A high-level integrated design for a Central Pickup and Drop-off point for air cargo at Amsterdam Airport Schiphol

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# Project details

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Preface
This research was conducted as final course for the Msc.-program Systems Engineering, Policy Analysis and Management of the Delft University of Technology. It was a great opportunity to apply the knowledge derived during the previous courses of the Msc.-program in this complex research problem. Exactly as I learned during my studies, the research contained both social and technical aspects. It was challenging to take all aspects into account and solve the problem with an integrated approach. I enjoyed the research and learned a lot from my time at Schiphol Cargo.

It would not have been possible for me to carry out this research without the help and support of my graduation committee.

Firstly I want to thank the chairman of my graduation committee Alexander Verbraeck, with whom I had multiple interesting discussions. The innovative ideas and valuable insights of Alexander Verbraeck challenged and motivated me. My first supervisor Martijn Warnier guided me through the research. In the various meetings I had with Martijn Warnier, he helped me with structuring my research. I was very lucky with such a helpful first supervisor. With his expertise about freight transportation, Hans van Ham was a valuable second supervisor. During the official meetings with the graduation committee he provided me with interesting insights and stimulated me in expanding the scope of my research. Hendriena Ritsema supervised me on behalf of Schiphol Cargo. Thanks to Hendriena Ritsema I felt at home at my graduation company from the very first day. She taught me a lot about the air cargo industry and Amsterdam Airport Schiphol. With her enthusiasm Hendriena Ritsema kept me ambitious and motivated until the final day of my research.

I also want to thank the full Cargo department of the Schiphol Group for hiring me as a graduation intern. It was a truly amazing experience to conduct a research in the inspiring Schiphol environment. Moreover I had a very nice time working besides and together with the various employees of the department. I truly hope that my research contributes to solving future problems at Amsterdam Airport Schiphol.

The meetings with and help from Rob Konings from OTB TU Delft and with Jafar Rezaei from the faculty of Technology, Policy and Management added significant value to this research.

Finally I want to express my great gratitude to my parents Margaret and Maarten. My parents supported me with my studies in all possible manners. I have had better and less joyful times and my parents were always there for me.

I am excited to present my Master Thesis.

Maurits van der Donk
Delft, March 2015
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AAS</td>
<td>Amsterdam Airport Schiphol</td>
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<tr>
<td>ACN</td>
<td>Air Cargo Netherlands</td>
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<tr>
<td>AWB</td>
<td>Airwaybill</td>
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<tr>
<td>BUP</td>
<td>Built Up Pallet</td>
</tr>
<tr>
<td>CPD</td>
<td>Central Pickup and Drop-off Point</td>
</tr>
<tr>
<td>FCC</td>
<td>Freight Consolidation Centre</td>
</tr>
<tr>
<td>FFM</td>
<td>Flight Manifest</td>
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<tr>
<td>FTL</td>
<td>Full Truck Load</td>
</tr>
<tr>
<td>HWB</td>
<td>Housewaybill</td>
</tr>
<tr>
<td>IATA</td>
<td>International Air Transport Association</td>
</tr>
<tr>
<td>LTL</td>
<td>Low Truck Load</td>
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<tr>
<td>RFS</td>
<td>Road Feeder Services</td>
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<tr>
<td>SADC</td>
<td>Schiphol Area Development Company</td>
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<tr>
<td>SGHA</td>
<td>Standard Ground Handling Agreement</td>
</tr>
<tr>
<td>SLA</td>
<td>Service Level Agreement</td>
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<tr>
<td>SRE</td>
<td>Schiphol Real Estate</td>
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<tr>
<td>UCC</td>
<td>Urban Consolidation Centre</td>
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<td>ULD</td>
<td>Unit Load Device</td>
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Executive summary

Introduction of problem
With 1.6 million tonnes of cargo being handled at Amsterdam Airport Schiphol (AAS) in 2014, AAS was the 3rd largest European cargo airport (Schiphol Group Traffic Analysis & Forecasts, 2015). Schiphol Group is the exploiter of AAS. Schiphol Cargo, a department of the Schiphol Group, is responsible for cargo. Growth of cargo via AAS is Schiphol Cargo’s main goal (Schiphol Cargo, 2014).

The expectation is that the annual cargo volume at AAS will increase to 3 million tonnes in 2030 (Nieuwsblad Transport, 2014). However, the airport does not have the capacity to handle so much freight. The bottleneck is the limited capacity of the (seven) cargo ground handlers. The cargo ground handlers are independent organizations with warehouses in which they transship air cargo between planes and trucks at AAS. Their warehouses must be located on the so-called first line area of AAS. The first line area is the area adjacent to the runways of AAS. Only if the ground handlers’ warehouses are located on the first line area, they have access to the cargo planes that they need to load and unload.

As a result of the limited size of their warehouses the cargo ground handlers can only handle 2 million tonnes of freight annually (van Doorne, 2013, Ashford et al., 2011, Antun et al., 2010). There is no space available on the first line area of AAS for expansion of the ground handlers’ warehouses (Schiphol Group, 2012, Schiphol Group, 2014b). To increase the capacity of the ground handlers’ warehouses another solution than physical expansion needs to be found, or growth of cargo via AAS can soon not be realized anymore.

A Central Pickup and Drop-off point (CPD) for air cargo at Amsterdam Airport Schiphol
Schiphol Cargo has initiated the idea of a Central Pickup and Drop-off point (CPD) for air cargo at AAS to increase the capacity of the ground handlers’ warehouses while taking into account the described limiting factors. The CPD will act as a central facility at which trucks can pick up or deliver air freight from/from the seven cargo ground handlers. Transportation of freight between the CPD and the ground handlers will take place via a shuttle service. Thereby the CPD does not need to be located on the scarce first line area of AAS; it can be located more inland. The CPD will take over some activities of the ground handlers that are required for the transshipment of freight between planes and trucks, such as the temporary storage of freight. These activities currently occupy room in the warehouses of the handlers. By moving them to the CPD in the future this room becomes available for the expansion of their other activities. Thereby the amount of freight that can be transshipped in the ground handlers’ warehouses increases. The CPD will increase the annual capacity of the handlers (and thereby of AAS as a cargo hub) without physical expansion of their warehouses.

Need for a business model for the CPD
The development of a business model of the potential future CPD at AAS is expected to increase its chances on successful implementation. A business model fully describes the design of a project or an organization from all points of view: technological, logistical, organizational, financial, etc. (Osterwalder and Pigneur, 2009, Teece, 2010, Zott and Amit, 2010). In the past multiple similar projects in the transportation sector (such as similar distribution centres) for which only a technological or logistical design was developed faced severe implementation issues. Especially in multi-actor settings, technologically/logistically well-designed projects often led to a failure or to complexities during implementation where business models of the projects were missing (Wiegmans et al., 2010, Konings et al., 2013, Veenstra et al., 2012, van Binsbergen et al., 2013).
Development of an integrated high-level design
A business model would fully describe the design of the CPD (from different perspectives) in detail. It would describe exactly how the CPD would fit in its environment: the AAS air cargo logistics chain. However, between the publication of this report and the actual CPD implementation the AAS air cargo logistics chain is subject to changes. It is hence at this stage of the research too early to develop a business model for the CPD.

At this stage of the research it is considered valuable to develop an integrated high-level design of the CPD. With “integrated” is meant that the CPD will be designed from all relevant perspectives (e.g. technological, logistical, organizational and financial). With “high-level” is meant that only the design variables that have a critical influence on the functioning of the CPD will be designed. The ability of a CPD to function in the AAS air cargo logistics chain depends on how these variables are designed. Once it is known that and how a CPD can be developed that is able to function in the chain, a business model can be designed at a later stage. A business model, which contains also less critical variables and details, will demonstrate how the CPD will exactly fit in its environment, but is not decisive for the ability of the CPD to function in the chain. This research gives answer to the research question below.

Can an integrated high-level design of a Central Pickup and Drop-off point (CPD) for air cargo at Amsterdam Airport Schiphol (AAS) be developed so that the facility will be able to function effectively in the AAS air cargo logistics chain?

If multiple integrated high-level designs can be developed that are able to function within the AAS air cargo logistics chain, the aim is to determine a preferred one.

Critical design variables of the CPD
Critical design variables for the functioning of a (air) freight consolidation centre, such as the CPD at AAS, are not explicitly mentioned in literature. To determine which design variables have a critical influence on the functioning of the CPD, studies about the design and functioning of similar consolidation centres were extensively analyzed. Researches about urban consolidation centres, sea freight consolidation centres and other air cargo consolidation centres were analyzed. With this analysis of literature six design variables were found which are considered to have a critical influence on the functioning of a CPD at AAS. These variables were validated in an expert interview with dr. J.W. (Rob) Konings, senior researcher freight transport at the OTB department of the TU Delft (Konings, 2014).

1. The proximity of the CPD to AAS
2. The level of obligation or stimulus for usage of the CPD
3. The range of services offered in the CPD
4. The ownership of the CPD
5. The responsibility for operating the CPD
6. The model of costs and gains sharing

The environment of the CPD: the AAS air cargo logistics chain
To determine whether and how a high-level CPD design can be developed such that the CPD will be able to function in the AAS air cargo logistics chain, this chain (the CPD environment) needs to be thoroughly understood. The AAS air cargo logistics chain was therefore analyzed from multiple perspectives with the use of literature, market studies, field researches and twenty in-depth interviews with representatives from organizations from the chain.
The AAS air cargo logistics chain imposes several requirements to the CPD design, such as legal and physical requirements. If a CPD design complies with these requirements, it is still very important for the ability to function in the chain that the CPD does not conflict with the cultures and beliefs of the important organizations in the chain. The most important organizations in this chain are the freight forwarders, KLM Cargo and the other cargo airlines. Finally, the influence of the CPD on hard performance indicators is important as well for its ability to function in the chain. Especially the financial consequences of the CPD are important in the highly competitive and low return air cargo industry.

**Stepwise evaluation methodology to find preferred integrated high-level CPD design**

Thousands of high-level CPD designs (consisting of the design of the six critical design variables) comply with the design requirements that the AAS air cargo logistics chain imposes to the CPD. To assess which of these thousands theoretically feasible design alternatives have the ability to function in the chain and which one is preferred if multiple alternatives have the ability to function in the chain, a stepwise evaluation methodology was developed and subsequently carried out. In this evaluation methodology the alternatives were gradually (in multiple steps) evaluated, until a preferred alternative was found. The stepwise evaluation methodology was set up such that it is representative for how projects or initiatives are evaluated in the AAS air cargo logistics chain. The importance of a non-conflicting influence on the cultures and beliefs of organizations for a project to be able to function in this chain was for example taken into account. The methodology was discussed with an expert in the field of Multi-Criteria Decision Analyses at the faculty of Technology, Policy and Management at the Delft University of Technology. After conducting several sensitivity analyses a preferred CPD design was found that has the ability to function in the chain. This alternative is expected to make sure that the ground handlers will become able to handle 3 million tonnes of freight annually without any expansion of their warehouses.

**Preferred CPD design**

The preferred high-level CPD design consists of two different facilities: an airside facility and a landside facility. The airside facility is located on the first line area of AAS, just like the current ground handlers’ warehouses. This facility occupies less space than it creates in the warehouses of the ground handlers by efficiently taking over some of their activities. Therefore space on the scarce first line area can be made available to construct this facility. Freight forwarders jointly operate the airside facility. Ground handlers jointly operate the landside facility, which is more located inland where space is less scarce. Different services are offered in the airside and the landside facility. The facilities are not competing with each other but complimentary. The combined development of the airside and the landside facility of this preferred CPD design is expected to realize in the capability of ground handlers (and thereby of AAS) to realize an annual freight turnover of 3 million tonnes without expansion of their warehouses.

The preferred CPD design has a positive influence on the cultures and beliefs of the important organizations, which is very important for the chances on successful implementation of a project in this chain. It is also expected to improve the chain financially and logistically. Compared to an imaginary situation in which the ground handlers would be able to physically expand their warehouses (to increase their annual ground handling capacity to 3 million tonnes of freight) the total costs for freight to flow through the chain are between 0.6% and 1.4% lower if this preferred CPD design gets implemented. Moreover, the implementation of this design is expected to result in 4% to 13% less truck movements as a result of air cargo at AAS. This corresponds to 35,000 to 135,000 truck movements yearly. The accessibility of AAS will increase for trucks carrying air cargo and other vehicles.
The design will not only likely solve the ground handlers’/AAS’ expected future capacity problems, but it is also expected to improve the competitive position of AAS as a cargo hub.

**Main conclusions and recommendations**

In this research a high-level CPD design is developed that has the ability to function in the AAS air cargo logistics chain. The design consists of an airside facility and a landside facility. With the implementation of this CPD design (the airside and landside facility) the annual ground handling capacity of the warehouses of the ground handlers is expected to rise to 3 million tonnes without any physical expansion. The CPD design fits in the future area development plans of Schiphol Group and contributes to achieving Schiphol Cargo’s main goal: growth of cargo via AAS. Moreover the implementation of the airside and the landside facility are expected to improve the competitive position of AAS as a cargo hub.

Schiphol Cargo is recommended to steer towards the quick development of the airside facility of the preferred CPD design. This airside facility is required (together with the landside facility of the preferred design) to solve the sketched capacity shortages of the ground handlers in the long-term future. The airside facility is however also expected to improve the competitive position of AAS as a cargo hub in the short-term future.

Another important recommendation is to carry out further research towards the development of business cases of the preferred CPD design for the different involved organizations. This research has shown that the CPD is viable and can achieve net positive results for all organizations combined. Positive business cases for the separate organizations are however required to make the design actually implementable. Further research should also be done towards an implementation plan for the facility. Schiphol Cargo can not impose this preferred CPD design to the involved organizations. It is recommended to research how willingness for and involvement in the CPD implementation can be created among the organizations in this chain.
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PART I: PRELIMINARY ANALYSIS AND SCOPING
1 Introduction

1.1 Air cargo at Amsterdam Airport Schiphol

On November 7th 1910 the first commercial cargo flight took place. This domestic flight in the United States of America launched the start of the air cargo industry (The Wright Stories, 2014). Since then the air cargo industry has grown enormously. Air cargo nowadays is characterized by its diversity in product types, such as veterinary products, flowers, live animals and aerospace parts (Schwarz, 2005). The value of the goods that are transported via the air each year exceeds €5 trillion. This accounts for approximately 40% of the value of the total world trade. Air cargo is a facilitator of global trade, a contributor to worldwide economic development and the employer of millions of people worldwide (IATA, 2014, Global air cargo advisory group, 2014, Tretheway and Andriulaitis, 2010).

Amsterdam Airport Schiphol (AAS) is the airport of arrival and departure of practically all cargo that is flown to and from the Netherlands. Apart from being one of the busiest European passenger airports, AAS also holds a primary position in the ranking of largest European cargo airports. AAS is Europe’s 3rd and the world’s 16th largest cargo airport and over the past years AAS has realized high growth rates in the cargo sector compared to other large European cargo airports (Airports Council International, 2014).

Air cargo is important for AAS. The incomes from air cargo contribute significantly to the total airport’s incomes. Cargo incomes are generated with landing fees and other airport charges to planes arriving at and departing from AAS with cargo. They are also generated with rental fees to organizations that are active in the air cargo industry at AAS and rent buildings from the airport (Osinga, 2014). These direct cargo incomes are not the only reason that air cargo is important for AAS. The success of AAS as a passenger airport is also partly dependent on the air cargo performances. Passenger connections (especially intercontinental passenger connections) are often only profitable for airlines if cargo can be carried on the airplanes (Burghouwt et al., 2012).

By providing companies opportunities to send time-critical and high value products, air cargo at AAS also facilitates and stimulates the national Dutch economic development (Ministerie van Verkeer en Waterstaat en het Ministerie van Volkshuisvesting Ruimtelijke Ordening en Milieubeheer, 2009, Yuan et al., 2010). The air cargo sector at AAS also stimulates the regional economy fiercely. More than 30,000 people in and around AAS are employed because of the air cargo activities (Gemeente Haarlemmermeer, 2013).

Growth of air cargo via AAS is important for AAS, the regional and the national Dutch economy.

1.2 Company profile: Schiphol Group and its cargo department

Schiphol Group fully owns and exploits the international Amsterdam Airport Schiphol. It has gained the license to exploit the airport by Dutch national law (Overheid.nl, 1992). Schiphol Group (registered by statute: “N.V. Luchthaven Schiphol”) is a privately operating company that is fully owned by its shareholders (Schiphol Group, 2014b). Shareholders of the Schiphol Group are the Kingdom of the Netherlands (69,77% of shares), the municipality of Amsterdam (20,03% of shares), the municipality of Rotterdam (2,20% of shares) and Aeroports de Paris (the owner and exploiter of France’ largest airport Paris Charles de Gaulle: 8,00% of shares) (Schiphol Group, 2014a). Schiphol Group is not listed on the stock market. Because governmental institutions own the majority of shares of the privately
operating Schiphol Group, Schiphol Group can be seen as a sort of semi-governmental organization.

At Schiphol Group there is a cargo department (7 employees) that is responsible for air cargo: Schiphol Cargo. Main goal of Schiphol Cargo is the growth of cargo via the AAS hub. To achieve this goal it has set itself the ambition to let AAS become Europe’s preferred cargo airport. For this to be possible, it is important that the network of flights increases, that the marketplace grows and that the quality of the logistic processes for air cargo at AAS improves (Schiphol Cargo, 2014).

Schiphol Cargo however does not carry out any actual activities itself. It solely has a facilitating role in the air cargo sector at AAS (Pieters, 2014). The role of Schiphol Cargo can be described as the market manager or supervisor (Burghouwt et al., 2012). Schiphol Cargo brings different actors together to settle conflicts, it tries to facilitate an environment at AAS in which the actors can function efficiently and competitively and it puts effort in marketing AAS as a cargo airport worldwide (Schiphol Group, 2014c).

1.3 AAS air cargo logistics chain

Many types of organizations are active in the air cargo industry. They all have different roles and jointly carry out the full transportation of a shipment from a shipper to a consignee.

The activities start with a shipper deciding to send goods to a consignee (typically in another continent) and outsourcing the full door-to-door transportation of the shipment to a freight forwarder. This makes the freight forwarder the central player in the logistic chain (Burghouwt et al., 2012). The forwarder subsequently books cargo space for the shipment on a flight of an airline. The forwarder is also responsible for transporting the shipment from the shipper to the airport of departure and generally always does this by road. Some forwarders do this with their own trucks, but most let trucking company do it on behalf of them. At the airport of departure the shipment gets handed over to a cargo ground handler. The ground handler unpacks the truck and loads an airplane with the goods. Some ground handlers belong to airlines or to the airport authority; others are privately owned and operating. Private third party ground handlers have temporary contracts with airlines to load and unload all their cargo planes at the respective airport. At AAS there are currently seven cargo ground handlers. One ground handlers belongs to AAS’ home carrier KLM. The other six are privately operating third party ground handlers.

After the airplane has made its journey, a ground handler at the airport of arrival unloads the airplane and loads a truck with the shipment. The forwarder arranges a truck to transport the shipment from here to the consignee. Figure 1-1 gives a simple schematic overview of the chain.
The AAS air cargo logistics chain is the chain in which all activities take place when air freight arrives at or departs from AAS. Different types of organizations are involved in this chain: the cargo airlines with cargo connections to and from AAS, the cargo ground handlers that are situated at AAS, the trucking companies that provide road transportation from and to AAS and the freight forwarders that make use of the airport.

1.4 A Central Pickup and Drop-off point for air cargo (CPD) at AAS

In 2014 more than 1.6 million tonnes of cargo were transported by air via the AAS hub (Schiphol Group Traffic Analysis & Forecasts, 2015). The forecast is that a volume of 3 million tonnes will be reached in 2030 (Nieuwsblad Transport, 2014). The cargo ground handlers at AAS however do not have enough capacity to handle 3 million tonnes of cargo annually. Warehouses of cargo ground handlers are located on the so-called first line area of AAS. This is the area between airside and landside, adjacent to the runways of airplanes. From here they have access to the planes of their customers (the airlines) to load and unload them.

Schiphol Group’s future airport area development plans are described in its so-called Masterplan. Among other development plans the Masterplan describes the relocation of three of the seven ground handlers at AAS (including the ground handler belonging to home carrier KLM) for the expansion of a passenger terminal (Schiphol Group, 2014b, Schiphol Group, 2012). At another location at AAS a piece of first line area is reserved for these three handlers. However, the reserved area is smaller than the land their warehouses currently occupy. Because of the forced relocation of these three ground handlers the total space available for cargo ground handlers at AAS on the first line area will soon reduce from 210,000 m$^2$ to a maximum of 200,000 m$^2$ (van Doorne, 2013, Ramaaker, 2012). According to standards of the International Air Transport Association (IATA) the capacity of the ground handling warehouses at AAS will not likely exceed 10 tonnes/m$^2$/year (Antun et al., 2010, Ashford et al., 2011). Because only 200,000 m$^2$ of first line area is reserved for the ground handlers in the future, their maximum yearly capacity will not likely exceed 2 million tonnes.
of freight. This maximum capacity of the ground handlers also determines the maximum capacity of AAS as a cargo hub. If no solution is found, Schiphol Cargo will soon not be able to reach its main goal anymore: growth of cargo via AAS.

To be able to deal with at least 3 million tonnes of cargo annually with the limited space available on the first line area for warehouses of cargo ground handlers, Schiphol Cargo has initiated the idea of a Central Pickup and Drop-off Point (CPD) for air cargo. This CPD will function as a sort of distribution centre for freight of all (or part of) the cargo ground handlers. It will be a central facility where trucks can pick up freight from all ground handlers and deliver freight for all ground handlers consolidated. Via a shuttle service transportation of freight between the different ground handlers and the CPD will take place. The CPD will offer some of the services that the ground handlers currently offer in their warehouses, such as the temporary storage of freight. As a result the ground handlers will become able to let part of their activities take place in the CPD, which will create room for expansion of other activities in their warehouses. The ground handling capacity will increase, without the ground handlers physically expanding. And because the CPD does not need to be located on the first line area of AAS, this solution will fit within the Masterplan of Schiphol Group. Schiphol Cargo sees the development of a CPD as a solution for handling 3 million tonnes of cargo annually with the limited amount of first line area being available at AAS for the ground handlers’ warehouses. Besides the creation of capacity in the ground handlers’ warehouses, the CPD may also be able to reduce the amount of truck movements at and around AAS if freight for and from multiple handlers can be picked up centrally at the CPD (Waters, 2013).

1.5 Need for high-level CPD design

In the transportation sector various examples exist of projects that could not be implemented or faced serious problems in the implementation phase. Many of such projects had innovative and well thought-out technological designs. However, the lack of a financial and/or organizational design of the project was often the reason for the complexities during implementation. Especially for a transportation project in a multi-actor setting its change on successful implementation is to a large extent dependent on a proper organizational and financial design (van Binsbergen et al., 2013). The environment in which a potential future CPD at AAS will need to be developed and implemented is one with many actors, such as ground handlers, forwarders and cargo airlines. The CPD will need to be designed from more perspectives than only the technological one to increase its chance on a successful implementation.

It is often referred to a lack of a business model as reason why projects with promising technological designs could not be implemented or faced serious issues in the implementation phase. An example of such a project, that was eventually not implemented, is the Underground Logistics System (ULS) Schiphol (Wiegmans et al., 2010). Other examples are different sea freight distribution centres serving the harbour of Rotterdam. Despite extensive researches that were done towards these distribution centres, many of them have not yet been implemented because business models were not designed for them (Konings et al., 2013, Veenstra et al., 2012).
To understand why a business model for a project or organization is this important, it must be better understood what exactly is meant with a business model. Researchers, such as Teece (2010), Zott and Amit (2010) and Osterwalder and Pigneur (2009) give different definitions of a business model. What can be concluded from these definitions is that an organization or a project is fully described by its business model. A business model describes the complete design of the project or organization (see Figure 1-2). It contains design aspects from a technological, organizational and financial point of view. A business model contains more than the technological design of a project, but also more than just the description of the costs and benefits related to a project and the demonstration that these costs and benefits lead to net positive results. Net positive results do not automatically mean that a project can be implemented. The rest of the business model needs to be adequately designed as well, such as the exact distribution of the costs and gains (van Binsbergen et al., 2009).

Figure 1-2: Content of business model visualized in Venn diagram

The development of a business model has a positive influence on the chance on a successful implementation of the CPD at AAS. This conclusion can be drawn from the knowledge derived from literature about previous projects in the transportation sector. A business model fully describes a project or organization. To be able to set up a business model for the CPD, the facility will hence need to be designed in detail and from all different perspectives. A complete design will need to be developed for the CPD that fully describes how the CPD will fit in the environment: the AAS air cargo logistics chain. However, between the publication of this report and the actual (potential) development of the CPD, the AAS air cargo logistics chain is expected to undergo changes. The organizational structure in the chain may change, tariffs may be adjusted, the shares of different product types may change, etc. It is hence at this stage of the research too early to develop a business model for the CPD.

At this stage of the research it is considered valuable to develop an integrated high-level design of the CPD. With “integrated” is meant that the CPD will be designed from all relevant perspectives (e.g. technological, logistical, organizational and financial). With “high-level” is meant that only the design variables that have a critical influence on the functioning of the CPD will be designed. The ability of a CPD to function in the AAS air cargo logistics chain depends on how these variables are designed. Once it is known that and how a CPD can be developed that is able to function in the chain, a business model can be designed at a later stage. A business model, which contains also less critical variables and details, will
demonstrate how the CPD will exactly fit in its environment, but is not decisive for the ability of the CPD to function in the chain. The high-level integrated CPD design forms the founding of its business model. The changes in the AAS air cargo logistics chain can be taken into account when developing the full business model at a later stage.

1.6 Problem statements and research objectives
Developing a high-level CPD design has both a scientific and a societal relevance. Explaining the scientific and practical problem statements and objectives illustrates this.

1.6.1 Scientific problem statement and objectives
The scientific problem statement is twofold.

The very few researches that were done towards (the design of) air cargo consolidation centres do not mention which design variables have a critical influence on the functioning of such a facility. More researches are done towards comparable freight consolidation centres (e.g. urban consolidation centres). In many of these researches the importance of designing such comparable freight consolidation centres from multiple perspectives to increase the chance on a successful implementation is explicated. Also in literature about other comparable freight consolidation centres it is however not mentioned what design variables are critical for their functioning. The first scientific research objective is to contribute to the research carried out towards freight consolidation centres by determining the design variables of an air cargo consolidation centre that have a critical influence on such a centre’s functioning.

It is not mentioned in literature what variables have a critical influence on the functioning of an air cargo consolidation centre (such as the CPD at AAS). If these variables were known, it would however still be unknown what would be an appropriate methodology to design them. Another scientific research is to determine what methodology can be used to design a high-level integrated design of an air cargo consolidation centre that contains the design of its critical design variables.

1.6.2 Practical problem statement and objectives
The practical problem statement is also twofold.

Schiphol Cargo sees a Central Pickup and Drop-off point as a promising solution for solving the future space shortages on the first line area of AAS and potentially also reducing truck movements. For Schiphol Cargo it is however unknown whether a CPD can be designed that will be able to function in the AAS air cargo logistics chain. The first practical research objective is to determine whether and how a high-level CPD design can be developed that has the ability to function in the AAS air cargo logistics chain.

Schiphol Cargo also does not yet know what the effect of a CPD will be on the performances of the AAS air cargo logistics chain. The second practical research objective is to assess what the impact will be of a CPD introduction on the performances of the chain.

1.7 Research questions
The aim of this research is to give answer to the main research question below:

Can an integrated high-level design of a Central Pickup and Drop-off point (CPD) for air cargo at Amsterdam Airport Schiphol (AAS) be developed so that the facility will be able to function effectively in the AAS air cargo logistics chain?
To answer the main research question, it will firstly be determined what design variables of an air cargo consolidation centre have a critical influence on its functioning.

**Research sub question 1:** Which design variables have a critical influence on the functioning of the potential future CPD at AAS?

The next step in the research is to determine what influence the AAS air cargo logistics chain has on the potential ability of a CPD to function in this chain. The influence of the AAS air cargo logistics on the possibilities to design the critical design variables of the CPD will be assessed.

**Research sub question 2:** What is the influence of the system-environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?

**Research sub question 3:** What is the influence of the actor-environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?

It can now be assessed how the Central Pickup and Drop-off point (CPD) for air cargo at AAS can theoretically be designed. The theoretical possibilities for designing the CPD from a high-level do not reflect whether the CPD with the different designs will be able to function in the chain. It purely reflects in what ways the high-level CPD design can theoretically be developed. Firstly all theoretically feasible design options for the critical design variables will be researched separately. Subsequently it will be researched what combinations of these options are theoretically feasible and so what are the theoretically feasible CPD designs.

**Research sub question 4:** What are the theoretically feasible options to design the critical design variables of a potential future CPD at AAS that were found in research sub question 1 separately?

**Research sub question 5:** Which theoretically feasible design options from research sub question 4 for the critical design variables separately can be combined to create theoretically feasible CPD designs?

When all theoretically feasible high-level CPD designs are found, a methodology is needed that helps with determining whether the feasible CPD designs have the ability to function in the AAS air cargo logistics chain. The methodology will also need to help with finding a preferred high-level CPD design if more than one theoretically feasible CPD design has the ability to function in the chain.

**Research sub question 6:** Can a methodology be developed with which a preferred alternative that has the ability to function effectively in the AAS air cargo logistics chain can be determined?

After developing this methodology, the methodology will be used to determine the preferred CPD alternative.
Research sub question 7: Is it possible to set up a high-level CPD design so that the CPD will be able to function effectively in the AAS air cargo logistics chain? If more than one design can be set up, which is preferred and why?

Finally it will be assessed how the preferred high-level CPD design, if a preferred alternative can be found, will influence the performances of the AAS air cargo logistics chain.

Research sub question 8: What influence does the preferred high-level CPD design have on the performances of the AAS air cargo logistics chain?

1.8 Research outline and methodology

The outline of this research is visualized in Figure 1-3. The research starts with a preliminary analysis in which the scope of the research is explained. In this part the AAS air cargo logistics chain is also analyzed and explained, because knowledge about this chain is required for the remainder of this research.

The second part of the research is the construction of the design directives. In this part the framework for the rest of the design study is set. The critical design variables for the functioning of the potential future CPD at AAS are determined in a literature study. Furthermore a research is done towards the influence of the environment of the CPD (the AAS air cargo logistics chain) on the CPD design and its functioning.

The third part of the research is the design section. In this part all theoretically feasible high-level CPD designs are set up. For these designs it is not sure yet whether they will all be able to function in the chain.

In the fourth part of the research all theoretically feasible CPD designs are evaluated. A stepwise evaluation methodology is developed and carried out to determine which designs have the ability to function in the AAS air cargo logistics chain. The stepwise approach also helps with finding a preferred alternative if multiple CPD designs have the ability to function in the chain.

In the final part of the research the conclusions of the study are drawn and explicated. It is explained whether a high-level CPD design can be set up so that the CPD will be able to function in the chain. The influence of this CPD on the performances of the chain is also explicated. Recommendations are given and the research is discussed and reflected.
1.9 Research scope

The aim of this research is to assess whether and how a high-level design for the potential future CPD at AAS can be developed so that the CPD will have the ability to function in its environment: the AAS air cargo logistics chain. How the CPD will exactly fit within the
environment must become clear when a detailed design is made in a later research. The high-level design only consists of variables that have a critical influence on the functioning of the CPD. It does not contain other variables or design details that are not critical for its functioning. To assess whether a CPD has the ability to function in the AAS air cargo logistics chain, its influence on the performances of the chain must be known. Therefore this research also describes the influence of the CPD on the chain’s performances.

This research is set up as a design study. The product of this research is a high-level CPD design that has the ability to function in the chain. For this the “harder” environment (system-environment) and “softer” environment (actor-environment) of the CPD will be taken into account. The product of this research is considered to be implementable since the full influence of the AAS air cargo logistics chain on the product is taken into account. However, the actual implementation of the final preferred design is not part of this study. For a successful implementation of the preferred design another extensive study with a different focus needs to be carried out. Focus of such a study needs to be on the influence of the design on the separate organizations (e.g. financial implications), instead of on the viability of the design from a full chain perspective (as is done in this research).
2 The AAS air cargo logistics chain explained

Before focusing on the development of a high-level design for a Central Pickup and Drop-off point (CPD) for air cargo at AAS, the basics of the AAS air cargo logistics chain should be understood. Basic knowledge about this chain is considered important for all assessments and decisions that are made in the continuing of this research. This chapter does not describe the relation between the AAS air cargo logistics chain and a potential future CPD. It does not describe how the environment of a potential future CPD at AAS influences its possible design options. This is a descriptive/informative chapter about the AAS air cargo logistics chain.

The environment (the AAS air cargo logistics chain) is described from a high-level perspective. In the first section the important actors of the chain and their activities are introduced by following one shipment through the chain. The contractual relationships between these actors becomes clear, as well as their different responsibilities and liabilities over freight. In the second section the contractual relationships that were already explained in section 2.1 are explicated. Whereas in section 2.1 the flow of a single shipment through the AAS air cargo logistics chain is described, section 2.3 explains how the flows of different shipments separately shape the total web of freight flows at AAS. Section 2.4 gives an overview of the chapter and contains the most important conclusions.

The AAS air cargo logistics chain is involved with transporting large amounts of freight over long distances (mostly intercontinental) on a daily basis. The chain is complex and involves multiple firms that all have different relationships with each other. These firms exchange money, information and goods with each other in a different way, on different places and on different times (Schwarz, 2005). A very simple visualization of the chain was already shown previously in this report in Figure 1-1.

2.1 The flow of a shipment through the AAS air cargo logistics chain

Different companies have different roles and perform different activities in the air cargo logistics chain. They have different contractual relationships with each other and exchange information, money and freight differently. This paragraph focuses hereon, by describing the course of a single shipment that flows through the chain.

Purchase agreement between shipper and consignee

The activities start when a shipper decides to send goods (a shipment) to a consignee, because the consignee has purchased these goods. In case of air freight from and to AAS, the consignee is practically always located in another continent than the shipper (Market Research Schiphol Group, 2014). Freight needs to be transported from the shipper’s factory or warehouse for example to the consignee’s warehouse or factory. The shipper and the consignee may be of different companies, but may also belong to the same firm. Transporting this freight is a complex task: transportation needs to take place over different modalities and within different countries, customs and security regulations must be met, etc. The shipper and consignee therefore along with the purchase agreement also need to decide who becomes responsible for arranging this full door-to-door transportation from shipper to consignee. The shipper or on the other hand the consignee may become fully responsible, but both parties may also become partly responsible for the transportation (Radstaak, 2014). The exact responsibilities of shipper and consignee for arranging the transportation of the shipment depend on the so-called incoterms that they agree upon. Table 2-1 shows the most frequently used incoterms by shipper and consignees in case of air freight. Table 2-1 also shows per type of incoterms the responsibilities for shipper and consignee for the most important steps in the full door-to-door transportation. The table is based on a similar table by Radstaak (2014).
Table 2-1: Most commonly used incoterms based on similar table by Radstaak (2014)

<table>
<thead>
<tr>
<th>TRANSPORTATION STEPS</th>
<th>INCOTERMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHIPPER (S)</td>
<td>Ex Works</td>
</tr>
<tr>
<td>CONSIGNEE (C)</td>
<td></td>
</tr>
<tr>
<td>Packaging shipment for transportation</td>
<td>C</td>
</tr>
<tr>
<td>Transportation to airport</td>
<td>C</td>
</tr>
<tr>
<td>Customs clearance (export) and documentation</td>
<td>C</td>
</tr>
<tr>
<td>Air transportation</td>
<td>C</td>
</tr>
<tr>
<td>Transportation insurance</td>
<td>C</td>
</tr>
<tr>
<td>Storage costs &gt; 24 hours</td>
<td>C</td>
</tr>
<tr>
<td>Transfer costs</td>
<td>C</td>
</tr>
<tr>
<td>Customs clearance (import) and import duty</td>
<td>C</td>
</tr>
<tr>
<td>Transportation to consignee</td>
<td>C</td>
</tr>
</tbody>
</table>

Door-to-door transportation outsourced by shipper/consignee to freight forwarder

The shipper and/or consignee (dependent on the incoterms) usually outsource the full door-to-door transportation to a freight forwarder. This makes the forwarder the central player in the logistic chain (Burghouwt et al., 2012) and gives the shipper and/or consignee a contractual relationship with this freight forwarder. The order for part of or the full door-to-door transportation is described and signed by the shipper/consignee and the forwarder in the Housewaybill (HWB). The HWB is a standard document of the International Air Transportation Association (IATA) (Burghouwt et al., 2012).

Cargo space for freight forwarder on airline’s flight

When the HWB has been signed, the forwarder books cargo space on a cargo flight of an airline. Dependent on the shipment forwarders book cargo space ad hoc and only on one specific flight, or through longer-term contracts on a regular basis (e.g. for one year a certain amount of space on every Thursday afternoon flight of a specific airline) (Schwarz, 2005).

Forwarders can either book cargo space in the belly of passenger planes or in planes that are only carrying cargo (full freighters). The bellies of passenger planes would otherwise be functionless, as it is space in passenger planes that is not used for passengers. It is empty space that shapes the aerodynamic form of the plane and is only partly used for passengers’ luggage (Tretheway and Andriulaitis, 2010). Figure 2-1 gives a cross-sectional view of a full freighter plane and a passenger plane with belly capacity for cargo and luggage of the
passengers.

Dedicated cargo airlines only own and fly with full freighters. Combined passenger and cargo airlines transport freight in the belly of passenger flights and some additionally also in full freighters. About 50% of the air cargo in the world is flown on in full freighters and the other half in the belly of passenger flights. The expectation is that the market share of full freighter cargo and belly cargo will stay constant in the coming 20 years (Boeing, 2014). At AAS full freighter flights account for approximately 60% of all cargo flown and this share has stayed relatively constant over the past years (Traffic Analysis & Forecasts Schiphol Group, 2014). For forwarders space in the belly of passenger airplanes is often cheaper than cargo space in full freighters. Belly cargo space is a subsidiary to the incomes generated from the passengers on the flight. Therefore the charges for the freight carried only need to cover marginal costs. Full freighter flights however offer several advantages over flights with only belly capacity. According to Boeing (2014), Morrell (2011) and Tretheway and Andriulaitis (2010), these advantages are amongst others:

- The schedule and route of freighter flights can be accustomed to the wishes of forwarders and/or shippers, whereas belly flights' schedules and routes are accustomed to the wishes of passengers.
- Large cargo does not fit and dangerous cargo is forbidden on belly flights.
- The reliability of cargo space in full freighter flights is higher than in belly flights. Bellies sometimes have lower capacity than expected, for example if more luggage of passengers gets loaded than was expected.
- The punctuality of a passenger plane is important for its passengers and therefore relatively high. Full freighters may wait for cargo that arrives delayed at the airport of departure, passenger planes with belly capacity will depart according to schedule.

The contract that the forwarder and the airline close both in case a forwarder books belly cargo space and in case the forwarder books full freighter cargo space is called an Airwaybill (AWB) (Burghouwt et al., 2012). The AWB is a standard IATA document. The AWB includes all specifications of the cargo of the forwarder and the cargo space of the airline.

**Transportation of shipment from shipper to airport of departure**

When the AWB is closed and the departure time of the respective flight is known, the forwarder gives a transportation order to a trucking company to pickup the shipment at the shipper and truck it to the airport of departure. There is no standard IATA document for this transportation order (contract between the forwarder and the trucking company). Some forwarders have own trucks and use those for trucking shipments from shippers to airports. Most forwarders hire trucking companies for this. Forwarders try to bundle shipments of various of their customers when hiring trucks to get volume discounts from the trucking companies. They also do the same when procuring cargo space of airlines. Trucking companies try to optimize their truck routes and truck loads by combining transportation orders from various forwarders (and other customers) (Radstaak, 2014). Some trucking companies have warehouses where they temporarily store and consolidate freight to optimize truck loads.

**Direct transportation between shippers/consignees and ground handlers**

There are various places at the airport of departure where the truck of the trucking company may need to deliver a shipment for a forwarder.
The shipment may need to be delivered directly at a so-called cargo ground handler. A ground handler is an organization that is responsible for unloading trucks and loading airplanes in case of export freight (freight departing from an airport) and vice versa for import freight (freight arriving at an airport). Warehouses of the ground handlers are located on the border between airside and landside. This area is called the first line area of an airport. Airside is the area at an airport where the airplanes are moving. To enter airside, persons and cargo need to go to security checks and customs clearance procedures need to take place. Special rules and regulations apply on airside, such as special traffic rules. Landside is the area before the security checks and customs clearance. Because the ground handlers are located on the first line area of AAS, airplanes can line up next to the ground handlers' warehouses on airside on specific cargo airplane platforms. These platforms are a sort of parking places for airplanes with multiple facilities to fuel them, load/unload them, etc. On the other side of the warehouses (on landside) conventional trucks can reach the warehouse of the ground handler without having to go through the security checks and the customs clearance procedure. Generally a cargo ground handler conducts the following activities (Radstaak, 2014, Pieters, 2014, Burghouwt et al., 2012):

- It loads/unloads trucks of forwarders and trucking companies.
- It performs warehouse activities in its warehouse. Trucks carry freight for/from multiple flights on skids (pallets that fit in trucks) and in loose form. Airplanes carry freight from/to multiple trucks in so-called Unit Load Devices (ULDs): standard boxes and plates that have shapes that fit well in the cylindrical shape of an airplane (see Figure 2-2). A ground handler repackages freight from ULDs to skids and vice versa. It also sorts freight from different trucks for one flight and vice versa.
- It transports ULDs between its warehouse and the airplanes (on airside).
- It loads/unloads airplanes with ULDs.

![Figure 2-2: Pictures of Unit Load Devices (ULDs) and a skid](image)

Ground handlers also conduct security checks in their warehouses and they execute the customs clearance procedures. For handling specific types of goods, ground handlers use special facilities. Cooling facilities are for example required to handle fresh fishes and other sorts of perishables. Air cargo is known for its great diversity in type, weight, volume, etc., but the handling process is quite similar for all cargo (van Doorne, 2013). Finally at AAS the ground handlers also facilitate Dutch customs with doing their inspections. Dutch customs does not inspect the shipments of every incoming or outgoing flight at AAS. Partly based on the risk profile of a flight and the shipments it is carrying, customs visits handlers at AAS to inspect specific shipments for example on forbidden goods (Zonneveld, 2014).

Some handlers belong to airlines themselves, others to the airport authorities. Other cargo ground handlers are privately owned and operating and are called third party handlers. Private (third party) handlers have temporary contracts with airlines. This contractual
agreement between a third party ground handler and an airline is called a Standard Ground Handling Agreement (SGHA). This is a standard IATA contract. The contract is closed on average for 2-3 years (Burghouwt et al., 2012). In the SGHA the handler is given the obligation and exclusive right to load all departing airplanes carrying cargo and to unload all arriving airplanes carrying cargo of the specific airline. This is independent from the shipper, forwarder or consignee the goods come from or are for and applies both to full freighters of the airline and to its passenger planes with belly cargo. The fee that the airline pays the handler (per volume or weight entity and per type of good) is included in the SGHA. To make sure that the handler’s handling services are conform a certain level of quality, an additional standard IATA contract is very often closed between the airline and the handler: a Service Level Agreement (SLA). Additionally for each flight separately a so-called Flight Manifest (FFM) is set up by the airline, in which the specific loading/unloading instructions are given to the ground handler (Burghouwt et al., 2012).

Currently there are seven ground handlers at AAS: six third party ground handlers that have contracts with airlines and one ground handler owned and operated by home carrier KLM.

Some trucks carrying shipments from one or multiple shippers are given the order by the forwarder to bring the shipment(s) directly to the ground handlers. The shipment(s) then get delivered at the ground handler(s) on skids or in loose form. In case of export freight this situation also happens. Trucking companies then get the order by forwarders to pick up the shipment(s) at the ground handler(s) and truck it/them directly to the consignee(s). In case of such direct transportation of shipments between the ground handlers and the shippers/consignee, the freight flows and activities are such as visualized in Figure 2-3.

![optional shipment flow at AAS #1](image)

**Figure 2-3:** Visualization of optional shipment flow #1 – flow of skids/loose cargo between handler and shipper/consignee

**Transportation of shipments between shippers/consignees and ground handlers via freight forwarder’s warehouses**

Some shipments are not directly trucked from shippers to ground handlers and from ground handlers to consignees, but via a warehouse of a forwarder. Such warehouses are located on landside, which is called the second line area of the airport. In case of import freight the shipment then passes this warehouse first before it is delivered at a ground handler. In case of export freight the shipment then passes this warehouse before it is delivered at the consignee. The shipment is directly trucked from the shipper to the ground handler or from the ground handler to the consignee if it is large, special, an urgent shipment, etc. Regular shipments often first get trucked to the warehouse of the forwarder. Temporary storage and consolidation of shipments for the same cargo flight and/or ground handler takes place here, before the shipments get trucked to a ground handler or consignee (Radstaak, 2014). The forwarder hereby realizes economies of scale. Apart from realizing economies of scale by storage and consolidation of freight, value added activities sometimes also take place in
forwarders’ warehouses (Hanke, 2012, Schwarz, 2005). The freight flows and activities that are conducted if a shipment is first trucked to a forwarder’s warehouse and subsequently to the ground handler (or vice versa first to the forwarder’s warehouse and then to the consignee) is shown in Figure 2-4.

**Figure 2-4:** Visualization of optional shipment flow #2 – flow of skids/loose cargo between handler and shipper/consignee via forwarder

Sometimes a forwarder has sufficient freight for the same flight to completely fill a Unit Load Device (ULD). When a ULD is completely filled with freight of one forwarder, the ULD is called a BUP (Build Up Pallet). In that case it can let the ground handler fill the BUP, but it can also fill the BUP itself in its own warehouse. Vice versa BUPS that arrive at an airport can be picked up as such at the ground handler and broken off (emptied) in the warehouse of this forwarder. In case a BUP is delivered or picked up at the ground handler by a forwarder, the freight flows and activities that are conducted look like as is represented in Figure 2-5. If a freight forwarder delivers or picks up BUPS at ground handlers, the ground handlers have less activities to carry out. Therefore the airlines need to pay the ground handlers less if freight forwarders deliver/pick up BUPS at the ground handlers. The freight forwarders get discounts on the cargo space they book.

**Figure 2-5:** Visualization of optional shipment flow #3 – flow of skids/loose cargo between forwarder and shipper/consignee and BUP between handler and forwarder

There are some forwarders allowed to deliver BUPs themselves directly to airside. These forwarders’ warehouses are located on landside, but they have access to a special gate to airside. From this gate, ground handlers transport the BUP to the airplane with a special vehicle and load the BUP on the airplane, because forwarders are not allowed to enter airside. These BUPs do not pass the warehouse of a ground handler. Whereas normally security checks and customs clearance takes place in the warehouse of the ground handler, this is now all carried out in the warehouse of the forwarder. Also potential customs inspections take place here. Also in case of import freight this can take place: then the ground handler transports the BUP(s) directly from the airplane to the gate between landside and airside. Forwarders with access to such a gate are located on the so-called ‘1½
line’ area of AAS. In case a forwarder makes use of its 1½ line location, the freight flows and the activities look like as is shown in Figure 2-6.

At AAS approximately 70% of freight is being trucked to and from the so-called ground handlers as loose cargo and cargo on skids, either directly from shippers or via a warehouse of a forwarder or a trucking company (de Wit, 2014). So for 70% of freight (both import and export) the freight flows visualized in Figure 2-3 and Figure 2-4 are representative. Only 20% of all air cargo at AAS is being picked up or delivered as BUPs at the ground handlers (de Wit, 2014). So for 20% of all freight (both import and export) the freight flows visualized in Figure 2-5 are representative. The rest of all air cargo at AAS (10%) gets picked up or delivered directly on airside by on BUPs by a 1½ line forwarder (de Wit, 2014). So for 10% of all freight (both import and export) the freight flows visualized in Figure 2-6 are representative. The overall visualization of freight flows in the AAS air cargo logistics chain is shown in Figure 2-7. As can be seen there is no standard procedure for freight flowing through the AAS air cargo logistics chain.

**Integrators**

Integrators are companies that fully fulfil the functions of forwarders, airlines, ground handlers and trucking companies themselves. They completely carry out the full door-to-
Describing the flow of a single shipment through the AAS air cargo logistics chain is hence cargo logistics chain were explained. The chain and business model of the integrators will not further be elaborated on. Integrators have a low market share at AAS and are not expected to gain significant market shares in the future. They generally concentrate their activities at lower cost (regional) airports (Ritsema, 2014, de Wit, 2014). For a more extensive explanation of the integrators appendix A can be consulted.

2.2 Contractual relationships in the AAS air cargo logistics chain

Figure 2-8 visualizes the contractual relationships between the organizations in the AAS air cargo logistics chain that were explained in the previous section. Flows of money and the exchange of information are also shown. The figure is based on visualizations of the air cargo logistics chain of Burghouwt et al. (2012), Hanke (2012) and Schwarz (2005).

![Diagram of contractual relationships in the AAS air cargo logistics chain]

Figure 2-8: Visualization of relationships in air cargo logistics chain based on visualizations by Hanke (2012), Schwarz (2005) and Burghouwt et al. (2012)

2.3 The overview of freight flows at Amsterdam Airport Schiphol

As said before, there are 7 ground handlers active at AAS. There are also thousands of shippers and consignees, hundreds of forwarders and hundreds of airlines that make use of the airport. In the previous section all optional flows of a shipment through the AAS air cargo logistics chain were explained. It became clear that there are various options; there is no standard procedure for freight flowing through the AAS air cargo logistics chain. Describing the flow of a single shipment through the AAS air cargo logistics chain is hence complex. It is even more complex to describe the totality of freight flows at AAS, as a result
of the seven ground handlers, hundreds of forwarders and airlines and thousands of shippers and consignees that all use multiple options to let their freight flow through this chain at the same time. The basics of this totality of freight flows that gets carried out simultaneously and each day in the AAS air cargo logistics chain must however be understood. That is because this totality of freight flows is the environment of a potential future CPD. The separate flows of shipments combined, not separately, shape its environment. The totality of freight flows will affect the CPD and vice versa.

<table>
<thead>
<tr>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed Unit Load Device (ULD) or Build up Pallet (BUP) (in full ULD)</td>
</tr>
<tr>
<td>Truck picking up Skids/loose cargo at one shipper; trucking it to three ground handlers and a 1½ line forwarder’s warehouse</td>
</tr>
<tr>
<td>Truck picking up Skids/loose cargo at two shippers; trucking it to two ground handlers</td>
</tr>
<tr>
<td>Truck picking up Skids/loose cargo at two shippers; trucking it to two ground handlers and a 1½ line forwarder’s warehouse</td>
</tr>
<tr>
<td>Truck picking up Skids/loose cargo at one shipper designated for two handlers; trucking it to second line forwarder’s warehouse</td>
</tr>
<tr>
<td>Truck picking up Skids/loose cargo at one shipper destined for one handler; trucking it to second line forwarder’s warehouse</td>
</tr>
<tr>
<td>Truck picking up Skids/loose cargo at one shipper, trucking it to second line forwarder’s warehouse</td>
</tr>
<tr>
<td>Truck picking up Skids/loose cargo at one shipper. Truck picking up BUP and loose cargo at second line forwarder’s warehouse; trucking it to two ground handlers</td>
</tr>
<tr>
<td>Truck picking up BUP at second line forwarder’s warehouse; trucking it to one ground handler</td>
</tr>
<tr>
<td>Truck picking up BUP at second line forwarder’s warehouse; trucking it to one ground handler</td>
</tr>
<tr>
<td>Truck picking up BUP at forwarder’s warehouse located on 1½ line area of AAS; trucking it to airside gate</td>
</tr>
<tr>
<td>Truck picking up BUP at one shipper; trucking it to 1½ line forwarder’s warehouse</td>
</tr>
<tr>
<td>Truck picking up BUP at a 1½ line area forwarder’s warehouse; trucking it to one ground handler</td>
</tr>
<tr>
<td>Special airside vehicle of ground handler transporting a BUP [of a 1½ line forwarder] from airside gate to airplane</td>
</tr>
</tbody>
</table>

Figure 2-9: Helicopter view visualization of totality of export freight flows in AAS air cargo logistics chain

To understand this totality of freight flows and thereby be able to understand the environment of a potential future CPD at AAS, helicopter view visualizations have been made. To decrease the complexity and make the helicopter views better understandable, the reality had to be simplified on some points. Some freight flows were also left out, such as the flows of transfer cargo to and from other European cargo airports. Moreover, different helicopter view visualizations have been made for the totality of import freight flows and the totality of export freight flows at AAS as a result of air cargo. This was also
done to make the visualizations more understandable, but in reality these flows happen simultaneously and so should be represented in the same visualization. The helicopter view visualization of the export freight flows can be found in Figure 2.9 and the helicopter view visualization of the import freight flows in Figure 2.10.

![Helicopter view of import flows of goods at AAS](image)

**Figure 2.10: Helicopter view visualization of totality of import freight flows in AAS air cargo logistics chain**

### 2.4 Conclusions of the AAS air cargo logistics chain explained

If air transportation is used for part of the transportation of a shipment from a shipper to a consignee, multiple organizations are involved. Multiple organizations are active in the AAS air cargo logistics chain that have different mutual contractual relationships, other responsibilities and liabilities over freight and carry out various activities. Freight forwarders are usually made responsible by the shippers and consignees for the full door-to-door transportation from shipper to consignee. Freight forwarders outsource air transportation to cargo airlines and road transportation to trucking companies. There are seven cargo ground handlers active at AAS that are responsible for transshipping freight from airplanes to trucks.
and vice versa. One of the cargo ground handlers is part of home carrier KLM Cargo. The other six ground handlers are privately operating. Other cargo airlines outsource their transshipping activities to these so-called third party ground handlers. Figure 2-8 visualizes the mutual contractual relationships between these organizations.

The flow of a single shipment through the AAS air cargo logistics chain was described in section 2.1. Shipments can flow in various ways through this chain. That is because different activities may need to be performed for different shipments and because different types of organizations may carry out the same activities. Because of the various options for shipments to flow through the chain, the web of total freight flows at AAS is complex. Figure 2-9 and Figure 2-10 show this complexity. Figure 2-11 shows the most important activities that are carried out in the AAS air cargo logistics chain (and in other air cargo chains) and shows what type of organizations may carry out these activities. In the rest of the report the terminology in Figure 2-11 is used to indicate the different activities.

![Diagram of activities versus organizations scheme AAS air cargo logistics chain](image)

Figure 2-11: Activities versus organizations scheme AAS air cargo logistics chain

**BUP/ULD airside transportation and airplane (un)loading** is always done by ground handlers on the restricted airside area of AAS.
Ground handlers only carry out **BUP transhipment** for freight forwarders that are located on the second line area of AAS and build up/ break down BUPs themselves. These freight forwarders build up/ break down their BUPs themselves, but let ground handlers temporary store the BUPs in their warehouses and optionally also carry out security checks and customs clearance procedures (= **BUP transhipment**).

Ground handlers traditionally carry out **BUP build-up and breakdown**. However, both freight forwarders on the second line area and on the 1½ line area of AAS have taken over this activity of the ground handlers. **BUP build-up and breakdown** includes loading/unloading the BUPs and conducting security checks, customs clearance procedures and temporary storing freight.

Only cargo ground handlers provide **ULD build-up and breakdown**. This includes loading/unloading the ULDs with freight of multiple freight forwarders and conducting security checks, customs clearance procedures and temporary storing freight.

**Destination (de)consolidation & value added activities** are only carried out by freight forwarders in their warehouses on the second and 1½ line and second line area. It includes the consolidation and deconsolidation of shipments of various shippers and consignees so that cargo space on trucks and airplanes can be acquired more efficiently and routes can be optimized. For some customers, value added activities are carried out.

Trucking companies traditionally provide **road transportation to/from/at AAS**, but some freight forwarders have their own trucks as well.
PART II: DESIGN DIRECTIVES
3 Literature study towards critical design variables

The aim of this research is to develop an integrated high-level design for the proposed Central Pickup and Drop-off point for air cargo at Amsterdam Airport Schiphol. To develop such a design it needs to be known which design variables have a critical influence on the functioning of the CPD. The high-level CPD design shall describe the design of these variables.

Various researchers emphasize the importance of non-technological and non-logistical design variables for the functioning and thereby successful implementation of a freight consolidation centre (Veenstra et al., 2012, Konings et al., 2013, van Binsbergen et al., 2013, Zhou and Wang, 2014). Researchers however do not mention which variables exactly have a critical influence on the functioning of freight consolidation centres, such as the potential future CPD at AAS. This chapter is therefore aimed at determining which design variables have a critical influence on the functioning of the potential future CPD at AAS.

Research sub question 1: Which design variables have a critical influence on the functioning of the potential future CPD at AAS?

In some researches towards the design of specific FCCs or in evaluations of specific FCCs, lists of important aspects in those specific cases can be found. A literature review is therefore carried out in sections one to three to become known with as many of such lists. These lists are brought together in section four. An overall list is composed of unique aspects that were important for specific FCCs in the different case studies. It is analyzed which of these aspects are actual design variables and which are other kind of aspects of design or implementation. With the design variables an influence diagram as described by Howard and Matheson (2005) is set up to find the mutual relations between the unique design variables. Based on the mutual influences that the variables have on each other, it is determined which variables are critical for the functioning of a freight consolidation centre. These are the variables that have the most influence on the design of other variables and are least influenced by other variables. The conclusions about the critical design variables of a CPD at AAS were validated in an expert interview with dr. J.W. (Rob) Konings, senior researcher freight transport at the OTB department of the TU Delft (Konings, 2014) and presented in section five.

Only comparable freight consolidation centres should be studies. To assess whether a freight consolidation centre is comparable to the potential CPD at AAS, the different types of logistical environments (sites or areas) that freight consolidation centres can serve should be understood. The different types of logistical environments are explicated in Figure 3-1.

The environment that the CPD at AAS will serve (the AAS air cargo logistics chain) is the third type of logistical environment. This is an environment in which multiple senders and receivers are present and inter environment freight flows take place (freight flows between different senders or receivers of freight in the area or at the site the freight consolidation centre serves). At AAS multiple ground handlers are present and trucks also drive with freight between these ground handlers. Studies of other FCCs that serve the third type of logistical environment from Figure 3-1 are hence consulted in sections one to three.
3.1 Air cargo consolidation centres

Only two comparable air cargo consolidation centres are known: the Finnish ASR Cargo centre and the Baraki City Cargo Terminal. Because more than 70% of air cargo from, to and via Finland is being trucked under Airwaybill by or on behalf of the airlines, much air cargo in Finland does not actually pass an airport. Hence, the ASR Cargo centre does not specifically serve one (large) airport, but is focused on improving the cost effectiveness of total air cargo trucking to/from/via Finland (ASR Cargo Center, 2014). No studies are available about the design, functioning and/or implementation of the ASR Cargo centre. The Baraki City Cargo
Terminal is an air cargo consolidation centre that serves the international airport of Tokyo (Mok, 1994). No literature has been written specifically about the design or implementation of the Baraki City Cargo Terminal. However, two decades ago an extensive design study was done by Mok (1994) about the potential development of an air cargo consolidation centre for the Hong Kong International Airport. In this study he analyzed the design and functioning of the Baraki City Cargo Terminal. Similarly to the proposed CPD at AAS, the objectives of this consolidation centre for the airport of Hong Kong were to reduce the need for space by ground handlers on the first line area of the airport and to reduce truck movements at and around the airport (Mok, 1994). Mok (1994) composed a list of most important aspects for a conceptual design for an air cargo consolidation centre serving the Hong Kong International Airport. These aspects are listed below.

- The proximity of the facility to the Hong Kong International Airport
- The responsibility for the operations in the facility
- The activities performed in the consolidation centre
- The setup of the link between the facility and the airport via road transportation (for example: type of vehicles, frequency, etc.)
- The way in which documentation and charging is setup

The study of Mok (1994) is the only available design study about air cargo consolidation centres.

### 3.2 Urban consolidation centres

An urban consolidation centre (UCC) refers to a central pickup and drop-off location for goods. A UCC can serve specific sites, such as shopping centres, or entire urban areas such as large cities. It is located at some distance from the site it serves. An urban consolidation centre makes sure that trucks do not have to visit the (often) congested sites anymore. Trucks can deliver freight for multiple receivers at the UCC or pick up freight from multiple senders. Transportation of freight between the urban consolidation centre and the site it serves is carried out with vehicles that can realize high average vehicle loads because of the consolidation of freight in the UCC. Thereby the site gets visited with fewer trucks than before (BEST Urban Freight Solutions, 2008, Browne et al., 2005, Allen et al., 2012, Lewis et al., 2010). An urban consolidation centre is considered comparable to potential future CPD at AAS. Generally UCCs also serve the third type of logistical environment from Figure 3-1.

An extensive literature review and field study about urban consolidation centres was conducted by Browne et al. (2005). In total 67 urban consolidation centres, built between 1970 and 2005 in Canada, Europe, Japan and the United States were analyzed. Browne et al. (2005) researched the influence of a different UCC designs on the functioning of the UCC. To do so Browne et al. (2005) listed the aspects that most characterize the nature of an urban consolidation centre. These aspects are listed below.

- Objectives of a UCC
- Distance from UCC to delivery area
- Spatial coverage
- Range and type of products handled
- Transport modes utilized
- Range of services provided
- Flexibility of operations (for example fixed delivery schedules or on demand)
- Ownership and operation of UCC
- Finance issues, particularly the nature of any financial support
- Responsibility for transport operations
- Degree of permanency of the centre and its operations
- Role of local authorities and other public sector bodies
- Compulsory or voluntary for users of the UCC
- Freestanding initiative or incorporated into the wider policy or regulatory framework of an urban area or region

Other extensive researches towards urban consolidation centres were carried out by BEST Urban Freight Solutions (BEST Urban Freight Solutions, 2005, BEST Urban Freight Solutions, 2008), a European think tank for urban freight problems. In one of these studies the main design issues when planning to develop an urban consolidation centre were mentioned. These main design issues are listed below (BEST Urban Freight Solutions, 2008).

- Participation of interested parties
- Proximity of the urban consolidation centre from the delivery area
- Management structure
- Products handled
- The operation of the UCC
- Funding

Other researches towards urban consolidation centres do not contain lists of important characteristics or planning issues of UCCs, such as the ones derived from Browne et al. (2005) and BEST Urban Freight Solutions (2008).

### 3.3 Sea freight consolidation centres for barges

With respect to the hinterland transportation from and to large seaports, such as the harbour of Rotterdam, similar problems to the expected future problems at AAS can be recognized.

- The creation of more capacity in these seaports has become difficult because of space shortage (and other physical and non-physical limitations to site expansion) (Slack, 1999, Rosa and Roscelli, 2009, Roso and Lumsden, 2009).
- Because of the larger freight volumes in these seaports congestion has grown for the vehicles carrying out hinterland transportation. As a result the accessibility of the seaports has decreased and dwell times for freight in these ports increased (Roso et al., 2009, Roso and Lumsden, 2009, Konings et al., 2013).

Over the past years several types of consolidation centres that have similarities to a CPD at AAS have been initiated (and some have been developed) to solve the above-mentioned problems in large seaports. Examples of such initiatives are satellite terminals (Slack, 1999), extended gates (Veenstra et al., 2012), barge hub terminals (Pielage et al., 2007) and dry ports (Roso and Lumsden, 2009). Because hinterland transportation from and to AAS differs from hinterland transportation from and to seaports, only some of such consolidation centres are comparable to a CPD at AAS.

- Hinterland transportation to and from large seaports, such as the port of Rotterdam, generally takes place via three different modalities: road, rail and inland waterways. Dependent on the harbour the shares of these different modalities of the total hinterland transportation differ (Roso and Lumsden, 2009, Konings et al., 2013). Hinterland transportation to and from AAS only takes place via the road.
- Trucks and trains carrying out the hinterland transportation to and from seaports generally do not need to visit multiple terminals in a seaport (van Der Horst and de Langen, 2008). Inland barges carrying out the hinterland transportation to and from...
seaports often do need to visit multiple terminals, just as trucks visiting AAS need to visit multiple ground handlers (Konings, 2007).

- Sea freight and its hinterland transportation is almost fully containerized. Both the deep sea vessels and the trucks, trains and barges carrying out hinterland transportation can carry these same containers (van Der Horst and de Langen, 2008). In case of air cargo airplanes are loaded with Unit Load Devices (ULDs), whereas trucks generally carry freight on wooden pallets (skids) (Radstaak, 2014). Cargo needs to be repackaged in between carriage by planes and by trucks.

Consolidation centres that were set up for solving problems with hinterland transportation to and from seaports via road and rail differ in two major ways from a potential future CPD at AAS. Firstly no repackaging of freight needs to take place in these centres, because of the containerization in the sea freight industry. Secondly in such consolidation centres no mixing or splitting up of freight from/to different senders or receivers needs to take place. All trucks and trains (generally) deliver or pick up freight at one terminal in the seaport. FCCs for trucks and trains serving seaports serve the first or second type of logistical environment from Figure 3-1. Studies about these types of FCCs are hence not studied.

When looking at (initiatives for) consolidation centres that were set up to solve problems with the hinterland transportation via barges to and from seaports, more similarities to a potential CPD at AAS can be recognized. A difference remains that the deep sea vessels and the inland barges carry the same containers, whereas airplanes and trucks carry freight that is differently packaged. A similarity is however that barges often need to visit multiple container handling terminals in a seaport when delivering or picking up freight. There are for example approximately 30 container handling terminals in this harbour (Notteboom and Konings, 2004) and inland barges often need to call at multiple terminals when they visit the harbour (Konings, 2007). In a freight consolidation centre for inland barges at a seaport, freight for and from different senders and receivers needs to be split up and mixed. Barges carry freight for/from multiple terminals, just like trucks at AAS carry freight for/from multiple ground handlers. Figure 3-2 illustrates this. FCCs for inland barges in a seaport serve the third type of logistical environment from Figure 3-1 and are therefore comparable to a CPD at AAS.

![Diagram of seaport and hinterland](image_url)

Figure 3-2: Typical transport operations of a barge vessel carrying out hinterland transportation from/to the harbour of Rotterdam as derived from Notteboom and Konings (2004)

Researches towards potential consolidation centres for inland barges in the harbour of Rotterdam were done by Notteboom and Konings (2004), Konings (2007), Pielage et al. (2007), Froeling (2008) and Konings et al. (2013). For the inland barges it would become able to pick up and deliver freight from/to multiple container handling terminals at this consolidation centre. Containers would be transported between the terminals and the
consolidation centre with a shuttle service. Konings et al. (2013) visualized how such a consolidation centre would influence the freight streams via the inland barges in the harbour of Rotterdam. This visualization is can be found in Figure 3-3. It can be recognized that such a consolidation centre will have a similar influence on the freight streams via the inland barges in the harbour of Rotterdam as a CPD is supposed to have on the freight streams via truck at Amsterdam Airport Schiphol.

![Diagram](image)

**Figure 3-3**: Transformation of current barge operations into hub-and-spoke network via central collection/distribution terminal as derived from Konings et al. (2013)

In researches towards potential freight consolidation centres for inland barges important design variables of the facilities are not explicitly mentioned. Many researches are conducted from a logistical point of view and do not take into account for example organizational and financial design issues. From a logistical point of view the following design variables are considered to be of high importance (Pielage et al., 2007, Froeling, 2008, Konings et al., 2013):

- The proximity of the consolidation centre to the container handling terminals
- The setup of the shuttle service
- The services offered in the consolidation centre

Moreover Pielage et al. (2007) mention that the setup of a model of costs and gains sharing for a freight consolidation centre for inland barges serving a seaport has a critical influence on its functioning.
3.4 Connection of findings from studies about different consolidation centres

Various researches towards specific freight consolidation centre(s) that all serve the third type of logistical environment from Figure 3-1 were studied. The studied researches include design studies and design evaluations of urban consolidation centres, consolidation centres for inland barges serving seaports and air cargo consolidation centres. In these researches different (design) aspects were named as being important for the functioning of the specific FCC(s). All these aspects are listed in Table 3-1. Aspects from the different studied researches that are considered similar are highlighted with the same colour. There are 19 unique important aspects for the functioning of a freight consolidation centre that serves a similar logistical environment as the AAS air cargo logistics chain.

Table 3-1: Overview of important design variables mentioned in literature about relevant consolidation centres

<table>
<thead>
<tr>
<th>Type</th>
<th>Air cargo consolidation centres</th>
<th>Urban consolidation centres</th>
<th>Seaport consolidation centres for inland barges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Konings et al. (2013), Froeling (2008) and Pielage et al. (2007)</td>
</tr>
<tr>
<td>Important design variables</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>mentioned</td>
<td>• Objectives of a UCC</td>
<td>• Participation of interested parties</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The proximity to site it serves</td>
<td>• The proximity to site it serves</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Spatial coverage</td>
<td>• Range of services offered</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Range and type of products handled</td>
<td>• The setup of shuttle service</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Transport modes utilized</td>
<td>• Management structure</td>
<td></td>
</tr>
<tr>
<td>• The proximity to site it serves</td>
<td></td>
<td>• Ownership</td>
<td></td>
</tr>
<tr>
<td>• Responsibility for the operations</td>
<td></td>
<td>• Responsibility for the operations</td>
<td></td>
</tr>
<tr>
<td>• The activities performed</td>
<td>• The setup of shuttle service</td>
<td>• Products handled</td>
<td></td>
</tr>
<tr>
<td>• The setup of the shuttle service</td>
<td></td>
<td>• The operations</td>
<td></td>
</tr>
<tr>
<td>• Setup of documentation and charging</td>
<td>• Finance issues</td>
<td>• Funding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Responsibility for shuttle service</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Degree of permanency</td>
<td></td>
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<td></td>
<td>• Role of local authorities</td>
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<tr>
<td></td>
<td>• Compulsory or voluntary for users</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Freestanding initiative or incorporated into wider policy</td>
<td></td>
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</tr>
</tbody>
</table>

To determine the critical design variables of a potential future CPD at AAS, the findings of this literature study (schematically represented in Table 3-1) were used to set up an
influence diagram as described by Howard and Matheson (2005). Figure 3-4 shows the influence diagram. The influence diagram was set up in two steps.

1. Dependent on the nature of the 19 unique important aspects from Table 3-1 each aspect was categorized as design variable or policy consideration. An aspect is considered a design variable if the functioning of a FCC (such as the CPD) is expected to get directly influenced by a different setup of the aspect. Otherwise an aspect is considered a policy consideration with no or indirect influence on the functioning of the FCC.

The mutual influences that the design variables have on each other were assessed. Many design variables influence the setup of other design variables. Many design variables also influence and get influenced by the same other variable. Only in case of a strong influence of one variable on another variable with a significantly weaker reverse influence, the influence was incorporated into the influence diagram. All incorporated influences are explained in Table 3-2. The definition of the six critical design variables for the CPD at AAS is therefore considered reliable.

![Influence Diagram Design Variables]

**Figure 3-4: Influence diagram design variables**

Legend:
- Critical design variable
- Non-critical design variable
- Policy considerations
- Influence
The more a variable has influence on how other variables can be/will be designed and the less it is influenced itself by how other variables are designed, the higher is its influence on the functioning of a freight consolidation centre such as a CPD at AAS. By setting up the influence diagram in Figure 3-4 design variables with a critical influence on the functioning of the potential future CPD were found. These critical design variables are listed below.

- The proximity of the CPD to AAS
- The level of obligation or stimulus for usage of the CPD
- The range of services offered in the CPD
- The ownership of the CPD
- The responsibility for operating the CPD
- The model of costs and gains sharing

The sketched influences between the different design variables are subject to the interpretation of the researcher. The results of the influence diagram (the six critical design variables that are listed above) are however considered to be robust against some adaptations in the influence diagram. The definition of the six critical design variables for the CPD at AAS is therefore considered reliable.

Table 3-2: Explanation of influence diagram

<table>
<thead>
<tr>
<th>#</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The participation of interested parties is an umbrella term that contains among other aspects how the management structure is set up.</td>
</tr>
<tr>
<td>2</td>
<td>A management structure must be set up in a way that the future owner of the facility will agree with.</td>
</tr>
<tr>
<td>3</td>
<td>The participation of interested parties is an umbrella term that contains among other aspects what organization(s) will become owner of the facility.</td>
</tr>
<tr>
<td>4</td>
<td>A management structure must be set up in a way that the organization(s) becoming responsible for the operations agree(s) with.</td>
</tr>
<tr>
<td>5</td>
<td>The way that new costs and gains that come with the development of a freight consolidation centre are shared determines how these costs can be charged.</td>
</tr>
<tr>
<td>6</td>
<td>The participation of interested parties is an umbrella term that contains among other aspects what organization(s) will become responsible for the operations in the FCC.</td>
</tr>
<tr>
<td>7</td>
<td>If a FCC is made compulsory or stimulated in another way the amount of users will be larger. More users inside and outside the site/area the FCC serves will mean a higher spatial coverage.</td>
</tr>
<tr>
<td>8</td>
<td>If a FCC is made compulsory or stimulated in another way the amount of products that will flow through the facility from organizations inside and outside the site/area that the FCC serves will be larger.</td>
</tr>
<tr>
<td>9</td>
<td>Dependent on which organization(s) will become responsible for operating the facility, different organizations will be involved in the charges and documentation as a result of the FCC.</td>
</tr>
<tr>
<td>10</td>
<td>If different services get offered in the CPD, different services will need to get charged and documented.</td>
</tr>
<tr>
<td>11</td>
<td>If the FCC is located far away from the site it serves, the FCC may not be suitable for senders and receivers that are located closer to the specific site and so its spatial coverage may be lower.</td>
</tr>
<tr>
<td>12</td>
<td>When different services get offered in the CPD, different organizations may become interested in making use of it both inside and outside the area/site it serves.</td>
</tr>
</tbody>
</table>
Only services for specific types of products may be offered in the facility, making the FCC not suitable for some organizations inside and outside the site/area it serves.

The shuttle service will need to connect to the operations in the CPD that are carried out by the responsible organization(s).

A setup of a shuttle service includes among other aspects the responsibility for it.

A setup of a shuttle service includes among other aspects the transport modes utilized.

Some transport modes are better suitable for larger and others for smaller distances.

### 3.5 Conclusion of literature study towards critical design variables

In this literature analysis studies about air cargo consolidation centres, urban consolidation centres and sea freight consolidation centres for inland barges were analyzed. These are all freight consolidation centres that serve the third type of logistical environment from Figure 3-1, just like a CPD at AAS is supposed to. In the different studies various important aspects for the functioning of the specific freight consolidation centres were mentioned. These aspects were analyzed in a structured way by setting up an influence diagram and thereby the critical design variables of a CPD at AAS were found. These are listed below.

- The proximity of the CPD to AAS
- The level of obligation or stimulus for usage of the CPD
- The range of services offered in the CPD
- The ownership of the CPD
- The responsibility for operating the CPD
- The model of costs and gains sharing

The findings were validated in an expert interview with dr. J.W. (Rob) Konings, senior researcher freight transport at the OTB department of the TU Delft (Konings, 2014). Also in the interpretation of Konings (2014) these design variables can be considered the ones with critical influence on the functioning of a CPD at AAS. Hereby answer is given to the sub research question below.

**Research sub question 1:** Which design variables have a critical influence on the functioning of the potential future CPD at AAS?
4 The AAS air cargo logistics chain system analyzed

In the previous chapter the critical design variables of a potential future CPD at AAS were defined. To develop an implementable high-level CPD design, these critical variables need to be designed in such a way that the CPD will have the ability to function in its environment: the AAS air cargo logistics chain. Knowledge is required about the demands and limitations that the AAS air cargo logistics chain imposes to the CPD design and functioning.

The environment or surrounding of the CPD can be subdivided into two sub-environments, although they influence each other and in some aspects are overlapping:

1. The “harder” environment, in other words system environment. One can think of for example physical or legal aspects of the chain.
2. The “softer” environment, in other words actor-environment. Hereby the actors in the chain with different interests, behaviour, rights, resources, etc. is meant.

This chapter contains the analysis of the “harder” environment (the system-environment) and it describes how this system-environment imposes demands and limitations to the CPD design and functioning. Thereby the second sub research question is answered.

Research sub question 2: What is the influence of the system-environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?

The first section of this chapter describes how the system-environment of the potential future CPD imposes requirements to the design features of the facility. The second section of the chapter describes what objectives of and constraints to the CPD come from the system-environment. Objectives of and constraints to the CPD come from the system-environment, because the aim of the CPD is to serve the whole chain and not merely Schiphol Cargo or another organization. The third section contains the conclusions of this chapter.

The system-environment of the potential future CPD at AAS is extensively analyzed. The system is analyzed with a literature review, market studies, a field research and more than 20 in-depth interviews. The in-depth interviews were mainly held to expand the knowledge derived from the literature review, market studies and field research with more in-depth information. Appendix G describes how the in-depth interviews were prepared and set up. A report was made of each in-depth interview and the interviewees approved all reports. These approved interview reports can be found in appendix T.

The system is analyzed by making use of the engineering design approach as described by Dym and Little (2009). According to Dym and Little (2009) the influence of an environment on the design of a project or organization can be translated into objectives of and constraints and requirements to the design:

- Requirements are required features of the design.
- Objectives are desired goals that the project or organization should achieve. In this case these goals come from the perspective of the system-environment.
- Constraints are threshold values of the objectives (minimum or maximum values).

The full analysis of the system-environment can be found in appendix E. In this appendix it is extensively explained how and why the different objectives of and constraints and requirements to the CPD design follow from the system-environment of the CPD.
4.1 Requirements to the CPD design from its system-environment

By analyzing the system-environment extensively several requirements to the CPD design are formulated (see Table 4-1). These required design features are of legal, physical and other natures. A future CPD design must comply with these requirements to be able to function in the AAS air cargo logistics chain from a system-perspective. For an extensive explanation of these requirements to the CPD design appendix E can be consulted.

Table 4-1: Requirements to the CPD design from its system-environment

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Requirement</th>
<th>Explanation/sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Functional requirement</td>
<td>The CPD design shall make sure that 3 million tonnes of cargo can be handled at AAS in 2030.</td>
<td>An annual cargo volume of 3 million tonnes is forecasted for 2030 (Nieuwsblad Transport, 2014).</td>
</tr>
<tr>
<td>2</td>
<td>Non-functional requirement</td>
<td>The CPD design shall make the CPD robust against uncertainty in future cargo volumes at AAS.</td>
<td>History has shown that cargo volumes at AAS are difficult to predict (de Wit, 2014, van Doorne, 2013, Algemene Rekenkamer, 1999).</td>
</tr>
<tr>
<td>3</td>
<td>Functional requirement</td>
<td>The CPD design will make sure that the weekly peaks in cargo volumes at AAS belonging to a yearly cargo volume of 3 million tonnes can be adequately handled.</td>
<td>On a weekly basis there are significant peaks and lows in air cargo volumes at AAS, because shippers and consignees close during the weekends (Ankersmit, 2013, de Wit, 2014, Pieters, 2014, van Doorne, 2013).</td>
</tr>
<tr>
<td>4</td>
<td>Non-functional requirement</td>
<td>The CPD shall treat all organizations from the AAS air cargo logistics chain fairly and equally.</td>
<td>Schiphol Group may not misuse its dominant economic position over aviation activities as exploiter of AAS (Overheid.nl, 1992, The Council of the European Communities, 1992) and the activities in a CPD are closely linked to aviation activities (Nederlandse Mededingingsautoriteit, 2010).</td>
</tr>
<tr>
<td>5</td>
<td>Non-functional requirement</td>
<td>If the exploitation of the CPD is set up as an aviation activity it will be financed only with incomes from aviation activities. If the exploitation of the CPD is organized as a non-aviation activity it will be financed only with incomes from non-aviation activities.</td>
<td>Only the direct costs related to the exploitation of aviation activities may be charged to the respective users of the airport (Overheid.nl, 1992) and the activities in a CPD are closely linked to aviation activities (Nederlandse Mededingingsautoriteit, 2010).</td>
</tr>
<tr>
<td>6</td>
<td>Non-functional requirement</td>
<td>The CPD shall not harm the full open market regime for cargo ground handling at AAS.</td>
<td>forbidden according to European Directive 96/97/EC on Ground Handling Services (Burghouwt et al., 2012).</td>
</tr>
<tr>
<td>7</td>
<td>Non-functional requirement</td>
<td>The introduction of the CPD shall not lead to additional interfaces between organizations with no contractual relationships.</td>
<td>In the AAS air cargo logistics chain an interface between two organizations with no contractual relationship has shown to lead to inefficiencies. This was mentioned during the interviews (appendix G) and in other researches (de Wit, 2014, Pieters, 2014).</td>
</tr>
</tbody>
</table>
4.2 Objectives of and constraints to CPD from its system environment

Schiphol Cargo, as initiator of the potential future CPD, is not merely the organization that should profit from the facility. The aim is that the chain as a whole benefits from the introduction of a CPD. The CPD should at least resolve the expected future capacity shortages of the AAS air cargo logistics chain as a whole and if possible contribute to the environment even more. Therefore objectives of and constraints to the CPD from the perspective of the system-environment are set up. These are shown in Table 4-2. Appendix E fully describes how these objectives and constraints are found/set up.

Table 4-2: Objectives of and constraints to CPD from its system environment

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Objective/constraint</th>
<th>Explanation/sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Medium objective</td>
<td>The minimization of first line area needed for ground handling facilities at AAS.</td>
<td>The less first line area is needed to handle 3 million tonnes of cargo annually, the higher is the growth potential of the AAS air cargo logistics chain with the limited amount of first line area available.</td>
</tr>
<tr>
<td>1</td>
<td>Constraint</td>
<td>A maximum of 200,000 m$^2$ of first line area shall be occupied by ground handling facilities at AAS.</td>
<td>The future area development plans of AAS are described in the Masterplan of Schiphol Group (Schiphol Group, 2012, Schiphol Group, 2014b). In this plan a maximum of 200,000 m$^2$ of first line area is reserved for the warehouses of the cargo ground handlers (Ramaaker, 2012, van Doorne, 2013).</td>
</tr>
<tr>
<td>2</td>
<td>Weak objective</td>
<td>The minimization of second line area needed for the potential CPD.</td>
<td>The more second line area is needed, the more difficult it is to find a suitable space for the CPD and the complexity of constructing, maintaining and operating it may rise (Ritsema, 2015a).</td>
</tr>
</tbody>
</table>

4.3 Conclusions of the AAS air cargo logistics chain system analyzed

In this chapter the system-environment of the potential future CPD at AAS is analyzed by making use of the engineering approach of Dym and Little (2009). Several requirements to the CPD design are set up. If the CPD does not comply with these required design features, the CPD will not be able to function in the AAS air cargo logistics chain. The requirements to the CPD design that come from the system-environment of the facility are listed in Table 4-1. Moreover objectives of and constraints to the CPD from the perspective of the system-environment are formulated and listed in Table 4-2. The objectives are set up, because the aim is that not merely Schiphol Cargo, but the whole AAS air cargo logistics chain will benefit
from the CPD introduction. The most important objectives from the perspective of the system-environment of the CPD are the minimization of first line area needed for ground handling at AAS and the minimization of truck movements for air cargo at the AAS area. One constraint (threshold value of an objective) was also formulated. No more than 200,000 m² of first line area at AAS may be occupied in the future for cargo ground handling facilities. That is because this is the amount of first line area that is reserved in the Masterplan of Schiphol Group (Ramaaker, 2012, van Doorne, 2013, Schiphol Group, 2014b, Schiphol Group, 2012).

Hereby an answer is given to the second research sub question.

Research sub question 2: What is the influence of the system-environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?
5 Analysis of the actors in the AAS air cargo logistics chain

The critical design variables of a potential future CPD, which were found in an earlier chapter, need to be designed in such a way that the CPD will have the ability to function in its environment. The ability of the CPD to function in the environment is influenced by the setup of the “harder” environment, or system-environment. This influence was described in the previous chapter. The “softer” environment of the potential future facility however also influences its ability to function in the AAS air cargo logistics chain.

This chapter contains the analysis of the actor-environment and it describes how this actor-environment imposes demands and limitations to the CPD design and functioning. With the actor-environment the actors in the chain with different interests, rights, resources, etc. are meant. The influence of the actor-environment on the possibilities to set up a CPD design is evaluated and thereby the third research sub question is answered.

Research sub question 3: What is the influence of the actor-environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?

Different steps are conducted in the analysis of the actor-environment. In the first section the importance of (soft) core values of the organizations in this chain on the ability of a CPD to function at AAS is explicated. In the second section a division is made between core players and serving parties in the chain. It is explained that the core players are directly related to the transportation of freight via AAS and that therefore these organizations are most important. In section three the most important actors among the earlier defined core players for the functioning and the performances of the chain (and the CPD) are determined. To do so, different actor-analysis tools as described by Enserink et al. (2010) are used. In this section objectives of and constraints and requirements to the CPD from the perspective of the critical actors are formulated. Moreover important core values of the critical actors are defined, because of the earlier mentioned importance of such soft factors on the ability of a CPD to function in the chain. The fourth section describes important historical and potential future power changes in the chain between different types of organizations. The fifth section of this chapter contains the most important conclusions.

The actor-environment of the potential future CPD at AAS is extensively analyzed. The actor-environment is analyzed with a literature review, market studies a field research and more than 20 in-depth interviews. The in-depth interviews were mainly held to expand the knowledge derived from the literature review, market studies and field research with more in-depth information. Appendix G describes how the in-depth interviews were prepared and set up. A report was made of each in-depth interview and the interviewees approved all reports. These approved interview reports can be found in appendix T.

5.1 Importance of (soft) core values of the actors

The engineering design approach as described by Dym and Little (2009) can be used to find the direct influence of the actor-environment on the design and functioning of a potential CPD at AAS. According to Dym and Little (2009) the influence of an environment (such as the actor-environment) on the design of a project or organization can be translated into objectives of and constraints and requirements to the design:

- Requirements are required features of the design.
- Objectives are desired goals that the project or organization should achieve. In this case these goals come from the perspective of the system-environment.
- Constraints are threshold values of the objectives (minimum or maximum values).
With these requirements, objectives and constraints the influence of the actor-environment is translated into relatively hard criteria. However, in different researches and during interviews it was mentioned that the influence of projects on soft values of the actors may not be underestimated (Ploumen, 2014, Ankersmit, 2013, Pieters, 2014). In history various projects in this chain faced complexities during implementation or could not be implemented because of a mismatch between the project and the beliefs and/or cultures of the organizations. Also projects that had very positive (expected) results on the performance of the chain and its separate actors and thereby well contributed to objectives faced such complexities (Ankersmit, 2013, Pieters, 2014).

Whether a CPD design is acceptable for an organization and therefore whether a CPD design will have the ability to function in the AAS air cargo logistics chain also heavily depends on the influence it has on the organization’s (soft) core values. Core values are fundamental beliefs that give guidance to organizations. Core values influence the opinions of organizations about policies and projects (Rokeach, 1973). An example of a core value of an organization could be environmental friendliness. Hence, it is important to research the core values of the different organizations in this chapter, so that the influence of potential CPD designs on these core values can be assessed in a later phase of the research.

5.2 Core players versus serving parties of the chain

All the different parties that are active in or around the air cargo logistics chain at AAS are directly or indirectly serving the shippers and consignees. The shippers and consignees are the real generators of freight traffic. Shippers and consignees produce goods and trade these products with each other. As a result, shipments need to be transported from one place to another. In case for whatever reason (part of) this journey needs to be carried out via the air, an air cargo logistics chain is being used. Many different kind of organizations are involved in the air cargo logistics chain. They all have different roles. These actors are extensively analyzed in appendix F. By analyzing every actor specifically, individually and independent from the other actors it has become clear that a distinction can be made between two types of actors. Before individual actors and their importance for the CPD design will be addressed later in this chapter, this distinction between two types of actors and the importance of it for the development of a CPD design is explained.

1. The core players. The core players are the actors that carry out the economic activities at and around AAS that are directly related to the transportation of a shipment from a shipper to a consignee via Amsterdam Airport Schiphol. Organizations belonging to the core players physically touch shipments.

2. The serving parties. These organizations do not carry out any economic activities that are directly related to the transportation of shipments. The serving parties serve the core players with carrying out their activities. The serving parties are not directly involved with transportation of shipments. They don’t touch shipments.

Both the core players and the serving parties are of importance for the functioning of the chain. Difference is however that the influence of the core players is directly decisive for the chain’s performances, whereas the serving parties have an indirect influence. To get a better feeling for this, Figure 5-1 should be analyzed. Figure 5-1 is a simplification of the network diagram in the appendix F.
Figure 5-1: Simplified network diagram AAS air cargo logistics chain

Some actors in Figure 5-1 are displayed in orange as a critical or semi-critical actor. Later in this chapter it will be explained what this means and why some actors are considered to be a critical (or semi-critical) and others not.

It can be recognized in Figure 5-1 that the core economic activities of the air cargo logistics chain at AAS take place within the box of the core players. The surrounding parties are serving the core players. Schiphol Real Estate (SRE), Chipshol Holding BV and Schiphol Area Development Company (SADC) are examples of real estate companies. They serve the core players by renting out land and buildings to them. The International Air Transport Association (IATA), Cargonaut and Air Cargo Netherlands (ACN) are examples of what is called interest groups in Figure 5-1. They have mainly mediating functions, although they have little power to impose some rules and regulations or standards. The influence of the core players on the performance of the air cargo logistics chain at AAS is much higher and more direct than the influence of the serving parties. If an airline for example withdraws from AAS as a result of a CPD introduction, the AAS air cargo logistics chain immediately gets affected. If Air Cargo Netherlands (ACN) on the other hand is opposed, consequences can not be as high, as ACN does not have a direct influence on the chain. Also real estate companies do not have a decisive role with direct power to influence processes. The reason that Dutch customs is a serving party is not because it does not physically touch the shipments. Dutch customs does touch shipments and is thereby directly involved in the air cargo logistics chain. It is however not concerned with the actual transportation of freight,
but with carrying out legal procedures. Dutch customs adjusts its processes to make sure that the processes in the chain get disturbed as least as possible. One of the main goals of customs is for example that the shipments that flow through the air cargo logistics chain at AAS get as minimally delayed as possible (Zonneveld, 2014).

For the development of the CPD design the interests and values of the core players are leading. The core players together carry the responsibility for the flows of shipments through the AAS air cargo logistics chain. The core players have a direct and decisive influence on the functioning and performances of the AAS air cargo logistics chain. In a future process design the focus may also be on getting support from the serving parties to increase the chance on successful implementation. In the current design phase of the potential future CPD at AAS the focus is however on aligning the design with the core players.

5.3 Core players in AAS air cargo logistics chain
The freight forwarders, KLM Cargo (airline and ground handler), other cargo airlines, third party ground handlers and the trucking companies are the core players in the air cargo logistics chain at AAS. They carry out the economic activities that are directly related to the transportation of shipments from shippers to consignees. Together they carry out the full door-to-door transportation from shipper to consignee. Within this delineated field of actors, a further distinction can be made between actual critical actors and non-critical actors with respect to a potential CPD introduction. Enserink et al. (2010) describe the difference between critical and non-critical actors as follows:

- Critical actors have unique resources, of which usage hereof has a large influence on the decision-making process, implementation process and/or performances of the project after it has been implemented. It is therefore very important to involve them/their interests in the decision making process.
- Non-critical actors. Non-critical actors either do not have unique resources or have resources with which they can not heavily influence the decision-making process, implementation process and/or performances of the project after implementation. It is therefore of fewer importance to involve them/their interests in the decision making process.

A more thorough analysis of the core players individually has been conducted to define their criticality for the CPD and thereby for the development of the CPD design.

Objectives of and requirements and constraints to the CPD design as described in the engineering design approach by Dym and Little (2009) are formulated from the perspective of the different critical actors of the chain. Whereas in the previous chapter the objective, requirements and constraints were set up from the integral system-environment perspective, in this chapter it is done per critical actor. Moreover core values as described by Rokeach (1973) are formulated for each of the critical actors. That is because the influence of the actor-environment of the CPD is to a large extent determined by soft values, beliefs and cultures of the different actors (Ploumen, 2014, Ankersmit, 2013, Pieters, 2014).

5.3.1 Critical actor #1: the freight forwarders
Freight forwarders are responsible for the full door-to-door transportation of shipments from shipper to consignee. Therewith they are the central player in the air cargo logistics chain (Burghouw et al., 2012). Some of them have own assets, others do not and therefore only have an administrative and guiding role (van Doorne, 2013). In general shippers/consignees do not know/care which airline, airport and trucking company the
A freight forwarder uses to carry out the door-to-door transportation, as long as the full door-to-door transportation is well taken care of. That is why the freight forwarders have enormous power. They decide whether freight will be flown via AAS or not (Pieters, 2014). What has increased the power of the forwarders over the past decades is the enormous consolidation that has taken place in this sector. Some decades ago the sector was characterized by a lot of small local companies providing similar services. Nowadays a few international players have a very large market share in the international freight forwarding sector (Treheway and Andriulaitis, 2010, Morrell, 2011, Bowen and Leinbach, 2003, Radstaak, 2014, Schwarz, 2005, Hanke, 2012). These large forwarders have bound shippers and consignees to them and have become responsible for arranging all their logistics worldwide (Bowen and Leinbach, 2003). If a large freight forwarder decides to make use of AAS, it may decide so for freight of thousands of shippers and consignees (Treheway and Andriulaitis, 2010). For the success of AAS as a cargo hub, it is hence extremely important to keep attracting the (large) forwarders. The forwarder is a critical actor, because of its high power (it organizes the international freight flows) and importance for the performances of AAS. If large freight forwarders leave the airport, cargo volumes will substantially decline.

Distances in Europe are small and the quality of the trucking network is high. Any place in Europe can be reached relatively easily from AAS and other large European cargo airports by truck (Morrell, 2011). Forwarders therefore make a choice for an airport based on the quality of the logistics services, rather than on the location of the airport (Aris, 2014). A forwarder can theoretically choose for another European airport for every incoming or outgoing shipment to optimize on costs and quality. Most forwarders however concentrate their activities around one or more airports to realize economies of scale, to be able to start partnerships with for example trucking companies and to make investments in assets such as their own warehouses more attractive. If AAS wants to stay an airport where large forwarders want to concentrate their activities around, it is important that the introduction of a CPD increases the attractiveness of AAS for these forwarders. When developing the CPD design this must be taken into account. A clear understanding of the business model of the forwarders is required.

Together with the above-mentioned consolidation in the freight forwarding industry, the business models of forwarders have changed in another way. Traditionally the freight forwarders created value by all conducting the similar activities listed below (Hanke, 2012).

1. Bundling orders by shippers/consignees.
2. Procuring transport capacities with large volume discounts.
3. Coordinating the different transport companies that together carry out the transportation of a shipment from a shipper to a consignee.

Over the past years freight forwarders have however increased the amount of assets they own and the amount of value added services they offer to their customers (with and without these assets). Some of them are doing the warehouse management for their customers. Others are providing shippers/consignees with IT solutions. Forwarders nowadays often procure insurances for the goods that are being shipped. Some have even taken over part of the assembly of the products of shippers and consignees to realize logistical cost savings. Freight forwarding has evaluated towards offering much more logistical services than only the procurement of freight capacities (The International Federation of Freight Forwarders Associations, 2014, Hanke, 2012, Treheway and Andriulaitis, 2010, Schwarz, 2005).
Freight forwarders want to be able to deliver very specific services for their different customers. Niche players have also arisen. This was not only found in literature. In interviews with freight forwarders it was also mentioned that offering value added and customer-specific services has become one of the important success criteria of a freight forwarder. In the future forwarders want to further innovate and increase the amount, diversity and flexibility of the services they can offer (Brink, 2014, van Breugel, 2014). The large forwarders are more and more expanding/trying to expand their control in the chain at the expense of airlines and ground handlers (Tretheway and Andriulaitis, 2010). Freight forwarders (worldwide and at AAS) increasingly put effort in:

1. Being able to offer more value added services.
2. Getting more control over the chain.
3. Being able to offer customer-specific services.

From this extensive research towards the forwarders in the AAS air cargo logistics chain, important core values for the potential introduction of a CPD are formulated.
Table 5-1: Important core values of freight forwarders

<table>
<thead>
<tr>
<th>#</th>
<th>Core value</th>
<th>Explanation/sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Responsibility</td>
<td>Responsibility over their core business (the core freight forwarding activities such as consolidation of shipments, carrying out value added activities, etc.) is important for the existence of the freight forwarder.</td>
</tr>
<tr>
<td>3</td>
<td>Efficiency</td>
<td>For the success of any logistics company, efficiency of operations is considered to be important.</td>
</tr>
<tr>
<td>4</td>
<td>Control</td>
<td>Forwarders increasingly put effort in expanding their control in the chain at the expense of airlines and ground handlers, by acquiring assets and taking over activities of these organizations (Tretheway and Andriulaitis, 2010, Hanke, 2012).</td>
</tr>
</tbody>
</table>

It is beneficial for the operations of forwarders to have their warehouses closely located to the places where large amounts of freight need to be picked up and delivered on a regular basis (Woorts, 2014, Mok, 1994). Some forwarders can thereby even arrange transportation of freight between their warehouse and the ground handlers themselves (van Breugel, 2014). Therefore many of the large forwarders that make use of AAS have warehouses that are located at or around the AAS area, either on 1½ line or on second line area. A requirement from the forwarder’s perspective can be formulated.

Table 5-2: Requirements to the CPD design from freight forwarders’ perspective

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Requirement</th>
<th>Explanation/sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Non-functional requirement</td>
<td>The CPD shall be located in proximity to the current forwarders’ warehouses on the 1½ line and second line area of AAS.</td>
<td>For the efficiency of the operations of the large forwarders at AAS it is important to have their warehouses closely located to places where freight needs to be picked up and delivered (Mok, 1994, Woorts, 2014).</td>
</tr>
</tbody>
</table>

5.3.2 Critical actor #2: KLM Cargo

The Royal Dutch airline KLM is the home carrier of AAS. KLM uses AAS as home base for its passenger and cargo flights and supporting activities and is the largest airline at AAS both in terms of passengers and yearly cargo volume (van Doorne, 2013). Most of the KLM flights have Amsterdam Airport Schiphol as airport of departure or arrival. KLM and its partners from the SkyTeam airline alliance were responsible for approximately 70% of all flights carried out to and from AAS in 2013 (Schiphol Group, 2014b). The majority of these flights was actually carried out by KLM itself. KLM used to be a fully independent Dutch airline, but it merged in 2003 with the French airline Air France. Within the new holding Air France – KLM the Dutch airline KLM however still operates its own separate airline. The cargo department of KLM is called KLM Cargo and is responsible for all cargo that is being flown with KLM airplanes, both with full freighters and in the bellies of passenger planes. From the moment Air France – KLM took over the Dutch airline Martinair several years ago, the cargo department of Martinair (Martinair Cargo) also became part of KLM Cargo (Aviationinfo.nl, 2014a).
Together with the other cargo airlines (and to minor extent also with freight flights of the integrators) KLM Cargo shapes the international network of cargo connections of AAS. KLM Cargo thereby has a large influence on the quality of AAS as a cargo hub. KLM Cargo is a critical actor, because the quality of AAS as a cargo hub is to a large extent dependent on KLM Cargo. KLM Cargo has a market share in the cargo sector of AAS of 40% (Schiphol Group Traffic Analysis & Forecasts, 2015).

In the full freighter sector, KLM Cargo’s share has dropped significantly over the past years (see Figure 5-3). Moreover, it can be expected that its share will even further drop in the short future. Currently KLM Cargo still operates ten full freighter airplanes (including the full freighters of Martinair Cargo), but in the coming years half of these full freighters will be taken out of operation because the profitability of the KLM full freighter services is declining (Aviationinfo.nl, 2014b). The full freighter operations are becoming smaller and less important for the whole KLM airline.

Although KLM Cargo’s market share in the full freighter segment of AAS has dropped over the past years and is expected to even further decrease, KLM Cargo is still considered a very important actor (critical actor) for AAS. Namely, the network of passenger flights of AAS is also dependent on the cargo department of KLM. To be able to transport cargo in the bellies of its passenger planes is very important for KLM. Continental air cargo in Europe hardly takes place, but intercontinental passenger connections are often made profitable because cargo is carried on these planes (Burghouwt et al., 2012). If passenger flights of KLM to and from AAS in the future can get less loaded with freight or if freight handling becomes more expensive for KLM at AAS, the profitability of the intercontinental passenger flights of KLM may drop. KLM might then decide to shrink its passenger (and cargo) operations or move it more to Paris Charles the Gaulle, which is the home hub of Air France. This would harm AAS’ position as a large international passenger (and cargo) hub.

KLM Cargo has its own ground handler or in other words is a self-handling airline. Some reasons for KLM Cargo to conduct its own ground handling are summed up below.

1. Because it is the largest cargo player at AAS it experiences economies of scale. It does not want other cargo airlines to profit from the large volumes of KLM Cargo by outsourcing ground handling activities to a third party ground handler. Other cargo airlines also do not let KLM Cargo profit from the large volumes they generate at their home hubs (Vreeburg, 2014).

2. As home hub AAS is the base of all KLM Cargo’s operations worldwide. KLM therefore wants to be sure that ground handling takes place here against high quality and especially reliability. For example, KLM Cargo does not want to risk that intercontinental passenger flights can not get loaded with freight, because delays have occurred or third party ground handlers have made mistakes. Therefore it wants to control these processes itself (Burghouwt et al., 2012).

Important core values of KLM Cargo for the potential introduction of a CPD are formulated.
Table 5-3: Important core values of KLM Cargo

<table>
<thead>
<tr>
<th>#</th>
<th>Core value</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Differentiation</td>
<td>For the success of a logistical company it is of importance to differentiate from competitors. For KLM Cargo it is important to be able to use the advantages of a home carrier to differentiate at its home hub (Vreeburg, 2014).</td>
</tr>
<tr>
<td>2</td>
<td>Responsibility</td>
<td>It is important for KLM Cargo to keep the responsibility over its own ground handling. This brings significant advantages and is even important for the performances of the passenger flights of the home carrier of AAS (Vreeburg, 2014, Burghouwt et al., 2012).</td>
</tr>
<tr>
<td>3</td>
<td>Efficiency</td>
<td>For the success of any logistics company, efficiency of operations is considered to be important.</td>
</tr>
</tbody>
</table>

From the perspective of KLM Cargo no objectives of, constraints or requirements to the CPD are formulated. The interests of KLM Cargo are captured in its core values (Table 5-3).

5.3.3 Critical actor #3: other cargo airlines

In this research with other cargo airlines the non-KLM airlines that offer air cargo services are meant. This does not mean that these airlines only offer air cargo services. Some of the cargo airlines also offer passenger services. They either do so because they only offer air cargo services in the bellies of passenger planes, or because they both operate full freighters and passenger planes. Approximately 60% of all cargo flown to and from AAS is flown by other carriers than KLM Cargo (Schiphol Group Traffic Analysis & Forecasts, 2015). Thereby other cargo airlines also significantly contribute to the network of cargo flights of AAS. Together with KLM Cargo they offer cargo connections from and to AAS and thereby make sure that freight forwarders can make use of the airport. AAS’ network and thereby AAS is also highly dependent on the other cargo airlines. The other cargo airlines are critical actors.

To analyze the importance of the other cargo airlines, the market shares of KLM Cargo and the other cargo airlines are researched for the years 2008, 2011 and 2014. The year 2008 is chosen because it was the year before the enormous drop in cargo volumes at AAS as a result of the financial crisis. The year 2011 is chosen because it was the year that cargo volumes for the first year stabilized again after the drop in 2009 (2010 was the year after the enormous drop so the year of the recovery). The year 2014 is chosen because these are the most recent annual figures available. The market shares of KLM Cargo versus the other cargo airlines are represented in Figure 5-3. The most important findings are listed below.

- The full freighter share of cargo flown to and from AAS is approximately 60% and has stayed relatively constant over the past years. The rest of cargo is flown in the bellies of passenger planes.
- KLM Cargo is currently still responsible for 40% of all air cargo flown via AAS, but its market share has been declining over the past years.
- The share of KLM Cargo among all belly cargo flown from and to AAS has stayed stable and high over the past years (approximately 75%).
- KLM Cargo has lost significant market share in the full freighter sector. In 2008 its share was still higher than 40%, whereas it was only 20% in 2014.
Other cargo airlines have become increasingly important for the cargo network of AAS, especially because of their high market share in the full freighter sector. Their share in this sector has risen from less than 60% in 2008 to 80% in 2014. Multiple airlines such as Air Bridge Cargo, Singapore Airlines Cargo and Saudi Airlines Cargo operate weekly to daily full freighter services from and to AAS. This segment (full freighters of non-KLM airlines) now accounts for approximately 50% of all cargo flown from and to AAS. Its importance for AAS as a cargo hub is substantial and is likely to further grow in the coming years. It is important to understand the interests of other cargo airlines operating full freighter services from and to AAS.

It needs to be known how airlines make a choice for an airport (such as AAS), not being their home hub, to operate their full freighter flights from/to. A literature review hereabout was carried out by Gardiner et al. (2005a) and a large international survey among airlines operating full freighters was conducted by Gardiner et al. (2005b) to verify the findings from literature. Both in the literature review and in the survey it was found that airlines base their choice for an airport for their full freighter operations mainly on the following criteria (Gardiner et al., 2005a, Gardiner et al., 2005b):

1. The overall costs of operating a full freighter on the airport.
2. The market place, shaped by the presence of freight forwarders and local origin-destination demand.
3. The possibility to conduct night operations from and to the airport.

The fact that the overall costs (first criterion) is an important consideration for full freighter airlines in their choice for an airport is strengthened by other findings from literature. There is only very little differentiation possible between cargo airlines. They all offer the same product. Competition is very much on costs and margins are very low in the industry (Morrell, 2011, Hanke, 2012, Seabury, 2013, Tretheway and Andriulaitis, 2010). During an interview with an employee of Malaysia Airlines Cargo it was explicated that the customers
of cargo airlines really focus on costs when booking cargo space (Sifneos, 2014). Especially in Europe, where Road Feeder Services (RFS) function very well, competition between airports is fierce and much more on costs than on location (Tretheway and Andriulaitis, 2010). RFS can be described as road transportation that replaces transport via the air. For an extensive explanation of RFS, appendix D be consulted. An objective of and constraint to the CPD from the perspective of the cargo airlines is formulated (see Table 5-4).

Table 5-4: Objectives of and constraints to the CPD from cargo airlines’ perspective

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Objective/constraint</th>
<th>Explanation/sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Strong objective</td>
<td>The minimization of costs for freight to flow through the AAS air cargo logistics chain.</td>
<td>Airlines base their choice for an airport for their full freighter operations mainly on costs (Gardiner et al., 2005a, Gardiner et al., 2005b, Sifneos, 2014).</td>
</tr>
<tr>
<td>2</td>
<td>Constraint</td>
<td>The CPD shall not make ground handling at AAS more expensive.</td>
<td>Airlines base their choice for an airport for their full freighter operations mainly on costs (Gardiner et al., 2005a, Gardiner et al., 2005b, Sifneos, 2014).</td>
</tr>
</tbody>
</table>

All cargo airlines at AAS outsource their ground handling to third party ground handlers. This outsourcing makes cargo airlines more flexible to adjust their connections from and to AAS. Because cargo airlines do not need to provide operations on the ground, they can adjust their connections without needing to acquire or sell assets, hire or fire personnel, etc.

By analyzing the other cargo airlines, important core values are formulated. These are listed in Table 5-5. Efficiency is not a core value for the other cargo airlines, because they outsource all ground operations to third party ground handlers.

Table 5-5: Important core values of other cargo airlines

<table>
<thead>
<tr>
<th>#</th>
<th>Core value</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Differentiation</td>
<td>For the success of a logistical company it is of importance to differentiate from competitors.</td>
</tr>
<tr>
<td>2</td>
<td>Flexibility</td>
<td>For non-home carrier airlines the ability to adjust their networks of flights at AAS is experienced as important. This is one of the reasons for them to currently outsource all ground handling at AAS.</td>
</tr>
</tbody>
</table>

5.3.4 Semi-critical actor: third party ground handlers

There are six third party cargo ground handlers at AAS (including the cargo ground handler belonging to KLM Cargo there are seven ground handlers at AAS). Most of them belong to large international firms. The third party cargo ground handlers have contracts with the airlines, which outsource their ground handling to the handlers. Sometimes worldwide contracts are closed between ground handlers and airlines. Other contracts are only closed between the airline and a local ground handling company or local department of a large international cargo ground handler at an airport (Radstaak, 2014).

For ground handlers it is more complex to determine whether they are a critical actor. On the one hand the functioning of the AAS air cargo logistics chain is not dependent on the ground handlers. Ground handlers follow forwarders and cargo airlines in their choices for airports. Cargo ground handlers serve the cargo airlines and indirectly also the forwarders.
Especially at AAS third party cargo ground handlers can come and go because of the full open market regime. On the other hand, the success of the CPD may be dependent on the attitude of the seated ground handlers towards the facility. If ground handlers en masse boycott the CPD, the facility will likely become a failure. Whether ground handlers have the power to boycott the facility, is however fully dependent on the design. Two very simple and imaginary examples illustrate this.

- In the integrated high-level CPD design the freight forwarders could get the responsibility for operating the facility. In this case the forwarders are able to influence the functioning of the CPD. The forwarders have control over the CPD and decide which freight will pass the facility. In this case the ground handlers do not have the power to boycott the facility and so they are not a critical actor.
- In another CPD design the ground handlers could get the responsibility for the operations. In this case the ground handlers are a critical actor. The ground handlers in this case can influence the functioning of the CPD. As long as they meet specific standards such as agreed upon in the Service Level Agreement (SLA), they remain free to arrange their operations themselves and operate the CPD in their own way.

The ground handlers are considered a semi-critical actor. The criticality of the cargo ground handler is determined by the chosen CPD design. Other than the forwarders, KLM Cargo and other cargo airlines, which are critical actors because of their decisive power in the chain, the third party ground handlers can become a critical actor in a CPD design because of their power to frustrate the facility. No solution for a CPD design has been chosen yet. Therefore it is yet uncertain whether support from the ground handlers is required for a successful CPD. To deal with this uncertainty, it is decided to keep in mind the interests of the third party cargo ground handlers at AAS.

Partly because of the full open market regime, there is much pressure on the margins of the ground handlers at AAS (Ankersmit, 2013, Pieters, 2014, Burghouwt et al., 2012). This was also mentioned during many interviews. In contractual relationships between airlines and ground handlers, the airlines have much more power and focus very much on costs (Morrell, 2011, Burghouwt et al., 2012). Because the margins are so low and because the airlines have so much power in the contractual negotiations, it can be expected that the seated ground handlers will boycott a CPD if it makes ground handling more expensive. This emphasizes the importance of the second objective and fourth constraint that were set up earlier in this chapter (see Table 5-4). The importance of this objective and constraint is again emphasized from another perspective in Table 5-6.

Table 5-6: Objectives of and constraints to the CPD from ground handlers’ perspective

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Objective/constraint</th>
<th>Explanation/sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Strong</td>
<td>The minimization of costs for freight to flow through the AAS air cargo logistics chain.</td>
<td>Margins of the ground handlers are very low (Ankersmit, 2013, Pieters, 2014, Burghouwt et al., 2012).</td>
</tr>
<tr>
<td>2</td>
<td>Constraint</td>
<td>The CPD shall not make ground handling at AAS more expensive.</td>
<td>The ground handlers are expected to boycott a CPD if their margins further decrease as a result of it.</td>
</tr>
</tbody>
</table>

A concern that was raised several times during the interviews, was that handlers are afraid that the possibility to distinguish themselves diminishes (Hockemeijer, 2014, Meerens, 2014). With such a fierce competition on costs and a very similar service that the different handlers offer it is already difficult for a ground handler to distinguish from the others,
which is at the expense of the quality of the ground handling processes at AAS (Roeven, 2014, Ploumen, 2014, Vreeburg, 2014, Air cargo news, 2014). The ability to differentiate is important for the ground handlers.

### Table 5-7: Important core values of ground handlers

<table>
<thead>
<tr>
<th>#</th>
<th>Core value</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Differentiation</td>
<td>With the fierce competition on costs and the similar services the ground handlers offer, differentiation is difficult. It is however considered important (Hockemeijer, 2014, Meerens, 2014).</td>
</tr>
<tr>
<td>2</td>
<td>Responsibility</td>
<td>Responsibility over their core business (the core ground handling activities such as building up/breaking off ULDs, carrying out security checks, etc.) is important for the existence of the ground handler.</td>
</tr>
<tr>
<td>3</td>
<td>Efficiency</td>
<td>For the success of any logistics company, efficiency of operations is considered to be important.</td>
</tr>
</tbody>
</table>

#### 5.3.5 Trucking companies

Trucking companies carry out road transportation in Europe on behalf of forwarders. Airlines also hire trucking companies to carry out Road Feeder Services (RFS). Trucking companies really serve the forwarders and airlines. Their business is very dependent on the freight streams that are shaped by the international forwarders and airlines. There are only a few international trucking companies. The industry is characterized by a lot of local players. Forwarders and airlines have many trucking companies to choose from. Product differentiation and barriers to entry are very low. Competition is mainly on costs. Because of these characteristics, that were both found in literature (Value Line, 2014, Hanke, 2012) and were mentioned during the interviews (Kleppers, 2014, Nagel, 2014), it can be concluded that the trucking companies are not a critical actor. Trucking companies do not have much influence on processes at and around AAS, nor on the international freight streams. Furthermore they are large in amount and with low barriers to enter the sector the dependency on trucking companies is also low.

This does not automatically mean that the trucking companies will not play a role in the CPD design. The CPD may have positive results for the trucking companies. In literature it has been emphasized that consolidation centres may have very positive effects on the operations of trucking companies (Regan and Golob, 2005) and trucking companies that are active at AAS have also already indicated to be interested in the introduction of a CPD (Waters, 2013). The trucking companies might be willing to play a role in the CPD introduction. However, their interests do not primarily need to be taken into account in this design phase of the potential future CPD at AAS.

### 5.4 Shifts of power in the air cargo logistics chain

The actor with most power in the chain is currently the freight forwarder. The freight forwarder shapes the international cargo streams. For each shipment it decides how freight will be transported from the shipper to the consignee and thousands of shippers and consignees rely on the large freight forwarders for their transport and logistics. Both in literature and during the interviews it was mentioned that the forwarder is the most powerful actor in the chain. (Tretheway and Andriulaitis, 2010, Schwarz, 2005, Pieters, 2014, Ankersmit, 2013, Roeven, 2014, Burghouwt et al., 2012). Several decades ago, when the forwarders were all still a bit smaller in size, the cargo airlines had the power (Tretheway and Andriulaitis, 2010, Schwarz, 2005). The cargo airlines at that time shaped their networks of flights and the freight forwarders had to adapt to it.
There are currently no signs yet that the power distribution between the cargo airlines and the forwarders will restore. There are however signs that forwarders may lose some power to the shippers and consignees. Cargo airlines could in that case indirectly, via the power increase of the shippers and consignees, get some of the power.

Whereas freight forwarders are currently still responsible for almost all air cargo transportation (Radstaak, 2014), shippers and consignees might get a larger role in the future. Because of developments in the IT sphere of the air cargo logistics chain, it is becoming possible for shippers to arrange door-to-door transportation themselves, without the involvement of a freight forwarder. Airlines are more and more marketing themselves directly to shippers and consignees by for example the introduction of dedicated cargo-booking websites at which shippers and consignees can book cargo space directly themselves (Schwarz, 2005, Hanke, 2012). As for now, shippers and consignees are not yet massively bypassing freight forwarders, partly because forwarders have created so much value added services that it has become impossible to ignore them (Roeven, 2014). Developments in the market may however strengthen the position of the shipper/consignee. An air freight rate index will for example be launched soon and resolve one of the concerns of shippers and consignees: the non-transparent air freight rates and therefore the inability to find out whether good deals with airlines are closed (The Load Star, 2014b). The traditional design in which shippers mainly do business with freight forwarders
is still the main one in the air cargo industry, but it is challenged (Ankersmit, 2013). The Belgian digital imaging company AGFA states that it saves 20% of its total air transport costs by bypassing the freight forwarder (The Load Star, 2014a). If shippers and consignees to a large extent will bypass the freight forwarder in the future, the question is what this will do with the power of the shipper and consignee respectively the power of the cargo airline.

Because it is still very uncertain whether shippers and consignees in the future will more bypass freight forwarders by booking air cargo directly at the cargo airlines, this is not taken into account in this research. It is however advised to monitor the potential shift in market power from the forwarders to the shippers and consignees in the coming years.

5.5 Conclusions of the analysis of the actors in the AAS air cargo logistics chain

In this chapter the influence of the actor-environment of the potential future CPD on the functioning of this facility is analyzed. First important conclusion is that the freight forwarders and to fewer extent KLM Cargo and other cargo airlines are the critical actors of the chain for the potential future CPD introduction. Critical actors have unique resources, of which usage hereof has a large influence on the decision-making process, implementation process and/or performances of the project after it has been implemented. It is therefore very important to involve them/their interests in the decision making process (Enserink et al., 2010). Freight forwarders are responsible for the international streams of air cargo, because they arrange the full door-to-door transportation for the shippers and consignees (Tretheway and Andriulaitis, 2010, Burghouwt et al., 2012). They decide to what extent freight will be flown via AAS after a potential CPD introduction. KLM Cargo and the other cargo airlines shape the network of international cargo flights from and to AAS and therefore give freight forwarders the possibility to make use of AAS. The setup of their network of cargo flights is however partly dependent on the presence/demand of the freight forwarders (Gardiner et al., 2005a, Gardiner et al., 2005b). The cargo ground handlers are semi-critical actors. Ground handlers serve cargo airlines and therefore have no influence on the freight streams at AAS. However, if cargo ground handlers are involved in the CPD design, they may have the possibility to frustrate the facility.

Second important conclusion of this chapter is the fact that the influence of the actor-environment can not be fully described with an engineering design approach, for example as described by Dym and Little (2009). The influence of the actor-environment can not be fully described with hard objectives of and constraints and requirements to the CPD design. Whether a CPD design is acceptable for an organization and therefore whether a CPD design will have the ability to function in the AAS air cargo logistics chain also heavily depends on the influence it has on the organization’s culture or beliefs (Ploumen, 2014, Ankersmit, 2013, Pieters, 2014). Therefore apart from objectives, constraints and requirements from the perspective of the actors in the AAS air cargo logistics chain, core values of the important actors are defined as well. The influence of a CPD design on the core values of the important actors to a large extent determines the ability of the CPD to function in the AAS air cargo logistics chain.

Requirements to the CPD design and objectives of and constraints to the CPD are set up from the perspective of the freight forwarders, KLM Cargo, other cargo airlines and the cargo ground handlers. Moreover important core values of these (semi-)critical actors have been formulated. Thereby the third research sub question is answered.

Research sub question 3: What is the influence of the actor-environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?
6 The AAS air cargo logistics chain qualitatively researched

In the previous chapter it was researched how the actor-environment imposes demands and limitations to the CPD design. The interests of the critical actors of the AAS air cargo logistics chain were researched by analyzing literature, market studies and conducting field researches (and conducting in-depth interviews to expand the knowledge). With these interests being clear important core values of the critical actors and objectives of, constraints and requirements to the CPD could be formulated. The view of actors against a project or policy however does not always follow logically from their interests. Opinions can for example (partly) be formed by fear, instead of rationality. If that is the case, the objectives, constraints, requirements and core values that were formulated in the previous chapter do not fully describe how the actor-environment influences the ability of a CPD to function in the AAS air cargo logistics chain. Additional objectives, constraints, requirements and core values may need to be set up.

With the 20 in-depth interviews with representatives from different organizations from the chain a qualitative research was therefore carried out to solve this knowledge gap. The aim of the qualitative research was to find underlying drivers of opinions of the critical actors, not being their interests. The full setup and results of the qualitative research can be found in appendix G. The interpretation of these results and the meaning of them for the development of the CPD design are described in this chapter. Thereby this chapter contributes to answering the third research sub question.

Research sub question 3: What is the influence of the actor-environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?

The first three sections of this chapter describe what additional requirements to the CPD design follow from this qualitative research. In the fourth section a concern of the organizations is mentioned and it is argued why this concern does not lead to an additional requirement. In the fifth section it is explained that the interests of the organizations in the chain are important, but the current field of supporters and opponents is not. The sixth section contains the conclusions of the AAS air cargo logistics chain qualitatively researched.

Appendix G describes the exact setup and results of the qualitative analysis. All the questions that were asked during the in-depth interviews are described. The interviews were not bounded by these questions. These questions formed the guidance through the interviews, but many other questions were asked as well. Many open questions were asked. The aim was to create open and unrestrained conversations mainly because of two reasons.

1. It makes it harder for the interviewee to give answer if she/he has not thought about it (which is for example better possible in case of multiple choice or yes/no questions). Hence, it stimulates the interviewee to think about the subject.
2. By not focusing per question on a very specific topic but keeping the subject a bit broader, the interviewee can mention the aspects that he/she finds most important. This might implicate that for the interviewee it is more important to arrange some aspects of the CPD design very well than other aspects.

The following actors were interviewed:

- Freight forwarders (4 in total)
- KLM Cargo
- Other cargo airlines (3 in total)
- Third party ground handlers (7 in total)
- Trucking companies (2 in total)
- Dutch customs at AAS
- Cargonaut

In appendix G it can be found why the actors listed above were interviewed and why for example in-depth interviews and not surveys were used. The exact results of the research towards the values of the actors, such as specific answers to questions, are also presented in appendix G. This chapter contains the most important lessons learned from the qualitative research for a potential future CPD at AAS.

### 6.1 High competitiveness complicates search for a CPD design

The air cargo industry is very competitive. Cargo airlines, freight forwarders and cargo ground handlers all operate in a very competitive environment. This competitiveness can partly be explained by the low margins and the little possibilities to differentiate. The enormous competitiveness between organizations in the air cargo industry is however also driven by a mindset. This was already noticed by Ankersmit (2013), who explicated that competitors in different links of the air cargo logistics chain at AAS are still very reluctant to cooperate with each other for unfounded reasons even if cooperation leads to mutual benefits. During the in-depth interviews it also became apparent that the environment of the potential future CPD is very competitive and that this has consequences for its ability to function in the chain. The two most important findings from the qualitative research with respect to this topic are listed below.

1. Players in all the different links of the chain (forwarders, cargo airlines and ground handlers) are afraid that competitors will get insight into their customer base as a result of the CPD introduction and profit from it.
2. Organizations in the air cargo logistics chain are afraid that competitors will profit relatively more from the CPD (or any other initiative) than they will themselves. Organizations in this chain consider it more important to achieve relative benefits compared to competitors than to achieve mutual benefits.

The first fear above is mainly applicable to cargo airlines and freight forwarders. The customers of the different ground handlers are commonly known (different airlines park their cargo planes in front of the ground handlers they have a contract with). If AAS becomes a place where the customers of forwarders and/or cargo airlines will get revealed, the attractiveness of the airport for these organizations may decrease. A requirement to the CPD design is set up to prevent this.

**Table 6-1: Requirements to the CPD design from qualitative research**

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Requirement</th>
<th>Explanation/sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Non-functional</td>
<td>The CPD shall not increase the visibility of the customer bases of forwarders and cargo airlines for competing organizations at AAS.</td>
<td>Multiple interviewees among whom Sifneos (2014) and Hockemeijer (2014) mention that a higher visibility of customers of an organization for competitors is a major obstacle towards a CPD realization.</td>
</tr>
</tbody>
</table>

From the second fear that is listed above an additional core value of the critical actors of the chain can be recognized. This core value is fairness. During the in-depth interviews it became
clear that opinions of actors are partly driven by fear that the facility will not be able to treat each organization fairly (see Table 6-2).

Table 6-2: Other core value of freight forwarders, KLM Cargo, other cargo airlines and cargo ground handlers

<table>
<thead>
<tr>
<th>#</th>
<th>Core value</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Fairness</td>
<td>Because of the fierce competition in the AAS air cargo logistics chain and the low mutual trust, an urge for fairness drives opinions of the organizations in this chain about a potential future CPD.</td>
</tr>
</tbody>
</table>

6.2 Good review of flexible (trading) climate at AAS

The flexible climate at AAS supports the freight forwarders with their desires to offer more value added services, gain more control in the chain, offer customer-specific services and differentiate themselves. Ground handlers also see the flexible trading climate as one of the key success criteria of AAS as a cargo airport (Rohrmeijer, 2014, Roeven, 2014). With the flexible climate at AAS a climate is meant in which little boundaries and limitations withhold organizations from optimizing their procedures.

- Forwarders are given the opportunity to pass the handlers’ warehouses in case they have BUPs. These are the warehouses of forwarders that have direct access to airside because they are located on the so-called 1½ line area of the airport.
- Customs clearance and inspections do not take place centrally. They do not even necessarily need to take place in ground handlers’ warehouse. Customs clearance and inspections may also take place in the forwarders’ warehouses, such as for BUPs that get directly picked up or delivered at airside (Zonneveld, 2014).
- Freight forwarders are allowed to setup unique relationships with ground handlers at AAS. Worldwide one of the largest forwarders and also one of the larger forwarders active at AAS is using the warehouse of a ground handler at AAS for consolidation of its shipments. Thereby it does not need to pick up/deliver freight at different ground handlers anymore (de Wit, 2014, Meerens, 2014, de Reus, 2014).
- Etc.

These are all aspects with which AAS distinguishes itself from other large European cargo airports. For the competitiveness of AAS it is important that the introduction of a CPD will strengthen this key asset of AAS: the flexible (trading) climate. If the opposite is achieved, the airport may loose some of its attractiveness for forwarders and the forwarders might decide to move activities to other European cargo airports. Then they will take with them enormous cargo volumes. Two additional requirements are formulated.

Table 6-3: Requirements to the CPD design from qualitative research part 2

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Requirement</th>
<th>Explanation/sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Non-functional requirement</td>
<td>Dutch customs shall be able to keep its flexible and dynamic character after the CPD introduction.</td>
<td>Multiple interviewees mention the setup of Dutch customs as one of the key success criteria of AAS as a cargo hub, among whom Kleppers (2014) and Roeven (2014).</td>
</tr>
<tr>
<td>11</td>
<td>Non-functional requirement</td>
<td>The CPD shall not harm the flexible and dynamic trading environment at AAS.</td>
<td>Multiple interviewees mention the flexible (trading) climate as one of the key success criteria of AAS as a cargo hub, among whom Rohrmeijer (2014) and Roeven (2014).</td>
</tr>
</tbody>
</table>
6.3 Scepticism about new setup of liabilities and responsibilities

It is feared by various organizations in the chain that a complex and new setup of liabilities and responsibilities over freight in the AAS air cargo logistics chain is required when the CPD is implemented. Interviewees doubt whether a CPD design can be set up in combination with a feasible setup of responsibilities and liabilities over freight that is compatible with the standard international roles of the different organizations and relationships between them. During the analysis of the system-environment it was already determined that no extra interface may be created between organizations that have no contractual relationship with each other. Meeting this requirement may not fully take away the concerns of the organizations in the chain about the new setup of responsibilities and liabilities. Two additional requirements are formulated.

Table 6-4: Requirements to the CPD design from qualitative research part 3

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Requirement</th>
<th>Explanation/sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Non-functional</td>
<td>The CPD design shall make sure that responsibilities and liabilities over freight in the new situation in the AAS air cargo logistics chain are clear.</td>
<td>One of the major fears of the interviewees is that no feasible new structure of liabilities and responsibilities can be set up (Meerens, 2014, Hockemeijer, 2014, van Breugel, 2014, Vreeburg, 2014).</td>
</tr>
<tr>
<td>13</td>
<td>Non-functional</td>
<td>The CPD design shall make sure that the new responsibilities and liabilities over freight in the AAS air cargo logistics chain are compatible with the standard international contractual relationships, responsibilities and liabilities.</td>
<td>One of the major fears of the interviewees is that no feasible new structure of liabilities and responsibilities can be set up (Meerens, 2014, Hockemeijer, 2014, van Breugel, 2014, Vreeburg, 2014).</td>
</tr>
</tbody>
</table>

6.4 CPD may not lead to increased throughput time

The high speed is one of the main reasons why shippers and consignees choose for air cargo and for example not for sea freight. The throughput time from door to door should hence not be threatened by the introduction of a CPD. This was mentioned multiple times during the 20 in-depth interviews. It is however often not the actual ground handling processes that take most time in the AAS air cargo logistics chain. The residence time of air freight is more determined by (The Load Star, 2014c, de Wit, 2014):

- Rules that ground handlers have about how many hours before the departure time of an airplane trucks must deliver freight and how many hours after the arrival of an airplane freight may be picked up.
- The long times that forwarders and trucking companies store their freight at ground handlers (both import and export freight).

Therefore the introduction of a CPD is not expected to threat the average throughput time of freight in the AAS air cargo logistics chain. It is decided not to convert this concern into a requirement.

6.5 Current field of supporters and opponents unimportant for CPD design

There is general consensus among the actors about inefficiencies in the chain, the potential advantages and disadvantages of a CPD, the strengths of AAS as a cargo hub, etc. When
looking at the support for and opposition against the CPD among the different organizations, a lot of variety can be recognized.

Forwarders that are mostly active in the general freight segment emphasize advantages of the potential development of a CPD (de Reus, 2014, Woorts, 2014). Forwarders that are more specialized in value added logistics and/or have gained an advantageous competitive position over other forwarders by their direct access to airside (forwarders that are located on the 1½ line area of AAS) more emphasize disadvantages of the CPD (van Breugel, 2014, Brink, 2014). Among the ground handlers, a similar observation was made. Ground handler Skylink has set up a unique relationship with one forwarder. It consolidates full ULDs coming from and going to all the different ground handlers in its warehouse for this forwarder. The introduction of a CPD might harm their value add for this forwarder and thereby the unique relationship it has with the forwarder (Meerens, 2014). Handlers with current overcapacity and with long-term rental agreements are less positive about a potential CPD introduction than handlers with expected shortage of capacity in the near future. Two important lessons can be learned from this.

1. It is very important that the CPD matches with the interests of the critical organizations in the chain, as well as with other drivers of their opinions. General advantages and disadvantages of the CPD should be taken into account, as well as concerns of the critical actors with respect to the potential CPD introduction.
2. The current field of supporters and opponents of the CPD is unimportant. The field of supporters and opponents is a snapshot of the current situation and is based on specific organizational concerns. External and organizational changes may result in a completely different field of supporters and opponents in the future when the CPD gets implemented. In the current design phase no coalitions need to be found yet.

6.6 Conclusions of the AAS air cargo logistics chain qualitatively analyzed

This chapter describes the most important findings of the qualitative research that was carried out with the 20 in-depth interviews with representatives from various organizations in the chain. It describes what drives the opinions of the organizations in this chain about a potential CPD introduction, other than their interests, and thereby contributes to answering the third research question.

Research sub question 3: What is the influence of the actor-environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?

Additional requirements to the CPD design from the perspective of the actor-environment of the facility followed from the qualitative research. They are listed in the course of this chapter. Another important core value of the freight forwarders, KLM Cargo, the other cargo airlines and the cargo ground handlers was defined: fairness. The organizations in the chain fear that the CPD will not be able to treat the different organizations in the chain equally and fairly. Finally it became clear that many organizations base their support for or opposition against the potential CPD introduction on organization specific concerns. It is important to take general interests of organizations into account as well as general experienced advantages and disadvantages, but not to pay attention to the current field of supporters and opponents. This field can be different in several years due to organizational and/or external changes.
7 Summary of chain’s influences on CPD design

This chapter summarizes the findings of the previous 3 chapters. It describes how the system-environment and actor-environment of the potential future CPD influence the ability of the facility to function in the chain. For exact details and motivations behind objectives, constraints, requirements and core values the previous chapters 4, 5 and 6 can be consulted. This chapter gives an overview of the answers to the second and third research question.

Research sub question 2: What is the influence of the system-environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?

Research sub question 3: What is the influence of the actor-environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?

The system- and actor-environment of the AAS air cargo logistics chain impose several requirements to the CPD design. The CPD design must comply with all these design features. The complete list of requirements to the CPD design is shown in Table 7-1. For the explanation and sources behind these requirements the previous chapters can be consulted.

Table 7-1: Overview of requirements of AAS air cargo logistics chain to CPD design

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Functional requirement</td>
<td>The CPD design shall make sure that 3 million tonnes of cargo can be handled at AAS in 2030.</td>
</tr>
<tr>
<td>2</td>
<td>Non-functional requirement</td>
<td>The CPD design shall make the CPD robust against uncertainty in future cargo volumes at AAS.</td>
</tr>
<tr>
<td>3</td>
<td>Functional requirement</td>
<td>The CPD design will make sure that the weekly peaks in cargo volumes at AAS belonging to a yearly cargo volume of 3 million tonnes can be adequately handled.</td>
</tr>
<tr>
<td>4</td>
<td>Non-functional requirement</td>
<td>The CPD shall treat all organizations from the AAS air cargo logistics chain fairly and equally.</td>
</tr>
<tr>
<td>5</td>
<td>Non-functional requirement</td>
<td>If the exploitation of the CPD is set up as an aviation activity it will be financed only with incomes from aviation activities. If the exploitation of the CPD is organized as a non-aviation activity it will be financed only with incomes from non-aviation activities.</td>
</tr>
<tr>
<td>6</td>
<td>Non-functional requirement</td>
<td>The CPD shall not harm the full open market regime for cargo ground handling at AAS.</td>
</tr>
<tr>
<td>7</td>
<td>Non-functional requirement</td>
<td>The introduction of the CPD shall not lead to additional interfaces between organizations with no contractual relationships.</td>
</tr>
<tr>
<td>8</td>
<td>Non-functional requirement</td>
<td>The CPD shall be located in proximity to the current forwarders’ warehouses on the 1½ line and second line area of AAS.</td>
</tr>
<tr>
<td>9</td>
<td>Non-functional</td>
<td>The CPD shall not increase the visibility of the customer bases of forwarders and cargo airlines for competing organizations at AAS.</td>
</tr>
<tr>
<td>10</td>
<td>Non-functional requirement</td>
<td>Dutch customs shall be able to keep its flexible and dynamic character after the CPD introduction.</td>
</tr>
<tr>
<td>11</td>
<td>Non-functional requirement</td>
<td>The CPD shall not harm the flexible and dynamic trading environment at AAS.</td>
</tr>
<tr>
<td>12</td>
<td>Non-functional</td>
<td>The CPD design shall make sure that responsibilities and liabilities over freight in the new situation in the AAS air cargo logistics chain are clear.</td>
</tr>
<tr>
<td>13</td>
<td>Non-functional</td>
<td>The CPD design shall make sure that the new responsibilities and</td>
</tr>
</tbody>
</table>
liabilities over freight in the AAS air cargo logistics chain are compatible with the standard international contractual relationships, responsibilities and liabilities.

From the analysis of the system-environment and the actor environment of the AAS air cargo logistics chain several full chain objectives came forward, which can be converted into performance indicators (criteria). The better a CPD design alternative scores on such an objective, the better it is. Table 7-2 contains all full chain objectives of the CPD. For the explanation and sources behind these objectives the previous chapters can be consulted.

Table 7-2: Overview of objectives of AAS air cargo logistics chain for CPD design

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Medium objective</td>
<td>The minimization of first line area needed for ground handling facilities at AAS.</td>
</tr>
<tr>
<td>2</td>
<td>Weak objective</td>
<td>The minimization of second line area needed for the potential CPD.</td>
</tr>
<tr>
<td>3</td>
<td>Medium objective</td>
<td>The minimization of truck movements for air cargo at the AAS area.</td>
</tr>
<tr>
<td>4</td>
<td>Strong objective</td>
<td>The minimization of costs for freight to flow through the AAS air cargo logistics chain</td>
</tr>
</tbody>
</table>

Constraints to the CPD design were also found while analyzing the “softer” and “harder” aspects of the AAS air cargo logistics chain. A CPD design alternative must be able to comply fulfil these constraints, or else it will not have the ability to function in the chain.

Table 7-3: Overview of constraints of AAS air cargo logistics chain to CPD design

<table>
<thead>
<tr>
<th>#</th>
<th>Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A maximum of 200.000 m$^2$ of first line area shall be occupied by ground handling facilities at AAS.</td>
</tr>
<tr>
<td>2</td>
<td>The CPD shall not make ground handling at AAS more expensive.</td>
</tr>
</tbody>
</table>

By analyzing the actor-environment of the potential future CPD and conducting a qualitative research, important core values of the critical actors of the AAS air cargo logistics chain were found. These core values are shown in Table 7-4. The influence of a CPD on these core values is of large influence on the ability of the facility to function in the chain.

Table 7-4: Overview of important core values of critical actors of the AAS air cargo logistics chain

<table>
<thead>
<tr>
<th>Core values</th>
<th>Freight forwarders</th>
<th>KLM Cargo</th>
<th>Cargo airlines</th>
<th>Cargo ground handlers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Differentiation</td>
<td>1. Differentiation</td>
<td>1. Differentiation</td>
<td>1. Differentiation</td>
</tr>
<tr>
<td></td>
<td>5. Fairness</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PART III: DESIGN DEVELOPMENT
8 Theoretically feasible design options for critical variables

At this point in the research it is known which variables need to be designed for a high-level CPD design (chapter 3) and how the environment of the CPD imposes demands and limitations to the CPD design (chapters 4, 5, 6 and 7). Given this knowledge, CPD design alternatives can be developed.

To optimize the quality and robustness of this research and in particular of the choice for a final preferred CPD design alternative, all possible CPD design alternatives that theoretically have the ability to function in the chain should be found (theoretically feasible CPD design alternatives). A CPD design alternative is considered theoretically feasible if it complies with the CPD design requirements that were formulated in chapters 4, 5 and 6 and are listed in the previous chapter. The influence of a CPD design on the core values of the critical actors and full chain objectives are not yet taken into account in the development of theoretically feasible alternatives.

The development of all theoretically feasible CPD design alternatives is done in two steps. In this chapter it is analyzed how each critical design variable of the CPD separately can be designed so that it complies with all requirements from its environment (that are listed in chapter 7). In chapter 9 it is researched how the critical design variables can be combined so that they form all CPD design alternatives that meet all design requirements. This chapter gives answer to the fourth research question.

Research sub question 4: What are the theoretically feasible options to design the critical design variables of a potential future CPD at AAS that were found in research sub question 1 separately?

The different sections in this paragraph describe the theoretically feasible design options for the different critical design variables. In the first section the theoretically feasible design options for the proximity of the CPD to AAS are explained. In the second section the design variables for the level of obligation or stimulus for usage of the CPD is described. The third section explicates the design options for the range of services offered in the CPD. Section four describes the design options for the ownership of the CPD. The theoretically feasible design options for the responsibility for operating the CPD are explained in section five. In the sixth section it is explained why in this phase of the research no design options for the model of costs and gains sharing are yet developed. Section seven contains the conclusions of the theoretically feasible design options for critical variables.

In this chapter it is analyzed how the different variables that have a critical influence on the functioning of a Central Pickup and Drop-off point (CPD) for air cargo at AAS can theoretically separately be designed. For each of these variables it is assessed what the theoretically feasible design options are with the criterion explained in the box below.

ASSUMPTION BY THE RESEARCHER
A design option for a critical design variable is considered theoretically feasible if the option meets all requirements to the CPD design that were formulated in the system-, actor- and qualitative analysis and are listed in chapter 7.

8.1 Design options for the proximity of the CPD to AAS
According to Konings et al. (2013) and Browne et al. (2005) a decision needs to be made whether a consolidation centre will be closely located to the site it serves, at medium
distance or at long distance. This choice has a decisive influence on the functioning of the consolidation centre (Browne et al., 2005, Konings et al., 2013). Browne et al. (2005) do not further define a small, medium or large distance. Konings et al. (2013) did a research towards a potential central barge handling terminal serving the port of Rotterdam and used a distance of 40 kilometres away from the port as small distance, 70 kilometres as medium distance and 135 kilometres as large distance. Other distances will need to be used for the CPD at AAS, because of the significant differences between hinterland transportation via barge and via truck. Hinterland transportation via barge takes place largely via the same links: the few large rivers that connect the port of Rotterdam with its hinterland. Because of the diffuse road network in the Netherlands and Europe, trucks take many more routes from and to AAS. A CPD will need to be closer located to AAS than a central barge handling terminal to the port of Rotterdam to be similarly accessible. The following design options for the proximity of the CPD to AAS can be considered:

- A location at or closely located to AAS such as at SRE’s or SADC’s land (small distance)
- A location >25 kilometres away from AAS (medium distance)
- A location >50 kilometres away from AAS (far distance)

Only one of above listed design options for the proximity of the CPD to AAS complies with all requirements to the CPD design. Only if the CPD is located at small distance from AAS (at or closely located to the AAS area such as at SRE’s or SADC’s land), it will be located in proximity to the current forwarders’ warehouses on the 1½ line and second line area of AAS. Therefore this is the only option that complies with requirement 8 from Table 7-1.

Table 8-1: Design options for the proximity of the CPD to AAS

<table>
<thead>
<tr>
<th>DESIGN OPTIONS FOR THE PROXIMITY OF THE CPD TO AAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A location at or closely located to AAS such as at SRE’s or SADC’s land (small distance)</td>
</tr>
</tbody>
</table>

8.2 Design options for the level of obligation or stimulus for usage of the CPD

To develop the theoretically feasible design options for this key design variable, the financial and non-financial measures that Schiphol Group may use to oblige or stimulate usage of the CPD are separately investigated.

Non-financial measures of Schiphol Group to oblige or stimulate usage of the CPD

Schiphol Real Estate (SRE) facilitates forwarders, trucking companies and ground handlers in conducting their activities by developing and renting out warehouses. Schiphol Group Aviation facilitates the cargo airlines with conducting their activities by making runways and other necessary infrastructure available to them. Schiphol Cargo only facilitates the AAS air cargo logistics chain by bringing parties together, lobbying for innovations, marketing AAS in- and outside the Netherlands among shippers/consignees, forwarders and airlines, etc. Schiphol Group does not have the power to non-financially directly interfere in the activities in the AAS air cargo logistics chain or in the interfaces between the different organizations.

Schiphol Group is however the owner and manager of the airport area. As such, Schiphol Group can impose rules and regulations for the usage of this area. With such rules and regulations Schiphol Group can stimulate the usage of the CPD. Schiphol Group can for example introduce a regulation that only allows electric vehicles to make use of the access roads to and from handlers. If the shuttle service between the CPD and the ground handlers gets carried out with electric vehicles, usage of the CPD is in an indirect way stimulated.
Financial measures of Schiphol Group to oblige or stimulate usage of the CPD
Besides stimulating usage of the CPD with non-financial measures, Schiphol Group can also financially stimulate it. Schiphol Real Estate business unit has rental agreements with different organizations, such as ground handlers and forwarders. It could give discounts on rental prices to freight forwarders or ground handlers if they make use of the CPD to a specific extent. The Schiphol Group Aviation business unit charges landing fees to cargo airlines to make use of AAS. If the CPD gets constructed and maintained with these incomes, organizations will also get a financial stimulus to make use of the CPD.

Conclusions of theoretically feasible design options for oblige/stimulating CPD usage
For Schiphol Group it is possible to oblige/stimulate usage of the CPD in a financial and non-financial way. However, if the Schiphol Group does so it will take over control/direction over the chain and steer from above the freight flows at AAS. The flexible (trading) climate at AAS will get harmed and thereby requirement 11 will get violated (see Table 7-1). There is only one theoretically feasible design option for the level of obligation or stimulus for usage of the CPD.

Table 8-2: Design options for the level of obligation or stimulus for usage of the CPD

<table>
<thead>
<tr>
<th>DESIGN OPTIONS FOR THE LEVEL OF OBLIGATION OR STIMULUS FOR USAGE OF THE CPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

8.3 Design options for the range of services offered in the CPD
Dependent on the services that get offered in the CPD, different kinds of freight flows might pass the CPD (Lubbe, 2015, de Wit, 2014, Mok, 1994):

- Import and export cargo are suitable to flow through the CPD, transfer cargo is not.
- Perishables, flowers, living animals and aerospace parts will never pass the CPD, whereas general cargo and dangerous goods are suitable to pass the CPD.
- Import and export streams of general cargo and dangerous goods account for 70% of all freight streams at AAS. It depends on other characteristics and on the services that get offered in the CPD whether these freight flows will pass the CPD. It is for example dependent on how the freight is built up and on characteristics of the hinterland transportation.

For a more extensive explanation hereof appendix H can be consulted.

Based on this knowledge and on the knowledge derived from other researches, several theoretically feasible options for the range of services offered are found. To review what knowledge is derived from other researches and how this knowledge is used to come to the seven options for the range of services offered that are explained below, appendix I can be consulted. This section only contains an explanation of the seven theoretically feasible options for the range of services offered in the potential future CPD at AAS.

Option 1: airside fast-track for BUPs
The first option is only to offer BUP transhipment in a CPD that is located on the border between landside and airside. The exact specifications of this option are listed in Table 8-3 and visualized in Figure 8-1.
Option 2: pure storage landside CPD
The second design option for the range of services offered is to only offer storage services for BUPs and skids/loose cargo in a CPD that is located on landside. Because no ULD build-up and breakdown takes place in this option, the facility is not suitable for temporary storing mixed ULDs. Ground handlers keep building up and breaking off mixed ULDs in their warehouses. A shuttle service will run between the ground handlers and the CPD. The exact specifications of this option are listed in Table 8-3 and visualized in Figure 8-2.

Option 3: landside CPD offering ULD build-up and breakdown
The third option is a landside CPD in which all services are offered that are currently only offered in the warehouses of the ground handlers. This facility is suitable for BUPs, mixed ULDs and skids/loose cargo. A shuttle service will need to be run between the ground handlers and this facility. The exact specifications of this option are listed in Table 8-3 and visualized in Figure 8-3.
Offered! Therefore! the! facility! can! not! be! used! to! temporary! store! mixed! UL
airside! CPD.! In! the! landside! CPD! only! storage! services! for! BUPs! and! skids/loose! cargo! are!
offered! in! the! warehouses! of! the! ground! handlers.

The! fifth! option! is! a! combination! of! options! one! and! two.! It! consists! of! a! landside! and! an!
service! will! need! to! be! run! between! the! ground! handlers! and! this! facility.! The

Option 4: landside CPD offering ULD build-up and breakdown and destination (de)consolidation & value added activities
The fourth option is a landside CPD in which all services are offered that are currently only
offered in the warehouses of the ground handlers and in the warehouses of the freight
forwarders. This facility is suitable for BUPs, mixed ULDs and skids/loose cargo. A shuttle
service will need to be run between the ground handlers and this facility. The exact
specifications of this option are listed in Table 8-3 and visualized in Figure 8-4.

Option 5: pure storage landside CPD combined with airside fast-track for BUPs
The fifth option is a combination of options one and two. It consists of a landside and an
airside CPD. In the landside CPD only storage services for BUPs and skids/loose cargo are
offered. Therefore the facility can not be used to temporary store mixed ULDs, as mixed
ULDs will need to be built up and broken off in the ground handlers’ warehouses. In the
airside CPD the transhipment of BUPs is offered. A shuttle service will need to be run
between the ground handlers and the landside CPD and between the airside CPD and the
landside CPD. The exact specifications of this option are listed in Table 8-3 and visualized in Figure 8-5.

**Option 6: a landside CPD offering ULD build-up and breakdown combined with an airside fast-track for BUPs**

The fifth option is a combination of options one and three. It consists of a landside and an airside CPD. In the landside CPD ULD and BUP build-up and breakdown takes place. Additionally BUPs and skids/loose cargo can be stored here. In the airside CPD BUP transhipment is offered. A shuttle service will need to be run between the ground handlers and the landside CPD and between the airside CPD and the landside CPD. The exact specifications of this option are listed in Table 8-3 and visualized in Figure 8-6.
Option 7: a landside CPD offering ULD build-up and breakdown and destination (de)consolidation & value added activities combined with an airside fast-track for BUPs

The seventh option is a combination of options one and four. It consists of a landside and an airside CPD. In the landside CPD ULD and BUP build-up and breakdown takes place. Additionally BUPs and skids/loose cargo can be stored here and destination (de)consolidation & value added activities are carried out. In the airside CPD BUP transhipment is offered. A shuttle service will need to be run between the ground handlers and the landside CPD and between the airside CPD and the landside CPD. The exact specifications of this option are listed in Table 8-3 and visualized in Figure 8-7.

![Figure 8-7: Visualization of the seventh option for the range of services offered: a landside CPD offering ULD build-up and breakdown and destination (de)consolidation & value added activities combined with an airside fast-track for BUPs](image)

All theoretically feasible design options for the range of services offered

There are seven theoretically feasible options for the range of services offered in the CPD. These were explained in the previous sections and are listed in Table 8-3.
Table 8-3: Design options for range of services offered in the CPD

<table>
<thead>
<tr>
<th>#</th>
<th>Name</th>
<th>Services offered in landside CPD (see Figure 2-11 for explanation)</th>
<th>Services offered in airside CPD (see Figure 2-11 for explanation)</th>
<th>Location</th>
<th>Shuttle service</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Airside fast-track for BUPs</td>
<td></td>
<td>• BUP transhipment</td>
<td>Airside</td>
<td>No shuttle service</td>
</tr>
<tr>
<td>2</td>
<td>Pure storage landside CPD</td>
<td>• Storage of BUPs</td>
<td></td>
<td>Landside</td>
<td>Between CPD and ground handlers</td>
</tr>
<tr>
<td>3</td>
<td>Landside CPD offering ULD build-up and breakdown</td>
<td>• ULD build-up and breakdown</td>
<td></td>
<td>Landside</td>
<td>Between CPD and ground handlers</td>
</tr>
<tr>
<td>4</td>
<td>Landside CPD offering ULD build-up and destination (de)consolidation &amp; value added activities</td>
<td>• ULD build-up and breakdown</td>
<td>• BUP storage and storage of skids/loose cargo</td>
<td>Landside</td>
<td>Between CPD and ground handlers</td>
</tr>
<tr>
<td>5</td>
<td>Pure storage landside CPD combined with airside fast-track for BUPs</td>
<td>• Storage of BUPs</td>
<td>• BUP transhipment</td>
<td>Airside and Landside</td>
<td>Between CPD and ground handlers &amp; between airside and landside CPD</td>
</tr>
<tr>
<td>6</td>
<td>Landside CPD offering ULD build-up and breakdown combined with an airside fast-track for BUPs</td>
<td>• ULD build-up and breakdown</td>
<td>• BUP transhipment</td>
<td>Airside and Landside</td>
<td>Between CPD and ground handlers &amp; between airside and landside CPD</td>
</tr>
<tr>
<td>7</td>
<td>Landside CPD offering ULD build-up and breakdown and destination (de)consolidation &amp; value added activities combined with an airside fast-track for BUPs</td>
<td>• ULD build-up and breakdown</td>
<td>• BUP transhipment</td>
<td>Airside and Landside</td>
<td>Between CPD and ground handlers &amp; between airside and landside CPD</td>
</tr>
</tbody>
</table>
8.4 Design options for the ownership of the CPD

Most land and buildings at and around the AAS area are owned and maintained by real estate companies, such as Schiphol Real Estate (SRE), Chipshol Holding B.V. and Schiphol Area Development Company (SADC). Most core players (see chapter 5 for the core players) in the AAS air cargo logistics chain rent buildings, such as warehouses, from these real estate companies. For these core players it is however also possible to become owner of a building at or around AAS themselves. Serving parties of the AAS air cargo logistics (see chapter 5 for the serving parties) chain can also become owner of the potential future CPD, just as organizations from outside the AAS air cargo logistics chain. The practically infinite amount of serving parties and organizations from outside the chain is denoted as a neutral third party, because for the functioning of the CPD it is not of influence which of these organizations will exactly become owner.

Finally the Aviation business unit of the Schiphol Group can invest in the facility with the incomes from aviation activities (which are mainly the incomes from landing fees) and thereby become owner of it. It can even invest in the equipment available in the facility and carry out the maintenance of the building and its equipment, just like Schiphol Group Aviation currently does for the baggage handling facilities at AAS. See appendix C for a comparison with the baggage handling facilities at AAS that are owned and maintained by the Schiphol Group Aviation business unit. The theoretically feasible design options for the ownership of the CPD are shown in Table 8-4.

Table 8-4: Design options for the ownership of the CPD

<table>
<thead>
<tr>
<th>DESIGN OPTIONS FOR THE OWNERSHIP OF THE CPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cargo ground handler(s)</td>
</tr>
<tr>
<td>2. Freight forwarder(s)</td>
</tr>
<tr>
<td>3. Cargo airline(s)</td>
</tr>
<tr>
<td>4. Trucking company/companies</td>
</tr>
<tr>
<td>5. Neutral third party</td>
</tr>
<tr>
<td>6. Real estate company</td>
</tr>
<tr>
<td>7. Schiphol Group Aviation</td>
</tr>
</tbody>
</table>

8.5 Design options for the responsibility for operating the CPD

The core players in the AAS air cargo logistics chain can all become responsible for operating the facility. The core players are already directly involved with the flow of a shipment through the AAS air cargo logistics chain. They all carry out activities and have responsibilities that are directly related to the transportation, transhipment and/or processing of freight. These players can all enhance their activities or replace part of their activities to the CPD by operating this facility. Similarly any serving party of the chain and every organization from outside the chain can theoretically become responsible for it. There are no requirements that will not get met if one of those organizations becomes responsible for the operations in the CPD. For the functioning of the CPD and the impact on the chain (such as on the contractual relationships within the chain) it does not matter which serving party of the chain or organization from outside the chain will become responsible for operating the facility. The practically infinite amount of those organizations can therefore be denoted as a neutral third party.

Many interviewees representing different types of organizations from the AAS air cargo logistics chain mentioned their unwillingness to let their freight come in the hands of competitors. Organizations in this chain are in general not willing to give away responsibility

- They do not want competitors to get insight into their customer base.
- They do not want to contribute to competitors’ incomes by bringing them work.

It is only considered theoretically feasible that either multiple cargo ground handlers, multiple freight forwarders, multiple cargo airlines or multiple trucking companies will become jointly responsible for operating the CPD. If only one of such organizations becomes responsible for the operations, only freight of this organization will likely flow through the facility. The CPD will thereby lose its functionally as a central place at AAS where air freight can be picked up and delivered. The theoretically feasible design options for the responsibility for operating the CPD are listed in Table 8-5.

Table 8-5: Design options for the responsibility for operating the CPD

<table>
<thead>
<tr>
<th>OPTIONS FOR THE RESPONSIBILITY FOR OPERATING THE CPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Cargo ground handlers jointly</td>
</tr>
<tr>
<td>2 Freight forwarders jointly</td>
</tr>
<tr>
<td>3 Cargo airlines jointly</td>
</tr>
<tr>
<td>4 Trucking companies jointly</td>
</tr>
<tr>
<td>5 Neutral third party</td>
</tr>
</tbody>
</table>

8.6 Design options for the model of costs and gains sharing

The model of costs and gains sharing describes how costs and gains related to the implementation of the CPD are distributed among different organizations. No theoretically feasible design option for the model of costs and gains sharing can be constructed without knowing how the other key design variables are designed. The costs and gains related to the development and operation of a CPD are dependent on the services that are offered in the CPD, the organizations that are responsible for operating the facility and the owners of the facility. The model of costs and gains sharing can only be constructed after these variables have been filled in. In this phase of the research there are still thousands of possible combinations of design options for the other key design variables. To develop a case-specific model of costs and gains sharing for each of these thousands of possible combinations would imply much unnecessary work and complexity. Therefore it is chosen to develop design options for the model of costs and gains sharing in a later stage of the research.

8.7 Conclusions of theoretically feasible design options for critical variables

In this chapter all theoretically feasible options to design the critical design variables of a potential future CPD separately were found. A design option for a critical design variable is considered theoretically feasible if the option meets all requirements to the CPD design that were formulated in the system-, actor- and qualitative analysis and are listed in Table 7-1 in chapter 7. For each critical design variable separately the theoretically feasible options were found by studying literature, making use of the knowledge derived during the in-depth interviews and field researches and by studying other researches. The results are visualized in Figure 8-8.
<table>
<thead>
<tr>
<th>Proximity to AAS</th>
<th>Level of obligation/ stimulus</th>
<th>Services offered</th>
<th>Owner</th>
<th>Responsible for operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>A location at or closely located to AAS</td>
<td>No financial or non-financial obligation/ stimulus by Schiphol Group</td>
<td>1. Airside fast-track for BUPs</td>
<td>Cargo ground handler(s)</td>
<td>Cargo ground handlers jointly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Pure storage landside CPD</td>
<td>Freight forwarder(s)</td>
<td>Freight forwarders jointly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Landside CPD offering ULD build-up and breakdown</td>
<td>Cargo airline(s)</td>
<td>Cargo airlines jointly</td>
</tr>
<tr>
<td></td>
<td>Model of costs and gains sharing</td>
<td>4. Landside CPD offering ULD build-up and breakdown and destination (de)consolidation &amp; value added services</td>
<td>Trucking company/ companies</td>
<td>Trucking companies jointly</td>
</tr>
<tr>
<td></td>
<td>Dependent on design of other critical design variables</td>
<td>5. Combination of 1 &amp; 2</td>
<td>Neutral third party</td>
<td>Neutral third party</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Combination of 1 &amp; 3</td>
<td>Real estate company</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Combination of 1 &amp; 4</td>
<td>Schiphol Group Aviation</td>
<td></td>
</tr>
</tbody>
</table>

Figure 8-8: Theoretically feasible design options for the critical design variables separately

Because this chapter contains all theoretically feasible options for the critical design variables of a CPD separately, it gives answer to the fourth sub research question.

Research sub question 4: What are the theoretically feasible options to design the critical design variables of a potential future CPD at AAS that were found in research sub question 1 separately?
9 Theoretically feasible CPD design alternatives

In the previous chapter all design options were found for the critical design variables of a CPD at AAS separately. Only for the model of costs and gains sharing no design options were set up. The model of costs and gains sharing cannot be set up separately from the other critical design variables. Therefore it was not considered valuable in this phase of the research to develop possible model of costs and gains sharing already.

In this chapter it is analyzed which combinations of the design options that were found for the critical design variables separately (combinations = theoretically feasible CPD design alternatives) can be made given the restrictions from the environment of the CPD. Thereby this chapter gives answer to the sub research question below.

Research sub question 5: Which theoretically feasible design options from research sub question 4 for the critical design variables separately can be combined to create theoretically feasible CPD designs?

The first section of this chapter explains why a specific combination of design options for different variables does not comply with all requirements. In the second section it is explained how alternatives for the combined options for the range of services (critical design variables) are found. Section three contains the conclusions of theoretically feasible CPD design alternatives.

To find out which separate design options can be combined to form complete theoretically feasible CPD alternatives, a criterion that determines the theoretical possibility of a combination of design options was set up by the researcher. This criterion is explained in the box below.

ASSUMPTION BY THE RESEARCHER

A combination of separate design options for two or more critical design variables is theoretically only possible if the combination complies with all requirements that were formulated in the system, actor and qualitative analysis and are listed in chapter 7.

9.1 Exclusion of Schiphol Group Aviation as owner and third party operating

If the Schiphol Group Aviation business unit becomes owner of the CPD and a neutral third party becomes responsible for operating the facility, not all requirements will get met. In this option Schiphol Group Aviation will need to charge the cargo airlines on their landing fees for the depreciation and maintenance of the facility and its equipment (because Schiphol Group Aviation may only derive incomes from aviation activities). Hence, all cargo airlines will financially contribute to the facility. If a neutral third party operates this CPD, the cargo airlines will have no other choice but to all let this neutral party carry out (part of) their ground handling or to not make use of the facility while paying for it. This combination of options therefore harms the open market regime for cargo ground handling at AAS. These theoretically feasible design options for the ownership of the CPD and the responsibility for operating the CPD do not comply with requirement 6 when combined. Therefore this combination is not considered theoretically feasible.

9.2 Designs for combinations of options for range of services offered

In the previous chapter all theoretically feasible design options for the critical design variables separately were found (see Figure 8-8). For the range of services offered, four base options were found (options one – four). Some of the base options were also combined and
thereby three additional combined options were found (options five – seven). The development of CPD design alternatives that contain one the base options for the range of services offered is straightforward. These single options can be combined with all theoretically feasible design options for the other critical variables (only the combination of Schiphol Group Aviation being owner and a neutral third party operating the CPD is not possible as is described above). For the development of all theoretically feasible CPD design alternative that contain a combined option for the range of services offered (option five, six or seven), an assumption is needed.

**ASSUMPTION BY THE RESEARCHER**

For each single design option for the range of services offered (design options one – four) all theoretically feasible complete CPD design alternatives can be constructed straightforward. The respective option needs to be combined with all possible design options of the other critical variables to find all theoretically feasible alternatives that contain the respective option for the range of services offered. For the combinations of design options for the range of services offered (design options five – seven), it is more complex. It is assumed that all alternatives containing the respective single design options can be combined. For example each CPD design alternative that includes the first option for the range of services offered is combined with each design alternative that includes the second option for the range of services offered to find all CPD design alternatives that include the fourth option for the range of services offered. Later in the research when screenings of the 3604 possible CPD design alternatives have taken place and when the alternatives include models of costs and gains sharing, this assumption will be validated for all separate remaining alternatives.

**9.3 Conclusions of theoretically feasible CPD design alternatives**

All theoretically feasible design options for the different critical design variables separately were found in the previous chapter.

One combination of design options for two different key design variables was excluded in this chapter, because the combination does not comply with all requirements to the CPD design. This is the combination of Schiphol Group Aviation being owner and a neutral third party operating the facility. All other combinations of different separate design options for the critical variables are considered theoretically feasible.

The fifth, sixth and seventh option for the range of services offered are respectively combinations of the first and second, first and third and first and fourth option for this variable. It is assumed that all complete theoretically feasible CPD design alternatives that contain the fifth, sixth or seventh option for the range of services offered can be found by combining all alternatives that contain the respective single options for the range of services offered.

Figure 9-1 represents all 3604 theoretically feasible alternatives for the high-level CPD design (without a model of costs and gains sharing yet included!). This figure can be studied in the following way.

1. To find a theoretically feasible CPD design alternative one of the single options for the range of services should firstly be selected (option one – four).
2. Second step is to select one of the theoretically feasible owners (can be any owner).
3. Only if the colour of the potential owner matches with one of the colours of a potential organization becoming responsible for the operations in the CPD, this option for the responsibility for operations can be chosen.
4. The proximity to AAS and the level of obligation/stimulus for the CPD is determined for every alternative; the model of costs and gains sharing is not yet included.
5. If the option for the range of services offered is option five, six or seven (a combination of options), steps 1-4 must be repeated for the other option for the range of services offered.

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Services offered</th>
<th>Owner</th>
<th>Responsible for operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>34</td>
<td>1. Airside fast-track for BUPs</td>
<td>Cargo ground handler(s)</td>
<td>Cargo ground handlers jointly</td>
</tr>
<tr>
<td>34</td>
<td>2. Pure storage landside CPD</td>
<td>Freight forwarder(s)</td>
<td>Freight forwarders jointly</td>
</tr>
<tr>
<td>34</td>
<td>3. Landside CPD offering ULD build-up and breakdown</td>
<td>Cargo airline(s)</td>
<td>Cargo airlines jointly</td>
</tr>
<tr>
<td>34</td>
<td>4. Landside CPD offering ULD build-up and breakdown and destination (de)consolidation &amp; value added services</td>
<td>Trucking company/companies</td>
<td>Trucking companies jointly</td>
</tr>
<tr>
<td>34 * 34 = 1156</td>
<td>5. Combination of 1 &amp; 2</td>
<td>Neutral third party</td>
<td>Neutral third party</td>
</tr>
<tr>
<td>34 * 34 = 1156</td>
<td>6. Combination of 1 &amp; 3</td>
<td>Real estate company</td>
<td></td>
</tr>
<tr>
<td>34 * 34 = 1156</td>
<td>7. Combination of 1 &amp; 4</td>
<td>Schiphol Group Aviation</td>
<td></td>
</tr>
</tbody>
</table>

Figure 9-1: Theoretically feasible CPD design alternatives

All theoretically feasible CPD design alternatives are found in this chapter. Thereby the fifth research question is answered.

Research sub question 5: Which theoretically feasible design options from research sub question 4 for the critical design variables separately can be combined to create theoretically feasible CPD designs?
PART IV: DESIGN EVALUATION
10 Stepwise evaluation methodology to find preferred design

In total 3604 theoretically feasible high-level CPD designs were found in chapter 9. The 3604 theoretically feasible CPD designs do not include a model of costs and gains sharing yet. These alternatives comply with all design requirements that came forward from the system-environment and the actor-environment of the potential future CPD. It is however yet uncertain what their practical implications will be. Their influence on the core values of the critical actors is uncertain, as well as their influence on the hard full chain performance indicators (the criteria derived from the objectives).

In this chapter a stepwise evaluation methodology is developed to determine the practical implications of the CPD design alternatives, to evaluate which CPD of the 3604 designs are able to function in the AAS air cargo logistics chain and eventually to choose a preferred CPD design. In this chapter an answer is given to the sixth sub research question of this chapter.

Research sub question 6: Can a methodology be developed with which a preferred alternative that has the ability to function effectively in the AAS air cargo logistics chain can be determined?

The developed stepwise evaluation methodology was discussed with an expert in the field of Multi-Criteria Decision Analyses at the faculty of Technology, Policy and Management of the Delft University of Technology. According to the expert the stepwise approach is reliable (although it might need some more careful and especially empirical investigations).

The stepwise evaluation methodology is explained in this chapter. The different steps of the stepwise methodology are carried out in the subsequent chapters of part IV of the thesis.

The different steps of the stepwise evaluation methodology are described in this chapter and more explicitly explained in the subsequent chapters in which the steps are carried out.

Step 1: Defining desired CPD design alternatives
It is firstly analyzed whether specific alternatives are considered undesired by the researcher. For such alternatives no models of costs and gains sharing need to be formulated. Their influence on the core values of the actors and/or hard performance indicators (criteria) of the chain also does not need to be researched.

ASSUMPTION BY THE RESEARCHER
A CPD design alternative that requires significant and/or complex adaptations to the current setup of the chain is considered undesired by the researcher. Worldwide the air cargo logistics chains are quite standardized. For the competitive position of AAS as a cargo hub it is considered undesired by the researcher that the AAS air cargo logistics chain becomes an exception to this standardization. Examples can be alternatives that require significant/complex adaptations to embedded contractual relationships or to embedded roles/business models of the different players in the chain.

Step 2: Developing models of costs and gains sharing for desired alternatives
For the theoretically feasible and desired alternatives models of costs and gains sharing are formulated to complete the high-level designs of the alternatives. This may lead to an expansion of the total amount of alternatives, if multiple models of costs and gains sharing can be set up for the same desired CPD design alternative.
Step 3: Defining most acceptable CPD design alternatives
The ability of the CPD to function in the AAS air cargo logistics chain is very dependent on its influence on the (soft) core values of the critical actors. Negative influences of a project or initiative on the cultures, beliefs or values (in summary: core values) of the organizations in the AAS air cargo logistics chain have often led to complexities during implementation or a project or initiative not being implementable at all. This has also been the case for projects or initiatives with promising positive influences on full chain performance indicators, such as logistical or financial ones (Ploumen, 2014, Pieters, 2014, Ankersmit, 2013). Before the CPD designs will be tested on the full chain objectives of the facility from a full chain perspective (minimize costs, minimize truck movements, minimize first line area needed and minimize second line area needed) the designs are therefore firstly tested on their influence on the core values of the actors, which are listed again below in Table 10-1.

Table 10-1: Another overview of important core values of critical actors of the AAS air cargo logistics chain

<table>
<thead>
<tr>
<th>Core values</th>
<th>Freight forwarders</th>
<th>KLM Cargo</th>
<th>Cargo airlines</th>
<th>Cargo ground handlers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Differentiation</td>
<td>1. Differentiation</td>
<td>1. Differentiation</td>
<td>1. Differentiation</td>
<td></td>
</tr>
<tr>
<td>5. Fairness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In this step the approximately five alternatives that have the most positive influence on the core values of the actors are selected for the next steps. These are the most acceptable CPD design alternatives from the critical actors’ perspective.

Step 4: Diversity of designs
The approximately five most acceptable designs from the previous step are tested on diversity. An additional alternative is added in this step if these most acceptable CPD design alternatives are very similar. This diversity check is carried out to get more insight in the next steps in which alternatives are tested on the full chain objectives (criteria). The outcomes of these steps can thereby be placed better into perspective; it can be reviewed whether alternatives score very high compared to a diverse group of CPD designs instead of only compared to similar designs.

Step 5.1: Setup of final Multi-Criteria Decision Analysis
In this step a final Multi-Criteria Decision Analysis (MCDA) is set up. The aim of this MCDA is to rank the most acceptable CPD designs (potentially added with a more divers alternative) based on their scores on the earlier formulated full chain objectives. In this step a choice is made for a specific MCDA method and the method is set up specifically for this research.

Step 5.2: Outcomes of final Multi-Criteria Decision Analysis
The MCDA that was set up in the previous step is carried out to determine the preferred alternative among the remaining CPD designs. It is reviewed whether all remaining alternatives fulfil the constraints and how they score on the full chain objectives. This step will result in a ranking of the most acceptable alternatives from a most preferred one until least preferred one. The most preferred one is the one that scores best on the full chain objectives. Sensitivity analyses are carried out to assess the robustness of the ranking. The scores of all the most acceptable CPD design alternatives (potentially added with a more divers alternative) on the full chain objectives become clear.
11 Desired CPD design alternatives (S1)

In total 3604 theoretically feasible design alternatives, without models of costs and gains sharing, were found in chapter 9. To find out which of these theoretically feasible alternatives have the ability to function in the chain and eventually which alternative is the preferred one a stepwise evaluation methodology was set up in chapter 10. In this chapter the first step of this evaluation methodology is carried out. It is evaluated whether the researcher considers all theoretically feasible alternatives desired. This step of the stepwise evaluation methodology is consciously carried out before models of costs and gains sharing are developed for the different CPD design alternatives. Thereby no models of costs and gains sharing are developed for undesired.

Firstly the separate design options for the critical variables are evaluated. Alternatives that contain an undesired design option for a critical variable can be ruled out. This is done in the first section. Subsequently it is evaluated whether combinations of design options for different critical variables are considered undesired. Alternatives that comprise such combinations of options can also be ruled out. This is done in the second section. The final section contains the conclusions of this chapter.

To carry out this step it needs to be concretized what determines the desirability of a CPD design alternatives. This is explained in the box below.

**ASSUMPTION BY THE RESEARCHER**
A CPD design alternative that requires significant and/or complex adaptations to the current setup of the chain is considered undesired by the researcher. Worldwide the air cargo logistics chains are quite standardized. For the competitive position of AAS as a cargo hub it is considered undesired by the researcher that the AAS air cargo logistics chain becomes an exception to this standardization. Examples can be alternatives that require significant/complex adaptations to embedded contractual relationships or to embedded roles/business models of the different players in the chain.

<table>
<thead>
<tr>
<th>Key design variable</th>
<th>Undesired option(s)</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership of the CPD</td>
<td>Ground handler(s), Freight forwarder(s), Cargo airline(s), Trucking company/companies, Neutral third party</td>
<td>Not the role of non real estate companies in the AAS air cargo logistics chain to invest in the construction or acquisition of real estate</td>
</tr>
</tbody>
</table>

The majority of organizations from the AAS air cargo logistics chain rents their building(s) from real estate companies, such as from Schiphol Real Estate (Schiphol Real Estate, 2015). There are various reasons for this
Investing in a building (either by constructing or acquiring it) and renting it out to another organization or group of organizations is the core business of a real estate company. Non real estate companies create value in other ways and are not specialized in creating or acquiring real estate and renting it out. For those organizations it means that a high investment for the piece of real estate needs to be done. This investment is done in an area that the company is not specialized in. The investment can also not be used for their core business. Moreover, the risks attached to becoming owner of a building at AAS are larger for non real estate companies than for real estate companies. In case of no demand for the building, a remaining unused building is of more value to a real estate company than to a non-real estate company. For a real estate company the building is part of its portfolio, while for the non real estate company it is an unusual and separate asset. For a non real estate company it is less attractive to invest in the facility and rent it out to another organization than for a real estate company.

It is also more attractive for the different organizations from the chain to rent a facility from a real estate company than to invest in a building for own use. An advantage for an organization to invest in a facility itself is that it can equip the facility completely according to own desires. Disadvantages are all the above described risks and disadvantages. Whether a building is owned or rented, the financial expenses look quite similar for the organization(s) running it. In case the building is owned, a bank loan for the investment will need to be paid back monthly and the maintenance costs will need to be paid. In case the facility is not owned, rent will need to be paid monthly to the owner of the facility. With this monthly rent the real estate company covers the costs of depreciation and maintenance.

Alternatives with core players from the chain or a neutral third party as owner of the CPD requires a complex adaptation to their current roles in the chain. Such alternatives are therefore considered undesired.

**Cargo airlines jointly becoming responsible for the operations in the CPD**

Table 11-2: Exclusion of alternatives in which cargo airlines jointly are responsible for the operations

<table>
<thead>
<tr>
<th>Key design variable</th>
<th>Undesired option(s)</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsibility for operating the CPD</td>
<td>Cargo airlines jointly</td>
<td>Cargo airlines do not carry out ground operations at AAS</td>
</tr>
</tbody>
</table>

At AAS all cargo airlines, except for home carrier KLM Cargo, outsource their ground operations to third party ground handlers. This is very embedded in the chain. Cargo airlines becoming responsible for ground operations would imply a radical adaptation to the roles of these cargo airlines at AAS. Therefore this option is considered undesired. Some reasons for cargo airlines to outsource ground operations at AAS to ground handlers are listed below.

1. Non-hub carriers have relatively low cargo volumes at AAS. For any cargo airline except for KLM Cargo it is therefore economically not beneficial to conduct cargo ground operations itself. A third party ground handler that carries out ground operations for multiple cargo airlines can realize economies of scale.
2. Cargo airlines want to be able to adjust their network of flights from/to AAS, for example if market demand changes or if landing fees or other costs become lower at other European airports. For this reason it is not attractive for a cargo airline to be responsible for ground operations at AAS itself. Doing so will make a cargo airline...
bonded to AAS. If such a cargo airline decides to quit or reduce operations at AAS, it will need to transfer or fire personnel, etc.

3. Cargo ground handling does not belong to the core business of cargo airlines.

It is also not an option for KLM Cargo to run the CPD on its own. KLM Cargo is very reluctant to let other cargo airlines profit from their large volumes at AAS and thereby from the economies of scale they realize with their ground handling (Vreeburg, 2014). Moreover, competition between cargo airlines is very fierce and cargo airlines therefore are not likely to entrust their freight to competitors (Sifneos, 2014). Theoretically feasible CPD designs in which cargo airlines are responsible for the operations are considered undesired.

11.2 Undesired combinations of design options for critical variables

In this section it is analyzed whether alternatives that contain a combination of options for key design variables can be excluded because the combination is considered undesired.

**Trucking companies taking over services from handlers/forwarders**

Table 11-3: Exclusion of alternatives in which trucking companies take over services from handlers/forwarders

<table>
<thead>
<tr>
<th>Undesired combination(s) of options for key design variables</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of services offered: Airside fast-track for BUPs, Landside CPD offering ULD build-up and breakdown, Landside CPD offering ULD build-up and breakdown and destination (de)consolidation &amp; value added services</td>
<td>Services of ground handlers and freight forwarders do not fit in the business model of the trucking companies</td>
</tr>
<tr>
<td>Responsibility for operating the CPD: Trucking companies jointly</td>
<td></td>
</tr>
</tbody>
</table>

The core activity of trucking companies is to truck freight of their customers through Europe. The trucking companies try to do this in a most cost-efficient way, for example by consolidating freight of various customers. This consolidation takes place in their warehouses, but also during truck rides. There is currently no trucking company that offers services that are offered by ground handlers and/or freight forwarders, such as ULD build-up and breakdown. Such services are not part of the business model of trucking companies. It is considered undesired that trucking companies take over services from ground handlers or forwarders, because a complex and radical adaptation to the role of the trucking companies is required for this. Only in the case of a pure storage landside CPD (second option for the range of services offered) it is considered desired that the trucking companies jointly will become responsible for the operations.

**Freight forwarders jointly operating a landside CPD in which ULD build-up and breakdown is offered**

Table 11-4: Exclusion of alternatives in which freight forwarders operate a landside CPD in which ULD build-up and breakdown is offered

<table>
<thead>
<tr>
<th>Undesired combination(s) of options for key design variables</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of services offered: Landside CPD offering ULD build-up and breakdown, Landside CPD offering ULD build-up and breakdown and destination (de)consolidation &amp; value added services</td>
<td>Forwarders must radically adapt their role to jointly build up and break off mixed ULDs</td>
</tr>
<tr>
<td>Responsibility for operating the CPD: Freight forwarders jointly</td>
<td></td>
</tr>
</tbody>
</table>

Forwarders do not jointly build up and break off mixed ULDs. When a forwarder books cargo space at a flight of an airline for freight that is not sufficient to completely fill a ULD, it lets
the ground handlers serving this cargo airline build up the ULD at the airport of departure and breakdown the mixed ULD at the airport of arrival. Alternatives in which forwarders will jointly become responsible for building up and breaking down mixed ULDs are considered undesired by the researcher because of the reasons listed below.

- A complex change in mutual contractual relationships is required. Currently forwarders separately from each other book cargo space at flights of cargo airlines, either for skids/loose cargo or for BUPs. If forwarders start with jointly filling ULDs, a new type of contractual relationships will need to be set up between the cargo airline and all freight forwarders which’ freight is in the mixed ULD.
- For forwarders it is a complex task to jointly build up or break down a mixed ULD. The rights, duties and responsibilities of the different freight forwarders must be set up and a high level of coordination is required. But even if that is achieved, questions remain what freight forwarder may load or unload its freight first in/from the mixed ULD.

Apart from these reasons for undesirability, it is also unlikely that forwarders will actually be willing to build up and break off mixed ULDs jointly.

- Freight forwarders do not want to show their freight to competitors (van Breugel, 2014). Knowledge about freight of competing forwarders is commercially very valuable. By becoming jointly responsible for mixed ULDs, freight forwarders will much easier get insight into each others’ freight and thereby into each others’ customers.
- The freight forwarding industry is more characterized by competition than by collaboration. Jointly building up and breaking off mixed ULDs and the need for fairness, equality and openness between different freight forwarders when doing so can therefore not be expected (Woorts, 2014).

Alternatives in which freight forwarders will jointly become responsible for operating a CPD in which mixed ULDs will be built up and broken down are considered undesired.

**11.3 Conclusions of desired CPD design alternatives (S1)**
Alternatives that require significant and/or complex adaptations to the current setup of the chain are considered undesired by the researcher. Worldwide the air cargo logistics chains are quite standardized. For the competitive position of AAS as a cargo hub it is considered undesired by the researcher that the AAS air cargo logistics chain becomes an exception to this standardization.

In the first section several alternatives were excluded because they contain a separate undesired design option for a critical variable. These are all alternatives in which another organization than a real estate company or Schiphol Group Aviation is the owner of the facility. All alternatives in which cargo airlines become responsible for the operations are excluded as well. In the second section alternatives that contain an undesired combination of options for key design variables were excluded. These are all alternatives in which trucking companies run another CPD than the pure storage landside CPD. Furthermore all alternatives in which freight forwarders become responsible for ULD build-up and breakdown are excluded.

The amount of CPD design alternatives without models of costs and gains sharing is reduced from 3604 to 77 by excluding the undesired alternatives. In the next chapter of this research models of costs and gains sharing are formulated for these 77 alternatives.
12 Models of costs and gains sharing desired alternatives (S2)

In the previous chapter it was concluded that only 77 of the 3604 theoretically feasible CPD design alternatives are considered desired. These 77 desired alternatives however still lack a model of costs and gains sharing. No models of costs and gains sharing were yet set up, because a model of costs and gains sharing is dependent on the design of all other variables. To develop a case-specific model of costs and gains sharing for each of the 3604 theoretically feasible alternatives would have resulted in much unnecessary work and complexity. In this chapter the 77 alternatives are completed with high-level models of costs and gains sharing.

A complete model of costs and gains sharing would describe how all costs and gains as a result of the CPD introduction would be distributed over the different organizations. For the development of a high-level CPD design, which is the aim of this research, it is however not considered valuable to set up such a detailed model of costs and gains sharing.

- Without a fully worked out detailed CPD design not all costs and gains related to the potential introduction of a CPD are known. The development of a detailed model of costs and gains sharing in this research would hence be speculative.
- A high-level model of costs and gains sharing is expected to have more influence on the functioning of the CPD than the exact and detailed division of costs and gains. New financial relationships between organizations and financial responsibilities over freight are expected to have more influence on the functioning of a CPD than how every cent is distributed in the future.

High-level models of costs and gains sharing are set up for the remaining (incomplete) CPD designs. A literature study was done towards costs and gains sharing in other similar freight consolidation centres. Appendix J contains this study. The knowledge gained during this literature study is used to develop different high-level models of costs and gains sharing for the 77 incomplete desired CPD design alternatives. From the literature study it became clear that two variables are of main importance for the development of a high-level model of costs and gains sharing for a CPD design alternative. The different ways that these two variables can be design for an alternative reflect all possible high-level models of gains sharing for the specific alternative. These two variables are explained in Table 12-1.

Table 12-1: Design variables of high-level model of costs and gains sharing for CPD

<table>
<thead>
<tr>
<th>Variable</th>
<th>Explanation of variable of high-level model of costs and gains sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paying parties</td>
<td>In several CPD design alternatives a neutral third party is responsible for operating the facility. Dependent on the range of services that get offered in the CPD, different organizations may be eligible to pay the neutral party.</td>
</tr>
<tr>
<td>Flexible or fixed CPD usage</td>
<td>If organizations from the chain jointly become responsible for operating the CPD, the organizations can fixed or flexibly make use of it. Fixed means they all rent a separate area in the facility and only carry out activities in their own areas. Flexibly means these organizations all carry out their own activities, but can use the full CPD and its equipment for it. They contribute to the total rent in line with their CPD usage (e.g. a price per tonne handled in the CPD or per m² per hour used). In case of an airside fast-track for BUPs it is practically impossible for the organizations to rent fixed areas, because this facility is not designed for it. If Schiphol Group Aviation owns the facility the fixed usage option is not possible. In that case Schiphol Group Aviation pays for the depreciation and maintenance of the facility with the incomes from landing fees and therefore is not able to rent out separate areas to different organizations.</td>
</tr>
</tbody>
</table>
With these two variables high-level models of costs and gains sharing for the 77 remaining alternatives can be set up. This results in a totality of 167 theoretically feasible and desired CPD alternatives including models of costs and gains sharing. The 167 alternatives are visualized in Figure 12-1, Figure 12-2, Figure 12-3, Figure 12-4 and Figure 12-5. These figures must be studied in the same way as Figure 9-1 (the text that introduces Figure 9-1 earlier in this research can be studied again if needed).

Figure 12-1: Desired CPD design alternatives including model of costs and gains sharing matrix I
Figure 12-2: Desired CPD design alternatives including model of costs and gains sharing matrix 2
Figure 12-3: Desired CPD design alternatives including model of costs and gains sharing matrix 3
<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Services offered</th>
<th>Owner</th>
<th>Responsible for operations</th>
<th>Model of costs and gains sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Airside fast-track for BUPs</td>
<td>Cargo ground handler(s)</td>
<td></td>
<td>Cargo ground handlers jointly</td>
<td>Flexible usage (by ground handlers)</td>
</tr>
<tr>
<td></td>
<td>Freight forwarder(s)</td>
<td></td>
<td>Freight forwarders jointly</td>
<td>Flexible usage (by ground handlers)</td>
</tr>
<tr>
<td></td>
<td>Cargo airline(s)</td>
<td></td>
<td>Cargo airlines jointly</td>
<td>Fixed usage (by ground handlers)</td>
</tr>
<tr>
<td></td>
<td>Trucking company/ companies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Pure storage landside CPD</td>
<td>Neutral third party</td>
<td></td>
<td>Trucking companies jointly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Real estate company</td>
<td></td>
<td>Neutral third party</td>
<td>Ground handlers pay (neutral party)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Landside CPD offering ULD build-up and breakdown</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Landside CPD offering ULD build-up and breakdown and destination (de)consolidation &amp; value added services</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Combination of 1 &amp; 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Combination of 1 &amp; 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Combination of 1 &amp; 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 12-4: Desired CPD design alternatives including model of costs and gains sharing matrix 4
<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Services offered</th>
<th>Owner</th>
<th>Responsible for operations</th>
<th>Model of costs and gains sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>(7)</td>
<td>1. Airside fast-track for BUPs</td>
<td>Cargo ground handler(s)</td>
<td>Cargo ground handlers jointly</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Freight forwarder(s)</td>
<td>Freight forwarders jointly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Pure storage landside CPD</td>
<td>Cargo airline(s)</td>
<td>Cargo airlines jointly</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trucking company/ companies</td>
<td>Trucking companies jointly</td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>3. Landside CPD offering ULD build-up and breakdown</td>
<td>Neutral third party</td>
<td>Neutral third party</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Real estate company</td>
<td>Schiphol Group Aviation</td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>4. Landside CPD offering ULD build-up and breakdown and destination (de)consolidation &amp; value added services</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7 x 10 = 70

5. Combination of 1 & 2

7 x 5 = 35

6. Combination of 1 & 3

7 x 5 = 35

7. Combination of 1 & 4

Figure 12-5: Desired CPD design alternatives including model of costs and gains sharing matrix 5

99
13 Most acceptable CPD design alternatives (S3)

In total 167 complete CPD design alternatives were formulated in the previous chapter that comply with all requirements to the CPD design (therefore they are theoretically feasible) and are considered desired by the researcher.

The influence of projects or initiatives in the AAS air cargo logistics chain on the cultures and beliefs of the organizations (which are captured in their core values) fiercely influences their ability to function in the chain (Ploumen, 2014, Ankersmit, 2013, Pieters, 2014). Previous projects in this chain faced serious complexities during implementation despite positive influences on full chain performance indicators (e.g. costs), because the projects did not match with the core values of the critical organizations. To avoid such a situation with a preferred CPD design alternative, the influence of the remaining alternatives on the core values of the critical actors is firstly assessed in this chapter, before alternatives are tested on the hard full chain objectives in later steps of the evaluation methodology. The aim of this step is to select the approximately five alternatives with the most positive influence on the core values of the (semi-)critical actors. These alternatives are considered to be most acceptable for the (semi-)critical organizations in the chain.

The structure of this chapter is as follows. Section describes how scores are given for the different alternatives on the core values of the (semi-)critical actors. In section two it is explained how these score are used to rank the remaining 167 alternatives. Section three explains what sensitivity analyses were carried out in this step and in section four the results are presented. The conclusions of this chapter are stated in section five.

13.1 The influence of alternatives on the core values

In the actor analysis in chapter 5 and the qualitative analysis in chapter 6 the core values of the critical actors were determined. These core values are again shown in Table 13-1 below.

Table 13-1: Core values per critical actor of the AAS air cargo logistics chain

<table>
<thead>
<tr>
<th>Core values</th>
<th>Freight forwarders</th>
<th>KLM Cargo</th>
<th>Cargo airlines</th>
<th>Cargo ground handlers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Differentiation</td>
<td>1. Differentiation</td>
<td>1. Differentiation</td>
<td>1. Differentiation</td>
</tr>
<tr>
<td></td>
<td>5. Fairness</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The usage of these core values for this step of the evaluation methodology already indicates a first assumption that was done by the researcher.

ASSUMPTION BY THE RESEARCHER

The researcher assigned core values to the critical actors, based on the extensive analyses of the actors in the actor and qualitative analyses of chapters 5 and 6. Critical actors themselves were not asked to communicate their core values. This was not asked because organizations have not always explicitly defined their core values and so asking a representative of an organization about it may lead to a personal interpretation. Also, asking critical actors about their core values may lead to strategic behaviour of the actors, if they know CPD designs will be evaluated on these core values.
To determine which alternatives are considered most acceptable for the (semi-)critical actors in the chain, the influence of all alternatives on those core values is first assessed. Appendix L explicates the influence of all remaining alternatives on all core values of the (semi-)critical actors. In total 2672 scores are shown in this appendix (scores for 167 alternatives on 16 core values). Scores from 1 to 7 were given and below is explained what these scores represent.

1: A very negative influence on the core value
2: A negative influence on the core value
3: A little negative influence on the core value
4: A neutral influence on the core value
5: A little positive influence on the core value
6: A positive influence on the core value
7: A very positive influence on the core value

To be able to assign the scores to each alternative per core value, another assumption had to be done by the researcher. This assumption is explained in the box below.

**ASSUMPTION BY THE RESEARCHER**
For each of the remaining 167 CPD design alternatives, the researcher assigned a score to the core values of the actors. Per alternative a score was assigned to 5 (freight forwarders) + 4 (KLM Cargo) + 3 (Cargo airlines) + 4 (Cargo ground handlers) = 16 core values of the different critical actors. This score was assigned with the knowledge that was acquired by the researcher during previous analyses in this research. For all these scores and an explanation of the scores appendix L can be consulted.

### 13.2 Methodology to rank alternatives based on their influence on core values

All the influences of the 167 alternatives on the core values of the (semi-)critical actors are defined and are represented in appendix L. A methodology is needed to use these scores to come to a ranking of most acceptable until least acceptable alternative from the actors’ point of view. In the search for such a methodology another assumption was done.

**ASSUMPTION BY THE RESEARCHER**
To rank various alternatives that are given scores on actor-specific criteria, a Multi-ACTOR Multi-Criteria Analysis such as the Analytical Hierarchy Process (AHP) would be suitable (Macharis et al., 2009). However, a very extensive analysis is needed to rank the 167 alternatives with scores on 16 core values of 4 different actors with the AHP-method (or another MAMCA method). It is therefore assumed better suitable in this step to compose an own method to rank the 167 remaining high-level design alternatives.

Deliberately two methods are chosen that deal differently with the scores of the alternatives on the core values, to make the outcomes in this step robust. That is because it is unknown how the actors will evaluate the scores on their core values. It is unknown whether an actor will prefer a score of 5 on two core values over a score of 3 on one core value and a score of 7 on another core value. The sum and average of the scores are equal, but the actor may still prefer one to the other because of the different scores these actors get on the core values. The aim is to find the approximately five most acceptable alternatives from the critical actors’ point of view with these two methods jointly. The methods are explained below.
13.2.1 Method 1: The weighted positive influence count method
In the first method it is counted per critical actor on how many core values an alternative has a positive influence (score of 5, 6 or 7). Per critical actor, this count is multiplied by the weight assigned to the critical actor. Higher weights are given to more important critical actors. By doing this multiplication a weighted positive influence count score is gained per critical actor. These scores are summed up to get the total weighted positive influence count score of the alternative. The higher this score is, the more acceptable the alternative is for the critical actors.

In this method it is assumed that the more core values are positively influenced by an alternative, the more the actor will prefer it. The formula with which the total weighted positive influence count score of an alternative is calculated is represented below.

\[
\text{Weighted positive influence count score (alternative } x) = \sum \text{ scores }>4 (\text{alternative } x \text{ on core values of actor } 1) \times \text{ weight (actor } 1) + \sum \text{ scores }>4 (\text{alternative } x \text{ on core values of actor } n-1) \times \text{ weight (actor } n-1) + \sum \text{ scores }>4 (\text{alternative } x \text{ on core values of actor } n) \times \text{ weight (actor } n)
\]

13.2.2 Method 2: The weighted average scores method
For each critical actor separately the average score of an alternative on its core values is calculated. The average score that an alternative gets for a specific critical actor is multiplied by the weight that is assigned to this critical actor. A higher weight implies that the critical actor is more important. For each critical actor a weighted average score on its core values is hereby obtained. By summing up these scores the total weighted average score of an alternative is found. The higher this score is, the more acceptable the alternative is for the critical actors.

In this method it is assumed for a critical actor the average score on the core values is leading for its preference. Although this method may theoretically not be used for qualitative criteria (Commissie voor de milieueffectrapportage, 2002), which is the case here, in practice the methodology has proven its validity to be used for qualitative criteria (Nijboer and van Westing, 1996). The formula with which the total weighted average score of an alternative is calculated is represented below.

\[
\text{Weighted average score (alternative } x) = \sum \text{ average score (alternative } x \text{ on core values of actor } 1) \times \text{ weight (actor } 1) + \sum \text{ average score (alternative } x \text{ on core values of actor } n-1) \times \text{ weight (actor } n-1) + \sum \text{ average score (alternative } x \text{ on core values of actor } n) \times \text{ weight (actor } n)
\]

From the description of both methodologies it can be recognized that the researcher did another assumption.

ASSUMPTION BY THE RESEARCHER
Based on the analyses in this research and the lessons learned during these analyses it was only considered possible to assign equal weights per critical actor to its core values. Critical actors themselves were not asked to assign weights to the defined core values. Asking a representative of an organization for the weights may lead to a personal interpretation. It may also lead to strategic behaviour of the actors, if they know CPD designs will be evaluated on the defined cores values and they can influence the importance of it.

13.3 Sensitivity analyses for developed methods
The outcomes of this step are made more robust by using two different. Additionally several sensitivity analyses are carried out, which are explained in this section.
Weights assigned to critical actors
The actor-environment of the AAS air cargo logistics chain was extensively analyzed in chapter 5. It became clear that the freight forwarders are the most important critical actor of the AAS air cargo logistics chain. Little less important for the functioning and performance of AAS as a cargo hub are KLM Cargo and the other cargo airlines. The ground handlers are a semi-critical actor. The ground handlers are only a critical actor in CPD designs in which they have the possibility to frustrate a potential CPD introduction and/or functioning. Only for such alternatives other scores than 4 (neutral influence) to their core values can be given.

Although it is clear that one critical actor is more important for AAS and the AAS air cargo logistics chain than another, it is difficult to translate this importance into exact weights of these actors. Therefore the above-described methods 1 and 2 are carried out with different weights assigned to the critical actors. A robust choice for the approximately five most acceptable alternatives from the critical actors’ point of view can hereby be made.

Including versus excluding alternatives that have a negative influence on any core value
As described earlier in this chapter, the chances on successful implementation of a project or initiative in this chain can be fiercely disturbed if the project/initiative does not match with a core value of an actor. A negative score on a core value of an actor may theoretically result in the actor immediately being opposed it, irrespective of the scores of the design on its other core values. A design that scores very high in both methods could hence still be non-implementable if it also has a negative influence on only one core value of an actor. To deal with this lack of knowledge, another sensitivity analysis was conducted. Both methods were carried out (for all different ranges of weights assigned to the critical actors) with two different ranges of CPD designs.

1. With all 167 remaining integrated high-level CPD design alternatives.
2. With only the alternatives that do not have a negative influence on any core value of any critical actor (a score of 4 or higher all the core values).

13.4 Results of most acceptable CPD design alternatives
The ranking of the approximately five most acceptable alternatives in both methods is different when different weights are assigned to the critical actors. However, the top seven consists of the same alternatives. The decision to include or not include alternatives that have a negative influence on any core value of any critical actor does not influence the ranking. For both ranges of alternatives included in the research the seven most acceptable alternatives are shown in Table 13-2.
Table 13-2: Most acceptable alternatives from critical actors’ point of view by weights assigned to critical actors

<table>
<thead>
<tr>
<th>Weights assigned to critical actors</th>
<th>Most acceptable alternatives from critical actors’ point of view</th>
<th>Method used to calculate score for each alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground handlers: 1</td>
<td>1. Alternative 66 (7pt)</td>
<td>Method 1</td>
</tr>
<tr>
<td>Cargo airlines: 1</td>
<td>3. Alternative 4 (6pt)</td>
<td></td>
</tr>
<tr>
<td>Freight forwarders: 2</td>
<td>4. Alternative 64 (6pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Alternative 65 (6pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Alternative 114 (6pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Alternative 115 (6pt)</td>
<td></td>
</tr>
<tr>
<td>Ground handlers: 1</td>
<td>1. Alternative 66 (10pt)</td>
<td>Method 1</td>
</tr>
<tr>
<td>KLM Cargo: 1</td>
<td>2. Alternative 67 (9pt)</td>
<td>Method 2</td>
</tr>
<tr>
<td>Cargo airlines: 1</td>
<td>3. Alternative 4 (9pt)</td>
<td></td>
</tr>
<tr>
<td>Freight forwarders: 3</td>
<td>4. Alternative 64 (9pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Alternative 65 (9pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Alternative 114 (9pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Alternative 115 (9pt)</td>
<td></td>
</tr>
<tr>
<td>Ground handlers: 1</td>
<td>1. Alternative 66 (11pt)</td>
<td>Method 1</td>
</tr>
<tr>
<td>KLM Cargo: 2</td>
<td>2. Alternative 67 (9pt)</td>
<td>Method 2</td>
</tr>
<tr>
<td>Cargo airlines: 2</td>
<td>3. Alternative 4 (9pt)</td>
<td></td>
</tr>
<tr>
<td>Freight forwarders: 3</td>
<td>4. Alternative 64 (9pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Alternative 65 (9pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Alternative 114 (9pt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Alternative 115 (9pt)</td>
<td></td>
</tr>
</tbody>
</table>
It can be concluded that the most acceptable CPD design alternatives from the critical actors’ point of view are alternatives 4, 64, 65, 66, 67, 114 and 115. These alternatives are schematically visualized in Figure 13-1.

**13.5 Conclusions of most acceptable CPD design alternatives**

In this chapter the influence of the 167 remaining alternatives on the core values of the (semi-)critical actors was used to define the most acceptable CPD designs from these actors’ points of view. The influences of the 167 alternatives on the different core values were assessed by the researcher based on the knowledge derived during the several analyses of the AAS air cargo logistics chain. Two methodologies were simultaneously used and several sensitivity analyses were carried out to make a robust assessment of the most acceptable CPD design alternatives. Table 13-3 represents all alternatives (4, 64, 65, 66, 67, 114 and
that are considered most acceptable and shows their influences on the core values of the different actors. Figure 13-1 schematically visualizes these alternatives.

Table 13-3: Scores of most acceptable alternatives on (semi-)critical actors’ core values

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Core values of the (semi-)critical actors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Freight forwarders</td>
</tr>
<tr>
<td></td>
<td>Differentiation</td>
</tr>
<tr>
<td>A4</td>
<td>4</td>
</tr>
<tr>
<td>A64</td>
<td>4</td>
</tr>
<tr>
<td>A65</td>
<td>4</td>
</tr>
<tr>
<td>A66</td>
<td>4</td>
</tr>
<tr>
<td>A67</td>
<td>4</td>
</tr>
<tr>
<td>A114</td>
<td>4</td>
</tr>
<tr>
<td>A115</td>
<td>4</td>
</tr>
</tbody>
</table>

All most acceptable alternatives from Table 13-3 have a positive influence on the core values of the freight forwarders. This is because in all alternatives the freight forwarders become responsible for operating the airside fast-track. By operating the airside facility the freight forwarders can carry out BUP transshipment here themselves and BUP build-up and breakdown in their own warehouses. Thereby all freight forwarders at AAS will get the opportunity to act as a 1½ line forwarder. Their responsibility over activities and control over the chain increases. Control is an important core value of the freight forwarders. Moreover the efficiency of the operations of the forwarders may increase, because the freight forwarders will be able to carry out activities for BUPs independent of the ground handlers and their regulations. Alternative 67 has an extra positive influence on the efficiency of the operations of the forwarders. This alternative gives the freight forwarders the opportunity to optimize their operations by outsourcing some logistics (consolidated transportation and storage) to the neutral third party that operates the pure storage landside CPD.

All other alternatives score at least a 4 on the core values of the other critical actors. In all alternatives KLM Cargo maintains the ability to carry out its own ground handling, which is considered important for the home carrier. For other cargo airlines the possibilities to outsource ground handling are not affected and the cargo ground handlers maintain the responsibility over their core activities (ULD build-up and breakdown). Alternative 67 has a positive influence on the efficiency of the operations of KLM Cargo and the cargo ground handlers. This alternative gives them the opportunity to optimize their operations by outsourcing some logistics (consolidated transportation and storage) to the neutral third party that operates the pure storage landside CPD.
14 Diversity of designs (S4)

In the previous chapter the seven most acceptable design alternatives from the critical actors’ perspective were found. These alternatives do not conflict with any core value of a critical actor and have a significant positive influence on several core values. To determine which of these seven most acceptable alternatives is the preferred design (has the ability to function most effectively in the AAS air cargo logistics chain), the influence of these alternatives on the full chain (hard) objectives will be evaluated in the next chapters. However, before this is done in the next chapters an evaluation of the diversity of the seven most acceptable designs is firstly carried out in this chapter. It is evaluated in this chapter whether the seven most acceptable designs (alternatives 4, 64, 65, 66, 67, 114 and 115) represent a diverse enough range of possible alternatives that were initially formulated. The reason for doing this is to get more insight in the next chapters, when the designs are scored on the CPD’s full chain objectives. If only very similar alternatives are evaluated and compared on these full chain objectives, the scores on the full chain objectives of these alternatives give less insight into the relative ‘quality’ of the alternatives than if a diverse group of alternatives is compared.

To evaluate the diversity it is evaluated per critical design variable whether a diverse enough range of design options is represented in the seven most acceptable design alternatives. The chapter ends with a very brief conclusion.

For each critical design variable (except for the proximity to AAS and the level of obligation or stimulus for usage of the CPD) it is evaluated in this chapter whether the seven most acceptable alternatives represent a diverse enough range of design options.

Design options for the range of services offered

In the seven most acceptable alternatives the following options for the range of services offered are represented:

- Option one: an airside fast-track for BUPs
- Option five: a pure storage landside CPD combined with an airside fast-track for BUPs
- Option six: a landside CPD offering ULD build-up and breakdown combined with an airside fast-track for BUPs,

The only option that is not represented separately and not in combination with another option is the landside CPD offering ULD build-up and breakdown and destination (de)consolidation & value added services. This option has very similar characteristics to a landside CPD offering ground handling services, which is represented in the seven most acceptable alternatives. The seven alternatives are therefore assumed to represent a diverse enough range of the possible options for the range of services offered.

Design options for the ownership of the CPD

The only theoretically feasible and desired owners of the CPD are a real estate and Schiphol Group Aviation. Core values of KLM Cargo and the other cargo airlines are negatively influenced if Schiphol Group Aviation becomes the owner. Therefore is it not seen as a problem that a real estate company is owner in all the seven most acceptable CPD design alternatives.
Design options for the responsibility for operating the CPD
In the seven most acceptable alternatives, various organizations are responsible for the operations in the airside and landside facilities: freight forwarders, cargo ground handlers, trucking companies and a neutral third party. Many possible design options for this key design variable are represented in the seven most acceptable CPD design alternatives.

Options for the model of costs and gains sharing of the CPD represented
The represented options for the model of costs and gains sharing are diverse enough as well. Options in which the organizations running the CPD also bear the costs of the operations, both with a fixed and a flexible scheme, are included. Options in which the organizations that run the CPD get paid for the operations by other organizations are also included. There is no need to expand the seven alternatives with one that has a different model of costs and gains sharing than these seven.

Conclusions of diversity of designs
Per critical design variable it has been evaluated whether the seven most acceptable alternatives represent a diverse enough range of possible design options. The conclusion is that these seven alternatives represent diverse options for the different critical design variables. Therefore the seven most acceptable alternatives are considered diverse enough. The conclusion of this assessment is that no additional alternative needs to be added before the alternatives are tested on the full chain objectives in the final Multi-Criteria Decision Analysis.
15 Setup of final Multi-Criteria Decision Analysis (S5.1)

Multiple full chain objectives of the CPD were formulated in the system-, actor- and qualitative analysis. The aim is to define a preferred CPD design among the seven most acceptable ones, based on the impact of these seven alternatives on the full chain objectives. The alternatives that were already evaluated on soft criteria (core values of the critical actors) are thereby subsequently evaluated on hard criteria (objectives). That represents well how projects and initiatives are evaluated in the AAS air cargo logistics chain.

To score different alternatives (in this case the seven most acceptable CPD designs) on multiple objectives, the execution of a Multi-Criteria Decision Analysis (MCDA) is very valuable (Pruyt, 2009). There are multiple types of MCDA methodologies that are all better suitable for different types of problems/situations. A specific MCDA methodology must be chosen and set up in a way that it deals well with this problem. In this chapter the choice for a MCDA methodology is very briefly explained and it is briefly explicated how the MCDA is set up to define the preferred alternative among the seven most acceptable ones in a representative, accurate and reliable way. For a more extensive explanation of the choice for the MCDA methodology and the set up of the MCDA appendix M can be consulted.

In the first section of this chapter the choice for the PROMETHEE I Multi-Criteria Decision Analysis method is explained. Section two explains how a forecast-model is set up to calculate the results of the different alternatives on the full chain objectives. In the third section it is explained how the PROMETHEE I method is setup to be able to deal with this specific decision problem. The final section contains the conclusions of this chapter.

This chapter very briefly explains the choice for a MCDA methodology to rank the seven most acceptable alternatives and the setup of the MCDA. For a complete explanation appendix M should be consulted.

15.1 PROMETHEE I the chosen Multi-Criteria Decision Analysis-method

The characteristics of this decision problem (e.g. the amount of alternatives to be ranked and the quantitative objectives) and the features of different MCDA methodologies as described by Pruyt (2009) were studied. Based on this study the PROMETHEE I method as explained by and Brans and Mareschal (2005) was chosen for this Multi-Criteria Decision Analysis. Appendix M fully explains the choice for this methodology.

15.2 Forecast-model

To be able to carry out the PROMETHEE I method for the seven chosen most acceptable alternatives (see Figure 13-1 for a visualization of these alternatives), scores need to be given per alternative to all four objectives. In the PROMETHEE I method these scores all have a value between 0 and 1. To assign a score to an alternative for a specific objective (criterion), the result of the alternative on the specific criterion needs to be known. Hence, for each of the seven alternatives it needs to become clear what is/are the:

1. Costs: the average costs for a tonne of cargo to flow through the AAS air cargo logistics chain after the CPD introduction
2. Truck movements: the number of truck movements as a result of air cargo arriving at or departing from AAS after the CPD introduction
3. First line area: the amount of first line area needed for ground handling
4. Second line area: the amount of second line area needed for the CPD
To gain these (resource allocation, transportation and financial) results a forecast-model in (the software tool) Microsoft Excel was set up. A full explanation of the forecast-model can be found in appendix M. Data and information was used from a large amount and variety of sources. Facts were obtained from Schiphol Group Traffic Analysis & Forecasts (2015). Information and data was used from the researches of de Wit (2014), Pieters (2014), van Doorne (2013) and Ramaaker (2012). Knowledge derived during the in-depth interviews, such as with Vreeburg (2014) from KLM Cargo and Hougee (2015) from Schiphol Real Estate (SRE), was also used. Standards and guidelines applicable to the air cargo industry were retrieved and taken into account, such as cargo ground handling standards and guidelines from Ashford et al. (2011) and Antun et al. (2010). Finally, some estimations had to be done based on the knowledge acquired during field research and/or by interpreting historical data. A face validity of the forecast-model was carried out with industry expert ir. Hendriena Ritsema (Director Strategic Development Cargo Schiphol Group). According to Hendriena Ritsema, all input data (whether estimated or derived from sources) and calculations done in the forecast-model give a good representation of the reality and expected future situation at AAS.

In the forecast-model firstly a representation of the current situation was set up: the year 2014 in which 1.6 million tonnes of cargo was handled at AAS. Hereby missing information about the current situation that is needed for future forecasts could be calculated. Secondly a 0-scenario was set up to represent an imaginary situation in which annually 3 million tonnes of freight is handled at AAS and there are no restrictions to the usage of first line area. This scenario was used as comparison case to assess whether an alternative can comply with the second constraint to each CPD design: “the CPD shall not make ground handling at AAS more expensive”. Finally a forecast was made for each most acceptable alternative. The results of the current situation and the 0-scenario on the criteria are shown in Table 15.1. Despite expected efficiency wins between today and 2030, the average costs for freight to flow through the chain will be higher in 2030. This is the result of inflation.

### Table 15-1: Results of current situation and 0-scenario on criteria

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Costs (€/tonne)</th>
<th>Truck movements (#/year)</th>
<th>First line area needed (m²)</th>
<th>Second line area needed (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current situation (1.6 million tonnes in 2015)</td>
<td>€106,08</td>
<td>518,261</td>
<td>210,000</td>
<td>0</td>
</tr>
<tr>
<td>0-scenario (3.0 million tonnes in 2030)</td>
<td>€125,54</td>
<td>938,959</td>
<td>265,000*</td>
<td>0</td>
</tr>
</tbody>
</table>

* Although the average ground handling capacity in the future is estimated at 10 tonnes/m²/year as indicated by Antun et al. (2010) and Ashford et al. (2011), only 265,000 m² is required to deal with 3 million tonnes of freight in the 0-scenario. That is because in total 35,000 tonnes of freight will not pass the ground handlers warehouses, because it are BUPs that will directly flow from airside to the warehouses of the 1½ line forwarders and vice versa.

### 15.3 Set up of the PROMETHEE I

Different parameters in the PROMETHEE I method needed to be set up specifically for this decision problem. The full setup of the PROMETHEE I can be found in appendix M. Among other things, weights were assigned to the different objectives. These weights are shown in Table 15-2. The weights in this table represent the base method, which is assumed to best represent the reality. To test the robustness of the scores of the alternatives in the MCDA
against varying weights of the objectives, multiple sensitivity analyses with different weights will be carried out in the next chapter.

Table 15-2: Weights of objectives in base model of MCDA

<table>
<thead>
<tr>
<th>Objective</th>
<th>Type of objective</th>
<th>Weight in base method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimize costs (€/tonne)</td>
<td>Strong objective</td>
<td>10</td>
</tr>
<tr>
<td>Minimize truck movements (#/year)</td>
<td>Medium objective</td>
<td>3</td>
</tr>
<tr>
<td>Minimize first line area needed (m$^2$)</td>
<td>Medium objective</td>
<td>5</td>
</tr>
<tr>
<td>Minimize second line area needed (m$^2$)</td>
<td>Weak objective</td>
<td>1</td>
</tr>
</tbody>
</table>

For determining the weights in the base method in Table 15-2 an assumption was done by the researcher, which is explained in the box below.

**ASSUMPTION BY THE RESEARCHER**
The weights are assigned to the full chain objectives (criteria) based on the knowledge that the researcher acquired while conducting the actor, system and qualitative analyses. It was decided to give single weights to the criteria. Another option was to allocate a different weight per critical actor to the criteria and work with multiple actor-specific weights per criterion. Because the seven remaining alternatives were already tested on actor acceptability in a previous step of this stepwise approach, the aim now is not to again find the alternative that best complies with the interests of the separate actors. The aim of this Multi-Criteria Decision Analysis is to get to know which alternative scores best on the objectives/criteria from a full chain perspective. Just as the objectives were set up from a full chain perspective, the weights assigned to the objectives are also set up from a full chain perspective.

15.4 Conclusions of setup of final Multi-Criteria Decision Analysis

A forecast model in (the software tool) Microsoft Excel was set up to calculate the influence of the most acceptable alternatives (alternative 4, 64, 65, 66, 67, 114 and 115) on the hard full chain objectives that were defined earlier in this research (in chapters 4, 5 and 6). A variety of sources was used to set up this model and a face validity of the forecast-model was carried out with industry expert ir. Hendriena Ritsema (Director Strategic Development Cargo Schiphol Group). In order to make a ranking of the alternatives with their scores on the different core values (calculated in the forecast-model), a Multi-Criteria Decision Analysis methodology was chosen and set up specifically to deal with this decision problem. The PROMETHEE I method was chosen after an extensive analysis of different possible MCDA methods.
16 Outcomes of final Multi-Criteria Decision Analysis (S5.2)

This chapter contains the final step of the stepwise evaluation methodology to find a preferred CPD design alternative. The PROMETHEE I MCDA that was set up in the previous chapter (and is more extensively explained in appendix M) is carried out. In this chapter the most acceptable CPD designs from the perspective of the (semi-)critical actors are ranked, based on their performances on the hard full chain objectives. Thereby a preferred CPD design is found and research sub question 7 is answered.

Research sub question 7: Is it possible to set up a high-level CPD design so that the CPD will be able to function effectively in the AAS air cargo logistics chain? If more than one design can be set up, which is preferred and why?

In the first section of this chapter the results of the PROMETHEE I Multi-Criteria Decision Analysis in the base (most likely) scenario are explicated. The most likely ranking of alternatives is shown. In section two several sensitivity analyses are conducted. With these sensitivity analyses the robustness of the outcomes of the first section against changing future circumstances and/or assumptions of the researcher are tested. Section three contains the conclusions of this research and explains what alternative is preferred, based on the extensive Multi-Criteria Decision Analysis that is carried out in this chapter.

The results of the seven most acceptable alternatives on the different full chain objectives (criteria) are calculated in a forecast-model in Microsoft Excel. By using the PROMETHEE I method these results are converted into scores and with these scores the alternatives can be ranked from a most preferred one (rank 1) to a least preferred one (rank 7). In this chapter this rank from the most preferred one to the least preferred one of the seven most acceptable alternatives is explicated.

16.1 Preferred CPD design alternative in MCDA base scenario

In the previous chapter the setup of the base forecast-model and the PROMETHEE I base method were briefly explained. More detailed explanations hereof can be found in appendix M. Both the setup of the base forecast-model and the PROMETHEE I base method are assumed to best represent reality. In the base forecast-model the assumptions, estimations and calculations are assumed to best represent reality. In the PROMETHEE I base method the setup of this method (functions in the method, weights assigned to the objectives, etc.) is assumed to best represent the reality. The joint usage of the base forecast-model and the PROMETHEE I base method to make a ranking of the most acceptable alternatives (alternative 4, 64, 65, 66, 67, 114 and 115) is called the base scenario in this MCDA. This section contains the results of the base scenario MCDA.

In the base scenario of the MCDA it is assumed that all BUPs will flow through the airside fast-track. The ground handlers will not handle BUPs anymore. No assumption is however done in the base scenario about the percentage of skids/loose cargo that will flow through the respective landside facility. This is the only parameter in the MCDA base scenario for which no most likely value was set up. That is because it is dependent on which ground handlers or trucking companies will make use of the landside facility (directly or via a neutral party) and on the characteristics of the skids/loose cargo that will flow through the facility.

In her research de Wit (2014) calculated possible future amounts of skids/loose cargo passing the landside CPD as share of total skids/loose cargo at AAS. She calculated what percentage of skids/loose cargo would pass the CPD if all general cargo and dangerous goods with a dwell time of more than 18 hours at the ground handlers would flow through
the CPD in the future. The same she did for dwell times of more than 8 and 4 hours. She calculated it assuming that skids/loose cargo of KLM Cargo would not flow through the CPD. With the total freight volumes of KLM Cargo being known, the calculation were also done in this research for freight of KLM Cargo flowing though the CPD. This is shown in Table 16-1.

Table 16-1: Share of skids/loose cargo passing landside CPD as percentage of total future amount of skids/loose cargo at AAS based on calculations by de Wit (2014)

<table>
<thead>
<tr>
<th>Percentage of skids/loose cargo passing landside CPD</th>
<th>&gt;18 hours</th>
<th>&gt;8 hours</th>
<th>&gt;4 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of skids/loose cargo without KLM Cargo participating</td>
<td>17%</td>
<td>24%</td>
<td>43%</td>
</tr>
<tr>
<td>Percentage of skids/loose cargo with KLM Cargo participating</td>
<td>31%</td>
<td>44%</td>
<td>81%</td>
</tr>
</tbody>
</table>

Participation (either directly or via a neutral third party) of KLM Cargo is still uncertain, as well as of the other ground handlers. To cope with this uncertainty the base scenario MCDA was carried out with different percentages of skids/loose cargo flowing through the landside CPD. For the quality and reliability of the final outcomes of this research it was chosen not to carry out the base scenario MCDA with the most positive scenario of Table 16-1 (81% of skids/loose cargo flowing through the landside facility). The MCDA in the base scenario was conducted with 17%, 24% and 44% of skids/loose cargo flowing through the landside CPD. Table 16-4 and Table 16-5 show the results of the seven alternatives on the four full chain objectives (criteria), as well as the ultimate ranking of the alternatives in the PROMETHEE I. Intermediate and total scores of the alternatives on the criteria in the carried out PROMETHEE I MCDA are not included, because these scores are of no meaning. These scores are only used to rank the alternatives. If an alternative is highlighted in red in one of the tables, the alternative does not fulfill all constraints. The text in red indicates on which criterion a constraint does not get fulfilled. The constraints to the CPD design were formulated earlier in this research and are again shown in Table 16-2.

Table 16-2: Overview of constraints of AAS air cargo logistics chain to CPD design

<table>
<thead>
<tr>
<th>#</th>
<th>Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A maximum of 200.000 m² of first line area shall be occupied by ground handling facilities at AAS.</td>
</tr>
<tr>
<td>2</td>
<td>The CPD shall not make ground handling at AAS more expensive.</td>
</tr>
</tbody>
</table>

Table 16-3: Results of MCDA in base scenario with 17% of skids/loose cargo passing landside CPD

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Costs (€/tonne)</th>
<th>Truck movements (#/year)</th>
<th>First line area needed (m²)</th>
<th>Second line area needed (m²)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base scenario 17%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>€125,54</td>
<td>938.959</td>
<td>265.000</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>A4</td>
<td>€124,24</td>
<td>938.959</td>
<td>238.750</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>A64</td>
<td>€124,90</td>
<td>901.651</td>
<td>223.740</td>
<td>12.008</td>
<td>X</td>
</tr>
<tr>
<td>A65</td>
<td>€125,01</td>
<td>901.651</td>
<td>223.740</td>
<td>15.010</td>
<td>X</td>
</tr>
<tr>
<td>A66</td>
<td>€124,90</td>
<td>901.651</td>
<td>223.740</td>
<td>12.008</td>
<td>X</td>
</tr>
<tr>
<td>A67</td>
<td>€124,90</td>
<td>901.651</td>
<td>223.740</td>
<td>12.008</td>
<td>X</td>
</tr>
<tr>
<td>A114</td>
<td>€124,84</td>
<td>901.651</td>
<td>210.480</td>
<td>27.920</td>
<td>X</td>
</tr>
<tr>
<td>A115</td>
<td>€125,11</td>
<td>901.651</td>
<td>210.480</td>
<td>34.900</td>
<td>X</td>
</tr>
</tbody>
</table>
If alternatives could not comply with all constraints, they were removed from the analysis before the actual ranking was made. This is because the ranking of alternatives in the PROMETHEE I method is subject to pair wise comparisons between all the alternatives that are included in the analysis. Pair wise comparisons should not be carried out with alternatives that do not meet all constraints, because such alternatives may not have an influence on the ranking. However, as a result hereof the first rank of alternative 114 in Table 16-4 and Table 16-5 only is the result of the pair wise comparison between alternatives 114 and 115. Therefore the same base scenario MCDA’s with 17%, 24% and 44% of skids/loose cargo passing the landside facility were carried out another time all alternatives. The results hereof are shown in Table 16-6.

Table 16-4: Results of MCDA in base scenario with 24% of skids/loose cargo passing landside CPD

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Costs (€/tonne)</th>
<th>Truck movements (#/year)</th>
<th>First line area needed (m²)</th>
<th>Second line area needed (m²)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>€125,54</td>
<td>938.959</td>
<td>265.000</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>A4</td>
<td>€124,24</td>
<td>938.959</td>
<td>238.750</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>A64</td>
<td>€124,81</td>
<td>880.854</td>
<td>218.280</td>
<td>16.376</td>
<td>X</td>
</tr>
<tr>
<td>A65</td>
<td>€124,97</td>
<td>880.854</td>
<td>218.280</td>
<td>20.470</td>
<td>X</td>
</tr>
<tr>
<td>A66</td>
<td>€124,81</td>
<td>880.854</td>
<td>218.280</td>
<td>16.376</td>
<td>X</td>
</tr>
<tr>
<td>A67</td>
<td>€124,81</td>
<td>880.854</td>
<td>218.280</td>
<td>16.376</td>
<td>X</td>
</tr>
<tr>
<td>A114</td>
<td>€124,73</td>
<td>880.854</td>
<td>199.560</td>
<td>38.840</td>
<td>1</td>
</tr>
<tr>
<td>A115</td>
<td>€125,10</td>
<td>880.854</td>
<td>199.560</td>
<td>48.550</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 16-5: Results of MCDA in base scenario with 44% of skids/loose cargo passing landside CPD

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Costs (€/tonne)</th>
<th>Truck movements (#/year)</th>
<th>First line area needed (m²)</th>
<th>Second line area needed (m²)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>€125,54</td>
<td>938.959</td>
<td>265.000</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>A4</td>
<td>€124,24</td>
<td>938.959</td>
<td>238.750</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>A64</td>
<td>€124,61</td>
<td>822.524</td>
<td>202.680</td>
<td>28.856</td>
<td>X</td>
</tr>
<tr>
<td>A65</td>
<td>€124,89</td>
<td>822.524</td>
<td>202.680</td>
<td>36.070</td>
<td>X</td>
</tr>
<tr>
<td>A114</td>
<td>€124,47</td>
<td>822.524</td>
<td>168.360</td>
<td>70.040</td>
<td>1</td>
</tr>
<tr>
<td>A115</td>
<td>€125,13</td>
<td>822.524</td>
<td>168.360</td>
<td>87.550</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 16-6: Rank of alternatives without influence of constraints on ranking

<table>
<thead>
<tr>
<th>Rank without influence of constraints</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base scenario 17%</td>
<td>Base scenario 24%</td>
</tr>
<tr>
<td>Alternative</td>
<td>-</td>
</tr>
<tr>
<td>A4</td>
<td>1</td>
</tr>
<tr>
<td>A64</td>
<td>3</td>
</tr>
<tr>
<td>A65</td>
<td>7</td>
</tr>
<tr>
<td>A66</td>
<td>3</td>
</tr>
<tr>
<td>A67</td>
<td>3</td>
</tr>
<tr>
<td>A114</td>
<td>2</td>
</tr>
<tr>
<td>A115</td>
<td>6</td>
</tr>
</tbody>
</table>
Based on the outcomes of the Multi-Criteria Decision Analysis in the base scenario with 17%, 24% and 44% of all skids/loose cargo flowing through the CPD, it can be concluded that alternative 114 is the preferred alternative. Alternative 114 is ranked first in two of the three base scenario MCDA's (Table 16-4 and Table 16-5). In the other base scenario MCDA no alternative can fulfil all constraints to the CPD business model and thereby no alternative is preferred (Table 16-3). If the base scenario MCDA's are carried out without taking into account the constraints to the CPD alternatives, alternative 114 is ranked first in two of the three scenarios as well (Table 16-6). Only in the 17% scenario alternative 114 is ranked second. The alternative that is ranked first then (alternative 4) is sure not to solve the expected space shortages on the first line area, because it only consists of an airside facility (no skids/loose cargo will flow through a landside CPD in this alternative so it is sure that 238.750 m² is needed for ground handling facilities on the first line area for this alternative). The preference for alternative 114 is hence not threatened by the outcome of this analysis.

16.2 Robustness of the outcomes of the final MCDA (sensitivity analyses)

The MCDA base scenario is considered to best represent the reality. It is considered to be the most likely scenario and was used to make a ranking of the alternatives in case 17%, 24% and 44% of all skids/loose cargo will flow through the landside CPD. In the MCDA base scenario the base forecast-model and the PROMETHEE I base method are used.

Although the three rankings in the MCDA base scenario (17%, 24% and 44% ranking) are considered to best represent the reality, the rankings are still subject to interpretations of the researcher. The setup of the PROMETHEE I MCDA is affected by subjectivity of the researcher, which is a clear disadvantage of the use of any MCDA (Olson, 2009). Furthermore several assumptions and estimations were needed to fill in the parameters and calculations in the forecast-model. Thereby also the input of the PROMETHEE I MCDA is subject to several interpretations of the researcher. To test the robustness of the rankings of the seven most acceptable alternatives in Table 16-3, Table 16-4 and Table 16-5 against a different interpretation of several parameters in the forecast-model and in the PROMETHEE I MCDA, a variety of one-dimensional sensitivity analyses is carried out. In the box below it is explained why only one-dimensional sensitivity analyses were carried out.

**ASSUMPTION OF THE RESEARCHER**

To test the robustness of the outcomes of the base scenario, in Table 16-4 multiple sensitivity analyses have been performed. The sensitivity analyses have been carried out one-dimensionally. Hereby it is meant that in each sensitivity analysis only one parameter has been adjusted in comparison with the MCDA base scenario. It was decided not to carry out more-dimensional sensitivity analyses to reduce the size and complexity of the sensitivity analyses. Because multiple one-dimensional sensitivity analysis were conducted for the parameters in the forecast-model, the setup of the functions in the PROMETHEE I MCDA and the weights assigned to the criteria in the PROMETHEE I MCDA, it was assumed by the researcher that the robustness of the outcomes of the PROMETHEE I MCDA in the base scenario was extensively tested. Moreover, all sensitivity analyses were again carried out for 17% of all skids/loose cargo flowing through the landside CPD, 24% of all skids/loose cargo flowing through the landside CPD and 44% flowing through the landside CPD. In total 63(!) one-dimensional sensitivity analyses were carried out to test the robustness of the outcomes of the final MCDA.

The one-dimensional sensitivity analyses have been conducted along different axes. The exact setup and results of all 63 sensitivity analyses can be found in appendix N. A summary of result is given below.
16.2.1 Sensitivity analyses of the parameters in the forecast-model

Because of the uncertainty of the future, the effect of a different setup of the (Microsoft Excel) forecast-model on the ranking of the seven most acceptable alternatives was analyzed. This was done by carrying out one-dimensional sensitivity analyses for the uncertain future parameters in the table below.

Table 16-7: Negative, base and positive scenarios of most uncertain and decisive parameters in forecast-model

<table>
<thead>
<tr>
<th>#</th>
<th>Parameter in forecast-model</th>
<th>Negative scenario (N)</th>
<th>Base scenario (B)</th>
<th>Positive scenario (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Share of BUPs that passes airside CPD and landside CPD (%)</td>
<td>15%</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>2</td>
<td>Future ground handling capacity – both in ground handlers’ warehouses and in landside CPD offering ground handling services (tonne/m²/year)</td>
<td>7,5</td>
<td>10</td>
<td>12,5</td>
</tr>
<tr>
<td>3</td>
<td>Future capacity of airside CPD (tonne/m²/year)</td>
<td>17</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Efficiency wins in second line area needed when making flexible use of any landside CPD instead of renting separate area (%)</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>5</td>
<td>Duration of ride of shuttle service between ground handlers and landside CPD and airside and landside CPD (min)</td>
<td>64</td>
<td>74</td>
<td>84</td>
</tr>
</tbody>
</table>

Only in one of the ten scenarios in Table 16-7 (five negative and five positive scenarios) alternative 114 was not ranked first. That is in the positive scenario for the future ground handling capacity (12,5 tonne/m²/year). Because it is very unlikely that the average future ground handling capacity will become that high (Antun et al., 2010, Ashford et al., 2011), the preference for 114 is robust against a different setup of the forecast-model. See appendix N for a full and detailed explanation of these sensitivity analyses.

16.2.2 Sensitivity analyses of the functions in the PROMETHEE I MCDA

In the PROMETHEE I method all alternatives are compared to each other on the different objectives. The difference between the scores of two alternatives on a specific objective leads to a score for both alternatives on this objective in this specific pair wise comparison. The results of all pair wise comparisons determine the final scores of the alternatives.

Functions need to be set up for the different objectives with which the scores of alternatives are calculated in the pair wise comparisons. These functions need to be set up by the researcher and therefore are subject to the interpretation of the researcher. To test the robustness of the rankings from most until least preferred alternative in the previous section of this chapter against a different setup of the functions of the objectives in the PROMETHEE I MCDA, multiple sensitivity analyses with a varying setup of functions were carried out. By carrying out these sensitivity analyses it became clear that the first rank of alternative 114 is robust against different setups of the functions. Only if the constraints to the CPD are not taken into account, alternative 4 can take over the first rank of alternative 114 in a small amount of cases. In those scenarios alternative 114 was ranked second. However, alternative 4 will never have the possibility to solve the expected future space shortages on the first line area of AAS and can only outrank alternative 114 in a few cases when this constraints is not taken into account. The first rank of alternative 114 is robust against
different setups of the functions in the PROMETHEE I MCDA. For a full explanation and all results of these sensitivity analyses, appendix N can be consulted.

16.2.3 Sensitivity analyses of the weights of the objectives
The allocation of weights to the different objectives in the setup of the PROMETHEE I MCDA is subject to the interpretation of the researcher. From the analyses of the AAS air cargo logistics chain earlier in this report it became clear that some objectives from a full chain perspective are more important than others. How this should be translated into actual quantitative weights is however very subjective. Therefore the MCDA was carried out (for 17%, 24% and 44% of skids/loose cargo flowing through the facility) with varying weights assigned to the full chain objectives.

Table 16-8: Weight scenarios for sensitivity analyses on the weights of the criteria

<table>
<thead>
<tr>
<th>Explanation of weight scenarios</th>
<th>Weight scenario (BS)</th>
<th>Weight scenario 1 (WS1)</th>
<th>Weight scenario 2 (WS2)</th>
<th>Weight scenario 3 (WS3)</th>
<th>Weight scenario 4 (WS4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs (€/tonne)</td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Truck movements (#/year)</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>First line area needed (m²)</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Second line area needed (m²)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

The first rank for alternative 114 is not sensitive to a different allocation of weights to the objectives as explained in Table 16-8. Only in some cases the first rank of alternative 114 is taken over by alternative 4. Because alternative 4 will sure not be able to solve the space shortages on the first line area of AAS in the future, this is not a real threat to the preference for alternative 114. For the exact outcomes of the MCDA with these different weights assigned to the objective, appendix N can be consulted.

16.3 Conclusions of the outcomes of the final Multi-Criteria Decision Analysis
In this chapter the seven most acceptable CPD design alternatives were evaluated on their influence on the hard full chain objectives. Their expected influences on the full chain objectives were calculated in a forecast-model in Microsoft Excel. With the results of these calculations a Multi-Criteria Decision Analysis (MCDA) was carried out. Alternative 114 scored significantly highest in various setups of this final MCDA. Alternative 114 is preferred among the seven most acceptable alternatives. In total 63 sensitivity analyses were carried out. The preference for this alternative is robust against uncertain future circumstances and (unconscious) subjectivity of the researcher in his interpretations/understanding of the chain. Alternative 114 is best capable to solve the expected future capacity problems of the ground handlers without physical expansion of their warehouses being necessary. Moreover it achieves best financial results of the seven most acceptable alternatives. In this chapter an answer is given to the seventh research sub question. The implications of alternative 114 for the chain are further explained in chapter 17.

Research sub question 7: Is it possible to set up a high-level CPD design so that the CPD will be able to function effectively in the AAS air cargo logistics chain? If more than one design can be set up, which is preferred and why?
PART V: SYNTHESIS
17 Synthesis

In chapters 8 and 9 all theoretically feasible CPD design alternatives were formulated. A design alternative is considered theoretically feasible if it complies with all design requirements that the AAS air cargo logistics chain imposes. In the various chapters of part IV of this research the theoretically feasible alternatives were evaluated. A stepwise evaluation methodology was developed to conduct this evaluation. By carrying out the multiple steps in this methodology an alternative was found that has the ability to function in the chain and is preferred over any other theoretically feasible alternative because of the influence of this preferred alternative on soft and hard performance criteria. In the different steps of the stepwise evaluation methodology multiple sensitivity analyses were carried out. The preference for this alternative (alternative 114) is hence considered robust against uncertain future circumstances and potential subjectivity of the researcher in his interpretations of the chain.

The final tests of the evaluation methodology and the eventual choice for alternative 114 as preferred CPD design were explicated in chapter 16. The implications of alternative 114 for the chain were briefly mentioned in chapter 16 and in previous chapters of part IV in which other steps of the evaluation methodology were carried out. An overview and more extensive explanation of the implications of alternative 114 for the chain were however not given. This chapter contains such an overview. It clearly describes the soft and hard influences of alternative 114 on the AAS air cargo logistics chain and thereby gives more meaning to the final finding of this design study. This chapter answers the 8th sub research question.

Research sub question 8: What influence does the preferred high-level CPD design have on the performances of the AAS air cargo logistics chain?

Section one explains the influence of alternative 114 on the cultures and beliefs (which are captured in their cores values) of the critical actors in this chain; section two explains its influence on full chain performance indicators. The financial consequences of alternative 114 for the separate involved organizations are briefly described in section three. The chapter ends with the conclusions in the fourth section.

The preferred high-level CPD design (alternative 114) consists of an airside fast-track for BUPs and a landside CPD offering ULD build-up and breakdown.

<table>
<thead>
<tr>
<th>Preferred CPD design alternative</th>
<th>Services offered</th>
<th>Owner</th>
<th>Responsible for operations</th>
<th>Model of costs and gains sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>A114</td>
<td>1. Airside fast-track for BUPs</td>
<td>Real estate company</td>
<td>Freight forwarders jointly</td>
<td>Flexible usage (by freight forwarders)</td>
</tr>
<tr>
<td></td>
<td>2. &amp; Landside CPD offering ULD build-up and breakdown</td>
<td>Real estate company</td>
<td>Ground handlers jointly</td>
<td>Flexible usage (by ground handlers)</td>
</tr>
</tbody>
</table>

Figure 17-1: Visualization of preferred high-level CPD design
In the airside fast-track BUP transshipment will take place. In the landside CPD offering ULD build-up and breakdown the services below will be offered.

- ULD build-up and breakdown
- BUP build-up and breakdown
- BUP storage
- Storage of skids/loose cargo

Alternative 114 is schematically visualized in Figure 17-1.

17.1 Acceptability of preferred alternative for critical actors

In total 3604 CPD designs were developed that are theoretically feasible because they comply with all design requirements that the AAS air cargo logistics chain imposes to the CPD. In the first step of the stepwise evaluation methodology the alternatives that are considered undesired by the researcher were ruled out. In a subsequent step of this methodology the remaining desired alternatives (167 alternatives) were tested on their influence on the core values of the (semi-)critical actors. The cultures and beliefs of actors are captured in their core values (Rokeach, 1973) and the influence of a project on the cultures and beliefs of the organizations in this chain is very important for its chance on successful implementation (Ankersmit, 2013, Pieters, 2014, Ploumen, 2014). Based on the influence of the remaining 167 desired alternatives on the core values of the (semi-)critical actors, seven alternatives were considered most acceptable for these actors. It are alternatives 4, 64, 65, 66, 67, 114 and 115. The influence of these alternatives on the actors’ cores values is visualized in Table 17-1. The meaning of the scores is explained below.

1: A very negative influence on the core value
2: A negative influence on the core value
3: A little negative influence on the core value
4: A neutral influence on the core value
5: A little positive influence on the core value
6: A positive influence on the core value
7: A very positive influence on the core value

Table 17-1: Influence of seven most acceptable alternatives on core values of (semi-)critical actors

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Core values of the (semi-)critical actors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Freight forwarders</td>
</tr>
<tr>
<td></td>
<td>Differentiation</td>
</tr>
<tr>
<td>A4</td>
<td>4</td>
</tr>
<tr>
<td>A64</td>
<td>4</td>
</tr>
<tr>
<td>A65</td>
<td>4</td>
</tr>
<tr>
<td>A66</td>
<td>4</td>
</tr>
<tr>
<td>A67</td>
<td>4</td>
</tr>
<tr>
<td>A114</td>
<td>4</td>
</tr>
<tr>
<td>A115</td>
<td>4</td>
</tr>
</tbody>
</table>
The scores of alternative 114 are explained in this section. The soft implications of alternative 114 for the AAS air cargo logistics chain are explained.

**Influence of alternative 114 on freight forwarders’ core values**
Currently cargo ground handlers are responsible for the transhipment of BUPs for/from freight forwarders that are located on the second line area of AAS. With the implementation of alternative 114 freight forwarders will jointly become responsible for operating an airside fast-track for BUPs. All freight forwarders will get the opportunity to carry out the transhipment of their BUPs themselves in this airside facility (and build-up and breakdown the BUPs in their own warehouses). Thereby all freight forwarders at AAS will get the opportunity to act as a 1½ line forwarder. By taking over the responsibility over the transhipment of BUPs from the ground handlers, the responsibility of freight forwarders over activities in the chain and their control over the chain will increase. Control over the chain is highly valued by freight forwarders (Tretheway and Andriulaitis, 2010). Moreover the efficiency of the operations of the forwarders is expected to improve, because the freight forwarders will become able to carry out the transhipment of BUPs independent of the ground handlers and their regulations. The implementation of the landside CPD offering ULD build-up and breakdown does not negatively influence the core values of the freight forwarders. They may become able to pick up and deliver freight more consolidated at this landside CPD and thereby improve the efficiency of their operations. However, because the ground handlers operate the landside CPD in alternative 114 the effect on the efficiency of the freight forwarders’ operations is yet unknown.

**Influence of alternative 114 on KLM Cargo’ core values**
Alternative 114 has a neutral influence on all core values of KLM Cargo. For the home carrier it is important to be able to carry out its own ground handling (Burghouwt et al., 2012, Vreeburg, 2014). The responsibility of ground handlers (including the cargo ground handler that is part of KLM Cargo) over the operations in the landside CPD of alternative 114 makes sure that KLM Cargo will not lose its responsibility over cargo ground handling. The forwarders will take over the responsibility over BUP transhipment from ground handler KLM Cargo by operating the airside fast-track for BUPs. However, this is not considered problematic. Currently forwarders that are located on the 1½ line area of AAS have also already taken over this responsibility. A fair situation is created because Schiphol Group Aviation is not the owner of the airside or landside CPD. If Schiphol Group Aviation would be the owner of any of those CPDs, KLM Cargo would need to contribute to the costs by charges on their landing fees, irrespective of whether KLM Cargo or its customers would make use of it.

**Influence of alternative 114 on other cargo airlines’ core values**
The influence of alternative 114 on the core values of the other cargo airlines is neutral. The flexibility for them to outsource ground handling at AAS is not affected, because no additional contracts need to be closed with a neutral third party. A fair situation is created because Schiphol Group Aviation is not the owner of the airside or landside CPD. If Schiphol Group Aviation would be the owner of any of those CPDs, all cargo airlines would need to contribute to the costs by charges on their landing fees, irrespective of whether they or their customers would make use of it.

**Influence of alternative 114 on cargo ground handlers’ core values**
The cargo ground handlers are a semi-critical actor. The influence of a CPD on their core values only needs to be taken into account where they have the power to frustrate the functioning or performances of the CPD. They have no power to frustrate the airside fast-
track for BUPs. This airside fast-track is not owned or operated by them and they have no say in what BUPs will pass it. The ground handlers do have the power to frustrate the functioning and the performances of the landside CPD offering ULD build-up and breakdown. The cargo ground handlers operate this facility in alternative 114. However, they are not expected to do so because their core values are not negatively influenced by it. Their responsibility over ULD build-up and breakdown remains and the financial construction is fair for them. Only where they make use of the facility a financial contribution is required.

17.2 Influences of preferred alternative on performances of the chain
The seven most acceptable alternatives were evaluated in a forecast-model on their influence on full chain performances. The results in the forecast-model were used to set up a PROMETHEE I Multi-Criteria Decision Analysis (MCDA). Chapter 15 describes how the MCDA was set up and carried out and led to the preference for alternative 114. In this section the execution of the MCDA is not discussed, but the results of the seven most acceptable alternatives on the full chain criteria are explicated. Based on these results the preference for alternative 114 and the implications of alternative 114 for hard performance indicators of the AAS air cargo logistics chain are explained. The results of the MCDA base scenarios are used. Multiple sensitivity analyses (see section 16.2) have shown that the results of the MCDA base scenarios are robust against uncertain future circumstances and subjectivity in the interpretation of the researcher of the chain.

Influence of alternative 114 on first line space usage
It is yet unknown what share of skids/loose cargo will flow through the landside CPD offering ULD build-up and breakdown in alternative 114 or any other alternative. This depends on the participation of the different organizations and on the logistical criteria that are maintained for skids/loose cargo to flow through the landside CPD (de Wit, 2014). Feasible shares are 17%, 24% and 44%. Table 17-2 shows how much first line area is needed for ground handling facilities at AAS for the seven most acceptable alternatives to handle 3 million tonnes of freight annually for these different shares.

Table 17-2: Score of seven most acceptable alternatives on first line area required

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Percentage of skids/loose cargo flowing through landside CPD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17%</td>
</tr>
<tr>
<td>Alternative 4</td>
<td>238.750 m²</td>
</tr>
<tr>
<td>Alternative 64</td>
<td>223.740 m²</td>
</tr>
<tr>
<td>Alternative 65</td>
<td>223.740 m²</td>
</tr>
<tr>
<td>Alternative 66</td>
<td>223.740 m²</td>
</tr>
<tr>
<td>Alternative 67</td>
<td>223.740 m²</td>
</tr>
<tr>
<td>Alternative 114</td>
<td>210.480 m²</td>
</tr>
<tr>
<td>Alternative 115</td>
<td>210.480 m²</td>
</tr>
</tbody>
</table>

Of all seven most acceptable design alternatives, alternatives 114 and 115 have the best potential to make sure that 3 million tonnes of freight can be handled at AAS annually with the maximum of 200,000 m² of first line area available for ground handling facilities. Only 24% of skids/loose cargo needs to flow through the landside CPD to realize this. Thereby alternative 114 and 115 can also realize it without the participation of KLM Cargo. And even for realizing it without participation of KLM Cargo no very strict logistical criteria for skids/loose cargo to flow through the landside CPD are required. With the participation of KLM Cargo all skids/loose cargo with a dwell time of more than 18 hours at the ground
handlers will need to flow through the landside CPD. Without the participation of KLM Cargo all skids/loose cargo with a dwell time of more than 8 hours at the ground handlers will need to flow through the landside CPD to realize an annual freight turnover of 3 million tonnes with less than 200,000 m² of first line area for the ground handlers required. Alternative 4 is unable in any base scenario to solve the expected future space shortages on the first line area for ground handlers’ warehouses. Therefore alternative 4 can be ruled out.

Influence of alternative 114 on total costs for freight to flow through the chain
In the previous section it was shown that alternatives 64-67 are very unlikely to solve space shortages on the first line area (and alternative 4 is unable to do so). Because costs are very important in the competitive and low return air cargo industry, alternatives 64-67 may potentially still be preferred if better financial results can be achieved with these alternatives. The average total costs for a tonne of freight to flow through the AAS air cargo logistics chain for the different alternatives are shown in Table 17-3.

Table 17-3: Score of most acceptable alternatives on average total costs for freight to flow through chain

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Percentage of skids/loose cargo flowing through landside CPD (%)</th>
<th>Average costs for a tonne of freight to flow through AAS air cargo logistics chain (€/tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 64</td>
<td>17%</td>
<td>€124,90</td>
</tr>
<tr>
<td>Alternative 65</td>
<td>17%</td>
<td>€125,01</td>
</tr>
<tr>
<td>Alternative 66</td>
<td>24%</td>
<td>€124,90</td>
</tr>
<tr>
<td>Alternative 67</td>
<td>24%</td>
<td>€124,90</td>
</tr>
<tr>
<td>Alternative 114</td>
<td>44%</td>
<td>€124,84</td>
</tr>
<tr>
<td>Alternative 115</td>
<td>44%</td>
<td>€125,11</td>
</tr>
<tr>
<td></td>
<td>17%</td>
<td>€124,81</td>
</tr>
<tr>
<td></td>
<td>24%</td>
<td>€124,97</td>
</tr>
<tr>
<td></td>
<td>44%</td>
<td>€124,61</td>
</tr>
<tr>
<td></td>
<td>17%</td>
<td>€124,90</td>
</tr>
<tr>
<td></td>
<td>24%</td>
<td>€124,81</td>
</tr>
<tr>
<td></td>
<td>44%</td>
<td>€124,61</td>
</tr>
<tr>
<td></td>
<td>17%</td>
<td>€124,84</td>
</tr>
<tr>
<td></td>
<td>24%</td>
<td>€124,73</td>
</tr>
<tr>
<td></td>
<td>44%</td>
<td>€124,47</td>
</tr>
<tr>
<td></td>
<td>17%</td>
<td>€125,11</td>
</tr>
<tr>
<td></td>
<td>24%</td>
<td>€125,10</td>
</tr>
<tr>
<td></td>
<td>44%</td>
<td>€125,13</td>
</tr>
</tbody>
</table>

Also financially alternatives 64-67 underperform alternative 114 (see Table 17-3). Alternative 114 also significantly outperforms alternative 115 in all base scenarios. The average total costs for a tonne of freight to flow through the chain is expected to become between €124,47 and €124,84 as a result of the implementation of alternative 114. The exact average total costs are dependent on the share of skids/loose cargo that will flow through the landside CPD. If physical expansion of the ground handlers’ warehouses on the first line area was possible and used as solution to increase the capacity of these warehouses to 3 million tonnes per year, the average total costs would become €125,54 per tonne. Hence, this alternative leads to a reduction in costs for freight to flow through the chain (between 0.6% and 0.8%).

In the base scenarios it is assumed that a small part of the BUPs at AAS will be handled in the airside fast-track and temporarily stored (before or after ground handling) in the landside CPD. The transportation of BUPs between the landside and airside CPD with a shuttle service fiercely increases the total average costs for freight to flow through the AAS air cargo logistics chain. If no transportation of BUPs would be carried out between both CPD’s, the average total costs of a tonne of freight to flow through the chain would become between €123,73 and €124,11. This is dependent on the share of skids/loose cargo that will flow through the landside CPD. If no shuttle service is operated between the airside and landside CPD, alternative 114 will realize a cost reduction between 1.1% and 1.4% compared to a situation in which the ground handlers’ warehouses on the first line area would physically be expanded to increase their capacity to 3 million tonnes of freight per year.
**Influence of alternative 114 truck movements**

Because of consolidation of skids/loose cargo in the landside CPD of alternative 114 the amount of multiple handler visits will decrease and average truckloads of trucks picking up or delivering skids/loose cargo at AAS will increase. Dependent on the exact amount of all skids/loose cargo that will flow through landside CPD, truck movements will reduce by 4%-13%. The accessibility of the airport will increase and positive environmental results will be achieved. Alternatives 64-67 and 115 will achieve the same results.

**Second line area required for alternative 114**

Dependent on the share of skids/loose cargo that will flow through the landside facility, between 27.000 m² and 70.000 m² of second line area is required for this landside CPD (offering ULD build-up and breakdown) in alternative 114. This is not assumed to be unrealistic, but should be verified at a real estate company. Alternative 115 requires more second line area. Alternatives 64-67 require less second line area. However, minimizing the amount of second line area is only a weak objective. The amount of second line area needed is not of influence on the performances and functioning of the chain, nor is it a bottleneck.

### 17.3 Financial consequences of alternative 114 for involved organizations

Alternative 114 is expected to decrease the average total costs for freight to flow through the AAS air cargo logistics chain. Because alternative 114 leads to net positive financial results for the full chain, the alternative is (financially) viable. However, the design contains the involvement of various organizations such as real estate companies, cargo ground handlers and freight forwarders. These organizations will only fulfil their role if alternative 114 also results in positive business cases for the organizations separately.

More knowledge, data and information is required to set up these business cases. Currently knowledge is for example missing about the tariffs of the different organizations. Moreover in this phase of the research only speculative estimations can be done about the participation of different organizations in the chain. The participation of the organizations has an effect on the performances of the CPD and thereby on the separate business cases for the involved organizations. This section hence only describes the expected financial consequences of alternative 114 for the different involved organizations, without further going into details. By describing these consequences it is explained that alternative 114 is also financially viable from the perspectives of the separate involved organizations. Business cases for the organizations should be developed in further researches.

**Financial consequences for real estate company/companies**

The costs of developing a new warehouse at AAS are approximately €830/m². Average rental incomes are €80/m²/year on the second line area of AAS and €105/m²/year on the first line area of AAS. Usually long-term contracts (e.g. contracts for 10 years) are closed with the organizations renting land and buildings (Hougee, 2015).

For real estate companies there are clear benefits and risks attached to their role in alternative 114. A benefit is that their incomes will directly increase compared to a situation in which they would not invest in and rent out the airside and landside CPDs that alternative 114 consists of. In such a situation only 200.000 m² of ground handling warehouses would be rented out. If alternative 114 gets implemented, additional incomes will be generated by renting out the landside CPD. Indirectly real estate companies are also expected to benefit from their role in alternative 114 as property developer. Because alternative 114 stimulates growth of cargo via AAS, the demand for other warehouses by freight forwarders and trucking companies on the second line area of AAS is expected to increase as well.
The development of the landside and airside CPD also imposes risks for the real estate companies. These risks are mainly the result of the nature of these facilities. Because it are shared facilities, it is questionable whether the operators of the CPDs will be willing to close long-term contracts. Moreover the desired size of the facilities may be unpredictable and variable over time, because the participation of organizations may be variable over time. In the development of a business case for the freight forwarders an accurate assessment of the benefits and risks should be made.

Financial consequences for freight forwarders
Currently when booking cargo space at a flight for a BUP, freight forwarders pay the respective cargo airline for the transhipment of the BUP. All cargo airlines except for KLM Cargo subsequently pay a third party ground handler at AAS to carry out the transhipment. In alternative 114 freight forwarders become able to carry out the transhipment of BUPs themselves in the airside fast-track they operate. It is expected that the costs for freight forwarders to operate this airside facility will be lower than what they currently pay the cargo airlines for transhipping their BUPs because of two reasons.

1. The profit margins of the ground handlers with respect to the transhipment of BUPs do not need to be paid anymore.
2. In the airside fast-track the transhipment of BUPs is expected to take place more efficiently than in the separate warehouses of the ground handlers. The facility is purely dedicated to the transhipment of BUPs and so an optimal design can be made for it. Moreover the freight forwarders can share the equipment of the fast-track.

To set up a financial relationship with the owner of the airside fast-track may be complicated. The desired size of the airside fast-track may be variable over time, dependent on the participation of freight forwarders. Moreover freight forwarders may be unwilling to close long-term relationships with the respective real estate company to maintain the opportunity to quit or reduce their usage of the facility. This must be taken into account when developing a business case.

The landside CPD offering ULD build-up and breakdown that alternative 114 also consist of is expected to lead to transportation wins for the freight forwarders. These wins are discussed under the financial consequences for the trucking companies.

Financial consequences for trucking companies
Trucking companies are not involved in the CPD design in alternative 114, but they are expected to experience benefits from it. Because of consolidation of skids/loose cargo in the landside CPD, the trucking companies may visit fewer ground handlers. Their average truckload when visiting the landside CPD will also be higher than their current average truckload when visiting AAS. In the imaginary situation in which the warehouses of ground handlers on the first line area of AAS would be physically expanded to deal with 3 million tonnes of air cargo annually, the average costs for a trucks to pick up or drop off a tonne of freight at AAS would become €31,54. With the introduction of alternative 114 to increase the yearly capacity of AAS to 3 million tonnes, the average costs for a truck to pick up or drop off a tonne of freight at AAS are expected to become between €3 and €10 lower.

Financial consequences for cargo ground handlers
In alternative 114 the forwarders become responsible for operating the airside fast-track. The forwarders will take over work of the ground handlers: the transhipment of BUPs. Both the incomes and costs related to the transhipment of BUPs will transfer to the forwarders.
Operating the landside CPD of alternative 114 will result in net costs for the ground handlers. Fixed costs for ground handlers will become lower. This is because they will need to rent less space on the expensive first line area of AAS compared to a situation in which they would expand their warehouses on the first line area to be able to deal with 3 million tonnes of freight annually. However, because of the high costs of having split operations (operations in their own warehouse and in the landside CPD) and the costs of running the shuttle service, alternative 114 has negative financial consequences for the ground handlers.

It is assessed whether the ground handlers can be compensated for their higher costs with the financial benefits the trucking companies experience. Therefore firstly the average costs were calculated for ground handlers to tranship a tonne of freight in the situation in which they would have physically expanded to be able to deal with 3 million tonnes of freight annually. Subsequently the average costs for ground handlers were calculated to tranship a tonne of freight after implementation of alternative 114 through the landside CPD. So these are not the average transhipping costs of all freight for the ground handlers in the new situation, but only the average transhipping costs (per tonne) of freight that passes the landside CPD. A share of skids/loose cargo will not pass the landside CPD in the new situation; this share is not taken into account because for this freight the trucking companies will not experience financial benefits. Similarly the average transportation costs for the trucking companies were calculated. This was first done for the imaginary situation in which the ground handlers have physically expanded their warehouses to handle 3 million tonnes of freight annually. The trucking companies would need to pick up and deliver all freight directly at the ground handlers’ warehouses in this situation. Subsequently it was done for the situation in which alternative 114 is implemented. For this situation only the average costs were calculated for a trucking company when it does not pick up freight at the ground handlers, but consolidated at the landside CPD. This will not always be the case; trucking companies will also keep visiting the ground handlers directly for example for special freight types.

Figure 17-2: Financial results as a result of the implementation of the landside CPD of alternative 114
The calculations were done for the scenario that 17%, 24% and 44% of skids/loose cargo will flow through the landside CPD. By drawing this comparison it became clear that the benefits of a landside CPD for trucking companies are sufficient to compensate the higher costs of the ground handlers (see Figure 17-2).

It can be concluded that it is also possible to set up a positive business case for the cargo ground handlers. Trucks that arrive at the landside CPD must be charged for picking up and delivering freight. Because of the financial benefits for trucking companies from picking up and delivering freight consolidated at this CPD, the trucking companies have acknowledged to be willing to pay such charges (Waters, 2013).

17.4 Conclusions of the synthesis
This chapter has explained the various consequences of preferred alternative 114. The positive influence of alternative 114 on the cultures and beliefs (which are captured in their core values) of the important organizations in this chain were illustrated. The ability of alternative 114 to increase the capacity of the ground handlers’ warehouses on the first line area of AAS was explained. Alternative 114 leads to net positive results for the AAS air cargo logistics chain and is therefore a viable project. Positive business cases for the separate involved organizations are required and still need to be constructed for the successful implementation of alternative 114. The third section of this chapter has briefly described that it is possible to set up such positive business cases, although further research is needed for it.
18 Conclusions

In the introduction of this research the main research question was set out.

Can an integrated high-level design of a Central Pickup and Drop-off point (CPD) for air cargo at Amsterdam Airport Schiphol (AAS) be developed so that the facility will be able to function effectively in the AAS air cargo logistics chain?

The introduction also explained the several sub research questions that were underlying this main research question. By carrying out the full research the several sub research questions could be answered. With the answers to the sub research questions an answer to the main research question is found. This chapter contains the answers to these questions and thereby the conclusions of the full research.

The answers to the sub research questions are briefly stated in sections one to six. The main research question is answered in section seven. The chapter ends with an explanation of the scientific and practical contributions of this research (sections eight and nine).

18.1 Critical design variables of the CPD

The ultimate aim of this research was to develop a high-level integrated design for the potential future CPD at AAS in such a way that the facility has the ability to function in the environment. For this it was firstly researched what design variables need to be designed to develop such a high-level integrated design. A research was done to determine what design variables have a critical influence on the functioning of the CPD and thereby on the ability of a CPD to function at AAS. Thereby an answer was found to the first research sub question.

Research sub question 1: Which design variables have a critical influence on the functioning of the potential future CPD at AAS?

An extensive analysis of literature about various similar freight consolidation centres was done. With this analysis design variables that have a critical influence on the functioning of the CPD at AAS were determined. These variables were validated in an expert interview with dr. J.W. (Rob) Konings, senior researcher freight transport at the OTB department of the TU Delft (Konings, 2014). They are listed below.

- The proximity to AAS
- The level of obligation or stimulus for usage of the CPD
- The range of services offered
- The ownership
- The responsibility for operations in the CPD
- The model of costs and gains sharing

The way these variables are designed has a critical influence on the functioning of a potential CPD at AAS. The high-level integrated design of the facility therefore needs to contain at least the design of these variables.

18.2 Influence of AAS air cargo logistics chain on ability of CPD to function

To determine whether a CPD will have the ability to function in the AAS air cargo logistics chain, it needs to be known how the chain imposes demands and limitations to the CPD design and functioning. Therefore the second and third research questions were answered.
Research sub question 2: What is the influence of the system environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?

Research sub question 3: What is the influence of the actor environment of the AAS air cargo logistics chain on the ability of a CPD to function in this chain?

The system-environment (“harder” environment) and actor-environment (“softer” environment) were extensively analyzed by means literature, market studies, field researches and by conducting more than 20 in-depth interviews with key players of organizations from the chain. The influence of the chain on the CPD design and functioning is represented in full chain objectives of the facility, requirements and constraints to the facility and core values of the most important types of organizations from the chain.

Both the system-environment and actor-environment impose design requirements to the CPD. Examples are legal and physical requirements. The CPD design must comply with these requirements, or else the CPD will not be able to function/be implemented in the chain.

The ability of a CPD to function in the chain is highly dependent on whether the facility matches with the core values of the most important organizations (critical actors) in the chain. The cultures and beliefs of organizations are captured in their core values. The most important organizations in the chain are the freight forwarders and to lower extent KLM Cargo and other cargo airlines. The success of AAS as a cargo hub is very dependent on them and their opinions about projects and initiatives are largely shaped by how their core values are influenced. The CPD must match with the core values of these organizations. If it does not, it can face complexities during implementation even if it has promising financial and/or logistical results. The ability of a CPD to function in the chain can however also be dependent on the influence it has on the core values of the cargo ground handlers. If the handlers are involved in the design of the facility, they may have the ability to frustrate the implementation and/or functioning if their core values are negatively influenced.

The influence of a CPD on hard criteria is also important. Designs that score better on the full chain objectives listed below have better chances on successful implementation.

1. The minimization of costs for freight to flow through the AAS air cargo logistics chain (strong objective)
2. The minimization of first line area needed for ground handling facilities at AAS (medium objective)
3. The minimization of truck movements for air cargo at the AAS area (medium objective)
4. The minimization of second line area needed for the potential CPD (weak objective)

Two constraints also followed from analyzing the chain. CPD designs that do not meet these constraints are not implementable. Firstly the CPD must make sure that no more than 200,000 m² of first line area is needed for ground handling facilities to deal with 3 million tonnes of freight annually. Else the facility will not comply with the future area development plans of Schiphol Group. Secondly the CPD must make sure that the average costs for freight to flow through the chain are lower than the average costs in case of the imaginary situation in which expansion of the ground handling facilities at the first line area would be possible. This is a result of the high competition and low returns in the air cargo industry.
18.3 Theoretically feasible high-level CPD design alternatives
A high-level integrated CPD design (containing the design of the six critical design variables that are listed in the first section of this chapter) is theoretically feasible if it complies with all requirements to the CPD design that come from the environment of the CPD (the AAS air cargo logistics chain). In total 3604 theoretically feasible CPD designs were found (see chapters 8 and 9). Thereby an answer was given to research sub questions four and five.

Research sub question 4: What are the theoretically feasible options to design the critical design variables of a potential future CPD at AAS that were found in research sub question 1 separately?

Research sub question 5: Which theoretically feasible design options from research sub question 4 for the critical design variables separately can be combined to create theoretically feasible CPD designs?

18.4 Stepwise evaluation methodology to find preferred CPD design alternative
A stepwise evaluation methodology was developed to determine the practical implications of the 3604 theoretically feasible CPD designs, find out which designs have the ability to function in the AAS air cargo logistics chain and which hereof is preferred. Sub research question six was thereby answered.

Research sub question 6: Can a methodology be developed with which a preferred alternative that has the ability to function effectively in the AAS air cargo logistics chain can be determined?

In the stepwise evaluation methodology the characteristics of the chain are taken into account. The methodology takes into account that the freight forwarders, KLM Cargo and other cargo airlines are most important for the functioning and performances of AAS as a cargo hub. It also takes into account that the influence of a design on the core values of the critical actors in this chain is often more decisive for the chances on successful implementation than the influence on the hard full chain performance indicators (derived from the full chain objectives of the CPD).

A full explanation of the developed methodology can be found in chapter 10. The developed stepwise approach was discussed with an expert in the field of Multi-Criteria Decision Analyses at the faculty of Technology, Policy and Management of the Delft University of Technology. According to the expert the stepwise approach is reliable (although it might need some more careful and especially empirical investigations).

18.5 Preferred CPD design alternative
The stepwise evaluation approach was used to determine which theoretically feasible CPD design alternative has the ability to function in the AAS air cargo logistics chain and is the preferred alternative. Sub research question seven was answered.

Research sub question 7: Is it possible to set up a high-level CPD design so that the CPD will be able to function in the AAS air cargo logistics chain? If more than one design can be set up, which is preferred and why?

By carrying out the developed stepwise evaluation methodology seven alternatives were found that have the most positive influences on the core values of the critical actors among
the 3604 theoretically feasible CPD designs. These seven alternatives do not negatively influence any core value of any important actor (freight forwarders, KLM Cargo, cargo airlines and cargo ground handlers). They have significant positive influences on various core values. Hence, these seven alternatives are most acceptable from the actor-perspective. Several sensitivity analyses were carried out (e.g. by varying the weights assigned to the different actors) and the choice for these seven alternatives is considered robust.

Subsequently the scores of the seven most acceptable CPD design alternatives on the full chain objectives were calculated. With these scores a Multi-Criteria Decision Analysis (PROMETHEE I methodology) was carried out to determine the preferred alternative among the seven most acceptable ones. Alternative 114 scored highest in the MCDA and therefore is the preferred alternative. The first rank of this alternative is not very sensitive to changing future circumstances (e.g. changes in future ground handling efficiency). It is also not very sensitive to a different setup of the MCDA (e.g. different weights assigned to the objectives).

Alternative 114 is considered to have the ability to function in the chain and solve the future space shortages on the first line area. It has a positive effect on soft and hard criteria of the chain. Alternative 114 consists of an airside facility and a landside facility. The airside facility offers BUP transhipment. ULD build-up and breakdown, BUP build-up and breakdown and storage of BUPS, skids and loose cargo are offered in the landside facility. Figure 18-1 visualizes exactly how the critical design variables of the CPD are designed for alternative 114.

![Diagram](image)

**Figure 18-1: Visualization of preferred CPD design alternative 114**

### 18.6 Influence of preferred CPD design alternative on performances of the chain

The influences of alternative 114 on the (soft) core values of the critical actors and on the hard full chain objectives were assessed in the evaluation methodology. These influences are explicated in this section. Hereby an answer is given to the last sub research question.

**Research sub question 8: What influence does the preferred high-level CPD design have on the performances of the AAS air cargo logistics chain?**

**Influence of alternative 114 on the core values of the critical actors**

Alternative 114 has a neutral influence on all core values of KLM Cargo, other cargo airlines and the cargo ground handlers. KLM Cargo maintains the ability to carry out its own ground handling, which is considered important for the home carrier. For other cargo airlines the
possibilities to outsource ground handling are not affected. The ground handlers maintain the responsibility over ULD build-up and breakdown and over storage of ULDs, skids and loose cargo in the landside CPD. They lose the responsibility over BUP build-up and breakdown and BUP transhipment to the freight forwarders in the airside CPD. However, this is not problematic because the ground handlers have no power to frustrate the functioning/performances of the airside CPD, because they have no role in it (ground handlers are a semi-critical actor; they are only critical where they can frustrate the CPD).

Alternative 114 positively influences several core values of the freight forwarders. By operating the airside facility the freight forwarders can carry out BUP transhipment here themselves and BUP build-up and breakdown in their own warehouses. Thereby all freight forwarders at AAS will get the opportunity to act as a ½ line forwarder. Their responsibility over activities and control over the chain increases. Control is an important core value of the freight forwarders. Moreover the efficiency of the operations of the forwarders may increase, because the freight forwarders will be able to carry out activities for BUPs independent of the ground handlers and their regulations.

Finally alternative 114 creates a fair situation for all organizations. Only the actual users of the airside and landside CPD will finance these facilities.

**Influence of alternative 114 on the usage of first line area**
Without the implementation of any type of Central Pickup or Drop-off point for air cargo the warehouses of ground handlers will need 265,000 m² of first line area at AAS to be able to deal with 3 million tonnes of freight annually. This is 65,000 m² more than is available in the Masterplan of Schiphol Group. Only 265,000 m² is required to handle 3 million tonnes of cargo annually, because 35,000 tonnes will flow as BUPs directly from/to the cargo planes to/from the warehouses of freight forwarders on the ½ line area of AAS. The average future capacity of the ground handlers’ warehouses is expected to become 10 tonnes/m²/year according to IATA standards (Antun et al., 2010, Ashford et al., 2011).

The amount of first line area that will be needed if alternative 114 gets implemented is dependent on several future circumstances. It is for example dependent on the share of skids/loose cargo that will pass the landside facility, which depends on the participation by ground handlers and the logistical criteria set up for skids/cargo to pass the landside CPD. However, it is likely that less than 200,000 m² of first line area (including the area needed for the airside CPD) will be needed to handle 3 million tonnes of air cargo at AAS annually with the implementation of alternative 114.

**Influence of alternative 114 on the costs for freight to flow through the chain**
The average costs for freight to flow through the AAS air cargo logistics chain were calculated for the imaginary situation in which physical expansion of the ground handlers’ warehouses is possible. In this imaginary situation 3 million tonnes of freight is annually handled with 265,000 m² of first line area being occupied by facilities of ground handlers. In such a situation it will cost most likely on average €125,54 for a tonne of freight to flow through the chain. If instead alternative 114 gets implemented (and thereby less first line area is needed for ground handling on the first line area), costs will likely be between 0.6% and 1.4% lower. Such a costs reduction is significant in the highly competitive and low return air cargo industry and will hence improve the competitive position of AAS as a cargo hub.
Influence of alternative 114 on the amount of truck movements at AAS
Compared to the imaginary situation in which expansion of the warehouses of the ground handlers is possible, alternative 114 results in 4% - 13% less truck movements as a result of air cargo at AAS. Annually 35.000 – 135.000 less truck movements are expected at AAS.

Second line area required for alternative 114
Dependent on the amount of skids/loose that will flow through the landside facility, between 27.000 m² and 70.000 m² of second line area at AAS is required for its construction.

18.7 Main research question answered
By answering the different sub questions the main research question can be answered.

Can an integrated high-level design of a Central Pickup and Drop-off point (CPD) for air cargo at Amsterdam Airport Schiphol (AAS) be developed so that the facility will be able to function effectively in the AAS air cargo logistics chain?

Alternative 114 (see Figure 18-1) contains the design of the variables of a CPD that have a critical influence on its functioning. Alternative 114 complies with all design requirements that the environment of the CPD imposes to the CPD design. It has neutral or positive influences on all core values of the important organization in the chain. Thereby it does not conflict with the cultures and beliefs of these organizations, which is very important for the ability of a project or initiative to be implementable in this chain. If alternative 114 gets implemented, it is expected that 3 million tonnes of freight can be handled at AAS with the maximum of 200.000 m² of first line area being available for ground handling facilities at AAS. Moreover it has a positive influence on the costs for freight to flow through the chain and reduces the amount of truck movements at AAS. Thereby alternative 114 is expected to improve the competitive position of AAS as a cargo hub and achieve environmental/logistical benefits.

18.8 Scientific contributions of research
This research has delivered a twofold scientific contribution.

Definition of design variables with a critical influence on the functioning of a FCC
Several projects and initiatives in the transportation sector could not be implemented or faced severe complexities during implementation. These projects and initiatives were often well designed from a technological and logistical point of view. The lack of design aspects from other perspectives (organizational, financial, etc.) often caused the implementation problems (van Binsbergen et al., 2013, Wiegmans et al., 2010). In various studies towards freight consolidation centres (FCCs) similar to the CPD at AAS the importance of non-technological and non-logistical design aspects are mentioned. Researchers explicate that the development of an organizational and financial design is critical for the ability of a freight consolidation centre to function in its environment (Konings et al., 2013, Veenstra et al., 2012, Zhou and Wang, 2014).

Despite this knowledge no research has yet been done to find what design variables exactly have a critical influence on the functioning of a freight consolidation centre. This might be the reason why also the focus in recent studies towards the design and evaluation of freight consolidation centres is on technological and logistical design components, such as in the researches by Correia et al. (2012), Konings et al. (2013) and (Veenstra et al., 2012). Organizational and financial designs can be complex and very comprehensive. Different pieces of literature only emphasize the importance of organizational and financial design
aspects, but do not concretize what aspects are meant. Researchers do not mention which
design variables specifically have a critical influence on the functioning of a FCC.

In this research critical design variables of a potential future CPD at AAS are defined:

- The proximity of the facility to the site it services
- The level of obligation or stimulus for usage of the facility
- The range of services offered in the facility
- The ownership of the facility
- The responsibility for operating the facility
- The model of costs and gains sharing

The design variables come from different design perspectives, such as the technological,
logistical, organizational and financial perspective. These critical design variables were
defined after studying literature about various types of freight consolidation centres. The
design variables are therefore considered to be critical for the functioning of any freight
consolidation centre. This is explicated in the scientific article attached to this research. The
design of these variables is considered to have a critical influence on the ability of any freight
consolidation centre to function in its environment. Thereby this research delivers a
scientific contribution. Until now researchers of FCCs only mentioned the importance of an
integrated design containing organizational and financial aspects, without concretizing what
aspect are important. This research specifies the design variables that have a critical
influence on functioning of a FCC. Designers of freight consolidation centres are advised to
take at least all these variables into account when designing such a FCC.

Development of stepwise evaluation methodology
To come from the 3604 theoretically feasible CPD designs to a preferred alternative that has
the ability to function in the AAS air cargo logistics chain, a stepwise evaluation approach
was developed. This stepwise approach was developed because in literature no
conventional evaluation methodology could be found that can deal with this amount of
initial alternatives and simultaneously with soft (core values) and hard criteria (hard
objectives).

An expert in the field of Multi-Criteria Decision Analyses at the faculty of Technology, Policy
and Management of the Delft University of Technology called the methodology reliable
(although it might need some more careful and especially empirical investigations). The
methodology represents well how projects and initiatives (such as the potential future CPD)
are assessed in the AAS air cargo logistics chain. It takes into account that the influence of a
project or initiative on important core values of the critical actors plays a decisive role in the
ability to function in this chain. This methodology is considered useful for the evaluation of
design alternatives of other projects in the AAS air cargo logistics chain and in environments
with similar characteristics (especially the importance of the soft core values of the actors).

18.9 Practical contributions of research
The practical contribution is also twofold.

Development of a preferred high-level CPD design alternative
Schiphol Cargo sees the introduction of a potential CPD at AAS as a manner to solve the
expected future space shortages at AAS. Prior to this study Schiphol Cargo did not know
what design variables have a critical influence on the functioning of the facility and whether
these variables can be designed in such a way that the CPD has the ability to function in the
chain. This study has shown which design variables are critical. It has also shown how these
variables can be designed so that the CPD will have the ability to function in the chain and will increase the annual capacity of the ground handlers to 3 million tonnes of freight without an expansion of their warehouses being necessary. The study has shown that the preferred CPD alternative will likely positively influence the core values of the critical actors and positively influence full chain objectives. These results provide Schiphol Cargo a step forward towards the actual realization of a CPD.

Influence of preferred CPD design alternative on AAS air cargo logistics chain
Before this research Schiphol Cargo had no knowledge about the potential influences of a CPD on the performances of the AAS air cargo logistics chain. This research has shown the potential of a CPD to solve the future first line area space shortages. It has also shown the potential of a CPD to reduce the average costs for freight to flow through the chain. Finally the positive influence of a CPD on the amount of truck movements at AAS has become clear.
19 Recommendations

In the previous chapter the conclusions of this research were drawn. In these conclusions the findings from the research are summarized and clearly displayed. An answer was given to all research questions and the scientific and practical contribution of the research was explicated. Additional recommendations can be given to Schiphol Cargo, because multiple lessons were learned during this research. Recommendations with respect to the potential future development of a CPD at AAS are given in sections one to three. Section four contains recommendations for future research.

19.1 Development of airside fast-track for BUPs

Seven CPD design alternatives were considered most acceptable for the critical actors of the AAS air cargo logistics chain. These seven alternatives are the designs that have the most positive influence on the core values of the critical actors. All seven do not have a negative influence on any core value of any critical actor and have a positive influence on multiple. The influence of a project or initiative on the core values of the organizations in this chain to a large extent determines whether it is implementable. So despite the fact that alternative 114 was eventually chosen as preferred alternative based on its results on full chain objectives, the other six most acceptable designs are very promising as well.

All seven most acceptable alternatives include an airside fast-track for BUPs. Six alternatives also consist of a landside facility; one alternative only consists of the airside fast-track. In all seven alternatives the fast-track is owned by a real estate company and operated by the freight forwarders jointly. The fact that the airside fast-track for BUPs in this setup (with a real estate company as owner and the freight forwarders jointly operating it) is represented in all seven most acceptable design alternatives, indicates its potential.

By being able to operate an airside fast-track for BUPs (independent of the presence of a landside CPD) freight forwarders will get more responsibility over activities and control over the chain. Freight forwarders have put much effort in gaining more control in the chain over the past decades (Tretheway and Andriulaitis, 2010) and this will therefore increase the attractiveness of AAS for freight forwarders. And because the freight forwarders are the central players in the air cargo industry that decide for thousands of shippers and consignees via which airports their shipments are flown, AAS is expected to benefit from this.

Apart from the important positive influence on the core values of the freight forwarders, an airside fast-track for BUPs has a significant positive influence on the performance of the full AAS air cargo logistics chain and thereby of AAS as a cargo hub.

- An airside fast-track decreases to a certain, but significant extent the need for first line area for ground handling facilities at AAS.
- An airside fast-track decreases the average costs for BUPs to flow through the chain. In the highly competitive and low return air cargo industry, this will also increase the competitive position of AAS as a cargo hub.

Besides the sketched advantages of the airside fast-track for BUPs, this facility is required in any CPD design alternative to solve the expected future space shortages of AAS. A landside CPD alone can not resolve the expected future space shortages at AAS.
For the short-term future a fast-track for BUPs that is owned by a real estate company and jointly operated by freight forwarders increases the competitive position of AAS as a large European cargo hub. In the long-term future it is required for solving the expected space shortages on the first line area. It is recommended to Schiphol Cargo to steer towards the quick development of a fast-track for BUPs that the forwarders can jointly operate. Schiphol Cargo does not have the resources to develop the airside facility itself and will also not get a role in it. Schiphol Real Estate (SRE), another department of the Schiphol Group, does have the resources to develop this facility and owns all first line area that is reserved for cargo ground handling in the future (thereby also ground that is needed for the airside fast-track). It is the right organization to construct this fast-track and rent it out to the freight forwarders. Schiphol Cargo is advised to lobby at SRE for the construction of this facility. While doing this, Schiphol Cargo should attract the freight forwarders and develop with them an organizational and financial construction how to jointly operate the CPD.

19.2 CPD as a manner to add value to AAS

The flexible trading and logistical climate of the AAS air cargo logistics chain, including the flexible setup of Dutch customs, is seen as one of the most important success criteria of the AAS air cargo logistics chain (Kleppers, 2014, Roeven, 2014, Rohrmeijer, 2014). To maintain this strength of AAS as a cargo hub, two requirements to the CPD design were dedicated to it. These are shown in Table 19-1.

<table>
<thead>
<tr>
<th>#</th>
<th>Type</th>
<th>Requirement</th>
<th>Explanation/sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Non-functional requirement</td>
<td>Dutch customs shall be able to keep its flexible and dynamic character after the CPD introduction.</td>
<td>Multiple interviewees mention the setup of Dutch customs as one of the key success criteria of AAS as a cargo hub, among whom Kleppers (2014) and Roeven (2014).</td>
</tr>
<tr>
<td>11</td>
<td>Non-functional requirement</td>
<td>The CPD shall not harm the flexible and dynamic trading environment at AAS.</td>
<td>Multiple interviewees mention the flexible (trading) climate as one of the key success criteria of AAS as a cargo hub, among whom Rohrmeijer (2014) and Roeven (2014).</td>
</tr>
</tbody>
</table>

It is recommended to Schiphol Cargo to not only maintain these strengths of the AAS air cargo logistics chain, but to expand them. The idea of the CPD is initiated by Schiphol Cargo to solve the expected space shortages on the first line area of AAS. Schiphol Cargo is however recommended to from now on see the improvement of the flexible trading climate at AAS as an additional objective of the CPD. Both the airside fast-track for BUPs different and the possible landside facilities have the potential to become assets with added value to the flexible (trading) climate at AAS and thereby strengthen the competitive position of AAS as a European cargo hub. They have the potential to provide freight forwarders (and ground handlers) additional options at AAS and thereby provide them the opportunity to further optimize their operations. Schiphol Cargo is advised to also actively pursue this objective with the potential future development of CPD.

19.3 No shuttle service between airside and landside CPD

If eventually an airside and a landside facility get developed (only the combination of an airside and a landside facility can solve the expected future first line space shortages at AAS), it is advised to Schiphol Cargo to no let a shuttle service be run between the facilities. This is independent of the services that get offered in the landside facility (the airside CPD is always
set up as a fast-track for BUPs). Such a shuttle service would provide the transportation of BUPs between the airside and landside facility so that BUPs can get temporarily stored in the landside facility. However, it is more cost efficient to temporarily store the BUPs in the airside facility (at the more expensive first line area) than to store them in the landside CPD (at the less expensive second line area) and transport them between the facilities with a shuttle service.

19.4 Recommendations for further research
In this research only a high-level design of the CPD is developed. Further researches are needed before the CPD can be actually implemented.

Business cases for involved organizations
This research has shown that alternative 114 is viable. It has shown that alternative 114 has the ability to function in the AAS air cargo logistics chain, has the potential to solve the expected future space shortages and can potentially achieve net positive results for all involved organizations (because the average costs for a tonne of freight to flow through the chain decrease). For the involved organizations separately positive business cases will however also need to be set up. Only thereby the organizations can be moved to undertake the necessary actions. A future research towards the setup of positive business cases for the real estate company, freight forwarders, trucking companies, cargo airlines and cargo ground handlers is recommended. Main challenge in developing the business cases is to distribute the costs and benefits in such a way that all organizations will experience net financial benefits and the financial risks are fairly spread over the organizations.

Process design for implementation of preferred CPD design alternative
Schiphol Cargo can not impose this preferred CPD design to the involved organizations. Trust in the solution, the feeling of involvement in the decision making process and mutual trust in each other are all aspects that may be very important for the actors to become willing to fulfil their role in the preferred alternative. With so many actors involved and the dependency of the CPD on all these actors, a process design that deals with such issues is of great importance. The process design shall need to describe how the different involved actors can be moved towards participation in the implementation of alternative 114. In the process design there may be room for the actors to optimize the less critical design variables and design details, but the design of the critical design variables in alternative 114 should not change anymore. Moreover the process design shall need to describe how strategic behaviour of the actors can be dealt with.

Power developments in the chain
Currently the most important and powerful type of organization in the air cargo industry is the (large) freight forwarder. As was mentioned in chapter 5, the shippers and consignees might however in the future book more cargo space directly at the cargo airlines and trucking companies without making use of a freight forwarder (Schwarz, 2005, Hanke, 2012, The Load Star, 2014b, The Load Star, 2014a). A research is advised towards the potential influence of a power shift from freight forwarders to shippers/consignees on the functioning of the CPD.

Feasibility of size of landside CPD
Alternative 114 consists of a landside CPD where ULD build-up and breakdown will be offered. For this landside CPD an area of 27,000 m² to 70,000 m² is required. Whether a facility of this size is feasible (both in terms of available area and in terms of feasibility of operating such a facility) is unknown. Further research towards this is recommended.
20 Discussion and reflection

The full research is conducted, conclusions are drawn and recommendations to Schiphol Cargo are given. In this final chapter the research is discussed and reflected upon. The methodologies and results of the research are discussed (both the interim and final results). Discussing and reflecting upon the methodologies reveals the limitations of the research. By reflecting upon the results of this research, the various outcomes and lessons learned can be placed better into perspective. A discussion and reflection enhances the understanding of the research and its usefulness for a potential future CPD development and for future researches.

Methodologies used in this research are discussed in sections one and two. Results are discussed in the third and fourth section. The fifth section explains how Schiphol Cargo can reuse the research when it has new knowledge about the AAS air cargo logistics chain. Section six contains a personal reflection.

20.1 Discussion of the methodology used to define critical design variables

To find design variables that have a critical influence on the functioning of a CPD at AAS, an analysis of literature was carried out in chapter 3. Literature was analyzed with a methodology that was set up by the author of this research. The steps below were successively carried out in this methodology.

1. Researches about the design and/or evaluation of designs of freight consolidation centres serving a similar type of logistical environment as the logistical environment at AAS (most complex logistical type of environment – see Figure 3-1) were selected.
2. Aspects that were named in these researches as characterizing or being important for the functioning of the different studied FCCs were brought together.
3. A distinction was made in these aspects between design variables and other kind of design aspects. Only aspects with a direct influence on the functioning of a freight consolidation centre were considered design variables.
4. An influence diagram as described by Howard and Matheson (2005) was made for the unique design variables. Design variables that have most influence on how other design variables can be/will be designed and are least influenced by the design of other variables were considered the critical design variables.
5. An expert interview was held to validate the definition of the critical design variables and thereby reduce the influence of personal interpretations of the researcher.

The founding of this methodology is the analysis of researches about equal facilities serving a similar complex logistical environment. A prerequisite for an accurate conduction of this methodology is hence the availability of sufficient reliable literature about similar facilities to the facility that is to be designed. The methodology, with and without expert validation, is not considered to be very sensitive to personal interpretations of the researcher. The researcher sets up the influence diagram, but the final outcomes of this diagram (the definition of the critical design variables) will not change immediately by some adaptations to the sketched relationships between the design variables in this diagram. Some different interpretations of another researcher will not immediately lead to different results. It can be concluded that the methodology is reliable if sufficient reliable literature is available.

The set up methodology is considered to be practically usable for defining the critical design variables of other types of facilities in the transportation sector. The different steps can be carried out with other literature about other types of facilities as well.
20.2 Discussion of the stepwise evaluation methodology

To come from 3604 theoretically feasible CPD design alternatives to a preferred alternative that has the ability to function in the AAS air cargo logistics chain, a stepwise evaluation methodology was developed for and carried out in this research. This methodology was developed because in literature no conventional evaluation methodology could be found that can deal with this many initial alternatives and simultaneously with soft (core values) and hard criteria (hard objectives). The methodology was discussed with an expert in the field of Multi-Criteria Decision Analyses at the faculty of Technology, Policy and Management of the Delft University of Technology. According to the expert the stepwise approach is reliable (although it might need some more careful and especially empirical investigations). Several aspects of this methodology can however be discussed.

Assumptions by the researcher

The stepwise evaluation methodology requires multiple assumptions by the researcher in all different steps of the methodology. The assumptions that had to be done by the researcher in the different steps of the evaluation methodology are explicitly mentioned in this research. This makes it clear to what assumptions by the researcher the (interim and final) results are subject. This however does not take away a disadvantage of the developed stepwise evaluation methodology: the outcomes are dependent on interpretations of the researcher. To identify the consequences of the interpretations of the researcher and test the robustness of the outcomes to potential different interpretations, extensive sensitivity analyses were carried out in different steps of the evaluation methodology. These are explicated later in this discussion of the stepwise evaluation methodology.

No direct influence of the (semi-)critical actors

No organizations were involved in the setup or execution of this evaluation methodology. The core values of critical actors, the influence of alternatives on these core values, the weights of the core values, the full chain objectives and the weights of these objectives were all set up by the researcher. All these interpretations were based on extensive analyses of the AAS air cargo logistics chain. However, the fact that the researcher determined this and did not validate his interpretations with different organizations in the chain is a limitation to this research. It is unknown whether the researcher interpreted the interests of the actors and characteristics of the chain correctly and thereby whether the final outcomes correctly reflect the reality. However, it was considered invaluable to involve the organizations in the execution of this stepwise evaluation methodology for the following reasons.

1. Asking representatives of organizations about such issues may lead to personal interpretations.
2. Asking representatives of organizations about such issues may lead to strategic behaviour of the actors, if they know that they can influence the course and outcomes of this research.

Methodology to come to most acceptable CPD design alternatives (S3)

Based on the influence of the different alternatives on the core values of the (semi-)critical actors, seven most acceptable CPD design alternatives were defined. In different stages this third step of the evaluation methodology was carried out.

1. Scores were given for each alternative to the core values of the (semi-)critical actors.
2. Weights were assigned to the different actors (freight forwarders, KLM cargo, other cargo airlines and ground handlers) that state their importance for AAS/the CPD.
3. Two methods were used to define the total score of each alternative on the core values of the actors: the ‘weighted positive influence count method’ and the ‘weighted average scores method’. These methods were carried for all alternatives and only for the alternatives that have neutral or higher scores on all core values.

The results in the first stage of this step (the allocation of scores for each alternative to the different core values) are subject to the interpretation of the researcher. No sensitivity analyses were carried out for this allocation of scores. With 167 remaining alternatives and 16 core values in total, 2672 scores had to be given. Carrying out a sensitivity analysis was considered unpractical because of the large amount of scores.

To test the sensitivity of the outcomes against the allocation of weights to the critical actors (stage 2), three sets of weights were set up. The same alternatives made it to the top seven for all three sets of weights.

In the last stage deliberately two different methods were used to increase the robustness of the final outcomes. Moreover, the methods were used to make a ranking of all alternatives and also to make a ranking only of the alternatives that do not influence any core value of any critical actor. That is because it is unknown what the influence of a negative score on one core value of a critical actor is on the implementation chances of an alternative that has very high scores on other core values. Maybe this single negative score can make an alternative unacceptable for one actor and thereby non-implementable, despite the other high scores. By carrying out the methods twice as described this uncertainty was covered. A remark must be placed to the use of the ‘weighted average scores’ method for the qualitative data in this step. Theoretically this method may only be used for quantitative data (Commissie voor de milieueffectrapportage, 2002). However, in practice it has proven its validity for problems with qualitative data (Nijboer and van Westing, 1996). Moreover, the outcomes of this method are validated with the outcomes of the ‘weighted positive influence count’ method. The usage of the ‘weighted average scores’ method for the qualitative data in this step of the research is therefore not seen as problematic.

To conclude, this step is considered reliable but the outcomes are subject to the scores that the researcher assigned per alternative to the core values of the actors (in the first stage). Although the assigned scores were based on extensive analyses of literature and market studies, field researches and more than 20 in-depth interviews with organizations from the chain, different scores and thereby different outcomes may be the result of another researcher assigning the scores.

**Final MCDA to come to preferred CPD design alternative (S5)**

In the final step of the stepwise evaluation methodology a Multi-Criteria Decision Analysis (PROMETHEE I method) was carried out. A significant disadvantage of the use of a Multi-Criteria Decision Analysis is the influence of subjectivity of the researcher, either deliberately or unconsciously, on the outcomes. Human preferences are involved with many aspects of a MCDM (Olson, 2009). In the PROMETHEE I method that was carried out in this research at least the following aspects are subject to the interpretations of the researcher:

- Parameters in the forecast-model (in Microsoft Excel) with which the scores of alternatives on hard performance indicators (criteria) were calculated.
- The weights assigned to the different criteria (objectives).
- The setup of the functions with which the differences between the results of the alternatives on the criteria were converted into scores.
To limit the sensitivity of the final outcomes to subjectivity of the researcher in the interpretation of the parameters of the forecast model, a face validity of the forecast-model was carried out with industry expert ir. Hendriena Ritsema (Director Strategic Development Cargo Schiphol Group). Moreover, the model was run in a base scenario and additionally in scenarios with positive and negative values of five different uncertain parameters. This gave a better picture of the influence of the seven most acceptable alternatives on costs, first and second line area needed and the number of truck movements given the uncertain future circumstances. Still there remains uncertainty, because the future is uncertain.

To further test the robustness of the outcomes of the final MCDA, the analysis was conducted with 8 different setups of functions and with 5 different setups of weights assigned to the criteria. This was done for the scenario in which 17% of skids/loose cargo will flow through the landside CPD, the scenario in which 24% of skids/loose cargo will flow through the landside CPD and the scenario in which 44% of skids/loose cargo will flow through the landside facility.

The outcomes of these sensitivity analyses confirmed the robustness of alternative 114 as preferred CPD design alternative. Based on other assumptions that are done in this research, the choice for alternative 114 as preferred CPD design alternative is not very sensitive to a different interpretation of parameters in the forecast model, a different setup of the functions of the criteria in the PROMETHEE I method or a different allocation of weights to the criteria.

In total 63 one-dimensional sensitivity analyses were conducted for the final MCDA. The outcomes of a MCDA are always subject to the interpretations of the researcher, but in this last step of the evaluation methodology it is shown that this sensitivity is not very significant.

20.3 Discussion of the results
This section discusses interim and final results of this research. It discusses the reliability and accuracy of the results, the sensitivity to other circumstances and the usability for other researches.

Discussion of the six critical design variables
Six critical design variables of a potential future CPD at AAS were defined in this research.

- The definition of these critical design variables was based on an analysis of a significant amount of studies about various (different types of) freight consolidation centres serving the most complex type of logistical environment (see Figure 3-1).
- The same or fewer design variables are considered to have a critical influence on the functioning of FCCs serving less complex logistical environments.

The defined critical design variables are therefore considered to have a critical influence on the functioning of any freight consolidation centre serving any type of logistical environment from Figure 3-1. This is more extensively explicated in the scientific article that is attached to this thesis. It is not certain whether these six variables are the only variables with a critical influence on the functioning of a FCC. Additional research may lead to an expansion of these critical design variables (a general expansion or case-specific expansion). However, designers of FCCs are advised to take at least these six variables into account when designing such a facility.
Influence of seven most acceptable alternatives on criteria (objectives and constraints)
To calculate the influence of the seven most acceptable alternatives on the criteria, a forecast-model was set up in (the software tool) Microsoft Excel. Assumptions about multiple parameters had to be done to set up this model, but the influence of these assumptions on the outcomes of the forecast model was reduced with sensitivity analyses. The most important conclusions of this forecast-model are listed below.

- All seven alternatives are expected to lower the costs for freight to flow through the chain compared to an imaginary situation in which expansion of the ground handlers warehouses on the first line area would be possible. Only the operations of a shuttle service between the airside and landside facility is a threat to this. If no shuttle service gets run, alternative 114 scores best on costs in all different setups of the forecast-model. The exact influence on costs depends of uncertain future circumstances.
- Apart from alternative 114 and 115, with no other alternative the future space shortages on the first line area of AAS can be solved.
- The amount of truck movements at AAS will be reduced with all seven alternatives except for alternative 4 (which only consists of an airside fast-track for BUPs).

Because of the sensitivity of the outcomes of the forecast model to interpretations of the parameters by the researcher, these are the most reliable conclusions that can be drawn.

Robustness of alternative 114 as preferred CPD design alternative in final MCDA
The seven most acceptable CPD design alternatives were evaluated in a final Multi-Criteria Decision Analysis (PROMETHEE I) on several (hard) full chain performance indicators. Based on this analysis, alternative 114 was defined as the preferred CPD design alternative. The choice for alternative 114 is considered to be very robust for the following reasons.

- Alternative 114 always results in the lowest costs for freight to flow through the chain of all seven most acceptable CPD designs.
- Alternate 114 and alternative 115 in every scenario result in the least first line area needed for ground handling facilities.
- The result on the amount of truck movements is the same for every alternative (except for alternative 4 that only consists of an airside fast-track).
- Alternative 115 requires most second line area for the landside CPD, followed by alternative 114.

Alternative 114 only does not score best in every scenario in the forecast-model on the amount of second line area that is needed for the CPD. This criterion is least important and the choice for alternative 114 as preferred CPD design is therefore considered very robust.

20.4 The results in other perspectives
This section tries to place the results in perspective by drawing a comparison with results of other researches and with results if the AAS air cargo logistics chain had different characteristics or was differently understood.

Comparison of results with results of research by de Wit (2014)
The research of de Wit (2014) was focused on a logistical design of the CPD at AAS, whereas the aim of this research was to develop a high-level integrated design. Therefore from a logistical point of view the design of de Wit (2014) is more extensive than the preferred design in this research. However, the way preferred alternative 114 in this research is set up from a logistical point of view is similar to the preferred design by de Wit (2014).
This similarity confirms especially the reliability of the setup of the forecast-model and the PROMETHEE I MCDA. Before this final MCDA was carried out, seven most acceptable designs from the critical actors’ points of view were selected in this research. These seven most acceptable CPD designs significantly differed from each other from a logistical point of view. The fact that a logistical design similar to the design of de Wit (2014) scored highest in the final MCDA emphasizes the applicability of the forecast-model and the final MCDA.

Another similar research was done by Lubbe (2015). Her research was only finished very shortly before the end of this research. Therefore no comparison could be drawn.

**The results if the chain is differently understood (the influence of soft core values)**

The influence of projects and initiatives on soft values, cultures and beliefs of the organizations in the AAS air cargo logistics chain is very important for their ability to function in this environment (Ankersmit, 2013, Pieters, 2014, Ploumen, 2014). This was taken into account in the development of the stepwise evaluation methodology. Alternatives were evaluated on their influences on core values of the critical actors before they are assessed on hard performance indicators (criteria) in this methodology.

If the influence on core values had not been taken into account, another alternative would likely be preferred: a landside CPD offering ULD build-up and breakdown and destination (de)consolidation & value added activities combined with an airside fast-track for BUPs (option seven for the range of services offered). This option for the range of services offered is expected to realize best financial and logistical results, because it implies that no truck movements need to take place between the landside CPD and warehouses of freight forwarders on the second line area. The reasons that no alternatives containing this option for the range of services offered scored sufficiently on the core values of the critical actors and therefore did not make it to the most acceptable CPD designs is explained below.

- Freight forwarders will not outsource their core business (destination (de)consolidation & value added activities) to others organizations.
- Freight forwarders are not considered willing and capable to jointly carry out ULD build-up and breakdown jointly, because of the reasons stated in section 11.2.
- As a result no organization can be found to offer all services in this landside CPD.

If alternatives would first be evaluated on the hard performance indicators (criteria) and subsequently on their influence on the core values of the critical actors, alternative 114 would be found as preferred alternative as well. Based on the hard criteria alternatives containing the seventh option for the range of services offered would be preferred. These alternatives would however all get excluded because of their negative influences on the core values (as is explained below). Based on the hard criteria alternatives containing the sixth option for the range of services offered score second highest. Of these designs, alternative 114 scores highest on the core values of the critical actors and would hence also in the reverse order be preferred.

**20.5 Future reuse of this research by Schiphol Cargo**

The research was carried out with the knowledge of today about the AAS air cargo logistics chain. Potentially the knowledge of Schiphol Cargo about the chain will grow/change in the future. This section describes how this research can then be reused to assess the influence of such expanded or different knowledge on the choice for a preferred CPD design.
A better or different understanding of the chain will not result in an adjustment to or expansion of the six critical design variables of a CPD at AAS. The definition of these variables was based on other researches, not on the AAS air cargo logistics chain.

Better knowledge about the chain can however lead to an adjustment to or expansion of other parameters that were used in this research. Table 20-1 describes how the research can be carried out again and how new results can be generated with the adjustments to or expansions of different parameters in this research.

Table 20-1: Explanation of reuse of the research

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Explanation of reuse of this research (to determine the implications)</th>
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<tbody>
<tr>
<td>Requirements to CPD design</td>
<td>If alternative 114 complies with the new requirements, alternative 114 will remain the preferred alternative. Else a new assessment needs to be made of the theoretically feasible CPD design alternatives (the alternatives that comply with all requirements). The full stepwise evaluation methodology can be carried out again for these alternatives exactly as described in this research. Thereby a new preferred CPD design can be found.</td>
</tr>
<tr>
<td>Core values</td>
<td>With different core values of the critical actors the most acceptable alternatives must be defined again. This can be done according to the sketched methodology in this research (step 3). Subsequently, the new most acceptable alternatives must run through all other steps from then on (steps 4 and 5). It is explained in this research how this is done. The forecast-model can again be used.</td>
</tr>
<tr>
<td>Future parameters</td>
<td>When better knowledge is available about parameters in the forecast-model, this model can accordingly be adjusted. The scores of the seven most acceptable alternatives on the full chain objectives can be recalculated and the final MCDA (PROMETHEE I) carried out again as explained in this research, but then with the new scores.</td>
</tr>
<tr>
<td>Full chain objectives</td>
<td>If full chain objectives turn out to be different, the seven most acceptable design alternatives remain the same. Only a new preferred alternative must be determined based on the new scores of the most acceptable alternatives on the full chain objectives. The adjustments to full chain objectives must be incorporated into the final MCDA. In case of an additional objective, the forecast-model must be adjusted as well to calculate the scores of alternatives on this new objective.</td>
</tr>
<tr>
<td>Other (qualitative) knowledge</td>
<td>The research is also very applicable to be reused with other types of new (qualitative) insights. For any set of alternatives the influences on the core values of the actors can be researched in appendix L. The forecast-model can be used for any alternative to assess logistical/financial implications of alternatives.</td>
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20.6 Managerial reflection Schiphol Cargo

Enno Osinga (Senior Vice President Cargo Schiphol Group) and Hendriena Ritsema (Director Strategic Development Cargo Schiphol Group) have reflected upon the establishment of the seven most acceptable design alternatives and eventually the choice for alternative 114 as preferred design from a managerial perspective.

According to Osinga (2015) the stepwise evaluation methodology used in this research to define a preferred CPD design is very valid. Scoping down the amount of alternatives with their influences on the core values of the critical actors before assessing them on hard performance indicators is supported by Osinga (2015). Osinga (2015) sees the seven most
acceptable CPD designs all as promising, logical and valid alternatives for the CPD. Alternative 114 scores highest on full chain objectives and is therefore preferred in this research. According to Osinga (2015) it is thereby not said that this alternative is most logical from a managerial perspective as well. A second more thorough assessment only of the seven most acceptable CPD designs on the soft values of the critical actors should show which of the seven is preferred from the soft perspective. The outcomes of this assessment in combination with the highest scores of alternative 114 on the hard full chain objectives should lead to a preferred design.

Also according to Ritsema (2015b) logical and valid alternatives are represented in the seven most acceptable alternatives. From a managerial perspective alternatives 114 and 115 seem most logical to Ritsema (2015b). Whether alternative 114 or alternative 115 is eventually better implementable is largely dependent on the attitude of the cargo ground handlers (Ritsema, 2015b).

These managerial reflections are very valuable for how the results of this research can be interpreted. The influences of alternatives on the core values of critical actors in this chain played a decisive role on the choice for a preferred alternative. From the managerial perspectives it becomes clear that these influences can however still make sure that the preferred alternative from this research is eventually not preferred. All seven most acceptable alternatives have a positive influence on the core values of the critical actors. Which of these alternatives if eventually preferred is not only dependent on their influence on the full chain performance indicators, but also on their exact influences of these alternatives on the critical actors’ core values or other cultural/organizational aspects. Researches from now on and practical experiences shall give clarity to these concerns.

20.7 Personal reflection
The execution of this research as Master Thesis Project has been an educative and challenging experience for me. It was a possibility to apply the skills that I learned during the Technology, Policy and Management bachelor program and Systems Engineering, Policy and Management (SEPAM) master program to a life case in an environment I had no knowledge about before the start of this research. During this project I most benefited from the knowledge I derived during my educations about structuring complex and ill-defined problems and dealing with multi-actor settings. I also learned a lot from this most extensive scientific research I have ever conducted. By carrying out more than 20 in-depth interviews my interview techniques improved significantly. The interim and final reflections on methodologies and results improved my reflection skills. This also increased my awareness of the importance of reflections/tests of methodologies and results for a scientific research. Moreover, talking about the research with so many people, in particular with my direct supervisors, learned me a lot. In summary the research was both very challenging and satisfied my personal learning objectives. Fortunately I also enjoyed the research.
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