesen) and Project drivers (Robertson and Robertson) are used for the same thing.

The divisions from the three sources and the division that is used in this project can be seen in the table below.

Lauesen (2002)	**Engelsman (2008)**	**Robertson and Robertson (2007)**	**Wexlog (2006)**	**This research**
Goal-level requirements		Project drivers	Business Benefits	Business goals
Domain-level requirements	Business requirements (problem domain)		"Provide"	Business requirements
Product-level	System		Feature	System

requirements	requirements (solution domain)	-Functional requirements -Non-functional requirements -Design constraints		requirements: -Functional requirements -Non-functional requirements (-Design constraints)

Table 1 Requirement types

We will give some examples of the requirements on the different levels:

Business goal:	With the system we should improve the customer satisfaction with twenty percent.
Business requirement:	The system should support tracking and tracing.
Functional requirement:	The system should register each unloading activity.
Nonfunctional requirement:	Each registered execution activity should be visible at the planning office within five minutes.
Design constraint	The board computer system should be able to communicate by XML.

The method that is delivered after this research will support the selection of the goals and requirements from the different levels.

3.4.3 Requirements prioritization

Transport companies can have a lot of wishes for their board computer, but not all of these are just as important. Therefore the selected requirements, both on higher and lower levels, have to be prioritized for the specific company. For this, several techniques can be used.

3.4.3.1 100 dollar method

The 100-dollar test is a very straightforward prioritization technique where the stakeholders are given 100 imaginary units (money, hours, etc.) to distribute between the goals or requirements. The result of the prioritization is presented on a ratio scale. When there are more than about twenty objects to prioritize, one can increase the fictitious amount to for example 1000 or 100.000 units but in the context of business goals 100 units is enough. (Berander and Andrews, 2005)

In this context CAPE considers their client, the transport company, as one stakeholder having one prioritized list of goals, and therefore the support of conflicting goals and requirements of various stakeholders is out of scope. (Berander and Andrews, 2005)

3.4.3.2 MoSCoW methodology

The MoSCoW methodology is a very useful prioritization technique used in business analysis and software development to reach a common understanding with stakeholders on the importance they place on the delivery of each requirement, also known as MoSCoW prioritization or MoSCoW analysis. The capital letters in MoSCoW stand for:

M - MUST have this. Requirements labeled as MUST have to be included order for it to be a success. If even one MUST requirement is not included, the project delivery should be considered a failure.

S - SHOULD have this if at all possible. SHOULD requirements are also critical to the success of the project, but are often not as time-critical or have workarounds, allowing another way of satisfying the requirement,.

C - COULD have this if it does not affect anything else. requirements labeled as COULD are less critical and often seen as *nice to have*. A few easily satisfied COULD requirements in a delivery can increase customer satisfaction for little development cost.

W - WON'T have this time but WOULD like in the future. WON'T requirements are either the least-critical, lowest-payback items, or not appropriate at that time. WON'T requirements are either dropped or reconsidered for inclusion in later timeboxes. Sometimes this is described simply as "Would like to have" in the future, this however leaves some ambiguity in the minds of the users as to its priority compared to the other mark (DSDM, 2009)

In a package selection project, when the relevant requirements are selected the MoSCoW method will be used to score the requirements. With these prioritized requirements the alternatives will be analyzed.

3.4.4 Non-functional requirements

For the specification of the non-functional requirements, standard list of factors are specified by various authors. In this research, the dimensions defined by McCall and Matsumoto (1980), ISO 9126 (1991) and IEEE 830 (1998) are combined to make a new list with factors that are relevant for the context of this research. The leveled list, which will be used in this method for the specification of nonfunctional requirements can is depicted below. Some terms are explained with another term between brackets. This is because there are various definitions in use for more or less the same requirements.

- Operation (daily use by end users)
    - Integrity (Security)
    - Correctness
    - Reliability
        - Maturity
        - Fault tolerance
        - Recoverability
        - Availability
        - Robustness
    - Usability (Ease of use)
    - Efficiency (Performance)
        - Accuracy
    - Suitability
    - Compliance
- Revision (maintenance and extension of the system)
    - Maintainability
        - Testability
        - Changeability
        - Analyzability
        - Stability
    - Testability
    - Flexibility
- Transition (use of the system in new (technical) surroundings)
    - Portability
        - Adaptability
        - Installability

    - Conformance
    - Replaceability
- Interoperability
- Reusability

3.4.5 Requirements quality

This research will produce a big amount of requirements for board computers, from which CAPE can select the relevant ones for individual companies. The requirements which will be specified during this research, have to fulfill the quality criteria for a good requirements specification, and will be checked on this. These criteria, from the widely accepted IEEE 830 Standard (IEEE, 1998), are:

- Correct
- Complete
- Unambiguous
- Consistent
- Ranked for importance and stability
- Modifiable
- Verifiable
- Traceable

3.4.6 Actual requirements

The input for the specification of the board computer requirements has come from several sources. Section 3.7 describes the road freight transport industry, which is an important source for the description of these requirements. Project documentation from five board computer projects has also been studied to get insight in the actual business processes at Dutch transport companies. Also, documentation of fifteen board computers vendors was used for this purpose, to make sure no requirements were missing in the previous projects. The interviews with CAPE experts, the meeting with board computer vendor Centric, the visit at Tielbeke and the accompanying of two Tielbeke truck drivers were used too. See Appendix Appendix D for a description of this empirical research.

Wexlog (2006) defined the following “crucial points” against which an Transport Management System has to be tested, which in fact are also the main requirements for a board Computer. According to Wexlog, the package has to:

1. Provide the right support for the operation:
    - Provide state of the art functionalities to ensure right level of quality and productivity.
    - Provide the ability to integrate with other systems (build as far as possible an automated workflow within the ecosystem).
    - Provide the ability to maintain the system operationally.
2. Support the need for evolution:
    - From support improvement loops (from providing optimization tools to enabling the change of the process itself).
    - To providing reasonable agility versus changes in the ecosystem (new customers, new partners, new suppliers; with new channels / processes, with an increasing number of users…).
3. ..with appropriate and controlled costs:
    - Clear short to mid term ROI.
    - Good estimate of mid to long term cost control on evolution and maintenance. (Wexlog, 2006)

3.5 Business process analysis

This research’s product will support the analysis of business processes, since this is an important step in the package selection process. The business processes will be represented by business process models for the development of insight on the business needs (requirements) for the different kind of board computer users. This approach is supported by both Hommes (2004), TTM (2009) and CAPE itself (see section 3.3). Hommes (2004) defines a business process as *a structure of organizational or*

inter-organizational activities that are necessary to accomplish a product or service. These activities are coordinated through communication, in a sequence of goal-directed actions.

The following sections define how and which (types of) business process models and business process reference models are used in this research.

3.5.1 Business process models

Hommes (2004) defines a business process model (BPM) as *the model of activities of people working on a collaborative task that has been broken down into a structure of specialized, coordinated activity, supported by technology*. In this research, business process models are used as the basis of requirements. The models have to show which processes take place when and where, and how they can be supported. Also, they have to show the flow of information. Thirdly, the diagrams have to be easy readable, because in the future they might have to be used by laymen. Taking these criteria in account, three techniques can be used:

- Extended Event driven Process Chains (E-EPC). EPC's are part of the ARIS Process Platform, which provides an integrated toolset for designing, implementing, and controlling business processes. The basic EPC notation has been extended with a number of symbols corresponding to various aspects of business modeling. Extended-EPC's allow the modeling of business processes using four different perspectives: organization, data, control, function and output. Event Driven Process Chains are currently widely used to model business processes by means of events and functions, especially in the context of Enterprise Resource Planning (ERP) systems. The extended version can also show to which person, position or department functions belong, and which information is input and output of the various functions, and much more. (Dumas et al, 2003)
- Behavior Diagrams. With BiZZdesign's BizzDesigner (BiZZdesign, 2009a) one can draw clear and easy readable Behavior Diagrams, which show the process steps and checks taking place at the various actors, and the interactions between the actors. BizzDesigner is very easy to use and allows users to zoom in on processes and to link for example requirements, data and actors to processes, using colors to show the relation.
- Business Process Modeling Notation (BPMN). BPMN is a very rich business process modeling notation, based on a flowcharting technique very similar to activity diagrams from Unified Modeling Language (UML). It is the most extensive of the three techniques and a very important standard in the field. It can be used to model both sequence and information flows, but also supports swim lanes, "zooming in" on processes, connecting processes an much more. BPMN is very suitable for this research since it has been specifically designed to coordinate the sequence of processes and the messages that flow between different process participants in a related set of activities. (BPMN, 2009)

After an analysis of the three alternatives, Behavior Diagrams from BizzDezigner are chosen to use. These diagrams are very easy readable, the software to create them is very user friendly and with BizzDesigner it is relatively easy to manage and work with a big amount of models and levels of models. One can zoom in on business processes, as many levels as wished, relate processes to actors or data items, and automatically create interesting color and other views with just a few clicks.

3.5.2 Reference models

In this research, the to be designed business process models are in fact reference models, since they represent a reference and not a specific situation: they can be used as the basis for the creation of specific models.

Thomas (2005) states models are made to create manageable artifacts which make the complexity of information systems controllable. He distinguishes specific information models, for the modeling of a specific situation, and reference models, having an initial conceptual approach and being a point of reference for the development of specific models since they represent a category of applications. Prominent examples of this in the scientific field are the reference model for industrial enterprises (Y-

CIM-Model), as well as the SAP R/3-reference model resulting from commercial practice. An example of the SAP R/3-reference model for the transport industry, acquired from the SAP Solution Composer, can be seen in Appendix C. C.2 shows the Reference model CapGemini made specifically for transport companies.

The possibility of orienting oneself on the technical content of such reference models promises the model-users savings in time and costs and also the quality of the model to be constructed can be increased by the use of a reference model.

Thomas defines a reference model as an *information model used for supporting the construction of other models, which has a reutilization character*. He emphasizes the universality, recommendation character and user-sided acceptance of them. Reference models are used as a *starting point* or *initial solutions* for the development of *solutions* or *project-specific models*. Also, some authors claim reference models to be abstract and existing within a certain environment.

In this research, business process reference models are made. The business process models that are delivered at the end of this research are reference models, since they can be used to support the construction of specific business process models for individual companies, to support the specification of requirements and as an initial solution for the development of a project-specific solution. The reference models from SAP and CapGemini are used to see the general process structure others defined for the transport industry.

3.5.3 Actual business processes

The input for the specification of business processes has come from several sources. Section 3.7 describes the road freight transport industry, which is an important source for the description of the business processes. Also project documentation from five board computer projects has been studied to get insight in the actual business processes at Dutch transport companies. The interviews with CAPE experts, the meeting with board computer vendor Centric, the visit at Tielbeke and the accompanying of two Tielbeke truck drivers are also used to get insight in these processes. See Appendix D for a description of this empirical research.

3.6 Enterprise architecture

It is very important that a chosen board computer system fits well within the implementing company and its IT landscape. Therefore the so called enterprise architecture of the specific company, and first the enterprise architecture of transport companies in general, has to be studied. Enterprise architecture is the structure of a business, formally defined by the MIT Center for Information Systems Research as:

"The organizing logic for business processes and IT infrastructure reflecting the integration and standardization requirements of the firm's operating model." (Weill, 2007)

This project focuses on the alignment of an application within the enterprise architecture; it is not economic feasible to make a custom made board computer system, but it is very important that the new COTS system fits in the environment. Therefore the following definition of application architecture alignment from Eck et al. (2002) will be used:

"Application architecture alignment is the process that determines the optimal fit between a software application and the existing software and business environment."

It is important to notice that the integration between various IT systems and applications within a company is not just a technological choice but also a strategic consideration. For example, most Board Computer vendors provide a web-interface which the planners can use to manually interact with the board computer and the driver, but this way of working is not very efficient. How strong the interaction of the Board Computer with other systems has to be depends on the IT strategy of the specific company, which will be depicted on the level of business goals. Some companies prefer complex integration with many other systems, very efficient but at high IT costs. Others want just low costs and don't ask for complex integration.

Papazoglou and Ribbers (2006) use the term Enterprise Application Integration (EAI) for the process and result of the integration of disparate systems (both new and legacy, that were independently developed, may use incompatible technology and remain independently managed) and the data that underlies these systems. EAI provides the infrastructure to reuse, rapidly connect, interface and unify information and business processes between an organization's internal applications into a cohesive corporate framework within the enterprise.

3.6.1 Enterprise architecture topologies

Papazoglou and Ribbers (2006) distinguish four hierarchical levels in EAI, which have to be considered when the integration of enterprise architecture is studied:

- The transportation layer handles connectivity to an application and transports data to it from other applications.
- The data integration layer coordinates sharing and seamless integration of enterprise data.
- The application programming interface integration layer concentrates on the sharing of business logic between applications.
- The business process integration layer provides the core infrastructure that permits business processes to cross enterprise boundaries and link and interact with counterpart processes operated by the enterprise's suppliers and trading partners.

Process-level EAI is implemented by means of standard infrastructure including:

- Integration brokers are responsible for brokering messages exchanged between two or more applications, providing the ability to transform, store and route messages and also for applying business rules and responding to events.
- Application servers are used to interconnect an enterprise with the outside world. An application server is a natural point for application integration as it provides a platform for development, deployment and management of web-based, transactional, secure, distributed and scalable enterprise applications. Application servers can be used in tandem with integration brokers through a cooperative interface. In this way the integration broker functions as an application integration backbone while the application server hosts custom business logic in the middle tier of a multi-tiered EAI architecture. (Papazoglou and Ribbers, 2006)

Papazoglou and Ribbers distinguish various EAI topologies, which in this research will be considered as possible scenarios. The most commonly encountered EAI topologies are:

- Point-to-point integration means applications are liked through hand-coded custom-built connectivity systems and data is interchanged directly between any two systems. The approach is generally to "build an interface" for each connection.
- Publish-subscribe (shared bus) topology used an integration "backbone" that allows any application to be installed and integrated with the rest of the business by amending its connector to the integration hub that manages all its interactions. This topology allows integration to be accomplished by following the rules of making information available via publishing (broadcasting) mechanisms.
- Hub-and-spoke topology uses a central node that manages all interactions between applications. The central node prevents an application from having to integrate multiple times with several other applications, and simple carries out one integration process on the central node. The central node then handles communicates with other applications. The most popular hub and spoke EAI solution for the inter-enterprise architecture is integration brokering, underpinned by message-oriented middleware.

Each of these topologies has a series of advantages and disadvantages with the most serious disadvantages being associated with point-to-point solutions, since that integration type is not scalable, is very complex and can quickly become unmanageable. The shared bus model is more

scalable than the hub and spoke model and can offer better performance. But implementation of the shared bus model is, in general, more complex, and the shared bus model can be hard to administer as the environment grows. Both the publish-subscribe and the hub-and-spoke model support looser forms of integration.

Since middleware and the enterprise service bus are concepts which are used a lot at CAPE, these concepts will be discussed below.

3.6.1.1 Middleware

In the EAI subject, middleware is an important solution. Middleware is connectivity software that is designed to help manage the complexity and heterogeneity inherent in distributed systems. It builds a bridge between different systems by enabling communication and transfer of data and is often used in a client/server environment. Middleware can be applied to manage disparate applications both within a single organization and between various independent organizations. Middleware encompasses a variety of different types of products with different capabilities that can be divided into five broad segments: Remote Procedure Calls, Message-oriented middleware, Data-access middleware, Transaction-oriented middleware, and Object Request Brokers. (Papazoglou and Ribbers, 2006)

In the case of board computer systems middleware is generally provided by the vendor of the board computer and is used for the connection between the mobile board computers and the IT in the back office.

3.6.1.2 Enterprise Service Bus

The Enterprise Service Bus (ESB) is an open standards-based message bus usually based on publish-subscribe and event-notification mechanisms that is designed to enable the implementation, deployment, and management of integration solutions. The ESB provides the distributed processing, standards-based integration, and enterprise-class backbone required for the integration.

The ESB offers a range of functions designed to provide a manageable standards-based IT backbone that extends Messaging Oriented Middleware functionality throughout the entire business value chain, connecting heterogeneous components and systems. The ESB is designed to provide interoperability between larger grained applications and other components via standards-based adapters and interfaces. The bus functions as both transport and transformation facilitator to allows distribution of these services over disparate systems and computing environments.

The general services which an ESB provides are:

- Mediating between service requester and service provider
- Standardizing communication with service requesters
- Transforming data between requester and provider
- Orchestrating settlement of request and forwarding to providers
- Monitoring service requests and generating reports on this.

Following on these functions, the advantages of an ESB are:

- (Partly) detach (loosely coupled) service requesters and providers.
- Simplify and standardize interfaces between requesters and providers.
- Stimulate reuse, because services are easily available centrally.
- Central and general way of service monitoring.
- Reduce time-to-market because of reuse and less implementation time. (Papazoglou and Ribbers, 2006)

ESB's are getting more popular at bigger transport companies because of the great integration advantages they give. In this research's product, an ESB is considered as a possible solution in the reference architecture.

3.6.2 Enterprise architecture modeling

For the modeling of the enterprise architectures BizzDesign Architect will be used (BizzDesign, 2009b), which is one of the few tools supporting the Archimate modeling language (Telematica Instituut, 2009). With this tool it is relatively easy to draw clear and easy readable models showing the business, application and technology layer which together make up the enterprise architecture.

The developers of BizzDesign Architect define Enterprise architecture as:

"A design which shows the relation between products, processes, organization, information delivery and infrastructure, based on a vision and certain explicit principles and preferences, aimed on the steering of changes." (BizzDesign, 2009b)

It should be noticed that in this context the goal is not to analyze the architectures into much detail and on a very technical level, but just to show the different types of architectures on quite an abstract level. The enterprise architecture model can be used by CAPE to show the important issues and to simplify the process of choosing which components are wanted by a company and how these parts should cooperate.

3.6.3 Reference architecture

In this research we need reference architectures to show possible scenarios and proven solutions. A reference architecture provides a proven template solution for an architecture for a particular domain. It also provides a common vocabulary with which to discuss implementations, often with the aim to stress commonality. A reference architecture often consists of a list of functions and some indication of their interfaces and interactions with each other and with functions located outside of the scope of the reference architecture.

CAPE is used to use a picture they made their self, showing the main components of the IT that is in place in a general transport company. This figure, depicted in Figure 14 in Appendix Appendix A, can be considered a reference architecture itself, and is used in this research to get insight on the architecture in transport companies. The architecture integration topologies and the mentioned solution components as described by Papazoglou and Ribbers (see section 3.6.1) are also used for the description of reference architecture.

Reference architectures can be defined at different levels of abstraction. A highly abstract one might show different pieces of equipment on a communications network, each providing different functions. A lower level one might demonstrate the interactions of procedures (or methods) within a computer program defined to perform a very specific task. In this research, highly abstract reference architecture is used to show the general business processes, applications and supporting technology needed for good functioning of the board computer and related systems.

3.6.4 Related systems

To be able to make a good reference architecture we need to know which systems are regularly used in transport companies. An important issue in the specification of requirements for a board computer is the position of the border between board computer, Transport Management System and Advanced Planning and Scheduling System. Theoretically, the TMS is meant to register and manage orders, the APS is meant to automatically optimally plan jobs using very smart algorithms, and a board computer is used for the driver instruction, message exchange and feedback of the execution.

Still, in practice the borders are more vague because some board computer vendors are providing very extensive office-side applications which are capable of manage orders or even plan the execution of them. For small companies which not already have their own TMS and APS this can be a smart way of arranging things.

In this research the division between TMS, APS and Board Computer will be as described above, having each system it's own specialties and responsibilities. The next sections describe the most relevant systems (TMS, APS, FMS and Salary system), their functions, types and the communicated data.

3.6.4.1 Transport Management System (TMS)

In the widest definition of Transport Management System, the TMS is the complete collection of all IT parts which together manage a complete transport company. The graphical representation of this vision on TMS's can be seen in Figure 7. (Beerens, 2008)

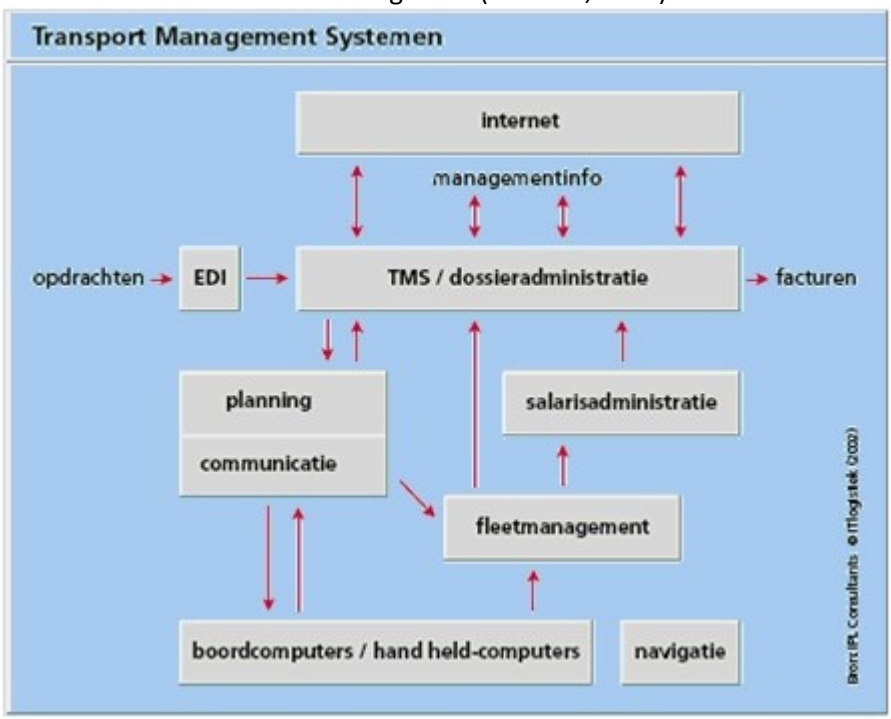


Figure 7 Representation of TMS in its widest definition (Beerens, 2008)

The main arguments for investing in a TMS are cost management and a higher service level, because the TMS reduces the number of manual routine activities, and creates an uniform way of working inside the company. All relations, quotes, order and tariff arrangement scan be recorded once and after that the system reuses this information when necessary. This prevents errors and accelerates the administrative settling.

The TMS also records knowledge of employees, decreasing the dependency of one or more people. When the TMS is used as central IT-system, this will lead to better gearing within the company, since everyone used the data from the same database. (Waenink, 2006)

Scope

The most complete TMS's also contain modules for order and relation management, garage and customs. In this research, and in most other cases, the definition TMS is meant to only cover the "TMS/file-administration" part, which (also with wider definitions) is the heart of the transport management. This file administration covers the registration system (software) for the filing of transport jobs, the management of transport resources, the creation of bills, and so on. In fact, a TMS is a kind of Enterprise Resource Planning-system specially for transport.

EDI is a protocol for the electronic exchange of messages such as transport jobs, which is also used outside the TMS, but the internet is taking over the function of EDI. Some (modern) TMS's consist of a data communication network for the data exchange between the file administration at the office and the board computers in the trucks. The main function of this is the sending of jobs to the drivers and the receiving of progress information from the drivers.

Architecture the main flaw

According to CapGemini, the last years hardly any vendors entered the market of TMS providers, while existing vendors are merging creating higher budgets for R&D. These vendors work hard on the integration and innovation of systems.

External visibility, which is supply chain visibility, is not much asked, but internal visibility is since this actual view on the performance of people and material is essential for a good performance. Also customs want more visibility, sometimes they are even looking live in the software.

There are not many differences between the functionality the various vendors are providing. The difference is made between the dynamics of the systems: is the system capable of adjusting to changing situations and a growing organizations? A good architecture of the TMS is essential for that.

This architecture is the weakness of many TMS's. There is a lot of old-fashioned software, which very hardly cope with changes, growth, and integration with other systems. Also the speed of the TMS depends a lot on the architecture. The software should be not one big system with many hardly separately functions, but this is the case with many systems. It should be better if the systems are flexible organizable, by the use of services. The architecture is also very important for how easy it is to implement the system. (CapGemini, 2007)

ERP-vendors know that the integration of systems is essential, and therefore create suites for all business functions, but transport is running behind on this. But the big TMS vendors are improving the integration possibilities with other packages. Even SOA (Service Oriented Architecture) is introducing in this area.

Board Computer as TMS

A new development can be seen, in which board computer vendors provide back office software overlapping with the TMS, having the functionality of order entry, combining order to a trip, sending in to the truck and printing the bill. Very specific functionality is missing, but for a company with not too many demands, this is an interesting way of working. The main advantage is the fact that one does not have to make a difficult integration between TMS and Board Computer, one does not have to invest in a "real" TMS but does have registration of the hours and kilometers from the driver, providing even management information. Some vendors also provide a graphical planning screen, the controlling of execution and even the rescheduling based on progress, functionality which misses in a normal TMS.

Vendor types

In the TMS sector, two types of systems can be distinguished. The first type contains the big systems from ERP vendors, customized for transport. These systems support a lot of processes and are suitable for big companies for which transport is not their core activity. The second type consists of systems from the "traditional" vendors, suitable for ordinary transport companies. These systems are smaller and cheaper, and faster and easier to implement, but support less business functions next to transportation. These traditional vendors implement their systems theirself, where ERP vendors are used to outsource this activity.

Most of the about 30 TMS vendors which are active in the Netherlands operate only in the Netherlands, but a trend can be seen in the internationalization of these vendors.

Communication and integration with board computer

When the TMS is defined as the file administration system which is used for the filing of transport jobs, the management of transport resources, the creation of bills, and so on, some data has to be exchanged with the board computer. The jobs (and related details) have to be send *to* the drivers and the progress information and proofs have to be received *from* the drivers.

Communication

The communication between the TMS and the Board Computer can be arranged in several ways, since various techniques and scenarios exist.

In some cases, the TMS vendor provides a platform for the communication (Centric is an example of this) between TMS and Board Computer, in other cases the Board Computer vendor provides this, and with a third scenario there is no standard platform for this available.

For the communication between the TMS and the Board Computer several standards exist, which are explained in the section on Enterprise Architecture Topologies, section 3.6.1.

3.6.4.2 Advanced Planning and Scheduling System (APS)

An Advanced Planning & Scheduling system calculates the mathematical optimal planning. The package uses mathematical intelligence and connects with a TMS. In most cases the APS calculates the big part of the planning, and a human planner checks and completes the proposed schedule. The building blocks of APS are so called solvers, modules specialized in a typical type of mathematical problems. The big difference between TMS and APS is that an APS can control and real-time update planning and execution on a detailed level and a TMS can not do this.

APS's are used for the calculation of production plannings, and in transport are used for the transport planning, for example the allocation of shipments to transport vehicles. This planning is based on rules which are defined by the transport company, which without an APS exist in the heads of the planners only.

Companies invest in an APS when the planning is getting too complicated to make, when they find out their resources are used inefficient, or when they want to save on people's salaries, making the planning by hand. (Beerens, 2008b)

Communication and Integration

An APS is implemented as addition on the used TMS, when the planning has to be automated. Therefore, job and resource data have to be exchanged between the TMS and APS.

The communication with the Board Computer typically takes place via the TMS, giving no direct requirements on the communication between APS and Board Computer in the context of this research.

When the company wants the APS to automatically reschedule activities based on the actual progress and status of jobs, this means the communication has to take place real time.

3.6.4.3 Fleet Management System (FMS)

Fleet Management Systems are used for the management of transport companies' fleet. With the system, the company can see how the vehicles are used, and support the maintenance of the vehicles. In most cases, the board computer has to deliver the data needed for this management and that way is integrated with fleet management.

The Fleet Management Systems Interface is a standard interface to vehicle data of commercial vehicles, developed by the six European truck manufacturers. When both the board computer and the truck support this (or another) standard, information like speed, fuel usage and axle weight can be exchanged from the truck to the board computer. The board computer on its way can send this data to other systems.

3.6.4.4 Salary system

Most companies have a separated system for the salary administration of their drivers. This system manages the data of all drivers, and receives the hour records of all drivers. When one wants to automate the settling process the salary system has to be integrated with the board computer system.

3.6.5 Actual enterprise architectures

The input for the specification of enterprise architectures has come from several sources. Section 3.7 describes the road freight transport industry, which is an important source for this. Also project documentation from five board computer projects has been studied to get insight in the actual enterprise architecture of Dutch transport companies and so were the interviews with CAPE experts and the meeting with board computer vendor Centric. See Appendix Appendix D for a description of this empirical research.

3.7 Road freight transport industry

We need information on the road freight transport industry in general, as background for the demands on board computers, and segmentation of the industry. Not much information on this can be found in literature and therefore most is gathered with empirical research. An explanation of the empirical research that has been done can be seen in Appendix D.

In this chapter first a description of the road freight transport industry is given together with the trends that raised in this industry the last years. After that a segmentation of the industry will be presented and the characteristics and accompanying demands on the shipper will be explained. These things together make up the drivers to implement a board computer system.

3.7.1 Road freight transport industry in the Netherlands

This research focuses on the road freight transport industry, which is the collection of all companies specialized in the transport of freight over road. Industries that compete with road freight transport are the rail, sea and inland shipping and air transport industries. Sea shipping and air transport off course are more focusing on the long distances and the other transport types are also suitable for shorter distances. Road transport has the advantage of more flexibility: goods can be loaded and unloaded at the door and when there are traffic congestions one can take an alternative route. On the other hand, the Dutch roads are getting busier and busier and therefore the problems with road congestions are getting bigger and bigger too.

In the Netherlands each year about 80.000.000.000 loadtonkilometer ('ladingtonkilometer') freight is transported over the Dutch road, from which about 40 percent is domestics and 60 percent is international transport (which uses the Dutch road but has a departure and/or destination location outside the Netherlands). The road transport takes about 68 percent of the total freight transport for its account, inland shipping about 28 and rail about 4 percent. (CBS, 2009)

3.7.2 Trends

The next sections will explain the trends that raised in the road freight the last years, which influence the processes in the industry and finally the requirements on the board computers. The wexlog whitepaper summarizes these trends as: "There is more recognition by the Logistics Service Providers (LSP) end-customers that their LSP represent a significant and strategic advantage for them. This in turn is leading to pressures and opportunities for the LSP themselves." (Wexlog, 2006)

3.7.2.1 Conservative and old-fashioned

The transport industry can be characterized as relatively conservative and old-fashioned. Many transport companies exists for many years, and the directors with relatively a low level of education are on the same position for a long time. Therefore, the companies tend to keep doing things in the same way, because they "always did it that way", and do not like innovations and other changes.

Not on the last place because of the conservative character of the industry, as explained above, both the development and adoption of Information Technology in the industry go relatively slow, keeping each other in a vicious circle. This makes that companies do not fully profit from the possibilities that technology can bring them. Companies are using a broad range of badly integrated legacy systems, which are not efficient and make the implementation of new systems very difficult. Because of this, employees unnecessary are doing a lot of things by hand, and manually insert and copy the same date multiple times, in the various systems, locations and process chains.

The transport companies are not very likely to implement a new system, and when they implement a system they give very much value on whether the system already proved itself. Therefore, these companies always want reference visits before they select a package. (CapGemini, 2007)

3.7.2.2 Additional services

Companies tend to outsource more and more of their logistics services to logistic service providers. These third party logistics providers (3PL) specialize in integrated operation, warehousing and transportation services that can be scaled and customized to customer's needs based on market

conditions and the demands and delivery service requirements for their products and materials. Transport companies can make good money with these value added logistics (VAL) and services (VAS). Additional activities can be warehousing or packaging; requested additional services are for example tracking and tracing or extra security. The various services have different processes and operations and need special communication and administration. (Logistiek, 2009) (Donselaar, 1997) (Wexlog, 2006)

3.7.2.3 Competition and security regulations

In the transport industry very tough competition exists. Therefore transport companies have to increase their efficiency and improve quality. Also they have to comply with all kinds of governmental, mostly security, regulations. Streamlining the communication and administration process can be a very effective way to reach these goals. (Wexlog, 2006)

3.7.2.4 Multi- and intermodal transport

To gain optimal efficiency, reduce environmental damage and handle the fast growth of freight transport, transport with several modalities in one transport chain is getting more popular, giving extra demands on the transporters because the different modalities have to connect to each other in a good way. One distinguishes multimodal and intermodal transport. With multimodal transport the cargo itself goes from one modality to another, without the cargo carrier. Intermodal transport means that the cargo carrier (f.e. a container or trailer) changes between several modalities. Intermodal transport is also called combined transport. One distinguishes the modalities Road, Rail, Water and Air. (Rail Cargo, 2009) (NEA, 2008) Some sources also consider pipeline as a modality. (Vos, 2009) but since this is a very specific modality which in this context in general can be considered as a “client” instead of a “modality”, we leave this modality outside scope.

3.7.2.5 Need for security

The number of thefts from truckloads is growing very fast. In 2007 the damage caused by these thefts was about 330 million euro in the Netherlands, and 8.2 billion euro in the European Union. One out of three cargo thefts takes place on public parking places. Together with the more stringent (regulation of) laws on the Hours of service, the need for save parking spaces increases and so does the need for other security measures for the prevention and solving of thefts from cargo and material. (NEA, 2008) (Wexlog, 2006)

3.7.2.6 Need for CO2-reduction

Transport companies have to deal with growing demands on the reduction of CO2-emision and other reductions of environmental damage. This asks for more efficient transport which can be reached by higher degree of load utilization, more efficient routes, sparing of certain locations on certain times, better driving behavior and so on. Also the monitoring of all these things is getting more important, to gain insight in the efficiency. (NEA, 2008)

3.7.2.7 Low margins

Because of the tough and growing competition in the market, carriers have to deal with very low margins. End-customers want better services for lower costs. This increases the importance of efficient operations and decreasing costs. (Wexlog, 2006)

3.7.2.8 Activity Based Costing and Pricing

With the majority of the transport jobs, there is a fixed price agreed on forehand, based on criteria like load size and weight, number of pallets, distance and storage time. In other cases, the sender has to pay a variable price depending on for example the actual driving time, the actual distance, loading and unloading time.

The last years, both transporters and shippers tend to ask for fairer prices of activities and services. The clients want a fair and competing price and the transporter needs a realistic insight in the real costs of the delivered service. When this is the case, all kind of actual information has to be

registered very accurate and send away as fast as possible to speed up the billing. The transport companies need a good and extensive administration of all activities and costs and a transparent organization. (NEA, 2008)

3.7.2.9 More, smaller and time critical jobs

A key trend in the logistics industry is a switch from FTL to LTL and DD. This switch is caused by the prevalence of just-in-time manufacturing which has placed an emphasis on the frequent replenishment of stocks in order to reduce inventory. This supply chain concept requires the supply side logistics industry to adopt more flexible, time sensitive business models, and results in smaller consignments which can be more easily unitized using pallets.

Together with the growing critical demands of the shippers, it is becoming more common that the transporters have to sign penalty clauses which tell the transporter to pay penalties when their performance is insufficient. (Transport intelligence, 2007)

3.7.2.10 Shorten order to cash cycle

Shippers are used to pay the bill for the transport job after they received the signed CMR. This makes the cash cycle relatively long, especially with international transport where the driver, and so the physical CMR, sometimes is away for a few weeks. Transport companies want to shorten their order to cash cycle by speeding up the billing process. A solution for this is to send the proofs digitally and real-time over the air, which makes that the billing and so the paying can be faster.

3.7.2.11 Supply Chain Management capability improvement

Supply Chain Management is getting more important and so is the capability to handle this. (Wexlog, 2006)

3.7.2.12 Consolidation, Mergers and Acquisitions

Both from the LSP and end-customer point of view consolidation, mergers and acquisitions take place, creating less but bigger organizations. (Wexlog, 2006)

3.7.2.13 Enhancing Customer Service

Customers are expecting better service and the transport companies have to deliver this. (Wexlog, 2006)

3.7.2.14 Globalization

Customers are globalizing, forcing their LSP to globalize to stay in business. (Wexlog, 2006)

3.7.3 Segmentation based on transport types

Which functionality is expected from a board computer and what communication takes place between the (planning) office and the driver mainly depends on the business processes during the execution, preparation and settlement of jobs. Therefore, in this research the industry will be segmented based on the business processes. This is a good way to divide the requirements for board computers. Most sources split up the market based on the number of individual shipments, the size of individual shipments and the number of stops, in one trip.

Transport companies have two basic operations, which are: driving and (un)loading. Companies whose core operation is driving are quite different from companies whose core is (un)loading. Whether or not an company's core operation is driving depends not only on the load, but also on the length of the haul. If the load is only transported over a short distance, and if it takes a relatively long time to (un)load the goods, the core operation of such an company will be (un)loading rather than driving. So, the key success factors (KSF) differ between the types of services. In transportation a key success factor is the percentage of non-empty driven kilometers and in distribution a KSF is the number of stops per trip. (Donselaar, 1997)

With the criteria mentioned above three categories can be defined, which are full truck load shipping, less than truck load shipping and dense distribution. (KPMG, 2000) (TWNA, 2009) (UMTRI,

2009) Based on the company's extensive experience CAPE distinguishes a fourth transport type which is rarely mentioned in literature but certainly has processes differing from the other types. This type is Trailer Trucking, meaning that a driver drives a truck of the transport company to move a trailer from the customer.

Table 2 shows the four road freight transport types which will be distinguished in this research. Figure 8 depicts the differences between the construction of the transport types in a visual way.

Type	Abbr.	Shipments per trip	Size per shipment	Explanation
Trailer Trucking	TT	1	Complete trailer	Truck/driver pulls the trailer of the client. Also called simply "Trucking".
Full Truck Load shipping	FTL	1	Full truck load	One shipment fills the complete truck and is shipped from A to B.
Less Than Truck Load shipping	LTL	2-10	Less than truck load	Several shipments together are loaded at several locations and unloaded at several locations. Sometimes the shipments are regrouped at a depot to create more efficient routes.
Dense Distribution	DD	>10	<500 kg	Also called "parcel carrying" or simply "distribution".

Table 2 Transport types

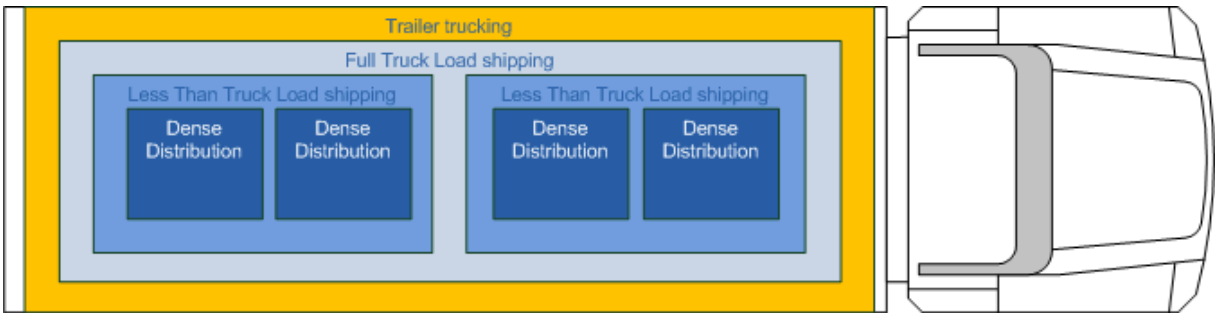


Figure 8 Segmentation of the transport industry, showing the four different transport types

3.7.3.1 Trailer trucking

With trailer trucking, the driver of a transport company drives in the company's truck to move the trailer of the client. This type of transport looks like FTL, except the driver has to couple and uncouple the trailer instead of load and unload the freight. In the most simple scenario the driver is only responsible for the transport of the trailer from A to B.

Trailer trucking is very useful for intermodal transport because the complete trailer can directly be transferred to a ship or a train. The transport companies that supply the truck and driver have establishments on strategic chosen locations, so that the drivers can driver from one branch to another without resting in between. At the branch location one can transfer the trailer to another driver and truck, creating higher efficiency. The client, the expeditor, does not have to make any investments and does not have to organize trucks and drivers, but is responsible for the load of the trailer and the accompanying flow of goods.

In the most simple trailer trucking scenario a trailer has to be coupled at location A and then driven to location B where it has to be uncoupled. But it is also possible that the driver has to couple the trailer and after that has to execute, for example, LTL-orders from the client. In this case TT and LTL are combined. The validation showed that it is not a good approach to define a case where trailer trucking is combined with another type of transport as trailer trucking transport, because otherwise the definitions are becoming too vague and ambiguous. Therefore we decided to define trailer

trucking exclusively as the transport type in which trailers are coupled, transported and uncoupled. Cases in which a transport company for example couples a client´s trailer and drives with it to execute distribution are defined as a combination of trailer trucking and distribution, in which the transport company is the charter.

In practice we can see many cases in which trailer trucking is combined with another type of transport, and the transport company operates as a charter. In this case the customer may want to directly communicate with the driver and telling him what to do, giving special demands on the board computer. Also, special activities exist in this submarket, such as coupling, decoupling, recoupling and solodriving, which possibly have to be instructed/directed and registered and by the board computer.

Several companies, like Heisterkamp and the European Trucking Services, are specialized in the Trailer Trucking type of business. (ETS, 2009) (Heisterkamp, 2009)

3.7.3.2 Full truck load shipping

With a full truck load shipment, a shipper sends a substantial amount of freight from A to B, being exclusively in a trailer. The driver drives to the shipper to load the freight and then drives directly to the consignee where he delivers the freight.

FTL shipping is relatively fast, since transit times are normally only constrained by the driver's availability according to Hours of service regulations and distance. Another advantage Full Truckload carriers have over Less than Truckload carriers is that the freight is never handled en route, whereas an LTL shipment will typically be transported on several different trailers. This absence of reloading decreases the chances of loss and dame of the freight. To make FTL economically feasible, the shipment has to be relatively big and fill the trailer and therefore it is not suitable for all shipments.

In the Netherlands, many (almost all) transport companies execute FTL shipments. For example, HST and Jan de Rijk do.

3.7.3.3 Less than truckload shipping

Less than truckload shipping is the transportation of relatively small freight in an economically feasible way. LTL carriers collect freight from various shippers in one trailer, and delivering the freight for various consignees with one trailer. In many cases, the delivered freight is consolidated in a trailer for linehaul movement to the delivering terminal, or to a hub terminal where the freight will be further sorted and consolidated for additional linehauls.

In most cases of national transport, drivers start the day by loading up and heading out to make deliveries first, then begin making pickups once the trailer has been emptied for return to the terminal for sorting and delivery next day; thus, most pickups are made in the afternoon and most deliveries are performed in the morning. In international transport truck drivers perform a milk run which is a long ride to a location, then various distribution points and then a long ride back.

LTL freight is subject to inspection to verify their conformity to the description contained in the accompanying paperwork. Transit times for LTL freight are longer than for FTL, because LTL transit times are not only related to the distance between shipper and consignee but depend upon the design of the network of terminals and breakbulks that are operated by a given carrier and that carrier's beyond agents and interline partners.

The main advantage to using an LTL carrier is that a shipment may be transported for a fraction of the cost of hiring an entire truck and trailer for an exclusive shipment. Also, a number of additional services are available from LTL carriers, which are not typically offered by FTL carriers. Because several shipments are send in one trailer, support is needed to distinct the various shipments during the process.

In the Netherlands, many (almost all) transport companies execute LTL shipments. For example, HST and Jan de Rijk do.

3.7.3.4 Dense distribution

Dense distribution is the shipment of small freight, also called 'parcel carrying'. With DD a truck makes many stops for pick-up and delivery a day, and in some cases small vans are used instead of big trucks. The delivery is mostly either performed on short distance, or distribution networks for longer distances are used. Some companies try to compete with LTL carriers by convincing shippers to break larger shipments down to smaller packages.

Efficiency is achieved by making sure high degree of capacity utilization are achieved and by optimizing the routes. Because with DD shipments have to be loaded, unloaded and regrouped several times, the speed of the shipping not only depends on the distance of the shipping but for a big part depends on the number and speed of the transfers and other stops. The optimization of the processes involved in loading, unloading and transferring is very important, giving special demands on the board computer.

Donselaar and Sharman (1997) define distribution as the set of trips, which satisfy at least one of the following characteristics:

- The loading plus unloading time is greater than 50 percent of the loading plus unloading time plus the driving time.
- The distance between the first and the last stop of a trip is greater than 50 percent of the total distance per trip.

The remaining set of trips is called "transportation".

In the Netherlands, many (almost all) transport companies execute dense distribution. For example, HST and Jan de Rijk do.

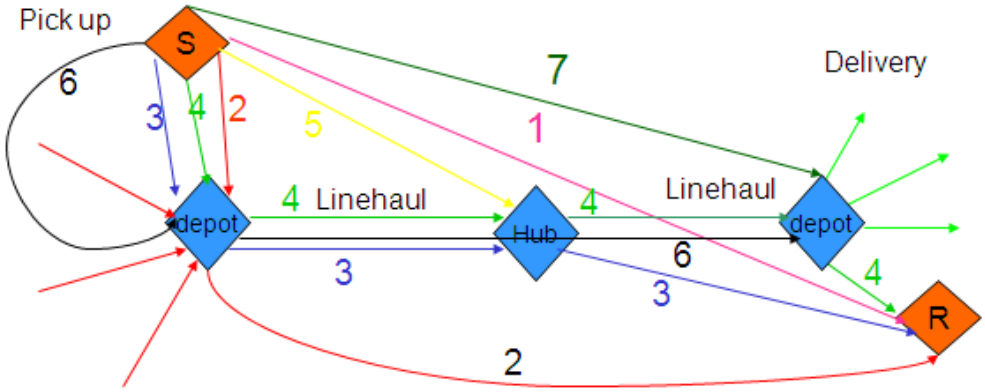
3.7.3.5 Integrating transport types

To get the best of multiple worlds it's possible to combine different transport types for one order. This combination can be made by the shipper itself or by the transporter. For example, if a shipper in Norway has a large quantity of shipments for Spain and Portugal then the shipper can realize significant cost savings by having an FTL carrier transport the freight to a facility nearest the center of such shipments in terms of the carriers network. The use of an FTL carrier to transport this freight is a cost savings because the freight will travel fewer miles in the LTL carrier's network, and a further benefit is realized because the freight will not be unloaded and reloaded as many times. This reduces the incidence of loss and damage in transit.

It is also possible that a shipper combines LTL and DD. An example of this is a shipper in the Netherlands that has 500 parcels destined for Belgium, 250 destined for Germany, and 250 destined for France. The shipper will segregate the parcels by their destination and first send them by LTL to the right countries. The parcel carrier will take the parcels off pallet and inject them into the parcel distribution system and deliver them to their final destination. This saves money since the costs of using a parcel carrier solely for long distance transportation of parcels is more costly per kilo than an LTL carrier.

The process of transferring less than truck loads from various origins into one truck to ship them together (because the consigners are located in more or less the same area) is called grouping.

The existence of these combinations means that there are many cases in which you can not put an order in a unique segment, since it is transported with several transport types during the various hops. Figure 9 depicts various transport scenarios with different processes and demands on the process support, control and settlement. (CAPE, 2008)



Alternative 1: direct delivery
Alternative 2: delivery through 1 depot
Alternative 3: delivery through depot and hub
Alternative 4: delivery through depot, hub and depot
Alternative 5: delivery through hub, then use 3 or 4
Alternative 6: delivery through depot and depot without hub
Alternative 7: delivery through delivery depot and then 4.

Figure 9 Transport scenarios

3.7.3.6 Other Important characteristics

Next to the criteria mentioned in the previous sections, one can distinguish some more (business and job) characteristics for segmentation which all ask for different operations. These criteria are (Donselaar, 1997):

- Type of goods which are transported or distributed
- Size of the company
- Whether general purpose trucks or specialized trucks (for container transport, transport of building materials, bulk transport of food, agricultural or chemical products, temperature-controlled transport, other transport) are used.
- Used Computer Systems; Enterprise architecture
- Logistics Service Provider Level (2PL/3PL/4PL)
- Geographic area the company operates (whether or not the trucks cross the border (national/international shipping))
- Client/consigner/consignee type
- Intermodality of transport
- Fixed/flexible delivery/pick-up time
- Confirmation needs
- Existence of additional services

Although these criteria indeed are important for how the operations and processes are designed, they are not used for the segmentation of the market, because otherwise the segmentation would get to difficult. But they are used for the typology of companies, its processes and requirements.

3.7.4 Typology of companies

This chapter described how the road freight transport industry looks like and how it can be segmented. It explained that next to the four main segments several other criteria exist for the typology of transport companies based on the type of jobs, operations and processes. The overview below depicts all these criteria, which will be used for the typology of specific companies.

- Shipments size and weight
- Shipment type
- Number of shipments per trip
- Trailer owned by transporter or shipper
- Haul length per trip
- Customer type
- Stops per trip (load/unloads and hubs/depots)
- Truck type used
- Additional services: VAL/VAS
- Ratio (un)loading/driving time
- Ratio haul length/total length
- Number of hubs/depots/transfers
- Multimodality of transport
- Size of the transport company
- Border crossing or not
- Distance per trip
- Dropweight per stop (<2000kg, >2000kg)
- Subcontractor or direct contractor?
- Fixed/flexible delivery/pick-up time
- Confirmation needs

3.8 Conclusion

This chapter described the literature that has been used for this research to support the development of the package selection method.

It was explained what a board computer is, what is does and how it is used. Also, the implementation drivers that are seen in practice and those that should be the drivers are described. Thirdly, the trends in board computers are described.

Three approaches are described that are found in literature for the selection of software packages, and the way CAPE did this in the past and wants to do this in the future. With this information a new package selection approach was presented that is an important basis of this method developed by this research.

Requirement specification is a very important step in the package selection process. Various methods for the arrangement of requirements are described and a new division, mainly based on the division from Lauesen but with other terms, was presented. In the method we will distinguish business goals, business requirements and system requirements. The system requirements will be divided into function requirements, non-functional requirements and design constraints. It was also described how the nonfunctional requirements will be arranged and which quality criteria the requirements have to fulfill.

Business process analysis is another essential part of package selection. Various methods for business process modeling were described and BizzDesigner Behavior Diagrams was chosen. Also, it was explained that reference models will be made, which can be used as an initial solution and as a start point for specific models.

Enterprise architecture has to be analyzed to make sure the board computer system fits in the company implementing it. It was described what enterprise architecture is, how it will be modeled

and what the role of reference architecture is. Archimate will be the technique to model the architecture, on a relatively high and abstract level.

It is important to know what the road freight transport industry looks like, to be able to give good advice on the support of this business by board computer. The industry was described, and the trends and a segmentation of the industry were given.

4 Requirements specification framework

Based on the research that is described in the previous chapter, a method for the requirements specification is made. When the conceptual version was ready, it was validated and based on this validation it was improved. See chapter 5 for an extensive description of this validation.

The goal of the method is to support CAPE Groep with the selection of the right board computer systems for specific road freight transport companies, their clients, by supporting the specification of requirements. In this chapter first is explained how the method is structured, how it should be used and what the important definitions are. Then, the various steps and concepts of the method are described and explained. Finally, a conclusion on the conceptual framework is given.

4.1 Method structure and use

This section will describe the structure of the developed method, which guides CAPE Groep in the package selection process. Figure 10 shows the package selection process CAPE is used to execute, as described in section 3.3.5. The process steps with an extra thick border - Specification of business goals, Analysis of business processes and Specification and prioritization of requirements - are explicitly supported by the method developed during this research, whereas the other steps are not.

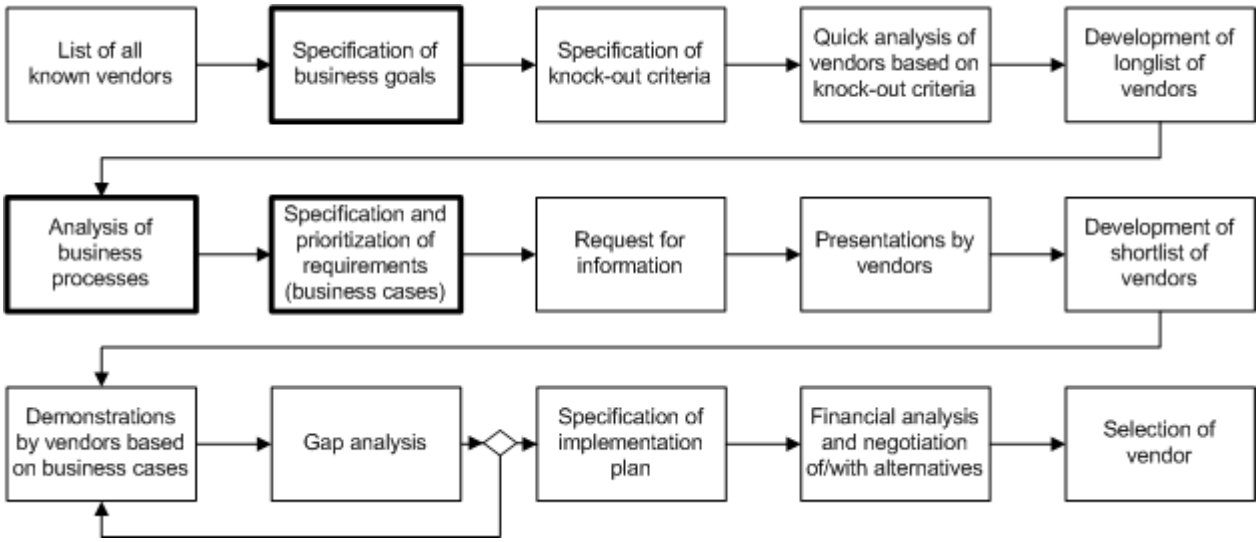


Figure 10 Package selection steps supported by this research's product

Figure 12 shows the steps from the method which are developed during this research, in the order they are taken when the method is used in practice. In this picture we can see two steps which were not explicitly mentioned in the general package selection process, but which play an important role in the developed method for board computer selection: the specification of the performed transport type(s) and the specification of the enterprise architecture. Both steps deliver important input for the requirements specification and therefore are part of the method too.

The specification of the performed transport type(s) takes place as the first step after the list of all known vendors is made, before the specification of the business goals is made. This step is added because preliminary research showed that which transport type(s) a company performs is crucial information for the choice of a board computer system, since each transport type asks specific requirements from a board computer. Therefore it is the best if we know the relevant transport type(s) as early as possible, information which can be used for the specification of the knock-out criteria too (which is out of scope of this research).

The specification of the Enterprise Architecture is added after the development of the longlist of vendors and before the analysis of the business processes. This step is added since preliminary research showed the importance of the good interaction between the board computer and related systems. Also, research showed that CAPE misses an reference overview of transport companies,

which can be used to discuss the specific situation of a transport company, showing the involved actors, processes, applications and systems. Third, CAPE wants something which can be used to discuss the wanted technical solutions (mainly on connection subjects) for the board computer. All these issues can be solved with the use of an enterprise architecture, and therefore the specification of this is added as an additional step in the selection process.

The specification of the enterprise architecture takes place before the analysis of business processes. Figure 11 shows the package selection process extended with these two important steps which were not explicitly mentioned in the previous version of the method.

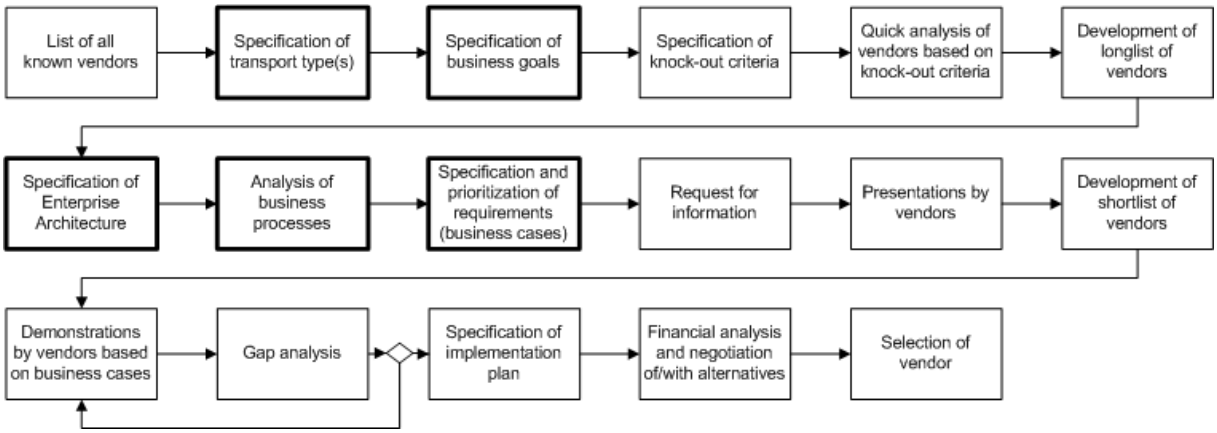


Figure 11 Extended package selection steps supported by this research's product

Figure 12 shows that each step of the method consists of input, method(s)/techniques and output. The input is partially developed during this research and partially will come from the specific transport company itself. The method (or technique) is chosen and explained in this research. The input and method together will lead to an output. The output of the first four steps will be used as input for the requirements specification step, which eventually will deliver the end result of the process the method supports.

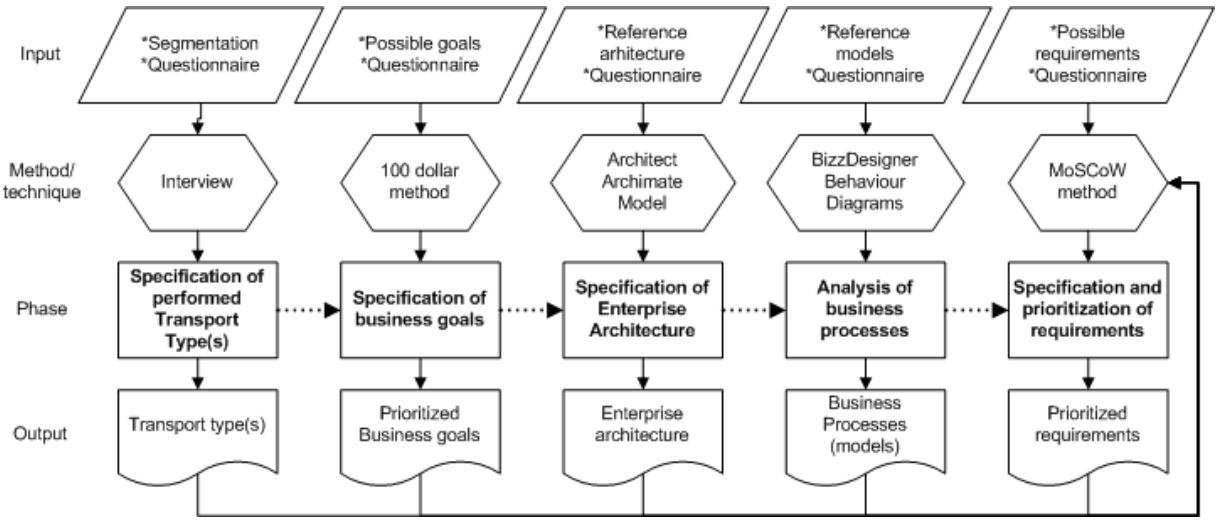


Figure 12 Method structure

We start with the step in which has to be specified which transport type(s) the company performs. In some cases this is completely clear on forehand, in other cases the transport company representatives' have to be interviewed to get this clear. The method contains a questionnaire to support this.

Then the business goals have to be defined. The transport company will have some explicit drivers for implementing a (new) board computer system, and it's CAPE's task to check whether there are other reasons for the company to implement a board computer. The method will support this by giving a list of possible project drivers and a questionnaire to select the relevant ones. This way, both CAPE

and the transport company get a realistic and concrete idea of the goals that should and can be achieved by the implementation of the board computer. The method does not support the specification of the knock-out criteria and also the specification of vendor criteria is left out of scope.

After this, a high-level enterprise architecture of the specific company can be made, based on the reference enterprise architecture (R.E.A.). The R.E.A. shows the business, application and technology layer for a transport company in general, on one side of paper. CAPE Groep together with their client can use this picture to specify the specific enterprise architecture for this specific company in an easy way, by selecting and connecting the relevant components. We use the R.E.A. because it is a very useful and quick way to get an overview of the 'big picture' of a company. This big picture is very useful for the transport company to *realize* what their company and the project is about, and for CAPE Groep to get to *know* the company. When the specific Enterprise Architecture is defined it is clear what the business processes, applications and technology at the transport company, relevant for a board computer and *on a very high level*, look like. Besides the picture of the architecture, there is also a questionnaire available which can be used to ask the company specific questions such as: which systems do you want to keep in place and which can be replaced?

When the enterprise architecture is made it is time to analyze the business processes. The method supports this by giving a big set of business process reference models for the complete transport process, from high to low level. Based on the made specific enterprise architecture this process model can already be modified a little on high-level. On the lower levels this has to be done in this phase, by passing all processes and adjusting them on the actual situation. Since it is known which transport type(s) the company performs, this business process analysis is made easier.

It is not the goal of the method to eventually specify the business processes on the lowest possible level with unique processes, but we have to zoom in to a relatively low level because that is the level on which the differences between the processes of the companies can be seen and so the differences in requirements can be found.

After the business processes have been analyzed the requirements can be specified. The method contains a big set of possible requirements from which the relevant ones have to be selected. The business processes as specified in the previous phase are the main input for this, and so is the enterprise architecture since this shows with which other systems the board computer has to interact. The requirements have to be specified on various levels: business and system requirements. The business requirements tell what the stakeholders want to achieve through the use of the system with no reference at all to a possible solution. The system requirements state how the system will meet the stakeholder requirements and are divided into functional requirements, nonfunctional requirements and design constraints. Next to the specification of the requirements, they have to be prioritized too.

When the requirements relevant for the specific company are specified and prioritized, the end of the method developed during this research is reached. The other phases in the package selection process are out of scope of this research.

4.1.1 People involved

When the method is used for a selection project the same people should be involved as in the situation of a selection project without the use of the method. This is because when the method is used the same things are analyzed as in the situation when the method is not used. This means we need people from the transport company from the high and middle management who can make decisions and know the business strategy. And we need representatives from the operational level, and represent the operational level, knowing how the processes look like.

For the specification of the enterprise architecture we need people with knowledge of the IT in the company, for the specification of the application and technology layer. This can be, for example, the IT manager.

When more details on the requirements and the implementation are specified employees from lower organization layers, such as planners and drivers themselves, have to be involved, but that is at a point in the process which is out of the scope of the developed method. Of course, these kinds of people can be involved in an earlier stage when the manager can not give enough information.

4.1.2 Divisions in project scope

In some cases, the transport company consists of several divisions which are quite clearly separated. When that is the case, and the Board Computer project does focus on only a part of the divisions, the method also focuses on the divisions involved. In that case, in the questions “the company” should be replaced with “the division(s) of the company this board computer focuses on”.

4.2 Confidential framework

The requirements specification framework developed for CAPE Groep to support the process of board computer selection is partly confidential since CAPE Groep wants to benefit from it optimally. Therefore, the remainder of this chapter is not available in the public version of this master thesis.

In the confidential version of this thesis the next sections of this chapter describe the various steps of the framework in detail and eventually give the conclusions of this chapter.

5 Framework validation

5.1 Introduction

To ensure the usefulness of the developed method and to find the weaknesses in the framework, it is validated together with employees from CAPE Groep. We have chosen to test the method on two cases CAPE Groep knows from practice, without practically involving people from transport companies. This approach was chosen since it was practically almost impossible to arrange appointments with transport companies to do this, and the chosen approach gave many chances to test the effectiveness of the method optimally.

The big advantages of the chosen validation approach is that the CAPE Groep employees playing the transport company representative both reflect on the method from the client side and can give feedback on the method afterwards, using all their experiences from real life situations. Also, we are free to choose scenarios which ask a lot from the method by presenting both broad and on the other hand quite unique situations and circumstances. For this reason we selected two cases from two companies with very different focuses.

5.2 Heisterkamp scenario

In the first scenario the author of the method performed the role of the consultant interviewing the transport company's representative. The role of the transport company's representative was played by Pieter Verkoost, a consultant from CAPE Groep with quite some years of experience in the transport industry and with board computer projects.

Pieter Verkoost was involved in several IT projects at Heisterkamp. Heisterkamp is the European market leader in providing trailer trucking services, owning about 800 pulling units, and next to the head establishment in Oldenzaal (east of the Netherlands) there are establishments in the other European cities Travemünde, Gent, Trier, Szczecin and Trelleborg. Heisterkamp also rents about 400 trucks and 700 trailers and provides breakdown service in Europe.

One of the projects Pieter Verkoost was involved in at Heisterkamp was the implementation of a board computer system, and especially the fit of the board computer within the organization. He worked on this for one and a half year, from 2007 until 2008, and therefore knows the Heisterkamp case very well.

Pieter Verkoost was not directly involved in the development of the method and before the validation process had not seen the method nor knew the argumentation behind it. Because of this he could objectively answer the questions and give objective feedback on the method. On the other hand, because he has experience with board computer projects as CAPE Groep consultant he could also give useful feedback on the usefulness of the method for CAPE.

For this validation scenario we have chosen to act as if Heisterkamp does not have a board computer already and wants to implement one.

5.2.1 Approach

In this case we performed all the steps from the method as prescribed in the previous chapter as if it was a real case. First we decided which case was appropriate to use. Then, after an explanation to Pieter Verkoost about the goal and approach of the study, questions were asked on the various sections for the Heisterkamp case: general background, transport type, other relevant company characteristics, business strategy and goals, enterprise architecture, business requirements, general nonfunctional requirements, processes and related requirements and other functional requirements.

Pieter Verkoost answered all questions as if he was the IT manager from Heisterkamp, the person who was involved in most (board computer) projects CAPE Groep supported in the past. Afterwards Pieter gave feedback on the method in general and the various steps specifically, in his real life role of CAPE Groep consultant.

For this case the version of the framework was used that was available at this time, which was a print of a big number of papers containing the various steps. After this validation case some adjustments were made and a Microsoft Excel version of the framework was made, which leaded to the version of the framework that was used for the second validation case.

5.2.2 Results

The use of the developed framework for the Heisterkamp case gave insight in both the way the method should be used and on the concrete content of the method. We will first describe the results for the method in general and then the results for the (content) of the various parts. Both the results experienced during the role-play and the feedback Pieter gave afterwards will be mentioned.

5.2.2.1 General

The Heisterkamp validation case confirmed the usefulness of the approach in general. By following the succeeding steps all relevant information and background both parties need to know can be gathered. That is, the information for the board computer selection process as described within the scope of this research.

The big advantage from the framework is that it supports a broad collection of topics, which are:

- general company topics such as strategy, business goals and general company characteristics;
- insight in the relevant technical issues in the company;
- overview of the overall business process and zooming in on the processes on a detailed level;
- eventually making a selection from a broad list of possible requirements, also based on the three previous topics

The role-play showed that with this list of subjects which are extensively discussed the consultant gets a good insight into the business and the transport company representative becomes conscious, and has to make explicit, how his business is organized. Also, the transport company representative gets a good insight in the possibilities of the board computer system and the goals that can be achieved with it. At last, the framework supports both parties in making explicit choices on what is really needed and what would be nice, eventually making up the prioritized requirement list needed for the selection process.

Although the list of all issues that have to be specified and questions that have to be answered is very big, this was not considered a real problem. The complete framework has to be followed only once during the selection process, which can be done in about five to ten hours depending on how detailed the various steps will be worked out. We evaluated this as a relatively small effort for the very important process in which both the complete business is overlooked and the requirements are specified, steps which are very important for the succeeding steps in a board computer selection and implementation project.

On the other hand, during the use of the complete framework in practice, we found out that some improvements on both the structure and content of the framework are very welcome, to optimize this process. With such an optimization both the effectiveness and efficiency of the framework can be improved, meaning that it will be faster and the outcome will be better. These points of improvement are further discussed below.

5.2.2.2 General motivation

We found out it is a good approach to start with some open questions on the general motivation of the transport company to start the board computer project. The consultant can use the answers on these questions as background information to be kept in the back of his head, and the transport company representative is forced to think about this fundamental topic.

Before the validation, only the question whether there was already a board computer system implemented, was present. The question on the main reasons for starting the project was not explicitly present as a question and was added.

5.2.2.3 Maturity level

We found out that it is very useful when CAPE can explicitly get clear what kind of system the company expects to get, in the start of the selection process. Also, it is useful to give the transport company a first idea of the possibilities of board computers. Therefore, after the validation we added a component that forces the representative to make explicit which of the three integration maturity levels (TLN, 2005) he wants.

On top of Level 3 a lot of additional functionality can be added, and we need a lot of information to make a board computer work well on this level. But when a company for example tells it needs only level 1 or 2 this will limit the requirements and thereby the analysis of the business a lot. By asking this question a lot of work can be saved, in case the company wants only a level one or two system.

Heisterkamp prefers the following order of maturity, starting with the support of the first point and ending with the last:

- Communication of text messages
- Localization
- Activity Registration
- Fuel management (instruction, prevent theft, driving behavior)
- Billing support
- Support of reports, damage registration, etc.
- Automatic billing
- Instruction

With this information we could conclude that Heisterkamp eventually wants to have a Board Computer system with maturity level 4, but prefers the functionality of level 1 most, showing that the defined classification matches practice.

5.2.2.4 Transport type

The division into the four transport types was evaluated as a good approach, but since Heisterkamp is a real trailer trucking company we found out that for this type of business the Trailer Trucking definition can be improved by adding some additional characteristics to it.

Trailer trucking was defined as driving with the trailer of the client, coupling it on location A and uncoupling it at location B, and the transport company was providing a truck and a driver. This definition fits all trailer trucking cases, but some companies – like Heisterkamp – provide more services between the coupling and uncoupling, beside driving.

In fact, companies can execute all three other transport types ‘within’ the trailer trucking transport, meaning that they execute for example Less Than Truckload transport (including, loading, cross docking, unloading, etc.) using the trailer of the client and most likely executing all assignments for one client. If that is the case, the company has to be allocated to the Trailer Trucking type and the other relevant transport types. In the case of Heisterkamp, the company is allocated to trailer trucking, full truck load and less than truck load (and not to dense distribution).

From the Heisterkamp case we learned some characteristics which are important to know specially for Trailer Trucking organizations. First, we should note the fact that a trailer trucking organization in many cases can be considered a charter company since in some cases the driver is directly instructed by the client. If that is the case, the client would like it a lot if he can connect with the board computer system and use many functionality the planner of the ‘driving transport company’ normally uses. These functionalities include instructing, track and trace, status overviews, and so on, depending on how exactly the business is organized.

Even when the client company directly instructs the driver the driving company also wants data from the board computer. First, for the settling process the hour and activity (and expense) registration is needed because the driver has to be paid based on his executed activities, no matter whether he is

driving as charter or not. Secondly, the coupling and uncoupling process has to be controlled and registered by the driving company, since those are the 'borders' of the activities executing for the client. And third, depending on the contract with the client (all) other activities have to be registered, for example to support the billing process. This should be done if the company is billed based on the real number of loads, the driven miles, etcetera. Also, it is possible that the client is an international company from which the local branches have to be billed separately on the activities in their country or region.

This new input on the trailer trucking transport inspired us to specify some additional questions which will make clear what specific kind of trailer trucking a trailer trucking company performs, and what the demands are. The bottom-line with all trailer trucking activities is that the coupling and uncoupling processes are the 'borders' from the execution process and are the most important to register, and the fact that trailer trucking companies in many cases can be considered a charter company, considering the fact that their drivers are directly instructed by the client, having the kind of requirements charter companies also have such as providing direct interaction with the board computer to the client company.

We did not really need the extended transport type questionnaire to determine the transport types Heisterkamp performs, but is was useful to quickly scan the questions to check both the CAPE consultant and the transport company representative use the same definition. Based on the feedback, the Question "What is the average transport speed" was added, since transport speed is a more used definition in the transport branch than driving/(un)loading ratio.

5.2.2.5 Other relevant company characteristics

The questions about the other relevant company characteristics were very useful to get insight in the company, the company processes and the company organization. Nevertheless, the validation provided us with a few additions to the questionnaire for the company typology.

We do not only want to know how many trucks the company has, but also how many drivers the company has. This ratio can differ between companies. Also, we want to know whether each driver has its own truck or whether they have another truck each trip. Questions are added to get this clear.

Based on the feedback during validation a note was added to the question on Bad mobile networks, which states that the CAPE consultant should know whether the company operates in bad network areas, based on the areas the company drives.

Heisterkamp transports expensive goods for some companies, which need special treatment. Therefore this type of goods was added as answer to the "special vehicles/goods" question.

In the case of Heisterkamp the documents "weight document", "expense document" and "trailer check report" are used, which were not available as answer. Therefore these three document types are added to the questionnaire.

5.2.2.6 Business goals

The presentation of possible business strategies was evaluated very useful since it supports the line of reasoning for both CAPE and the transport company since the business goals can be related to the business strategy.

It is practically not possible to sum up all possible low-level strategies in the framework, but the overview gives a good starting point and can be used to guide the process of thinking and talking.

Heisterkamps strategy can be summarized by (in their own words):

- Provide 100 percent fit with the customer; flexibility: 'everything is possible'. (quality and scope)
- Focus on the area from the Belgium coast up to Scandinavia. (segmentation)
- Be cheap. (costs)
- Have economies of scale by big vehicle park. (costs)

- Be fast by, for example, recoupling trailers and two drivers in one truck. (speed)
- Do not provide special types of transport such as bulk or cooled transport. It has much experience in, for example, the automotive industry. Because of the financial crisis it has chosen to provide a more broad spectrum of transport. (segmentation)
- Convince the clients that Heisterkamp is better than the competition. (Marketing)

In the case of Heisterkamp, all business strategies except "innovation" are applicable, and this will be the case with many, especially big, companies. Therefore it is important to notice that the strategies have to be prioritized. For the case of Heisterkamp, this gives a score as depicted in the table below, which shows Costs is the most important one:

	Differentiation					***Cost***	***Segmentation***
	Quality	**Speed**	**Scope**	**Marketing**	**Innovation**	**Costs**	**Segmentation**
Score	15	15	15	10	0	30	15

Table 3 Business Strategy scorecard for Heisterkamp

Heisterkamp values its flexibility a lot, meaning that it's willing to adapt to the wishes of its clients. Also, we found out that the Quality dimension is too vague because a transport company can have many ways to deliver quality. Therefore, after this case we defined sub dimensions of Quality, being Correctness, Information supply and Flexibility.

The presentation of possible business goals was evaluated very useful. It supports the line of reasoning for both CAPE and the transport company since the lower level goals can be related to the business goals. In the Heisterkamp case, the company wants to achieve a lot of goals, but it was possible for them to make a distinction between the most important and less important ones.

The main goal, as with almost all companies implementing their first board computer, was to decrease costs by mainly decreasing the communication costs, but also decreasing the fuel costs and vehicle maintenance costs.

Secondly, they wanted to increase the efficiency of mainly the billing and settling processes. Thirdly, they wanted to improve the security. Fourth, they wanted to provide internal transparency and fifthly they wanted to improve quality and customer satisfaction with the board computer.

The questions on scope and willingness were also useful. Heisterkamp had a few important concrete cultural aspects:

- It is willing to modify processes if that is needed to benefit more from the board computer.
- The drivers should not be overloaded with questions.
- Everyone should be involved in the process.
- The product should be Multilanguage.

These questions are already covered in the questionnaire, so no modifications are needed.

5.2.2.7 Enterprise architecture

The presented reference enterprise architecture was evaluated as useful during the validation. It shows the important issues on the three layers. In the two top layers the transport company and CAPE consultant can easily adjust the architecture to make it fit the specific company situation, so both parties know what the situation is.

The bottom layer shows the alternatives in the technology, which helps the company to get insight in the issues on this subject. The validation showed that is has to be emphasized that the technology layer should not be discussed into detail with non-technical people from the transport company. Nevertheless it is useful to discuss with the representative what topology is currently in use and whether this should be changed when the board computer comes in place.

During the discussion on the technology layer we once more found out the importance of the insight in the charter characteristics. In the case of Heisterkamp, which is a charter as trailer trucker, clients want to directly control the driver as if they are a planner of Heisterkamp. This means they want access to the board computer system as if they are the planner. This gives special demands on the board computer middleware: it should provide a very good (web) portal, or it should support good interaction with the client's systems.

Also, based on the validation we changed some things in the enterprise architecture. The alternatives in the Wireless communication between the Board Computer device and the Board Computer middleware are now distinguished in network/technique choices, provider choices and APN choices. And in the Board Computer and truck devices Scanner was separated in Document scanner and Barcode Scanner, and Camera was added.

Heisterkamp does not have the actors Transport company and Warehouse involved. It does not have an APS, trailer track system and a WMS. It has some systems such as "Schade", "Diesel" and "Tol" but for the scope of this project these are all integrated into the TMS, which in the case of Heisterkamp is an ERP Baan system. The technical architecture topology that matches Heisterkamp the best is the Point-to-point technology with various direct database connections.

5.2.2.8 Business requirements

The validation showed that the list of business requirements helps the company to select which requirements it wants to be fulfilled, and thereby eventually what product is needed. The connection between the business goals and business requirements was judged to be not really clear and therefore after the validation this relation is better explained. Also, after the validation per business requirement is depicted what maturity level fits the requirement. This way, one can directly see what maturity level is needed, if that was not chosen in an earlier phase. Or the other way around, if the maturity level is chosen: which business requirements belong to that level.

5.2.2.9 General nonfunctional requirements

Although the list of general nonfunctional requirements is evaluated as very useful, a few nonfunctional requirements were considered missing and they were added after the validation. 'The product should be easy to implement' and 'The product should be easy to build-in' were added below the 'Portability (Adaptability, Installability, Conformance, Replaceability)' section.

The case also learned that each company has its routines in the communication with their drivers. For example, many companies tell their driver to refuel before they go to an expensive country, to check their truck for stowaways before they go to Great Britain, and so on. It is not doable to insert all these specifics into the requirements, and therefore we have chosen to add the requirement "The product should support easy modification or addition of new question paths" under the Flexibility topic, which covers all these specific topics now.

- We added the requirement that the product should support a simulation version of the board computer, which can be used to test functionality and performance on a PC, and to support the use of the Board Computer. This should support the Testability and Usability. Companies have very positive experiences with this functionality.
- We added explicit requirements for the CANbus-data, since this a very important requirement for Heisterkamp: mileage records are very important Key Performance Indicators.
- We added a requirement for remote accessibility to support Ease of Use.

5.2.2.10 Processes and related requirements

The long list of all business processes (and process models) relevant for the board computer and the related requirements is evaluated as very positive. It is a long list, but it is very useful for both parties to walk through it, and make explicit how all these processes take place in the company. Also, it is very practical that there is a standard list of requirements related to the various processes, from

which CAPE and the company together can select the relevant ones, depending on the company characteristics and the goals that should be achieved with the board computer.

From the Heisterkamp case we learned it is important to distinguish, for the processes on the office-side, which ones should be possible to execute by a client company (which uses Heisterkamp as charter) and which ones should only be possible to perform by the transport company itself. A note for this issue has been added next to the business processes for which this can be relevant, which are Driver instruction and Execution support.

Also, based on the validation case, we made the following small changes:

- For the Driver instruction process we added to the activity types the “obligatory” and “voluntary” activities.
- We added the requirement “the product should support smart question paths” which means for example that it should be impossible to unload when the truck is not loaded before (since the trailer is empty then).
- We added the requirement The product should support the presentation of (a summary of) the executed activities to the driver to the Execution Support; Activity registration process.
- We added the requirement ‘The product should support the registration of reference numbers’ for the Expense administration, because those reference numbers support the administration by finding the bills for the declarations at a later moment.
- For the requirements “the board computer should support the registration/identification of the co-driver” under Log On, we added the following subrequirements:
    - The product should register the activities for both drivers.
    - The product should register one active and one inactive driver.
    - The product should register different activities for the active and the inactive driver.

For text messaging we made the following requirement explicit:

- The product should support a history function of the sent and received messages
    - On office side
    - On truck side
- We added the requirement of supporting the announcement at ferries or trains by presenting the booking number, since that is the way Heisterkamp is used to send this number by phone to the driver, and then the driver tells this number to the ferry office employee.
- We added the note that for each activity, one should specify whether there is an additional question path wanted. For example: when a driver registers damage, should he be asked whether he did the paperwork?

5.2.2.11 Other functional requirements

During the validation it was evaluated as useful to have a separated section in which the company can specify some additional function requirements, which are not really directly related to the business processes or goals. Some companies, especially those which perform long international runs, want to have some additional functionality like music and video playing possibilities. Therefore, some requirements for this are added. These functionalities in general are always just ‘nice to have’ and not a ‘must have’.

The nonfunctional requirements already covered the case in which the company does not want the board computer device itself to provide the mentioned functionalities, but wants the board computer to support the running of other applications on it. For this, the choice of the operating system running on the hardware is very important.

5.3 Tielbeke scenario

In the second role-playing scenario one consultant from CAPE Groep used the framework as a consultant to interview another consultant, who played a transport company representative.

Consultant Dennis Brugging played the role of the director of Tielbeke, the transport company that is looking for a new board computer system in this scenario. Tielbeke is a logistic service provider owning about 125 trucks and employing about 200 people. The company has establishments in both Lemelerveld and Zwolle (both in the east of the Netherlands), and provides (dedicated) transport, distribution and warehousing in the Benelux, Germany and Scandinavia. According to the segmentation used in this research, Tielbeke performs activities for all transport types: Trailer Trucking, Full Truck Load, Less Than Truck Load and Dense Distribution. Next to the "ordinary customers" which Tielbeke has, the company participates in some logistic networks. Appendix D.2 gives an extensive description of the company.

Dennis Brugging was and is involved in various IT projects at Tielbeke and therefore knows the company very well. Recently, the company actually asked CAPE Groep to help them to find an appropriate new board computer system, making this validation case very useful and interesting.

In this scenario consultant Pieter Verkoost used the framework, after a short explanation and instruction, to interview Dennis Brugging on the characteristics of the company and the wishes for the to be selected board computer system. The developer of the framework quickly explained the framework to Pieter Verkoost and then observed the use of the framework. The two consultants gave feedback from both the role they played and their experiences as consultant.

5.3.1 Approach

At first, the developer of the framework and the two consultants discussed what case would be useful to use for the validation, and eventually we selected the Tielbeke scenario. After that, the developer of the method gave Pieter Verkoost a short explanation on the method and a short introduction on how to use it. Dennis Brugging was told we were going to validate a framework for board computer selection, and that he had to play the role of the director of Tielbeke, a company he knows very well that is looking for a new board computer system.

Pieter Verkoost walked through the framework in Excel, as prescribed in the previous chapter, as if it was a real case in which he worked as CAPE Groep consultant. Dennis Brugging just answered the questions he was asked as if he was the director of Tielbeke, the person that converses with CAPE Groep in this kind of projects in the first phases. The author of the framework noted interesting comments on the use of the framework he observed himself and noted the feedback both the interviewer and the interviewee gave. Afterwards Pieter Verkoost and Dennis Brugging also gave feedback from their real-life experiences as CAPE Groep consultants which were written down too.

For this case the version of the framework was used that was available at this time, which was a collection of Microsoft Excel sheets and prints of reference architectures. In this version, the results from the first validation case were processed. After this validation case some final adjustments were made to the framework, which led to the final version of the framework that is presented in this document.

5.3.2 Results

The use of the developed framework for the Tielbeke case gave insight in both the way the method should be used and on the concrete content of the method. We will first describe the results for the method in general and then the results for the (content) of the various parts. The results that are given are combined from the observations during the validation, the feedback from the users of the framework in their role-playing role, and their feedback given as experienced consultants.

5.3.2.1 General

The Tielbeke validation case again confirmed the usefulness of the approach in general. By following the succeeding steps all relevant information and background both parties need to know can be

gathered. That is, the information for the board computer selection process as described within the scope of this research. This was the conclusion of the Heisterkamp case too, so for an extensive enumeration of these advantages we refer to section 5.2.2.

On the other hand, the Heisterkamp validation case showed that we needed a better structure and overview of the method to be able to use it really efficiently, meaning that it will be faster and the outcome will be better, as described in section 5.2.2. These recommendations were implemented in the new version of the framework, which was used in the Tielbeke scenario.

To improve the usability and efficiency, the method was summarized in a collection of Excel sheets. This new version indeed made the method more surveyable and faster in use, but on the other hand it brought one disadvantage, which was the lack of explanation and background of the various steps. This criticism was used to adjust the framework for the last time, and this way the final framework combines the surveyability and efficiency with comprehensibility.

The CAPE Groep consultants needed better instructions on how and when to use the method, before they can use it for the first time. This information is covered in chapter 4 of this document, and can be told orally, but was not present in the framework for CAPE itself. Therefore this information was added to the framework after the validation.

For example, it was not explicitly mentioned that the consultants can deviate from the questionnaires: they are free to skip questions, slightly modify questions or ask additional questions depending on the situation. A note to make this explicit was added to the framework. Also, the consultants liked it a lot that they could use the Excel sheets to fill in the answers on the various questions, but missed the questions themselves. These were added to the framework too.

The framework does contain various steps which focus on the general background of the company, but during the validation once more it turned out that the framework is not appropriate to use during the very first contact with a transport company. First, the CAPE Groep consultant should have an introduction conversation with the transport company's representative, to get an idea of the company's background and motivation to get in touch with CAPE Groep. After that first session, the framework can be used, also to make the background information that was discussed in the open conversation explicit. This recommendation on the (moment of) use of the framework was added to the framework and the sections on the use and scope of the method.

In line with the discussion on the phase of the process in which the framework should be used, one can discuss on the best order of the framework's steps. Eventually we have chosen to keep it the way it was. This means that the framework first focuses on the general motivation and ideas of the company, and after that the company characteristics are discussed. We maintain that order because we think it is very important to start answering the question why the transport company starts the project at all. The argument that CAPE Groep should first know what kind of company the client is can be refuted by the fact that the consultant should know this already a little before starting to use the framework.

The next sections will describe the results from the Tielbeke validation case. To keep this chapter surveyable only the results are presented which were not already concluded from the Heisterkamp validation case.

5.3.2.2 General motivation

This part of the framework is evaluated as very important since it is the starting point for the complete process. With respect to this step it again has to be noticed that an introduction conversation always has to take place before the framework will be used.

In the case a company already has a board computer, the representative should be asked whether the company wants a complete new system or that a reimplementation of the old system is an option too. Also, if the company already has a board computer system it should be asked what system the company has. These questions were added afterwards.

5.3.2.3 Maturity level

CAPE Groep is used to distinguish four instead of three maturity levels, and therefore after the validation this four-level classification was implemented in the framework. After the validation we also added the explicit question on which level the possibly current implemented board computer system operates.

We discussed whether the questions on the maturity level should be asked in this early phase, but eventually we decided to keep this order because for the next phases it is useful to keep in mind what the general goal of the board computer is, and thereby what maturity level is needed. Of course, when the company does not have any clue on the maturity level, one can skip this step and refer to it later.

5.3.2.4 Transport types

Many companies perform all transport types, and Tielbeke does too, but the proportions between the various types can differ a lot between companies. For example, these ratios between Heisterkamp and Tielbeke differ a lot. Therefore, from the validation we learned that it is useful to write down the portions of the performed transport types. After the validation we have reserved space for this to fill in this information in the framework.

Also, we found out that it is important to know whether the various transport types have to be supported by the same board computer, or that various devices are wanted, since Tielbeke considers the option of using various devices. This information was added to the framework after the validation.

5.3.2.5 Company characteristics

Since Tielbeke performs a lot of activities, but some only sporadic, as with the question on the transport types, we learned that not only information is needed on what/where/how transport is done, but also the ratios of the various characteristics are needed. This information was added to the framework after the validation.

The consultants also considered a few important characteristics missing. LZV was missing as special vehicle/freight type and a question asking the company whether it has its own garage was missing. On the subject of the documents that are used during execution, it should also be asked how fast the (filled in) documents should be returned to the office. These things were added to the framework after the validation.

Some questions, like for example whether the company operates in areas with bad communication networks, have to be answered by the CAPE Groep consultants themselves. It was not clear enough which questions this applied to, and therefore after the validation these kinds of questions are marked, by printing them Italic.

5.3.2.6 Business strategy

As mentioned in the general comments we found out that the consultants needed a better explanation on the background and use of the method. This was also the case for the Business Strategy step, and therefore after the validation we added a more extensive explanation on the various possible business strategies. Also, for some companies, like Tielbeke, it is hard to tell what strategy they focus on but they do have some kind of motto or mission statement. Therefore we added a field in which the consultant can fill in this statement so that one can look back on this at a later moment. And third, we defined sub dimensions of Quality, being Correctness, Information supply and Flexibility.

5.3.2.7 Business goals

It was evaluated as unclear what the relation was between the various strategies and business goals. Therefore after the validation the order of goals and strategies was better tuned to each other and the strategies were repeated in the business goals sheet.

During the validation we once more were confronted with the various functions of the framework, which is not only to make the goals and wishes of the transport company explicit, but also to teach the company's representative what the possibilities are. Because of this, we found out the business goals should be filled in in four successive steps. First, it should be made explicit which goals should be achieved based on the business strategy. Then, in the case the company already has a board computer, one should specify which goals are already achieved by the current system. And third, it should be defined what other goals the company does want to achieve, also based on the motivation for the project as defined in the first step. Then, as a last step, the company should be explained what other goals possibly can be achieved and the company can select additional goals from this overview. This order of steps was added after the Tielbeke validation case.

5.3.2.8 Scope and willingness

The two CAPE Groep consultants at first did not really understand what was meant with Scope and willingness, and after the validation this is better explained by adding some example scenarios.

5.3.2.9 Enterprise architecture

In the case of Tielbeke, the company's representative CAPE Groep speaks with is the director. He will only be able to give insight in the business layer of the company. This scenario will hold for many cases, and therefore after the validation the recommendation was added to only discuss the business layer in detail during the first contacts with the company. For the discussion of especially the detailed technology a technical representative is needed. The needed devices around the board computer device on the other hand can be specified when one has insight in the wishes of the company.

5.3.2.10 Nonfunctional requirements

The validation emphasized the distinction between various kinds of nonfunctional requirements in the nonfunctional requirements overview. Some requirements have to be always fulfilled, for all companies and cases, and are written down only to support the verification process, where others are optional and differ between companies. This distinction has been implemented after the validation.

We found out that it is not possible to fill in concrete values for all nonfunctional requirements in the early phase the framework is meant for, but for some values this can be done. The recommendation therefore is to fill in as many values as possible, the process itself of choosing the values definitely useful.

5.3.2.11 Other functional requirements

The Tielbeke case delivered a special type of requirement for the subject of other functional requirements, since Tielbeke explicitly wants to make watching DVD's or listening to MP3's with the board computer impossible. Therefore after the validation the abbreviation "I" was added, which means that it should be Impossible to use these kinds of functionality.

5.3.2.12 Processes and related requirements

As with the first validation case, the overview of all processes and related requirements gave good insight in the company and the company's wishes. The automatic presentation of the relations between the various characteristics and requirements was evaluated as useful. The selection of the main features and choices was a big improvement in comparison to the version that was used during the first validation case, but the usefulness of the framework can be improved by making this step more surveyable. This improvement is the most important recommendation for future research.

5.4 Conclusion

We have validated the developed framework by testing it in two role-playing settings. First a role-play was performed in which the developer of the method played the consultant using the framework to interview a CAPE Groep consultant playing a transport company representative. This

study showed the usefulness of the framework and provided some recommendations for improvement of the method.

The recommendations from the first validation were implemented into the method and then the new version was validated with a second role-play. In that second study the framework was used by two consultants from CAPE Groep. One of them played his normal role of consultant and the other one played the role of a transport company representative. This validation case again proved the usefulness of the method and also provided some recommendations for improvement of the method. Most of these recommendations are already implemented in the version of the framework that is presented with this research project, some other recommendations are used as recommendations for future work.

5.4.1 First validation

The most important conclusions from the first validation case were:

- We experienced that the framework in general was very useful, not only to specify the requirements but also, for both the transport company and CAPE Groep, to get a good insight in the transport company and the possibilities of board computers.
- Trailer Trucking was in this research defined simply as transporting trailers of clients, but we found out that some transport companies see Trailer Trucking as a much broader type of work. Especially the charter style of this transport type is very important. Therefore, the explanation of the Trailer Trucking definition was modified after the validation.
- The Theory chapter of this thesis mentioned the various maturity levels that can be distinguished between board computer systems, but these levels were not implemented in the framework. We missed this during the validation, and added it afterwards.
- The first validation was done with the framework on a big number of papers. It was possible to use the framework in this form, but we thought it would be better to summarize the important issues and make the framework more surveyable. Therefore, the framework was transformed into a collection of Excel sheets.
- We found out that the Business strategies that were collected from Theory were useful for the transport industry, but that the Quality strategy was not specific enough. Therefore, we divided this definition into special types of quality.
- And finally, during the validation we made up additional (functional and nonfunctional) requirements specified, which were added to the framework. We concluded that probably each case will bring up new requirements and therefore the framework should be updated after each use.

5.4.2 Second validation

The recommendations mentioned above were implemented into the framework after the first validation. From the second validation case, in which we used the new version of the framework, also provided us with new insights on the framework and the use of the framework. The most important conclusions from the second validation case were:

- The new version of the framework collected the various steps in a collection of Excel sheets. This adjustment proved the method to be indeed more surveyable and faster in use, but on the other hand it brought one disadvantage, which was the lack of explanation and background of the various steps. This criticism was used to adjust the framework for the last time, and this way the final framework combines the surveyability and efficiency with comprehensibility.
- The validation emphasized that the framework should not be used during the first contact with the transport company. This was added in the recommendations for the use and scope of the framework.

- Various questions were considered missing and added afterwards. These questions were on the topics: the relative share(s) of the various transport types and other characteristics; the board computer the company has currently implemented, in case it has one; whether the company wants different board computers for the various transport types; whether the company has it's own garage; whether the company drives LZV vehicles;
- The relation between business strategy and business goals was not clear enough, and the relation between them was showed better afterwards.
- After the validation the business goals were divided into three steps, because that way it is more clear to trace origin of these goals.
- A fourth maturity level was added, because CAPE Groep was used to use four levels.
- The validation showed one should not try to specify the complete enterprise architecture when the framework is used to interview a non-technical company's representative. Therefore a part of this specification is moved to a later moment.
- It was requested to accelerate the selection of the nonfunctional requirements and therefore they were divided into standard and optional ones afterwards.
- The validation showed some companies explicitly want some functionalities to be absent. This option was added as a separate demand afterwards.
- Again, the overview of all processes and related requirements was very useful and so was the automatic presentation of the relations between the various characteristics and requirements was evaluated useful and the selection of the main features and choices. But the usefulness of the framework can still be improved by making this step more surveyable, and this improvement is the most important recommendation for future research.

5.4.3 Both validations

Both validations showed the usefulness of the developed method and the second validation showed positive effects of the improvements on the first version. Especially the facts that the new version was better organized and easier to use in practice were very positively evaluated. One can still discuss the order of the different steps, but we argued why we think the current order is the best, and therefore kept it that way.

Still, also during the validations we noticed that the final step of the method, the real specification of the functional requirements, can be improved. We succeeded in making the wanted method for specifying the requirements, but the way we do this can be made more efficient. It would be better if the requirements were calculated in an automatic way, based on the input of business characteristics and wishes. Together with that, an adaptive digital questionnaire which determines the questions based on the answers on previous ones would also make the method more efficient, but on the other hand taking away the power from the consultant. The improvement of this flaw is the main recommendation for the improvement of the method in the future.

5.4.4 Key questions

Next to the insight the validation gave in the usefulness and the advantages and disadvantages of the method, we found out what the key questions are, when CAPE wants to specify the requirements for a board computer system for a company.

Our conclusion on this topic is that all issues that are treated in the various steps in the method are important to treat, when one wants to make a complete and fitting list of requirements for a company. We need to know what the company looks like, what processes are performed and how they are performed and organized, what the strategy and goals of the company are, how the company is organized, and finally how the company wants the board computer to support all this.

In spite of the fact that all questions are important, we distinguished a list of key characteristics, which is depicted below.

- **Already a Board Computer?**
  - Why a new one? General motivation?
- **Maturity level wanted?**
  - Just level 1 or 2 -> many requirements can be removed.
- **Transport type:**
  - TT -> No Loading, Unloading, Cross-docking, etc. No visits at office for a long time.
  - FTL -> in between. No visits at office for a long time?
  - LTL -> in between
  - DD -> Many stops, high speed needed, but visits at office regularly. High demands on load, unload, cross-dock support.
- **Other most important issues**
  - Charter?
  - International?
  - Freight type?
  - Additional services?
  - Flexibility?
- **Business goals**
  - Costs?
  - Quality?
- **Enterprise architecture**
  - Typology?
  - Systems to connect to?
- **Business requirements**
  - Costs?
  - Quality?
- **Nonfunctional requirements**
  - Maximum load
- **Processes and requirements (also main differences between vendors)**
  - Mobile?
  - Registration?
  - Proving?
  - Mobile
  - Activity registration? Track-trace support
  - Instruction?
  - Scanning?
    - Barcode
    - Document
  - Trailer interface?
  - Tacho-communication?

- Camera?
- Charters, connection:
    - -portal
    - -data

All the issues mentioned above guide us to a very long list of requirements. From this list, and by looking at the functionalities of various vendors (see section D.4), we extracted a list of key features, which we can use to make a preselection, and to distinguish the various existing systems. These key features are summarized in the next section.

5.4.5 Key features

The validation helped us to define a list of key features of board computers, which can be used to differentiate vendors and create a longlist of vendors for a specific company. This list of key features, which in fact are the key requirements if they are reformulated, can be found below.

- Mobile device
- BC middleware accessible by customers
- Flexible Question Path
- Instructions modifiable afterwards
- Integration with TMS/APS
- Control HOS
- Support truck service
- Guard security
- Activity Registration
- Automatic Activity registration
- Connection with digital tachograph
- Connection with CANbus
- Sensors
- Show status overview
- Text messaging
- Calling
- Expense administration
- Damage registration/support
- Navigation
    - Automatic input
    - Traffic jams
    - ETA's
    - Truck
    - Adaptive
- Geofencing
- Preannouncement
- Selection/registration/proof (of orders)
    - Tablet PC
    - Digital pen

        - Barcode
        - RFID
        - Truck printing
        - Mobile Printing
        - Digital Camera
        - Document scanning
    - Packaging support
    - COD support

6 Conclusions, recommendations and reflection

In this chapter we describe what we have done and what the main results of our research are. Also, we reflect on our work and we make recommendations for CAPE and general future work related to this research.

6.1 What has been done

During this research project a requirements specification framework is made which CAPE Groep can use to support road freight transport companies with the selection process of C.O.T.S. board computer systems, eventually by specifying the requirements relevant to specific companies. The approach used in the framework is based on knowledge and methods found in literature on the topics of package selection, requirements engineering, (reference) enterprise architecture and (reference) business process modeling. Also, literature from transport (IT) organizations and the advice and experiences from CAPE Groep consultants are used to develop the framework's approach.

The contents of the various steps of the framework are based on the information found in literature, documentation from board computer projects CAPE Groep was involved in, documentation from board computer vendors, a meeting with a Board Computer vendor, discussions with CAPE Groep consultants, two visits at a transport company and by accompanying two truck drivers.

After the framework was developed it has been validated with two case studies in which the functioning of the method was tested by applying it to two companies that were looking for a (new) board computer system. These studies were performed by two role-plays. In the first one the author of the framework played a consultant, and a CAPE Groep consultant played a transport company's representative. In the second role-play one CAPE Groep consultant played a consultant and another CAPE Groep consultant played a transport company's representative. With both studies, the consultant was interviewing the company's representative with the use of the framework.

6.2 Main results and implications

Our research provided some important results and implications which are summed in the overview below, explaining the main choices for our framework:

- The business processes are the basis of the developed framework since they prescribe what demands the board computer system should fulfill, guiding the requirements.
- Before studying the processes within a specific company the framework starts with steps for the specification of some more high-level company characteristics such as the type of transport the company executes, the working area, the company size, and so on.
- Many transport companies start selecting and implementing a board computer without really knowing what they want to achieve with it and what the possibilities of board computers are. Therefore the framework consists of a step in which the business goals of a company, resulting from the business strategy, are specified to communicate other possible goals that can be achieved. Besides this, the very first step in the developed framework is to ask the company what their general motivation is to select and implement a (new) board computer system, and what level of board computer maturity they want.
- It is very important to specify the enterprise architecture for the successful integration of a board computer in a company. Therefore we made a reference architecture with a few standard topologies in which the to-be selected board computer should fit. Our validation taught us that in many cases the technical specification of the architecture should be left for a later moment, since the company representative involved in the early phase of the project is not technically capable to do this.

- The developed requirements specification framework should be completely followed to get the best result, but it is also possible for CAPE to perform only specific steps of the total framework, which are:
  - General motivation
  - Maturity level
  - Transport types
  - Company characteristics
  - Business strategies
  - Business goals
  - Scope and willingness
  - Business requirements
  - Enterprise architecture
  - General nonfunctional requirements
  - Other functional requirements
  - Processes and related requirements
- It is very important to notice that our research, and the developed method which is one of the deliverables, does not only help to specify requirements and other issues but also to create insight in the transport industry. Both CAPE Groep can increase its knowledge and thereby can the companies that are supported by the method. The method can be used to communicate all kind of possibilities of board computers, and scenario´s for companies, to both CAPE Groep and the transport companies.
- With all the steps depicted above, and with the summarizing method CAPE can use in practice very easily (see Appendix F) the research goal defined at the start of the project is achieved and CAPE will be able to advise its clients much better and more efficiently.

The picture below shows the basic concepts of the developed framework in an overview which is also comprehensible for people without much in-depth knowledge. It shows the six main steps in the process of specifying requirements for board computer selection, each step having certain techniques which are used to deliver a certain output.

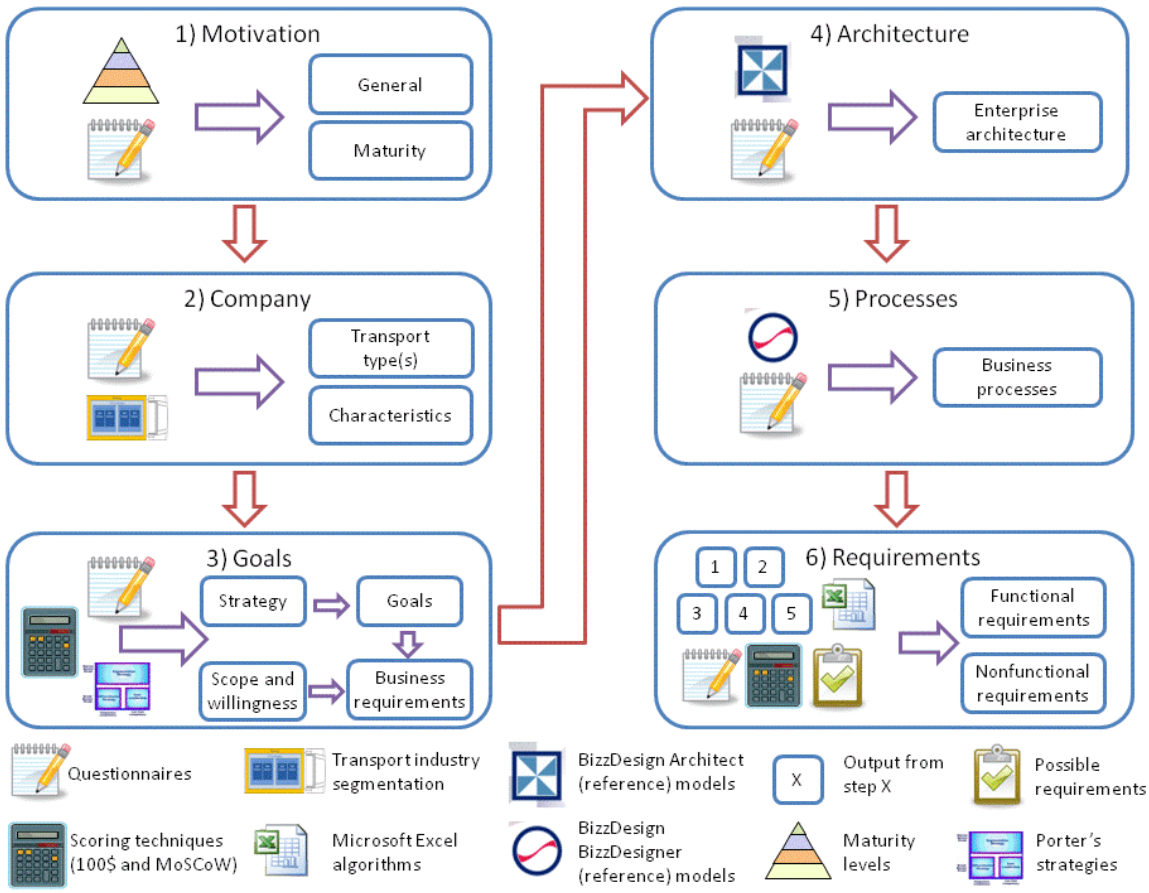


Figure 13 Framework overview

6.3 Answers to research questions

We started this thesis by presenting the Research goal (see section 1.6), which was "To develop a validated method for CAPE to effectively advise road freight transport companies on the selection of Board Computer systems". This research goal was reformulated into the problem statement (see section 2.1) depicted in the next section.

6.3.1 Answer to problem statement

How can we develop a method for CAPE to effectively advise road freight transport companies on the selection of Board Computer systems?

Chapter 4 presents the requirements specification framework which does help CAPE to effectively advise road freight transport companies on the selection of Board Computer systems. The effectiveness of the method is validated in Chapter 5. How this method is developed is described in chapter 3. This way we have answered the problem statement and achieved the research goal.

The developed framework does not only help the specification of requirements for a transport company looking for a board computer, but also supports CAPE Groep to write down, and keep in mind, other issues important for the choice of a board computer, such as business goals, company characteristics and the enterprise architecture. Furthermore, the use of the method provides the transport company with more insight in the possibilities of board computers and the choices that have to be made, since CAPE Groep can use the method to communicate to 'teach' the company and communicate with the company.

To accomplish the research goal that is depicted above we wrote down the sub-questions (see section 2.2) depicted in the next section, which were answered one by one in the previous chapters.

6.3.2 Answer to research question 1

1) What does the road freight transport industry look like and how can it be segmented?

One of the first topics that was studied after the design of the research was the road freight transport industry and the segmentation of this industry. Section 3.7 gives a description of the road freight industry, and section 3.7.3 presents a segmentation of the industry based on the four types of transport that can be distinguished in road freight transport. This way we answered the first research question.

After a general definition of the road freight transport industry, which is characterized quite conservatively, we mentioned the most important trends in the market, which are the arising and increase of the following phenomena: additional services; competition and low margins; regulation; multi- and intermodal transport; security needs; CO2-reduction needs; Activity Based Costing; more, smaller and time-critical jobs; shortening of the order-to-cash cycle; supply-chain-management capability improvement; consolidation, mergers and acquisitions; enhancement of customer service and finally globalization.

Board computers are meant to support the business processes and therefore we choose to divide the road freight transport market into four segments based on the transport type that is performed, each transport type having its own business process, especially during execution. The four specified segments are: Trailer Trucking, Full Truck Load, Less Than Truck Load and Dense Distribution.

6.3.3 Answer to research question 2

2) What are the non-specific frequently used requirements for Board Computers that hold for all road freight transport companies?

In section 3.4 we described how requirements engineering should take place, especially for the selection of COTS systems. In this section we specified a division for requirements into business goals, business requirements and system requirements, the latter consisting of functional requirements, nonfunctional requirements and design constraints (see section 3.4.2). Also we selected two requirements prioritization methods from theory, for the various types of requirements that are used, which are the 100-dollar method and the MoSCoW methodology (see section 3.4.3).

Our research, including infield research and the study of previous board computer projects, showed that only a small minority of the found possible requirements does not hold for all transport types, meaning that most requirements can be relevant for all segments. Though, the priority of the requirements does differ a lot between the various segments, because the share and importance of specific business processes and activities varies a lot between them. Besides the differences between transport types, we also saw a big influence of all kind of other characteristics of the businesses on the requirements, not only on the priority of requirements but even on the presence or absence of requirements.

We have found a big list of non-specific requirements that hold for many transport companies, which are depicted in the actual framework, and in chapter 4, to be more specific in the section on business requirements **Error! Reference source not found.**, nonfunctional requirements **Error! Reference source not found.** and functional requirements **Error! Reference source not found.**.

6.3.4 Answer to research question 3a

3a) What do the business processes look like for the road freight transport segments?

In section 3.5 we described the use of reference business process models to support the creation of specific business process models for specific transport companies, and selected the BizzDesigner tool to make these (reference) business process models. These models are based on the research that is described in chapter 3 and validated with two case studies. We draw process models from a high level which provides an overview of the complete business until a very low levels which shows specific detailed activities. These models are part of the practical framework (see Appendix E and Appendix F), and for each process and activity we have indicated for which transport type(s) it is

applicable. Section **Error! Reference source not found.**, which describes the business processes, related requirements and some background, explains these models too.

6.3.5 Answer to research question 3b

3b) Which requirements for Board Computers result from these processes?

Almost all requirements can be directly related to specific processes, and therefore the developed method (see Appendix F) presents these requirements next to the processes, which is also the case in section Appendix E, which describes the business processes, related requirements and some background. These requirements are based on the research described in chapter 3 and validated with two case studies.

6.3.6 Answer to research question 4a

4a) Which main enterprise architectures can be distinguished in the road freight transport industry?

In an early phase of this research we found out that the enterprise architecture of a company has a big influence on the requirements for the board computer for that company. Section 3.6 describes the role of enterprise architecture in more detail and explains how the reference enterprise architectures that are made and implemented in the framework should be used. In this section the choices for the tool Architect and the language Archimate are also explained.

We have made one big reference enterprise architecture, from which the elements from the business, application and technology layer relevant for a specific company can be selected. This reference enterprise architecture should fit all companies from all segments. We have made three enterprise architecture integration topologies, which show the possible scenarios for the technology layer on which the board computer should fit.

The made reference enterprise architecture and topologies can be found in section **Error! Reference source not found.** and how the enterprise architecture specification is implemented in the method to be used by CAPE Groep can be seen in Appendix F.

6.3.7 Answer to research question 4b

4b) Which requirements for Board Computers result from these architectures?

The enterprise architecture of a transport company contains three layers, which are the business, application and technology layer. The business layer provides requirements resulting from the overall business process and the involved people and organizations. The application layer provides requirements on the applications the board computer has to cooperate with, and data has to be exchanged with. The technology layer, and the relevant integration topology, provides us with requirements on the way data has to be exchanged. The scenarios for these topics and the requirements resulting from this can be found in section **Error! Reference source not found.**.

6.3.8 Answer to research question 5

5) Are there other important discriminating business characteristics relevant for the Board Computers requirements and which new requirements may result from these characteristics?

The business characteristics which were not explicitly formulated in the research questions (which were defined at the start of the research project) but which are relevant for the requirements have to do with the motivation and goals of the transport company looking for a (new) board computer. These issues are treated in the first few steps of the method. In these steps we formulate the general motivation of the company to start looking for a (new) board computer (see section **Error! Reference source not found.**), the maturity level that is wanted (see section **Error! Reference source not found.**), and the business strategy (see section **Error! Reference source not found.**) and business goals (see section **Error! Reference source not found.**) of the company. Also, the developed method discusses the scope and willingness of the project (see section **Error! Reference source not found.**), meaning how to what extent the processes of the company can be modified in favor of the board computer.

6.3.9 Answer to research question 6

6) Which questions have to be asked by CAPE during the requirements specification process, to select the relevant requirements for Board Computers for specific road freight transport companies, in order to narrow the range of possible solutions?

For all steps in the method we formulated questions to specify all kind of characteristics, which provide requirements and eventually can be used to narrow the range of possible solutions. All these questions can be found in the sections on the relevant topics in chapter 4.

6.4 Recommendations to CAPE Groep

We performed an extensive research to develop a method which CAPE Groep can use to advise transport companies on the selection of board computer systems. The previous sections of this chapter described what we have done and what the results of this research were. In this section we give recommendations for CAPE on how to use and improve the framework, and recommendations for future work on the research topic in general. The main recommendations to CAPE Groep are:

- Validate the method more extensively by using it (parallel to the old approach) and see the results during the verification phase, implement it gradually by letting consultants teach their colleagues to use it, and to continuously improve the method based on the results and the developments in the market.
- Profit from the additional benefits from the developed method, next to the improved support for the board computer system selection, which are: using the framework for marketing purposes, adjusting the framework to make it usable for other IT projects in the transport industry, and to use the framework to get insight in transport companies and the transport industry in general and to show possible scenarios, chances and possibilities of board computers.
- Improve the framework by: validate it more extensively, partly automate the walk through of the framework, specify more detailed priorities of the requirements and extend the framework with vendor requirements, project requirements, financial issues and support for requirements verification.

6.4.1 Implementation at CAPE Groep's daily practice

We have some recommendations for CAPE Groep on how to implement the developed method in its daily practice. At first, we think that in spite of the fact that the method is validated with two cases during this research project, CAPE Groep should perform more evaluation cases internally. One can use board computer cases from the past to improve the method based on the results.

After this, a few consultants can use the framework in practice, possibly parallel to the old approach. Then, CAPE Groep should evaluate the success of the framework. This should also be done by testing how well the results of the method can be used for the verification process. Then, based on the use in practice, the framework should be improved.

Now all consultants should be trained to use the framework. Therefore, they can read this document, read the method and the instructions, get instructions from their colleagues and see how their colleagues use the method. When the method is completely implemented CAPE Groep should continuously keep improving the framework based on the results one should evaluate the method after each use) and the developments in the market. Board Computer vendors will provide more and more functionality, and more companies will already have a board computer which has to be replaced, and the framework has to respond to these developments.

6.4.2 Additional benefits from the research and method

The main goal of this research was to develop a method which can be used by CAPE Groep to support transport companies with the selection of board computer systems. To be more concrete: by specifying requirements for (specific) transport companies. This goal is achieved, but the research and developed method provided also additional benefits for CAPE Groep which we recommend to profit from. In this section we describe these benefits.

- We recommend using the framework for marketing purposes, by promoting the framework to potential customers.
- We recommend adjusting the framework for projects other than Board Computer selection, since most steps of characterizing the company are useful for other projects at transport companies too.
- We recommend realizing that the framework is not only meant to specify requirements, but also to increase the insight in the companies, in the industry and in board computers by both CAPE Groep and the transport companies. The framework helps to show possible scenarios, chances and possibilities of board computers.

6.4.3 Improvements and future work

We have achieved the goal of this research but still many improvements can be made to the developed framework, and future work in line with this research can be done. Below we will describe the most important improvements that can be made and future work that can be done.

- The framework can be validated more extensively. It has not been tested with small companies and also not outside the Netherlands.
- The framework can be automated in a way in which one can automatically walk through (part of) the process. For example an adaptive questionnaire on a website on which the answers determine the next questions and on which the answers are real-time translated to relevant requirements by intelligent algorithms. There is a pitfall in this approach, because one should not try to completely automate the framework. It is also very useful for both parties to scan the complete list, learn from each other and from the suggestions in the method, also when this takes a complete day.
- The framework can be improved by specifying more detailed scores (priorities) for the requirements.
- The framework can be extended by a part which specifies the “vendor requirements”, which are left out of scope in this research but which are used by CAPE Groep in COTS selection projects (see section 3.3.4 and 3.3.5.2).
- The framework can be extended by a part which specifies project requirements on topics such as costs and implementation issues.
- The framework can be extended by a part which relates the requirements to financial issues such as costs and return on investment (ROI). That way one can make a financial decision on what functionality should be chosen.
- The framework can be extended by a part which can be used to verify the specified requirements for various vendor products. Such a step should at least contain a form in which the scores for various products on all requirements can be recorded and the totals can be (automatically) calculated.
- The requirements specification method mentioned in the previous recommendation can be used to perform verification for of the most popular board computer products. With this verification it might be possible to make some kind of classification of products types/segments, based on the set of requirements they fulfill. Based on the found classification the requirements specification framework can be improved, since with the classification we know better what the important differences are.
- Based on the defined technology layer from the enterprise architecture, more detailed technical solution can be recommended for different scenarios.
- We recommended CAPE Groep to adapt the framework and apply it to other kind of projects. To be able to do this, of course, whether and how the framework can be applied to projects different to board computer projects has to be studied.

6.5 Reflection and discussion

This research project is finished by reflecting on the project as it was executed. In this reflection we will discuss the approach, the validation, the results and finally reflect on the personal experiences and lessons.

6.5.1 Reflection on approach

To guard the project progress and success, at the start of this research a certain project scope and approach were chosen, which were preserved – besides some small changes - during the project. This approach prescribed to focus on the processes in transport companies and the requirements following on this. The validation cases showed the result of this approach was very useful, since the processes guide the requirements. The other company characteristics which were implemented in the method during the research project were also found to be very useful.

Use of documentation from previous projects, discussions with CAPE Groep consultants and company and driver visits were very useful. But maybe board computer products should have been studied in more detail to find the discriminating characteristics between the products. Maybe more companies should have been visited to get a broader impression of the industry to get an optimal result. On the other hand, practical limits made it impossible to do all this within the time constraints and therefore we think we have chosen the right approach.

The scope of the research was quite broad at the start of the research project, and became even bigger during the research. This made the research very broad and complete, and delivered a usable complete method for CAPE. On the other hand, it made it impossible to zoom in very deep on the various topics, neither was it possible to do a very extensive validation. Therefore, we recommend CAPE Groep to do additional research, especially on the topic of (automatic calculating of) the relation between the company characteristics and the requirements.

6.5.2 Reflection on validation

Only two cases were studied, therefore the study is not representative for the complete market. But companies from the cases performed broad spectrum of activities, and where therefore probably quite representative for most companies. It is possible that especially very small companies are not represented in the validation, since the used cases were on relatively big companies. Therefore we recommend evaluating the use of the method with small companies in the future.

6.5.3 Reflection on results

Since our scope was relatively broad (see section 6.5.1), we created a very complete list of subjects which covers all issues we found to be relevant, both high and low-level. But this broad scope maybe had a negative influence on the details. Also, the surveyability of the last step of the delivered method can be better, although it is very hard to get this perfect with the big number of issues and relations. We think given the time constraints the results are well, and the made spreadsheet gives a good starting point for an improved version of the method.

6.5.4 Personal reflection

I'm very confident with the way I managed to find and use input, consisted of scientific sources, other sources from internet, documentation from vendors and previous projects, conversations with people from practice and my experiences in practice. I found a lot of useful sources and think I combined them well in my research.

This research project gave me very helpful experiences in working in a small company, and I obtained a lot knowledge on the theories that are involved in this research and experience in using them. Also, I obtained much knowledge on the transport industry, IT in the transport industry and board computers specific.

It was hard to find the good scope for the project and especially to manage this scope, because many times new topics rise which were too interesting to keep out of scope. This made it hard to make realistic plannings, because most jobs took more time than expected. That way, deadlines that

seemed very easy to meet on forehand eventually turned out to be quite ambitious. Also, it was hard to accept that it is impossible to be perfect and all-embracing within the time horizon.

It was very interesting to study the topic of board computers, since it is a technology which can improve businesses a lot, especially when companies chose the right ones. The visits at various locations of Tielbeke were very informative and accompanying the two truck drivers are experiences I will not quickly forget.

References

Alves, C. and Castro, J. (2001). *CRE: A Systematic Method for COTS Components Selection*. Proceedings of the XV Brazilian Symposium on Software Engineering.

Bass, L., et al. (2007). *Software Architecture in Practice*. Boston: Addison-Wesley.

Beal, R. M. (2000) *Competing effectively: Environmental scanning, competitive strategy, and organizational performance in small manufacturing firms*. In: Journal of Small Business Management, Vol. 38, No. 1, pp. 27-47.

Beerens, H. (2008). *Wat is een TMS?*. Logistiek.nl. Retrieved from http://www.logistiek.nl/dossierartikelen/id51-Wat_is_een_TMS.html on April 20, 2009.

Beerens, H. (2008b). *Wat is advanced planning & scheduling (APS)?* Retrieved from http://www.logistiek.nl/dossierartikelen/id225-Wat_is_advanced_planning__scheduling_APS.html at April 20, 2009.

Berander, P. and Andrews, A. (2005). *Engineering and Managing Software Requirements*. Chapter 4: Requirements Prioritization. Berlin: Springer Berlin Heidelberg.

BiZZdesign (2009a). *BiZZdesign BizzDesigner*. Retrieved from http://www.bizzdesign.nl/joomla/products/bizzdesigner.html at February 11, 2009.

BiZZdesign (2009b). *BiZZdesign Architect*. Retrieved from http://www.bizzdesign.nl/joomla/products/architect.html at March 10, 2009.

BPMN (2009). *Business Process Management Notation.* Retrieved from http://www.bpmn.org. Last visited at February 10, 2009.

CAPE (2008). *Description Master Assignment Board Computers*. Hellendoorn: Intern document from CAPE Group.

CAPE (2009). *Presentation given by Rob ter Brugge from CAPE Groep at Punch Telematix Symposium*. May, 2009. Hellendoorn: CAPE Groep.

CAPE Systems Integration (2009). *Proof of Concept implementation Enterprise Service Bus Sonic*. Retrieved from http://www.capesystemsintegration.nl/en/projecten/projects.php?project=23 at July 10, 2009. Hellendoorn: CAPE Groep.

CapGemini (2007). *Transportation Report*. August 2007. Retrieved from http://www.capgemini.com/resources/thought_leadership/transportation-report-2007 at February 12, 2009. Utrecht, The Netherlands: CapGemini Consulting.

CBS (2009). *Cijfers verkeer en vervoer*. Retrieved from http://www.cbs.nl/nl-NL/menu/themas/verkeer-vervoer/cijfers/default.htm at March 10, 2009. Den Haag: Centraal Bureau voor de Statistiek.

Cooper, D.R. and Schindler, P.S. (2006). *Business research methods*. Boston: McGraw Hill.

Donselaar, K. and Sharman, G. (1997). *An innovative survey in the transportation and distribution sector*. In: International Journal of Operations & Production Management, Vol. 17, No. 7, 1997, pp. 707-720. MCB University Press.

DSDM (2009). *DSDM public version*. Retrieved from http://www.dsdm.org on May 8 2009. Kent, United Kingdom: The DSDM Consortium.

Dumas, M.; Aalst, W.M.P. van der; Hofstede, A.H.M. ter (2005). *Process-Aware Information Systems Bridging People and Software Through Process Technology*. Wiley Interscience.

Eck, P.A.T. van et al. (2002). *A conceptual framework for architecture alignment guidelines*. Project GRAAL WP1 whitepaper. Enschede: Centre for Telematics and Information Technology.

Engelsman W. (2008). *A method for Requirements Management and modeling*. Master Thesis, University of Twente. Enschede, The Netherlands.

European Trucking Service (2009). *ETS Trailer Trucking way of working*. Retrieved from http://www.ets-trucking.com/NewFiles/ETS_Way_of_working.html at March 10, 2009. Ittervoort, The Netherlands: European Trucking Services.

FMS (2009). *FMS Standard information*. Retrieved from http://www.fms-standard.com at June 2, 2009. FMS Standard Organization: Krailling, Germany.

Franch, X. (2005) *On the Lightweight Use of Goal Oriented Models for Software Package Selection*. In: Proceedings of the 17th International Conference on Advanced Information Systems Engineering: pp. 551-566.

Geurts, P.A.T.M. (1999). *Van probleem naar onderzoek*. Bussum, The Netherlands: Coutinho.

Gregor 2006. *The nature of theory in Information Systems*. MIS Quarterly, 30(3), pp. 611-642

Heisterkamp (2009). *Heitsterkamp Trucking*. Retrieved from http://www.heisterkamp.nl/page.php?lang=ned&dbname=trucking at March 10, 2009. Oldenzaal, The Netherlands: Heisterkamp.

Hommes, B.J. (2004). The evaluation of business process modeling techniques. Oud-Beijerland, The Netherlands: PhD thesis Technical University Delft.

IEEE (1990). *IEEE-Std.610.12 Standard Glossary of Software Engineering Terminology*.

IEEE (1998). *IEEE-Std.830. recommended practice for software requirements specifications*.

ISO (1991*). ISO/IEC 9126 Information Technology, software product evaluation, quality characteristics and guidelines for their use*. International Organization for Standardization, Geneva.

ISO (2001). ISO/IEC 9126-1:2001 Software engineering -- Product quality -- Part 1: Quality model. International Organization for Standardization, Geneva.

Jacobs, T., Toebak, H., Woude, A. van der (2004). *Business Process Management, Een onderzoek naar BPM-tools*. Utrecht.

KPMG (2000) KPMG European Transportation & Distribution Benchmark Survey. Retrieved from http://www.bearingpoint.de/media/industries_infrastructure_services/european_transport_benchmark_kpmg.pdf at March 9, 2009. Rotterdam: KPMG Transportation & Distribution.

Kuypers, G. (2003). *ABC van een onderzoeksopzet*. Bussum, The Netherlands: Coutinho.

Lauesen, S. (2002). *Software requirements*. London, UK: Addison-Wesley Professional.

Lewis, J.P. (2005). *Project Planning, Scheduling & Control: A Hands-On Guide to Bringing Projects in on Time and on Budget*. 4th edition. McGraw-Hill

Little, D. (1998). *Development of a package selection method and tool for small and medium sized enterprises (SME's)*. Computer Integrated Manufacturing Systems, 11(4): pp. 351-355.

Lloyd Masters (2009). *Goal Directed Planning, What is it?* Retrieved from http://www.lloydmasters.com/lloydmasters/expertise/whatisgdp.pdf. Visited at February 11, 2009.

Logistiek (2009). *Retourlogistiek is booming*. Retrieved from http://www.logistiek.nl/nieuws/id3151-Retourlogistiek_is_booming.html at March 10, 2009. Reed Business: Logistiek.

Maiden, N.A.M. and Rugg, G. (1996). *ACRE - Selecting Methods for Requirements Acquisition*. In: Software Engineering Journal.

McCall, J.A. and Matsumoto, M. (1980). *Software Quality Metrics Enhancements*. Vol. I-II, Rome Air Development Center.

Ncube, C. and Maiden, N.A.M. (1999). PORE: *Procurement Oriented Requirements Engineering Method for Component Based Systems Engineering Development Paradigm*. International Workshop on Component-Based Software Engineering.

NEA (2008). *NEA Jaarverslag 2007*. Retrieved from http://www.nea.nl at March 10, 2009. Zoetermeer: NEA Transportonderzoek en –opleiding.

Oberndorf, P. (1997) *Facilitating Component-Based Software Engineering: COTS and Open Systems*. In: Proceedings of the Fifth International Symposium on Assessment of Software Tools. SAST 97.

Papazoglou, M.P. and Ribbers, P.M.A. (2006). *E-business: organizational and technical foundations*. Wiley.

Pfleeger, S. L. (1998). *Software Engineering – Theory and Practice*. 2nd Edition, Prentice Hall.

Porter, M.E. (1980). *Competitive Strategy: Techniques for Analysing Industries and Competitors*. New York, NY, USA: The Free Press.

Rail Cargo (2009). *Rail Cargo Begrippen- en afkortingenlijst*. Retrieved from http://www.railcargo.nl/index.cfm/menuid/6/HoofdCat/38/SubCat/92/Product/120 at March 10, 2009. Hoogvliet: Stichting Rail Cargo information Netherlands.

Robertson, J. and Robertson S. (2007). *Volere Requirements Specification Template*. Edition 13. Atlantic Systems Guild. Received from http://www.volere.co.uk/template.htm

Telematica Instituut (2009). Website Archimate. Received from http://archimate.telin.nl. Last visited at February 10, 2009. Enschede, The Netherlands.

The Standish Group (2001). *Extreme Chaos*. Research Report. Boston: 2001.

Thomas, O. (2005). *Understanding the term reference model in information systems research: History, literature, analysis and explanation*. In: Proceedings of the Workshop on Business Process Reference Models (BPRM 2005). Nancy, France, pp. 16-29.

TLN (2005). *TLN Infoblad: De boordcomputer.* Zoetermeer, 17 February 2005.

TLN (2008). *Automatiseringsonderzoek 2008*. Zoetermeer, 24 May 2008.

Transport intelligence (2007). *UK Pallet Networks 2008.* Retrieved from http://www.transportintelligence.com/assets/files/UK_Pallet_Networks_2008_brochure.pdf. December 2007.

TTM (2009). *Boordcomputer brengt rust op de planning*. Retrieved from http://www.ttm.nl/ttmarchief/id2229-boordcomputer-brengt-rust-op-de-planning.html. Last visited at January 29, 2009.

TWNA (2009). *TWNA Glossary - Trucking Terms*. Retrieved from http://www.twna.org/trucking_terms.htm. Last visited at January 5, 2009. Charlotte: Truck Writers of North America

UMTRI (2009). *Truck and bus glossary*. Retrieved from http://www.umtri.umich.edu/divisionPage.php?pageID=201. Last visited at January 5, 2009. Michigan: University of Michigan, Transport Research Institute.

Verschuren, P. and Doorewaard, H. (2007). *Het ontwerpen van een onderzoek*. Den Haag: Lemma.

Vodafone (2009). *APN's explained*. Retrieved from http://www.vodafone-dataworld.co.uk/default.aspx?pageId=41 at June 3, 2009.

Vos (2009). *Vos Logistics Woordenboek*. Retrieved from http://85.17.160.92/?Language=Dutch&id=276 on March 10, 2009. Oss, The Netherlands: Vos Logistics.

Waenink, S. (2006). *Breed aanbod TMS maakt keuze moeilijk*. Retrieved from http://www.logistiek.cluster20.e-active.nl/dossierartikelen/did11804-Breed_aanbod_TMS_maakt_keuze_moeilijk.html at April 20, 2009.

Weill, P. (2007). *Innovating with Information Systems: What do the most agile firms in the world do?* In: Sixth e-Business Conference, Barcelona, Spain, March 27, 2007.

Wexlog (2006). *Achieving benefits of new TMS generation: White Paper*. Milano, Spain, June 2006.

Wieringa, R. J. and Heerkens, J.M.G. (2005). *Requirements engineering as problem analysis*.

Wieringa, R. J. and Heerkens, J.M.G. (2006). *The methodological soundness of requirements engineering papers: a conceptual framework and two case studies*. Requirements engineering , vol. 11: pp. 295-307.

Wieringa, R. J. and Heerkens, J.M.G. (2004). *Evaluating the Structure of Research Papers: A Case Study*. In: Second International Workshop in Comparative Evaluation of Requirements Engineering: pp. 41-50.

Wieringa, R.J. (2003). *Design methods for Reactive Systems*. San Francisco: Morgan Kaufmann Publishers.

Wikipedia Foundation (2008a). *Less than truckload shipping*. Retrieved from http://en.wikipedia.org/wiki/Less_than_truckload/ at December 2, 2008.

Wikipedia Foundation (2009a). *Glossary of trucking industry terms in the United States*. Retrieved from http://en.wikipedia.org/wiki/List_of_trucking_industry_terms_in_the_United_States at January 5, 2009.

Wikipedia Foundation (2009b). *Access point name*. Retrieved from http://en.wikipedia.org/wiki/Access_Point_Name at June 3, 2009.

Appendix A Various illustrations

This Appendix shows a few images which illustrate the context of board computers and show the visualization of requirements. Also, the use of an Enterprise Service Bus is demonstrated.

A.1 Context of Board Computers

The picture below depicts the context of a board computer within a transport organization.

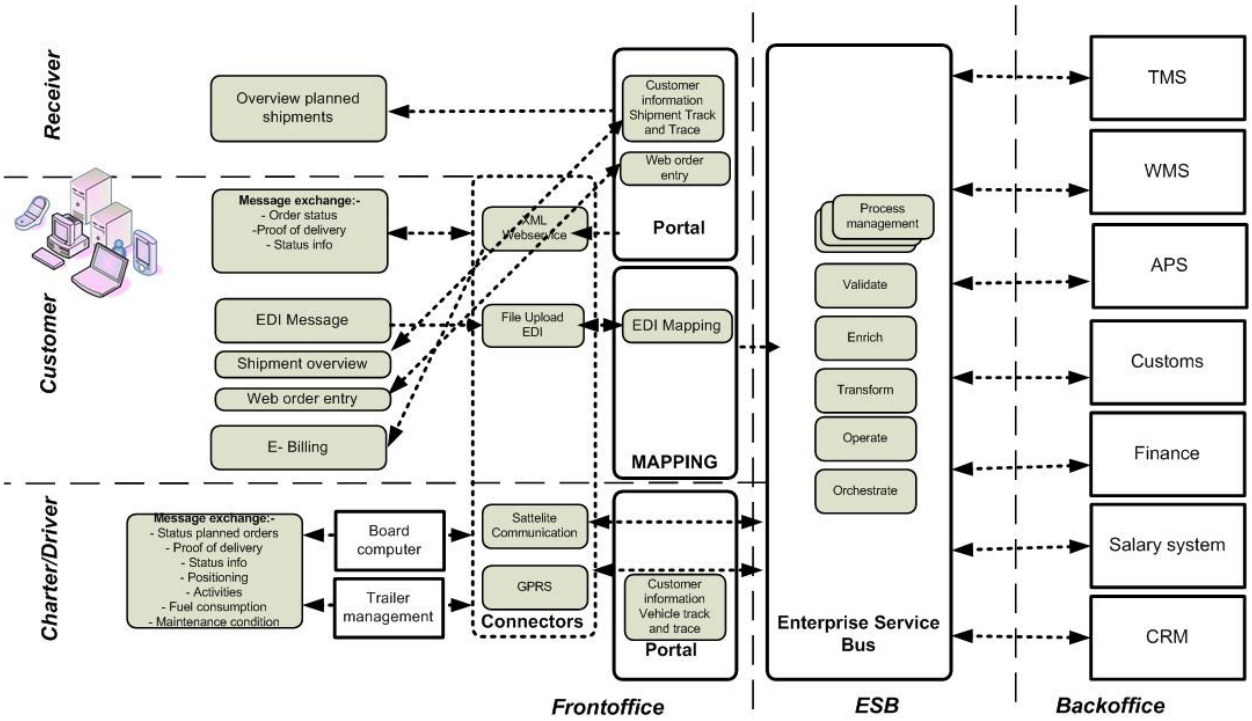
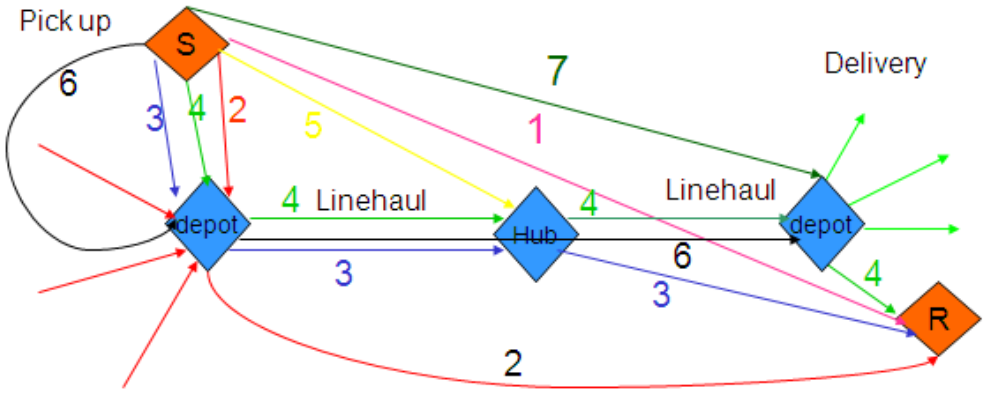


Figure 14 Context of board computer (CAPE, 2008)

A.2 Process settlement alternatives

The picture below depicts possible alternatives for the process settlement of transport jobs.



Alternative 1: direct delivery
Alternative 2: delivery through 1 depot
Alternative 3: delivery through depot and hub
Alternative 4: delivery through depot, hub and depot
Alternative 5: delivery through hub, then use 3 or 4
Alternative 6: delivery through depot and depot without hub
Alternative 7: delivery through delivery depot and then 4.

Figure 15 Process settlement alternatives (CAPE, 2007)

A.3 Board Computer maturity levels

The picture below depicts the four board computer maturity levels.

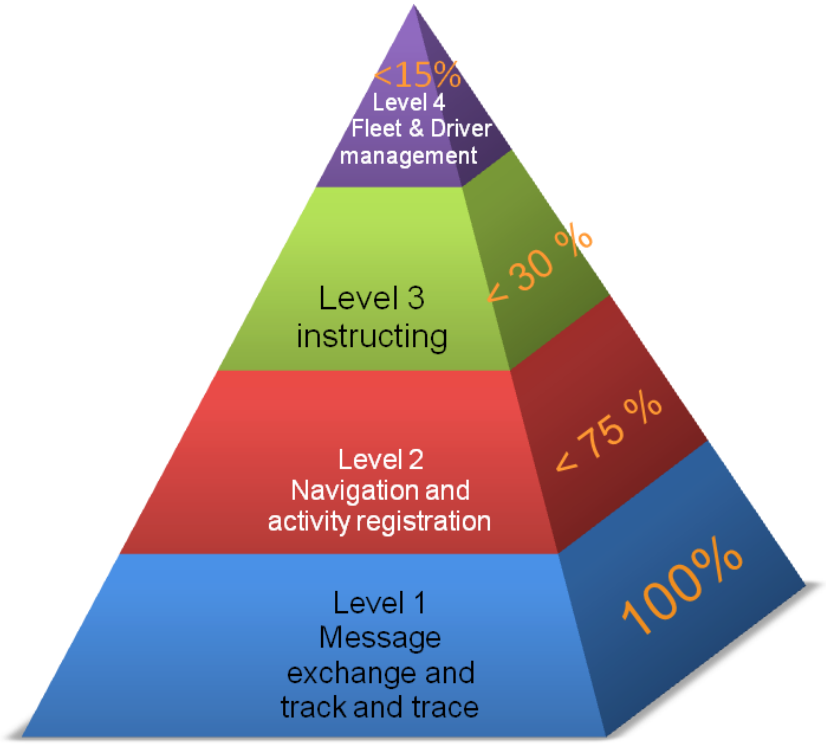


Figure 16 Board Computer Maturity levels (CAPE, 2009)

A.4 ESB Proof of Concept at HST

The picture and text below explain the proof of concept CAPE Groep made for the transport company HST, to show how an Enterprise Service Bus can help the organization integrating various systems and organizations.

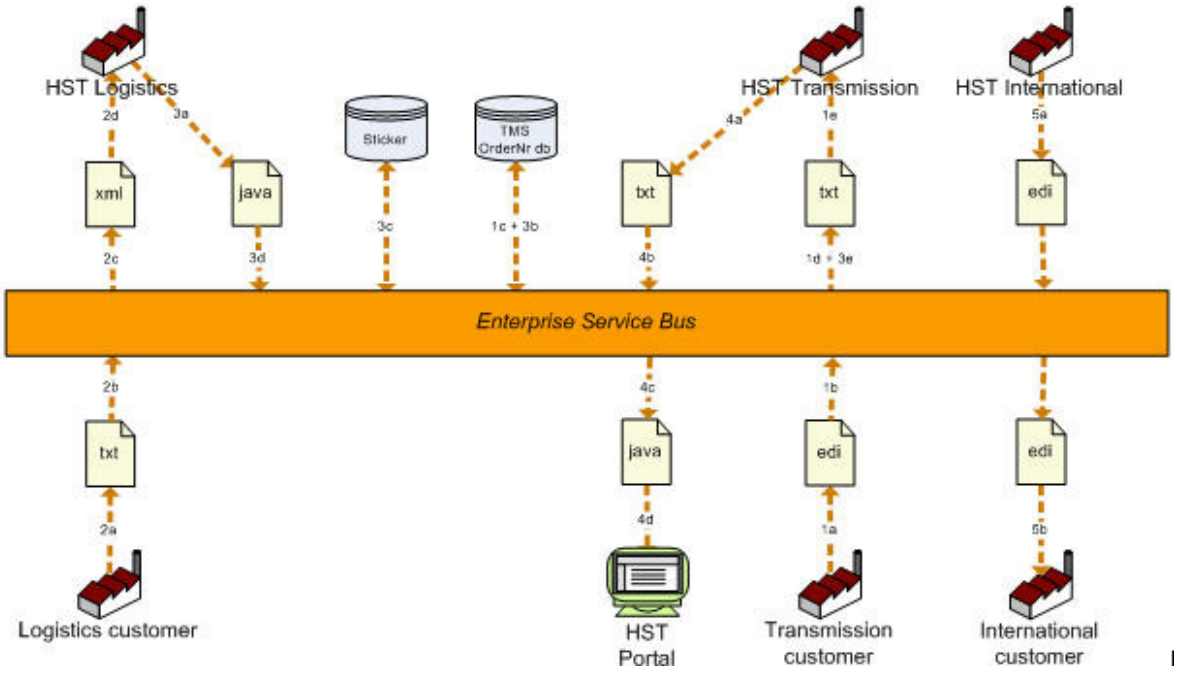


Figure 17 CAPE Groep ESB Project at HST (CAPE Systems Integration, 2009)

1) HST Transmission – Transport message

a) ESB picks up a daily EDIFACT Transport message, from a FTP-site of a HST Transmission customer.

b) This message is transformed to the Common Data Model (CDM) for a HST Transport order message.

c) An order number is retrieved from a database to provide the message with a Transport order number.

d) The HST Transport order message is being transformed to a specific Transport order message, which is suitable for the BackOffice.

e) The Transport order message is placed in the right location and will be imported by the BackOffice and all interested parties will receive an e-mail.

2) HST Logistics – Logistics outgoing message

a) ESB picks up a daily Logistic outgoing message, placed by an HST Logistics customer on a FTP location.

b) This message is transformed to the CDM for a HST Logistics outgoing message.

c) The HST Logistics outgoing message is being transformed to the specific Logistics outgoing message, which is suitable for the BackOffice.

d) The Transport outgoing message is placed in the right location and will be imported by the BackOffice and all interested parties will receive an e-mail.

3) HST Logistics – Transport message

a) ESB listens on a queue where daily transport orders (outgoing warehouse orders) for HST Transmission stands from HST Logistics.

b) An order number is retrieved from a database to provide the message with a Transport order number.

c) A label application is started to print labels for the transport assignment.

d) The message is being transformed to an HST Transport order message

e) The process continues like 1d.

4) HST Transmission – Transport status message

a) The ESB will search for Transport status messages in a certain directory placed there by board computers of HST Transmission.

b) This message will be transformed to an HST Transport status message.

c) This HST Transport status message will be transformed to a specific Transport status message, which is suitable for the portal (also see reference).

d) After this the Transport status message will be placed in the portal queue and directly processed and the Transport status will be available for HST customers on the portal.

5) HST International – Transport message

a) ESB picks up a daily EDIFACT Transport message, placed by HST International on a FTP location for an HST International customer.

b) The International Transport message will be placed in a outgoing FTP location so the the HST International customer can pick up his message. (CAPE Systems Integration, 2009)

Appendix B Definitions

This chapter shows the definitions of the most important terms in the context of this research.

3PL	Third-party logistics provider. A firm that provides outsourced or "third party" logistics services to companies for part, or sometimes all of their supply chain management function. Third party logistics providers typically specialize in integrated operation, warehousing and transportation services that can be scaled and customized to customer's needs based on market conditions and the demands and delivery service requirements for their products and materials. Literature also distinguishes 4PL and 5PL, meaning even higher degrees of outsourcing.
Activity Based Costing (ABC)	A costing model that identifies the real costs per individual activity. This way the profitability and efficiency of all activities, clients, drivers and so on can be calculated. A board computer can support this approach.
ADR	European agreement concerning the International carriage of dangerous goods by road. (Accord européen relatif au transport international des marchandises Dangereuses par Route)
Advanced Planning and Scheduling System (APS)	Advanced Planning and Scheduling System. System running at the back-office of mainly bigger transport companies, which automatically creates and real-time updates planning based on special algorithms.
Board computer	A device which registers all kind of information (like location data by means of GPS and truck information by communication with the CANbus (Controlled Area Network)) and communicates two-ways with various systems in a transport organization by means of wireless communication techniques such as GSM, GPRS, satellite or UMTS. This communication takes place on different levels and for different purposes, e.g. track and trace, hour registration and planning. The device is build-in in the truck or is mobile so that the driver can take it out of the truck to the customers.
Business Process	A structure of organizational or inter-organizational activities that are necessary to accomplish a product or service. These activities are coordinated through communication, in a sequence of goal-directed actions. For a primary process, the goal is directly related to the production of a result of value for a customer. For a secondary process, a process that created the necessary conditions for other processes to be carried out, its goal is indirectly related. (Hommes, 2004)
Business Process Model (BPM)	Business Process Model. Model of activities of people working on a collaborative task that has been broken down into a structure of specialized, coordinated activity, supported by technology. (Hommes, 2004)
CANbus	Controller-area-network-bus. A vehicle bus standard designed to allow microcontrollers and devices to communicate with each other within a vehicle without a host computer. Alternative for FMS-interface.
Cash on Delivery (COD)	In Dutch: "Rembours". Additional service performed by a logistic service provider.
CMR	Convention on the contract for the international carriage of goods by road. (Convention relative au contrat de transport international de Marchandises par Route.) ("Beurtvaartadres")
Commercial-Off-The-	A term for software or hardware, generally technology or computer

Shelf (COTS)	products, that are ready-made and available for sale, lease, or license to the general public; that is usually available without source code; that is supported and evolved by the vendor who returns the intellectual property rights. They are often used as alternatives to in-house developments or one-off government-funded developments. (Oberndorf, 1997)
Consignee	Receiver of a shipment. Usually has to sign the Proof of Delivery.
Consigner	Sender of a shipment. Sometimes has to sign the Proof of Collection. Usually wants the driver to sign the Proof of Collection.
Dense Distribution	Transport type, sometimes simply called distribution. The transportation of relatively small freight.
Depot	Location of a transport company at which trips can start and end and at which freight is grouped and forwarded.
Drop weight	Weight of the cargo that is unloaded at one location.
Estimated Time of Arival (ETA)	The time a person or a system expects a truck to arrive at a certain location, needed for optimal efficiency. A board computer can help to continuously update and communicate the ETA.
Fleet Management Software (FMS)	System used by transport companies to manage the fleet of the transport company. With this software the company can see how the vehicles are used, and support the maintenance of the vehicles. In most cases, the board computer has to deliver the data needed for this management and that way is integrated with fleet management.
FMS-interface	Fleet Management Systems Interface. A standard interface to vehicle data of commercial vehicles, like Daimler AG, MAN AG, Scania, Volvo (incl. Renault), DAF Trucks and IVECO. Alternative for CANbus.
Full truck load (FTL)	Transport Type. Full truckload carriers normally drive with the truck-filling freight from one client directly to the consignee.
Functional Requirement	Fundamental or essential subject matter of the product. Describes what the product has to do or what processing actions it is to take.
Grouping	Combining shipments that are smaller than a full truck load, in such a way that the truck is filled. Done to increase the efficiency, and decrease the costs.
Hours of Service (HOS)	Regulating governing the hours a truck driver is allowed to drive. In Dutch these are called “Rijtijden”.
Intermodal transport	Type of transport with which the cargo carrier (e.g. a container or trailer) changes between several modalities. Intermodal transport is also called combined transport.
Leg	The distance a shipment is transported in one truck. A shipment can follow several legs because it is forwarded in multiple trucks.
Less than truckload (LTL)	Transport Type. The transportation of relatively small freight, with a size between distribution and full truck load freight. Less than truckload carriers collect freight from various shippers and consolidate that freight onto enclosed trailers for linehaul to the delivering terminal or to a hub terminal where the freight will be further sorted and consolidated for additional linehauls. In most cases, drivers start the day by loading up and heading out to make deliveries first, then begin making pickups once the trailer has been emptied for return to the terminal for sorting and delivery next day; thus, most pickups are made isn the afternoon and most deliveries are performed

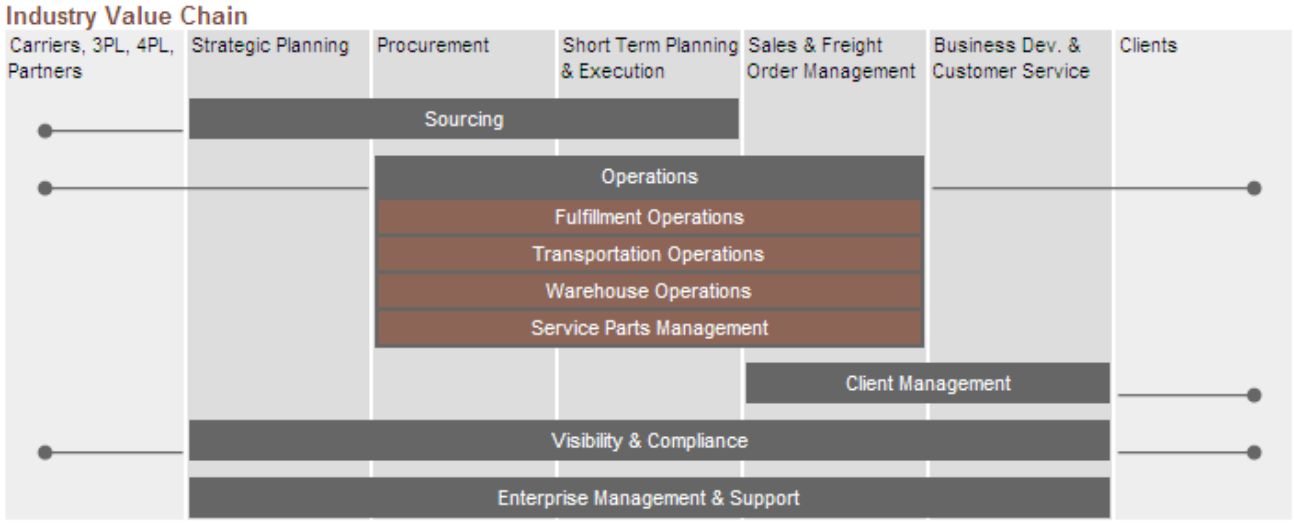
	in the morning.
Logistics Service Provider (LSP)	Broad definition for companies providing logistic services. Transport companies are examples of LSP's.
Multimodal transport	Type of transport with which the cargo itself goes from one modality to another, without the cargo carrier.
Non-functional requirement	Property that the functions must have, such as performance and usability. Also called Quality Requirement.
Packaging	Packaging of freight which is worth money when it's returned, for example pallet boards. When a driver brings pallets to a consignee, this has to be registered. A board computer can support this process. In Dutch we call this "Emballage".
Proof of delivery (POD)	A (digital) form which has to be signed by the consignee to proof to the consigner that the freight has been delivered.
Question path	Standard order of questions that have to be answered when certain activities are performed. The question path support by the board computer is very important when a board computer is chosen.
Reference architecture	Architecture used for the construction of specific architecture. (Thomas, 2005)
Reference model	Model used for supporting the construction of specific models. (Thomas, 2005)
Relevant systems	In the context of this research different type of related systems which are in use at the transport company. The most important ones are TMS, APS and FMS.
Requirement	A feature of the system or a description of something the system is capable of doing in order to fulfill the system's purpose. (Pfleeger, 1998) Alternative: (IEEE, 1999)
Requirements engineering	The process of determining the needs and conditions to meet a certain result, consisting of an elicitation, verification and validation phase.
Segment	Part of the complete transport sector, distinguishing on certain characteristics. For this research, the segmentation will be based on the type of transport, since that is the discriminator for the type and sequence of business processes and thus for the user needs. See Transport Type.
Task (assignment)	Activity performed by a truck driver. In the board computer context it is important to distinguish the differences between Multiple or Single and Controlled or Not-controlled assignments.
Trailer	Pulled unit. Connected to a truck and filled with cargo.
Trailer trucking (TT)	Transport Type. The driver of a transportation company drives in the company's truck to move the trailer of the client, and the driver only couples and uncouples trailers and does not do loading and unloading.
Transport Management System (TMS)	In the widest definition the TMS is the complete collection of all IT parts which together manage a complete transport company. More specific, a TMS is responsible for the management of jobs.
Transport type	The way goods are transported in the truck transport sector. The way of transporting is a balance between speed and customization on one hand and costs on the other hand. The four types distinghuished in this research are Trailer Trucking, Full Truck Load, Less Than Truck Load and Dense

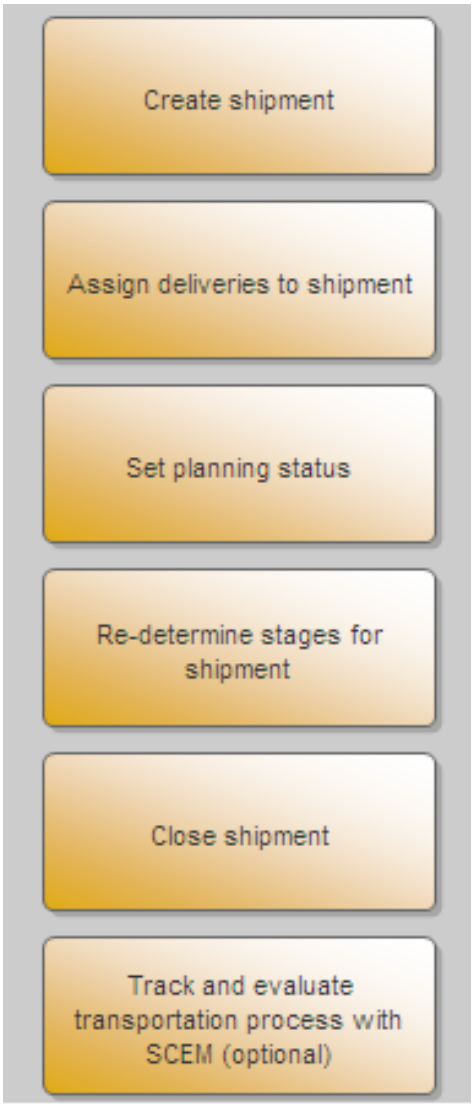
	Distribution.
Trip	Activity performed by a truck driver, in national transport mainly performed on one day starting from the moment the driver leaves the company until the moment he returns at the company. A trip can contain several stops and legs.
Truck	Pulling unit. Connected to a trailer.
Truck navigation	Special type of navigation software meant for trucks, which contains and uses extra information such as bridge heights, prohibitions for trucks (with dangerous cargo), etc.

Appendix C Reference models

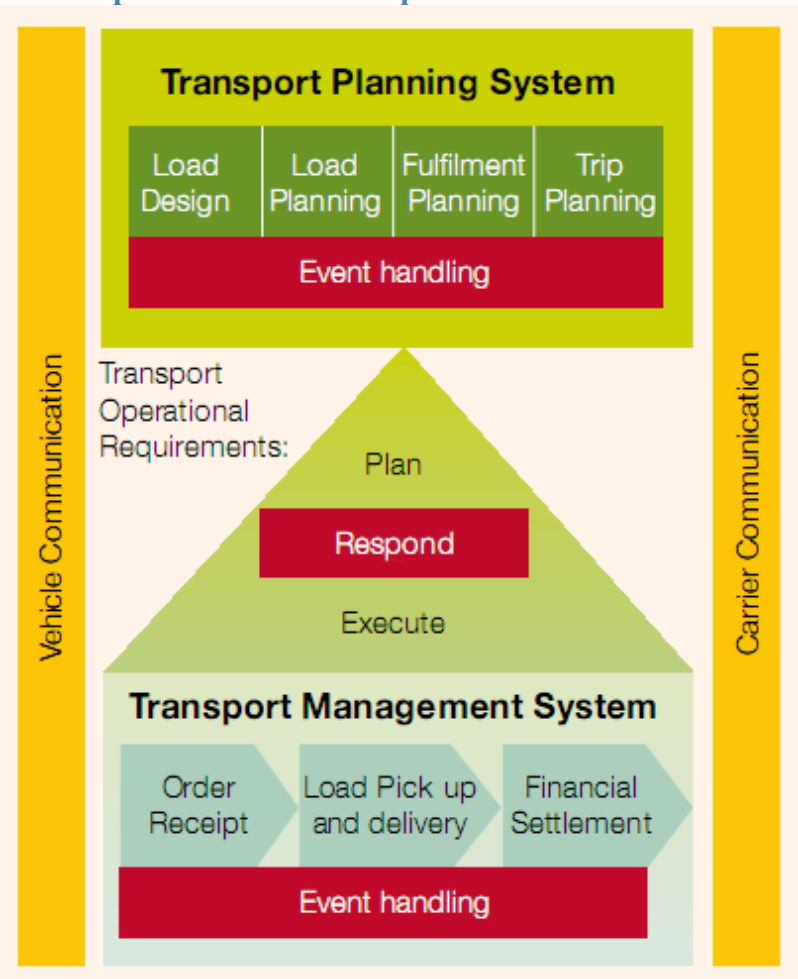
This appendix shows three examples of reference models, defined by SAP, CapGemini and Wexlog.

C.1 SAP R/3 Reference model example





C.2 CapGemini Reference process model



C.3 Wexlog reference model example

Wexlog (2006) presents the following reference model for both the operational execution and financial settlement level.

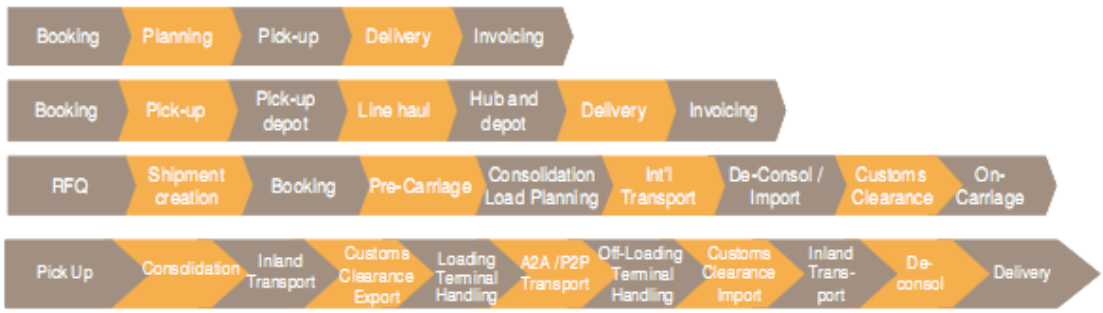


Figure 18 Wexlog operational execution and financial settlement reference model (Wexlog, 2006)

Appendix D Description of empirical research

This appendix presents an extensive description of the empirical research that has been done.

First of all, employees from CAPE were interviewed on their experiences during board computer projects: why do companies want a board computer, what is the role of CAPE in the projects and what can be improved?

To gain insight in the transport industry, board computers and the use of these board computers in the industry, a transport company has been visited and two truck drivers are accompanied. A planner demonstrated his work and was interviewed on his experiences and so were the truck drivers. These visits were meant to get better feeling with the industry and the context of the research.

Also, documentation of various board computer projects and board computers was studied to gain insight on the functions of board computers and the demands on these board computers. For the same reason board computer vendor representatives demonstrated their product and answered questions.

The most important conclusions of this empirical research are summarized in the conclusion section of this appendix, section D.6.

D.1 Interviews with CAPE experts

At the start of the project and during the project CAPE experts are interviewed to gain insight in their experiences during previous projects on the selection and implementation of board computer systems. This way we get an idea of the project drivers for board computer implementations, the role of CAPE Groep and their demands for the to be delivered method and on other important issues. The interviewees are Rob ter Brugge, director, and Dennis Brugging, consultant, both with various years of experience at Cape. They were involved in various board computer projects, and provided the following information.

D.1.1 Project drivers for board computer implementations

One of the main reasons for transport companies to implement a board computer is to decrease communication costs. The companies see the board computers mainly as a useful device for the effective exchange of messages. This, and the fact that they simply want to follow the “trend” of implementing a board computer are the main reasons to implement such a system. The communication costs indeed can decrease dramatically, so this is a valid argument to implement a board computer, but with this vision a lot of chances and possibilities are unseen.

D.1.2 The role of CAPE Groep

CAPE Groep has much experience in the transport industry in general, and with board computer specific. Transport companies heard about this extensive experience and want help from CAPE Groep. CAPE Groep can assist with the management of the project, with advice with respect to the context and by using their contacts in the industry. They can use previous projects as best practice examples, and know the vendors active in the market. CAPE Groep can give a fresh objective vision on the company and provide the company with the necessary technical knowledge which most companies miss.

D.1.3 Points of improvement

The people from CAPE Groep guided several Board Computer projects, and are confident about how they did this and will do it in the future. They know quite well what the important issues are that a board computer can solve, and know quite some details on the most used board computers. Still, it would help them a lot if they have a more structured and predefined way to clear up the processes in a transport company, the demands for the board computer following from those processes, and the wished interaction with other systems.

This way, CAPE Groep wants to be capable of advising transport companies faster on the needs for a board computer, and the most appropriate board computer fulfilling those needs.

D.1.4 Border between Board Computer and TMS/APS

During the interviews with CAPE people, we found the position of the border between board computer, TMS and APS is an important issue in the specification of requirements for a board computer. Theoretically, the TMS is meant to register and manager orders, the APS is meant to automatically optimally plan jobs using very smart algorithms, and a board computer is used for the driver instruction, message exchange and feedback of the execution.

Still, in practice the borders are more vague because some board computer vendors are providing very extensive office-side applications which are capable of manage orders or even plan the execution of them. For small companies which not already have their own TMS and APS this can be a smart way of arranging things.

In this research we choose the division between TMS, APS and Board Computer to be as described above, having each system it's own specialties and responsibilities.

D.2 Company and truck visit

To gain insight in the daily practice of the work processes at a transport company, on April 2, 2009 Tielbeke has been visited and two Tielbeke truck drivers were accompanied. The night, garage and warehouse processes of this company were studied on May 13, 2009. Tielbeke, a client of CAPE Groep, is a Dutch logistic service provider active in various kinds of transport and therefore a very interesting company. At Tielbeke one of the planners explained his experiences with Tielbeke's Board Computer system, MobiCoach, and demonstrated the use of this and related systems. Also, two truck drivers were accompanied during their work, to see the execution process and how MobiCoach is involved in that.

The most important conclusions, related to board computers, of these visits are summarized in the conclusion section of this appendix, section D.6.

D.2.1 Tielbeke

Tielbeke is a logistic service provider owning 125 trucks and employing 200 people. The company has establishments in both Lemelerveld and Zwolle (both in the east of the Netherlands), and provides (dedicated) transport , distribution and warehousing in the Benelux, Germany and Scandinavia. According to the segmentation used in this research, Tielbeke performs activities for all transport types: Trailer Trucking, Full Truck Load, Less Than Truck Load and Dense Distribution. Next to the "ordinary customers" which Tielbeke has, the company participates in two logistic networks, which are TeamTrans and DHB.

At Tielbeke next to the ordinary cars, trucks and trailers we saw special vehicles: cooled trailers (e.g. for food), heated trailers (e.g. for paint on water basis which may not freeze) and silo trailers (e.g. for active carbon in powder and grain form).

D.2.2 MobiCoach at Tielbeke

Tielbeke implemented MobiCoach in the period between the fall of 2006 and the spring of 2007. Before that moment the company had a very simple system which in fact only showed the jobs for that day. The company wanted to have one device with several functionalities in stead of separated navigation, communication and registration systems and eventually choose MobiCoach.

The planning departments sends all runs to the board computers over the air. When the driver logs on to the board computer with his chip card, he sees the jobs for that day. The navigation automatically uses the address belonging to a job, and the telephone system automatically uses the accompanying phone number(s). On the screen of the MobiCoach the driver can see the details of each job, and when he executed it he has to check it off and type in the name of the consignee as

confirmation, and insert for example package registration data. This information is used to inform the planning department and the customers about the progress and status of the orders.

MobiCoach registers all activities. The speed of the truck is monitored and when the truck stops the driver has to select what he is doing: loading, unloading, resting, and so on. This information is used for the hour registration and so the payment of the drivers.

The registration and collection of POD's is still done on paper at Tielbeke. The drivers receive all orders for their trip on paper, and the consignees sign them with an ordinary pen. At night, these papers - on which each job is accompanied with a barcode - are digitally scanned and processed. Tielbeke considers the use of barcode scanners and digital signatures but has not implemented them because they expect them to be easily lost and be not solid enough.

When a driver has checked off an order, the next one is automatically presented and the navigation is started. This way, the process is walked through easily. The planners can follow the status and location of all trucks on a map, and based on that they can assign additional urgent orders to the most appropriate driver.

Communication between driver and planner takes place mostly by the exchange of free text messages which can be send with MobiCoach. With urgent issues the telephone is used. There are no message templates such as "I'm half an hour late" or "I will call you later" available.

D.2.3 DHB Planning Department

Gerrit Horstman is one of the planners at Tielbeke. He is responsible for the allocation of the shipments to drivers and material, and handles all kinds of administrative processes. Horstman works at Tielbeke for more than 25 years, from which more than ten years as planner. He has seen many developments in the automation of the process: the introduction of the mobile phone, the implementation of a very primitive board computer and two and half years ago the implementation of the MobiCoach board computer system.

Gerrit Horstman showed how the APS plans runs automatically, and what the planners have to do by hand. Also, he showed how he can track the drivers during their work, how he can communicate with them, and how he processes the (partly manual) administration before and afterwards the execution of runs.

Horstman likes the Board Computer system because it saves a lot of work and works simple and effective. He tells that some drivers were resisting the system in the first period after the implementation because they did not like to change their way of working, and were feeling spied. But these days, everyone is used to the system and realizes the benefits of it. Therefore they have no real problems using MobiChoach, although there are some small issues in the system.

D.2.4 Truck driver Marco Hollenberg

Marco Hollenberg works as truck driver at Tielbeke for about five years. He drives for the national distribution work area. Marco has been accompanied for one day, from the start at the Tielbeke depot early in the morning until the return at the depot late at night. This way, the complete work process of a driver and the way the board computer is involved in that could be seen.

When Hollenberg starts talking about the MobiCoach system he is not very positive. According to Marco, the system is slow and asks extra efforts from him. The first problem Marco mentions is the difference between the time registration from the digital tachograph and the time registration from the board computer. The tachograph time starts running from the moment that the truck drives one kilometer an hour or faster, but the board computer starts counting driving time when the truck drives thirty kilometers an hour or faster. This difference makes it hard for the planning to schedule additional 'urgent' jobs, since it is always unsure how many hours of service are left for a driver.

Marco also experienced that the MobiCoach system is not very quick to use. It takes about twenty to thirty seconds for each job or shipment to load, which is a direct waste of time. This lack of speed is extra annoying when a driver has to load or unload multiple shipments on one address. When there

are thirty shipments for or from one address, which is not unusual, the driver has to check them all off one by one with MobiCoach. This can take about ten minutes then, in which the driver can do nothing else. It would be much faster when the driver could check off all thirty shipments at once.

MobiCoach is set up in such a way that when a driver is driving he can only do things use functions such as navigation and sending and receiving messages. Marco dislikes this, because during driving he wants to have the possibility to for example check off shipments he unloaded a few minutes before, saving him time standing still.

With the MobiCoach system it is not very easy to register traffic jams. As soon as the speed increases a little, the activity switches from traffic jam to driving automatically, and when the speed decreases the driver has to select traffic jam activity again. This creates a lot of frustration and extra work.

When Marco is asked to think some more whether MobiCoach brings efforts, he does see the benefits of the MobiCoach system. He had no problems getting used to the system when it was implemented, since he thinks it works very intuitive. The exchange of messages goes very smoothly and what the driver sees as the most important: the hour registration is done with the system, so when the driver uses the system right he is sure he will get the money he should get.

D.2.5 Truck driver Henk Zanting

Henk Zanting works as truck driver at Tielbeke for about eight years. He drives not only in the Netherlands but also drives in Germany, which means he sometimes has to sleep in his truck for one or two nights. Henk Zanting is accompanied too during his work. He mentions more or less the same experiences as Marco Hollenberg, but also calls additional problems with the navigation.

Henk Zanting tells that the addresses which are send to the Board Computer are not always exactly correct or not correct interpreted by the system, which causes the navigation software to send the driver to the wrong destination. Also, sometimes the navigation just not advises the optimal route. The advised route then is not the fastest or is not feasible for a truck and trailer combination.

Zanting drives also in Germany, but the navigation is only available for the Netherlands, which off course is a shortcoming too.

A good think with the MobiCoach navigation is that when the advised destination for a certain address turns out to be not correct, the system will eventually change the advised destination when another destination is used for three times, no matter by which driver or truck.

D.2.6 Dock/Warehouse

Harry Kamtjes, dock coordinator, showed us the activities that take place in the dock/warehouse (Dutch: loods), the so called cross-docking process. He explained that, next to the “ordinary customers” Tielbeke has, Tielbeke participates in two logistic networks, which are Teamtrans and DHB. The shipments from the various networks arrive at Tielbeke in different ways, have to be registered in various ways and leave the warehouse in various ways.

Teamtrans is a distribution network, a collaboration of fifteen independent logistic providers which together provide the distribution of smaller shipments (between 1 and 500 kilogram) in the complete Netherlands. Each day, Tielbeke on average processes 400-500 outgoing and 500-600 ingoing shipments in this network.

DHB (Distributie Holland België) is a distribution network, a collaboration of five independent logistic companies which together provide distribution and storage for the complete Benelux. It is founded in 2008, together having 750 employees, 400 pulling units and 270.000 square meters warehousing.

Tielbeke transports shipments with very unusual sizes (for example concrete mixers), which is one of the unique selling points of the company. This makes it very hard to automate the cross-docking process and makes this process very complicated.

When the shipments reach the dock at Lemelerveld, at the end of the day, in the evening and at night, they are unloaded. Then they have to be regrouped depending on the destination address. In

between some registration takes place, mainly to see whether there are defects or shortages (Dutch: manco's) and whether the shipment matches the reported size and weight. How this process takes place exactly depends on the network the shipment is from and also on the size op the shipment.

Early in the morning the drivers arrive at Tielbeke and have to load their truck. They do this with the help of their personal loading/shipment list for that day. On this list, they have to register the found defects or shortcomings. Most shipments are already sorted on zip code and that way are relatively easy to find, but other are much harder to find in the dock. In some cases the loading of the truck is done by employees other than the driver, but also in that case the driver is responsible for checking that this is done properly. Right now, the board computer is not used in this process.

When the truck is loaded, the driver brings the loading/shipment list with the found defects on it to the planning department. That department processes these defects, gives the shipment documents to the driver and the jobs are send to the board computer. Then the driver is ready to go.

D.2.7 TeamTrans Planning

Teamtrans Planner John Marsch explained and showed his work at the planning department. At night he works at the office planning the runs for the next day. With the TMS Transknowledge he sees all jobs that have to be done and he knows which trucks and drivers are available.

Then he starts making a planning based on some parameters which are "in his head". After that, the APS plans the rest of the jobs. And after the APS has done its work John optimizes the suggested planning by hand.

When the planning is made, John has to print some documents and then the drivers arrive at the office. They report the defects to him which he has to process in the system. Before the drivers leave Lemelerveld John sends the jobs to the board computers. John tells this sending takes very much time and therefore he at first sends only the first few jobs, so the drivers can start. When the drivers are busy with the first ones he sends the rest of the jobs to the board computer.

During the morning John is busy monitoring the trucks with the information that comes in via the board computer. For example, he monitors whether all shipments which contractually have to be delivered before a certain time, are on schedule. Also, he communicates with the drivers via the board computer and by phone. When there is, for example, a problem delivering something because there is no one at the delivery address, John will call the customer, discuss what to do and then communicate this to the driver.

Later in the day, John and his colleagues plan a big part of the pick-up jobs, based on the status of the trucks, and send these jobs to the board computers.

When a driver returns at the office and finished his job, the hour registration data is printed. The truck driver has to sign this paper and hand It in at the planning office. That way the registration is official and the settling can automatically take place. When the driver has a good argument for a deviation from the registration from the board computer, or when the planner thinks the registration should be different, the planner can manually modify the registered data.

D.2.8 Garage

We saw the processes at the garage of Tielbeke at Lemelerveld. The board computer is not used very much in this processes. It is used for keeping track of the mileage records of both the trucks and the trailers. It is registered which trailer is connected to which trailer and that way the mileage record of a trailer increases together with the truck connected to it. These mileages are used to monitor the statuses of all tires too.

D.2.9 Warehouse Zwolle

Marius Verschuuren was director IT and Logistics at Tielbeke and since a few months is director of DHB Logistics B.V. He showed the very big warehouse of Tielbeke in Zwolle, where Tielbeke

warehouses the stock of a few big customers. He explained which processes take place here and what important issues are in these processes.

D.3 Documentation of previous board computer related projects

The last years CAPE Groep worked on various projects related to board computers. For this research, the documentation of a few of them are studied. With the study of these documents, insight has been gained on the way these projects are carried out, on the business processes, on the most important issues and drivers, and on requirements for board computers.

D.3.1 Heisterkamp

Heisterkamp is the European market leader in the providing of trailer trucking services. The company has 700 pulling units, and next to the head establishment in Oldenzaal (east of the Netherlands) there are establishments in Travemunde, Gent, Trier, Szczecin and Trelleborg. The company was growing and therefore in 2006 it decided to revise the processes and automated systems. The focus points in this were the planning and billing.

In 2006 and 2007 CAPE Groep worked on the project “digital day record/statement” (Dutch: “digitale dagstaat”). The goal of this project was to generate a digital day record which registers all manual and automatic activities (including expenses) that a driver executes on a day per trip or trip part. This data can be used for billing and settling and should replace the manual data, decreasing the work load and decrease the chance of making errors.

The documentation of this project provided insight on:

- A trailer trucking organization in general
- Business processes, general and in detail
- Possible activities, with details
- Requirements for a board computer
- Definitions
- Used systems
- Drivers for automation
- Project approach

D.3.2 HST

HST Groep is a service provider with a large range of logistics discipline, varying from international road transport to warehousing. The HST Groep has approximately 270 employees, and serves customers in the Netherlands as well as in other countries.

In 2008 and 2009 CAPE Groep worked on a “Sustainable logistics TMS portal” which provides customers online with environmental performance indicators. The documentation from this project provided insight on:

- Business processes
- Possible activities, with details
- Definitions
- Used systems
- Project approach

D.3.3 Jan de Rijk

Jan de Rijk Logistics is one of Europe's leading providers of integrated logistics services, providing four major activities: International Transport, Temperature controlled transport, Benelux Distribution, and Warehousing. Jan de Rijk Logistics has over 900 employees, stationed in 23 offices in 13 countries.

In 2008 Jan de Rijk started a project for the selection of new board computers, which lasted until 2009. CAPE Groep played an important role in this project. The main goals were to get efficient

communication between drivers and planners, to prepare the company for Activity Based Costing and to achieve fuel savings by controlling the driving behavior.

The documentation of this project provided insight on:

- Requirements for a board computer
- Definitions
- Details on driving behavior and fuel usage/saving
- Business processes, general and in detail
- Possible activities, with details
- Drivers for board computer implementation
- Project approach

D.3.4 Transmission

TransMission is a cooperation between 18 independent transport in the Netherlands and Belgium. Each partner is responsible for the load and unload of shipments in their postal code area which are assigned to them by the Transmission network. Orders outside their postal code area are outsourced to other partners. The partners bill each others for their executed services, and in fact are customers of each other. The communication takes place via the general TMS system.

Transmission counts in total 1100 employees and 500 trucks, which together executed about 12.000 transport orders a day. Transmission 24-hours distribution within the Benelux, full and less than truck loads, express services, collection logistics (pick-ups and returns), pick-up and forward services.

In 2006 Transmission started looking for a new custom-made Board Computer system (TOBIE II), as a succession of their current custom-made Board Computer system. (TOBIE)

The documentation of this project provided insight on:

- A cooperation organization in general
- Business processes, general and in detail
- Possible activities, with details
- Detailed requirements for a board computer
- Definitions
- Used systems
- Problems with a board computer that is in use
- Project approach for the implementation of a custom-made system

D.3.5 Raben

The Raben Group has been operating on the Polish market since 1991. The company has establishments in about 10 European countries. In Poland Raben has 19 establishments and about 2500 employees. Raben provides the following services: Raben Logistics, consisting of national forwarding, international forwarding and warehousing and distribution of dry products. Fresh Logistics, consisting of warehousing and distribution of fresh products and Fast Parcel consisting of parcel services.

In 2002 Raben Poland started a project which consisted of three steps: business analysis, business restructuring, software selection and software implementation. With this project, Raven wanted to achieve the following goals: establish a uniform, controllable and flexible information system, improve the transport planning system, improve the cash collection & invoicing system, achieve quality goals, extend customer information and improve the order entry process.

The documentation of this project provided insight on:

- Business processes, general and in detail, of the complete process from order receipt until order close
- Business structure and restructuration for optimization
- Details on the control process
- Possible activities, with details
- Requirements for a board computer
- Relevant systems
- Details on information flows
- Definitions

D.4 Documentation of board computer systems

The possible requirements for board computers have been specified based on the information that was gathered from transport companies: documentation, visits and interviews with CAPE experts. To make sure no important requirements were missing, documentation from many board computer vendors was studied. Based on these documents specified requirements were reformulated and additional requirements were formulated.

Documentation from board computers from the following vendors has been studied:

- Aventeon LogisticsOne
- CarrierWeb
- Centric
- Honeywell
- Prometheus
- PTV
- Punch Telematix CarCub FleetWorx
- Qualcomm Enterprise Services Europe
- Sycada
- Tensing
- Tom Tom Work
- Trailer Connect
- Transics
- Triopsys
- Vogel Nederland
- V-tron

D.5 Meeting with Centric Logistic Solutions

To get an impression of the vision and considerations from a board computer vendor, and to see a board computer on both truck and office side in (simulated) action, a meeting with two representatives from Centric Logistic Solutions, a board computer vendor, was organized.

An account manager and product manager of The Logistic Solutions department of Centric have given a extensive presentation on Roady, Centric's board computer, and the other related systems. Next to the presentation they answered questions, and substantiated their choices and plans for the future.

After this session, the complete working system was demonstrated in action in a demonstration van, showing both the truck- and back-office side. Also, Centric's managers answered questions.

The visit of the Centric people gave insight on various subjects:

- The transport industry in general
- Roady and other related systems

- Developments in the market
- Board Computer Functions and Details
- Architecture
- Processes
- Requirements from transport companies
- Future plans
- Considerations during the development
- Motivations on the choices for the Roady system

D.6 Conclusion

This chapter described the research, and its results, that has been performed by interviewing, accompanying and discussing (with) people from the practical world, and by studying documentation from previous board computer related projects and documentation from board computer systems.

D.6.1 CAPE Experts

According to the CAPE experts the main reasons for implementing board computers are the ability to decrease communication costs and to follow the trend, a vision with which a lot of chances and possibilities are unseen. CAPE is asked to assist in the selection and implementation process because of its extensive experience, contacts in the market and technical knowledge. CAPE wants to improve the speed of requirements specification, and therefore wanted to start this research. It would help them a lot if they have a more structured and predefined way to clear up the processes in a transport company, the demands for the board computer following from those processes, and the wished interaction with other systems. An important issue is the border between Board Computer, TMS and APS which is very vague in some cases.

D.6.2 Tielbeke visits

The visits at the planning department of the transport company Tielbeke gave insight in the practical situation. The planners like the Board Computer system because it saves a lot of work and works simple and effective. It is easy to communicate with the drivers with “SMS-like” messages. It is also easy to monitor the status of the drivers, although the board computer sends back a lot of data which is not used. Also, it is very useful that job instructions can be changed during the day. It is a problem that it takes a lot of time to send the instructions to the board computer because the drivers have to wait for it when they start working. The digital registration of names instead of signatures is a good alternative for digital signatures, since it gives a quick proof until the paper signature returned at the office and is scanned. The hour report which is printed and signed by the driver at the end of the day is a good way to validate and finalize the registered hours.

The accompanying of two drivers from Tielbeke gave clear insight in the practical use of Board Computers. Some drivers were resisting the system in the first period after the implementation but nowadays everyone is used to the system and realizes the benefits of it. The truck drivers think the board computer is slow, which is specially a big issue in distribution because then a lot of shipments have to be registered. Also they mention some issues with the navigation, since it is not really appropriate for truck navigation. The drivers also dislike the way traffic queues have to be registered and the fact that the board computer time registration differs with the tachograph time. They do think the board computer is easy to use and are glad the hour registration, essential for their salary, is done in a good way now. Also the function which changes the registered GPS coordinates after a location was three times found to be different than registered

The (cross)docking process was found to be very complicated, since a lot of shipments have to be distributed cross the dock. It is not very easy for the driver to make sure he has all shipments that are planned for his trip. A scanning or RFID device could makes this last process much easier, giving opportunities for a new board computer.

D.6.3 Board Computer projects

The documentation of five of CAPE's projects related to board computers have been studied, giving insight in the way these projects are carried out, transport organizations in general, business processes and activities, used definitions, the most important issues and drivers and last but not least on requirements for board computers. Since these documents gave such a pile of information, they were the main input for the process and architecture descriptions and requirements specified in this research.

D.6.4 Board computer vendor documentation

The documentation from about fifteen board computer vendors was studied and a meeting with a board computer vendor was held. These things were used to check no requirements or project drivers were missing. But requirements were not copied when they could not be derived from the business processes or architecture. The meeting with the board computer vendor gave insight in the transport industry in general, and "how things work" in this sector.

Appendix E Processes and related requirements

The requirements specification framework developed for CAPE Groep to support the process of board computer selection is partly confidential since CAPE Groep wants to benefit from it optimally. Therefore, this appendix is not available in the public version of this master thesis.

In the confidential version of this thesis this appendix shows the complete collection of all drawn business process reference models plus the accompanying descriptions, explanations, questions and requirements.

Appendix F Impression of the method to be used by CAPE

This appendix gives an impression of the developed method as it will exactly be used by CAPE, which is a collection of Excel sheets. On the bottom of the screen we can see the various sheets, which are the steps of the method in the order that they should be performed. Each sheet contains a form which has to be filled in the way that is told on the bottom of the form. The answers in many sheets have relations with many other sheets but these relations are not yet automatically calculated or showed. The final sheet (next to some explanatory sheets) shows the complete list of all possible requirements, plotted against various characteristics such as the transport type and whether the company operates international. We have depicted the relation between these characteristics and requirements, and when they are filled in for a specific company, various algorithms automatically calculate the consequences of this on the requirements. This means the priorities of the requirements are automatically calculated, and showed with numbers and colors, and irrelevant requirements can be automatically hided.

Next to the relation between company characteristics and requirements, the relation is also shown between requirements and main features of the board computers. These main features are important differentiators between the various vendors, such as whether the device should be mobile, support calling, have CANbus integration, have intelligent navigation, and so on. The priorities of these wanted features can be also calculated and are very useful to make a preselection of vendors, without having to study them into detail.

The next three figures depict the sheets for the Transport Type specification, Business Goals specification, Business Requirements specification and Processes and Requirements specification in the method to be used by CAPE.

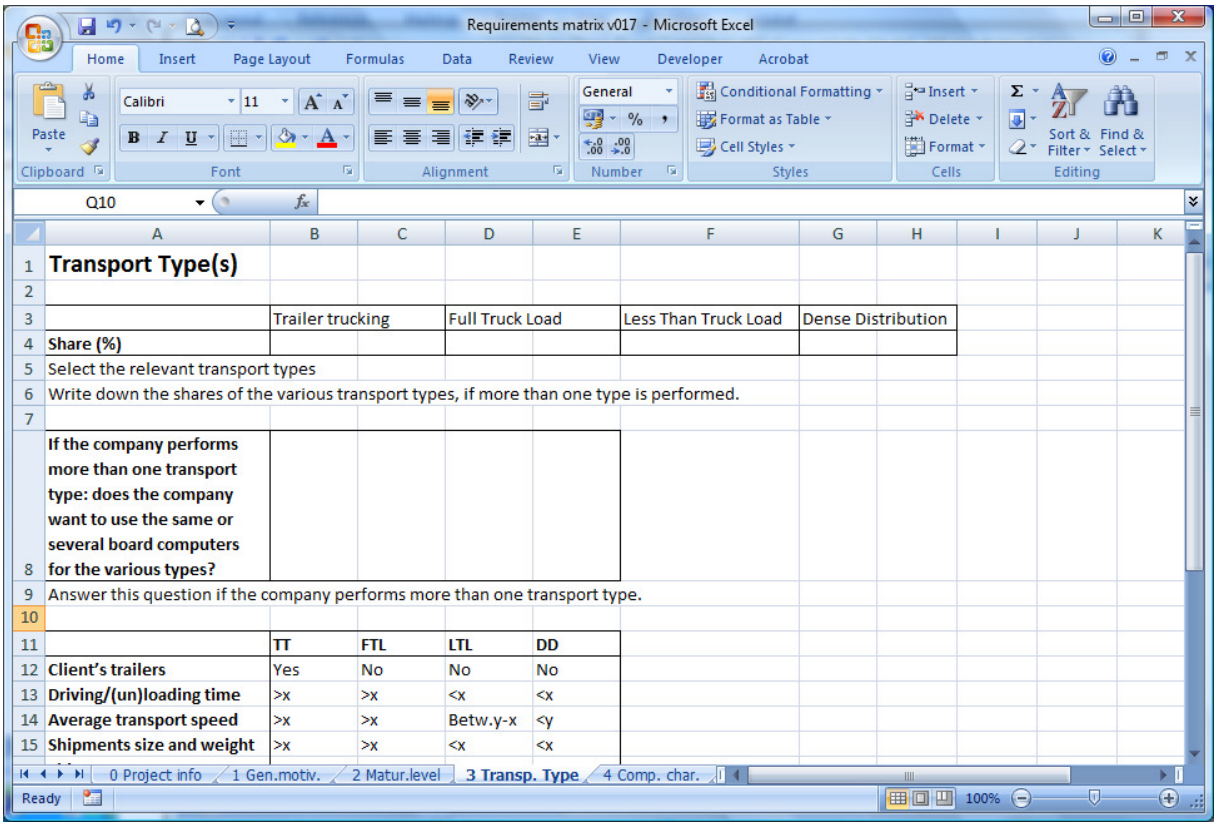


Figure 19 Transport type specification in the method to be used by CAPE

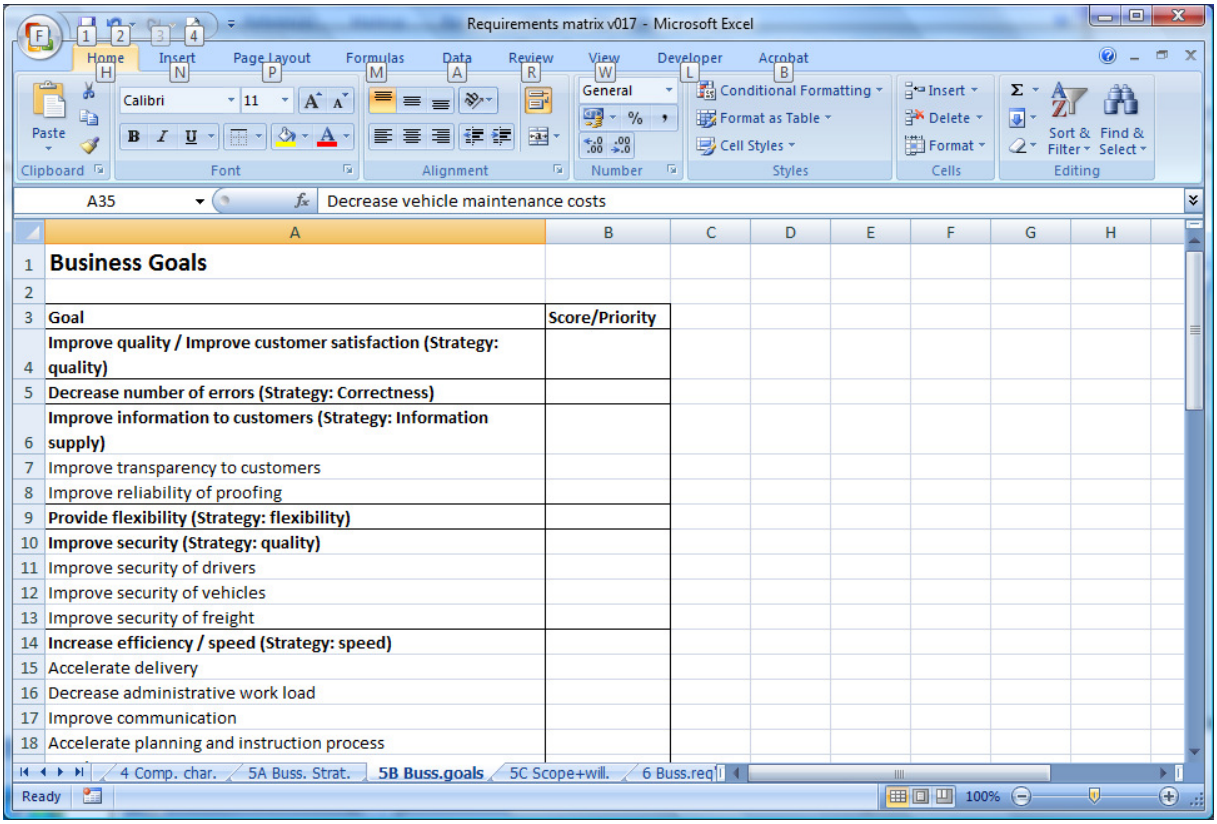


Figure 20 Business goals specification in the method to be used by CAPE

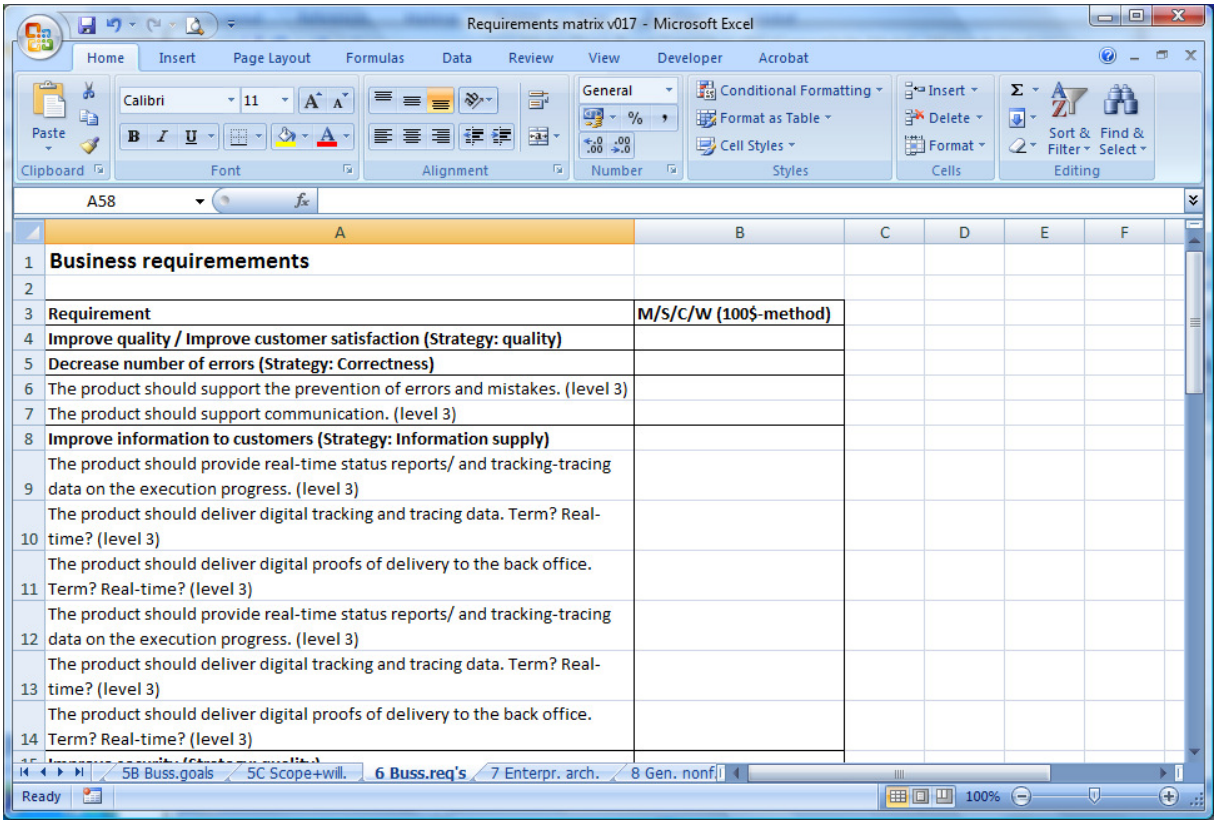


Figure 21 Business requirements specification in the method to be used by CAPE

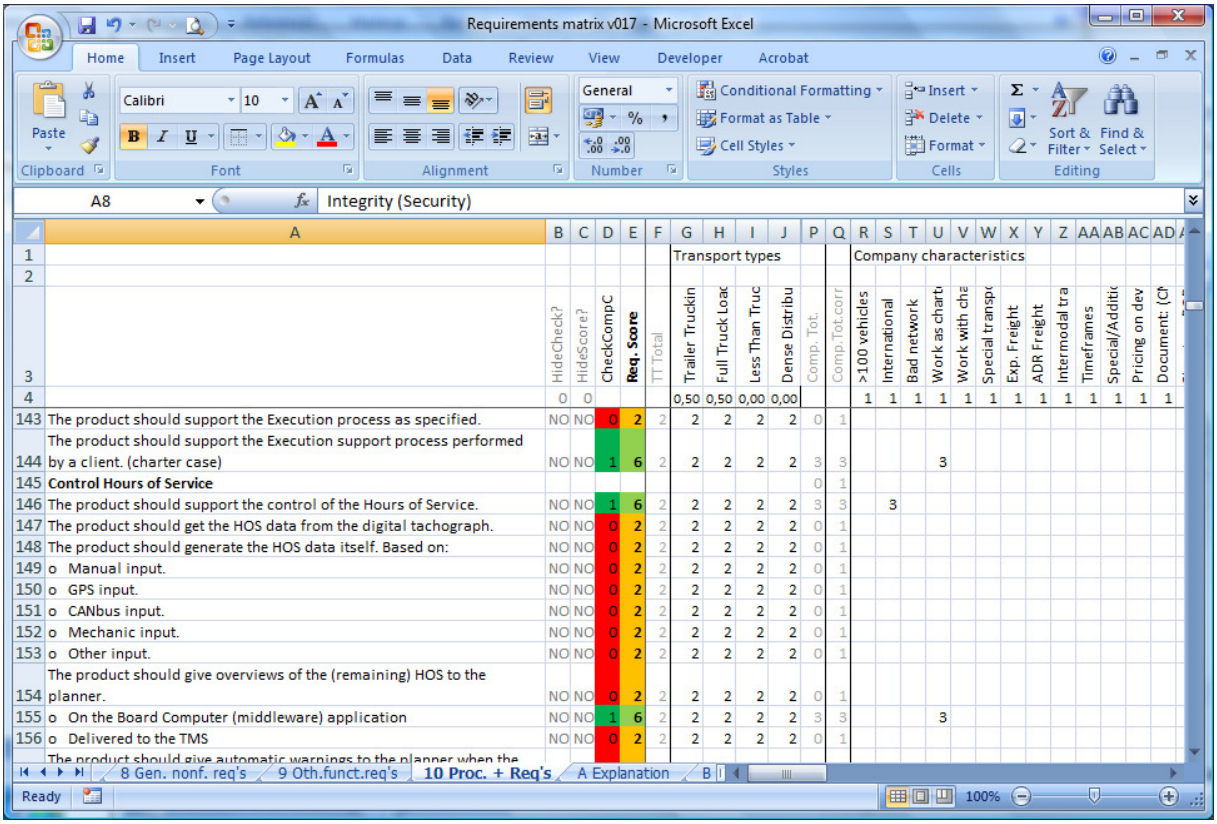


Figure 22 Processes and requirements specification in the method to be used by CAPE