Multi-Perspective Design of a Fast-Track Facility for Cargo Transhipment at Amsterdam Airport Schiphol

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This research is conducted for the Master Thesis project of the MSc. Transport, Infrastructure and Logistics which is a combined programme of the faculties Civil Engineering, Mechanical Engineering and Systems Engineering, Policy Analysis & Management.

I would like to thank my supervisor from Schiphol Cargo, Hendriena Ritsema, who has been extremely supportive and helpful during my entire internship period. Thanks to her trust in me, I was able to perform my research at the Schiphol Cargo department.

During my internship I have learned to apply my scientific knowledge on a practical problem. Because of the neutral position of the Schiphol Cargo in the AAS air cargo supply chain and the department’s network I was welcomed by multiple companies in their facilities. I was given the opportunity to look around and gain knowledge on the functional and non-functional relationships of the chain’s actors. This opportunity is very much appreciated and besides Hendriena I want to seize the opportunity to thank the entire department for welcoming me this past 8 months with open arms.

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With pride I present to you my Master Thesis.

Noortje Kallen
Delft, December 2015
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<tr>
<td>AWB</td>
<td>Air Way Bill</td>
</tr>
<tr>
<td>BUP</td>
<td>Build Up pallet</td>
</tr>
<tr>
<td>CPD</td>
<td>Central Pickup and Drop-off Point</td>
</tr>
<tr>
<td>CRD</td>
<td>Causal Relation Diagram</td>
</tr>
<tr>
<td>ETV</td>
<td>Elevating Transfer Vehicle</td>
</tr>
<tr>
<td>FTF</td>
<td>Fast-Track Facility</td>
</tr>
<tr>
<td>FTT</td>
<td>Fast-Track Terminal</td>
</tr>
<tr>
<td>IATA</td>
<td>International Air Transport Association</td>
</tr>
<tr>
<td>JIC</td>
<td>Joint Inspection Centre</td>
</tr>
<tr>
<td>PCHS</td>
<td>Pallet Container Handling System</td>
</tr>
<tr>
<td>ULD</td>
<td>Unit Load Device</td>
</tr>
<tr>
<td>VOT</td>
<td>Value of Time</td>
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III Summary

Introduction
Amsterdam Schiphol Airport is currently one of the major airports in Europe and is exploited by enterprise Schiphol Group. Besides the well-known passenger operations, Schiphol is a major player in the cargo sector. In 2014 a record of 1.6 tons of cargo was handled at AAS (Schiphol Group, 2014). A growth of the AAS cargo volume towards 3 million tons per year is expected in the future (Ritsema, 2015). Facilitation and stimulation of high speed logistic processes increase Schiphol’s competitive advantage over other European airports and attracts business and cargo volume to AAS.

Problem Statement
Due to the expansion of the passenger terminal at Schiphol Centre, the airport has planned to relocate the cargo terminals at Schiphol Centre & Schiphol South to Schiphol South-East (Schiphol Group, 2012). This means that growing volumes are expected, while the cargo handling area decreases. An unchanging 1st line cargo handling capacity at AAS will eventually result in an annual demand surplus of 1 million tons. The general problem statement of Schiphol is thus:

“How can Schiphol facilitate the handling of increasing cargo volumes on the limited 1st line area of Schiphol South-East in order to secure their competitive position in the future?”

An option which could increase the 1st line productivity, and thus handling capacity, is recommended by several previous researches: the investigation of a 1st line Fast-Track Facility.

Fast-Track Facility Concept
A Fast-Track Facility entails a terminal, located on the 1st line, which enables certain cargo to bypass the 1st line ground handler warehouses and be transhipped as fast as possible. This implies that suitable fast-track cargo does not require build-up or break-down activities at the 1st line. Unit Load Device’s, either in the form of pallets or containers, consisting of multiple shipments destined for the exact same flight (export) or forwarder (import) are suitable for a Fast-Track Facility. These ULDs are referred to as Build Up Pallets (BUPs). The FTF concept should bundle BUP flows from different clients. The most important expected effects of a FTF at AAS are: an increase in the AAS productivity, a decrease in cargo lead time and reduced truck movements.

Research Question & Methodology
The goal of this thesis is to provide an answer to the main research question:

“What is the Design Space for a 1st line cargo Fast-Track Facility at AAS South-East, which increases AAS 1st line Productivity and allows itself to be Integrated in the Multi-Actor Cargo Supply Chain at Schiphol?”

In order to find an answer, the research question has been tackled from two perspectives: a technological and an institutional perspective. The technological perspective targets the design configuration of the Fast-Track Facility while the institutional perspective targets the usability of the
FTF. These perspectives have been integrated in a systems engineering design framework which provides the guidelines for the research approach.

Current BUP System Analysis

The most important characteristics of the current BUP transhipment system at AAS are presented in table S1 below. The BUP volumes are based on the expert estimations which state that currently 35% of the import and 15% of the export cargo is transhipped over AAS as a BUP unit. The BUP lead time refers to the minimum time in which handlers currently guarantee to make the import cargo available at the truck docks.

Table S1: Characteristics Current BUP System AAS

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Current Situation</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available 1\textsuperscript{st} Line Area AAS</td>
<td>210,000</td>
<td>m\textsuperscript{2}</td>
</tr>
<tr>
<td>Occupied 1\textsuperscript{st} Line Area Handlers</td>
<td>205,000</td>
<td>m\textsuperscript{2}</td>
</tr>
<tr>
<td>Occupied 1\textsuperscript{st} line width</td>
<td>2020</td>
<td>m</td>
</tr>
<tr>
<td>Productivity AAS (weighed)</td>
<td>9.3</td>
<td>ton/year/m\textsuperscript{2}</td>
</tr>
<tr>
<td>Total AAS Throughput</td>
<td>1.6</td>
<td>(million ton/year)</td>
</tr>
<tr>
<td>Total BUP Throughput</td>
<td>293,600</td>
<td>ton/year</td>
</tr>
<tr>
<td>Of which Export BUP</td>
<td>93,850</td>
<td>#/year</td>
</tr>
<tr>
<td>Of which Import BUP</td>
<td>20,100</td>
<td>#/year</td>
</tr>
<tr>
<td>Of which Import BUP</td>
<td>73,750</td>
<td>#/year</td>
</tr>
<tr>
<td>Min. BUP Lead Time (Import)</td>
<td>3</td>
<td>hour/BUP</td>
</tr>
</tbody>
</table>

FTF Requirements

The design of the Fast-Track Facility is based on the logistic cross-dock concept. Because this concept requires seamless transhipment, which cannot be guaranteed for plane to truck transhipment, a storage buffer is required. Furthermore, due to the large perishable BUP volumes, a cooled storage facility should be included in the FTF. Because of the fact that handlers and forwarders demand handling privacy and export transhipment requires manual dimension and build-up checks, the export transhipment function is not feasible in a FTF. The feasible functions for the FTF are thus: import BUP transhipment and (cooled)storage.

The physical boundary conditions for the design are imposed by the area and height restrictions of AAS. The FTF can have a maximum width of 650 meters wide, be 150 meter deep and 21 meters high. In order to approximate a cross-dock situation, a seamless flow without queues and bottleneck is required. Besides the storage buffer which contributes to this goal, the truck system, which is responsible for FTF output is required to function in a Milkrun configuration. A Milkrun refers to trucks which combine shipments from different clients. A second important process requirement is the necessary split between BUPs and ULDs before the cargo enters the facility at airside.
Technological Designs

The terminal design options of the Fast-Track Facility are not very wide. The most important variables are the storage system, the amount of truck and airside docks and the number of storage positions. Two designs are created which are designed from contrasting starting points: a design with a focus on manual labour and an automated design. Both designs are simulated with a discrete event simulation model. The simulation is used to retrieve the optimal configuration of the designs for the previously mentioned variables. Also, the average and minimum BUP lead time comes forward from the models.

Compared to the current BUP transhipment system, both interpretations of the design space contribute to AAS productivity and result in a decreased lead time. Both alternatives are able to handle at least 2.75 times the current estimated BUP throughput.

<table>
<thead>
<tr>
<th>Technological Criteria</th>
<th>Unit</th>
<th>Current System</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Productivity AAS</td>
<td>[ton/year/m²]</td>
<td>9.3</td>
<td>23.5</td>
<td>42.5</td>
</tr>
<tr>
<td>C2 Productivity FTF</td>
<td>[ton/year/m²]</td>
<td>-</td>
<td>70</td>
<td>207</td>
</tr>
<tr>
<td>C3 Occupied Area</td>
<td>[m²]</td>
<td>-</td>
<td>6460</td>
<td>2200</td>
</tr>
<tr>
<td>C4 Max. Throughput FTF</td>
<td>[ton]</td>
<td>-</td>
<td>682.740</td>
<td>625.845</td>
</tr>
<tr>
<td>C5 Lead Time FTF (Import)</td>
<td>[hour : min]</td>
<td>2.5</td>
<td>1:11</td>
<td>1:09</td>
</tr>
<tr>
<td>C6 Investment Costs FTF</td>
<td>[million €]</td>
<td>-</td>
<td>4</td>
<td>3.7</td>
</tr>
</tbody>
</table>

However, the automated alternative has a much higher contribution due to the compact lay-out which is a result of the integrated multi-level automated storage system. The capacity of the design is approximately 550 pallets/day and because of the design’s flexibility, this maximum can be stretched with an extra storage layer (costing 0.3 million) towards a capacity of more than 606 pallets/day. The automated alternative is therefore suggested as the preferable technological design alternative. The lay-out of the alternative is presented in figure S1.

Figure S1: Lay-Out and Profile Automated Design Alternative

1 In order to compare with the FTF lead time, approximately 30 minutes of airside transport is subtracted from the 3 hours.
The robustness of the suggested FTF design for fluctuations in the BUP share and total AAS throughput is presented in graph 1. It is clear that the boundaries of the suggested design allow severe changes in the uncertain factors. If the total AAS throughput is 3 million tons per year, the automated FTF is still able to coop with a BUP share of 60%.

![Graph S1: FTF Throughput Scenario's for suggested Automated Design](image)

**Institutional Fast-Track Facility Design**

As the main requirement for FTF success is actual usage, an institutional design configuration is proposed which stimulates this. The suggested configuration for the institutional design of the Fast-Track Facility is presented in table 34.

**Table S3: Overview suggested Institutional Design**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Institutional Design Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>o Schiphol Real Estate</td>
</tr>
<tr>
<td>Operator Responsible</td>
<td>o Neutral 3rd Party</td>
</tr>
<tr>
<td></td>
<td>o Forwarders</td>
</tr>
<tr>
<td></td>
<td>o Handling Priority Requirements: Schiphol</td>
</tr>
<tr>
<td>Costs and Gains</td>
<td>o Forwarder pays FTF operator per Use</td>
</tr>
<tr>
<td></td>
<td>o No change in other cash flows</td>
</tr>
<tr>
<td></td>
<td>o Forwarder gains from: Decrease in Truck Movements &amp; Lead Time</td>
</tr>
<tr>
<td>Schiphol Stimulant</td>
<td>o Initial investment terminal building and equipment</td>
</tr>
<tr>
<td></td>
<td>o Initial Price Subsidy per Pallet</td>
</tr>
</tbody>
</table>

This institutional configuration does not financially disadvantage the ground handlers. The financial burden is allocated to the forwards which pay the transhipment costs for the pallets through the FTF on top of the regular handler costs. However, if the forwarder gains in the form of truck movement decrease, faster lead times and less storage costs transcend the costs per pallet (which for the suggested design alternative\(^2\) is 5 euro’s) the configuration is acceptable for all critical actors.

---

\(^2\) Integrating the automated technological design with the suggested institutional configuration
Conclusion & Recommendations

Conclusion regarding the Added Value of the Design

The added value of the suggested combination between the technological and institutional design is two-fold. On the one hand, the FTF contributes to the facilitation of cargo volumes by an increase in the AAS productivity while on the other hand the FTF contributes to the creation of volumes by increasing the attractiveness of Schiphol as a cargo market place.

Development of a FTF according to the proposed configuration contributes highly to AAS productivity. An FTF with a maximum throughput of 606 pallets/day increases AAS productivity to 42.5 ton/year/m². This however means that the current handlers still need to increase their productivity with approximately 3 ton/year/m² in order to cope with the expected increase in cargo volumes on the AAS south-east area.

Furthermore, the unique FTF concept in combination with a solid Milkrun system provides an average import BUP lead time of 1.5 hours and ensures a lead time under 2.5 hours. This initiative stimulates data-sharing and collaboration between the chain’s actors. A step towards vertical chain integration is made, by offering the forwarders the chance to gain responsibility over their own sending in an earlier stage (the moment the cargo enters first line). The fast transhipment possibilities might attract new business to Schiphol and therefore new volumes. Because of the ‘pay per use’ concept and the initial investment of Schiphol, the FTF is also attractive for smaller parties.

Recommendations

It is recommended to develop the Fast-Track Facility. However, as the FTF is dependent on continuous output, a mature Milkrun configuration must be developed before implementing the FTF. Milkrun project stimulation is therefore strongly recommended. Because the FTF is not able to solve the complete demand surplus, stimulation of research and projects concerning handler and warehouse efficiency is required.

In order to strengthen the FTF research, further research should be conducted on the effect of the FTF on the airside movements, the creation and sharing of commodity and BUP related data of a data ‘platform’, the financial gains for the forwarder as a result of FTF usage, the configuration of the FTF client ‘priority’ treatment procedures and the possibility of the removal of a secluded airside and truck terrain for the FTF.

The Fast-Track Facility contributes to the agility of AAS as a node in global transport network. Implementing the unique FTF concept provides AAS with a head-start as opposed to competitive airports in Europe when it comes to fast-transhipment, collaboration and customer focus.
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1 Introduction

Over the past decades globalization has enforced organizations to acquire, produce and distribute raw materials and components all around the world (Damme, Radstaak, & Santbulte, 2014). Besides the increase of global processes in organizations, private parties are able to demand goods from all over the world due to the fast, safe and cheap manners offered for transporting goods. These trends have led to an enormous increase in worldwide cargo flows.

90% of the intercontinental cargo is transported with sea-going vessels (Damme, Radstaak, & Santbulte, 2014). While only 2 to 3% of the total cargo volume is transported through the air, this small percentage does represent approximately 30% of the transported cargo value (Damme, Radstaak, & Santbulte, 2014).

Table 1 presents the cargo travelling costs per kilometre per modality. In figure 1 an efficiency frontier illustrates what mode of transport is efficient when aiming for a certain travel time and price. It can be concluded that air cargo is a costly but extremely fast modality and due to the high prices and high speed of air transport it is primarily efficient to transport products through the air with a high value of time.

This ‘high VOT’ cargo is characterized by three main factors: urgency, value density and economical or physical perishability (Damme, Radstaak, & Santbulte, 2014). Because of these factors the most important requirement for the entire air cargo logistic chain is speed.

Table 1: Costs Modalities
(Damme, Radstaak, & Santbulte, 2014)

<table>
<thead>
<tr>
<th>Mode of Transport</th>
<th>Costs per Kilometre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airplane</td>
<td>€ 334</td>
</tr>
<tr>
<td>Truck</td>
<td>€ 100</td>
</tr>
<tr>
<td>Train</td>
<td>€ 23</td>
</tr>
<tr>
<td>Vessel</td>
<td>€ 7</td>
</tr>
</tbody>
</table>

Figure 1: Efficiency Frontier (Tavassy, 2013)
1.1 The Air Cargo Logistics Chain

The air cargo logistics chain consists of several processes, actors and their mutual relationships which are visualized in figure 2.

The incentive for the chain to initiate operations is when a shipper receives an order for a shipment from a consignee. The shipper then contracts a freight forwarder which is responsible for door-to-door transport of the shipment. The freight forwarder chooses the mode of transport and the route. If the characteristics of the shipment and the requirements of the shipper and consignee result in the need for air transport, the freight forwarder books cargo space on the flight of an airline. Subsequently, the forwarder arranges the truck transport required for the pre- and end-haulage to and from the airport. This process step is often outsourced to an external trucking company or, when the freight forwarder offers trucking facilities itself, it is performed by the trucking department of the freight forwarder. The actual physical transport of the shipment is thus arranged by the freight forwarder and performed by the airline and the trucking company (either in or external).

The transhipment of the cargo at the airports is performed by third party ground handlers contracted by the airlines. When an airline receives the cargo space booking, the cargo is handled at the airport by the specific handler. ‘On airport cargo handling’ includes the (un)loading of aircrafts, airside cargo transport and transhipment from airside to trucks at landside. Ground handlers are either privately owned parties or a department of an airline. KLM, for example, owns a cargo department which handles KLM’s and other airlines cargo. The arrows at the top of figure 2 represent the processes performed by the various actors.

Besides the actors which serve the traditional air cargo logistic chain, there are the so-called integrators. These integrators are companies that fulfil the functions of forwarders, airlines, ground handlers and trucking companies and therefore represent the entire chain themselves (Donk, 2015, p. 29). Over the years a lot of companies have settled at Schiphol, resulting in a dazzling number of approximately 180 trucking companies, 7 ground handlers, 2 integrators and 90 freight forwarders (Wit, 2014).

In the brief explanation of the air cargo logistics chain, one important actor has not been mentioned yet: the airport authorities. The authority at AAS, Schiphol Group, has a facilitating function in the air cargo logistics chain. They provide the runways and aircraft stands for the airlines and facilitate warehouses for the handlers and forwarders.
1.2 Amsterdam Airport Schiphol

Amsterdam Schiphol Airport is currently one of the major airports in Europe and is exploited by enterprise Schiphol Group. Besides the well-known passenger operations, Schiphol is also a major player in the cargo sector. In 2014 a record of 1.6 million tons of cargo was handled at AAS (Schiphol Group, 2014). This provides Schiphol a third place on the European Cargo Airport ranking.

The cargo handling and operations at Schiphol are currently concentrated at Schiphol South, Southeast and a part of Schiphol Centre. These locations are near the Kaagbaan where there is good airside accessibility. Figure 3 illustrates the position of the cargo areas within the entire Schiphol premises. The black marked buildings are actual cargo warehouses while the red marked areas are plots with a potential warehouse destination.

In order to understand the following report it is important to provide a brief introduction of the cargo handling area at AAS, illustrated in figure 4. Adjacent to the ‘Airside’, which refers to the platforms and runways, are the 1st line facilities. These facilities, owned by Schiphol Real Estate, are exploited by 1st line handler companies which provide the cargo transhipment between air- and landside. The entire area behind these 1st line facilities is called ‘Landside’. Every building at landside is automatically called a 2nd line facility. These 2nd line facilities can be exploited by several kinds of companies such as freight forwarders, integrators or trucking companies. The third and last kind of building is the 1 and a half line facility. These buildings are situated on landside, but have direct airside access through a roadway with a gate. These warehouses are used predominantly by parties that in general do not load or unload aircrafts, but want the option to do so when necessary (Doorne, 2013).

Schiphol Cargo is strengthening the airport’s competitiveness among European airports as well as creating an attractive market place and increasing its share of available business (Schiphol Cargo, 2015). Providing facilities which stimulate high speed logistic processes increase Schiphol's competitive advantage over other European airports. The cargo department is therefore continuously searching for new innovations and improvements which contribute to these goals. The steering direction of the future plans for the Schiphol Cargo and therefore the direction of research is influenced and led by several developments. These developments are described in the following paragraph.
1.3 Relevant AAS developments for Schiphol Cargo

Several relevant developments have influenced the strategy and therefore the research direction of Schiphol Cargo in the past.

Demand Fluctuation

In 2007 the economic crisis had a great negative effect on the air cargo demand. The demand lowered unexpectedly which resulted in a lower quality of the air cargo supply at Schiphol when cuts had to be made. Pieters (2014) argues that the event of lowering quality of the cargo handling process has endangered the competitive position of Schiphol.

However, in 2014 the annual cargo volumes handled at Schiphol have outgrown the previous maximum peak of 2007. In 2014 a record of 1.6 million tons of cargo was handled at AAS (Schiphol Group, 2014). It is assumed that the demand for Schiphol will grow towards 3 million tons in the near future (Ritsema, 2015).

The Master Plan

Due to the extension of the passenger terminal with three optional piers at Schiphol Centre, the airport’s has planned a scenario in which the cargo area’s at Centre and South AAS (figure 3) will be relocated to Schiphol South-East (Schiphol Group, 2012). This means that all the cargo would be handled at AAS South-East in the future. Doorne (2013) has stated that there will be no capacity problem at the platforms. The expected bottleneck for this scenario is the limited available 1st line area at Schiphol South-East. Table 2 explains the area problem for this scenario when the expected growth becomes reality.

The yearly throughput capacity of AAS is based on the assumption that the maximum productivity of 1st line warehouses is 10 tons/year/m² (Damme, Radstaak, & Santbulte, 2014). Multiplying the productivity with the available first line area results in an annual demand surplus of 1 million tons in the future ³.

<table>
<thead>
<tr>
<th>First Line Area</th>
<th>2015</th>
<th>Future 'Expected'</th>
</tr>
</thead>
<tbody>
<tr>
<td>[m²]</td>
<td>210.000</td>
<td>200.000</td>
</tr>
<tr>
<td>Maximum 1st Line Productivity [tons/year/m²]</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Throughput Capacity AAS [million tons]</td>
<td>2.1</td>
<td>2.0</td>
</tr>
<tr>
<td>(Expected) Throughput [million tons]</td>
<td>1.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Difference Capacity and volume [million tons]</td>
<td>0.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

³ When the expected 3 million tons of throughput is reached
1.4 General Problem Statement and Objective Schiphol Cargo

A general overview of the air cargo logistics chain and Amsterdam Airport Schiphol has been provided. Based on this information and the relevant AAS Cargo developments, the general objective and problem statement of Schiphol Cargo have been formulated.

In order to reach a competitive advantage over other European airports, strengthen the cargo market place and attract cargo volumes, Schiphol Cargo is continuously searching for new innovations and improvements which contribute to increasing speed and efficiency of the logistics processes which take place on the Schiphol premises. Schiphol Cargo's general objective is thus:

‘Continuously increase the competitive position of Schiphol within the European cargo market and become Europe’s preferred cargo airport.’

However, due to the consequences for the AAS cargo area in the master plan, severe problems of the fixed first line warehouse resources can be expected. These developments could endanger the general objective of Schiphol Cargo. Thus, the general problem statement of Schiphol Cargo is:

‘How can Schiphol facilitate the handling of increasing cargo volumes on the limited 1st line area of Schiphol South-East in order to strengthen their competitive position in the future?’

The next chapter aims at converging the general problem statement towards the detailed problem statement which lies at the basis of this research paper.
2 Problem Analysis

In this chapter a detailed analysis of the problem is performed. Previously performed research and findings will be addressed and the fast-track concept is introduced. In the last paragraph, the main research question and the associated sub-questions are presented.

2.1 Previous Research & Findings

The researched solution space for the general problem statement is visualized with a means-ends diagram (figure 5). Theoretically, there are three ways to facilitate increasing cargo volumes on the limited 1st line area at Schiphol. The first and simplest way: ‘increasing the physical 1st line area’ is simply not possible due to the un-changing configuration of the AAS runways and the area restrictions of the Schiphol premises. The other two options are to increase the 1st line productivity(2) and decrease the 1st line volumes. These options provide a great range of means\(^4\). The means which previously or currently researched are mentioned in the means-end diagram.

Redeveloping innovative 1st line configurations (a) is currently being researched by Schiphol Cargo and SRE. Multiple level warehouses are an example of a different warehouse configuration. Furthermore, SRE has conducted a research on the possibility of a flexible 1st line renting concept (b) while Schiphol Cargo has researched the possibility and effect of outsourcing handling activities to a second line consolidation centre (c).

\(^4\) Of which only a few are mentioned in the diagram.
2.1.1 Flexible 1st line renting concept – SRE research
Flexible renting entails the possibility for handlers to temporarily rent handling units within a first line facility. This concept is a good way to cope with peak capacity and dedicated niche handling demand. However, it requires quite some risk and investment costs (Schiphol Real Estate, 2014). It is advised by SRE to research central cargo handling options, a flexible fast-track renting concept and alternative 1st line cargo models with multi-level facilities.

2.1.2 Central Pick-up and Drop-off Point – Schiphol Cargo Research
Investigating the possibility for the outsourcing of activities to a Central Pickup and Drop-off point (CPD) has been opted by the Schiphol Cargo department and subsequently recommended by Doorne (2013) and Pieters (2014).

The location, concept and integrated design for such a CPD have been investigated by de Wit (2014), Lubbe (2015) and van der Donk (2015) successively. The basic idea for a CPD is a central facility on the 2nd line at which trucks can pick up or deliver air freight from or for the ground handlers (Donk, 2015). In this facility several functions of the 1st line warehouses are to be performed, resulting in a more efficient 1st line fitment, enabling an increasing capacity of the ground handlers warehouses on the 1st line.

De Wit (2014) has stated that about 50% of the cargo is appropriate for handling in a CPD facility. According to this report the most promising design for a CPD was the combination of a 1st line Fast-Track Facility with an airside 2nd line CPD. Lubbe (2015) agreed to this and concluded that the combination of a 2nd line CPD performing ULD build-up and breakdown and destination (de-) consolidation with an airside CPD performing fast-track handling is most preferable.

Van der Donk (2015) concluded with 6 preferable integrated designs for the 2nd line CPD, each one including a 1st line Fast-Track Facility, which are able to cope with the expected growing cargo volumes at Schiphol. A difference between these conclusions is, that van der Donk (2015) has calculated future space constraints to be nearly met, while Lubbe (2015) argues that the space constraints may not be solved with implementations of these CPD alternatives.
2.2 The Fast-Track Concept

All previously performed research strongly recommend the investigation of a Fast-Track Facility at 1st line. Generally, a fast-track concept entails a facility located on the 1st line which enables certain cargo to bypass the 1st line ground handler warehouses and allows cargo to be transhipped as fast as possible. This implies that suitable fast-track cargo does not have the need to be broken down or build up at the first line.

Standard air cargo transport units are referred to as unit load device’s (ULDs). ULDs appear in two standard forms, the container and the pallet (appendix F1). Unit Load Device’s consisting of shipments allocated to the exact same flight which are delivered at 1st line are suitable for an export fast-track. Import-wise, the ULDs consisting entirely of shipments which are all destined for the same forwarder, are suitable for an import fast-track. All ULDs, in the form of pallets or containers, which meet these conditions are referred to as Build Up Pallets (BUPs).

The expected effects of a Fast-Track Facility at the 1st line of AAS are visualized in the causal relation diagram (figure 6). The CRD indicates that all routes lead to one major expected advantage: the increase of the AAS productivity. This productivity increase is the effect of several factors which are influenced by a Fast-Track Facility.

Figure 6: Causal Relations Diagram
In the CRD, two ‘external’ factors are coloured dark blue: the ‘FTF Usage’ and the ‘FTF Capacity and Design Configuration’. Several routes through the CRD which visualize the expected effects are indicated and start at the ‘FTF Throughput’ block which is influenced by the two target factors.

The orange route in the CDR indicates that: BUPs which are transhipped through a Fast-Track Facility do not require resources within the 1st line handlers warehouses. Therefore more capacity is available inside the warehouses for ULDs (and loose cargo) which is actually in need of warehouse operations, like build-up or break-down. This means that the productivity and gains for the handlers increase.

The green route indicates that: if the fast-track productivity is higher than the average handler’s productivity, the overall AAS productivity is bound to increase. A high productivity rate is expected for a Fast-Track Facility when it is able to transship large BUP volumes on a relatively small area.

The blue route indicates that: a high fast-track increases the AAS overall transhipment time. The overall transhipment time is directly influenced by the fast-BUP transhipment in the facility (low lead time) and indirectly by the decreasing amount of truck movements as a result of the Milkrun usage which decreases road congestion at AAS.

2.3 Detailed Problem Statement Schiphol Group

To reach their objective, Schiphol Cargo should target the ‘FTF usage’ and ‘FTF Capacity and Design Configuration’ in such a way that the AAS productivity increases. Because of the multiple and circular effects which are illustrated in the CRD, it is not certain what the design space of the target-factors is. Two associated knowledge gaps are formulated:

**Gap 1: What is the design space for a Fast-Track Facility configuration which contributes to a higher AAS productivity?**

The design space for the Fast-Track Facility refers to the boundary conditions and design options for the fast-track terminal design and the processes in and around the Fast-Track Facility.

It is assumed that the Fast-Track Facility will have a positive influence on AAS productivity, but there is currently no detailed or quantified information on the expected advantages of the system. In order to know the added value of the Fast-Track Facility, this expectation should be tested. Besides the productivity, the added value of the system could come forward in multiple criteria which are to be identified.

---

5 Only outgoing arrows
Gap 2: How can Fast-Track Facility usage be achieved in order to create (initial and sufficient) FTF throughput?

A Fast-Track Facility of any design configuration is only successful when the facility is actually used. In order to attract a critical mass for the facility to be profitable and contribute to Schiphol Cargo’s goals, critical actors must accept and be willing to use the new and innovative idea of a Fast-Track Facility. A thought through actor analysis and institutional design for the Fast-Track Facility contributes to actor willingness and acceptance.

From the problem exploration and the knowledge gaps, it has become clear that there is need for a thorough investigation of the fast-track concept.

2.4 Thesis Research Question

This paragraph presents the main research question followed by a brief explanation of the various aspects mentioned in the research question. The main research question for this research is:

‘What is the design space for a 1st line cargo Fast-Track Facility at AAS South-East, which increases AAS 1st line productivity and allows itself to be integrated in the multi-actor cargo supply chain at Schiphol?’

A design space refers to the ‘identification of the boundary conditions of the design’ as well as ‘providing an interpretation of the design variables’ and ‘system behaviour’. Thus, the goal is not to search for the optimal design, but to explore the design space for the processes, the physical Fast-Track Facility and the institutional design of the Fast-Track Facility. All solutions within the design space must contribute to the goals of Schiphol Group.

The FTF must be situated at Amsterdam Airport South-East. The area lay-out and its dimensions is provided in appendix G1 and the location is presented in figure 3. The FTF should contribute to the increase of the AAS 1st line productivity. An increase in productivity should increase Schiphol’s capacity in the future and allow the expected future throughput volumes (table 2).

The design of the FTF must comply with critical actor requirements and the institutional configuration should be designed such that willingness, acceptance and support amongst the critical AAS actor environment are created. All solutions within the design space must be acceptable for all relevant actors.

In order to provide a concise answer to the main research question, various sub-questions have been formulated. An overview of the knowledge gaps and sub-questions addressed in each chapter is provided in table 3.
<table>
<thead>
<tr>
<th>Sub-Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are the characteristics of the current BUP transhipment system at AAS?</td>
</tr>
<tr>
<td>2. What are the trivial requirements for the Fast-Track Facility design?</td>
</tr>
<tr>
<td>3. What is the technological design space for the FTF?</td>
</tr>
<tr>
<td>4. What is the influence of the technological alternatives on the BUP transhipment system?</td>
</tr>
<tr>
<td>5. What is the suggested configuration for an institutional FTF design?</td>
</tr>
<tr>
<td>6. What is the added value of the suggested integrated design alternative for AAS?</td>
</tr>
<tr>
<td>7. What is the robustness of the suggested integrated design alternative?</td>
</tr>
</tbody>
</table>

In order to answer the main and sub-questions and give substance to the knowledge gaps, a research approach is formulated in chapter 3.
3 Methodology

In this section, the applied methodology for this research is explained. Paragraph 3.1 expands on the applicability, as well as the various sections of the methodological framework. Paragraph 3.2 presents the reading guide which clarifies the framework and sub-questions breakdown over the upcoming chapters.

3.1 Methodological Framework

The aim of the main research question is to investigate the design space of a Fast-Track Facility. A systems engineering approach is therefore applicable, considering the goal of this research resembles to following statement: ‘design a system which takes into account difficulties associated with the production of functional, reliable and trustworthy systems of large scale and scope’ (Sage, Systems Engineering and Management for Sustainable Development, 2008).

3.1 Systems Engineering Approach

The two-dimensional systems engineering framework (figure 7) as presented in (Sage & Armstrong, 2000) takes into account the 7 phases required for a large and complex system design. The framework combines these phases with the necessary systems engineering steps which basically indicate the ‘actual activities’ associated with each phase. For a more detailed explanation of the components and the environment of the systems engineering framework (Sage & Armstrong, 2000) can be consulted.

3.2 TIP Approach

The CRD of the Fast-Track Facility has shown that Schiphol has the possibility to alter the technological and the institutional design of a fast-track system in such a way that the productivity of AAS increases. A multi-perspective approach is therefore applicable.

Thus, besides solely following the 2-dimensional systems engineering framework, the TIP Approach (Koppenjan & Groenewegen, 2005) is integrated in this methodological framework. According to this approach, a complex design or in this case the ‘substance of the design space’ is tackled from three perspectives: process, technological and institutional. This multi-perspective approach is applicable for the design of the fast-track system because of several characteristics: ‘The technological component can be characterized as unruly (it is important, but does not determine the entire functioning of the
system) & there are multiple parties involved which have both private and public interests’ (Koppenjan & Groenewegen, 2005).

Based on the TIP approach this research consists of two sections. The first is Technological Perspective. This includes the process and the technological design. The Institutional Perspective is addressed in the Institutional Design.

In the methodological framework, as presented in table 4, these two sections are visualized in blue (technological design) and orange (institutional design). The white cells are general activities or activities in which the two perspectives are merged. The various cells within the framework represent a systems engineering activity performed in order to answer the main research question.

In order to identify the various activities for the ‘Fast-Track Facility Design’ the framework for warehouse design created by Baker (2009) is consulted. This framework identifies the iterative steps for warehouse design and provides tools for performing these steps. Appendix C explains how this framework is integrated in the systems design.

Table 4: Design Framework

<table>
<thead>
<tr>
<th>2 Basic Phases</th>
<th>3 Basic Steps</th>
<th>Formulation</th>
<th>Analysis</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Steps 4 Phases</td>
<td>Problem Definition</td>
<td>Value System design</td>
<td>System Synthesis</td>
<td>System Analysis &amp; Modelling</td>
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<tr>
<td>Conceptual Design</td>
<td>Activity 2: State &amp; Argue Design Options</td>
<td>Activity 3: Create Alternatives</td>
<td></td>
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<td>Activity ID 1: State Design Variables</td>
<td>Activity ID 2: Argue Design Options</td>
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<tr>
<td>Logical Design &amp; Physical Architecture</td>
<td>Activity TD 4: Simulate Alternatives</td>
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<tr>
<td>Detail Design and Testing</td>
<td>Activity TD 5: Refine &amp; Asses Alternatives</td>
<td>Activity 6: Conclusions</td>
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<td></td>
<td></td>
<td>Activity 7: Recommendations</td>
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<td></td>
<td></td>
<td>Activity 8: Discussion</td>
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</tbody>
</table>
3.2 Reading Guide

Table 5 presents the reading guide for this research. Activities of the methodological framework are sub-divided in chapters. The methods used for performing this framework section are presented. The applied methods include a variety of qualitative and quantitative approaches that enable formulation, analysis and interpretation of the phased efforts that are associated with the definition, development and deployment of both an appropriate process and the product that results from use of this process (Sage & Armstrong, Introduction to Systems Engineering, 2000). Several sub-questions are answered in each chapter, the addressed sub-questions per chapter are included in the reading guide.

Table 5: Reading Guide

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Framework Activity</th>
<th>Applied Method</th>
<th>Sub-Questions Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A1 Problem Statement</td>
<td>A1 Literature Research</td>
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<tr>
<td>2</td>
<td>Problem Analysis</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>A1 Problem Statement</td>
<td>A1 Literature Research</td>
<td></td>
</tr>
<tr>
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<td>A2 RQ &amp; Criteria</td>
<td>A2 Objectives tree</td>
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</tr>
<tr>
<td>3</td>
<td>Methodology</td>
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<td>Systems Engineering &amp; TIP Approach</td>
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<td>Current BUP System Analysis</td>
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<td>A4 Current System Analysis</td>
<td>A3 Process Flow Diagrams &amp; Literature &amp; Field Research &amp; Requirement Analysis</td>
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<td></td>
<td>A5 Actor Analysis</td>
<td>A5 Qualitative Actor Research &amp; Requirement Analysis</td>
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<td>A1 Technological Design</td>
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<tr>
<td>6</td>
<td>FTF Functions</td>
<td>TD1 Function Design</td>
<td>Literature</td>
</tr>
<tr>
<td>7</td>
<td>FTF Process Design</td>
<td>TD1 Process Design</td>
<td>Case Studies</td>
</tr>
<tr>
<td>8</td>
<td>Conceptual FTF Designs</td>
<td>TD1 State Design Parameters</td>
<td>Literature &amp; Case Studies</td>
</tr>
<tr>
<td></td>
<td>TD2 State Argue Design Options</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TD3 Create Alternatives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Discrete Event Simulation FTF</td>
<td>TD4 Simulate Alternatives</td>
<td>Discrete Arena Simulation</td>
</tr>
<tr>
<td>10</td>
<td>Refined FTF Designs</td>
<td>TD5 Refine Alternatives</td>
<td>Simulation Output combined with Literature</td>
</tr>
<tr>
<td></td>
<td>TD5 Assess Alternatives</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A Institutional Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Institutional FTF Designs</td>
<td>ID1 State Design Variables</td>
<td>Literature Studies &amp; Qualitative Actor Research</td>
</tr>
<tr>
<td></td>
<td>ID2 Argue Design Options</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Conclusion, Recommendations &amp; Discussion</td>
<td>A6 Conclusions</td>
<td>Literature Studies</td>
</tr>
<tr>
<td></td>
<td>A7 Recommendations</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A8 Discussion</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4 Current BUP System Analysis AAS

This section provides the analysis of the current BUP transhipment system at AAS. In paragraph 4.1 an overview of the different cargo flows are described. The detailed BUP handling processes are visualized in paragraph 4.2. In paragraph 4.3 the performed data analysis which aims to approximate the currently transhipped BUPs volumes is described. The chapter is concluded in paragraph 4.4 with an overview of the most important BUP transhipment characteristics at AAS.

4.1 Possible Cargo Flows at AAS

There are several optional shipment flows in the air cargo logistics chain. The flow routes are visualized in figure 8 and depend on various actor decisions as well as the cargo transport unit. In the image, a distinction is made between the different units: skids & loose cargo, Unit Load Devices and Build Up Pallets. The BUP flows are described in detail.

Figure 8: Overview of all Optional Shipment Flows in AAS Cargo Logistics Chain (Donk, 2015)

BUP Export Flows

Loose export cargo (skids) coming from the shipper can be build up into BUPs at three different locations: at the second line forwarder, the one and a half line forwarder or at the ground handler’s facility. If the volumes of the shipments allocated to the same flight are large enough to (almost) completely fill one pallet or container, these shipments are build-up as a BUP. If the BUP is build-up at 2nd line, the BUP is transported to the 1st line handlers facility with a truck. One exceptional shipment
flow from the one and a half line forwarder, includes the usage of an airside gate through which BUPs are immediately transported from the forwarder to the aircraft stand. These BUPs are delivered at the gate where a ground handler with airside access brings these BUPs to the aircraft stand.

**Import Flows**

The import BUPs follow the same routes accept for the fact that every step happens in the opposite direction. Furthermore, all the ‘build up activities’ as stated in the export process are replaced by ‘break down’ activities. A detailed break-down of the general import and export shipment flows is provided in Appendix E1.

**Current Ground Handlers Facilities**

The basic lay-out of the ground handlers warehouses where either the loose cargo (or skids) are build-up into a BUP or where the BUPs are transhipped over a ‘BUP’ bypass fast-track is presented in figure 9.

Currently, the four largest handlers at AAS: Aviapartner, KLM, Menzies and Swissport already own and operate one or multiple fast-tracks in their first line warehouses. These handlers use the fast-tracks for fast transhipment of cargo between the first and second line. The tracks are used for import and export streams, but in practice the import volumes over the tracks appear to be much larger than the export volumes (Appendix N). In general, the fast-tracks are rollerbed systems which are positioned in a straight line from air to landside through the handler’s warehouse. Often, there is a small buffer beside the track which is a rollerbed area at the same height as the track used for short-term storage and ordering the BUPs. Most handlers’ facilities currently own a large storage facility which can store ULDs and is operated automatically by an Elevating Transfer Vehicle (Appendix H3).

Aviapartner operates 5 fast-tracks of which three are allocated to export and two are allocated to import cargo. In the Menzies facility there are 4 fast-tracks of which 3 are operated by Menzies. One of these three tracks is dedicated to flower import and the other two tracks are bi-directional import and export tracks for other cargo commodities. On top of these bi-directional tracks is an ETV-operated pallet storage location. Swissport operates one import fast-track in their warehouse. KLM owns a pallet container handling system (PCHS) which is situated entirely on the 1st floor. The PCHS is a system which lifts the pallets to the 1st floor and stores them until they are needed for the flight or truck pick-up. There is also an automated ETV-operated storage at airside where the BUPs and the ULDs (build up by KLM) are merged and stored together for the same flight.
The smaller ground handlers: WFS, Freshport and Skylink do not operate their own fast-track inside their 1st line warehouse. Freshport is a dedicated perishables and live animals handler which handles according to specific European guidelines and is therefore not suitable for a fast-track. WFS and Skylink do not have the cargo volumes for a fast-track as they both have great number smaller airlines as their clients.

**Dedicated Fast-Tracks at AAS**

Besides the fast-tracks owned and operated by the ground handlers, there are two cases at AAS where the operating configuration differs. There is a dedicated DB Schenker fast-track situated in the Skylink warehouse at first line. This means that the fast-track in the Skylink warehouse is solely used for DB Schenkers BUPs. The fast-track is physically operated by Skylink, but legally and substantively DB Schenker is responsible for the cargo from the moment it enters the Skylink warehouse. A more detailed description of their fast-track processes is described in Appendix N6. The second example is the dedicated flower track for forwarder Kuehne-Nagel. This import track is situated in the Menzies warehouse. However, Kuehne-Nagel is performing the track operations themselves in order to provide additional service and quality for their customers (Lubbe, 2015). Most ground handlers offer express handling which guarantees the import shipment to be ready for pick-up within three hours after actual time of plane arrival.

**4.2 Current BUP Process Flows Breakdown**

Figures 11 to 14 present the flow diagrams of the current BUP import and export processes in 1st line warehouses with and without an available fast-track. Note that there is a low amount of BUPs transhipped in the warehouses without an available Fast-Track Facility. But even when a fast-track is available at a handler not all BUPs are transhipped via the fast-track. The process model for ‘no available fast-track’ is therefore also applicable for these BUPs. Figure 10 shows the responsible parties for the various operations of which the colours are linked to the process diagrams.

The airside handler is usually similar to the ground handler which operates the facility. However, there are some handlers which do not have airside acces themselves. They, contract a ground handler with airside acces to perform airside movements and drop the cargo at their facility.
Figure 11: BUP Import Process Flow Diagram: Available Fast-Track at Handler’s Facility

Figure 12: BUP Import Process Flow Diagram: No Available Fast-Track at Handler’s Facility
**BUP import with available fast-track**

The first step for a BUP which is transhipped through a handlers facility with an available fast-track (figure 11) is the loading of the BUP on the transportation equipment at the aircraft stand. According to the nearness of the handlers facility to the aircraft stand it is decided whether dollies\(^6\) or transporters are used for transportation. This decision is actually already made at the handlers facility where the equipment is send towards the right aircraft stand. If the aircraft stand is near the handler and no customs check is needed, according to the information provided in the scan (all cargo tags are scanned at the aircraft stand), the cargo is loaded on transporters and moved to a storage spot in the handlers warehouse.

If the aircraft stand is far away from the handler, the cargo is loaded on the dolly's at the platform. According to the customs information from the scan it is decided whether the cargo needs to be inspected by customs. If so, the dolly is transported to customs and the cargo is checked. After the check the cargo is transported to the handlers facility. If a dolly is used, the cargo is transhipped to a transporter in order to be able to place the cargo in the warehouse.

At this point, the distinction between ULDs and BUPs is made. The further handling of the ULDs is outside the scope of this research. The BUPs are checked on the correctness of the paperwork (number of colli\(^7\) & AWB's) and afterwards they are placed on the fast-track. The BUP is rolled to the buffer zone bypass and according to the truck arrival information it is either placed on the buffer zone, tilted of the track to an off-track storage spot or immediately pushed through to the truck unloading dock. If the BUP is placed in an off-track storage spot or a pallet storage system, the BUP will be either placed on the track again or rolled to the fast-track unloading dock. At the unloading dock the truck is loaded and transports the BUPs (and possibly other cargo) to a 2\(^{rd}\) line facility.

**BUP import without available fast-track**

The airside processes for a BUP which is not transhipped over a fast-track are similar to the process described in the previous paragraph. When the cargo arrives in the handlers facility the the BUPs are placed in a warehouse storage spot (either on the ground floor or in an automated storage system). The BUP is checked according to correctness of the AWB’s and number of colli. If the truck has arrived, the pallet is transported with a forklift to the truck docks and the truck are loaded. The trucks transport the BUPs to the 2\(^{rd}\) line facilities.

---

\(^6\) A dollie train can pull 5 cargo units, a transporter can carry one cargo unit.

\(^7\) Individual piece/sending in one shipment.
Figure 13: BUP Export Process Flow Diagram: Available Fast-Track at Handler’s Facility

Figure 14: BUP Import Process Flow Diagram: No Available Fast-Track at Handler’s Facility
BUP Export with Available Fast-Track

The export of BUPs through a handlers facility with an available fast-track (figure 13) starts with the transport of the BUP from the forwarders facility to the ground handler. Specific BUP trucks\(^8\) are loaded with BUPs only or a combination of BUPs and loose cargo/skids. The cargo is unloaded at the fast-track unloading dock. The process concerning further handling of the loose cargo/skids is beyond the scope of this research.

The BUPs are transhipped from the truck to the fast-track at a truck dock and rolled to a checking zone. Here the BUP is checked for looks (is it firmly and logically build up) and leakage. Furthermore the dimensions the BUP weight is checked according to the load plan\(^9\). If something is wrong with the BUP and it needs rebuilding, it is taken of the fast-track and the airline or the forwarder are contacted to decide on further steps that need to be taken. The airline and forwarder can either decide on rebuilding the BUP themselves (which requires an extra truck movement) or they can request the handler to rebuild the BUP and agree on an extra fee to be paid. The last option will increase chances of the cargo to catch the destined flight.

If they agree on utilizing the handlers services, the BUP is broken down and build-up correct according to the load plan. Afterwards the BUP is checked on the looks, leaks and the measurements and finally it is weighed. If the critical time before flight departure is reached (this time differs between full freighter and belly cargo) the BUP is rolled to airside fast-track dock. If the aircraft stand is near the handlers facility the BUPs are loaded on transporters and transported to the aircraft stand. In case of a far away aircraft stand (probably belly cargo) the BUPs are placed on dollies and transported to the aircraft stand.

If the BUPs are delivered before the ‘critical time before flight departure’ the BUPs are either rolled to a fast-track connected pallet storage system where the BUP is placed for storage by an ETV or rolled to a fast-track bypass where the BUP is transhipped to an off-track pallet storage spot. If the critical time before departure is reached the BUPs are placed on the track (when taken off) and rolled to the airside dock.

BUP import without available Fast-Track

The landside processes for an export BUP which is not transhipped over a fast-track are quite similar to the processes in figure 14. Once the BUP is unloaded from the truck it is checked on the looks, leakage, measurements and weight. The procedure described in the previous paragraph is relevant when the BUPs are not build up correctly. The main difference with the ‘available fast-track processes’ is that the movements of the BUP within the handlers facility are generally performed with a forklift. If the critical time before departure is not yet reached, the BUP will be placed on a pallet storage spot. Once the critical time is reached, the BUP is transported to airside by either dolly or transporter dependent on the nearness of the aircraft stand to the handlers facility.

---

\(^8\) These trucks have a sliding system which is found in planes as well to fasten the ULDs (or BUPs).

\(^9\) The load plan has pre-arranged the ULD positions on a flight complying with the critical weight and balance requirements for each aircraft.
4.3 Build-Up Pallet Volumes at AAS

Currently, the percentage of import BUPs relative to the total handled cargo volumes at AAS is estimated by experts to be 35%. The percentage of export BUPs is estimated at 15%. (Appendix N and (Donk, 2015)). According to cargo expert Ritsema (2015) the BUP volumes are currently increasing and will be increasing in the future. More forwarders start build up and break down activities in their 2nd line facilities. Forwarders integrate vertically in order to increase their grip on the air cargo supply chain.

Various cargo commodities are transhipped. The commodity categories as defined by the Schiphol traffic analysis department and AAS customs are presented in table 6. A distinction can be made between commodities suitable or unsuitable for a fast-track. In practice, all categories could be build up as a BUP. However, transhipment of live animals requires facilities like stables, animal houses and skilled care professionals. Therefore the live animals category is not taken into account in this research. The ‘perishables’ category is estimated to be the most common BUP category.

<table>
<thead>
<tr>
<th>Commodity Categories</th>
<th>Cargo Commodity Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Equipment &amp; Machinery</td>
<td>Live Animals</td>
</tr>
<tr>
<td>Chemicals &amp; Products</td>
<td>Machinery parts, Components, Supplies &amp; Manufactures</td>
</tr>
<tr>
<td>Consumer Fashion Goods</td>
<td>Raw Materials Industrial consumables &amp; Foods</td>
</tr>
<tr>
<td>Consumer personal &amp; household goods</td>
<td>Secure or Special Handling</td>
</tr>
<tr>
<td>High Technology</td>
<td>Temperature or Climate Control</td>
</tr>
<tr>
<td>Land Vehicles &amp; Parts</td>
<td></td>
</tr>
</tbody>
</table>

Direct information on current BUP (or ULD) volumes is not available at AAS. The available cargo information at Schiphol is presented in tonnage. A breakdown of the total tonnage per arriving or departing flight is available.

It is chosen to analyse the plane load data of all flights which departed or arrived at AAS in February 2015. According to experts, February is a month with relatively high BUP shares due to Valentine’s day and Russian Mother’s day and because the month total volumes is a representative 1/12th of the expected 1.6 million tons total throughput in 2015. The basic information on the number of flights and the plane cargo loads is presented in table 7. The veracious data from the month of February together with the expected total throughput of 1.6 million tons in 2015 are used to estimate the figures of 2015.

<table>
<thead>
<tr>
<th>Commodity Categories</th>
<th>Cargo Commodity Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Equipment &amp; Machinery</td>
<td>Live Animals</td>
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<td>Chemicals &amp; Products</td>
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<tr>
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<tr>
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<td>Secure or Special Handling</td>
</tr>
<tr>
<td>High Technology</td>
<td>Temperature or Climate Control</td>
</tr>
<tr>
<td>Land Vehicles &amp; Parts</td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Nr. of flights and Cargo Loads

<table>
<thead>
<tr>
<th>Flights [#]</th>
<th>Cargo Load [ton]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>February 2015</strong> (Schiphol Group: TAF, 2015)</td>
<td>Import 6.007</td>
</tr>
<tr>
<td></td>
<td>Export 5.598</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong> 11.606</td>
</tr>
<tr>
<td><strong>2015</strong> (Estimation)</td>
<td>Import 76.300</td>
</tr>
<tr>
<td></td>
<td>Export 71.100</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong> 147.400</td>
</tr>
</tbody>
</table>

10 Which increases the demand for flowers, which are in the common BUO category ‘Perishables’.
11 12.7th exactly
In order to gain insight in the BUP volumes which are transhipped at Schiphol, two data conversion steps are required.

1. **Tonne to ULD & ULD to BUP**

An extensive data analysis is performed in order to make these transformations and approach the unknown BUP amount. During this data analysis, several assumptions are made.

In order to perform the first conversion step, it is assumed that the average load factor of a ULD is 75% (Berkelaar, 2014) and that the average ULD volume is 21m³ (Appendix F3). With this information the number of ULDs on each plane is calculated. Data on commodity shares for the cargo network (Seabury, 2015) are used to approximate the commodities of these on-board ULDs.

The second conversion is based on the expert estimations of the BUP percentages at AAS as mentioned in paragraph 4.1. Furthermore, if the weight of a commodity share on board of a plane does not transcend the average weight of one ULD (for this commodity), it can never be a BUP. The extensive data calculations and the sensitivity analysis on the assumptions can be consulted in appendix J.

The approximation of the BUP transhipment figures for February 2015 and the whole of 2015 are presented in table 8. According to the data analysis, approximately 294.000 tons of cargo is transhipped as a BUP in 2015. This amounts to approximately 94.000 BUPs per year of which 78% is imported. If the expected total throughput of 3 million tons is reached, an estimated 176.000 BUPs require transhipment at AAS which amounts to over 550.000 tons. This approximation can only be made under the condition that the BUP shares stay similar.

<table>
<thead>
<tr>
<th>Table 8: Cargo and BUP Figures Current &amp; Future</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="#" alt="Table 8" /></td>
</tr>
<tr>
<td>Import</td>
</tr>
<tr>
<td>Export</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
<tr>
<td><strong>Future (Approximation)</strong></td>
</tr>
<tr>
<td>Import</td>
</tr>
<tr>
<td>Export</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>
4.4 Conclusion current BUP Process Analysis

Build Up Pallets are suitable for a Fast-Track Facility because this cargo category does not require any handling processes besides transhipment.

Currently, import BUPs are either transhipped over a fast-track conveyer system or simply transported with a fork-lift truck. Export BUPs are build up or broken down at either the ground handler (1st line) or the forwarders facility (2nd line). If this happens at the forwarder’s facility, the BUPs are only moved through the ground handlers facility from air to landside or the other way around.

Most handlers state that ‘priority’ import shipments can be made available 3 hours after time of arrival. This indicates the fastest import lead time which is currently realized for handler’s. Export BUPs are rarely transhipped with fast-track conveyer systems. Export BUPs require checks regarding the dimensions, weight and looks and leakage before they are transhipped to airside, which complicates the export fast-track process.

Experts estimate that currently 35% of the import and 15% of the export cargo which is transhipped over AAS is build up as a BUP unit. According to the data analysis, this amounts to approximately 94,000 BUPs per year which represent 294,000 tons of cargo. 79% of the BUPs is imported.

A summary of the current AAS BUP transhipment system is presented in table 9. These characteristics can be used to compare the current situation at AAS with potential future ‘Fast-Track Facility scenario’s’.

Table 9: Characteristics Current BUP System AAS

<table>
<thead>
<tr>
<th>Characteristics Current BUP System AAS</th>
<th>Unit</th>
<th>AAS Current Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available 1st Line Area AAS</td>
<td>m²</td>
<td>210,000</td>
</tr>
<tr>
<td>Occupied 1st Line Area Handlers</td>
<td>m²</td>
<td>205,000</td>
</tr>
<tr>
<td>Occupied 1st line width</td>
<td>m</td>
<td>2020</td>
</tr>
<tr>
<td>Productivity AAS</td>
<td>[ton/year/m²]</td>
<td>9.3</td>
</tr>
<tr>
<td>Total AAS Throughput</td>
<td>[million ton/year]</td>
<td>1.6</td>
</tr>
<tr>
<td>Total BUP</td>
<td>[ton/year]</td>
<td>293,600</td>
</tr>
<tr>
<td>Total BUP</td>
<td>[#/year]</td>
<td>93,850</td>
</tr>
<tr>
<td>Export BUP</td>
<td>[#/year]</td>
<td>20,100</td>
</tr>
<tr>
<td>Import BUP</td>
<td>[#/year]</td>
<td>73,750</td>
</tr>
<tr>
<td>Min. BUP Lead Time (Import)</td>
<td>[hour/BUP]</td>
<td>3</td>
</tr>
</tbody>
</table>

Several requirements concerning the processes of a Fast-Track Facility are retrieved from the current BUP transhipment analysis. A full list of process requirements is provided in appendix D.
5 Actor Analysis BUP Chain AAS

The research question has clearly stated that a design for a Fast-Track Facility at AAS should allow itself to be integrated in the multi-actor cargo supply chain. In order to create a detailed image of the actors which play a role within this chain, a general actor analysis (appendix A) has been performed.

The identified actors (or actor clusters) are: Schiphol, Schiphol Real Estate, Customs, Airlines, Handlers, Forwarders, Integrators and Sector Supporting organizations such as ACN and Cargonaut. In this analysis not only the tasks and responsibilities of the actors are explained, the gap between the actor’s goals and desired situation is clarified as well. The common goal of the actors is the chain’s profitability. This is why actually the goal of Schiphol, to become Europe’s most preferred airport, is applicable to all involved actor’s playing a role in the AAS cargo supply chain.

Besides the general actor analysis, a qualitative research is performed in order identify the critical actor’s for the BUP supply chain in specific and to obtain information on the attitude of the critical actors towards the idea of a Fast-Track Facility at Schiphol. Several expert interviews (reported in appendix N) have been conducted. The attitude of the actor’s towards the Fast-Track Facility has created a clear idea of the actor’s criticality (appendix B2) and the actor requirements for the realization of a successful Fast-Track Facility.

5.1 Actor Criticality and FTF Attitude

Schiphol Cargo, SRE, forwarders, ground handlers and the airlines\textsuperscript{12} are the critical actors or actor clusters in the BUP chain at AAS and for the design process of a Fast-Track Facility at AAS. These actors are not substitutable and successful FTF realization depends on these actor’s cooperation.

Previous research has stated that high competitiveness among these actors results in slow adaption of innovations. Pieters (2014) as well as de Wit (2014), van der Donk (2015) and Lubbe (2015) have stated that the actors within the air cargo logistics chain at Schiphol have quite a conservative character. This conservative character together with the low-level of cooperation and willingness to invest urges the need for taking into account the actor’s requirements and attitude in the FTF design.

The most important points of attention per critical actor which are to be taken into account for the Fast-Track Facility design are summarized in table 10 till 13. It has to be noted that the attitude of the problem owner (Schiphol) depends on the performance of the FTF. The attitude of Schiphol can therefore be viewed as an expected or desired situation. The detailed output of the qualitative critical

\textsuperscript{12} KLM included as ground handler and airline
actor research is presented in appendix B3. Several actor requirements for the FTF design are retrieved from the qualitative actor research and are listed in appendix D1.

Table 10: Schiphol’s Perspective on the FTF concept

<table>
<thead>
<tr>
<th>Schiphol (SRE)</th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>A Fast-Track Facility could increase AAS productivity and therefore allow Schiphol to cope with expected future throughput.</td>
<td>A Fast-Track Facility requires an possible investment from Schiphol</td>
</tr>
<tr>
<td></td>
<td>A Fast-Track Facility could increase Schiphol’s competitive positions due to the possibility for faster transhipment which would attract business on the long run.</td>
<td>A Fast-Track Facility requires first line area, which is already scarce.</td>
</tr>
<tr>
<td></td>
<td>A Fast-Track Facility could decrease truck congestion.</td>
<td></td>
</tr>
</tbody>
</table>

Table 11: Ground Handlers Perspectives on the FTF concept

<table>
<thead>
<tr>
<th>Ground Handlers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Table 12: Forwarders Perspectives on the FTF concept

<table>
<thead>
<tr>
<th>Forwarders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
### Table 13: Airline Perspectives on the FTF concept

<table>
<thead>
<tr>
<th>Airlines</th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive</strong></td>
<td>Cargo arrival reliability could increase with FTF usage. For export cargo, reliability is important for airlines.</td>
<td>An extra contract with a first line party is not desired. Airlines have a long-lasting relationship with ground handlers and are therefore not eager to change handler contracts.</td>
</tr>
<tr>
<td><strong>Negative</strong></td>
<td></td>
<td>Airlines trust the handlers which they have a contract with. They have less grip if handlers outsource a part of the cargo.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Don't see the need for a change in the system</td>
</tr>
</tbody>
</table>

### 5.2 Conclusion Actor Analysis

The general attitude towards the Fast-Track Facility is divided. Handlers are quite sceptic, forwarders and Schiphol see possibilities and airlines do not see why a change in the current ‘working system’ is necessary.

The reason for the scepticism is primarily the fear of negative effects on the owned business. Handlers fear the loss of volumes through their facilities without a guarantee for volume (or rent) compensations. Airlines have long-lasting relationships with handlers which they do not want to endanger with an extra process step which could require extra contractual agreements. The sceptic or neutral attitude towards the FTF is explained by the fact that these two parties are not expected to gain directly from the FTF.

Schiphol is eager to learn what the effects of a Fast-Track Facility would be. Forwarders would gain from a decreased lead time and an increase in the grip on the entire transhipment process. The positive attitude towards the FTF is explained by the fact that these two parties are expected to gain (in)directly from the FTF.
VI TECHNOLOGICAL PERSPECTIVE
6

Fast-Track Facility Functions

In order to create a FTF design which allows itself to be integrated in the multi-actor cargo supply chain it is of great importance to decide which functions are incorporated in the FTF. Paragraph 6.1 provides a description of the basic terminal functions of a first line facility and their applicability for a FTF. Paragraph 6.2 re-evaluates the applicability for the FTF functions while taking into account the critical actors perspectives and requirements.

6.1 Applicability 1st Line Functions for an FTF

The basic terminal functions of a 1st line cargo handling terminal are: transhipment, storage, building up and breaking down. Besides the basic terminal functions there are several additional functions which could be added in a terminal. In this paragraph the applicability of the terminal functions on an FTF is argued from a practical perspective.

Transhipment

The major function of a FTF is transhipment. The goal of a Fast-Track terminal is stated by the name, which implicates the importance of fast cargo transhipment. A Fast-Track Terminal can distinguish itself from current handlers facilities when providing faster transhipment then currently possible. The basic design for a Fast-Track Terminal would therefore include nothing but a system which allows fast transhipment to find its passage from airside to landside (figure 15).

![Figure 15: Basic Fast-Track Configuration](image)

Two sorts of transhipment flows are possible: import cargo transhipment and export cargo transhipment. The detailed analysis of the BUP import and export processes in chapter 4 has provided several system requirements (appendix D1) for both transhipment directions. Fast BUP import transhipment requires at least an airside dock, a rollerbed and a truck dock. Fast export BUP transhipment requires at least a truck dock, a scaling and scanning system, a rollerbed and an airside dock.

Storage

Within retail distribution and truck transportation networks the basic fast-track design configuration as presented in figure 15 is referred to as a cross dock. A cross dock is a terminal design type which completely eliminates storage and order picking functions of a warehouse while still allowing it to serve it's receiving an shipping functions (Bartholdi & Gue, 2004). According to Bartholdi & Gue (2004) storage and order picking is the most costly function of a warehouse due to inventory holding and
labour costs. A cross-docking terminal is commonly used as an intermediate node in a distribution network which is exclusively dedicated to the transhipment of truck loads (Boysen & Fliedner, 2010). While currently cross docking is primarily used for consolidation and de-consolidation purposes, the principle has potential for air cargo transhipment. A similar-to-cross dock design decreases lead time and area usage while increasing productivity. These goals exactly align with Schiphol’s goals. However, a cross-dock design, which totally eliminates the terminal storage function, imposes several requirements on the transhipment process.

A storage-less design requires a seamless transhipment process from airplane to truck. This means that import cargo is unloaded from an aircraft, transported to the Fast-Track Facility, placed on the rollerbed and immediately rolled into a truck which is ready at a landside dock at the exact right moment. Seamless export transhipment would require the truck to drop-off the BUP at the FTF at a certain moment before actual time of departure allowing the exact correct time window for rolling the pallet through the facility and transporting it to the aircraft stand. Furthermore, no blockages may arise on the fast-track conveyer system. Seamless transhipment therefore requires extremely punctual and predictable truck, airplane and fast-track terminal processes which never deviate from the expected situation. It is imaginable that this level of punctuality decreases when throughput volumes increase.

No matter how predictable the fast-track terminal processes are arranged, still external factors such as weather and traffic influence truck and plane predictability. A Fast-Track Facility which aims at bundling all BUP flows at AAS, resulting in high throughput, increases unpredictability which contradicts with the requirements for seamless behaviour. This means that complete elimination of storage is not a possible option for a fast-track terminal at an airport. While the ultimate goal of a 1st line FTF is to behave as a cross dock, a storage facility acting as a buffer to cope with unpredictable external events, is necessary in order to prevent a blockage on the fast-track conveyer system and be able to at least guarantee the predictable fast-track processes.

**Build Up and Break Down**

Principally, BUP transhipment does not require build-up and break-down activities. The goal of the FTF is transhipment of pallets which do not require this activities. There is however one situation during which these functions might be necessary. When an export BUP is delivered at the FTF and it is rejected due to wrong weight, dimensions or leakage, and it is chosen to rebuild inside the facility, this function is required.

**Additional Functions**
The addition of extra functions to the Fast-Track terminal is only preferable when these functions contribute to the main goal of the FTF, which is fast transhipment. One additional function which could decrease BUP lead time is the integration of a customs control function for import BUPs. It is assumed that export cargo is checked at the forwarders facility before transporting to the FTF. Import BUPs
however, could be in need of a customs check for which a detour at airside is required. Integrating the customs control function in the Fast-Track terminal could possibly save time.

6.2 Feasible Fast-Track Facility Functions

According to the previous paragraph, the minimal required functions of the FTF are transhipment and storage. In this paragraph a distinction is made between import and export transhipment. Optional functions for the FTF are: ‘export rebuilding’ and ‘in-house customs control’ for import cargo. The five identified functions are re-evaluated while taking into account the critical actors perspectives and requirements. The contribution of the function to the FTF usage and the feasibility of the function integration is argued.

Import Transhipment

Import BUP transshipment through a FTF certainly contributes to the usage. Throughput is created by offering the transhipment function. The estimated amount of import BUPs amounts to approximately 140,000 BUPs per year with a total AAS throughput of 3 million tons. Furthermore, import BUPs do not require any checks or other procedures during first line transhipment accept for the incidental customs clearance. Import transhipment is, due to its large volumes, an essential function of the FTF.

Export BUP Transhipment and Rebuilding

The estimated amount of import BUPs is approximately 40,000 BUPs per year with a total AAS throughput of 3 million tons. This is a little over one fourth of the amount of import BUPs. According to experts, export BUPs which are currently delivered at ground handlers are rejected approximately 15% of the time (appendix N). The cause of these rejections is primarily, wrong dimensions, wrong weights or poorly build-up pallets which can collapse and damage the cargo. This last option is common for flower transhipment. Rejected cargo requires rebuilding. Export rebuilding requires skilled employees which perform the rebuilding process according to the service level agreement between airline and handler. Ground handlers and forwarders have stated that combined handling processes are very undesirable due to the highly competitive nature of these parties (Baas, 2015) (Boot, 2015) (Bruijs, 2015) (Brink, 2015) (Kervezee, 2015).

Ground handlers and forwarders do not want other companies to know their clients database. This means that either all handlers outsource one employee to the FTF to perform rebuilding, which does not meet the competitive requirements. The second option is that a neutral third party rebuilds the rejected export cargo in the FTF. This requires one company to poses knowledge about the different service level agreements between all handlers and all airlines. Because these differ and are quite detailed, this is not a realistic option. Because in-house export rebuilding is not a realistic option from a critical actor’s point of view, all rejected export BUPs are then forced to be send back towards the responsible forwarders facility or to the associated handlers facility. This process is undesirable due to the substantial increase in export lead time, the necessary extra (priority) truck movement and the increase in the chances of the BUP missing the destined flight.
Due to the rebuilding and privacy hurdles combined with the relatively low export BUP volumes, the ‘export transhipment and rebuilding’ functions for the Fast-Track Facility are assessed as undesirable for the FTF. They will not contribute to FTF usage and usability for neither the owner and operator, nor the clients of the FTF. These functions will not be taken into account in further research.

**Storage**

The need for storage in a Fast-Track Facility is basically driven by the fact that the air cargo supply chain is not seamless. The previous paragraph argues the necessity of the storage function which acts as a buffer during air cargo transhipment. The usability of the FTF is not directly increased by offering a storage function. As the goal of a FTF is fast transhipment, storage contradicts with this goal. However, storage is argued to be indispensable as long as the air cargo supply chain is not seamless. On the other hand, a storage function does increase the usability of the FTF because it creates a certain flexibility for forwarders and trucking companies which could be defined as customer friendly.

Data analysis (appendix J) shows that approximately 50% of the import BUPs and 40% of the export BUPs are perishables. It is of great importance to offer an unbroken cold chain for perishable transhipment. Each interruption in the cold chain influences the quality of perishables which often results in a decreased turnover rate (van der Hulst, 2004). As a storage function is argued to be indispensable for a FTF, critical actor’s require this storage function to integrate a sufficient amount of cooled storage positions.

**Customs Function**

An integrated customs facility in the FTF is desirable because of the increase in the import BUP lead time. BUPs do not have to be redirected via the Joint Inspection Centre (JIC), when a remote customs scanner scans the cargo in the FTF. However, a scanner is estimated to cost 1.8 million euros (Perez, 2015). Such a high investment should contribute to the return of the FTF. It is not expected that a small average decrease of the lead time (as approximately 10% requires customs checks (Zonneveld, 2015)) provides the rate of return which is necessary to justify the initial scanner costs. It is however interesting to take speculate with the possibility for an in-house customs function.

### 6.3 Conclusions FTF Functions

A Fast-Track Facility should perform import transhipment and be equipped with a (cooled)storage function which acts as a buffer. Export transhipment is unfeasible for a FTF at AAS because of the fierce actor competition and the need for client privacy. Furthermore, export BUP volumes are currently a quarter of the import BUP volumes and export processes impose a lot of equipment requirements on an FTF design. Export transhipment could be interesting when the actor environment changes and the export BUP demand increases. An integrated customs function in an FTF is costly, but results in a lead time decrease. The return of investment should be researched before the customs function should be implemented in an FTF.
7 Fast-Track Facility Process Design

In this chapter a feasible configuration of the processes in and around the Fast-Track Facility is provided. This process design is based on identified BUP transhipment process requirements. The goal of the process design is to best integrate the facility within the current AAS cargo supply chain.

Since export transhipment and rebuilding is not a feasible function for the FTF, the process taken into account for the Fast-Track Facility process design is one-sided. The part of the import process which is taken into account reaches from: unloading the plane at the aircraft stand until the unloading of the trucks at the second line facility. The process design is split into three sub-designs which are presented in figure 16.

Figure 16: Three Sub-Designs: Landside, Airside and Fast-Track Facility Processes

Despite the fact that export processes are not taken into account in this research, they are investigated in case export transhipment becomes interesting in the future. The export process designs can be consulted in appendix E2.2, E2.3 and E2.5.

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13 This sketch is not leading nor input for any further designs. Furthermore the sketch is not scaled nor detailed.
7.1 Airside Process Design

The airside process design refers to the import processes at airside which are required in order to facilitate a general fast-track principle at AAS. The process flow diagrams including the actor responsibility can be found in appendix A2.

![Figure 17: Overview Process Design, Airside Marked](image)

**Airside Import Process**

The options for airside import processes which enable FTF usage are visualized in figure 19. The process flow diagrams including the actor responsibility can be found in appendix E2.1. The biggest difference between the two variations is the moment when the BUPs are split from the ULDs.

**Variation 1: Splitting the BUPs from the ULDs at the aircraft stand**

If there is time to split cargo at the aircraft stand, the tag on each pallet is scanned there and then in order to check whether the pallet is a BUP or not. It is assumed this information is available in the ground handlers IT system and linked to the scan equipment. All BUPs are placed on one or multiple\(^{14}\) dedicated FTF dolly train(s) or transporters, depending on the distance from the aircraft stand to the handling facility and the need for a customs check\(^{15}\). If a customs check is not required and the aircraft stand is very near to the handling facility, the BUPs are driven to the facility with transporters.

If the aircraft stand is not near the facility, the BUPs are loaded on dollies. The BUPs in need of a customs check are loaded on a separate dolly train from those which are not in need of a check. The normal (not in need of check) BUP train(s) depart towards the FTF. The customs train departs towards the Joint Inspection Centre\(^{16}\) where it is scanned (figure 18). After the customs check, the responsible handler delivers the dolly train at the airside terrain of the FTF.

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\(^{14}\) This depends on the amount of BUP’s. A dolly train can transport a maximum of 5 pallets at once (Doorne, 2013).

\(^{15}\) The scanner information indicates whether or not a pallet needs to pass customs.

\(^{16}\) Joint Inspection Centre is estimated to be operational in 2017 (Schiphol Smartgate Cargo, 2015)
At the airside terrain of the FTF the BUPs are loaded from the dollies onto transporters in order to load them into the FTF on the airside loading docks. BUPs that were transported from the aircraft stand with a transporter are immediately loaded onto the FTF at the airside loading dock. The entire process is performed by the responsible ground handler.

**Variation 2: Splitting the BUPs from the ULDs at the Ground Handlers facility**

All cargo which is not in need of a customs check is transported from the aircraft stand to the associated ground handler’s facility with either dollies or transporters (depending on the distance from the aircraft stand to the ground handler). All cargo in need of a customs check is transported to the Joint Inspection Centre, is scanned, and afterwards transported to the ground handlers facility.

At the airside terrain of the ground handler, the ULDs are split from the BUPs based on scanning information. The BUPs are assembled on a dolly train, and transported to the FTF. The ULDs are handled in the handlers facility. The BUPs are loaded onto transporters in order to load the pallets into the FTF at the airside loading docks.

### 7.2 Fast-Track Terminal Process Design

The process design for the fast-track terminal is relatively simple. Functions which are to be performed inside the fast-track terminal have been stated and explained in chapter 6. Because the processes inside the Fast-Track Facility merely depend on the used equipment and the lay-out of the terminal, only a general explanation of the processes inside the fast-track terminal is provided in this section. A detailed explanation of the inside processes comes forward from the terminal design and simulation performed in chapter 8 and 9.
Figure 20: Overview Process Design, Terminal Marked

**Basic Fast-Track Terminal Import Process**

The import cargo is placed at an airside dock, from a dolly or a transporter onto the fast-track rollerbed system. It is then decided whether or not a BUP is immediately pushed through to a landside dock or if the BUP is stored. This decision depends on various factors:

1. Is there a truck present at a truck dock?
2. Is the rollerbed system not too crowded?
3. Is there a storage position available?

If the BUP is pushed through, it is loaded into the truck at a truck dock. If it is decided that the BUP is stored, it is placed in the nearest storage position within the storage system. Once a truck is available and the conveyers are not too crowded, the BUP is retrieved from storage and placed on the conveyers system. The import process of the Fast-Track Facility works with a first come first serve principle. BUPs which enter the facility first have priority for truck transhipment.

If the customs function is integrated in the Fast-Track Facility, the BUPs which are in need of a customs scan are directed via the conveyer system to the customs scanner. If cargo is rejected in the customs scanner, it is broken down at the in-house customs facility. If the cargo passes the scan it is conveyed towards the storage or the truck docks based on the previously mentioned conditions.
7.3 Landside Process Design

The landside process design refers to the import processes at landside which are required in order to facilitate a fast-track system at AAS. The landside processes are based on the Milkrun principle (appendix E3) which stimulates forwarders to combine their truck loads.

![Figure 21: Overview Process Design, Landside Marked](image)

A Fast-Track Facility software system (FTF system) allocates BUPs and trucks to certain docks. It is assumed that a Fast-Track Facility Milkrun software system is compatible with existing Milkrun software.

**Landside Import Process**

The landside import process is visualized in figure 22. The process flow diagrams including the actor responsibility can be found in appendix E2.4. When a plane lands at Schiphol and the BUPs are split from the ULDs at the aircraft stand, a signal is send to the FTF System. At that point the trucker knows that a truck must be available for cargo pick-up at the Fast-Track Facility within a certain period of time. This period of time is called the ‘Truck Notice Time’.

A truck heads towards the Fast-Track Facility. The truck driver must signal the FTF system when he is on its way. The system is informed with the information of the ‘almost’ arriving truck and prepares the truck load at a certain dock.

The allocated truck dock is placed in the FTF system including a docking time-window of 15 minutes. The truck driver knows which dock to head to and also knows exactly at what time it is supposed to dock. If the dock is not immediately available, the truck parks at a truck buffer position dedicated to the allocated dock. The amount of truck buffer positions at landside is limited to two per dock.

![Figure 22: Landside Import Process](image)
Once the truck is docked, the import cargo is loaded in the truck and as soon as the truck is fully loaded, it departs. If the truck is not fully loaded but the maximum truck waiting time has expired, the truck departs as well. The maximum truck waiting time for a truck is similar to the docking time window and commences once the truck has officially docked and the loading process begins. The truck drops off the BUPs at the correct forwarders via a Milkrun.

### 7.4 Conclusion FTF Process Design

In order to integrate the Fast-Track Facility in the current handling processes it is of great importance to split the BUPs from the ULDs on time. For import cargo this means that the BUPs must be split at the aircraft stand or at the handler’s facility. This means that it should all handler’s software should be able to deliver information on whether a ULD is a BUP or not during scanning.

In order to facilitate the fastest and most seamless transhipment through the Fast-Track Facility, the truck processes should be arranged with a Milkrun system. This system has two advantages which contribute to the goals of Schiphol. The reliability of truck processes increases which enhances lower transhipment times. Secondly, a Milkrun increases truck load factors which decrease AAS congestion and contributes to a fast overall transhipment time.

In order to create seamless transhipment between the trucks and the Fast-Track Facility, a software system which is compatible with the Milkrun software system should be developed. This software system provides pick up and drop off time windows and dock allocations for the truckers. For the fast-track terminal storage system this software provides the information which influences the storing and retrieving processes.

The fast-track terminal should work with a first come first serve (FIFO) method for import cargo. Cargo which enters the facility first, should be the first to be loaded into a truck first. The decision for storage or push through to the truck dock is based on the availability of a truck (spot), the conveyor system utilization and the storage availability.

**Requirement Check Process Design:** The process design for import transhipment complies with all previously stated process and actor requirements as is shown in appendix D2.2. The specific export requirements are marked as ‘not applicable’. Furthermore, some actor requirements depend on the institutional design of the FTF.
Conceptual Fast-Track Terminal Designs

In this section, the technological design of the fast-track terminal building is addressed. Two conceptual designs, which integrate the terminal process design (paragraph 7.2) with a detailed ‘terminal lay-out and equipment design’, are introduced.

The design of the Fast-Track terminal is based on an outside-in approach. First, the criteria for the fast-track design are identified in paragraph 8.1. Secondly, the designated area for a FTF is analysed in paragraph 8.2 in order to investigate the boundary conditions of the Fast-Track Terminal design. In paragraph 8.3 the options for the Fast-Track Terminal design are analysed and combined into two plausible alternatives based on contrasting starting points.

8.1 Criteria Fast-Track Terminal

In order to be able to assess the fast-track terminal design, a set of criteria based on the main research question is identified. Criteria are the measurable characteristics of a system which represents goals of the actors (de Haan, 2009). The applicable criteria are extracted with an objectives tree (figure 23) (de Haan, 2009).

The main objective of Schiphol Cargo is to facilitate increasing cargo volumes on the limited 1st line area of AAS South-East which actually means that the AAS productivity needs to increase. Contribution to AAS productivity can be measured with three underlying criteria.

1. A Fast-Track Facility design should be compact. The smaller the area which is occupied by the fast-track terminal, the higher the productivity of the terminal and thus, the higher the productivity of the entire AAS 1st line is.

2. A high BUP throughput in the Fast-Track terminal. A high throughput in the fast-track terminal contributes directly to the FTF productivity and therefore directly to the AAS productivity. There is also an indirect contribution to the AAS productivity which is visualized in figure 24 and basically explains that each BUP which is transhipped through the FTF relieves the handler’s facilities.

3. Provide fast transhipment in the Fast-Track terminal. When the lead time of a pallet through the Fast-Track Facility is minimized, more pallets can be transhipped through the terminal in the same amount of time.

Figure 23: Means-Ends Diagram (Zoom-In)
The criteria for the FTF design are thus:

**C1:** Productivity AAS [ton/year/m²]

**C2:** Productivity FTF [ton/year/m²]

**C3:** Occupied Area FTF [area]

**C4:** Max. Throughput FTF [ton/year]

**C5:** Lead Time FTF [Hour/BUP]

**C6:** Investment Costs FTF [€]

Although costs (C6) of the Fast-Track Facility are not included in the objectives tree, this criterion is added in order to be able to provide basic insight in the financial aspect of a Fast-Track Facility for the problem owner as this might be critical to eventual decision making.

### 8.2 Fast –Track Terminal Boundary Conditions

The designated area for potential FTF realization is Schiphol South-East. The theoretical maximum width of the of the area which is marked red in figure 25 is 1620 meters (appendix G1).

The average depth of an AAS airside terrain at 1st line is 30 meters and the average depth of a truck terrain is 40 meters. The depth of current existing handling terminals is between 80 and 100 meters. Furthermore, various handlers have stated that 100 meters is the ideal depth for a 1st line terminal (Kervezee, 2015) (Baas, 2015).

The admissible building height of a terminal at AAS South-East is based on mandatory sightlines for airplanes (SRE, 2015). The maximum building height of a terminal at airside is approximately 21.5 metres and the maximum building height at landside varies between 15 and 5 metres depending on the distance from airside.

The boundary conditions for the FTF are presented in figure 26. The depth and height of the facility are boundary conditions, the width of the facility is a variable which depends on the terminal lay-out and should be minimized in order to maximize the throughput of Schiphols 1st line area.
8.3 Fast-Track Terminal Design Variables

There are various variables which determine the design of the Fast-Track Terminal. The variables applicable to a Fast-Track Terminal are retrieved from literature (appendix G) and the current BUP process analysis in chapter 4. The variables are classified in three categories: general, configuration and equipment variables (table 14)

The general variables broadly determine the order size of the terminal design. The configuration and equipment variables determine the detailed internal lay-out of the Fast-Track terminal. For each variable several applicable design options are identified. A combination of feasible design options for all variables results in a possible alternative for the Fast-Track Terminal Design. In order to narrow down the amount of alternatives a morphological approach is used. The details of this approach including an extensive list of all the design options is presented in Appendix G3.

In contrast to the general and equipment variables, the design options for the configuration variables can only be estimated for the conceptual design alternatives. These estimated values for the configuration variables are refined with the help of a simulation model described in chapter 9.

<table>
<thead>
<tr>
<th>General Variables</th>
<th>Equipment Variables</th>
<th>Configuration Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Terminals</td>
<td>Storage System</td>
<td>Rollerbed Lanes [#]</td>
</tr>
<tr>
<td>Terminal Shape</td>
<td>Storage Equipment</td>
<td>Storage Capacity [#]</td>
</tr>
<tr>
<td>Terminal Levels</td>
<td>Main Transport Mean</td>
<td>Cooled Storage Capacity [#]</td>
</tr>
<tr>
<td>Transhipment Direction</td>
<td>Truck Docks</td>
<td>Airside Import Docks [#]</td>
</tr>
<tr>
<td>Customs Control Function</td>
<td>Scale &amp; Scanner</td>
<td>Truck Docks [#]</td>
</tr>
<tr>
<td></td>
<td>Inspection Equipment</td>
<td>Storage Equipment [#]</td>
</tr>
</tbody>
</table>

8.4 Fast-Track Terminal Design Alternatives

Two design alternatives have come forward from the morphological approach (appendix G3) which are created based on the aim for a certain ‘level of automation’. Creating one automated alternative and one manual alternative results in two contrasting design alternatives which tend to differ in the scores on the earlier set criteria for the terminal design. This selection method is chosen in order to retrieve diverse and broad information on the various design options. A short explanation, the goal and the included functions for each alternative are presented in table 15.
Table 15: Alternative Explanation

<table>
<thead>
<tr>
<th>Alternative Name</th>
<th>Goal</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 The Manual Design</td>
<td>Minimize Investment Costs [€]</td>
<td>Import Transhipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Storage (Cooled)</td>
</tr>
</tbody>
</table>

The starting point of this alternative is to integrate manual processes inside the fast-track terminal. The aim for this design is to be investment cost efficient which will result in a combination of cheapest design options which enhance these manual processes.

<table>
<thead>
<tr>
<th>2 The Automated Design</th>
<th>Maximize Performance [ton/year/m²]</th>
<th>Import Transhipment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Storage (Cooled)</td>
</tr>
</tbody>
</table>

The starting point of the automated design alternative is to integrate automated processes inside the fast-track terminal with the goal to maximize the FTF performance. The aim is to exclude manual labour as much as possible. This design alternative will enhance multiple level automated storage which results in a compact design.

The two conceptual design alternatives are presented and described in detail in section 8.4.1 and 8.4.2. The interpretation of the design variables per alternative is presented in table 16. For each variable, the design option is chosen which contributes most goal of the alternative. The design options for the general variables are similar for both alternatives. The number of terminals(G1), the terminal levels(G2), shape(G3) and transport direction(G4) are respectively 1,1, I-Shaped and Import only. Both alternatives have external customs control(G5). A detailed list of design options is presented in appendix G3.

Table 16: Design Options per Alternative

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment Variables</td>
<td>Ground Floor Storage</td>
<td>Automated Rack Storage</td>
</tr>
<tr>
<td>E1 Storage System</td>
<td></td>
<td>Slave Pallet Mover</td>
<td>ETV</td>
</tr>
<tr>
<td>E2 Storing Equipment</td>
<td></td>
<td>Rollerbed</td>
<td>Automated Rollerbed</td>
</tr>
<tr>
<td>E3 Main transport mean</td>
<td></td>
<td>Inside</td>
<td>Outside</td>
</tr>
<tr>
<td>E4 Truck Docks</td>
<td>Configuration Variables (estimation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1 Import Rollerbed Lanes</td>
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<td>2</td>
</tr>
<tr>
<td>A3 Storage Capacity</td>
<td></td>
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<td>126</td>
</tr>
<tr>
<td>A4 Cooled Storage Capacity</td>
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<td>0</td>
</tr>
<tr>
<td>A5 Workstation</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>A6 Airside Import Docks</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>A7 Airside Export Docks</td>
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<td>0</td>
<td>1</td>
</tr>
<tr>
<td>A8 Import Truck Docks</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>A9 Export Truck Dock</td>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>A10 Storage Equipment</td>
<td></td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
8.4.1 Conceptual Design Alternative 1: The Manual Design

The conceptual design (figure 27) of the manual alternative consists of one rollerbed system with one airside and one landside dock were pallets enter and leave the physical FTF. The BUPs can be retrieved from and placed on the rollerbed with slave pallet movers which are operated by employees. The BUPs are stored on the ground floor. Several ground floor storage positions are within a cool cell. An employee in the function of controller with mechanic knowledge for the maintenance and operation of the conveyer system is required. A control room is integrated in the design for the employee(s).
8.4.2 Conceptual Design Alternative 2: The Automated Design

The conceptual design of the automated terminal (figure 28) consists of two import rollerbeds which are both linked to one airside and one landside dock where pallets enter and leave the terminal. The ETV's can move alongside the rollerbeds in the middle of the facility. The ETV can retrieve from and place BUPs on the rollerbeds. The ETV places import pallets in need of storage in the nearest available storage positions. Part of the storage positions are cooled. A controller with mechanic knowledge is required for the maintenance and control of the automated storage and rollerbed system. A control room is integrated in the design for the employees.

Figure 28: Alternative 2 Conceptual Lay-Out & Profile
8.5 Conclusion Conceptual Fast-Track Terminal Design

Two different alternatives for the technological design of the fast-track terminal are presented. The first alternative is based on manual labor and low investment costs. This has resulted in a lay-out with ground floor storage and slave pallet movers operated by employees. The second alternative is based on an automated process which excludes manual labor as far as possible. This starting point has resulted an automated storage system equipped with elevating transfer vehicles which place and retrieve the BUPs from storage.

**Requirement Check Conceptual Terminal Designs:** Both conceptual designs comply with the previously identified functional requirements (area and equipment requirements) as is shown in appendix D2.1. The requirement regarding sufficient storage capacity depends on the quantitative analysis which is performed in the next chapter.
Discrete Event Simulation Fast-Track Facility

In section 9, the three conceptual designs from chapter 8 are quantitatively analysed with a discrete event simulation model in Arena Software. The applicability of discrete event simulation and this simulation software package is described in appendix I.1.

The first goal of the simulation model is to replace the initial estimations of the configuration variables with underpinned values. These values are used in chapter 10 to refine the conceptual alternatives towards detailed designs. The second goal of the model is to retrieve values for the model performance indicators.

The configuration variables and performance indicators which are to be retrieved from the analysis are stated per conceptual design alternative in table 17 and 18.

For the performance indicators a distinction is made between the Key Performance Indicators and extra performance indicator. The Key Performance Indicators are: the ‘Maximum Fast-Track Terminal Throughput’ (or capacity) and the ‘BUP Lead Time’. A detailed explanation of the performance indicators is presented in appendix l.2.

### Table 17: Configuration Variables

<table>
<thead>
<tr>
<th>Configuration Variables</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rollerbed Lanes [#]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Positions [#]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooled Storage Positions [#]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck Docks [#]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airside Docks [#]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slave pallet movers [#]</td>
<td></td>
<td>ETV’s [#]</td>
</tr>
</tbody>
</table>

### Table 18: (Key)Performance Indicators

<table>
<thead>
<tr>
<th>Key Performance Indicators</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Throughput (Capacity) [pallet]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Lead time [hour]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Extra Performance Indicator**

<table>
<thead>
<tr>
<th>Extra Performance Indicator</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck Movements [#]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Lead Time (Import)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9.1 Simulation Model Conceptualization

The simulation model conceptualization consists of the model scope (9.1.1), the description of the model in and output (9.1.2), summing the modelling assumptions which lie at the basis of the simulation model (9.1.3), providing a description of the meta-model lay-out (9.1.4) and the model data (9.1.2).

9.1.1 Model Scope

The processes taken into account for the simulation model are described and visualized below. The import processes are modelled from: unloading the transporter at the FTF airside terrain until the loading of the import trucks at a landside truck dock.

![Figure 29: Scope Simulation Model](image)

9.1.2 Model Input and Output

In order to run the model, a model input is generated. The entities which enter the Arena model represent BUPs. There are two BUP categories which enter the GFTF. These are:

- Import BUPs
- Import Perishable BUPs

A distinction between perishable and normal BUPs is made because of the extreme high value of time of the commodity category ‘perishables’ mainly due to the physical perishability (Damme, Radstaak, & Santbulte, 2014). This commodity category could therefore require privileged treatment and cooling facilities. Some decisions in the model are based on the entity type. Besides the BUPs there are entities in the model which represent trucks. The truck entities which enter and leave the model are referred to as:

- Import Trucks
### 9.1.3 Model Assumptions

In order to represent reality in a model, assumptions have to be made. In some situations a detailed resemblance of the reality complicates the model to an unnecessary extend (Altiok & Melamed, 2010). The model assumptions simplify processes as much as possible in order to allow simulation. Validation is used in order to control whether the model (including the assumptions) is representative for reality. The list below provides the various assumptions that are made in order to simplify and thereafter specify the FTF model.

1. It is assumed that all BUPs in the model have a similar shape. This similar shape is the based on the most common used BUP in air cargo (Menzies, 2015). The following dimensions apply to the standard 10 ft. BUP: length 3,60m, width: 2,70m and height: 3m (Boeing, 2012).
2. The basic distance unit in the model is 3,60m, which is the length of one basic BUP.
3. It is assumed that the queuing mechanism ‘First In First Out’ applies during the entire process. It is assumed that cargo which enters the model first, needs to leave first. Therefore, the release condition from the storage has priority over the decision whether a BUP is stored or not.
4. The only exception for the queuing mechanism is the priority treatment for perishables, it is assumed that these BUPs require more speed and have therefore looser push through requirements.
5. It is assumed that the truck procedures are arranged with a Milkrun System. Because the trucks are arranged via a Milkrun, BUPs are not dedicated to a certain truck.
6. Import BUPs with the same 2nd line destination are assumed to have entered the model consecutively, and therefore leave the model according to the ‘First In First Out’ principle consecutively. It is assumed that BUPs which are in the same shipment or for the same forwarders are all stored or pushed through together.
7. The positions where BUPs are retrieved from the conveyer system (referred to as the ‘Storage Bypass’ stations) are fixed in the model, while in reality BUPs can be retrieved from the conveyer system at any point.
8. The positions where BUPs are placed back on the conveyers (referred to as ‘Truck and Transporter load buffer Station’ in the model) are fixed in the model, while the real-life situation allows flexible placing.
9. It is assumed that the time it takes to place BUPs in storage positions is dependent on the amount of occupied storage positions on that certain storage level. The aim is to place the BUP as nearby as possible. Therefore placing and retrieving BUPs takes longer when more storage positions are occupied. The BUP is then placed further away.
9.1.4 Meta-Model

The two conceptual design alternatives for the ‘Fast-Track Facility’ are integrated in one meta-model. All components are modelled in the meta-model of which the lay-out is presented in figure 30. Not all components are used for each alternative. For example, when alternative 1 is running, the ETV storage component in the meta-model is disabled. The numbers inside the sub-model blocks indicate which components are used during simulation of a certain alternative. The detailed specification of the simulation model is presented in appendix I.3.3.

These main entities, BUPs, have various flow paths through the model which are guided by various important decisions. The associated possible import BUP flows and critical decisions are presented in figures 31 and 32 below. The import BUPs are indicated with a pink arrows.

The Meta-Model in figure 30 is actually a section of the complete Meta-Model (appendix I) in which export flows are taken into account for completeness. The model conceptualization and specification in appendix I therefore includes export transhipment components which can be connected if required. The potential export flows can be found in appendix I.3.
Alternative 1: Manual
In alternative 1 a decision is made whether the import BUPs are stored or pushed through towards the truck docks. If the utilization of the conveyer system exceeds 65% (or 75% for perishables) or there is no BUP position available in a docked truck, the BUP is stored. The condition for storage release is similar. The capacity of the import storage therefore merely depends on the ‘Truck Notice Time’ (TNT) and truck punctuality. The TNT is the time period which is imposed on forwarders and trucking companies for BUP pick-up.

Alternative 2: Automated
The first decision decides on which rollerbed the BUP is placed. This decision depends on the priority of the BUP, the utilization of the rollerbed and the need for storage. The second decision, made further along the conveyer, addresses whether the import BUP is stored or pushed through towards the truck docks. If the utilization of the conveyer system exceeds 65% (or 75% for perishables) or there is no BUP position available in a docked truck, the BUP is stored. The condition for storage release is similar. The capacity of the import storage therefore merely depends on the ‘Truck Notice Time’ (TNT) and truck punctuality. The TNT is the time period which is imposed on forwarders and trucking companies for BUP pick-up.
9.1.5 Model Data
The number of BUP entities which are created in the Arena model is based on the current BUP approximations of February 2015 which are described in paragraph 4.3.

The number of BUP entities which are created in the Arena model is based on an external excel datasheet which includes the estimated BUP amounts. The extensive data analysis as described in paragraph 4.3 (and appendix J) is performed in order to retrieve the BUP units which are used as model input.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>58.580</td>
<td>18.9</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

The general and perishable BUP amounts that enter the simulation model are read from the datasheet every hour during 28 days. The model replication length is thus 672 hours and the number of replications is 25 in order to retrieve reliable numbers for the KPI's. Appendix I5 provides an in-depth explanation of the model run setup.

9.2 Verification and Validation
Model verification is performed check whether the implemented model is according to specification. Model validation checks whether the model is fit to provide answers regarding the real world situation.

9.2.1 Verification
The model has been verified in various ways. The model constants are checked for correctness and the model is debugged. Furthermore flow checks have been performed and special entities are traced through the model. During model runs visualization of the storage utilization and the conveyer system is used. Also, the decision counters are often consulted in single-entity runs order to verify the entity flows of the several alternative variations.

Sensitivity tests are performed in which small changes for (expert estimated) model constants, such as the percentage of rejected export cargo, are implemented in order to see what the influence is. For an extensive explanation of the verification and the graphic results of the sensitivity tests appendix I.8 can be consulted.

9.2.2 Validation
The definition of model validation according to Schlesinger (1979) is ‘substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model’. Various manners for validation of the model

17 All BUP amounts are estimations.
exist. One of the manners, comparing the input and output with historical data, is not possible due to the fact that this Fast-Track Facility is a design of a fictive situation of which no historical data exists. During validation of the model, the BUP Input data and the Truck Notice Time(TNT) are approximated towards a feasible value, which is comparable, but will slightly outdo current processes.

The TNT is an input variable in the model which has a very large impact on the model lead time. In order to simulate the model it is important to choose a realistic value for this variable, which approaches the fictive system and at the same time ensures that the cargo lead times meet the requirements for ‘smooth processes’. The complicated thing about the TNT is that it is a value which a FTF owner or operator could impose on the trucker or forwarder. However, the FTF owner or operator never knows whether these parties keep to the agreements.

From the validation a realistic value of the TNT has come forward which meets the lead time requirements. The TNT is distributed uniform between 1 and 2.5 hours in order to simulate the unexpected events and compensate for potential failing truck and plane punctuality. The explanation of the iterative validation of these values can be found in appendix I.6.2.

### 9.3 Alternative Configuration

The model configurations for the two alternatives should be able to comply with the expected future throughput of 3 million tons per year. In order to approximate the expected throughput, the BUP input is almost doubled for the several categories. With this input, the alternative configurations must run smoothly and the equipment must be used efficiently. Therefore, the configuration variables of both alternatives are adjusted such, that the model output meets four quantified criteria stated below. The quantified requirements of the criteria are explained in detail in appendix I.7.1. The adjustment of the variables is performed iteratively.

1. The amount of pallets leaving the FTF is at least 99% of the amount which entered the FTF.
2. No bottlenecks in the form of queues or blockages can exist in the conveyer system. Converyer queues are below 0.01 and conveyer utilization is below 50%.
3. The maximum average lead time per import BUP must not exceed 2.5 hours
4. The maximum average utilization of the mobile and embeddable equipment (besides the conveyer system) within the FTF should be between a minimum average of 30% and a maximum average of 50%.

**Truck Blockage Test**

After the iteratively performed alternative configuration a blockage test is performed in order to test the flexibility of the alternatives. This test creates a situation in which the trucks are not able to reach the FTF for approximately 5 hours. The TNT of the first blocked truck is 6.5 hours and the TNT decreases

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18 The expected future throughput is 3 million tons of cargo, currently approximately 1.6 million tons is handled. So multiplied with 1.875.
with 15 minutes for each consecutive truck. After approximately two hours, the blockage is solved and the trucks arrive according to the normal procedure. The influence of this blockage on the amount of required storage positions is taken into account for alternative configuration.

The outcome of the alternative configuration is presented in table 20. The detailed output including the scores of the alternative configurations on the five requirements for smooth processes and efficient resource usage can be found in appendix 1.7.2.

<table>
<thead>
<tr>
<th>Configuration Variables</th>
<th>Unit</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Import Rollerbeds</td>
<td>#</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Import Truck Docks</td>
<td>#</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Import Airside Docks</td>
<td>#</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Slave Pallet Movers</td>
<td>#</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>ETV</td>
<td>#</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Import Storage Positions</td>
<td>#</td>
<td>152</td>
<td>114</td>
</tr>
<tr>
<td>Cooled Storage Positions</td>
<td>#</td>
<td>15</td>
<td>6</td>
</tr>
</tbody>
</table>

### 9.4 Experimental Plan

Two experiments are performed for each alternative. The minimum lead time and the maximum throughput (capacity) is tested.

**The Minimum Lead Time is tested.**

One of the future goals for the AAS cargo supply chain is to enhance further seamless truck transhipment. Various initiatives such as the Milkrun are initiated in order approach the cross-dock effect at Schiphol. Therefore, it is interesting to implement this future 'flawless truck pick-up' scenario on the FTF model and test what the lead time would be when trucks would always be on time. The settings of the model are adjusted such that the minimum time it takes for a pallet to enter and leave the FTF is retrieved. The minimum lead time is the long term objective for the FTF usage and can only be reached when seamless truck transhipment is guaranteed.

**The Maximum Throughput (Capacity) is tested.**

In order to test the flexibility and robustness of the alternatives, the throughput is increased and the effect of this increase on the equipment utilization, lead time and storage is tested. Once one or multiple of the criteria for smooth processes and efficient resource usage are not fulfilled, the maximum throughput for that alternative configuration is reached. The interdependency between the maximum throughput and the higher truck notice time is also analysed for alternative 1.

The minimum lead time and the maximum throughput for both alternatives is presented in I.9 and table 19 in the next paragraph.
9.5 The Simulation Model Output & Conclusion

The eventual model output of the performance indicators and the configuration variables for the simulation models of both alternatives are presented in table 21 and 22. For more and detailed simulation results, appendix I.9 can be consulted. For output of the export including alternatives, appendix L2 can be consulted.

Table 21: (Key) Performance Indicators Model Output

<table>
<thead>
<tr>
<th>Key Performance Indicators</th>
<th>Unit</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Throughput Import</td>
<td>[tons/year]</td>
<td>682.740</td>
<td>625.845</td>
</tr>
<tr>
<td></td>
<td>[pallet/year]</td>
<td>221.256</td>
<td>202.740</td>
</tr>
<tr>
<td></td>
<td>[pallet/day]</td>
<td>606</td>
<td>555</td>
</tr>
<tr>
<td>Average Lead time Import</td>
<td>[hour:min]</td>
<td>1:11</td>
<td>1:06</td>
</tr>
<tr>
<td>Extra Performance Indicators</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck Movements</td>
<td>[#]</td>
<td>3073</td>
<td>3073</td>
</tr>
<tr>
<td>Minimum Lead Time (Import)</td>
<td>[hour:min]</td>
<td>1:03</td>
<td>0:45</td>
</tr>
</tbody>
</table>

The following conclusions are retrieved from the quantitative simulation of the FTF with Arena software.

Architectural Parameters

- The amount of truck and airside docks for import cargo is 5 for both alternatives.
- The automated alternative requires the least amount of storage equipment. 3 ETV's are required, versus 6 slave pallet movers in the ‘manual’ alternative.
- The automated alternative results in the least amount of storage positions: 120 versus 167 in the manual alternative 1.

Key Performance Indicators

- The manual alternative is most flexible and able to handle the highest total throughput. It can handle up to three times the current estimated amount of BUPs which are transhipped in 2015. The automated alternative can handle 2.75 times the amount of current estimated import BUPs. This means that the manual alternative is able to handle an average of 50 BUPs per day more without compromising the criteria for smooth processes.
- Both alternatives have a similar average lead time. The automated alternative is 5 minutes faster on average and takes one hour and 6 minutes.
- Both alternatives require the same amount of truck movements.
- The minimum lead time of the automated alternative is 18 minutes lower than the manual alternative.
10 Refined Fast-Track Terminal Designs

In this section, the conceptual designs from chapter 8 are refined. The refined designs are based on the simulation output of the configuration parameters (table 20) and research on warehouses and air cargo equipment (appendix G and H).

Paragraph 10.1 presents the lay-out and profile of the two refined fast-track terminal designs. Paragraph 10.2 presents the scores of the alternatives on the technological criteria. Refined designs for the export alternatives are presented in appendix L3.

10.1 Lay-out Refined Designs

The lay-out and the profile of the refined designs are visualized in figure 32 and 33. The focus of the designs is the terminal, the land and airside terrains of the Fast-Track Facility are not designed in detail.

10.1.1 Alternative 1: Manual

Refining the manual focussed alternative with the simulation results, provides the following lay-out and profile design.

![Figure 32: Refined Lay-out and Profile Alternative 1: Manual](image-url)
10.1.2 Alternative 2: Automated

Refining the automated focussed alternative with the simulation results, provides the following lay-out and profile design.

![Figure 33: Refined Lay-out and Profile Alternative 2: Automated](image)

The calculated amount of required storage positions for the base throughput of 455.160 tons/year is 102 normal and 4 cooled positions. Unlike the manual alternative, this alternative can be extended without influencing the criteria scores of the alternative, except for the costs.

Two storage levels are needed anyway in order to facilitate 120 storage positions. However, the second layer would not be entirely filled. Therefore it is chosen to extend the second level to full usage, which creates 130 storage positions (without an increase in terminal area).

After this increase, the design is still flexible. In the future a third storage layer could be implemented without compromising the alternatives criteria accept for the investment costs. A third layer would increase the number of storage positions with 69 spots, allowing the design to cope with more than three times the estimated current BUP throughput.
10.2 Assessing Technological Designs

An overview of the criteria assessment of the manual and automated alternative is provided in table 22. The previously identified criteria are explained in chapter 8.1. Scores on criteria C3(Area), C4(Maximum throughput) and C5(Lead Time) are retrieved directly from the simulation results and the lay-out of the refined designs. The scores on criteria C1(AAS productivity), C2(FTF productivity) and C6(investment costs) require additional calculations.

A break-down of the alternative costs is presented in appendix K3. The (expected) FTF productivity is calculated by dividing the occupied terminal area (C3) by the expected throughput of 455.160 tons/year\(^{19}\). The AAS productivity is the result of calculations including the current occupied area for all first line handlers and their market share. A certain FTF throughput (with its associated productivity) relieves the handlers throughput based on their current market share\(^{20}\). This results in a new weighed AAS productivity which takes into account the handlers as well as the FTF throughput on the occupied terminal areas. The detailed calculations of the scores on the AAS and FTF productivity are presented in appendix K1&2.

Table 22: Assessment Refined Alternatives on Technological Criteria

<table>
<thead>
<tr>
<th>Technological Criteria</th>
<th>Unit</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Productivity AAS</td>
<td>[ton/year/m(^2)]</td>
<td>23.5</td>
<td>42.5</td>
</tr>
<tr>
<td>2015: 9.3 &amp; Future: 18.6</td>
<td></td>
<td>24.5</td>
<td>42.5</td>
</tr>
<tr>
<td>Req. Handler Productivity</td>
<td>[ton/year/m(^2)]</td>
<td>13.7</td>
<td>13.7</td>
</tr>
<tr>
<td>C2 Productivity FTF</td>
<td>[ton/year/m(^2)]</td>
<td>70</td>
<td>207</td>
</tr>
<tr>
<td>C3 Occupied Area</td>
<td>[m(^2)]</td>
<td>6460</td>
<td>2200</td>
</tr>
<tr>
<td>Occupied 1(^{st}) line width</td>
<td>[m]</td>
<td>68</td>
<td>22</td>
</tr>
<tr>
<td>C4 Max. Throughput FTF</td>
<td>[ton]</td>
<td>682.740</td>
<td>625.845</td>
</tr>
<tr>
<td>Min. throughput FTF</td>
<td>[ton]</td>
<td>240.000</td>
<td>80.000</td>
</tr>
<tr>
<td>C5 Lead Time FTF (Import)</td>
<td>[hour : min]</td>
<td>1:11</td>
<td>1:06</td>
</tr>
<tr>
<td>C6 Investment Costs FTF</td>
<td>[million €]</td>
<td>4</td>
<td>3.7</td>
</tr>
</tbody>
</table>

The terminal in the automated alternative occupies 2200 m\(^2\) and requires only 22 meters of 1\(^{st}\) line width while the manual alternative occupies a much larger area of 6460 m\(^2\) which results in a width of 68 meters. In comparison, the smallest 1\(^{st}\) line building which is currently situated at AAS has a width of 122 meters.

The FTF productivity for the automated alternative is extremely high and amounts to 207 ton/year/m\(^2\). If this alternative is implemented in the future, the total AAS productivity rises from 18.5 to 42.5 ton/year/m\(^2\). The FTF is responsible for a large part of this increase. The average required AAS handler productivity in this situation will be 13.7 ton/year/m\(^2\) which requires an increase in handler productivity of 4.3 ton/year/m\(^2\).

If the manual alternative is implemented in the future, the total AAS productivity rises from 18.5 to 23.5 ton/year/m\(^2\). The required average AAS handler productivity is similar to alternative 2 as these calculations are based on similar throughputs.

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\(^{19}\) This expected throughput is based on a total AAS throughput of 3 million tons

\(^{20}\) For this calculation it is assumed that the future handler market share is similar to 2015
The high costs for the manual alternative are caused by the terminal building which needs to cover the required area of 6460m$^2$. Most of the costs for automated alternative are caused by the ETV storage system which is equipped with 3 expensive elevating transfer vehicles and the high amount of multi-level storage racks.

### 10.3 Conclusion Refined FTF Designs

Implementing the automated alternative could contribute enormously to relieving the 1$^{st}$ line from overcapacity. There is great potential for an increase in the AAS productivity towards 42.5 ton/year/m$^2$ due to a very high FTF productivity. The manual alternative requires a large surface which causes a much lower AAS productivity 23.5 ton/year/m$^2$. The BUP lead time is almost similar for both alternatives and amounts to approximately 1 hour and 8 minutes.

The automated alternative scores best on all criteria accept for the maximum throughput. However, the maximum throughput of this alternative is limited by the amount of storage positions and the refined designs shows that there is room to increase the amount of storage positions without compromising the other criteria, accept for the costs. An extra storage level increases the costs of the automated alternative with 350.000 euro resulting in investment costs of 4 million euro’s which is then similar to the manual alternative. For these reasons, the automated alternative comes forwards as the most contributing design for Schiphol’s objectives.

**Requirement Check Refined Terminal Designs:** Both refined designs comply with the previously identified performance requirements as is shown in appendix D2.2. The equipment requirement regarding sufficient storage capacity is now satisfied.
VII INSTITUTIONAL PERSPECTIVE
The automated design alternative is proposed as the design configuration which contributes most to Schiphol’s goals. However, the main requirement for this contribution is the actual usage of the facility. Creating an institutional design which is acceptable and complies with critical actor requirements is the most important mean for Schiphol to stimulate this. Figure 34 shows where the institutional design targets the AAS transhipment system.

An acceptable institutional design increases the ‘acceptance of’ and ‘willingness to use’ the Fast-Track Facility. Higher fast-track utilization means increased fast-track volumes which increases the total AAS throughput. An increase in the throughput of AAS together with all other side-effects (figure 34) increase the main objective of Schiphol Cargo, productivity. The unique selling point of a Fast-Track Facility for the potential clients is the fast transhipment. An overall decreased transhipment time is an effect of the FTF which is integrated in the increased productivity.

Furthermore, interesting effects of the FTF for actors are the increase in the punctuality of the handling process and the increased amount of grip which clients have on the handling process of their cargo over the 1st line. These positive effects of the FTF increase the acceptance and willingness to use of the Fast-Track Facility which results in a positive loop. The institutional design can be seen as a kick-start for FTF throughput creation. Once the FTF is up and running, the effects of the FTF should function as its very own marketing tool.

In the first paragraph four applicable institutional variables are identified. Paragraph 11.2 till 11.5 argue the design options per variable and qualitatively assess the influence of the design options on the measure of FTF usability while taking into account the critical actors perspectives and requirements retrieved from chapter 5. In paragraph 11.6 it is concluded which combination of design options contributes to FTF usability most.
11.1 Institutional Design Variables

Van der Donk (2015) has identified six variables which have a critical influence on the functioning of a second line CPD at AAS (figure 35). These critical variables ought to influence multiple secondary variables, but are not influenced by changes in other variables themselves. This makes the critical variables non-correlating and allows combinations between the variable design options. Six variables have a critical influence on the functioning of a general Fast-Track Facility. However, variable 4, the proximity to AAS, is obviously at the 1st line and is therefore excluded from further investigation. Variable 3, the range of services offered inside the FTF, has been discussed in chapter 6 and is used as input for the technological design of the FTF. The design options for the four remaining variables are analysed and rated on the measure of increase in usability while meeting the critical actor requirements.

![Figure 35: 6 critical design variables for a 2nd line CPD (Donk, 2015)](image)

11.2 Design Options for the ownership of the FTF

Theoretically, several design options for the ownership of the FTF exist. Buildings could be owned by Ground Handlers, Forwarders, Schiphol real Estate or other Real estate companies. All 1st line warehouses except for KLM Cargo\(^{21}\) are owned and maintained by SRE (Schiphol Real Estate, 2015). The ground handlers rent the buildings from SRE. Therefore it seems logical that the ownership of a relatively ‘small’ first line facility is in SRE’s hands. From the handlers point of view, SRE is a neutral party, which does not conflict with their requirements. If SRE would own a Fast-Track Facility, the possibility for integrating this in the design of other facilities at AAS South-East in the future exist. This is under the condition that operations within this building do not mix. SRE owning the Fast-Track Facility would increase usability due to the neutral position of SRE. Other ownership options are either far-fetch or not according to competitive actor requirements.

\(^{21}\) KLM buildings are owned by KLM itself
11.3 Design options for the Operations within the FTF
The party performing operations inside the FTF does not necessarily have to be the responsible party. A distinction can therefore be made between the responsible and operating party. The design options for these configurations are interdependent.

The operating party refers to the company which performs physical handling. This party operates and maintains the rollerbed and storage system. The responsible party refers to the company which benefits from correct physical handing inside the fast-track terminal. The responsible party is therefore dependent on the actions of the operating party. Furthermore, this is the party which is responsible when a step within the handling process goes wrong.

11.3.1 Current Responsible and Operating Party 1st Line Facilities
Currently, two parties are responsible for 1st line cargo transhipment. The forwarders (or a contracted trucking company) and the handlers share the responsibility of handling processes between the aircraft stand and the 2nd line facility. The responsibility is ‘transferred’ when the truck is completely loaded with the correct truck load and the doors of the truck are fastened. At that point the forwarder (or trucker) is responsible for the shipment. The same two parties perform the physical operations of the 1st line cargo transhipment.

![Figure 36: Current Responsible and Operating Parties](image)

11.3.2 Options FTF Responsible and Operating Party
Operating and responsibility variations are desirable in the least possible process steps because every variation as opposed to the current system requires new agreements. Four variable FTF sections are identified which would cause the least confusion in current operations. The responsibilities for the cargo stay as much unchanged as possible. The variable sections are illustrated in figure 37.

![Figure 37: Variable Responsible and Operating Parties](image)
First Line FTF Operations
In order to comply with the critical actor requirements the operating function within the FTF must be executed by a neutral party. Since neither forwarders, nor handlers are neutral and Schiphol has no experience (nor is interested) in operating a warehouse, the only possibility for the FTF operations is to outsource these to a neutral 3rd party. Operations should be as easy as possible in order to minimize handling mistakes. An automated handling system is therefore required.

Because land and airside operations on the fast-track terrain are not the core function of a Fast-Track Facility and these do not influence the operations within the facility, these operations are most likely to be executed by the experienced party.

Operations performed by the same party which operates at airside and landside results in a possible unnecessary seclusion of the FTF airside and truck terrain. Eliminating a seclusion increases fast procedures, as there are no fence or ports which could create a bottleneck. Furthermore it provides a clear ‘responsibility transfer’ between the handlers at airside and the ‘forwarders’ at landside. Not including an airside terrain does require good functioning of the earlier mentioned ‘FTF software system’. The control border between landside and airside then moves to the wall of the Fast-Track Facility instead of between the airside terrain of the FTF and actual airside.

First Line FTF Responsibility
The final possible variation is the responsible party inside the Fast-Track terminal. Schiphol, a neutral party, the forwarders(jointly) or handlers(jointly) could be responsible. A joint responsibility refers to each forwarder or handler being responsible for its ‘own’ cargo which is transhipped through the FTF. Because a neutral party operated the FTF system, there has to be a contract between the responsible FTF party(s) and the neutral 3rd party.

3rd Party Responsible
A third party being responsible inside the FTF is useful because of the fact that this is the same party which is operating. However, a responsible and operating third party creates a gap in the supply chain between the forwarders and handlers. A gap requires the third party to collaborate and communicate with all forwarders as well as all handlers which utilize the FTF. Furthermore, if something happens to the cargo inside the facility, the third party has little knowledge about the actual sending or the treatment of the sending which again increases communication with both actor groups.
Schiphol Responsible

Schiphol being responsible for operations is a far-fetched option as Schiphol currently outsources everything except for the facilitation of terminal buildings and has no experience in cargo operations. However, Schiphol is a fair player when it comes to handling priority and equal treatment. Being responsible for operations requires extra manpower and knowledge. Furthermore, introducing Schiphol as the responsible party creates a similar gap between handlers and forwarders as a third party does.

Grounds Handlers Responsible for their own Cargo

As handlers are currently responsible for cargo which transships through their facilities, they know what this responsibility entails. Handlers being responsible for their own cargo is a possibility since in essence little changes. Furthermore, this option entails only seven extra contracts in total. However, it is imaginable that the handlers are not keen on being responsible for the operations inside the FTF and prefer to transfer responsibility at the airside wall. This option is only applicable when the model of costs and gains sharing is constructed, such that the handlers are not financially disadvantaged when they are not responsible. Handlers are currently having a financial hard time (FNV Luchtvaart, 2015). Furthermore if the handlers are disadvantaged financially, they would want to be responsible for FTF operations in order to earn back the disadvantage.

Forwarders responsible for their own Cargo

The current collaboration between Skylink and DB Schenker is an example of Forwarder responsibility. Skylink physically pushes DB Schenker’s import BUPs over the fast-track while DB Schenker is responsible from the moment the cargo enters the Skylink terminal at airside. This collaboration proves that forwarders are willing to be responsible for the cargo at an earlier stage in the chain and that this group is able to trust another party with their sendings. This design option provides the forwarder with more grip on the 1st line transhipment process which leads to a decrease in the transhipment time (Brujs, 2015). As the main selling point of forwarders is speed, a decrease offers opportunities for forwarders to increase air-freight pricing (Reynolds-Feighan, 2001). Any change in the process increasing this is therefore welcomed.

Based on the analysis and positive influence on the usage of the FTF, the proposed design option for FTF responsibility, is a situation in which the forwarder is responsible for its own cargo. This configuration is proposed, under certain required conditions, because this party seems to benefit most from being responsible. Because of the benefit, they will care and interest for the FTF functioning, which eventually is expected to create a positive influence on the Fast-Track Facility Usage.
### 11.3.3 Handling Priority

A design option in which SRE owns the terminal building, the third party operates and the forwarder is responsible for the FTF creates questions regarding the handling priority inside the FTF. The ideal situation would be that all cargo from different parties could be treated equally. However, in a multi-actor environment at Schiphol which includes large variations in handling volumes per company, there is bound to be urge for priority.

Ideally, the third party FTF operator is neutral and purely operates according to previously imposed requirements for handling. Schiphol is a party which could impose these requirements for handling priority. Other parties would have too much personal interests and Schiphol is already a player which proportions the goals and interests of all actor’s at Schiphol. They could make sure to practice the same standards in the FTF as they do at the rest of AAS. Certain examples of Handling Priority which Schiphol could impose are:

- Prioritize large throughput volumes: If you guarantee throughput volumes above a certain threshold, your cargo is prioritized over other shipments, which decreases transshipment time and increases the odds for punctuality.
- Priority treatment for the one party which delivers the largest volumes: This creates possibilities for including KLM business inside the FTF.
- Create price segmentation for priority treatment: If you pay may more, you’re cargo is prioritized. For this rule, additional discounts could be provided for parties which deliver large volumes.

In order to impose certain requirements, Schiphol has to outsource the operations towards the third party. A similar construction would be created as the baggage halls at Schiphol currently have. The only difference is that the responsibility for quality and treatment lies in the forwarders hands. The proposed design for operations and responsibility inside the FTF is presented in figure 39.
11.4 Design options for the Model of Costs and Gains Sharing

Taking into account the conclusions from the previous paragraphs, the financial design options for an FTF in which a neutral party transships import cargo for which the associated forwarder is responsible need to be opted. In order to present a plausible model which contributes to FTF usage the current cash flows are investigated before new cash flow options are provided.

Current Cash flows

The current cash flows and contracts between the critical actors for general 1st line transhipment are visualized in figure 40. Because the FTF is a small addition to the chain which only influences BUP handling most of the contracts and cash flows remain. The BUP cash flows are:

1. The Consignee pays the Shipper 5. The Airline pays the Handler
2. The Shipper pays the Forwarder 6. Forwarder pays incidental fees to Handler
3. The Forwarder pays the Airline 7. Handler pays rent to the Owner
4. The Forwarder pays the trucker

The relevant cash flows for the FTF are number 4, 5 and 6. BUP transhipment through an FTF bypasses the handlers facility. This means that payment number five will never occur. Instead the forwarder pays fees to the Neutral 3rd Party operating the FTF. Because of the requirement opted in paragraph 11.3 which states that the handler must not be disadvantaged financially, cash flow 4 should be maintained. The FTF rent is logically paid by the FTF operator to the owner. This means that FTF cash flows are configured as follows:

Figure 40: Visualization of relationships in the air cargo logistics chain (Donk, 2015)
1. The Consignee pays the Shipper  
2. The Airline pays the Handler  
3. The Shipper pays the Forwarder  
4. Forwarder pays fees to Neutral 3rd Party  
5. Neutral 3rd Party pays rent to the Owner

Because of the major changes in cash flows 5 and 6, the cash flows of the FTF operator and the forwarder are analysed in more detail.

**Cash Flows third Party FTF Operator**

The current business model of a 1st line handler is presented in figure 41. This overview presents the major expenses. The expense shares for a FTF differ from the current 1st line handlers. Especially the employee costs are expected to be much lower. The rental costs for first line operators at AAS is fixed. The rent rate per m² at first line is approximately 120 euros (SRE, Rent Prices, 2015).

In table 23 an estimation of the costs structure of the FTF operator is presented. The costs are calculated in appendix M and are partly based on the current business model of a 1st line handler. Despite the fact that the automated alternative has been presented as the most contributing alternative from the technological perspective, it is interesting to see what the influence of both design configurations on the institutional design is. Therefore cost and gain calculations are made for both alternatives.

![Figure 41: Costs Break-Down Current Handlers (Schiphol Real Estate, 2014)](image)

<table>
<thead>
<tr>
<th>Costs Structure FTF operator</th>
<th>Unit</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximation Rental Costs FTF</td>
<td>[€/year]</td>
<td>775.200</td>
<td>264.000</td>
</tr>
<tr>
<td>Approximation Employee Costs FTF</td>
<td>[€/year]</td>
<td>332.500</td>
<td>165.000</td>
</tr>
<tr>
<td>Approximation Operating Costs FTF</td>
<td>[€/year]</td>
<td>775.200</td>
<td>264.000</td>
</tr>
<tr>
<td>Total Costs Approximation</td>
<td>[€/year]</td>
<td>1.882.900</td>
<td>693.000</td>
</tr>
</tbody>
</table>

The costs and gains for the FTF operator (table 24) show that for the current estimations, the automated alternative enables the cheapest services. Including a 5% profit margin, which is slightly higher than 1st line handlers currently have, the cost price for transhipment of an import pallet through the FTF is approximately 5 euro’s.

![Table 24: Costs and Gains FTF Operator](image)

<table>
<thead>
<tr>
<th>Costs and Gains FTF operator</th>
<th>Unit</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Costs Approximation</td>
<td>[€/year]</td>
<td>1.882.900</td>
<td>693.000</td>
</tr>
<tr>
<td>Estimated Future FTF throughput</td>
<td>[pallet/year]</td>
<td>147.444</td>
<td>147.444</td>
</tr>
<tr>
<td>FTF operator costs/pallet</td>
<td>€</td>
<td>12.77</td>
<td>4.70</td>
</tr>
<tr>
<td>FTF Price per pallet</td>
<td>€</td>
<td>13.44</td>
<td>4.95</td>
</tr>
<tr>
<td>FTF operator profit/pallet (5% margin)</td>
<td>€</td>
<td>0.67</td>
<td>0.25</td>
</tr>
</tbody>
</table>
**Cash Flows Forwarder**

The forwarder’s cash flows depend on the contract they have with the FTF operator. There are two basic options for these contracts. They can be based on either a certain time period or on the throughput volumes. Furthermore the contracts can include storage payments or not. A pay per use option is preferred by forwarders (Brink, 2015) (Brujs, 2015). This means that a certain amount is paid per pallet which is transshipped through the FTF.

In order to be and stay a fast-track, storage costs should be included in order to stimulate pick-up within the Truck Notice Time window. These storage costs can be similar to the current incidental storage costs at the handlers but with a shorter free period. When an import BUP is stored at the handler longer than 18 hours, the forwarders pays a fee. The storage charges differ per handler, but are approximately 10 cents/kg/day for perishables and 6 cents/kg/day for normal cargo (appendix M). For one average sized BUP with 3000 kilos (appendix F3) this amounts to respectively 300 and 240 euros per hour. As these storage costs are not necessary anymore, this is one of the gains for the forwarder.

The simulated Truck Notice Time actually represents the maximum storage time. Trucks are imposed to pick up their sendings within 2.5 hours in order for the system to run according to the results of the simulation and the simulation based designs. It is assumed however, that due to the Milkrun system, trucks will never be later than 2.5 hours and storage costs at the FTF will only occur in exceptional situations.

**Costs and Gains Forwarder**

The total costs and gains for the forwarder FTF transhipments are presented below.

<table>
<thead>
<tr>
<th>Costs and Gains Forwarder</th>
<th>Unit</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs per Pallet FTF</td>
<td>€</td>
<td>13.44</td>
<td>4.95</td>
</tr>
<tr>
<td>Storage Gains: No storage costs at handler</td>
<td>Should transcend the costs per pallet through the FTF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Gains: Faster lead time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck gains: Less Truck Movements</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The forwarder gains from the FTF in several ways. The import storage costs at the handler disappear, less truck movements are required and the forwarder could offer faster lead times which could lead to an increase transhipment prices for its clients. These gains should transcend the costs per pallet through the FTF in order for the forwarders to gain from using the facility.
11.5 Design Options for the Level of Obligation or Stimulus

There are several design options for the level of stimulus and obligation from Schiphol. Each of these design options should stimulate FTF usage. For this category it is important to argue which options are feasible from a Schiphol point of view.

Obligations are in contrast with the free handler market which has been stimulated over the past few years (Ritsema, 2015). Therefore solely measures of stimulus are looked into. Several sorts of stimulating incentives exist. Schiphol could invest in multiple ways, arrange discount, take responsibility for operation or subsidize certain activities.

Investing in the building and or the equipment

An investment in the FTF building would stimulate usage of the FTF extremely. As SRE would be owner, an investment in the building would make sense. Investing in the equipment would definitely lower the entrance barrier for the FTF. The following investment costs (table 27) are necessary for the designed alternatives.

<table>
<thead>
<tr>
<th>Costs Approximation</th>
<th>Unit</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal Building</td>
<td>[million €]</td>
<td>3.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Equipment</td>
<td>[million €]</td>
<td>0.5 (+0.3 for storage extension)</td>
<td>2.5</td>
</tr>
<tr>
<td>Total</td>
<td>[million €]</td>
<td>4.0</td>
<td>3.7 (4.0)</td>
</tr>
</tbody>
</table>

Operation: Schiphol hires the FTF Operator

Schiphol could outsource operations and maintenance to the 3rd party, which actually means that Schiphol hires them. This is the construction which is currently used for the passenger baggage handling system at Schiphol. This has never happened for cargo operations, but it might be necessary in order to impose requirements on the handling priority.

Schiphol arranges a discount on rental prices.

According to Osinga (2009) a discount on rental prices emits the wrong signal the role of the airport is to aggressively recruit new customers. All parties at Schiphol benefit from a customer based approach (Osinga, 2009).

Schiphol subsidizes the FTF operator in the start-up phase

With a subsidy in the start-up phase of the FTF, the 3rd party could offer lower transhipment prices. Once the added value of the FTF processes are visible and the forwarders notice that they gain from FTF usage the subsidy could phase out. This subsidy is useful to bridge the period between start-up and results as there is a certain lead time (figure 34) between changing the ‘target factors’ of the causal relation diagram and feeling the return of the FTF.
A subsidy during the start-up phase of the FTF which is integrated in the pallet transhipment price stimulates initial usage. Schiphol could subsidize a certain amount of euros per transshipped pallet in order to create lower prices. Table 27 shows that, when the minimum FTF operates with minimum throughput\(^{22}\), the price which the operator should ask for one pallet increase to 11 euros in order to cover costs. If Schiphol subsidizes approximately 6 euro per pallet\(^ {23} \), taking into account minimum throughput, the subsidy costs amount to 200.000 euro per year. This subsidy can be phased out once the FTF advantages are insightful for the forwarders and the expected throughput is reached.

**Table 27: Costs and Gains FTF Operator Minimum Throughput**

<table>
<thead>
<tr>
<th>Costs and Gains FTF operator</th>
<th>Unit</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Costs Approximation</td>
<td>[€/year]</td>
<td>1.882.900</td>
<td>693.000</td>
</tr>
<tr>
<td>Minimum FTF Throughput</td>
<td>[pallet/year]</td>
<td>200.000</td>
<td>66.666</td>
</tr>
<tr>
<td>FTF Price per pallet (minimum throughput)</td>
<td>€</td>
<td>9.90</td>
<td>10.94</td>
</tr>
<tr>
<td>FTF Price per pallet (expected throughput)</td>
<td>€</td>
<td>13.44</td>
<td>4.95</td>
</tr>
<tr>
<td>Subsidy per pallet</td>
<td>€</td>
<td>3.54</td>
<td>6.01</td>
</tr>
</tbody>
</table>

**Proposed measures of Stimulant**

It is proposed to invest in the FTF building and equipment. Compared to the costs for moving of all cargo buildings to South-East and the building of the new A-pier, a FTF is a relatively small investment. The estimated costs of the A-pier amount to approximately half a billion euros (ANP, 2014) and the terminal costs are approximately 4 million. Furthermore, an initial subsidy for the FTF operator in the start-up phase is proposed which would increase usage to a point where the FTF feels its own benefits. The initial subsidy for the pallet price through the FTF is to be phased out.

**11.6 Conclusion Institutional Design**

The actor configuration of the FTF is visualized in figure 42. The suggested FTF actor configuration is plausible under the three conditions which are stated.

---

\(^{22}\) Minimum throughput refers to the amount of throughput necessary to ensure that total AAS productivity is at least similar or increased for a certain configuration.

\(^{23}\) which is the difference between the price with minimum and expected throughput,
Owner: Schiphol Real Estate
SRE owning the Fast-Track Facility would increase usability due to the neutral position of SRE. Other ownership options are either far-fetched or not according to competitive actor requirements.

Operator: Neutral 3rd party
The two options for an operating party which meets actor’s requirements is either an operating neutral third party or Schiphol itself. As Schiphol has no experience in this field the better option is to outsource FTF operations.

Responsible: Forwarders Jointly
A joint forwarders responsibility means that the forwarders are responsible for their own import sendings which are transhipped through the FTF. The forwarder seems to benefit most from being responsible which is expected to stimulate FTF usage.

Handling Priority Requirements: Schiphol
Schiphol as owner of the terminal building and the party which outsources operations to the third party, should impose handling priority requirements on the 3rd party.

FTF Cash Flows: Pay per Use
The most important changes in the cash flows are presented in table 29. Two cash flow steps are altered when a FTF is implemented.

<table>
<thead>
<tr>
<th>Current Cash Flows</th>
<th>FTF Cash Flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forwarder pays incidental fees to Handler</td>
<td>Forwarder pays fees to Neutral 3rd Party</td>
</tr>
<tr>
<td>Handler pays rent to SRE</td>
<td>Neutral 3rd Party pays rent to SRE</td>
</tr>
</tbody>
</table>

These cash flows result in an adjusted model of costs and gains for the 3rd party FTF operator and the forwarder. The most important conclusion is that the forwarder bares the difference between the costs and the gains of the FTF system. The gains in the form of ‘no storage costs’, ‘less truck movements’ and a ‘lower lead time’ should transcend the costs per pallet through the FTF (table 26). If forwarders pay 5 euros per transhipped pallet in the automated design configuration, the FTF operator has a 5% profit margin.

Stimulant: Initial Building Investment and Price Subsidy during FTF Start-up Period
It is proposed to invest in the Fast-track terminal building as well as subsidizing the FTF operator in the start-up phase such that the price per pallet is similar to the price which can be asked when FTF expected throughput is reached.
12 Conclusion, Recommendations & Discussion

The goal of this analysis is to provide an answer to the main research question:

‘What is the Design Space for a 1st line cargo Fast-Track Facility at AAS South-East, which increases AAS 1st line Productivity and allows itself to be Integrated in the Multi-Actor Cargo Supply Chain at Schiphol?’

In paragraph 12.1 the conclusion of this research is provided by means of answering all sub-questions. In paragraph 12.2 various recommendations for the Schiphol cargo department are listed concerning on the one hand specifically the Fast-Track Facility strategy and on the other hand general recommendations. Paragraph 12.3 discusses the research assumptions and the Fast-Track as a logistic concept.

12.1 Conclusion Research

The sub-questions which have been formulated in paragraph 2.4 and tackled in chapter 4 till 11 are answered in this paragraph. Each sub-question contributes to answering the main research question.

SQ1. What are the characteristics of the current BUP transhipment system?

The current BUP transhipment system is characterized by individualism. Several handlers operate fast-tracks in their own facilities which are not used very intensively. The most important characteristics of the current BUP transhipment system at AAS are presented in table 29 below.

<table>
<thead>
<tr>
<th>Characteristics Current BUP System AAS</th>
<th>AAS Current Situation</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available 1st Line Area AAS</td>
<td>210.000</td>
<td>m²</td>
</tr>
<tr>
<td>Occupied 1st Line Area Handlers</td>
<td>205.000</td>
<td>m²</td>
</tr>
<tr>
<td>Occupied 1st line width</td>
<td>2020</td>
<td>m</td>
</tr>
<tr>
<td>Productivity AAS (weighed)</td>
<td>9.3</td>
<td>ton/year/m²</td>
</tr>
<tr>
<td>Total AAS Throughput</td>
<td>1.6</td>
<td>million ton/year</td>
</tr>
<tr>
<td>Total BUP Throughput</td>
<td>293.600</td>
<td>ton/year</td>
</tr>
<tr>
<td>Of which Export BUP</td>
<td>20.100</td>
<td>#/year</td>
</tr>
<tr>
<td>Of which Import BUP</td>
<td>73.750</td>
<td>#/year</td>
</tr>
<tr>
<td>Min. BUP Lead Time (Import)</td>
<td>3</td>
<td>hour/BUP</td>
</tr>
</tbody>
</table>

The BUP volumes are based on the experts estimations which state that currently 35% of the import and 15% of the export cargo is transhipped over AAS as a BUP unit. The BUP lead time refers to the minimum time in which handlers currently guarantee to make the import cargo available at the truck docks.
SQ2. What are the trivial requirements for the FTF design?

The design of the Fast-Track Facility is based on the logistic cross-dock concept (Boysen & Fliedner, 2010). Because this concept requires seamless transhipment, which cannot be guaranteed for plane to truck transhipment, a storage buffer is required. Furthermore, due to the large perishable BUP volumes, a cooled storage facility should be included in the FTF. The trivial privacy handling requirement set by handlers and forwarders results in the exclusion of the export transhipment function from further research.

Automated storage equipment, a rollerbed system and docks are necessary for FTF functioning. The physical boundary conditions for the design are imposed by the area and height restrictions of AAS. The FTF can have a maximum width of 650 meters wide, be 150 meter deep and 21 meters high. In order to approximate a cross-dock situation, a seamless flow without queues and bottleneck is required. Besides the storage buffer which contributes to this goal, the truck system, which is responsible for FTF output is required to function in a Milkrun configuration (appendix E3). A second important process requirement is the necessary split between BUPs and ULDs before the cargo enters the facility at airside, this can either be done at the aircraft stand or at the handler's facility.

A technological design which in terms of capacity is able to contribute to the goals of Schiphol, needs to be used in order to actually deliver the possible contribution. An acceptable institutional design is required which stimulates FTF usage. An full list of requirements is provided in appendix D.

SQ3. What is the technological design space for the FTF?

The terminal design options of the Fast-Track Facility are not very wide. The most important variables are the storage system, the amount of truck and airside docks and the number of storage positions. The terminal building needs to comply with the boundary conditions. Two designs are created which are designed from opposite starting points: a design with a focus on manual labour which uses ground floor storage and Slave Pallet Movers and an automated design which places pallets in the automated multi-level storage system with elevating transfer vehicles.

SQ4. What is the influence of the technological alternatives on the BUP transhipment system?

Compared to the current BUP transhipment system (table 30), both interpretations of the design space contribute to AAS productivity and provide a decreased lead time. Both alternatives are able to handle at least 2.75 times the current estimated BUP throughput.

It can be concluded that both interpretations of the FTF technological design space contribute to Schiphol’s goals. However, the automated alternative has a much higher contribution due to the compact lay-out which is a result of the integrated multi-level automated storage system. This alternative is therefore suggested as a preferable technological design alternative.
Table 30: Assessment Refined Alternatives on Technological Criteria compared with the Current System

<table>
<thead>
<tr>
<th>Technological Criteria</th>
<th>Unit</th>
<th>Current System</th>
<th>Alternative 1: Manual</th>
<th>Alternative 2: Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Productivity AAS</td>
<td>[ton/year/m²]</td>
<td>9.3</td>
<td>23.5</td>
<td>42.5</td>
</tr>
<tr>
<td>C2 Productivity FTF</td>
<td>[ton/year/m²]</td>
<td>-</td>
<td>70</td>
<td>207</td>
</tr>
<tr>
<td>C3 Occupied Area</td>
<td>[m²]</td>
<td>-</td>
<td>6460</td>
<td>2200</td>
</tr>
<tr>
<td>C4 Max. Throughput FTF</td>
<td>[ton]</td>
<td>-</td>
<td>682.740</td>
<td>625.845</td>
</tr>
<tr>
<td>C5 Lead Time FTF (Import)</td>
<td>[hour : min]</td>
<td>2.5**</td>
<td>1.11</td>
<td>1.09</td>
</tr>
<tr>
<td>C6 Investment Costs FTF</td>
<td>[million €]</td>
<td>-</td>
<td>4</td>
<td>3.7</td>
</tr>
</tbody>
</table>

SQ5. What is the suggested configuration for an institutional FTF design?

As the main requirement for FTF success is actual usage, an institutional design configuration is proposed which stimulates this. Design options for four variables are presented and qualitatively assessed on the measure of usage stimulation. The proposed configuration for the institutional design of the Fast-Track Facility is presented in table 31.

Table 31: Overview Suggested Institutional Design

<table>
<thead>
<tr>
<th>Variables</th>
<th>Institutional Design Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>Schiphol Real Estate</td>
</tr>
<tr>
<td>Operator Responsible</td>
<td>Neutral 3rd Party</td>
</tr>
<tr>
<td></td>
<td>Forwards</td>
</tr>
<tr>
<td></td>
<td>Schiphol: Impose Handling Priority Requirements</td>
</tr>
<tr>
<td>Costs and Gains</td>
<td>Forwarder pays FTF operator per Use</td>
</tr>
<tr>
<td></td>
<td>No change in other cash flows</td>
</tr>
<tr>
<td></td>
<td>Forwarder gains from: Decrease in Truck Movements &amp; Lead Time</td>
</tr>
<tr>
<td>Schiphol Stimulus</td>
<td>Initial investment terminal building and equipment</td>
</tr>
<tr>
<td></td>
<td>Initial Price Subsidy per Pallet</td>
</tr>
</tbody>
</table>

This institutional configuration does not financially disadvantage the handlers. The financial burden is for the forwarders which pay the handlers as well as the transhipment fee for the FTF. However, if the forwarders gains in the form of: truck movement decrease, faster lead times and less storage costs transcend the costs per pallet, which for the suggested design alternative is 5 euros, the configuration is acceptable for all critical actor’s.

SQ6. What is the added value of the suggested integrated design alternative for AAS?

The added value of the suggested integrated design is two-fold. On the one hand, the FTF contributes to the facilitation of cargo volumes by an increase in the AAS productivity while on the other hand the FTF contributes to the creation of volumes by increasing the attractiveness of Schiphol as a cargo market place.

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24 In order to compare with the FTF lead time, approximately 30 minutes of airside transport is subtracted from the 3 hours.

25 Integrating the automated technological design with the suggested institutional configuration
Productivity

Four future scenarios are described in order to present a solid image of the added value of the automated FTF automated design combined with the suggested institutional configuration.

Table 32: Assessment Refined Alternatives on Technological Criteria

<table>
<thead>
<tr>
<th>Scenario 0</th>
<th>Scenario 1: Minimum</th>
<th>Scenario 2: Expected</th>
<th>Scenario 3: Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>If</td>
<td>Nothing changes and the FTF is not operational in the future.</td>
<td>The automated FTF configuration is operational with minimum future throughput.</td>
<td>The automated FTF configuration is operational with expected future throughput.</td>
</tr>
</tbody>
</table>
| And        | -The AAS throughput demand has indeed grown to 3 million tons per year  
- The handlers market share is similar to 2015 | - 80,000 tons/year is handled in the FTF  
- The AAS throughput demand has grown to 3 million tons per year  
- The handlers market share is similar to 2015 | - 455,160 tons/year is handled in the FTF  
- The AAS throughput demand has grown to 3 million tons per year  
- The handlers market share is similar to 2015 | - 625,845 tons/year is handled in the FTF  
- The AAS throughput demand has grown to 3 million tons per year  
- The handlers market share is similar to 2015 |
| Then       | The handlers need to increase their average productivity with 9.23 ton/year/m² in order for AAS to cope with the growth. | The handlers need to increase their average productivity with 4.34 ton/year/m² in order for AAS to cope with the growth. | The handlers need to increase their average productivity with 4.45 ton/year/m² in order for AAS to cope with the growth. | The handlers need to increase their average productivity with 2.84 ton/year/m² in order for AAS to cope with the growth. |
| AAS Costs  | 0 | 3.7 million investment  
0.5 million subsidy | 3.7 million investment  
0.5 million subsidy | 4 million investment  
0.5 million subsidy |

Introducing a FTF according to the proposed configuration highly contributes to Schiphol’s objectives. An FTF with a high throughput could increase the AAS productivity to a point where the current handlers only need to increase their productivity with 2.84 ton/year/m². This means that the FTF contributes highly, but cannot solve the entire problem of the expected increase in cargo volumes on the restricted AAS south-east area.

AAS Cargo Marketplace

Besides the practical productivity contribution, which helps Schiphol to facilitate growing cargo volumes, the FTF also directly attracts volumes in the future. The unique FTF concept in combination with a solid Milkrun system provides an average import BUP lead time under 1 hour and 10 minutes and ensures a lead time under 2.5 hours. This initiative stimulates data-sharing and collaboration between the chain’s actors. A step towards vertical chain integration is made, by offering the forwarders the chance to gain responsibility over their own sending in an earlier stage (the moment the cargo enters first line). The fast transhipment possibilities might attract new business to Schiphol and therefore new volumes. Because of the ‘pay per use’ concept and the initial investment of Schiphol, the FTF is also attractive for smaller parties.
SQ7. What is the robustness of the suggested integrated design alternative?

A robust design is one that is able to tolerate a variability of the input parameters without the output being affected (Paixao & Marlow, 2003). This research is based on several fundamental assumptions. Taking into account the time window and the strategic approach is interesting to argue the robustness of the design for changes in these fundamental assumptions.

**BUP Shares & Expected growth**

The BUP volumes used in this research is an approximation of the truth based on expert estimations of the BUP shares. Furthermore, the expected cargo volumes BUP Volumes are based on interpolations of previous cargo data. The BUP shares and AAS throughput volumes lie at the basis of this research and are influential for changes in the future. Economical, humane and geographical external factors such could cause severe fluctuations in the estimated BUP shares and AAS throughput volumes. The robustness of the FTF suggested design for these potential fluctuation is presented in graph 1.

**Graph 1: FTF Throughput Scenario's**

It is clear that the boundaries of the suggested design allow severe changes in the uncertain factors. If the total throughput is 3 million tons per year at AAS the FTF is maximally able to cope with a BUP share of 60% for the suggested automated design configuration and 65% for the extended suggested design.
**Milkrun**

The FTF design is sensitive for the existence of the Milkrun truck configuration. The FTF output is dependent on the truck movements. A more punctual continuous output contributes to the cross-dock concept approximation of the FTF. If the Milkrun is not up and running by the time the FTF is developed, it can be expected that the FTF buffer needs to be increased severely. It has a great effect on the transhipment process inside the FTF because instead of loading a BUP in the first possible truck position, the BUPs are all allocated to one specific truck. A buffer platform might be required in the FTF design which allows BUP order shuffles and more truck docks and storage positions are required. This has a negative influence on the BUP lead time and the truck load factor. The secondary result is that the added value of as well the productivity (larger area required & lower volumes) as the attractiveness of the marketplace (higher lead times & concept less unique) decrease. The results in the conclusion that a successful FTF requires a stable Milkrun configuration.

**Actor Environment**

It is assumed for this research that the actor environment at Schiphol is not changing. Over the long-term this might be an unrealistic assumption. The influence of changes for primarily the amount of handlers which are situated at AAS is influential on outcome of this research. If in the future export volumes rise and the handler and forwarder privacy requirements are dismissed or not leading, the possibility for export transhipment could become interesting. Appendix I and L argue the requirements and suggest various design configurations for FTF export transhipment. These designs include dimension and weight scanners and rebuilding stations. Furthermore, extra manpower is required for checking the export cargo and potential rebuilding.

**Main Research Question:** ‘What is the Design Space for a 1st line cargo Fast-Track Facility at AAS South-East, which increases AAS 1st line Productivity and allows itself to be Integrated in the Multi-Actor Cargo Supply Chain at Schiphol?’

A FTF which allows itself to be integrated in the AAS cargo chain guarantees private handling and is therefore not able to tranship export BUPs. Thus, the facility transships solely import BUPs and is operated by a neutral 3rd party. Airport authorities own the FTF and impose handling priority requirements on a third party operator. Furthermore, the investment costs for the facility and potential prices subsidy for pallet transhipment costs are taken on by the airport authorities.

A Fast-Track Facility which contributes to AAS productivity requires the width and throughput combinations to be in the positive area of graph 2. The graph shows that if expected BUP volumes are transhipped through the FTF, the productivity results are far beyond minimum. An AAS specific Fast-Track Facility should offer an automated storage system besides the conveyer system which functions as a buffer. The output on the landside of the Fast-Track Facility should be as fast as possible, preferably arranged with a Milkrun. In order to reach the average lead time of 1 hour and 6 minutes a Truck Notice Time of 2.5 hours should be imposed on the trucks. For a combination of the suggested FTF configuration with a Milkrun system an increase of 100 pallets per day requires an approximate increase of 15 storage positions.
11.2 Recommendations for Schiphol Cargo

Recommendations for Schiphol are divided in three categories. The recommendations concerning the development of the FTF, recommendations for FTF research improvement and recommendations for further research and current project stimulant.

11.2.1 Development of the Fast-Track Facility

The implementation of a Fast-Track Facility is highly recommended to Schiphol. The main requirement for Fast-Track Facility implementation is the availability of a matured Milkrun project. The forwarders which tranship their cargo through the fast-track should be able to join in on the Milkrun project. The contribution to the productivity of Schiphol is dependent on the usage but has great potential for contribution.

11.2.2 Recommendations for FTF Research Improvement

Data Creation and Sharing

It is highly recommended to retrieve more detailed shipment data. The current commodity specific data retrieved from customs sources is only an approximation of the truth as this data does not take the road feeder network into account.

1. Information on the content of the ULD is helpful for cargo commodity analysis. Knowledge on the amount of ton/commodity which is transhipped at AAS could influence cargo strategies such as the attraction of new companies and processes.

2. Especially for the Fast-Track Facility is would be necessary to know which ULD is a BUP. This information is needed in order to split the import shipment before entering the facilities. Furthermore, this information is useful for data analysis on BUP trends. With this data the expected BUP volumes could be predicted.

In the future Schiphol could stimulate neutral parties like Cargonaut or ACN to setup a plan for data retrieval. Real, specific data helps to gain more insight in the cargo processes at AAS and to strategically make decisions about new investments, market segments and parties to attract in order to stay Europe’s preferred cargo airport.
Furthermore, a seamless FTF chain requires a software ‘platform’ which is compatible with the Milkrun software. Data sharing is necessary in order to acquire BUP, plane load data and truck data. It is also required to stimulate handlers to share their data on shipments in this platform. This is necessary to be able to identify a ULD as a BUP at airside and categorize the BUP as ‘perishable’.

**Client Treatment Procedures**

Further investigation or brainstorming at the Cargo department is required for the client (priority) treatment procedures in the FTF. There are multiple manners in which the several clients can be treated when it comes to precedence for BUP transhipment. A price or volumes segmentation could be made which results in priority handling. These procedures have to be though-through in order to prevent jealousy under the FTF clients. The procedures are however necessary to be able to segment between clients which deliver greater volumes then others.

**Investigate Forwarder Gains**

In the proposed design for the FTF, the costs land on the shoulders of the forwarders. It is clear that forwarders are able to recoup the FTF usage costs. DB Schenker has proved that using a fast-track, while paying the handler the exact same amount as before, is profitable due to cost reductions. A shorter lead time opens the door for higher forwarder pricing. However if all forwarders use the FTF, the forwarders won’t stand out. The amount of truck movements can be decreased and the storage costs at handlers are decreased. It is recommended to quantitatively investigate the gains for the forwarders in order to be able to persuade these actors to use the FTF. These are the critical actors for a succeeding project.

**Investigate the airside Movements**

The airside processes for the FTF could be performed in two ways as described in chapter 7. It is interesting to investigate what time the splitting of the BUPs from the ULDs at the aircraft stand takes, in order to see whether this is possible. If this is not possible, the split happens at the responsible handler facility. Furthermore, it is not clear what the extra costs for the handler is when this party performs and ‘extra’ airside ride. In order to minimize the negative attitude of the handlers towards an FTF, it is wise to qualitatively investigate this and then re-evaluate the proposed process designs.

**Investigate need for secluded air and landside terrains**

The suggested design in this research does not require a secluded airside and truck terrain. However, further investigation needs to be conducted in order to find out whether the removal of truck and airside terrains is a feasible option. There might be custom requirements or additional personal checks necessary for which a bundled stream through a port or fence is necessary.
11.2.3 Recommendations for simultaneous Stimulant

Stimulate the Milkrun Project
The challenge for the FTF concept is at the output side. The arrangement of the truck procedures are of a trivial influence for the functioning of the FTF. This is why Schiphol should stimulate and steer the current Milkrun project trials towards a generally used and collectively accepted way of road transport at AAS.

Stimulate Handler Warehouse Efficiency
Conclusions have pointed out that an FTF can highly contribute to AAS productivity increase in the future. However, it has also shown an FTF cannot solve the entire problem of the expected increase in cargo volumes on the restricted AAS south-east area. The results of this research show that when the FTF is used to its full capacity or when all ‘expected’ BUPs are transshipped through the FTF, still the handler productivity is required to increase with approximately 3 ton/year/m². This means that Schiphol should maintain efficiency stimulation at handlers and perform research on the possibilities for efficient warehouse lay-out and configurations. Handling and warehouse efficiency should be stimulated alongside FTF development and Milkrun stimulation.

11.3 Research Discussion
The research discussion is divided in two parts. First, the assumptions which are made in the research are discussed and secondly the fast-track concept is placed in a larger context and the applicability for the concept in other network nodes or airports is argued.

11.3.1 Research Assumptions

BUP Volume Calculations
As earlier mentioned the input data for the simulation is based on several assumptions (chapter 9.1.5 and Appendix J). Although a sensitivity analysis (appendix J3&4) is performed with this input, it is still questionable whether the amount of BUPs which are calculated to be currently transhipped at AAS is correct. The assumptions for the average volume, weight & the load factor of a ULD combined with the expert estimations on BUP percentages create an unstable data analysis. Unstable data is the reason for recommendations on future BUP and commodity data retrieval.

Secondly, in this research it is assumed that the market and BUP shares do not change in the future. This would mean that if AAS throughput doubles, that the amount of BUPs also doubles. These assumptions not a certainty. Various players could enter or leave the market and various external factors could influence the share BUPs relative to total cargo volumes. One potential external factor is the modality shift of perishables from air to sea transport. Another possibility would be that only integrators will flourish in the future and the handler and forwarder business goes extinct. Furthermore, the amount of full freighters verses belly cargo (fleet configuration) is changing which could affect the average ULD volumes and shapes and the BUP network.
Milkrun in Simulation

The presence of the Milkrun is assumed during the simulation in chapter 9. It has come forward that the FTF performance is highly dependent on the truck processes. If the continuous output is not guaranteed, the amount of storage positions required in the FTF is much higher than the output of the simulation study as described in paragraph 9.5. It is therefore highly recommended in paragraph 11.2.2 to stimulate the Milkrun Project and make sure that this is a mature concept at AAS before FTF development is commences.

11.3.2 The Fast-Track Concept

FTF Concept in Larger Logistic Context

The simple principle behind the fast-track concept is: do more with less. For cargo operations at specifically at AAS this means: provide more and faster transhipment on a small area with less facilities. A FTF concept can be seen as an opportunity to reach this principle. The goal of ‘doing more with less’ lies at the basis of several logistic concepts.

Cross docking (van Belle, Valckenaers, & Catrysse, 2012), which is primarily used for de-consolidation purposes in truck transhipment, can be seen as the ultimate goal of the FTF concept. From the performed research it is stated that the aim to approximate the cross-dock concept is primarily dependent on the output. The FTF requires a matured Milkrun system which is based on horizontal collaboration between truck and forwarding companies (Akersmit, 2013). The aim towards the decrease of storage positions and storage time combined with the stimulation of horizontal collaboration contributes to general logistic issues such as traffic bottlenecks (Kuipers & Verkade, 1992) and long lead times.

‘The benefits of cross-docking are well aligned with the goals of lean and agile supply chain management’ (Cook, Gibson, & MacCurdy, 2005) It could therefore be stated that the FTF concept aims at the increase of the airports’ agility and lean approach. It contributes to the most important characteristic of the cargo supply chain: speed. Furthermore, the design of the FTF concept as suggested in this research in combination with horizontal collaboration and vertical chain integration aims at the creation of a cross-dock situation at an airport.

FTF Concept Applicability for Port Design

As ports are besides airports the main nodes for intermodal transhipment, it is interesting to argue whether the FTF concept is applicable. The primary function of a port is transhipment (Notteboom, 2002). Ports usually do not focus on (de)consolidation purposes, which actually makes the entire port logistics similar to the FTF concept. The goals for port logistics align with the goals of the FTF concept. ‘From the logistics point of view, ports are systems along the supply chain which have to respond to pull logistics; their action will contribute towards the reduction of inventory levels along the logistics pipeline, a fall in associated costs, and the fulfilment of tighter customers’ requirements through high service levels within shorter lead-times’ (Ainsworth, 1992).
The past few years ports have aimed to adopt agility as a logistic approach in order to cope with uncertain cargo growth patterns. The goal of this adoption is to develop seamless transport systems (Paixao & Marlow, 2003). The development of agility in port design processes imposes 5 main design attributes: 1. Flow, 2. Flexibility, 3. Short cycle times, 4. Short lead times and 5. Superior service performance (Paixao & Marlow, 2003). The FTF concept aligns with especially the 1st, 4th and 5th design attribute for innovative port design. Therefore, the performance and design of the FTF concept should definitely be investigated for ports.

The performance of this concept for other modalities requires investigation as the characteristics of the modalities and the transport units differ. The technological fast-track concept needs to be of a larger scale in order to house complete containers. Anyhow, the FTF is primarily a concept for transshipment node lay-out design of which success is dependent on another challenge: the creation of flawless node in and output. The FTF concept definitely serves as an example for similar multi-modal transhipment nodes but research is needed to investigate the possibility of continuous in and output at ports and stimulation of these processes by port authorities.

**Applicability FTF Concept for Competitive Airports**

From the research three main requirements for Fast-Track applicability come forward:

- Large BUP Volumes
- Actor Environment which allows a FTF Concept
- Continuous Fast-Track Output

The main cargo competitors of AAS in Europe are Frankfurt, Paris Charles de Gaulle and London Heathrow. These airports transship higher (or similar) total cargo volumes, which amount to respectively 2.1, 1.9, and 1.6 million tons (Airports Council International, 2015). Another competitive airport is Brussels, because of the proximity to AAS. However, Brussels only transships less than half a million tons of cargo per year which reduces the need for an FTF concept. If Brussels would have the same growth perspectives as AAS, the cargo handling area of 95.000 m² (Brussels Airport, 2015) would still be enough in the future.

Frankfurt airport, better known as Fraport, is the only airport which is served by one neutral service provider: Fraport Cargo Services (Fraport, 2015). The actor environment and the cargo volumes therefore meet the requirements for applicability of the FTF concept. Fraport Cargo Services currently offers a guaranteed lead time of 4 hours for import cargo (Fraport, 2015). Because implementation of an FTF could decrease lead time by approximately two hours and Fraport meets the requirements, the FTF could be a useful solution for Frankfurt. London and Paris both have multiple handlers facilitated at the airport; these airports are therefore more similar to AAS and require a solid institutional design when an FTF concept is implemented. Implementation of the FTF at Schiphol would create an advantage over especially Paris and Frankfurt when it comes to new innovative design concepts and creating a desired market place for players in the air cargo industry.
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