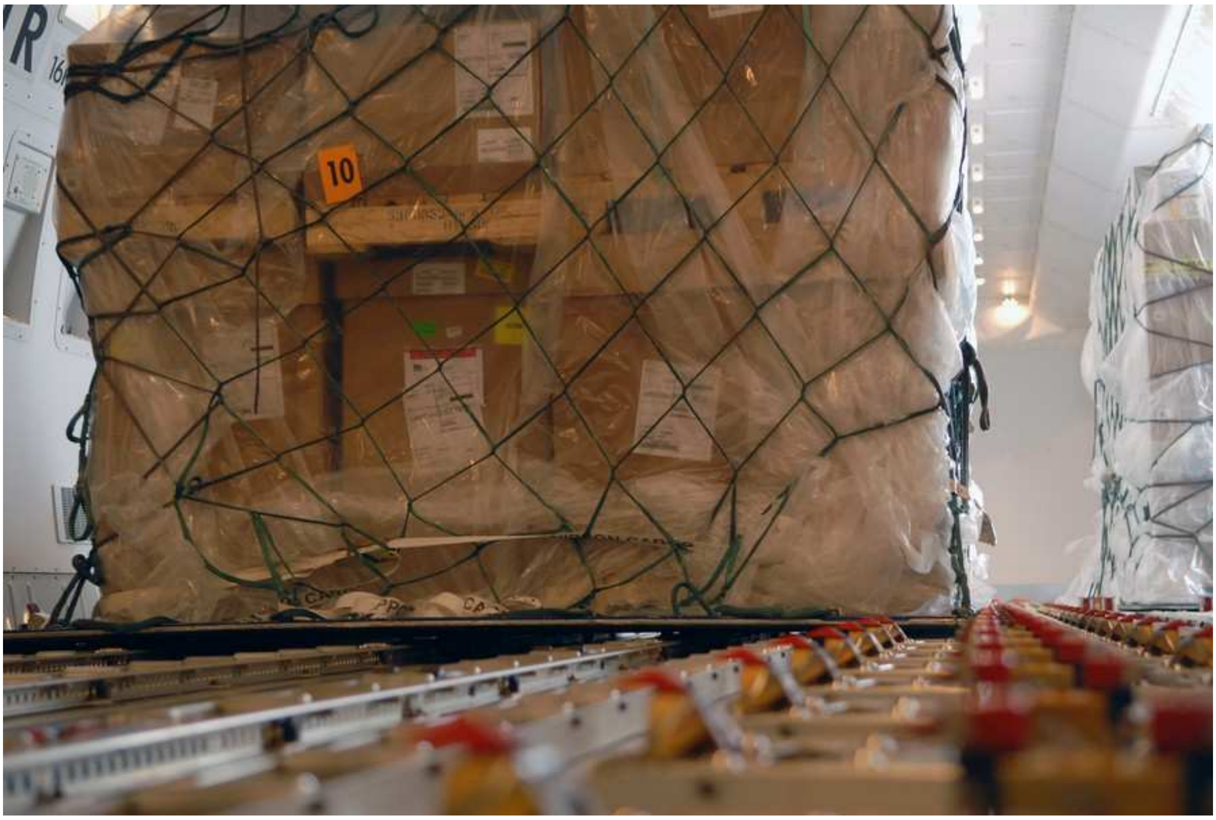
MASTER THESIS FINAL REPORT: MAIN DOCUMENT

From vertical to horizontal collaboration in the air cargo sector

A system analysis of the value of horizontal collaborative logistics applied on inner airport air cargo transport movements at Schiphol.

Steven Ankersmit



Faculty of Technology, Policy and Management

FROM VERTICAL TO HORIZONTAL COLLABORATION IN THE AIR CARGO SECTOR

A system analysis of the value of horizontal collaborative logistics applied on inner airport air cargo transport movements at Schiphol.

Master Thesis final document

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PREFACE

This report is written as part of the final second year course SPM5910 SEPAM Master's Thesis Project of the two year master program System Engineering, Policy Analysis & Management (SEPAM) of the Technical University of Delft. The purpose of the master thesis project is to apply theory of both general courses and domain specific knowledge of the master to a specific project. Transport collaboration is a research topic that has been relatively unexplored in the air cargo industry in relation to the use by large freight forwarders, as many of these forwarders are using their own dedicated transport. However recently several large freight forwarders at Schiphol have started to acknowledge that collaboration on transport might result in operational improvements that cannot be realized by single company transport. Having had the unique opportunity to support and analyze the development of Schiphol airports first truly coordinated and shared transport services for large freight forwarders, was both extremely valuable for my research and a very interesting experience. The last few months, I have been able to gain a great insight in the current and future challenges within the air cargo industry, without my involvement with the pilot project this would have not been possible.

I would therefore hereby like to thank both the entire staff at Air Cargo Netherlands (ACN) and my graduation committee members of my university (TU Delft), who all supported me during my research, by providing valuable feedback and suggestions during scheduled and non-scheduled meetings. I would like to hereby especially tank Leo de Haas, without him I would have not been able to support my research with the data that I obtained and next to that Leo de Haas always made time for me to discuss my research and talk about interesting air cargo developments.

I also want to thank the staff members of all companies involved within the work group (milkrun) at ACN of the pilot project and all other companies that contributed to my research during my research at ACN. The frequency and extensive discussions with all of these companies were extremely helpful and valuable for my research. I would therefore also like to thank all staff members of the companies who either directly or indirectly supported my research. I want to specially thank Sebastiaan van der Meij and Thijs Boonekamp, who both supported my research on a daily basis, by actively engaging with me in extensive discussions and making my research period at ACN truly enjoyable. Finally I want to thank my family and friends who supported me during my research period.

Schiphol, May 2013 (FLTR, Steven Ankersmit, Thijs Boonekamp and Sebastiaan van der Meij)

LIST OF ABBREVIATIONS

ACN – Air Cargo Netherlands

AWB – Air way bill

CW – Chargeable weight

DGVS - Douane Goederen Volg System

DINALOG – Dutch institute for advanced logistics

EDC - European Distribution Center

ETS - Emission trading scheme

FMCG – Fast moving consumer goods

GC – General Cargo

HLF – Healthcare Logistics Forum

IATA – International Air Transport Association

ICT – Information Communication Technology

KPI - Key Performance Indicator

LLC- Low Cost Carrier

LF – Load factor

MDP – Main Deck Pallet

SADT – Structured Analysis & Design Technique

T-ULD – Unit Load Device that is prepared by a forwarder

ULD - Unit Load Device

UML – Unified Modeling Langue

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EXECUTIVE SUMMARY

Introduction

The air transport market in Western Europe has seen extensive growth over the last few decades, both European and international traffic volumes and amount of services have grown for air cargo and passenger related operations. A great amount of this growth has been realized due to several major developments around the globe of which influenced the growth of air transport, the most important being;

- the liberalization of air transport markets
- the increasing efficiency of air transport
- growth of international trade
- development information technology

Growth of aviation transport is still expected for the entire aviation sector around the globe, however most of this growth will not be generated at Western European airports. Schiphol airport is currently one of Europe's largest cargo airports, as the airport services an extensive variety of airlines that provide both air cargo services for passenger and full cargo aircraft on a regular or ad hoc basis. Schiphol airport has been very succesfull in attracting companies that frequently use air cargo transport, however, recently major users of air cargo transport have started to move away from only using established airports in Western Europe. This has resulted in increased use of secondary airports, as these operate under less restricted environmental constrains or simply offer the ability to reduce costs. Next to these development, airports located in Eastern Europe have been gaining importance, as companies that utilize air cargo transport are slowly sifting their production and warehouses facilities from West to East.

Each of the airlines that operate from Schiphol airport has a contracted handling company which provides loading and unloading services that enable an airline to operate aircraft operations to and from the airport. In addition, the handling company receives and delivers the shipments from and to the airlines' customer, which are the freight forwarders. Currently, there are six general air cargo handlers active at the airport, which are located at three different locations within the airport. Around 80 different freight forwarders operate in close proximity of Schiphol airport. Most of these forwarder deliver and collect their shipments to/from the air cargo handlers by using or hiring own dedicated transport means. More than 100 airlines currently operate on a scheduled basis at Schiphol airport, the majority of these airlines also offer capacity for cargo shipments on their aircraft, about 50% of the cargo shipments that pass through Schiphol are flown on passenger aircraft and this percentage is expected to increase in the future.

With the extensive number of airlines and flights operating at Schiphol and the increase of capacity that is becoming available on passenger aircraft, overcapacity is a major challenge on important air cargo trade lanes to and from Amsterdam in the present market. Also on the ground, all air cargo handling facilities at Schiphol are operating below their maximum capacity, as most facilities were built with previously higher expected growth rates in mind for the near future. This had impacted the average air freight rates for Western Europe, which have been declining in last few years. In general, these developments have resulted in different use of air cargo transport, by both airlines and forwarders at major air cargo airport like Schiphol. In other words, the demand for air cargo transport on specific routes and between key facilities has become a lot less stable and average shipment size transported by air has also declined in many important markets.

These developments have increased the difficulty of both air cargo handling companies and forwarders, to realize effective and efficient truck transport between the air cargo handlers' and the forwarders' warehouses. Costs cutting measures by air cargo handlers and reduction of average shipments sizes in general, have resulted in lower reliability of handling processes and longer waiting times, in particular during peak times at several air cargo handlers. Hence, both the air cargo handlers and the forwarders at Schiphol are currently looking for measures to improve the reliability for air cargo transport between their warehouses and reduce transportation costs. At the same time, for sustainability reasons, they are also looking for ways to reduce the number of truck movements for collection and delivery of air cargo shipments.

Research focus, objective and main question

Vertical collaboration between forwarding companies and air cargo handlers at the airport has been in place on air cargo transport since the airport started to grow its air cargo related activities. Most of this type collaboration has been aimed at large forwarders and handlers, which could justify vertical collaboration based on volume and average shipment size. However, with the current dynamics and challenging market conditions, a new assessment of the current and future collaboration models for truck transport is needed in order to improve truck transport logistics at the airport both on cost and performance. Given the declining shipment sizes and ineffective use of transport means by individually companies, this research will focus on transport collaboration by companies operating on the same level of the value chain. This type of collaboration is known as horizontal collaboration, whereas the current collaboration practices is mostly aimed at vertical collaboration that relates to collaboration by two or more companies that operate on a different level of the value chain. The main objective and research question is presented below.

The objective of this research therefore was: *to analyze the potential of one or more collaborative horizontal transport concepts for improving inner airport truck transport (between the air cargo handlers and forwarder warehouses) at Schiphol.*

Main research question was defined as: *To which extent can the logistic operations of truck movements between the freight forwarders and air cargo handlers at Schiphol be improved, through application of one or more (new) horizontal collaborative logistic concepts?*

Research method(s)

A literature review on developments regarding transport collaboration in supply chain management literature was first conducted, in order to understand the developments and differences between vertical and horizontal collaboration in theory. Next to this, several cases of transport collaboration in different industries are assessed to gain insight in the application and challenges of collaboration in actual transport/logistic systems and how these relate to the air cargo transport system. Key developments of air cargo transport systems around the world and especially within competing airport systems similar to Schiphol, have also analyzed in order to obtain insight in different success factors of airports and to find out what the most important measures taken by airports are to maintain and attract new air cargo operators and how these relate to transport collaboration potential. This is followed by an analysis of the current ground transport system for air cargo at Schiphol. The different handling facilities and their processes are studied in depth to understand what concepts are and have been applied in relation to organization of transport of air cargos shipments and to reveal what can be expected to be applied in the near future. Besides the system analysis in this study, a practical pilot project on horizontal transport collaboration on loose import cargo with a limited amount forwarders at Schiphol to and from one air cargo handler was closely followed during this research. With the construction of the simulation model, valuable insights in the import and exports flows of shipments of the involved forwarding companies were acquired and this was used in order to quantity the potential benefits and drawbacks of horizontal collaboration compared to the use of single company transport. Data analysis on shipment sizes for key import and export destinations from the Netherlands has also been performed to be able to generalize the potential of transport collaboration based on shipment data of all forwarders active within Schiphol airport. Finally, literature regarding transport collaboration partnerships and segmentation was used to define a conceptual model that can be used to assess the potential of transport collaboration, and also points out important managerial implications of the development and support of combined transport in a dynamic transport system, such as the air cargo transport system.

Results

The results of this research consist of four segments that are both qualitative and quantitative based. The first part relates to a qualitative analysis of transport collaboration in general and the developments that are taking place around the globe relating to the use of air cargo systems at Schiphol and major competing airports. Secondly, a quantitative part was based on an extensive simulation model which assesses the differences between single company and combined transport performance. The third part provides a limited analysis of the potential system value of horizontal collaboration on loose cargo around Schiphol in current and future growth scenarios, based both on results of simulation model and data analysis of a large amount of shipments that have been imported or exported from the Netherlands. Finally a qualitative analysis is described on the most import aspects from a managerial aspect to develop and maintain horizontal transport collaboration, based on findings of supporting the transport pilot and literature regarding transport collaboration.

Qualitative results (part one/four)

Assessment of current transport collaboration and global air cargo system use developments at major air cargo airports (part one)

The increasing difficulty related to a constantly changing customer demand and desire for flexibility while also expecting lower costs, can make it much more difficult for forwarding companies to improve their supply chain costs and operational performance by only working with partner companies on a vertical level. This is why in many industries it has become accepted and supported to work with competitors, on a horizontal way for part or complete organization of transport logistics on either large established or niche markets. Horizontal collaboration on transport can provide benefits that can outperform vertical collaboration on;

- transport costs
- transport performance
- sustainability
- effective/efficient use of organizational resources/assets

Additional benefits that have been identified for air cargo system are;

- stabilize transport flows
- improve relationships between key stakeholders (forwarders/air cargo handler/ transport company /airline)

With the observed limited abilities of even major air cargo freight forwarding companies at large airports, to support vertical collaboration in an effective way for all their transport flows, horizontal collaboration may provide benefits that result in costs reductions and improve the operational transport performance which outperform individual (vertical) company transport systems. However, the small distances between the air cargo handling facilities and the forwarder warehouses around the airport, do not in all cases make horizontal collaboration the most effective solution. The success of transport collaboration approaches therefore depends on the operational ability of the involved companies and the willingness to support and or adapt their complete logistics operation in such a way that improvements can be realized for both combined transport and the remaining single transports. Next to this, companies will have to have sufficient and regular volumes of cargo shipments that are suitable for collaborative transport. Using shared transport capacity can of course only be effective if the air cargo flows of the involved companies can be combined. The most suitable type of cargo for collaboration based on findings of this research is loose “general cargo”, as this is the least valuable type of cargo, does not require special handling, is the least time sensitive cargo and often has a small weight and volume. But, findings of the pilot case also show that adding ULD shipment to loose cargo collaboration could be very valuable to increase the amount of cargo that is transported and make combined transport more effective. This also has to do with the fact that many shipments can arrive on both ULD and loose combined loads.

In the current situation at Schiphol, with the presence of six air cargo handlers, it can thus be difficult to find concepts that can support transport collaboration in an effective way with a limited amount of companies on a regular basis by only offering one type of transport collaboration. With the increasing focus on costs reductions and limited expected potential for revenue improvements at Western European markets, the use of more extensive collaboration does seem to be a cost effective way to increase stability certain of transport flows, improve relation between stakeholders and, most importantly, make the air cargo transport system at Schiphol more attractive. The current single company minded operational improvement strategies applied by major forwarders have shown to reinforce congestion problems and increase handling process times at handling facilities. This has resulted in higher transport costs and less stable relationships between stakeholders. The average load factors of on airport trucks and their utilization rates clearly show that there is much room for improvement and some of these improvements can be realized by more collaboration on a horizontal level, whereas other improvements can be realized more effectively by supporting vertical collaboration for a selective number of forwarding companies. Therefore a combination of both vertical and horizontal transport collaboration is needed to effectively and efficiently manage total transport needs for several forwarders from one specific handler.

Managerial implications regarding horizontal transport collaboration (part four)

Based on a case study of transport collaboration and literature on collaboration, important aspects regarding the developments, support and improvement of horizontal transport collaboration have been defined. The extent of possible horizontal transport collaboration depends on many different aspects of involved organizations; the most important aspects that have been identified are;

- technical shipment transport requirements
- drivers for transport collaboration
- company facilitators for transport collaboration
- companies ability and willingness to support both collaborative and single company transport
- ability to segment collaboration regarding specific shipments

Figure 1 below aims to capture these aspects and their relation regarding the potential and actual amount of collaborative transport that can be realized. It shows that it not straightforward or an easy task to assess if companies can support and maintain effective transport collaboration. Companies also have to be able and willing to transport collaboration in such a way that it makes it possible to realize effective combined transport. In order for companies to form sustainable partnerships, their cooperate comparability and company symmetry also have to be in line with each other, thus making it even more challenging to find companies that can support transport collaboration. However, stated before, the current challenging dynamics and low operating margins in the air cargo transport system, are forcing companies to accept and support alternative forms of transport. Supporting both shared use of trailer trucks or dedicated single company transport costs and capacity by several forwarders are key concepts that need to be in line with how forwarders should support collaborative transport in order to make such transport more cost effective and operational attractive.

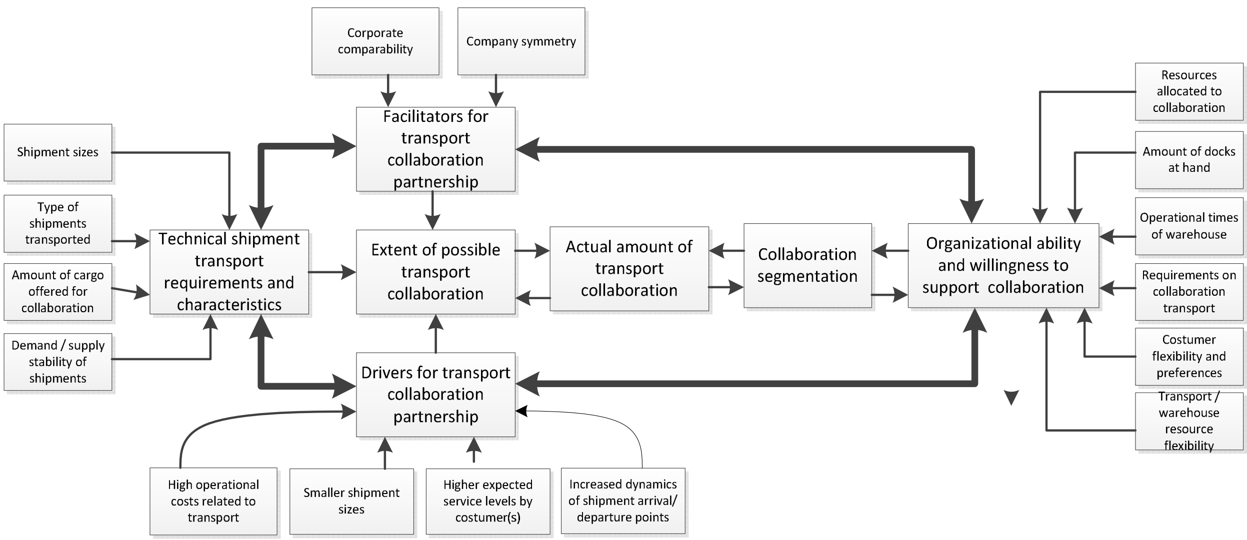

Figure 1: Conceptual model for assessment of transport collaboration potential based on key aspects that define and impact the actual amount of transport collaboration that can be realized

Quantitative results (part two and three)

Case study simulation results (part two)

The simulation model that has been constructed for this research aims to show the key differences between using single company transport and combined transport, by assessing important aspects of company and systems performance for both single and combined transport use. The model analyzed both for ULD and loose transport separately, and this is why the findings related to these different types of transport will also be presented individually. But in general, based on the cost calculations of the analyzed individual companies, a minimum of 50% of shipment volume of the three involved companies should be allocated to combined transport, in order to achieve similar or lower transport costs for all involved companies. This means that restrictions on shipments size or limitations on the use of capacity of combined transport that result in lower amount of cargo transport by combined transport, should be compensated with higher amount of cargo allocated to the concept in order to maintain lower costs than single company transport use. Figure 2 and Figure 3 below, show for different levels of collaboration, what the effects of using combined transport are on transport movements and transport costs per kilo, it reveals that improvements on reduction potential of movements and costs defer based on the extent of collaboration.

Loose cargo transport

The results of the model show that in theory, collaboration on loose import cargo transport from one air cargo handler can reduce the transport costs of the involved forwarding companies on the transported amount of cargo by 20 to 70%, compared to single transport costs. A reduction of transport movements to and from handling facility can be realized of between 20 to 40%, this relates to a 100 to 300 less truck movements at the involved air cargo handler for a period of a month involving the movements of only three forwarders. The large difference in potential reductions relates to the operational flexibility and requirements that are set by the forwarding and handling company involved in the collaboration. Combined transport in the model increases the average throughput time and minimum throughput time of shipments in almost all cases, between the forwarders warehouse and handling facility. To which extent this increase is acceptable, will define the amount of potential savings and reductions in transport movements that can actually be achieved. Throughput times increase on average between 1 to 3 hours for loose cargo transport, compared to single transport use, the difference depends on the way collaboration transport is restricted and organized. For example, limiting the amount of combined transport when shipments are waiting for collection, has a high positive impact on the load factor, but will increase the average throughput time of shipments with a minimum of 30 minutes. Import collaboration on loose cargo can potential be realized for much more shipments than for export, as increases in throughput times for export are less acceptable and it will also be more difficult to combine export, as the arrival and processing of these shipments within the different warehouses of forwarders is not coordinated.

ULD transport

Based on the model, ULD transport results shows that collaboration only has a minor impact on the reduction of transport movements in certain simulation setups, and also the throughput time shipments compared to single company ULD transport sees a significant increase for the involved forwarding companies on export, regardless of the extent of collaboration. Fixed transport capacity use of ULD transport collaboration, can however reduce the transport costs between 5 to 40%, compared to single company ULD transport. The load factor of ULD transport for import and export transport until a certain level of collaboration (medium) can improve, whereas adding even more ULD shipments to the concept negatively influences the amount of ULD's that are actually transported by combined transport system. This means that working with the defined fixed capacity of the model for ULD transport collaboration can only be effective up a certain level, more fixed or variable capacity should be added to support higher degrees of collaboration given the amount of ULD's in the system and transport capacity at hand. Applying waiting policies for ULD transport has not been assessed with the constructed simulation model. It has been assumed that forwarders would like to receive ULD's as soon as possible, given the fact that ULD's will have to be broken down for onward transport.

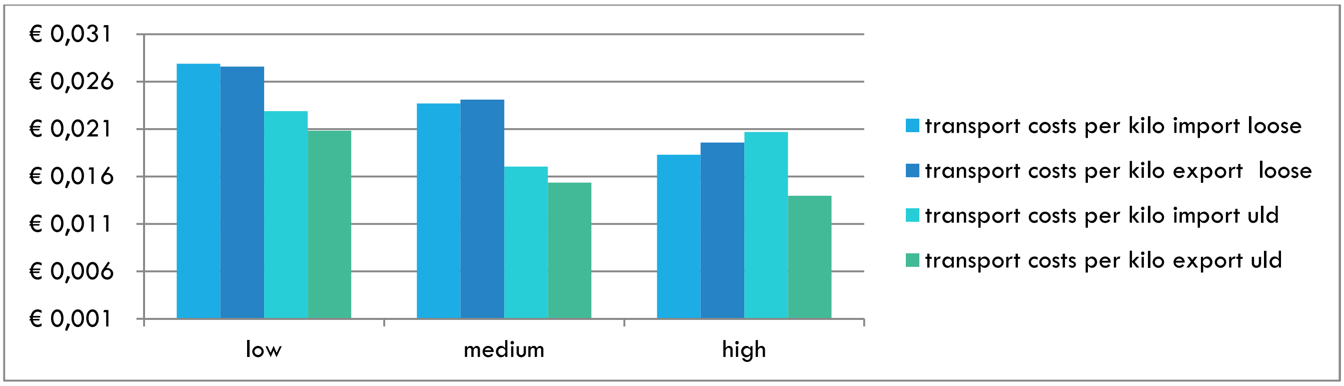

Figure 2: Transport costs for combined transport based on level of collaboration for loose and uld shipment transport.

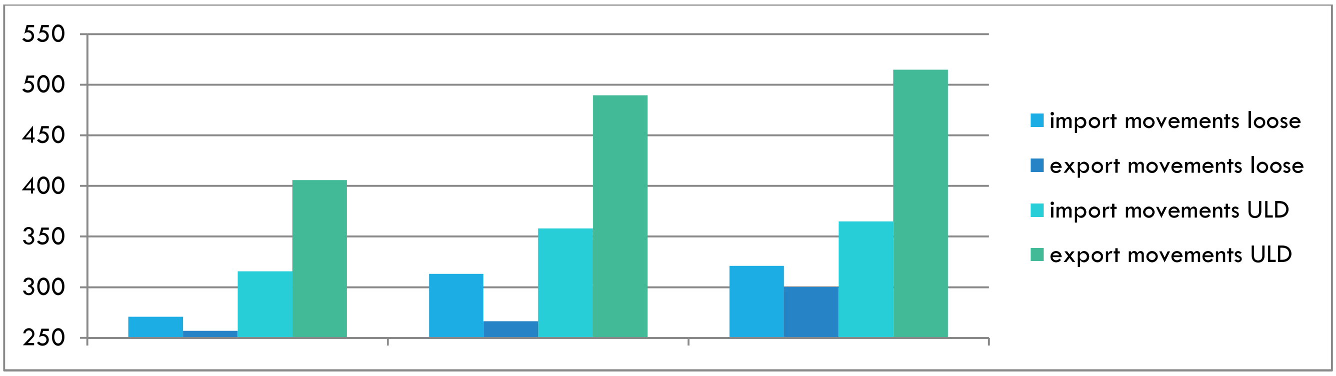

Figure 3: Transport movements generated by combined transport for ULD and loose shipment transport

General Transport collaboration potential

The extent to which defined benefits can be realized for the analyzed transport flows depends on the constrains and commitment that the involved companies agree upon. It can be expected that in most cases the use of combined transport will result in longer throughput times of shipments and not all companies will be able to benefit in the same way by supporting the collaboration, when ULD and loose cargo are not combined. Smaller forwarding companies could in certain collaboration situations reduce both their transport costs to a greater extent than larger companies and can also benefit more from frequency of transport deliveries and collections to their warehouse. This means that the right balance has to be found between the amount of transport generated for the throughput times and number of deliveries for all forwarding companies that are involved in the transport collaboration. Complex allocation methods of costs sharing based on transport movements and distances traveled could be applied to make benefits sharing more fairly disturbed between the companies, however calculated and supporting these benefits with the dynamics of air shipments transport of the involved companies in the collaboration is not likely to add any value regarding on airport transport. Working with a fixed price per kilo is much more accepted within the air cargo industry and other horizontal collaboration projects have demonstrated that the involved companies are often only interested in reducing their transport cost and maintaining an acceptable level op transport performance. Besides these arguments, variable prices of transport could make the decision logic for using either combined or single transport more complex and unstable, whereas the strength and performance of combined transport will largely depend on the stability of transport flows that can be created. However, when all transport is organized by a specific transport company both for combined and single company transport with shared use of transport resources, different prices for transport of shipments can be effectively realized and accepted.

System perspective of loose cargo transport collaboration with the Schiphol air cargo system (part three)

Current situation

The simulation model has been based on selective data of three forwarding companies at one specific air cargo handler. In order to assess the full potential of combined transport at Schiphol, an analysis of the complete air cargo market at Schiphol for general air cargo handlers has also been conducted. Based on expert judgment, a selective data acquired from several data sources in the air cargo industry about the handling market and weight distribution of AWB's to and from the Netherlands, several interesting findings related to collaboration potential of loose cargo can be made. About 60 to 70% of all cargo shipments that are handled at Schiphol airport can be linked to forwarding companies that are active around the airport. Shipments that are smaller than 1000 kilo have been selected as loose cargo shipments for this analysis, as the challenge related to transport performance has been linked to small sized loose cargo shipments. These shipments represent between 10% to 20% of the total weight of shipments that pass thru the airport and make up 60% to 80% of the total amount shipments, which are processed at the airport for both import and export flows. These figures reveal that loose cargo shipments are a very important flow of shipments for both the inbound and outbound flows at the airport and support that a large degree of these flows are generated by forwarders active within the surroundings. These findings further support the existing challenge a large amount of forwarders have, to collect loose shipments at the airport, as the average weight of these type shipments is only 300 to 400 kilo per shipment. The actual potential of transport collaboration for each air cargo handlers for these specifics type of loose cargo shipments, depend on many other factors. The most important factors that have been identified in this research are;

- the number of forwarders within Schiphol area at a specific handing facility
- the frequency & weight of loose cargo shipment at a handling facility for of a specific forwarding company
- the location of the forwarding company in relation to air cargo handler
- the possibility to combine ULD and loose cargo shipments flows with a selective amount of forwarders

In order to estimate the collaboration perspective for each of the six handlers at Schiphol in relation to the three defined factors above, two figures are presented below. These figures show what the estimated amount of loose cargo shipments for forwarding companies around Schiphol are [DGVS area] at the different facilities and how much loose cargo is handled at these facilities for forwarding companies that are based around the airport. Based on these two figures it can be concluded that currently there are three handling facilities which can be expected to have sufficient volume of loose cargo for forwarders around Schiphol and also have sufficient amount of shipments to make collaboration work with a selective amount of forwarding companies. The air cargo handlers can also guarantee a certain stability of cargo flows, given the extensive amount of airlines and/or flights they process.

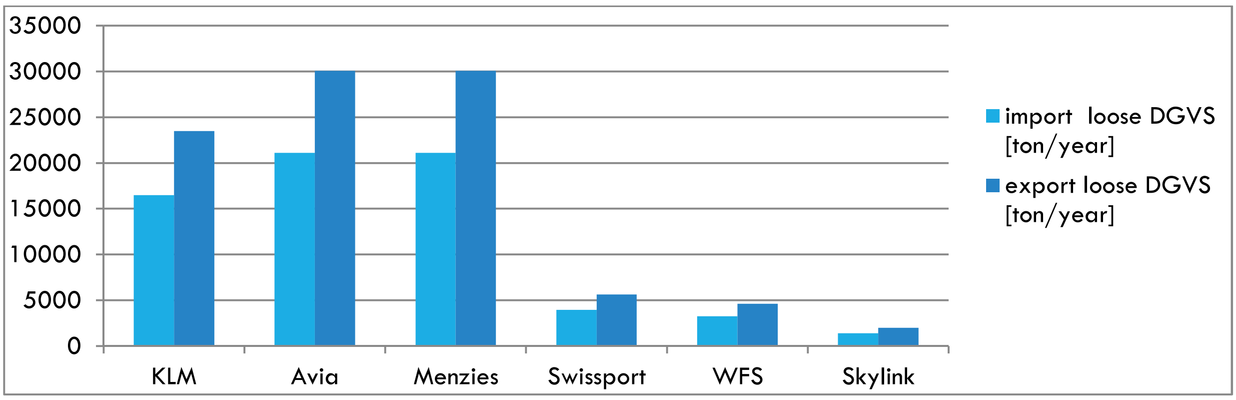

Figure 4: Estimated yearly amount of loose cargo processed by the different handlers for Schiphol based forwarders [ton/year].

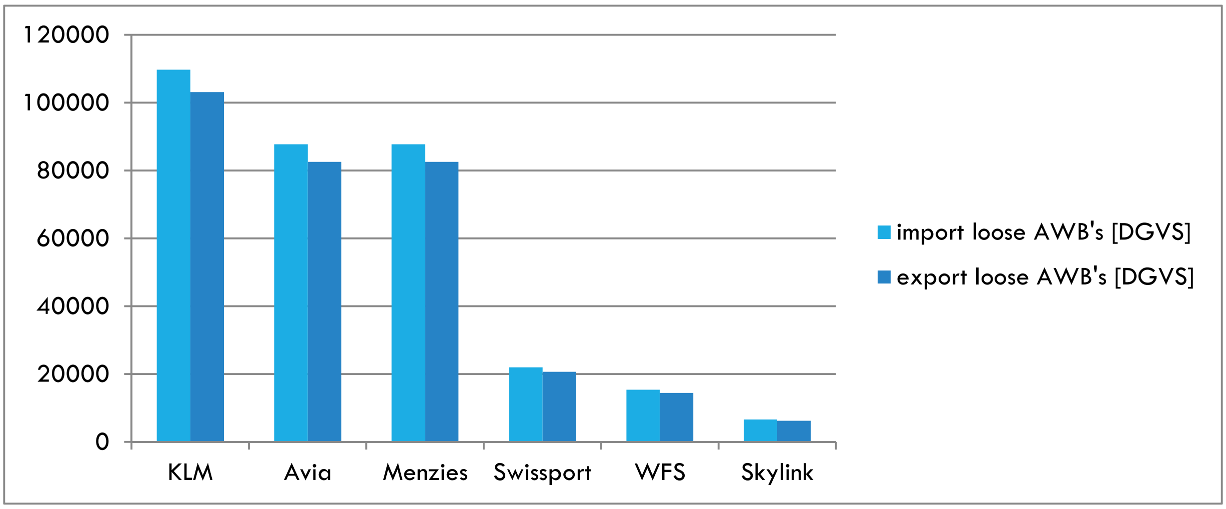

Figure 5: Estimated yearly amount of loose cargo shipments processed by the different handlers for Schiphol based forwarders [AWB's / year].

Results of this research both on qualitative and quantitative findings show that more collaboration on transport can be expected, as in several situations better transport performance can be achieved by collaboration, than solely focusing on individual organized transport. Transport collaboration may for certain types of cargo shipments reduce the transport costs significantly, while also reducing the amount of truck visits to certain air cargo handlers and maintain being able to maintain an acceptable average throughput time of shipments. The increased dynamics of the air cargo system at Schiphol make the justification on transport collaboration much more supported, as transport collaboration can result in more stable flow of cargo that is more reliable when dedicated to the support of processing this transport is given. For export collaboration on transport, several development at Schiphol airport could be used to further increase the potential of collaboration. With the expected changes to security and custom related procedures that can and will enable forwarder to undertake certain processes at the warehouse, coordination of these processes could potentially also be linked to transport collaboration based on flight (destination) or air cargo handler. The most important indirect benefits that could be derived from transport collaboration for forwarders/handlers are;

- the expected reduction in truck movements at air cargo handler
- the ability of the air cargo handler to better plan its resources
- the ability of freight forwarder to better plan and utilize its resources within its warehouse and related to its transport
- better relationship between forwarder, transport company and air cargo handler

It can however not be expected that all major forwarder will support horizontal collaboration on transport within the airport between their warehouses and a handling facility, as during this research it became clear that several large forwarders simply refuse to collaborate on transport without any supported argument. However, when benefits of combined transport will become widely known and collaborating forwarders succeed in not only reducing costs but also realizing additional indirect benefits, it could well be that all major forwarders will have to support some way of collaboration transport or will lose their competitive advantage in certain customer segments of air cargo transport. Next to horizontal collaboration as discussed, coordinated single company use of transport also has a high potential and could be used for companies that are reluctant to collaborate on horizontal shared transport way. Besides these points it is also of course crucial that the air cargo handlers at Schiphol fully support collaboration transport, as currently not all of the major air cargo handlers are willing to support extensive collaboration with different forwarders, so this also limits the current potential of horizontal transport collaboration.

Future air cargo market at Schiphol

Most of the air cargo handling facilities and forwarder warehouses have been built with high growth expectations, it is however not realistic to expect further growth as extensive as before, as market growth expectations have changed. Even with high growth rates for the coming 10 years there will be enough handling capacity at the current facilities at Schiphol, with the dynamic and uncertain growth future it can also be much less likely that the existence of future handling companies will invest in high automated handling facilities, given the high costs and long return on investment times. Therefore, the main variable that will impact the extent of collaboration on a horizontal level for transport will depend on the amount of air cargo handlers and to which extent this influences the ability of forwarders to organize either vertical or horizontal transport collaboration in an effective way. For different sized forwarders, growth and amount of handlers will impact the potential of both vertical and horizontal collaboration in another way, as can be seen in Figure 6 below. Developments regarding the use of ULD shipments are also crucial, as these will mostly likely demand the shared use of transport for both ULD and loose shipments in order to guarantee sufficient volume and frequency with limited amount of parties.

	Collaboration	High amount of handlers		Small amount of handlers	
		High growth	Low growth	High growth	Low growth
Large forwarders	horizontal	Mixed potential	**High potential**	Limited potential	Mixed potential
	vertical	**High potential**	Limited potential	**High potential**	Mixed potential
Medium forwarders	horizontal	**High potential**	Mixed potential	**High potential**	Mixed potential
	vertical	Limited potential	Limited potential	Mixed potential	Limited potential
Small forwarders	horizontal	Limited potential	No direct potential	Limited potential	No direct potential
	vertical	No direct potential	No direct potential	No direct potential	No direct potential

Figure 6: Potential of vertical or horizontal transport collaboration based on amount of air cargo handlers and growth rate of air cargo at Schiphol.

Next steps

Both parts of the quantitative and qualitative analysis conducted within this research have been based on general average of shipment data for a limited period, the findings have only been validated on the basis of partial information and assumptions based on hands-on experience within the air cargo system at Schiphol. This is also why the model that has been constructed was simplified to great extent, as complex decision logic both for single and combined transport logic that may be in place in reality could not be validated. In order to support the use and findings of the constructed model, further consultation and analysis is needed based on more actual detailed data that can be used to further specify and validate the constructed transport model. To support the general applicability of the findings of this research, data regarding other forwarders at Schiphol and comparable air cargo system at other airports also has to be analyzed more in depth. The use of fixed capacity transport for combined transport, as it has been modeled for this research actually demonstrates the worst case scenario of combined transport, as variable truck capacity use can potentially improve the combined transport performance to great extent. This is why future research should be focused on using real case data on arrival of shipments for collaboration transport in order to assess what the effect would be on certain variable capacity usage policies for combined transport performance and costs. Next to this, in an optimal transport situation, one single company would be organizing transport between the forwarders and handling facilities, for all types of transport. Given the fact that combined transport will impact the remaining single transport performance, research should also be focused on how the remaining single company transport of both ULD and loose cargo could be organized or coordinated or even provided by one single transport company in order to future improve the systems use of resources and the performance of both single and combined transport. Most forwarders currently have a limited idea on how their single transport can be improved by using combined transport or other types of collaboration, this should also be an important aspect of future research. In general, both air cargo handlers and forwarders should therefore invest time and recourses to analyze their individual transport and operational performance for certain types of transport to much more detail, as only when such analysis has been conducted will it be possible to truly compare the differences of using single transport or combined transport. Currently it is however very difficult and expensive for stakeholders within the air cargo system to analyze the needed data. Therefore it is advised to set up an organization at Schiphol that provides cost effective analysis on air cargo shipment transport on basis of actual data derived from the different ict-system at Schiphol. Only when such an organization is set up and supported by the air cargo industry will the air cargo system at Schiphol be able to continuously improve its system operations in cost effective ways. Besides this new innovative, projects at Schiphol that are supported by government funding should be managed by organizations that can guarantee a fair and balanced process during the project, as this can avoid undesired stakeholder behavior. One way to support this is to let the managing of horizontal transport project be done by an independent party that can act as a trustee, to manage and analyze company sensitive data in order to improve the effectiveness and support for combined transport.

1 INTRODUCTION INTO THE AIR CARGO INDUSTRY

1.1 INTRODUCTION TO THE RESEARCH

The aviation sector has seen extensive growth rates in the last decades both in established and new air transport markets, this growth has been mostly realized based on;

- advances in the manufacturing of aircraft
- de-regulation of the air transport sector in important air transport markets
- developments in information and communication technology
- international trade growth around the world
- global supply chain developments

This continuous annual high traffic growth rates has made it possible for most major companies in the aviation industry to be selective in past in the way they collaborated with other companies. Growth of the aviation sector is still expected to continue around the world in the next decades both in the number of passengers and the volume of cargo transported by air. The rate of growth of aviation is estimated to continue at about four to five percent on yearly basis around the globe (ACI, 2007; Boeing, 2010). However most of this growth will be realized in emerging markets like China (Boretos, 2009) and will be lower than average growth rates that have been realized in the last decades, especially for major established aviation markets like Western Europe (Eurocontrol, 2012).

The aviation landscape and therefore its dynamics has also changed drastically in the last decades, as it moved from a market dominated by national flag carries to a much more competitive and diverse carrier market than before. For example in Europe and other developed air markets, most air carriers are currently operating with registrations of other countries than the country where they have established a base. More flexible or even complete open sky agreements, between key countries, that represent major air services markets, have opened up the opportunities for foreign carriers to establish themselves and grow in other countries than their own. Besides this the possibility of foreign ownership of airlines was very limited in the previous century, especially before 1990. The rules on foreign ownership have also changed dramatically around the world, especially in the European Union (HSU & CHANG, 2005). These developments have significantly increased the amount of both national and foreign airlines operating at major airports like Schiphol airport, at Schiphol airport for example more than 100 airlines operate on regular basis and less than 10 airlines that operate at Schiphol are actually operating under a Dutch registration. Another important change for the aviation system has been the development and acceptance of low cost passenger's (LCC's) airlines services, which are well established in Western Europe and North America and are becoming widely accepted in Asia and other markets too. This and other developments have made the share of the traditional air carriers in regards to the total amount of passengers carried and distance flown with these passengers much smaller and more uncertain for the long term (Linz, 2012). Due to the fact that an important part of cargo shipments are also flown on passenger aircraft and the share of cargo shipments flow on passenger aircraft is also increasing, this also has had a significant impact on the dynamics of air cargo system.

In the air cargo segment, operators however have not yet seen the full scale development of low cost carriers or related hybrid services, the dynamics of the air cargo market there for have not changed to the extent of passenger operations, but it is expected that the entrance of low cost carriers can occur in the near future. Besides passenger airlines that do not operate dedicated cargo flights and express operators could also be taking over part of the used cargo capacity that is currently provided by full freighter aircraft operators, which offer cargo capacity to multiple companies. New medium and long haul passenger aircraft will offer even more 'belly' space, to transport additional volumes of air cargo and also express carriers are also able to deliver goods faster than traditional full freighter operators used air cargo transport networks (Hedge, 2012). These described developments will likely have an impact on the dynamics of the air cargo sector and the way operations are organized (Linz, 2012). Major passenger and air cargo airports around the world are also becoming more capacity constrained, with stricter regulations and growing urbanization around these airports. Currently about 40% of the 1000 biggest airports in the world, are already operating at or close to their maximum capacity (Reichmuth, Berster, & Gelhausen, 2011). This means that it is becoming increasingly difficult for airlines to realize demand for growth at key airports for both dedicated cargo and passenger operations. Another important development in European Union has been the gradual opening up of the ground handling market. Directive 96/97/EC made it possible for new ground handling companies to establish themselves at major airports(EP, 2012). This has caused increase in amount of air cargo handlers operating at major airports, reduced the handling costs and increased investments in new handling capacity.

ICT developments

Part of the growth of the aviation sector and solutions for the main challenges the air cargo industry currently faces can be related to innovations in the field of information communication technology (ICT). ICT innovations already have had a tremendous effects on the business models and operations of airlines around the globe (Buhalis, 2004), airlines have invested heavily in their ict-systems to make their operations more competitive and effective and have done so with great success for passenger related operations. The need to further invest in ict-systems will only continue to rise in the near future across the entire sector, as airlines and partner services providers are becoming increasingly integrated. A key example of this are the large number alliances and other forms partnership both in the air and on the ground that have been established for passenger related services. The ICT infrastructure that has been developed is in itself also becoming ever more complex, due to costumer and government requirements which often require different specifications. Besides these developments, investments in ICT innovations are also needed, due to the increased competition within the aviation sector and alternative transport developments; such as rail networks and sea transport. It can therefore be expected that ICT developments will continue to influence the aviation sector both in a positive and negative way, as it can make the industry more competitive and effective, but it can also make it possible for innovative products and services to be developed which have a much lower cost base than air related services, for example the development of conference call systems negatively impacts passengers air traffic and the introduction of 3d printing might also negatively impact the demand of certain air cargo transport markets. Compared to passenger carriers, air cargo carriers and their involved logistic partners in this field are still using more traditional based systems, which are either completely paper based or only partly supported by advanced digital ICT systems. Recent developments initiated by; major airports, airlines and initiatives supported by the International Air Transport Association (IATA) are however also forcing the entire air cargo industry to further support the digitalization opportunities for cargo operations. Multiple large cargo airports and full cargo carriers have taken the lead in supporting the digitalization of documentation needed for the transport of shipment via air cargo operations (IATA, 2012).

E-freight developments and challenges

At Schiphol airport for example the project E-freight@NL is currently being executed, which aims at making it possible for Schiphol airport to support a truly paperless air cargo hub. The difficulty related to this development is that many airlines and destinations that can be reached from Schiphol do not have the same level of support and funding to quickly realize and rollout of e-freight and related processes. This makes it impossible to handle all air cargo freight in a digital way, as many destinations from e-freight airports still require some sort of paper documents to be attached to air cargo shipments. The change towards a more digital environment in the air cargo supply chain is also expected to have a big effect on the power and position of key stakeholders in the industry. Currently freight forwarders have a strong position in the air cargo industry, as they control much of the used air cargo capacity on important trade routes, handle and consolidate shipments of several shippers and combine this with the needed documentation process, this gives them the ability to often charge a premium for shipping and processing of air cargo shipments. The developments related to e-freight can however enable other stakeholders, such as the shippers of air cargo to directly send all shipment related information about cargo shipments to other stakeholders, or support part of the needed processes themselves. This development can influence the amount of processes and services that are needed from a freight forwarder by shippers for air cargo shipments. It gives shippers of air cargo different possibilities of how they want to organize and process air cargo shipments and also makes them more aware of air cargo shipment costs and processes, as transparency will increase. This development will be forcing traditional freight forwarders to reduce costs or provide additional value added services in order to stay competitive in a more e-freight supported environment. These developments will also increases the involvement of shippers in a traditionally 'agent owned' supply chain designs, the agent is the freight forwarder in charge of shipment.

Difficult market conditions at major airports

In many large air cargo hub airports, like Schiphol, there is a diverse and extensive amount of companies operating as transport and or forwarding agent, these companies range from being large companies with global presence to small local companies with a partner network in other countries. The current difficult economic conditions and modest growth expectations for the future air cargo market from Schiphol are expected to make it more difficulty for the small companies in the air cargo system to survive on their own. This will make it more likely that further consolidation transport and forwarding companies for the air cargo business will take place in well established markets where operating margins are diminishing and growth of air cargo is more uncertain and less sustainable. Besides the economic considerations for further consolidation is that international freight forwarders with a global presence, can support global firms better in offering truly global solutions for their supply chains (J. Bowen & Leinbach, 2004).

1.2 RESEARCH PROBLEM

The dynamics of the aviation market are becoming ever more complex and challenging, which has been described in the previous paragraph. These developments are mostly related regarding the ability/challenges of current stakeholders to maintain a healthy operating environment and make the right investments which are impacted by;

- lower yielding air cargo traffic from established markets
- lower amount of growth of air cargo transport from established markets for key trade routes
- the increased difficulties for established carriers and airports to growth and maintain their current position
- the limited ability of companies involved in the air cargo system, to realize grow and make the right investments on the short term on their own

Both the changing dynamics and the weak current market conditions are having a major effect on companies that are involved in the air cargo business within established markets, as the operating margins regarding operations in established markets are becoming ever more under pressure and dynamic. The main stakeholders involved in the industry thus are facing a more uncertain future with lower expected operating margins. Possible changes in the power balance of the main stakeholders in the air cargo industry both on the ground and within the air are also likely to occur in the near future. The undergoing e-freight developments and the existing struggle of many transport companies in the current air cargo business in established markets, will make it even more difficult for most companies in the industry to increase the effectiveness of the industry on the short term. Air cargo operations are also more complex to manage compared to passenger operations, this makes it more challenging to find solutions that can improve the air cargo system compared to passenger operations. Key examples related to air cargo operation challenges that are not found in passenger operations are; that the demand for a certain type of cargo is mostly one way and the difference between loads based on weight and dimension on each flight. This can make it difficult to manage and plan air cargo operations, especially with the involvement of several companies in the preparation of cargo shipments under a very restricted timeframe. Changes in economy development and investments made by mainly high tech industries companies also have a large effect on the demand for air cargo around the globe, as air cargo demand is very sensitive to international trade growth and specific investments regarding high tech industries (Bartodziej, Derigs, & Zils, 2007). In established markets, like for example the Western Europe air cargo market, the shift of production and other high tech facilities to areas closer to Europe has reduced the need for air cargo services, as many of these destinations are now in reach of alternative transport means and also cost differences between the use of air transport and other forms of transport is also increasing. To make sure companies in the air cargo industry can stay profitable in the future; investments are needed to make the operations more effective and efficient to face the mentioned challenges and complexity of the industry. Realizing these investments on an individual company level is often difficult, given the average low operating margins, the amount of tasks that are already subcontracted to other companies and the lack of economics of scale that are required to undertake the right investments. The competiveness within the air cargo industry and the diversity of companies involved in the industry make it difficult for collaborative concepts to gain a foothold on a system level. Major ICT developments in air cargo industry are therefore often realized within one company or alliance, leaving out the smaller companies/specialized operators in the industry, this makes it difficult for system wide innovations and solutions to be realized and be used for their full potential. Besides this, collaboration within airlines alliances on passenger activities cannot always be aligned with cargo collaboration efforts, as the involved companies and markets defer to much (Agarwal, Ergun, Houghtalen, & Ozener, 2009). The development of alliances in the air cargo industry can however create opportunities within an alliance, to collaborate more and to align systems, but often two or more airlines not belonging to the same alliance are involved in specific collaboration which makes it harder to integrate systems. Added to this, the freight forwarders which book air cargo transport also want to be able to ship their cargo via different airlines and alliances. In the cases where different airlines and their involved supply chain partners actually all work together on cross sector ICT projects, the process is often slow and the extent of collaboration is limited. The main example of a slow system wide collaboration project that still has not been completed, is the already mentioned implementation of e-freight, which still lacks the needed support across the air cargo industry to be fully succesfull. Many attempts have been made in the past decades to provide cross company ict systems for air cargo operations that can be used by multiple airlines and forwarders, most of these developments have failed for different reasons, one reason being that freight forwarders fear that they are forced to use a system that undermines their role and choices (Christiaanse, Been, & van Diepen, 1996). This is way when collaboration concepts are realized it is often achieved on the vertical flow of the supply chain, very limited collaboration has been currently achieved on a horizontal level in the air cargo industry, besides the collaboration regarding airline alliances. In general and not specific to the air cargo industry, companies are more likely to collaborate with partner companies that do not offer the same services/products in the value chain, given that risks of such collaboration, it is often assumed that collaboration with companies on different level of the value chain relates to lower level risks. Customers of the air cargo industry often support collaboration between competing companies on a vertical level, whereas this is need to support collaboration is much more present on a horizontal level, as horizontal collaboration is much more complex to support and involves much preparation compared to vertical collaboration (Reniers, Dullaert, & Visser, 2010).

For this research all direct and coordinated collaboration that involves companies operating at the same level of the value chain is defined as horizontal collaboration and therefore all collaboration between companies that operate on different level of the value chain is considered vertical collaboration. The growth that is predicted for the aviation sector still looks reasonable for the coming decades, but will be mostly realized in emerging markets and it may often be generated by lower margin passengers/cargo operations, this will not always justify the costs for full cargo aircraft operations (Francis, Humphreys, Ison, & Aicken, 2006). This can make it more difficult for specialized air cargo companies within the air cargo industry in established markets to stay profitable. Especially for airlines that require to provide both passenger and full cargo services, which require the combined use of full freighter and passenger operating flights with cargo capacity. When such operations are not possible anymore at a given airport, the attractiveness of the airport will likely go down, as several types of air cargo transport can only be provided by the use of full freighter operations. Established airports that face most of these mentioned challenges should therefore increase their focus on improving the effectiveness and attractiveness of the airport. Given the notion that the costs for investments that are needed in the air cargo industry are increasing and the profits of the involved companies are declining, supporting the needed investments combined with the uncertainty of cargo market developments, many of the needed investments are currently not realized. Companies in the aviation sector cannot always put aside sufficient capital for the needed investments, to realize a sufficient level of innovations within the industry in established markets. Next to the financial issues and increased dynamics of the market, companies in the air cargo industry are often focused at working on internal solutions or with key partners in form of vertical collaboration with other companies to achieve efficiency gains and increase their competiveness. This approach is even present in the air cargo sector, as the air cargo industry can be viewed generally very conservative industry, regarding the in the way it supports investments and collaborations projects (Hertwig & Rau, 2012). This also explains why many major companies in the air cargo industry are often reluctant to collaborate on large scale solutions with key competitors in the industry on a horizontal level. It could also have to do with different ict systems that are used by companies in the air cargo industry, which are in fact seen as a competitive assets and the fact that no system wide operational ict system for example has been on the market that supports all current e freight handling (Claessens & Harte, 2011). Horizontal collaboration can however help in achieving larger efficiency gains compared to vertical supply chain collaboration, as most efficiency gains have been already achieved by focusing on the vertical level in the supply chain(Vanovermeire, Sörensen, Van Breedam, Van Nieuwen Huyse, & Verstrepen, 2012). Current research on horizontal collaborative supply chain concepts for logistic operations is often focused on different sectors and type of logistic operations. City logistics, which by definition requires an integrated supply chain for a part of the journey is found to be relatively frequent discussed topic for horizontal collaboration (Crainic, Ricciardi, & Storchi, 2009). Another major field of collaboration on the field of supply chain management is e-business, as many core supply chain can be put into practice more effectively by using e-business and collaboration, but this type of collaboration is mostly applied to vertical collaboration(Harrison, Lee, Neale, & Whang, 2004). These and other current collaboration research might not be directly suitable for application to the air cargo industry, but nevertheless do offer potential value and new approaches to horizontal collaboration for the air cargo sector. In order to be able to define, which type of logistic concepts will be considered first for this research, several relevant logistic concepts on a horizontal level will now be described below. Next to this the partnership model from the research of (Lambert, Emmelhainz, & Gardner, 1996) is used to define key components of collaboration. This will lead to a set of conditions that logistic concepts will have to meet in order to be considered for this research.

Milk run concept

The milk run concept is the first logistic concept that is considered for this research. In this concept, that originated from the dairy industry and which is used frequently within the automotive industry, truck operations from several different companies to one or more final destinations are merged into a single truck journey that is predefined on a fixed schedule (Brar & Saini, 2011). By combining shipments of different companies into one way single journey to a shared destination, the number of truck movements can be reduced and the average load volume/weight of a truck can be increased. Given the need to align and coordinate the routing and loading of several different companies, this concept does require extensive collaboration on horizontal level both on planning and operational level.

Intermodal hub concept

The second logistic concept that is analyzed and involves collaboration on a horizontal level is the use of one or more intermodal hubs that are used by several companies for a part of their transport needs. An example of this concept and the difference in cost for the total transport in the fast moving goods sector is given in the paper of (Groothedde, Ruijgrok, & Tavasszy, 2005), in this paper multimodal transport is proposed by using shared logistic hubs. These used hubs are of sufficient size to generate economics of scale and can handle different modes of transport by combining transport demand of several different companies. This analyzed example demonstrates in quantifiable analysis, the positive economic outcomes that supporting collaboration can have for the involved companies on their logistic costs, when the volume and scale of operations are sufficient by combining the transport demand of several companies.

Shared using of parking facility

The use of one or more parking facilities that are shared with different logistic companies is another example considered for this research, it has been manly used in urban areas for distribution of goods to shopping areas, where space and logistic infrastructure is limited (Nemoto, 1997). A shared parking facility can offer companies the opportunity to better plan and align their transport operations and to utilize waiting times by performing value added services that cannot be applied on general public parking faculties.

Rail terminal

The final example of horizontal collaboration comes from within the air cargo industry. It is a logistic concept that is currently considered by several air cargo companies that are not part of the same parent company or alliance. The concept involves the use of high speed rail for cargo transport in Europe and the project called CAREX. In this project several air cargo carrier operators within the air cargo industry in Western Europe have been looking at the use of high speed rail cargo operations for part of their short and medium haul cargo destinations from major cargo hubs, however this project is still in the development phase (EuroCarex, 2011). The main idea behind this project is that high speed rail terminal at or near major airports will be used by several companies combined, which means that the cargo on the trains can be of one or more companies and the schedule of operations is coordinated in a central way. In order to structure and support the conditions on which logistic concepts will be selected for this research, the eight components of the partnership model of (Lambert et al., 1996) are assessed and several aspects are derived from the previous examples of horizontal collaboration, which seem suitable for the research case.

These components of the partnership model are:

- planning
- joint operating controls
- communication

- risk/reward sharing
- trust and commitment
- contract style
- scope
- financial investment

For this research the following components are defined as vital for air cargo logistics in relation to collaboration;

- planning
- joint operating controls
- communication
- scope and risks & reward sharing

The current analysis, based on literature and interviews taken at Schiphol with involved logistic companies has shown that the selected components above are and have been crucial related to the success of collaborative concepts within the air cargo industry. All components of the partnership model should however should be considered, this does not mean that all of these components, are always considered to the same extent, for each of the logistic concepts that is analyzed and applied in this research. Planning is an important aspect for air cargo logistics as demand and operations are different from day to day. Air cargo demand is generated by a mix of frequent and irregular shipments demand and also the routes on which it is flown can change from day to day, planning therefore is a major challenge for the involved stakeholders. Previous collaboration concepts have failed to enforce a joint operational control in an effective way for the Schiphol operations, because these concepts were applied to a limited amount of companies with insufficient scale of operations. This made it difficult to align these concepts with operations for non-participating companies, making it in fact almost impossible to align the activities of handlers and transport companies in an effective way. Also air cargo shipments are a mix of specialized and general goods time critical goods, therefore the scope of collaboration is important, as certain goods cannot be transported in a joint manner due to costumer requirement or business process that are currently in place. Finally companies in the air cargo industry have a complex cost structure related to specific operations, this can mean that operating costs for similar companies can defer and therefore, the scope and level of rewards and risks of certain logistic concepts are different from company to company. When collaboration is applied this component regarding risks and reward sharing and scope, also has to be considered in great detail.

In this research any logistic solution that can be applied to truck movement at Schiphol is considered a collaborative logistic concept on a horizontal level, if one or more of the following aspects are included:

- The collaboration consists of sharing of information related to either planning or actual logistic operations at hand. This information can be shared in two ways:
    - A passive way, as just one way communication, where the organizations involved receive information but cannot request changes from other involved stakeholders based on this information.
    - An active way, as two way communication where the involved stakeholders can also change or propose changes to the external party on the logistic operations involved, based on the information they have acquired. This can relate to the component of joint operational control.
- The collaboration involves the shared use and or operation of a physical location for part of the logistic activities; these can involve many components of collaboration.
- The collaboration involves the shared use of logistics equipment with other companies that is used to for part or all of the related transportation needs.
- The collaboration concept involves of two or more competing companies operating on the same level of the value chain, which are using the concept together.

To date no in-depth analysis has been found in existing literature that compares one or more collaborative logistic concepts on a horizontal level both on value and suitability to an existing air cargo logistic system of a major airport hub. Based on the analysis above four knowledge gaps are defined below which are deemed interesting for further research

Knowledge gaps:

- Currently logistic concepts within an industry are mainly applied and compared within the same industry, there has been no clear framework or assessment tool identified, that can compare several logistic concepts of different industries on the similar key performance indicators (KPI)
- The suitability and value of alternative collaborative logistics concepts on horizontal level, that can truly integrate supply chain management for truck movements at a major airport, has not been analyzed in air cargo industry, as a case study.
- Most collaboration concepts for logistics have been found, focus on vertical integration of logistic processes within a supply chain, limited research has been found that focuses on the value and application of horizontal collaboration for logistic optimization, especially regarding on airport transport.
- The effects of applying new logistic concepts to the air cargo industry related to the management of collaboration related issues, has also not been found to be studied in-depth in the current literature.

Problem statement

The physical transport infrastructure used by the freight forwarding companies for air cargo shipment transport at Schiphol, will be changing in the coming decades. The ICT environment will also become more complex that supports the logistic operations of key stakeholders at Schiphol, competition with other major cargo airports will increase and the amount of airlines operating at different airports will increase these developments will make the transport flows between different facilities at the airport more dynamic and finally companies in the air cargo industry are expected to have more difficulties investing in key innovations and other solutions because of financial challenges, which come from expected lower operating margins. The problem statement of this research is therefore defined as following:

The air cargo operations from established airports, like Schiphol airport, will see a more dynamic operating environment in the future that will become ever more complex, competitive and diverse. Individual companies within the industry will not always be able to make the right investments and support individual measures related to their own logistic operations, to maintain and improve the competitiveness of the air cargo sector from established airports and on the same time also secure their own survival in the long term.

The mentioned challenges in the problem statement can create the opportunity to support new collaborative logistic concepts at established air cargo airports for several different stakeholders involved in the air cargo system. Given the assumption that certain measures can potentially be more effective and supported, with less financial risks and better outcomes for the involved companies, when multiple companies within the industry are involved in the operation and investment of new logistic concepts. Therefore supporting concepts with multiple stakeholders can make it less challenging to face a more complex and dynamic air cargo industry, which the is actually the type of challenge that major stakeholders in established markets are and or expected to be facing. The increased use of ict related systems for both passenger and cargo operations at major airports can support the realization of collaborative concepts that involves multiple different stakeholders, it is becoming less costly than before to develop or adjust current ict system to share specific cargo shipment related information with the ongoing ict developments. The challenges and lack of current assessment of more collaborative approach on organization and management of transport movements between major forwarding warehouses and air cargo handlers justify an in-depth analysis from a system level, that can show, how suitable and effective the application of (new) collaborative concepts for transport operations for freight forwarders at a major airport are, in order to improve both the competitiveness of established air cargo airports and improve the financial viability of forwarder companies that operate at the airport. Currently no research has been found that specifically analyses; the value and support of different collaborative logistic concepts for the air cargo industry on case study basis for a major airport like Schiphol both on efficiency and managerial aspects.

Delineation of the research scope

For this research the focus will be based around a case study that will quantify the suitability and effectiveness of more collaborative logistic transport operations on a horizontal level, for the air cargo truck movements at Schiphol at a system level. Currently no in-depth research has been found on the application of more collaborative logistics for truck movements on horizontal level between the warehouses of different freight forwarders and one or more air cargo handlers at the airport. Added to this the future logistic situation at Schiphol may provide additional benefits for more extensive collaboration on logistic operations, given the increasing concentration of the of air cargo related operations and the expansion of logistic activities at and near Schiphol South-East. Therefore this research will focus both on the current and expected logistic infrastructure layout of Schiphol for the coming decade related to cargo transport operations at the airport. The expected difference between the current and future situation is briefly explained below and will be described in more detail in other parts of this research.

Current situation at Schiphol

In the current situation both KLM Cargo and Aviapartner are still offering cargo handling related services from Schiphol Centre, at Schiphol South-East the remaining 75% of cargo handling activities are currently being performed (BS, 2011), at Schiphol South-East four general air cargo handlers are currently operating. KLM Cargo has indicated that it will in the future move to Schiphol South-East to be able to better align their operations with Martinair and realize more competitive operations, as its facilities are currently outdated and can only support limited growth in cargo processed. Recently WFS, a major air cargo handling company around the world that is also active at Schiphol, has taken over Aviapartner. Since both companies are located at other parts of Schiphol the takeover could also result in further consolidation. Schiphol South-East seems the most likely location for this to take place at given the intent of the airport to move all cargo related operations to Schiphol South-East and the extensive amount of large freight forwarders that are already operating from this area of the airport.

Future situation at Schiphol

In the near future the area of Schiphol South-East will see development of more logistic related infrastructure and related companies. The possible move of the operations of KLM Cargo and modifications to the N201 road are two key examples of changes that will further increase the developments at Schiphol South-East regarding air cargo operations and transport. Part of the cargo operations at Schiphol Centre will have to be moved to Schiphol South-East, because of the planned expansion of the passenger terminal that is currently designed to be developed on the location of current cargo handling facilities of KLM Cargo. Close to the area of Schiphol South East, a new area of 300 hectares will also be developed that is intended to be mainly used for companies that are involved in logistic related activities, this area may in the future also be connected with a dedicated transport connection to the high speed rail terminal (expected to be build), the airport and the Greenport of Aalsmeer. These and other developments are expected to make the concentration of logistic activities higher around the air cargo handling area at Schiphol South-East and infrastructure connectivity to Schiphol South-East will become more attractive compared to cargo handling at Schiphol Centre. These developments are however also expected to increase the amount of transport movements within this area of Schiphol if no changes are made to the transport use of major forwarding companies, this can make the transport infrastructure more congested and result in more transport movements between the different facilities over time.

1.2.2 RESEARCH OBJECTIVE

The objective of this research is to provide Air Cargo Nederland with an in depth analysis of the suitability and feasibility of (new) logistic concepts that use collaboration on a horizontal level for the operations of air cargo trucks at Schiphol within the coming decade. This research will provide analysis on the current collaboration between the members of ACN and to which extent new collaboration concepts should be applied to support the logistic operations of major forwarding companies at Schiphol regarding their truck transport use. The main objective for this research will be to provide ACN with a simulation model that can show the theoretical value on a set of KPI's of at least one horizontal collaboration concept for truck transport at Schiphol that is currently not being applied and also provide insight in the way truck collaboration transport should be supported by ACN as organization in the future both on qualitative and quantitative basis. The research objective is aimed at assessing both the effects on logistic operations on system level and case study basis, by using a set of KPI's to benchmark logistic changes compared to the current system and also includes the managerial aspect of the application of more collaborative logistic concepts at Schiphol air cargo system, in order analyze and justify the suitability of logistic changes from an organizational perspective. The feasibility aspect is focused on the financial challenges at hand in order to realize and support the proposed concepts for the short and long term. Next to these two aspects this research aims to improve the general understanding and value of application collaborative logistic concepts for the air cargo industry. This research will try to realize this, by assessing the key benefits and drawbacks of collaborative logistics concepts for truck movements at Schiphol. This will be done by looking at the business case of collaboration concepts for different cargo flows at Schiphol airport not only the companies that are assessed in the case study but to look to look at the suitability of these concepts for other forwarding companies at the airport.

The focus of this research on the truck movements within Schiphol is made, because currently during peak hours, several air cargo handlers at Schiphol are experiencing operational challenges related to the loading and unloading of trucks and this affects the entire chain of operations at other involved logistic companies around the airport. Freight forwarding companies around the airport represent a large share of both import and export flow of cargo shipments that are processed at Schiphol, therefore their landside transport movements are important part of the transport system at Schiphol. Currently there is still sufficient transport capacity on the airside infrastructure of the airport, which makes research on landside transport more valuable. Besides this the current development of ict systems used for air cargo operations at Schiphol, will make it much easier in the near future to apply more collaborative logistics concepts for truck movements Also as explained before, in the coming decade most of the air cargo handling operations at Schiphol will be located at one side of the airport (Schiphol South-East), this makes it more likely that collaborative logistic concepts related to truck movements can actually realize efficiency gains, given the concentration of cargo activities and the derived demand for air cargo shipment transport. The fact that large growth of logistic activities in these areas of Schiphol is still expected for the near future, it may also require a more controlled environment of logistic operations in order to keep the flow of cargo within the system stable. Finally changes and requirements related to custom inspections for air cargo shipments are likely to increase in the future, which can also justify more intensive collaboration to better streamline the required checks that have to be performed in relation to transport movements.

This research will be conducted for Air Cargo Netherlands (ACN), which main objective is to support and maintain the development of the air cargo industry in the Netherlands. This research is part of the Airlink project which ACN is actively supporting. The Airlink project is in itself is part of the 'seamless connections program which goal it is to improve the speed, connectivity and quality of logistic chains in the area surrounding Amsterdam. The objective of the Airlink project is to realize measures that can make the handling of air cargo at Schiphol more efficient and effective, which can result in more competitive air cargo market at Schiphol airport.

1.2.3 EXPECTED OUTPUT OF THIS RESEARCH

In order to realize the objective of this research the following output is expected from this research:

- A simulation model of truck movements in current and future situation of Schiphol, which can benchmark the different logistic concept for the truck movements at Schiphol on a set of predefined KPI's.
- A framework/assessment tool to compare different logistic concepts on similar KPI's.
- A summary of the key challenges and opportunities related to management in the air cargo sector related to the analyzed collaborative logistic concepts.
- An assessment of the current and future competitiveness of Schiphol airport, compared to competing airports around the globe.

This research should result in an advice to the air cargo industry in the Netherlands on how the current movements air cargo trucks within the airports surroundings, can be further improved and better supported by the involved stakeholders with the application of one or more collaborative logistic concepts. It can indirectly also create and support other collaborative initiatives by showing the true value of collaboration concepts and pointing out solutions to overcome collaboration challenges that currently exist in the air cargo industry.

1.2.4 SCIENTIFIC RELEVANCE

Logistics concepts that involve extensive collaboration are gaining more and more importance, as they can realize higher efficiency gains and make relationships between stakeholders more stable (Audy & D'Amours, 2008). The air cargo industry is known for the limited use/support of fully integrated collaborative logistic concepts, especially related to ground transport part of air cargo system. This research will attempt to reveal how collaboration approaches in the air cargo industry can be further enhanced, by looking at several collaborative logistic concepts on a horizontal level. Concepts from different industries will be assessed in relation to air cargo system and strategies to realize and maintain more extensive collaboration in complex network of stakeholders will be derived and possibly combined from existing literature on stakeholder and process management. This research will try to contribute to improve the understanding and application of current management approaches for collaboration in the air transport domain, by looking at currently applied approaches within the aviation sector and other industries. In order to compare different logistic concepts an assessment tool will be developed, that can be used to compare different logistic concepts on similar set of KPI's this currently is a difficult task looking at the literature at hand. This research can also contribute to scientific knowledge related to comparing different logistic concepts from several industries in a more structured way and will point the difference and similarities for supporting collaboration. As no research has been found that focuses specially on air cargo sector opportunities of different collaborative logistics concepts on a case study basis on both economic value and management related issues, this research can point out future research on how to combine quantitative methods about the system value of the analyzed concepts with more qualitative methods that relate to the management of these concepts. Given the dynamics of the air cargo system, this research will also try to point out the key differences of managing horizontal transport projects in a dynamic environment, as most currently assessed horizontal transport projects are applied to air flows that are relatively stable between two or more major warehouses.

1.2.5 SOCIAL RELEVANCE

The transportation of goods by air is very expensive compared to road transport or other transport alternatives, but is however often needed to support time critical transportation or high value transport that cannot be transported by other transport means, given the existing time and operational restrictions. The generated air cargo transport operations produce various negative external effects; the most known negative products are air pollution and noise. Besides these negative effects generated by air cargo transport, the sector also provides companies with the opportunity to work more effectively on a global scale and it can give society access to wide range of time critical products from around the globe. The use of air cargo transport can support higher economic growth and better standard of living in the country that is benefiting from the air transport services. In this way air cargo transport can contribute in a positive way to a society, related to welfare and economic growth within a country. Schiphol airport currently ranks 4th in Europe in the area of passenger traffic and 3rd in Europe on cargo volume (Schiphol, 2012b). Making logistic operations to and from the airport more effective can thus results in significant improvements to economic growth in the Netherlands and Western Europe. Schiphol airport and the related business activities around the airport contribute about 26 billion euro a year to the Dutch economic, equal to 3,3% of the gross domestic product (Schiphol, 2012a). This research can also contribute to new solutions for the operation of truck movements at Schiphol, which can both reduce the negative external effects of these operations and in the same time reduce the costs of air cargo transportation making the air cargo system of Schiphol more competitive. Next to this practical knowledge on setting up and understanding the challenges of horizontal logistic transport projects, could be applied to other industries in order to reduce the amount of empty transport movements and also reduce the amount of trucks on the road.

1.3 STRUCTURE OF THE RESEARCH

In the chapter two, the research approach will be explained more in detail by introducing the main research questions and methods that are used to answer the proposed questions. In the following chapter three, a literature review on collaboration within supply chains for both vertical and horizontal collaboration is conducted and a selected amount of industries will be assessed in relation to their collaboration use within Europe. Chapter four will give an overview of key developments of air cargo system and competing air cargo hubs of Schiphol airport, in order to better understand the current and future developments that the air cargo system at Schiphol will face and to which extent collaboration on truck logistics is an important aspects for staying competitive. In chapter five an in-depth analysis is presented relating to the air cargo system operations at Schiphol airport and the collaboration concepts that are currently applied will be assed and compared. Chapter six provides an extensive stakeholder analysis of the most important stakeholders of the air cargo system at Schiphol and how their current and future position will influence the support and development of collaboration. The case study horizontal collaboration will be explained and presented in chapter seven. Chapter eight will follow with definition of the simulation model based on the case study. The simulation model will be specified in chapter nine. Testing different types of transport use and results based on the simulation model will be presented in chapter ten. In chapter eleven the findings of the simulation model will be combined with other previous analysis of this research and data regarding import and export shipments at Schiphol, to define the system potential of transport collaboration on loose cargo. Chapter twelve will reveal the most important managerial implications of horizontal transport projects. Finally in chapter thirteen the conclusion and direction for future research are presented.

2 Research approach

In order to structure and explain the research approach in this chapter, the research questions that are derived from the problem statement and research objective will be defined and research methods are proposed, that are needed to be able to answer research questions and support the analysis of this research.

2.1 RESEARCH QUESTIONS

The main research question this research will try to answer is:

To which extent can the logistic operations of truck movements between the freight forwarders and air cargo handlers at Schiphol be improved, thru application of one or more (new) horizontal collaborative logistic concepts?

The main questions relate to the problem statement and research objective in the following way, the problem owner of this research wants to assess if it should advise its members to support more extensive collaboration for the logistic operations of trucks around the airport in the future. Given the notion that in the current situation an assessment on the system level, that compares different collaborative concepts for truck movement, is missing at Schiphol, answering this main research question can provide direction to and insight into the suitability of a more collaborative approach for truck transport use in the future. This research will also try to answer the question what managerial challenges can follow from the application of a more collaborative logistic approach for truck movements at Schiphol and how these challenges can be dealt with. To structure and specify how this research question should be answered more in detail five sub questions defined relation to the main research question, which can be found below. **Figure 7** on the next page shows the relation between the defined sub questions and the steps proposed for this research.

Sub question(s)

1. *Which concepts for truck movements have logistic operators at Schiphol currently considered for improving their operations and how have they selected them?*

2. *How do the expected changes in the coming decade of infrastructure for logistic operations at Schiphol airport effect the application of logistic collaboration on a horizontal level?*

3. *How can the most important KPI"s used both in the aviation sector and other industries be best compared and assessed?*

4. *How does the current logistic system for truck movements compare with the (new) collaborative logistic concepts on key logistic KPI's both on individual company level and system level?*

5. *What are the most important stakeholder management issues related to the different collaborative logistic concepts that can be applied to Schiphol air cargo truck movement operations?*

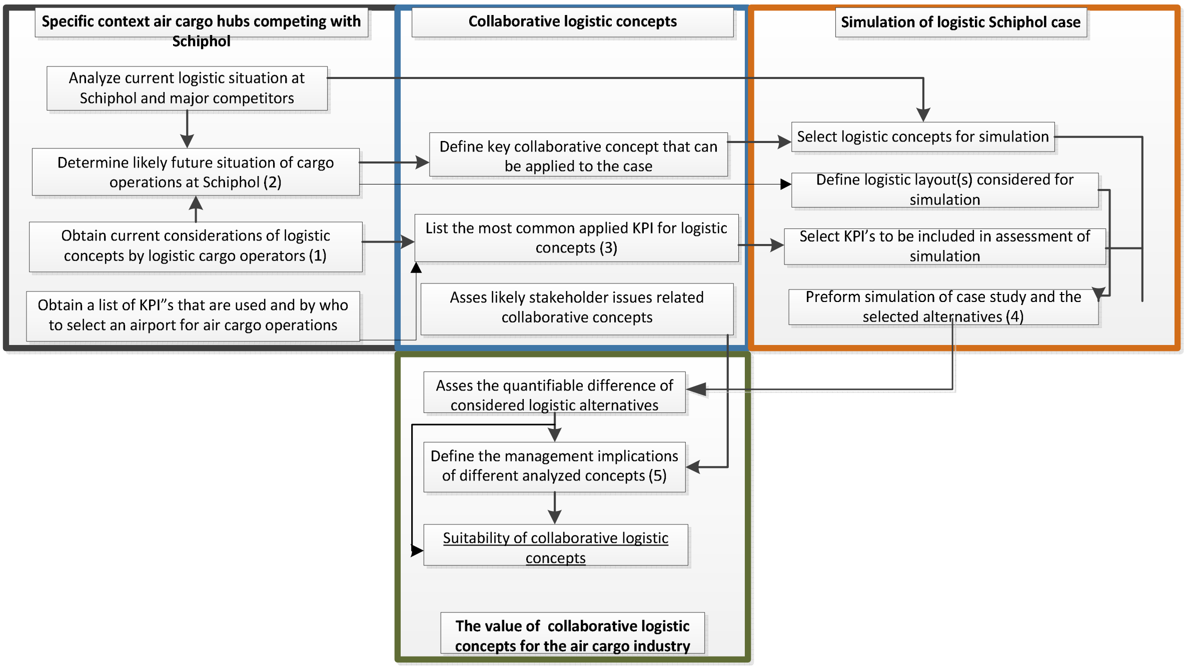

Figure 7: Proposed main steps of this research and relation between the different research questions.

2.2 RESEARCH METHODS

In order to answers the research questions of previous paragraph one or more research methods will now be defined for each sub question. The suitability of defined methods is briefly augmented in relation to the question that is answered. Figure 7 above shows for each sub questions how each sub question is answered in relation to the other questions and reveals which previous analysis is input for further parts of the research. The following three methods will be used extensively in this research in order to answer all research questions.

- literature review
- interviewing
- simulation

A literature review is needed to able to compare and analysis existing practices applied in logistic field with a collaborative aspect that relate to the subject of this research. Also the literature review method can help to find and combine different concepts and theories that are not found in current individual reports. Several scientific search engines are used in order to find suitable literature for this research. The most frequently consulted websites are Scopus and web of science. Most scientific literature focuses on the comparison of logistic concepts within an industry; therefore it is needed to analyze literature of several different of industries. And because of the limited research on this subject within the aviation industry journals from outside the aviation sector are also considered. Since simulation is a key part of this research in order to compare and benchmark the different logistic concepts on a case study basis, literature related to simulation of logistic operations will also be considered.

Journal's that are analyzed specifically for this research are:

- *Journal of Air Transport Management*
- *International Journal of Transport Management*
- *Journal of Transport Geography*
- *Simulation Modelling Practice and Theory Journal*
- *Journal of Operations and Supply chain management*
- *International Journal of Logistics Systems and Management*
- *Journal of Transport Science*

When scientific literature is not available, limited or outdated and no alternative literature from other sources can be found, interviews will be conducted with industry and university and other knowledge center experts who are able to obtain or provide the additional information. Added to this the pilot project supported by ACN on truck movement collaboration will be used to obtaining real operational issues and challenges related to collaboration in the air cargo system at Schiphol. It was indented to be used to benchmark changes to systems performance when the pilot was expected to be launched in January 2013. Due to delays with setup of the pilot only the preparation phase of pilot has been included for this research. In order to assess if parts of the analysis from this research are supported by the involved stakeholders, the interview method is also proposed, because given the project duration and the construction of a simulation model, designing and applying a complete survey or method would be to extensive and would also not give the desired results. Finally to compare and quantify the suitability of the logistic concepts for the truck movements with the current approach on a system and company level, simulation approach is used as method, in order to be able to analysis the differences between single and combined transport and to assess which processes and procedures are crucial for success of combined transport in relation to individual transport.

1. Analyzing current literature, combined with interviews with key air cargo management staff at Schiphol will be used as main methods to answer question one. These methods will be combined as there is very limited literature at hand that define current applied concepts at Schiphol and also look into the reasons behind way certain concepts are considered. The interview method can help overcome the lack of literature and help obtain the real reasons for supporting certain logistic concepts and alternatives that are considered currently by the involved stakeholders.

2. Two methods are selected for answering questions two; a literature review and interviewing experts. By first assessing the current literature and conducting several interviews with experts within the aviation industry how the most likely scenario's for the future of cargo handling at Schiphol will have an impact the potential the analyzed logistic concepts, a decision will be made later in the report if it is needed to use scenario analysis to more look more extensively into possible scenario developments that require a more systematic approach.

3. Using current literature, combined with conducting interviews with both air cargo industry experts and university logistics experts are methods used to answer question three. This should be done in this way because both types of experts available, can help define the most important KPI's used within the aviation and other important sectors and existing literature on KPI's of logistic operations in different industries can be used to further enrich the analysis.

4. Question four will be answered by using previous analyses of questions 1 to 4 and partly by consulting experts, especially simulation experts from the TU Delft and air cargo sector on the basis of the previous analysis and an additional literature review can be conducted if needed to select the right simulation method and to added extra factors or criteria that are relevant to compare the different logistic concepts.

5. Two methods are suggested to answer question five; a literature review related to challenges for applying collaborative concepts in the field of logistic and expert consultation from both the industry as university. It is believed that the specific nature and difficulty of realizing system collaboration in the aviation sector requires in-depth knowledge that can only be obtained by consulting experts. Literature related to logistic system collaboration can also be helpful but is not sufficient.

2.3 DATA USAGE

In order to compare alternatives and criteria of multiple stakeholders several ways to collect data effectively have to be organized. This is pointed out below by the three most important data collection issues. The first issue relates to ability of ranking the analyzed alternatives on criteria with key staff involved in the logistics management of truck operations from the involved companies. The second issue relates to data needed to perform a simulation analysis of the current and future (alternative) solutions of trucks movements at Schiphol. Data will be gathered, which contains relevant data of current and expected truck movements to the cargo handlers at Schiphol for a given period of time.

1. First several air cargo stakeholders operating in the field of logistics, will be interviewed in an attempt to obtain information that represent the entire industry on the criteria they use for their logistic concepts and to establish a list considered logistic concepts that are not currently applied.

2. Obtaining correct and sufficient data regarding the truck movements to and from is a major challenge. The involved logistic companies need to share their operational data in order to make a simulation model that is accurate and represents the actual system. Several companies will be approached to provide these data and hopefully when a certain group of stakeholders has provided these data, others will follow or be more supportive in providing the data, especially if a confidentiality agreement is in place. Research of another student at ACN (Sebastiaan Meij) who was focusing on a pilot case setup of the milk run at ACN will also help to obtain realtime data that can be used for the simulation model.

Given the fact that the project owner (ACN) has good relationships with the involved stakeholders and is actively engaged in multiple projects and workgroups during the time of this research, all current scheduled projects and meetings with key stakeholders will be used to obtain data and feedback for this research.

2.4 PROJECT SCOPE

This research will focus on the air cargo truck movements within the surroundings of Schiphol, which are either performed by ACN members or at ACN member facilities. The situation will be first assessed for the area surrounding Schiphol +/- 20km from Schiphol center. If needed, based on analyzed logistic concepts and involved companies the area of research can be further extended or reduced. The intention is to focus on the value of collaborative logistic concepts between the air cargo truck transport, from the freight forwarder and the air cargo handlers at Schiphol, again if the analyzed concepts can also add value from the freight forwarder to clients outside Schiphol this will also be considered given the time and data are at hand. In Figure 8 below a map is presented to make clear, what type of companies will be included in this research and that can also be included in the simulation part if possible. The complete list of companies on the map can be retrieved using the following link http://goo.gl/fnsMK. Stakeholders on whom this research focuses on in the beginning are: the airlines, the air cargo handlers, the freight forwarders and the trucking companies as they together are involved or are directly influenced by the way truck movements at Schiphol are organized for air cargo handling operations.

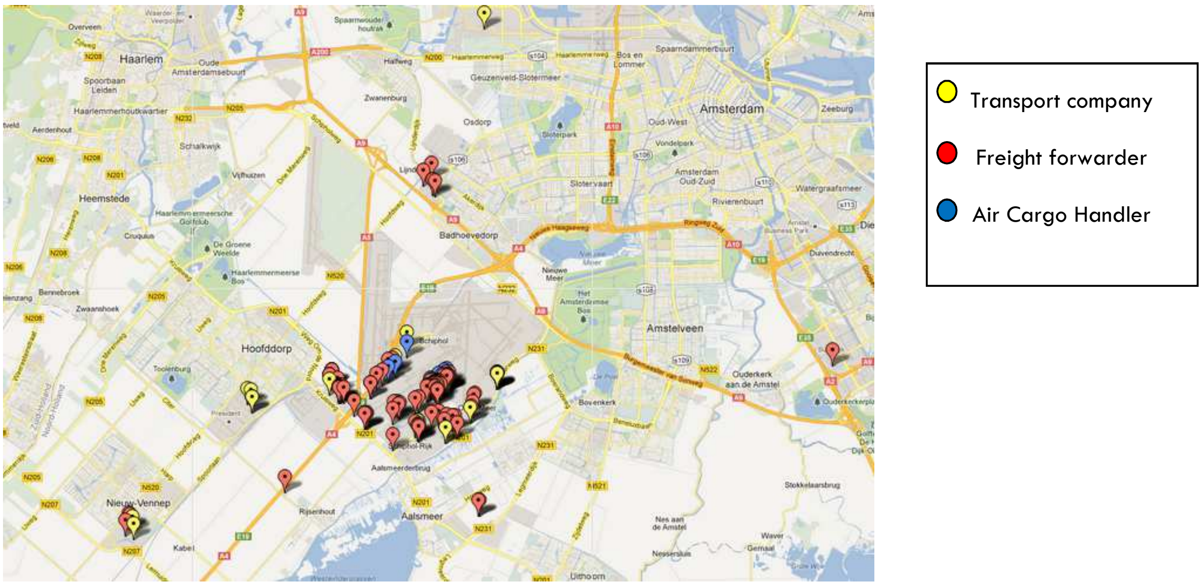

Figure 8: Overview of locations of potential stakeholders for this research.

3 SUPPLY CHAIN COLLABORATION

In this chapter current and future supply chain development in relation to the use of collaboration for transport logistics will be defined based on existing general literature and several cases examples both on vertical and horizontal collaboration for logistic operations in selected industries will be analyzed. This analysis is needed to obtain better understanding of application and development of both horizontal and vertical collaboration and to obtain information about case examples of collaboration in other industries. Next to that this chapter can help define factors for collaboration which can be formulated as KPI's, which can be used to compare logistic concepts the effect of different logistic concepts. By understanding the different reasons for applying and support horizontal and vertical collaboration on transport a better value assessment of horizontal collaboration for air cargo transport can be made.

3.1 SUPPLY CHAIN MANAGEMENT DEVELOPMENTS

The shift of transport & logistic operations and planning from within individual companies to involvement of all stakeholders from productions to product delivery to end costumer has been developing over the last thirty years (Mason, Lalwani, & Boughton, 2007). To manage and support collaboration and involvement of logistics between companies, the supply chain management approach has been developed. Supply chain management is focused on linking and optimizing the flows of goods and related activities between the different companies involved in the physical exchange of goods(Mason et al., 2007). Whereas logistics management especially before the nineties in the previous century was aimed more at management of financial, managerial, information and physical systems to organize the flows of goods in time and space within a company (Visser, 2009). The shift from an individual company focus to transport planning and control of flow of goods, to an integrated management of this flows between companies can be largely explained by the globalization of production and increase in mass production. These two developments have made it more challenging for large manufacturing companies to optimize and provide effective transport logistics by only focusing on internal transport and control management.

<u>Different strategies to support and improve supply chain management</u>

The way supply chain management is approached in a specific sector of relates to a large degree on the way companies relations are present with the sector and how complex the produced products are. Often the way these relations are supported is derived from the way the strategies for product sales are supported. Two distinct strategies that have and are still widely used based on (Mason et al., 2007) research are:

- Make strategy (vertical integration/hierarchy)
- Buy strategy (vertical dis-integration/market)

These strategies require a different management of the supply chain and thus relation between stakeholders. The make strategy often demands more control to ensure control over production in order to realize own production and the buy strategy requires less control as products/services can be bought from external companies. However it is not always the case that either vertical integration or complete vertical disintegration can achieve the best result of a supply chain management. This is why a third strategy has seen increase use within supply chain management, the integrated strategy (vertical synchronization/network). This third strategy is applied more often as more complexity, scale of operations and specialization of key partners of add value services within the supply chain can make it impossible to fully utilize the advantages of each involved company by only focusing on the make or buy strategy

<u>Partnership management in supply chain management</u>

The way partnerships within and between supply chains are managed, depends on many different factors, but a large part has to do with the time horizon of relationships and the intended economic effects of the relationship. Short term collaboration is often indented at obtaining minimal direct operation costs; the focus thus is purely on operational relationship. While true collaborative relationships focus on optimal value of costs for both parties, this involves both strategic and operational goals (Hines & Samuel, 2004). Due to the fact that supply chains are becoming more competitive in complex in the current environment often more long term collaborative relations are demanded in order to be able to realize the optimal balance between costs and benefits between stakeholders

(Lambert et al., 1996), However this insight has not been acknowledge by all firms that are heavily involved in complex supply chains.

Collaboration & Logistic service providers

The term collaboration has and will be used in this research and other reports many times, in order to avoid confusion the following definition of collaboration will be used in this research from on:

"Collaboration is as an effective, voluntary, mutually shared process where two or more actors work together, have a mutual understanding, a common vision, share resources, and achieve common goals "(Visser, 2009, p. 7)

In this research sometimes transport providing companies are defined as logistic service providers. In a sense all transport companies provide logistic services ranging from basic element of providing collection and delivery of goods to added value of services. Logistic service providers are transport companies that do not only provide or arrange transport services but can also provide added value services that utilize their expertise and support systems and resources.

3.2 APPLICATION OF VERTICAL COLLABORATION

Supply chain collaboration on vertical level with other companies has been the main type of supply chain management collaboration in the lasts decades. Companies within a supply chain have been using vertical collaboration, to make their supply chain more competitive, in relation to competing supply chains(Sahay, 2003). They have done this by optimizing the flow of information and goods between companies for different parts the value chain. In the fast moving consumer goods (FMCG) sector for example the current focus has still manly focusing on collaboration with key partners on a vertical level (Excel, 2010). The increased use of third party logistic providers by almost all major production companies in world has however reduced the competitive advantage that can be obtained by solely focusing on optimization of the supply chain by vertical collaboration and outsourcing of logistic activities. An increased share of products require a different approach to fit costumer requirements that are different from mass productions products (Jüttner, Baker, & Christopher, 2004). Vertical collaboration can in many cases still offer the best approach, to realize more effective and efficient supply chain solutions with key partners, especially when both the volume and frequency of shipments are high between companies. Also when the value and nature of the products requires more secure and restricted control of transport that cannot easily be realized in the same way when other types of collaboration are utilized, vertical collaboration is often still used. Even within companies the value of information and costs of being able to offer sharing information within and between companies is still often an obstacle, realizing more effective vertical collaboration between companies can therefore often still be improved. Companies or internal departments of companies are often still reluctant to share information even with supply chain partners (Barratt, 2004), as they often believe that sharing information could result in revenue losses, this could come from the information itself or the costs of be able to share such information (GCI, 2009). Next to this legal considerations and system compatibility can often make it more difficult to share information in the most effective way. When competitive gains related to logistic operations cannot be optimized anymore by further vertical collaboration often companies still focus their efforts on this type of collaboration, as they are reluctant to collaboration with competing companies and want to limit the amount of companies involved in their daily operations. It is thus often viewed much safer, stable and easier to collaborate on vertical level, because collaboration has already been established, abuse of collaboration gains is more difficult and long term relationship value is easier to assess. The application of vertical collaboration in the current supply chain has however in general changed from a strategic competitive advantage to a basic necessity that is needed to offer the same expected services as competing companies provide by utilizing vertical collaboration.

3.3 APPLICATION OF HORIZONTAL COLLABORATION

Horizontal collaboration within supply chain management can be defined as collaboration between companies that are active on the same level of the value chain. This means that these companies to some extent can be directly competing for the same costumer market. Horizontal collaboration across major industries is still only applied to a limited extent, as the challenges that exists for vertical collaboration are often more difficult to overcome in horizontal collaboration (Stephens, 2006) and the experience/knowledge about the application possibilities of horizontal collaboration are not widely known (Muir, 2010). Collaboration often is only supported when internal optimization cannot result in higher gains, to can be argued that horizontal collaboration is only supported in the current supply chain management environment when vertical collaboration benefits are significant lower than those that can be realized by horizontal collaboration. However the research of (Cruijssen, Cools, & Dullaert, 2007) shows that horizontal collaboration can not only reduce costs of core logistic activities, but also improve the effectiveness of companies related to core activities in some cases more than is expected. The application of horizontal collaboration is currently mainly applied for specific factors that differentiate between types of market in which a supply chain is operating. The research (Excel, 2010) for examples defines different horizontal collaboration factors for developed and developing markets, which are explained below.

Horizontal collaboration factors for developed markets.

In a developed market the key factors to apply horizontal collaboration are often directly related to operational challenges and costs the main factors are:

- to reduce transport costs
- the provide more reliable delivery than individual organization can
- to increase frequency of delivery to costumers without higher transport costs
- improve the environmental impact of transport logistics (sustainability aspect)

Horizontal collaboration factors for developing markets.

In developing markets there is often uncertainty about demand on the short and long term; also financial risks related to a full scale development of a dedicated supply chain for a new market can be very high. This can make it more attractive for companies to share risks of logistic operations and costs with multiple companies and be able to offer higher service level for its customers by utilizing horizontal collaboration.

The main factors are:

- the be able to offer a sufficient logistic service level with a limited volume of products in new markets
- to limit the risks in investments related to logistics operations (contracts, fixed and variable costs

3.4 FUTURE OF SUPPLY CHAIN MANAGEMENT

Supply chain management in major industries around the globe is becoming an increasing challenging and complex tasks as resources, regulations and customer requirements will increasingly demand higher flexibility at lower costs. This will demand a more diverse strategy on supply chain application of both vertical and horizontal collaboration (McKinnon, 2004; Soosay, Hyland, & Ferrer, 2008), in other words the complex environment requires continuous assessment of both horizontal and vertical collaboration concepts to find optimal balance in costs and quality of logistics operations. Based on literature assed above several developments in logistics which can explain the challenges at for managing a supply chain are defined and explained below.

Key developments related to supply chain collaboration focus

1. use of multimodal transport
2. rise of energy prices
3. pressure to improve sustainability of transport
4. congestion of road transport in major consumer markets
5. increasing demand for customization of products with short production cycles
6. demand of faster delivery thru more different channels
7. widespread use of external logistic service providers for value added services
8. development of ICT systems

The first three developments pointed out above are directly linked and are re-enforcing each other in positive way. Examples of collaboration cases that are being currently applied will be given in the next paragraph, which will relate to all eight points mentioned above. The rise of energy prices is making it more attractive to utilize multi modal transport; this development can directly reduce the environmental impact of transport. In order to realize effective and efficient use of multi model transport companies often have to collaborate on the planning and transport to multi model hub, as individual companies do not have sufficient volume of goods to sustain the use of multimodal transport system in effective way and efficient way. Transport for large costumer markets of goods are in urban areas are increasingly facing congestion of road infrastructure and local, regional and national governments are implementing policies that encourage combined use transport. Given the ongoing technology advances which are increasing both the possibilities for customization of products at lower costs and the higher awareness of consumers in relation to product choices, this will require more flexible and faster supply chains, as customization will reduce the production size of products and increase product offerings will make demand for products less certain. It is therefore becoming increasingly difficult even for major companies to be able to offer the right frequency of delivery at low costs for all of its customers. This is why more and more companies are not only using external companies for their transport needs, but also utilize their expertise to provide warehouse and value added activities for transport logistics. As pressure for reduction in logistic transport costs is still increasing and major logistic service providers work for competing companies more and more shared warehouses of major competitors are managed by one logistic service provider. The main challenge in current and future supply chains will likely be revolving around the ability to share relevant information between the companies involved not only in the own value chain, but which are combining demand and capacity for transport. With the increased pressure to reduce logistic costs the need for systems logistic systems that share relevant logistic information will only increase as third party logistic providers are increasingly in control of the key information flows of their costumers, they will make it possible to utilize this information to organize more effective transport logistics if their costumers support this development.

3.5 VERTICAL AND HORIZONTAL COLLABORATION PRACTICES IN SELECTED INDUSTRIES

In the introduction of this research collaboration practices using a shared transshipment facility was found within the fast moving consumer goods (FMCG) sector in the Netherlands (Groothedde et al., 2005). As FMCG goods also increasingly require flexibility and speed with low profit margins (Capgemini, 2010), this sector can be related to air cargo system to some extent. Based on research within a European project called collaboration concepts for co-modality (CO_3) the willingness of several sectors to support horizontal collaboration for their transport needs is derived. In the presentation (Saenz, 2012) based on consultation with over 100 key companies in Europe the following three sectors were defined as most supportive for horizontal collaboration:

1. FMCG & Food / Agriculture
2. Pharmaceutical & Healthcare
3. Chemistry

Part of the products of the sectors mentioned above are also using air cargo transportation and can have specifics that require fast and highly reliable handling. Products within these sectors can either lose their value fast (food, pharmaceutical, healthcare) or have such a high value of use that transport speed is needed to optimize benefits and reduce costs (chemistry or FMCG sector). Examples of the three sectors above will thus be used in order to interesting case analysis on horizontal collaboration cases.

3.5.1 FAST MOVING COSTUMERS GOODS (FMCG) COLLABORATION ON TRANSPORT RELATED ACTIVITIES

Collaboration practices on transport logistics related activities have been applied in many different ways within the FMCG sector, ranging from sharing of warehouses to transport directly to customers with supply chain partners, competing companies and non-competing companies of a different industry. The increased use of external companies to provide and support logistic activities has resulted in operational conditions where sharing of warehouses between similar companies and or transport helps to reduce costs and increase transport flexibility at the same time. The FMCG market is become ever more complex, demanding and uncertain for part of the users, companies within this sector therefore need to increase order fulfillment, be aware of changes in the environment, shortening product introduction times and reduce transport costs at the same time (Capgemini, 2010). In order to achieve this they need more volume and better supported logistic operations, which often can only be provided by specialized logistic transport companies that can combine cargo flows of different companies. Next to this producers within the FMCG sector are increasing their use of multimodal transport for both cost and sustainability reasons, often the use a combination of different transport means involves the use of transshipment facilities that are used by multiple companies, as only very large single producers have sufficient volume and frequency to operate their own multimodal services. These developments have increases the potential of horizontal collaboration to and from these transshipment facilities in order to obtain lower costs and higher frequency of the used services. Besides this development producers of high value products within FMCG sector have recently focused more collaboration attention on vertical level with key costumer's sales points. On shelf availability is becoming an important issue to make sure that end costumers can by a desired product without finding an empty shelve at the point of sale, hereby increasing revenue and costumers satisfaction (Trautrims, Grant, Fernie, & Harrison, 2009). The research (Groothedde et al., 2005) mentions three different types of intermodal transport use by Unilever, Bavaria & Coca Cola, which have failed in the past. Most of these initiatives were undertaken by companies individually, they had difficulty obtaining the right scale of operations in a costs effective way, given the infrastructure and operational flexibility within the organization.

Heineken intermodal transport use

The Heineken multi model transport case, is one of the most successful collaboration between a transport company, producer and the harbor of Rotterdam within the Netherlands. The largest brewery facility of Heineken in the Netherlands at Zoeterwoude switched from transport with use of trucks to the Rotterdam harbor to transporting its containers for part of the journey by the use of inland ships. Volume and frequency of cargo largely contribute to the success of this intermodal collaboration, in this case the volume of goods produced by Heineken alone is so high and continuous that this alone already supports the viability of the multi model transport. Besides this the support of the harbor of Rotterdam by leasing the land for terminal to logistic service provider that is in charge of the terminal has also contributed to the success of this collaboration. The costs and risks were made lower by setting the specifying the leasing contract for duration of several years (Greenport, 2011). Heineken currently uses the facility only for export flow, therefore there is currently an imbalance, as no import costumer flow has yet been established, but several companies are at the moment looking at the possibility of using the transshipment facility that Heineken uses for its export transport for their import transport from the harbor of Rotterdam.

Key factors that influence the support collaboration in FMCG sector that have been identified both on the Heineken case and other consulted literature are:

- increased complexity of transport demands
- delivery time/frequency challenges
- pressure to reduce transport costs
- use of external transport company to transport and organize logistics activities
- increasing use of multi modal transport
- on-shelf availability
- logistic hub owner support collaboration
- one directional flow of goods

<u>Relation to air cargo system</u>

A large part of the customers of large producers of FMCG have several large retails/supermarket chains, as main costumers, working together with competitors on transport to key customers can often result extensive reduction in costs, as destinations are often similar between major competing companies. This can be viewed in a similar way to export for air cargo shipments to a specific air cargo handler, as different freight forwarders/ or shippers for one destination have to utilize the same air cargo handlers and will need to deliver their goods within the same time. Besides this the average air cargo shipments weight is also decreasing while volume is increasing and margin for air cargo are going down. This can present a similar dilemma and support for collaboration with both the air cargo and FMCG the sector, as lower transport costs and faster delivery can only be achieved with bundling of cargo shipments from competing companies to similar destinations, given the decrease in weight and amount of shipments per order. Also the time between ordering a product and time it has to be shipped are short for both air cargo shipments and key products from FMCG sector. The nature of products within the FMCG sector is like air cargo goods flow one directional, it can be that products will be later recycled, but generally products are not collected as return shipments with same type of transport means.

3.5.2 FLOWER TRADE COLLABORATION ON TRANSPORT LOGISTICS RELATED ACTIVITIES

Traditionally international flower trade has mainly been using air cargo transport, as alternative forms of transport could not guarantee high quality transport within short transport time. Changes however in technology and increased costs of fuel have resulted in changes to the way flowers can now be transported between countries on one continent and even between continents has resulted in use of other forms of transport. For certain types of flowers transportation the use of sea containers on Atlantic crossings can save both on costs and emissions for the entire transport, while maintaining a high quality product for arrival (Harkema & Mensink, 2009). In traditional supply chain of the flower trade producers of flowers ship their flowers to flower auction, where the flowers are sold and transported either directly to customers or are transported to third party warehouse before being transported to its final location. A large part of flower producers is already using third party logistic service providers to transport their flowers to the auction location, but still about 33% of transport to auctions is done by flower producers themselves (Cruijssen & Salomon, 2004). Due to the time sensitive nature of the flower product, vertical collaboration between stakeholders has always been an important aspect for maintaining a good functioning business. However the increased use of different types of transport, congestion of truck transport infrastructure at busy moments at the main actions and complexity of product demand and related services will be required further more extensive support collaboration efforts within the sector. Three collaboration concepts that are currently applied in the Dutch flower sector on transport logistics will be briefly discussed below

Greenbarge inland shipping concept

Is a concept which is being currently trailed in The Netherlands, the concept uses inland shipping transport for short distances (from region of Amsterdam) towards/from the East of the Netherlands. The concept is supported by a selective group of companies involved in the floriculture business. The concept is used as an alternative for only utilizing truck transport. The idea is to utilize both existing and potential new terminals on inland ship transport operating services within the Netherland(Dinalog, 2012). The service is not dedicated to use for flower related cargo only, but tries to utilize cargo demand for other non-cooled containerized products in order to increase the amount of cargo that is transported on the used services and reduce the transport costs. The pilot that is currently being trailed want to demonstrate that short distance ship transport can be a cost effective alternative for road transport.

Greenrail long distance rail collaboration.

This is an initiative of flower auction FloraHolland and the association of wholesale sales of flowers and plants. The idea of this concept is to test the operational suitability of multimodal transport for medium to long haul destinations with the use of train transport for part of the journey(Greenrail, 2011). The project is currently in its second phase as the first set of projects was completed successfully and has resulted in the weekly transport of flowers by rail to Hungary, Romania and Italy with the a single special designed reefer container onboard a scheduled train. After the first pilot, the first commercial services has been set up to Italy from Venlo using a weekly train service, up to 5 containers are transported per week using the rail service. The concept has proven to be; cost effective, environmental friendly (50% reduction of $C0^2$) and reliable (97%) of the shipments was delivered on time compared to traditional truck services.

Dutch Agricultural Virtualized International Network with Coordination, Consolidation, Collaboration and Information availability (DAVINCI).

Is a project started in 2011 with aim of making the Dutch agriculture sector more competitive in the virtual trading network of flower trading. This development has resulted in research about new logistics concepts and assessment of current practices, which have been discussed in previously mentioned paper of (Vorst, Bloemhof, & Keizer, 2012). As traditional flows of flower transport are changing in relation to use of auction centers, for the Netherlands need to maintain its position as a large player in the agricultural sector it is needed to be a front runner supporting innovate ways of trading of flowers that occur without a physical flow of flowers via auction location within the Netherlands.

Several measures have been identified to increase success of collaboration within the Dutch flower based on the analyzed concepts:

- start with existing routes and services for other products, to trail operational effectiveness
- start with collaborative transport to best suitable markets given the operational conditions that are required,
    - large international markets
    - transport to auctions
    - transport to large costumers
- support innovative projects ahead of competition

Besides this the research of (Vorst et al., 2012) identified key challenges with the flower business has to face in relation to logistic operations within the Netherlands

- strong dynamics and uncertainty in supply and demand
- differentiated logistic concepts are needed related to support all sales channels
- increased need for advanced information systems that can share information between parties
- collaborative distribution challenges (push/pull)
- collaborative bundling of transport

<u>Relation to air cargo system</u>

Similar to the air cargo system, flower transport can only be arranged a short time before the product is needed or ordered, as value of the products in flower sector cannot easily determined before a certain moment. Often the value of air cargo shipping also only becomes known when alternative forms of transport do not perform as intended or products problems occur that require immediate attention. In this way it is difficult to match demand and capacity for both the air transport, as for the needed truck transport from the shipper to the airport. This can be viewed in a similar way for the flower transport from flower producers to auction locations, only just before transport is needed will it become clear from which producer's collection to the auction has to be arranged. The Netherlands has the largest flower market in the world. For flower trading the Netherlands has two main centrally located locations for trading of flowers and is facing changes in use of transport modalities and routes, which can in future mean that the physical flower product will not be handled at an auction, but instead direct transport from producer to costumer is utilized. The increase used in different modalities and bypassing of certain stakeholders in the value chain can be also be related to the challenges the air cargo system is facing at Schiphol, with the direct transport of airlines to freight forwarder/costumers at locations outside the airport at which the air cargo is actual flown to (import). Traditional freight forwarders in the air cargo system can also be viewed as auction centers of the flower business, where up until now the need to physically handling air cargo shipments and documents at forwarder before onward air transport (export) of most of the air cargo shipments is decreasing, as the documentation process can more and more be realized in digital way and cargo bookings can be done directly with an airline without the intermediation of a freight forwarder. The facilitating of a digital booking system for flower trade by auction house Flora Holland show and three explained cases of collaboration within the Dutch flower sector show that compared to the air cargo sector in the Netherlands the flower sector is much more already supporting and developing new digital and multi model concepts to improve the competiveness of the sector than that is happing the air cargo sector. Part of this can be explained by the direct involvement in financial term of the producers of flowers in the auctioning of flowers, so when traditional auctions become less competitive it is in the interest of the flower producers to support more competitive auction systems and related logistics in order to improve their financial return. In the air cargo system the shipper of air cargo normally has no direct financial investment in other stakeholders of air cargo system and traditional freight forwarders still control the market.

3.5.3 PHARMACEUTICAL INDUSTRY & HEALTHCARE COLLABORATION ON TRANSPORT LOGISTICS RELATED ACTIVITIES

In the pharmaceutical industry many different flows of both information and goods exists (Pedroso & Nakano, 2009). Products can be delivered directly to end costumers or will go between several warehouses before they reach their end costumer. Many large research and production facilities of pharmaceutical products are clustered around specific areas and consolidation in healthcare providers is also taken place, this gives opportunities for competing companies to utilize shared transport logistics between major production and costumer markets of pharmaceutical products. Next to this further distance markets that do not realize sufficient demand for products from one pharmaceutical company can be better served by multiple companies, in order to provide the right service level at the right price(PT.com, 2011). However collaboration within the pharmaceutical industry is still focused on vertical collaboration with key supply chain partners, by optimizing information about orders and delivery of products(Christiansen, 2003). For healthcare sector logistic related to medical technology products, the publication of (NRI, 2010) point out that medical equipment sector is lagging behind in the way it supports and utilize supply chain management and its related logistics. Four issues for the limited development of logistic collaboration are given by NRI research:

- the use of the supply chain is not regarded as a driver for success
- there is a high involvement of third parties in value chain,(not being producers)
- lack of transparency in the supply chain
- lack of complete system approach towards improvements

Healthcare Logistics Forum (HLF) concept

The healthcare logistic forum is a platform that can be used by manufacturing and distribution companies in Europe that are active in healthcare industry in order to discuss common problems and challenges form a supply chain and logistic perspective(HLF, 2012).

Key factors for support collaboration on transport logistics defined by the HLF forum are:

- Reduction of transport costs
- Ability to serve small markets with strict transport requirement (speed and reliability) even with low volume and frequency of own product flows
- Ability to better satisfy frequency and flexibility of major customers without higher transport costs

Relation to the air cargo system

The focus on vertical collaboration where possible and limited transparency within the supply chain combined with high power of third parties as defined in the healthcare sector can be for large extent related to the air cargo system. Shippers of air cargo still have to use traditional freight forwarders in order to reach their customers with the use air cargo transport and forwarders are trying to create more transparency in a limited way in order to limit the ability of shippers to utilize other forms of collaboration directly with airlines. The limited system view of related to supply chain is much less present in the air cargo system at Schiphol. Schiphol airport is actively trying to not only improve its inbound and outbound procedures, but is also trying to arrange better operational process at large connected airports that produce large inbound or outbound flows of air cargo. The Healthcare Logistic Forum concept can be viewed as part of the facilities ACN provides to its members at Schiphol. Member companies of ACN can discuss logistic and supply chain challenges openly with other members at ACN to come up with supportive solutions by multiple companies.

3.5.6 CHEMISTRY COLLABORATION ON TRANSPORT LOGISTICS RELATED ACTIVITIES

In other sectors like the chemical industry the potential for horizontal collaboration has defined as very high, this mainly has to do with the fact that vertical collaboration cannot achieve similar efficiency gains anymore. Vertical collaboration with the chemical industry has been successfully applied by major chemical product producers, major involved logistic companies and large customers. Currently the advantage of applying vertical collaboration is still much more visible and obtained faster than application thru horizontal collaboration. As for large part of the chemical industry the scale of chemical production facilities to keep producing around the clock often justifies specific transport collaboration with one logistic service provider, given the high production volumes(MacGregor, 2006). However another large part of the chemical industry focus on small production of specialized products of high value, which could be more supported by horizontal collaboration (Visser, 2009). However in Europe for example many logistic service providers active in the chemical industry are small sized companies that lack the resources or expertise to provide complex arrangements that utilize horizontal collaboration concepts. The complexity of realizing horizontal collaboration is also much higher and influenced by not only direct hard operational factors, but also by soft factors which are much more difficult to measure or influence(Reniers et al., 2010).

Important soft factors related to the applicability of horizontal collaboration according to (Reniers et al., 2010) are:

- openness between companies
- trust
- cultural fit between companies
- external willingness to collaborate

Investments in chemical facilities are often high and extensive collaboration in the chemical industry is not focused on transport logistics alone. Collaboration can also be supported in order to have a better return on investments or a better market position. Several potential logistics collaboration measures are proposed for both horizontal and vertical concepts in the chemical industry based on (McKinnon, 2004)

<u>Vertical collaboration</u>

- increasing the degree of bulk products shipments
- increasing price to pay for distribution based on more complex customer requirements
- providing vendor managed inventory services to customers

<u>Horizontal collaboration</u>

- develop swap arrangements
- pooling of logistic resources
- improving back loading of vehicles and containers
- raise the level of supply chain skills in the chemical industry

<u>Relation to the air cargo system</u>

The chemical industry is characterized by stability of production flows of chemical products; this makes the demand for transport much more certain from production facilities than the flow for air cargo products. The main similarity of air cargo system related to logistics is that chemical production often relates to one dimensional flow of products, just like air cargo shipments normally are only transported by air in one direction. Also both the chemical industry as the air cargo sector around Schiphol are supported by a wide range of logistic service providers for transport needs that often lack the individual scale and knowledge to fully support complex collaboration concepts for logistics, as they are often specialized in providing a specific type of transport service for one or more large costumers.

3.6 CROSS SECTOR REMARKS ON LOGISTIC TRANSPORT COLLABORATION APPROACH

The paper (Reniers et al., 2010) introduced the term collaborability, which relates to ability of a company to either utilize vertical, horizontal or combination of both types of collaboration. According to this analyzed article horizontal and vertical collaboration cannot be researched and applied independently. Especially when suitability goals are the main objective, the focus on benefits of collaboration should therefore not only relate to short and medium term cost but also to long term, direct and possible benefits. All of the analyzed collaboration concepts above in the different industries acknowledge that there is potential for improving the supply chain by supporting more horizontal collaboration in the future. As it became clear from the analysis of the different sectors the development of horizontal collaboration on logistics is still not supported as much as vertical collaboration is.

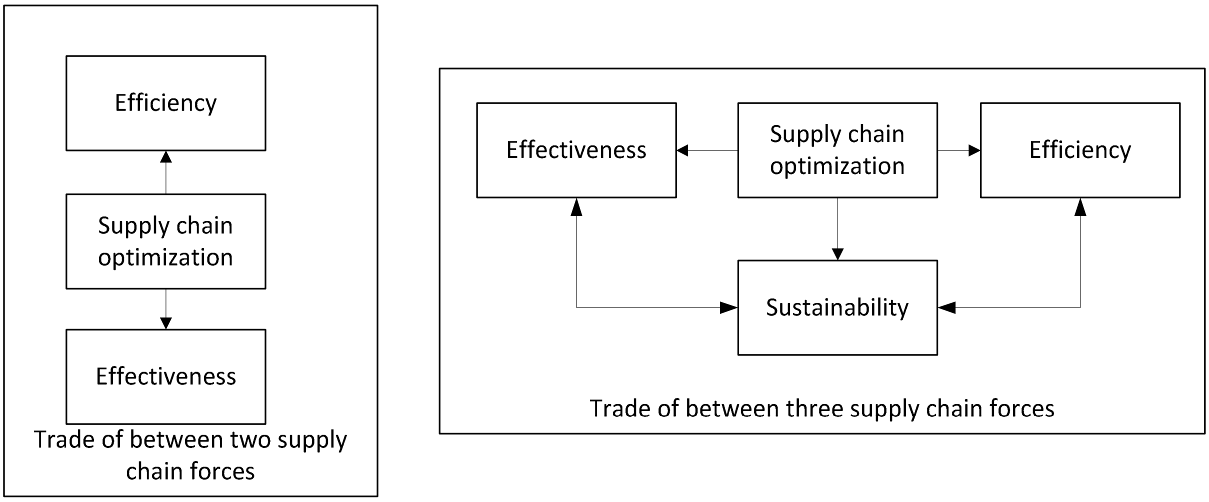

Figure 9: Difference between supply chain optimization focus on two and on three aspects.

In all sectors the major driver for implementing horizontal collaboration has related to three important aspects of logistics that can be often be positively influenced by the application of horizontal collaboration given the current supply chain developments, these aspects are

- transport costs (related to efficiency of supply chain)
- transport operations demands (related to the effectiveness of supply chain)
- sustainability of used transport (related to difficulty of using transport capacity by one company in effective way)

Figure 9 above shows the important aspects of supply chain optimization, as most companies are currently focusing not only on effectiveness and efficiency but also on sustainability it becomes much harder for companies to optimize the supply chain from individual companies system on all three aspects effectively. This means that in logistics operations, where sustainability factor is of limited importance, it is much more likely that vertical collaboration will be supported than in operations where sustainability is also important factor. While focusing on either efficiency or effectiveness, can be achieved by applying vertical collaboration, the inclusion of sustainability makes it often impossible to realize gains for all three aspects by individual company related to its transport needs.

Besides these aspects in several cases it has been identified that horizontal collaboration can:

- improve effectiveness of secondary logistics operations processes (stability of flows)
- improve the effectiveness of both core and non-activities of involved companies (only focus on special transport needs)
- reduce investments that are needed in logistics (systems and interfaces have less interfaces to be adapted for individual companies)

Given the fact that collaboration with external parties in certain areas can be better realized by another company by either its resources availability its expertise or combination of both, this makes it possible for the other involved company to more effectively utilize its resources and expertise in other areas(Visser, 2009). Part of the challenge in future improvement of collaboration in transport logistics in analyzed sectors can often only be improved if the current focus on reduction of direct costs will not be the main focus anymore. As this direct costs focused leads to no pro activity behavior and risks taking, making the logistics activities in the end less competitive on the long term(Visser, 2009). As key costumers of sectors that rely heavenly on the of transport logistics are faced with increased choice and information availability for costumers, this puts much more pressure on companies to perform according to customer requirements(M., 2005). In a sense, customer awareness and control is forcing companies to improve the effectiveness and efficiency of their logistic system and this will be often realized more and more via collaboration on a horizontal, vertical or both levels as individual efficiency improvements can't realize the same effect. Knowledge and expertise about the applicability of horizontal collaboration concepts is still limited at best in sectors were this type of collaboration can be best applied. Most of the analyzed literature is focused on identifying the factors that support horizontal collaboration in different sectors and highlight that the actual cases of horizontal collaboration in different sectors is very low.

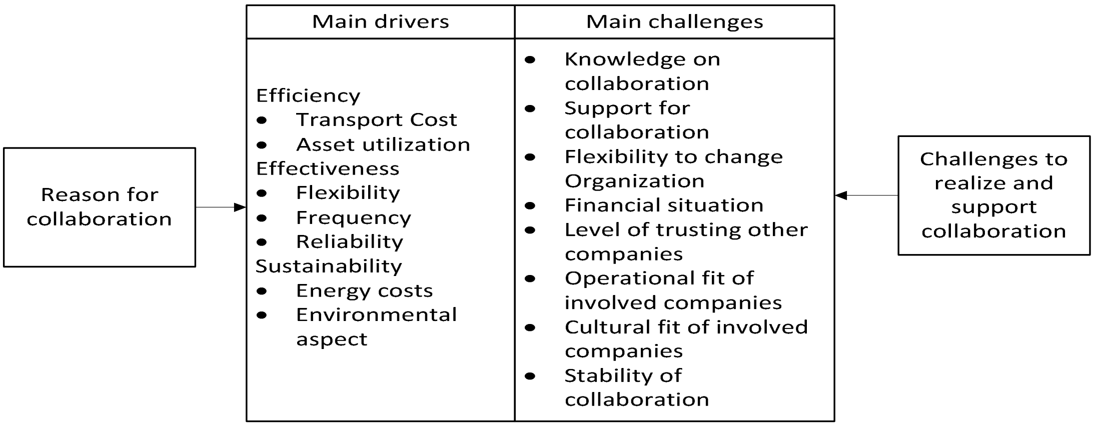

Figure 10: Key reasons for collaboration on logistic transport and the challenges to support collaboration

Figure 10 above tries to capture the main drivers based on the different analyzed sectors to collaborate on logistic transport activities. As pointed out in previous Figure 9 the sustainability driver can often only be realized in combination with the other drivers when horizontal collaboration is applied. The challenges mentioned for realizing and maintaining collaboration can be related to both vertical and horizontal collaboration, but are much more important for horizontal collaboration. As horizontal collaboration is often much more difficult to realize and maintain these main challenges should be well considered before realizing horizontal collaboration.

4 THE PRESENT AND FUTURE OF THE AIR CARGO INDUSTRY AROUND THE GLOBE

In this chapter the most important recent and current are cargo airport developments of major competing airports of Schiphol and air cargo developments around the world are described. This is done in order to asses to which extent logistic transport from an airport is considered/valued by airlines in their decision to operate from an airport, an analysis on the most important factors of cargo operating airlines is conducted on the basis of current literature. Directly competing cargo airports and airports that are similar in relation to Schiphol airport operations on cargo and passage operations are analyzed more in detail in order focus more on specific relevant airports for this research. Finally the most important internal as external developments for Schiphol airport are defined, in order to relate this developments with other airports challenges and air cargo airlines preferences.

4.1 MAJOR AIR CARGO AIRPORTS DEVELOPMENTS

Cargo airport developments in the last decade in Middle East and Asia

Airport development in the last decade has been very extensive in the Middle East and Asia compared to developments in other established air market continents. The development of industrial and manufacturing plants and new infrastructure transport has in Asia has contributed to large growth for both passenger and air related air transport services. In the Middle East strategies by governments to diversify their economy have resulted in extreme growth rates of three Middle Eastern airlines that are involved in both passenger and cargo services (Emirates, Etihad & Qatar Airways). In Dubai for example a new airport has been constructed between Dubai international airport (DXB) home of Emirates airline and the Abu Dhabi international airport (AUD) home to Etihad Airways, this new airport will be able to handle up to 12 million tons of air freight a year when fully completed and this volume is added to 3 million tons of cargo that can already be handled at DXB. To put this in perspective this is 3 times the amount of air cargo currently handled at the biggest air cargo airport in the world Hong Kong International airport (HGK) (EVA, 2012), and HGK is positioned right between major production facilities of Asia, which provide both North America and Europe with large extent of consumer and industry products that are shipped by air. Airports like DXB were previously mainly used as a location for technical stops from EU to India flights, due to range and operational constrains, but are now being used as a gateways Africa and destinations in other continents that are too far apart to offer competitive nonstop services from other locations. Also the Middle Eastern airports around Dubai are located in the right position to provide a combination of sea/air transport services from many major Asian port destinations via sea transport to Dubai and air transport to Europe, which has been used for high value non-time critical goods in the past few years. Airports of Singapore, Hong Kong and Seoul have also seen large growth for sea air combined transport services, for certain types of goods.(Lee & Yang, 2003a; Raguraman, 1997)

Restrictions on development of well-established airports

Major airports in established markets have been represented in the top 100 air cargo airports around the globe for decades due to; long lasting trade relations, consolidation and merges in freight business and the developments of passenger related air services. The position of several established airports as major cargo airport will be challenged in the near future by new emerging airports, as requirements for air cargo operations are becoming ever more complex and conflicting with legal and other operational constrains at hand at established Western airports. Regulations related to night operations, expansion of existing airports and the development of new airport infrastructure in less established markets can shift the demand for air cargo away from the currently preferred airports in well-established air cargo markets.

Use of large airport cargo hub and specialized cargo airports

Major freight forwarders and integrators have been developing global networks in the last decades that are operating from major airports, these developments directly and indirectly put competitive pressure on airports via the airlines that operate at these airports. To say it in a other way: global networks can only be competitive if the actors within the network are efficient, and capable of meeting requirements relating to speed, punctuality, reliability and the availability of storage space(Neiberger, 2008). This can partly explain why several large cargo airports around the globe have recently or in the past specialized their operations for certain type of cargo operations. Key examples are the development of FedEx express hub in Memphis (MEM), the establishment of the hub TNT at Liege airport

(LGG) for the express operations and the move of the DHL Europe hub for express flights from Brussels Zaventem airport (BRU) to Leipzig/Halle airport (LEJ) for its European hub in 2006. The increasing cargo capacity in passenger aircraft and mixed us full freight carriers, integrator carriers and passenger carrier flights for air cargo shipments makes it harder for smaller non specialized cargo airports to be seen as attractive location for air cargo operations. As airports that can offer a wide arrange of different type of air services on a large scale and with limited restrictions for operations are able develop business related activities at the airport that can in itself attract more business to the airport, this can have a positive self-enforcing effect on the attractiveness of an airport. A key example of an airport which has been succesfull in realizing this is Schiphol airport. Schiphol has been one of the first airports that has applied the airport city concept, which tries to make the airport surrounding not only attractive for flight operations, but also for business and leisure related activities at and around the airport. These developments can also why many smaller cargo airports see only a limited amount of actual air cargo flights, most of the air cargo is actually trucked to and from the airport and is only flown by air from a major other air cargo hub.

International and domestic use of air cargo transport

Products that used to be shipped by air are more often transported via other slower means of transport that offer a more cost effective solution (Loadstar, 2013). This development has been further strengthened by recent air transport distributions around the world, which revealed the dependence of companies on air cargo transport. Based on these developments large shippers of shipments that used air cargo transport have redeveloped their supply chain transport. In the United States currently there is still a large degree of air cargo flown not internationally but instead only domestically, again due to increasing cost of fuel and other operating expenses and better organized alternative transport means, a shift is expected in the near future from air cargo to road transport for goods that were previously transported by air. FedEx the largest airlines in freight ton kilometers for domestic operations for example has recently announced a 1.7 billion restructuring plan which shows that there is an expected decline in the next 10 year for air cargo demand in the United States and they state the shift from using more ground transport, especially for domestic cargo is not temporally but permanent (BOMKAMP, 2012)

Movement of production around the globe shift within Asia and Europe

20 of the 100 largest air cargo airports in the world are currently located in greater China, this includes two of three top air cargo airports which are Hong Kong International airport (HGK) (ranked 1st) and Shanghai Pudong International airport (PVG) (ranked 3rd) based on traffic figures of 2011. In China the government is actively encouraging to shift production from the east to the west of the country where both wages and land costs are much lower than in the Eastern part of China. This has already had a big effect on the growth of airports in the West of China and resulted in lower growth at established airports in East of China (Appold & Kasarda, 2011). These kind of developments could also result in Europe and other parts of Asia in the use of different airports than the preferred airport at the moment for air cargo operations. In the European Union factory production a big part of the production capacity of high value products has already been moved from West to Eastern Europe and this can thus justify under some conditions the use of alternative airports. In general growth of the air cargo industry in the last decades can be almost directly be linked to the general growth of international trade, which has led to higher wealth and related spending of consumers on air freight transported goods. Also to the development of truly globally connected supply chains, which have been increasingly utilizing the air transportation for business to business (B2B) goods for their global activities (Bridger, 2009), as has been defined as the 'the airlinked assembly line has contributed to air cargo transport growth. Globally operating companies have also been increasing the use of air cargo transport for the introduction and trail of products in new markets, afterwards when sufficient demand has been created in a market the supply chain of the company can be changed to utilize less expensive means of transport compared to air transport(Saghir & Hoekman, 2009). Many factories, which were operating from Western Europe production facilities producing electronics and other high value have been moved to Asia in the last decades, this has actually had a positive effect on the growth of air cargo transport to Asia from Europe. The large distance between Asian production facilities and the consumer market in Europe can often justifies the use of air transportation for part of the high value produced products. Recently however more and more companies that were active in Western Europe before are moving part of their production to Eastern Europe (Eurostat, 2011). The combination of low labor cost and improved transportation infrastructure in Eastern Europe can explain part of this movement, but also rising energy costs and labor costs in Asia contribute towards this change in production locations. Many global companies have already established factories in Eastern Europe and this trend is likely to continue, this is expected to generate growth for air cargo transport to the countries where the factories are build and

will possibly lower growth of air cargo transport from major Western European airports, as cargo can easily be transported by truck to Eastern Europe countries.

<u>Movement of European distribution centers</u>

Major airports attract and support both economic activities that are directly related to aviation business and those that benefit from the infrastructure and companies that are based around the airport. This is why large international distribution centers are usually found near major airports or other transport hubs. These distribution centers can utilize the transport infrastructure around the airport and use the air services provided from the airport, of course this alone does not always justify the creation of major distribution in a specific area. Other important factors related to the decision of building a large distribution center are; level of company tax, availability of workforce, geographic location and cross country trade conditions have to be good compared to other locations justify the investment in economic and operational effective way (Duijvendijk, Huitema, Lenders, Pronk, & Plante, 2003). Schiphol airport in collaboration with the Dutch government has in the last decades developed an environment that has provided excellent conditions for companies to base their European Distribution Center (EDC) around the airport or in other parts of the country. The Netherlands as a whole has been very succesfull in attracting and maintain EDC's in Europe, currently about 50% of EDC in Europe are located within the Netherlands(Mazars, 2011). Most EDC's are used by international companies from outside Europe, which can thus result in additional air cargo movements to airports close to the EDC's location. In recent years the preferred location for EDC in Europe and within the Netherlands has however shifted more to the East (Duijvendijk et al., 2003). This development is expected to continue and will probably results in optimal location being located outside the Netherlands. This shift has to do with the shift of production to Eastern Europe, the improved logistic infrastructure in Eastern European countries and the lower operating costs of EDC's in Eastern Europe. This development and the shift of production facilities to Eastern European countries can be seen as big threat to air cargo growth in Western Europe as both aspects are important for the generation and support of air cargo demand.

4.2 FACTORS FOR CHOOSING AND MAINTAINING AIRPORTS AS AIR CARGO DESTINATION

Based on the analysis of the previous paragraph several different aspects, which can be important for choosing airport as an air cargo destination could already be defined. To ensure that the most relevant factors are included in this research and are related to the value of improving logistic system of ground handling at Schiphol airport, a literature review on airport selection of airlines involved in cargo operations is conducted in this paragraph. This will result in an overview of the key factors that influence the start, complete switch to other airports or change of the frequency of flights to a certain airport for cargo operations. Ofcourse the importance also depends on the type of airline involved in the transport of cargo, as express, full freight or combination of passenger and freight service airlines have different requirements and operation characteristics (Zhang & Zhang, 2002). Factors related to cargo operations for airlines are based on variables that can or cannot be directly influenced by the airport that is considered. Factors that are outside of the geographic or direct managerial influence are considered external and factors that can directly influenced by the airport are defined as internal factors. Several factors can be however influenced by both airport and other stakeholders, these factors will be defined in third group which can be either internal or external influenced. A total of 22 factors have been delivered from the literature, which will be presented below. This will be followed by overview of the most important factors, based on the frequency of the factors occurring in literature and the importance assigned to certain factors in the two analyzed papers that used a survey (Gardiner & Ison, 2008; Gardiner, Ison, & Humphreys, 2005a), these will be presented in Figure **11** at the end of this paragraph. The complete list of factors is presented in three tables in Appendix A for key factors, possible key factors and minor factors. The most important identified factors will now be defined below.

External airport factors

- weather conditions at the airport, most important for time sensitive air cargo operators such as integrators(Cosmas & Martini, 2007)
- government intervention/ bilateral flight agreements(Zhang & Zhang, 2002)
- extent and quality of Regional and national infrastructure landside access(Gardiner & Ison, 2008; Zhang & Zhang, 2002)
- large costumers request to relocate to new airport (Gardiner et al., 2005a)

- airport location (Gardiner et al., 2005a) (Gardiner & Ison, 2008)
- amount of intra airport shuttle services(Hall, 2002; KISO & DELJANIN, 2008)
- amount of local demand for air cargo(Gardiner & Ison, 2008; Gardiner et al., 2005a; Zhang & Zhang, 2002)
    - regular cargo demand
    - seasonal cargo demand

Internal airport factors

- airport charges(Gardiner et al., 2005a; Zhang, 2003b)
    - general fee
    - startup fee(Gardiner & Ison, 2008)
- airport reputation (Gardiner et al., 2005a)
- airport dedication to cargo operations(Gardiner et al., 2005a)
- airport infrastructure operation efficiency (airside/landside)(J. T. Bowen, 2004; Gardiner et al., 2005a)
    - average time to deliver air cargo from platform to handler
    - average time to process air cargo at handler
    - average time to collect cargo at handler
- freight forwarders active around the airport(J. T. Bowen, 2004; Gardiner et al., 2005a)
    - amount of freight forwarders
    - amount of partnerships with freight forwarders
- amount of passenger flights with cargo volume or potential(Gardiner & Ison, 2008; Hall, 2002; Scholz & von Cossel, 2011)
- amount of full cargo flights (Gardiner & Ison, 2008; Hall, 2002; Zhang & Zhang, 2002)
    - total amount of cargo flights
    - total amount of cargo operators
    - destinations severed by competitor
    - amount of handling capacity used at airport(Yuan, Low, & Ching Tang, 2010)
- airside operations possibilities for integrators(Neiberger, 2008)
    - amount of airside locations open to freight forwarders
    - amount of airside collaboration practices supported at the airport
- airport capacity short & long term(J. T. Bowen, 2004; DHL, 2008)
- airport road access(Gardiner, Ison, & Humphreys, 2005b)

Factors that can involve both internal airport external stakeholders' decisions

- active engagement of airport authority with local and national businesses to use airport for air cargo operations (Gardiner et al., 2005a)
- environmental costs (Gardiner & Ison, 2008)
    - landing charges based on type of aircraft
    - landing charges based on arrival and departure time
- environmental restrictions
    - operating times/ban based on type of aircraft(Gardiner & Ison, 2008)
    - operating restrictions based on arrival and departure time(Gardiner et al., 2005a; Marsh, 2009)
- intermodal infrastructure options near the airport(Gardiner & Ison, 2008; KISO & DELJANIN, 2008; Lee & Yang, 2003b; Zhang, 2003a)
    - amount of transshipment facility for road transport
    - amount of transshipment facilities for rail transport
    - amount of transshipment facilities for water/sea transport
- amount of value added logistics service offered at or near the airport(Yuan et al., 2010)
    - amount of manufacturing location near airport
    - amount of large warehouses of global companies near the airport(Raguraman, 1997)

Based on the factors that were defined, the most important factors that either were mentioned by several different sources or were defined as crucial have been assigned to specific aspect of air cargo operations to and from an airport in Figure 11 below.

Factors for choosing airport	Key factor
forwarder aspect	Amount of forwarders at airport [12]
Airport aspect	Operational conditions related cargo operator needs [16] | collaboration with business to attract air cargo [10/18]
Airline aspect	Operating competitors airlines at airport (amount/freqency) [13/14]
Transport time	flying time from connected airport(s) (location) [5]
Demand near airport	local air cargo demand [7] (yield and volume stability)
Handling aspect	handling time aircraft cargo (airport infrastucture stablity) [11] [23]
(Push)factors for switching airport	large demand switch, better facilities, lower charges, request of large customer[4], bilateral restrictions [2], night restrictions/ noise restrictions [20] and emission costs [19]

Figure 11: Key factors for cargo airlines to use or switch operations to and from airports

Next to these identified factors, given the difficult market conditions which both airlines and freight forwarders are facing now larger freight forwarders and airlines are now actively supporting partnerships on certain routes and destination with each other. This can also have a big impact the way air cargo handlers are utilized at major hubs. At Schiphol for example major forwarders are working more closely with airlines to optimize operations at both the departing and arrival airport thru specific agreements about the handling and transport of cargo directly to their facilities. So not only the amount of forwarder is an important aspect but also the scale of their operations, as forwarders contribute directly to about 2/3 of the total air cargo revenue by fixed capacity contracts they buy from airlines for specific route and period (Koning, 2012). Besides this air cargo transport from secondary airports to major hubs via road transport is also becoming more and more attractive for freight forwarders to use based on pricing, this can result in air cargo transport to Schiphol, but without the actual use of the air cargo handlers at Schiphol, transport can be directly to freight forwarders facilities. Based on literature analysis above the amount of handlers and the handling capacity should have a positive impact on the choice of airlines to operate from a specific airport. This is however only the case in healthy business environment, this thus means that should be sufficient capacity and balance between demand for price on which companies can operate their facilities with sufficient staff and quality. In the case of Schiphol airport this can currently be questioned, as there is a major over capacity of handling operations, most staff at the handlers are flex workers and the handling costs have been declining for year while the fixed costs of stayed the same or risen. More about the handling capacity and facilities will be explained in further analysis of this research in other chapters of this research.

4.3 COMPARISON OF COMPETING CARGO AIRPORT AROUND THE WORLD

Major air cargo airport in Europe

Currently four airports in Europe are present in the top 20 air cargo airports of the world, based on the air cargo volume that was transported thru the airport in 2010, for the complete data list and comparison see (Appendix B):

- Paris-Charles de Gaulle (CDG) ranked 6th in the world / 1st in Europe
- Frankfurt airport (FRA) ranked 7th in the world / 2st in Europe
- London Heathrow airport (LHR) ranked 15th in the world / 3nd in Europe
- Amsterdam airport Schiphol (AMS) ranked 17th in the world / 4rd in Europe

Most major airports for cargo activities also have extensive passenger activities, which are used to feed the cargo related flights and vice versa. Large air cargo airports often have one or more major home carrier(s) that provide an extensive network of destinations for passenger transport. For this research airports that operate with a similar share of cargo volume in relation to passenger traffic are considered the most suitable for to study more in depth. In order to focus on a limited amount of airports on the basis two categories the three airports will be selected for further analysis. The categories are based on their similarity or cargo size compared to Schiphol or on their larger size of cargo operations and for each category the biggest airports of the major air traffic continents are considered (Asia, Europe, and North America).

Air cargo airports similar to Schiphol Airport

In order to assess which airports are similar to Schiphol airport the ration between passenger traffic and air cargo tonnage is calculated. A difference between the ratio at Schiphol of 30% is allowed in compare to a certain number of airports that are either similar in passenger, cargo or both operations. Data are obtained for the operating year 2010, using information from Airport International Council. In Appendix (B) the compete overview of airports analyzed and their ranking can be viewed. The airports marked in bold below are studied in more detail due to their size of the three analyzed continents.

Airports that are similar in passenger to cargo ratio are:

- **Paris Charles de Gaulle (CDG)**
- Frankfurt International Airport (FRA)
- Dubai International Airport (DXB)
- Singapore Changi Airport (SIN)
- New York John F Kennedy Airport (JFK)
- **Suvarnabhumi Bangkok International Airport (BKK)**
- Guangzhou Baiyun International Airport (CAN)
- Newark Liberty International Airport (EWR)
- Shenzhen Airport (SXZ)
- **Los Angeles Airport (LAX)**

Paris Charles de Gaulle Airport (CDG)

CDG currently is the largest airport in term of passengers and cargo in France and also is in the top 5 airports of Europe for both cargo and passenger totals. The airport will likely maintain within the top airports of Europe in the future as the airport excellent opportunities, at least in regards of land space to expand in the future compared to major airports like LHR and FRA which have limited expansion possibilities(Smit, 2003). In current system and future Charles de Gaulle is expected to remain the airport that has the most available slots for flights within Europe, so there is a large potential for growth without the long and extensive political/legal and technical problems that are faced to realize growth at other airport (Kolkman & Korteweg, 2009). CDG also has excellent road/rail connections at the airport, which could also proof to be very valuable in the future for air cargo operations when night restrictions for flight operations at major airports become more severe in Europe. In 2009 a total of 16 all cargo operators were operating from CDG and the airport handled 2 million tons of freight with a maximum handling capacity of 3.1 million ton of air cargo per year. Almost half of the air cargo transported via the air is transported on passenger aircraft, which is similar to other large airports. From the airport a large number of destinations can be reached with the highest amount of connection possibilities compared to all other airports in Europe within a week. There are an astonishing number 22000 connection possible per week possible between the flights operation from the airport, which can also be used for some part by air cargo (AeroportParis, 2010).

The main unique selling points of CDG airport for cargo are:

- a major hub airport for several full freight airlines, passenger (Air France) and express air carriers (FedEx)
- highest amount of connection possibilities for flights in Europe per week of any airport
- cargo information network implemented in 2011, similar to Cargonaut system at Schiphol making information exchange between cargo handlers, freight forwarders and customs authorities fast and efficient (AeroportParis, 2011).
- 11 of the world's 15 largest logistic service providers are active within the airport (AeroportParis, 2010)
- major expansion possibilities around the airport (300 hectare), opening of new air cargo handling facility in 2012 (next to the already four existing handling facilities, of which three were previously owned by the airport authority and one by Air France - KLM

- joint development of new logistic areas with private and public partners supported by the airport authority
- collaboration with surrounding airports and optimization of current and new infrastructure to the airport (AeroportParis, 2010)
- having four runways in place, which can be used for parallel landings in south or north direction

Suvarnabhumi airport (BKK)

Suvarnabhumi airport was opened in 2006 as the new international airport of Bangkok. The airport has a maximum capacity of 45 million passengers and cargo capacity of 3.2 million tons of air cargo a year given its current layout. During the design of the airport plans for further expansion were incorporated and these plans can increase the passenger capacity to over 100 million passengers a year and double the cargo capacity. BKK airport is a complete new airport with high potential for growth, this makes it possible for the airport to grow in effective and efficient way compared to airports that are operating at an older or more growth constrained airport. Thailand has seen large growth of industrial production facilities and international tourism, this can partly be derived from the central location in East-Asia and the good climate for tourism(Sussangkarn, 1997). Both of these areas of growth have facilitated aviation growth in Thailand and this is expected to continue in the future as many regional infrastructure projects are being developed to further improve the connectivity of Thailand with its neighboring countries. Besides this Thailand also produces a large degree of agriculture products of high value that are also exported by air. At Bangkok airport Thai Cargo has been given the task by the national government of Thailand to handle cargo operations at BKK airport, which has resulted in the design of a large air cargo handling facility. Next to the operations of Thai Cargo one other general handling agent is active at BKK, its name is Bangkok flight services and its facility has a capacity of around 500000 ton/year. Compared to Singapore airport and Kuala Lumpur International Airport (KUL), the amount of connections to South East Asia is much higher at Bangkok airport(Songguang, 2007), competition between Bangkok and Singapore is more related to non-Asian air traffic and the most efficient handling operations currently available at Singapore airport. Figure 12 below shows in visual way the good location and connections offered from Bangkok to South East Asia in relation to competing airports in the region.

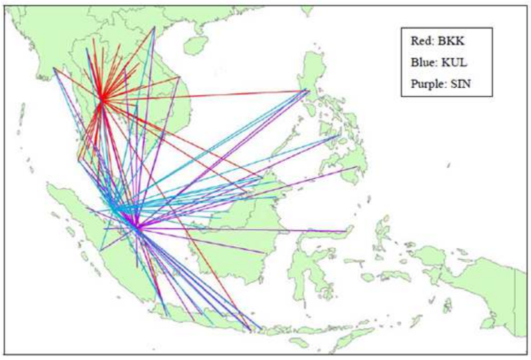

Figure 12: Comparison of direct flight connections from Bangkok, Singapore and Kuala Lumpur's main airports derived from (Songguang, 2007)

Unique selling points of BKK airport are:

- completely new airport infrastructure compared to competing airports
- located close to major production facilities in South-East Asia with land access to several countries
- sufficient room for expansion of facilities and runways, already planned for expansion
- two general handling companies that collaborate on special cargo perishables
- no competing air cargo airport in Thailand for same market (based on volume/size)
- high frequency of connections to many other South East Asia cities
- Bangkok Airport is used as secondary hub airport by several airlines (Emirates, Sri Lankan & Cathay Pacific)

Los Angeles International airport (LAX)

LAX airport is the largest air cargo airport in California and 5th Cargo airport in North America, most of the air cargo is transported by international airlines operating passenger services to Asia, several major international airlines operating passenger's services to LAX also operate full freighter aircraft to LAX (Caltrans, 2012). Other airports in California also provide air cargo operations and have attempted to obtain part of the cargo volume that is transported to and from LAX. Given the large passengers and cargo operations, which are also oriented towards international services it is almost impossible for air cargo operators to realize the same competitive advantage as LAX has at alternative airports. LAX is seen as the gateway airport to West Coast and thus attracts passengers, integrators and all cargo operators with regular services. LAX currently offers a capacity of 3.1 million ton cargo per year and this can in the future be expanded to 4.2 million tons. The growth of LAX airport in the future is however not certain as land prices around the airport are very high, landside congestion is becoming an ever increasing problem and several alternative airports in California are actively trying to capture part of the cargo operations(LFA, 2002). LAX currently utilizes four different cargo handling complexes that are used for dedicated airlines (Singapore Airlines/Qantas) or are shared by several companies.

- presence of several major freight forwarders near the airport and a total of more than 400 forwarders active at the airport
- large amount of passenger services flights with a high frequency to major markets in Asia and Europe and to the Pacific
- multiple airlines operating a mix of dedicated freight and passenger flights on daily basis
- major operations of all major integrator airlines and several large US based airlines at the airport
- significant regional economy reliance on air cargo for international trade in California and large scale difference between LAX airport and competing airports in California for air cargo
- possibility to still expand its cargo capacity to double the current demand at the airport

Major air cargo airports larger than in passenger cargo ratio Schiphol Airport

In order to assess if more cargo focused airports also operate under different conditions that airports with a similar cargo/passenger ratio, the largest cargo airports of Asia, North America and Europe compared to Schiphol are analyzed below, the airports marked in bold are gain the ones that will be analyzed in more detail.

- **Hong Kong International Airport (HKIA) (ranked nr1 in the world on cargo)**
- **Memphis Airport (MEM) (ranked nr 2 in the world on cargo)**
- Shanghai Pudong Airport (PVG)
- Inchon Airport (ICN)
- Anchorage Airport (ANC)
- **Frankfurt International Airport (FRA) (ranked nr 7 in the world on cargo)**

Hong Kong International airport (HKIA/HGK)

HGK was opened in 1998 as replacement of the old Hong Kong airport; it currently has two runways and handles about 50 million passengers and 4 million tons of cargo a year. The airport is directly connected to 160 destinations by scheduled flight services this includes 40 mainland China cities(HKSRG, 2011). Compared to other airports in Asia, Hong Kong is by far located at the best location for Asian Pacific flight operations(Zhang, 2003b). The airport receives a large degree of wide body aircraft (70%) which is higher than the average percentage of wide body aircraft at other major cargo airports. For cargo handling the airport currently has two general (HKACT/AATCL) and two specialized handling (DHL/Hong Kong Post) facilities and a new facility will open later this year or in the beginning of next year (operated by Cathay Pacific). With this new facility HGK airport will have a cargo capacity of more than 6.5 million tons per year. The city of Hong Kong has developed its cargo operations policies and operations over the last decades due to its excellent international geographic location, the role it has played to facilitate trade between mainland China and Taiwan and its close location by sea and road infrastructure to the main manufacturing locations in the Pearl River Delta of mainland China. Due to its current status as a free trade zone location and its inherited international flight arrangement from its previous status as British Colony until 1997, Hong Kong airport has a much higher degree of international operations than other competing airport in mainland China. It is expected that due to efficiency of the facilities of the current air handling facilities and the excellent support for cargo flows to Chinese mainland destinations that growth of cargo volume for both transit via the air and truck will still increase(Man-cheong, 2007). HGK has both the biggest, most advanced and supported air cargo facilities of the world, making air cargo handling processes much more effective than at other airports. This combined with the largest volume of freight and frequency of flights with high cargo capacity make the aircraft very attractive to use, even though generally the charges at the airport have been higher than competing airports.

Key success factors for HGK airport are:

- efficient handling of air cargo, which is highly automated and focused on providing optimal services to different freight forwarders for local and mainland China cargo flows
- extensive use of wide body aircraft for both regional and cross continent flights
- high degree of transit cargo traffic between mainland China and Taiwan
- the existence of extensive and fast infrastructure for both road and sea transshipment
- the combination of high frequency passengers flights and full freighter operations
- the presence of Asian hub of DHL at the airport
- the amount of handling capacity at the airport at hand when a new facility will open and ability to further increase cargo capacity to maximum of 9 million tons a year with a three runway system, planning ahead of demand
- ability to handle more than 1.5 million documents of express freight per day by using two dedicated express facilities
- unprecedented location compared to other airports in Asia for Asian Pacific flights operations
- large degree of international flights to major destinations with high frequency
- efficient support systems, the good legal system and established trade networks are also a key factor for using transport via Hong Kong and not from closer alternative airports
- the entrance of China intro the World Trade Organization (WTO) has made international trade to and from China increase
- extensive open sky policy for establishment of new flights

Memphis International airport (MEM)

Memphis airport derives its cargo operations to large extent from integrator services to and from the airport, more than 99% of the cargo volume is generated by this type of operations. This directly reveals the biggest weaknesses of the airport for other types of cargo operations. Four types of cargo related services are offered from the airport and number of freight forwarders is active at the airport. From 1993 till 2009 MEM has been the largest air cargo airport in the world, only being surpassed by HGK in 2010 for the first time. The reasons MEM had been able to maintain the number one position has to do with the fact, previously growth of express operations within America and internationally were higher on yearly average when compared to general cargo operations on non-integrated services. However the domestic air cargo market for express goods is likely to decline or have limited growth in the near future. Due to rising fuel costs and changing customer requirements more and more domestic cargo is not shipped via the air. The airport has a relative low numbers of passenger and cargo operators compared to its freight volume, in 2007 17 cargo airlines and 32 passenger airlines operated from the airport(Waldo, 2010). At LAX airport for example the numbers of airlines operating was 106 passenger airlines and 36 cargo operators in 2007 with a much lower cargo volume. Although MEM is used as a passenger hub by Delta Airlines it does not transport a large volume of cargo with these operations. Besides this Memphis airport only has two general handling facilities to handle cargo and does not handle perishable cargo shipments. The land infrastructure around Memphis airport can however be viewed as excellent with the presence of 3 truck terminals, a four lane highways right next to the airport and close connection to train track. Also the amount of airside space for cargo operations and landing and takeoff are very high compared to competing airports, but most of it is used by FedEx. Memphis airport has one the most sophisticated landing systems in the world and operates four runways that can facilitate landings in parallel.

- largest integrator facility for handling express cargo in the world hub (FedEx) combined with 3rd largest facility of integrator UPS

- located right in the middle of North America it can give good access to all states within America
- large degree of major warehouses are located near the airport
- high potential for linking intra-regional trade with combining rail, road and air services given the good location of the airport
- modest weather conditions have limited negative effect on air operations(IL, 2008)
- high degree of large warehouses are located near the airport

Frankfurt am Main airport (FRA)

FRA airport is the largest passenger and freight airport in Germany and second biggest airport in Europe based on cargo volume. The development of Frankfurt as a major airport in Germany started soon after the Second World War as many American military bases where located near the airport. Lufthansa started operating from Frankfurt airport from 1955 and has been developing the airport ever since as its main hub for both cargo and passenger operations. The airport authority (Fraport) has been closely working together with Lufthansa to develop the airport infrastructure so it can support growth of passenger and cargo operations(Felsenstein, Schamp, & Shachar, 2002). A 107 passenger airlines with (207 destinations) and 30 cargo airlines with (84 destinations) operate from the airport (Fraport, 2012a). FRA has four runways of which two can only be used for either takeoff or landing. Frankfurt airport also has two cargo locations at the airport (Cargo City South) and (Cargo City North). There are three different cargo handlers that operate at Frankfurt airport; Lufthansa Cargo, LUG Handling and Fraport Cargo Handling services, the airport handled about 2.2 million tons of air cargo and can handle up to 4.5 million tons of cargo per year. Three major freight integrators also operate from the airport being DHL (own/shared flights), FedEx and TNT express. The future of part of the air cargo operations at Frankfurt airport is however uncertain, as severe night restrictions have been introduced in 2012 making it impossible to operate night flights from the airport, this has already resulted in a decline of full freighter flights and is also likely to affect operations for key passenger destinations. Due to the large passenger operations of Lufthansa and its partner airlines however cargo growth can still be realized with passenger flights, but it will be more difficult to offer the right balance of full cargo and passenger generated cargo capacity to certain destinations that require night departures or arrivals. Fraport has stated that the right balance between full cargo and passenger flights has been one of the key reasons for its success of cargo operations at the airport(Fraport, 2012b). It remains to be seen to which extent this balance can be maintained in the future with the restrictions on air cargo night operations.

Key success factors of FRA airport are:

- located close to major production facilities of German companies
- large amount of both passenger and full freighter services with a high frequency from both home and non-home carriers
- sufficient amount of free capacity available for cargo handling and operations spread over two cargo locations and three air cargo handling facilities, with a recently opened handling location that differentiates it services based on forwarder operations.
- large amount of international freight forwarders present at the airport
- good road and infrastructure connection to on regional level and to the rest of Germany
- having operations multiple different airlines operating an extensive passenger, full freighter and integrator hub operation from the airport
- large amount of flights slots during day time thanks to opening of fourth runway (Kolkman & Korteweg, 2009)

Based on the analysis above of competing airports and their unique selling points, the following aspects that are important for major air cargo airports competitiveness can be defined;

- good weather conditions all year round (derived from MEM airport)
- current runway/handling capacity in combination with expansion possibilities and current demand for air cargo (CDG/BKK/HGK)

- efficiency of handling air cargo and scale of operations (capacity per hour/handling timing) (HGK)
- a good balance between the amount of air cargo handlers and air cargo handled per company (HGK/FRA)
- specific air cargo handling operations designed for freight forwarder specific operations and products (FRA/HGK)
- the amount of bilateral agreements on key air transport routes (HGK)
- the government and or airport authority support of cargo developments at the airport in balanced way between cargo and passenger activities (CDG,FRA,HGK)
- the combination of frequent long haul cargo flights with the use of both full cargo aircraft and passenger aircraft (FRA,LAX)
- extent and quality of landside connectivity and measures in place to facilitate seamless cross border cargo transport via landside to neighboring countries that lake similar quality airport infrastructure and flight frequencies (BKK/ HGK)
- the amount of connecting flights per week possible from the airport both within the region and to key international destinations (CDG/BKK/HGK)
- transshipment possibilities between different transport types for further transport , sea transport possibilities (HGK) and future possibilities for rail cargo at (FRA/CDG)
- the use of the airport by one or more integrators as hub airport (LAX, FRA,CDG,BKK,HGK)

These factors further support the notion that successful air cargo hubs should have sufficient scale of operation and have the ability to expand in short and long term to cope with potential growth. Also the current facilities should be able to handle increase in cargo demand with existing infrastructure. The presence of an extensive international network of both dedicated cargo and passenger flights on high frequency and with sufficient cargo capacity is also shown as valuable aspect. The speed cargo shipments can be processed within airports ground handling system and how they can be transported to onward destinations has also been found in several cases as an aspect, which is of growing importance, as fewer large airports will need to attract air cargo shipments from more distant destinations to growth their operations. Finally both airport and government involvement in a balanced way of support for passenger and cargo operation has been defined as key success point for several airports.

4.4 FUTURE OF AIR CARGO AND RELATED LOGISTICS AT SCHIPHOL

Based on the developments of the air cargo systems around the globe at major airports and interviews undertaken at Schiphol with companies that are involved in the air cargo system, several important internal and external developments in relation to future air cargo developments will be described in this paragraph, to be able to asses to which extent the current system at Schiphol will likely be influenced by internal and external developments.

4.4.1 EXTERNAL DEVELOPMENTS

Freight forwarder mixed use of airports from gateways

Most large freight forwarders that are using air transport business for part of their operations, are utilizing not only cargo capacity from major gateways where they operate from with physical location, but also are utilizing capacity on of secondary airports as combined with the facilities at major gateways. It can be expected that the mix between air cargo handled at local air cargo handling facilities and cargo that comes directly to freight forwarders from secondary or competing airports will increase. This will make it possible for freight forwarders to use different airlines and routes in order to maximize their revenue potential and utilize the different flight schedules of the involved airlines, it will however make the flow of shipments to and from air cargo handlers at their local airport smaller and less stable if growth rates of air cargo transport stay low.

Gateway developments

Another development related to the previous mentioned mix use of airports is that large freight forwarders have already started using fewer airports as dedicated operation centers from where they organize air cargo related transport for a whole region, this region can serve one or several different countries. These gateways stations often offer extensive value added activities and also involve long-term collaboration with major handlers, airlines and transport companies involved in the air cargo business. This gateway development is expected to influence the percentage of buildup cargo handled by air cargo handlers and the airside access use of large forwarders. Large forwarders already ship more than 30% of their cargo on own build up pallets, called T-ULD's, with the increase use of gateways for air cargo shipment build up and break down the percentage of shipments transport on complete T-ULD's is expected to increase. Another important development within the use of gateways is that different gateways of a single forwarders are intensiving their collaboration, were as before they were solely operating for a specific region they can now actively exchange capacity and shipments between gateways more easily and frequent. These two developments can help to reduce the transport costs, the damage to shipments, and speed up the delivery thereby improving the handling process. CEVA, a large forwarder active at Schiphol for example, has also been able to dramatically reduce its truck movements from air cargo handlers by obtaining air side access and requesting airside delivery from air cargo handlers for both lose and ULD cargo on inbound side (import).

Last minute adaptive booking by forwarders/shippers

Traditionally as explained before forwarders have been mostly using their fixed allotments on busy air cargo trade lanes. Recently however due to continuation of bad market conditions, airlines have started to use more ad hoc booking approach in order to increase their revenue. Thus inbound and outbound flows from one airline and forwarder have become even more dynamic by the way capacity is being sold and bought. This can mean that stability of air cargo shipments to and from air cargo handler at a specific handler for one larger forwarder fluctuates more than before, as last minute demand and supply of air cargo capacity to and from another airport will dictate the use of airline and handler and not always fixed capacity on a certain airline. Another development that further facilitates last minute adaptive booking, is the creation of online air cargo booking tools, this enables shippers to select and book air cargo shipments via website without having the contact a traditional forwarder.

Increasing complex regulations and focus of governments on aviation

In the past decades growth of air cargo has been extensive even surpassing the growth of passenger air transport, as explained in the introduction of this research. This growth has been possible thanks to decline costs of use of air cargo, that is the direct result from efficiency improvements of the system wide use of jet engine aircraft (Hummels, 2007) and the growth of international trade. Relative stable and affordable fuel prices, compared to the efficiency increases, for the last 50 years until the end of 20th century, combined with limited attention environmental regulations on transport has also resulted in limited impact of environmental regulations on the use of certain type of aircraft operations and growth of flight operations. In the beginning of 21st century within the European Union, the growth of air transport and its relation to negative environmental external effects had resulted in much more attention to the negative effects generated by this type transport. Not only did it become clear that the current amount of air transport related activities and type of energy source generally used are causing a larger negative contribution to the environment in relation to the total energy usage within the European Union, but also with the growth of air transport in general the negative effects to society will further increase if no measures are taken. The expected growth of transport energy usage is directly conflicting with the goals set by the European Commission to reduce its energy usage and the amount of greenhouse gasses that are produced within its territory. Transport developments are seen as a crucial supporter of economy developments for both the short and long term within the European Union. Therefore transport policies have been developed to further strengthen key transport infrastructure within member states. At the same time measures have been defined to reduce the use of energy transport in general and to support the use of environmental friendly transport means at a EU level, which will be enforced on member state level via legislation and other policy tools(Comission, 2011). Due to the fact that cargo shipments can only reach a limited distance with the use alternative means of transport such as road or sea shipping transport, there is often no real alternative for using air cargo transport for long distances with fast delivery speeds that are often required. In the recent past (last decade) it was common practices to use of old converted passenger aircraft for air cargo operations and this had resulted in strong negative effects of dedicated air cargo operations in the past, especially for short/medium distant flights and in developing countries/continents where new aircraft are often not used that extensively. The use of inefficient and environmental unfriendly aircraft has however been changing for most of the major air cargo operators with Europe, environmental related measures are in place at all airport that restrict certain operations based on amount of negative emissions. However it can be up to member states themselves to implement stricter regulations when desired to reduce the environmental impact of transport. These regulation developments can also partly explain the limited growth of air cargo flights for example within

Europe, while growth has been extensive for long distance intercontinental destinations. As cargo can now be transported by a truck from Western Europe towards much further destinations within 1 or 2 days, making transport by aircraft for many destinations not a necessity anymore, as alternative truck transport is much more competitive based on price, time and flexibility compared to aircraft operated services. For the routes where air cargo transport by aircraft is still needed the current and expected high fuel prices have contributed to use of much more fuel efficient aircraft, as their wise wide consensus within the air cargo industry that high oil prices are here to stay (Curtis, 2009) An example of investment in new aircraft can be found by looking at the recent operational changes that have occurred at the major full freight airline Cargolux, which is based in Luxembourg. It has invested heavily in the use of new aircraft for its flights operations, which has resulted in extensive CO^2 reductions (Cargolux, 2007). Furthermore the European Union had started with the inclusion of the aviation sector in the Emission trading scheme (ETS), as it believes that charging the sector based on the amount of CO^2 admitted can realize the best possible balance between environmental and economic interests and improve the efficiency of aircraft operations. However the ETS inclusion for the aviation sector is currently put on hold. Environmental concerns related to aircraft operations at major Western European airports have already had a negative impact on the operational performance for air cargo freight operators. Most large hub airports for passenger and cargo flights are operating at or close to their maximum number of flights possible within Western Europe, these restrictions on capacity are derived from technical, operational and environmental constrains that limit the airports ability to allow further growth. It is expected that these restrictions will continue to negatively affect the air cargo development, especially of night operated flights (Upham, Thomas, Gillingwater, & Raper, 2003). As the most frequently used hub airports are located close to densely populated areas, that are subjected to the strictest regulations related to night operations and other environmental constrains. For example the use of night slots has been limited, this has been compensated with additional capacity for passenger flights during the day at Schiphol. The exchange of night flights for day flights has also applied at other airports with relative few night flights (Marsh, 2009). At Frankfurt airport, the opening of the fourth runway in 2012 has resulted in much more restrictive policy related to night's operations, which has manly affected dedicated air cargo operations. There are however expectations related this type of government approach in other EU members' states like for example Luxembourg and Belgium have set up specific policies to be able to attract air cargo flights operations with the least amount of restrictions. These countries are utilizing their freedom to not enforce stricter than needed regulations on environmental issues. Also the European Union is investing thru various infrastructure funds in growth of underdeveloped airports, mostly in Eastern Europe. The developments above on regulation can make it more difficult for large hub airports like Schiphol to growth without major investments and has opened up opportunities for other European members states to further develop underutilized airports for cargo operations in the future.

Slot capacity at major competing airports

In the research (Kolkman & Korteweg, 2009) several large airports are compared to Schiphol airport on airport slot capacity. In report analyses to which extent current and future capacity of flights is fully utilized at major airports in Western Europe. When looking at the maximum slot capacity per hour and availability of slots during peak hours, Schiphol still has limited room to increase its flights operations. However when you look at the amount of capacity that is currently utilized and the expected development for the future, major competing airport of Schiphol (Frankfurt/Paris) have much more spare capacity for future growth. This spare capacity during certain operating days/times can be crucial to maintain or obtain future flights for both passenger and full cargo flights. The slot capacity development at major airport will mostly influenced by a mix of national and European legalization at major airports as explained previously in this paragraph.

Airport competition on costs and quality of infrastructure

Major air cargo airports often compete on costs, quality or on both aspects in order to maintain and attract air cargo operations (Graham, 2004). Increased liberation of both air cargo market, airlines and airport ownership have made the competition between airports increase. Niche airports often try to provide low costs operation base for specific type of air cargo operators Liege/Luxembourg, while other airports focus on quality like Schiphol or both quality and price Hong Kong airport. It is important to notice that Hong Kong is able to compete both on quality and costs, due government policies, high investments in automation and sufficient scale of operations with a well located airport for the main air cargo markets. For airports that either do not have the scale of air cargo operations, higher labor costs, lack the financial commitment to support investments and are losing air cargo related production it is much harder to focus on both quality and cost leadership in an effective way. Schiphol airport is a prime example airport that tries to focus on both aspects with limited means, as the current situation the airport is in does not justify support of the high investments that are needed to improve both quality and price. The fact that the location for air cargo demand is shifting away from Schiphol airport and its labor costs are higher than in surrounding countries as our the real estate rent prices, does not make it a very attractive airport to invest in for cargo related operations on short and long term, compared to other airports that are seeing high growth or less restrictions on development.

Liberalization of air cargo handling market at European airports

After the implementation of directive 96/67/EC in the European Union, the liberalization of ground handling facilities at European airports, the market and amount companies active at major airports has been developing very fast (Schmidberger, Bals, Hartmann, & Jahns, 2009). Competition and amount of (new) handlers active at major European airports have increased significantly, it is currently for example much easier than it was previously to establish a ground handling company at an airport in the European Union. For major airports a minimum amount of potential operators for handling has been defined. Due to increased competition and takeovers of large ground handling companies, changes to the ground handling market are expected to continue in Europe. Some of these developments have already affected the ground handling at Schiphol in the past and will in the future. As global active handlers have signed contracts with key costumers they are sometimes forced to start operations at airports to maintain high value costumers even if market conditions at certain airport would not justify entrance to the market completely. In order for airport systems to stay competitive in the future performance measurement of ground handling facilities will become more important (Hartmann & Schmidberger, 2005; Schmidberger et al., 2009). Several large airports have already started to utilize performance measurement and benchmarking between ground handling companies at one or more airports to improve ground handling processes. The future development of this European Directive and behavior of current or future market players at major European airports can thus have a high impact on the effectiveness and efficiency of handling operations. When this development is negatively influenced by future changes, airports could become less competitive within European Union, so this developments needs to be followed by major airports and actions should be taken if an undesired situation in relation to handling capacity and quality arises.

4.4.2 INTERNAL DEVELOPMENTS AT SCHIPHOL AIRPORT

Movement of KLM Cargo handling facility

It is expected that KLM Cargo (handling) will move to a new location at Schiphol South-East in the future, because its current facility is both outdated and space it currently uses will be used for terminal expansion of passenger activities of the airport. Land has already been reserved for KLM Cargo handling facility at a new location on the other side of the airport (Schiphol South-East), but due to the bad market conditions and high investment costs of the construction of new facility a is difficult to assess the move of KLM Cargo will occur and how this will be executed As the entire Air France - KLM Cargo group is currently responsible for about 60% of the air cargo volume at the Schiphol this move and construction of a new facility will have a major impact both on the logistic operations at and around the airport but also on the competiveness of other air cargo handlers. KLM can outclass the performance of all other handlers when it will invest in a state of the airport air cargo handling facility.

Takeover of Aviapartner by WFS

Currently there are six general air cargo handlers at Schiphol, with a combined overcapacity of about 60000m2 in handling space (Ramaaker, 2012). The takeover of Aviapartner by WFS could reduce this overcapacity if these companies merge their operations and close down part of their facilities. It is however not expected that such a consolidation is an easy task or will be conducted during these challenging economic times added to this both WFS and Aviapartner are serving an different type of costumers and use different process and system to organize and support air cargo handling, the operational difference can make it difficult to collaborate directly to large extent. Except for Freshport which is focused on handling of a specific type of import cargo for several air cargo handlers and forwarders, Skylink is the only truly local general air cargo handler at Schiphol. It is expected that due to low operating margins, high fixed costs and decline cargo volumes future consolidation will take place within the handling operators. This could mean takeovers like the one currently going on between WFS and Aviapartner or collapse of handling agents that do not have sufficient capital and volume to survive or become stronger during this economic times like Skylink, as Skylink has also recently lost it largest costumer Emirates. These developments could increase the scale of operations of all air cargo handlers, which will make it possible for the entire air cargo handling system to become more effective and efficient.

Cross sector collaboration initiatives

The airport authority at Schiphol and ACN are jointly and actively engaged within several programs and projects that are indented to make the airport and its logistics more competitive and effective. The Schiphol group believes it will need to continue to be the frontrunner in collaboration with key partners from both business, government and research to be able to offer considerable advantage for the use of the airport in relation to often cheaper airports that are better situated outside the Netherlands for the European air cargo market and to overcome for its more extensive environmental operation restrictions. Two important initiatives that the airport is actively supports are; the seamless connections project and the Dinalog institute.

<u>Seamless connections</u>

As explained before this research is part of the Seamless connection project in which the main goal is to realize and support a seamless flow of goods between the different logistic points in the region of Amsterdam. In order to realize this an attempt is made to realize effective collaboration between key stakeholders and transport modes by connecting systems, increasing the speed of logistic operations and further strengthen logistic chains within the region.

<u>Dutch Institute for Advanced Logistics (DINALOG)</u>

Dinalog has been established with the goal to improve the position of the Netherlands within Europe on the amount of cargo transported between other member states via the Netherlands. Dinalog tries to realize this goal, by starting and supporting projects between different stakeholders such as; research institutes and companies involved within the logistic field, which may further improve the logistic position and attractiveness of the Netherlands. DINALOG tries to bring together companies that are using innovative concepts, are involved with other collaborative projects on logistics or are interested in supporting such projects in the future. The seamless connection program is an example of one of the projects that DINALOG also is involved in.

4.5 THE IMPACT ON THE FUTURE OF AIR CARGO SYSTEM AT SCHIPHOL BASED ON AIR CARGO DEVELOPMENT

The described developments that will take at Schiphol and other major air cargo airports developments can have a high impact on the future dynamics of air cargo transported via Schiphol airport and also impact the growth potential of the air cargo industry at established air cargo airports in general. Although already most of the described developments have been taken into account by the modest growth rates of air cargo at established Western European air cargo hubs, the mentioned developments however further support the notion that Schiphol airport will have to be even more proactive in supporting projects that can improve efficiency, effectiveness and sustainability of the air cargo system and support business development of air cargo related industries around the airport in order to maintain its current position as one of the largest air cargo hubs in Western Europe. External changes on regulations and investments of competing airport have to be closely followed and if needed acted upon, otherwise Schiphol could easily lose its leading cargo and passenger position within Europe. Schiphol airport should therefore try to come up with solutions for the current overcapacity of air cargo handling and also try to support a smooth transition of air cargo handling from Schiphol Centre to Schiphol South East in the near future, with development of new facilities and concepts that will make the handling of air cargo at the airport far more superior than that which is offered at competing airports. There has to be a more balanced way of supporting the development of potential needed handling capacity, real estate charges utilization of handling capacity and scale of handling operations at the different air cargo handlers. Besides this investments that are needed to support the joint development of cargo and passenger services.

4.6 SCHIPHOL AIRPORT ASSESSMENT ON KEY FACTORS FOR AIRPORT SELECTION AND OPERATIONS FOR CARGO RELATED ACTIVITIES

Figure 13 below gives an brief overview of how Schiphol airport scores on the most important factors for air cargo services at an airport compared to its major 'competitors' within Europe, the factors that Schiphol and the other airports were scored on were derived from the literature review at the beginning of this chapter and the airports have scored based on the airport analysis and the defined external and internal airport developments at the defined airports.

Europe					
nr	factor	internal/external	Schiphol	Frankfurt	Paris
1	weather conditions airport	external	4	3	4
2	airport's government support/involvement in flight agreements with third countries	external	5	4	4
3	Quality and extensiveness of regional / national infrastructure (landside)	external	5	5	5
4	Large costumer of air cargo request to move to airport	external			
5	Airport location	external	2	4	4
6	Amount of airport truck shuttles	external	4	5	5
7	Amount of local demand for air cargo	external	3	5	5
8	airport charges	internal	3	2	3
9	airport reputation	internal	5	4	4
10	airport dedication to air cargo	internal	4	4	4
11	airport infrastructure efficiency	internal	5	4	5
12	freight forwarder active around the airport	internal	5	5	5
13	amount of passenger destinations with cargo potential	internal	5	4	5
14	amount of full cargo flights	internal	4	5	5
15	airside possibilities for forwarders	internal	5	4	4
16	airport capacity (short/long term)	internal	4	3	5
17	extent and quality of airport road access (landside)	internal	5	5	4
18	active engagement with business for air cargo use at the airport	internal/external	5	3	5
19	environmental costs of operating at airport	internal/external	3	2	3
20	environmental restrictions related to operations	internal/external	3	2	4
21	intermodal transhipment facilities near/at airport	internal/external	4	3	5
22	amount of value added logistic activities near airport	internal/external	5	5	5
23	total demand of transit cargo	internal/external	4	4	4
		total score	92	85	97
		rank	2	3	1
		actual rank cargo	4	2	1

Figure 13: Scoring of Schiphol airport on air cargo operation selection criteria compared to other major cargo airports in Europe

Based on the scores defined for the factors above of three airports on 5 point scale in Figure 13 above, whereas a score of 1 is most negative and 5 is the most positive score, it becomes clear that Schiphol airport has and is trying to actively be involved in making the airport more attractive to compensate for its shortcomings compared to competing airports in Europe. The location and the charges for handling can be seen as major drawbacks of using Schiphol as an airport, compared to secondary airports or even compared to use of Frankfurt in Western Europe with lower charges and better geographic position for air cargo shipments. However the good mix of cargo capacity available at Schiphol when looking at the amount of scheduled cargo and passenger's flights per week that operate from the airport, still make Schiphol an attractive airport for the majority of air cargo freight forwarders. Also the infrastructure around the airport and within the Netherlands is of good quality and many global firms have their European distribution center close to the airport. Finally the amount of different air cargo handlers can make competition between air cargo handlers higher, which can result in better services offered for airlines or forwarders compared to airport were only one or two handler are active. Besides this other initiatives cross sector programs are also supporting air cargo related project such as such as Dutch Institute for Advanced Logistics (DINALOG) and the top sector program of the Dutch government make Schiphol score high on government support. The branch organization for air cargo in the Netherlands (ACN) also works closely with government, business and other institutions to improve the air cargo market to and from the Netherlands and improve Schiphol airports dedication to cargo operation. Both government and industry supported initiatives within and outside the air cargo domain have and are making the efficiency and effectiveness of air cargo handling and transport to and from Schiphol airport stand out in relation to competing airports. However given the growth of air cargo in recent decades, many large airports in Western countries have been focused on only facilitating air cargo growth and not purely on maintaining quality and efficient infrastructure for handling related activities. When the need for air cargo transport was high and prices were at a more healthy level, it was not that urgent as it is now to focus on the handling part of the air cargo system. The declining handling costs per cargo shipment, as in costs per kilo and lower transport costs, have not improved the efficiency and quality of the system. This trend has been developing at almost all airports in Western countries, where growth has been lower than expected and alternative forms for air cargo transport are being utilized more often.

5 SYSTEM ANALYSIS OF AIR CARGO SYSTEM AT SCHIPHOL AIRPORT

In order to fully understand the way air cargo shipments are handled at the airport for both inbound and outbound flow. A system analysis of the process air cargo shipments go thru on the ground at airport will be conducted in this chapter. Next to the general analysis, the different types of collaboration within this system are analyzed to be able to define challenges and potential of different types of collaboration for the current and future air cargo system at Schiphol.

5.1 INTRODUCTION INTO THE AIRPORT AIR CARGO SYSTEM

Schiphol airport is used extensively for both for passenger and cargo operations as a hub, it has a wide arrange of services and companies operating at the airport offering both dedicated and shared services for freight operations. In some parts of the chapter passenger operations are also described, because these are also important for the transport of air cargo, as about 50% of the total volume of cargo at Schiphol is transported onboard of passenger aircraft, the focus of this analysis will be on the different elements of the air cargo transport system at Schiphol, this consists of all operations related to cargo transport operations. In this chapter transport is often defined at transport to a location, but this also relates to the transport from that given location, this means both import and export related flows of goods are considered and can even be combined in given transport flows. To make clear what is meant when the terms landside, airside and airside access are used, Figure 14 below gives a simplified overview of handling locations related to the terms used.

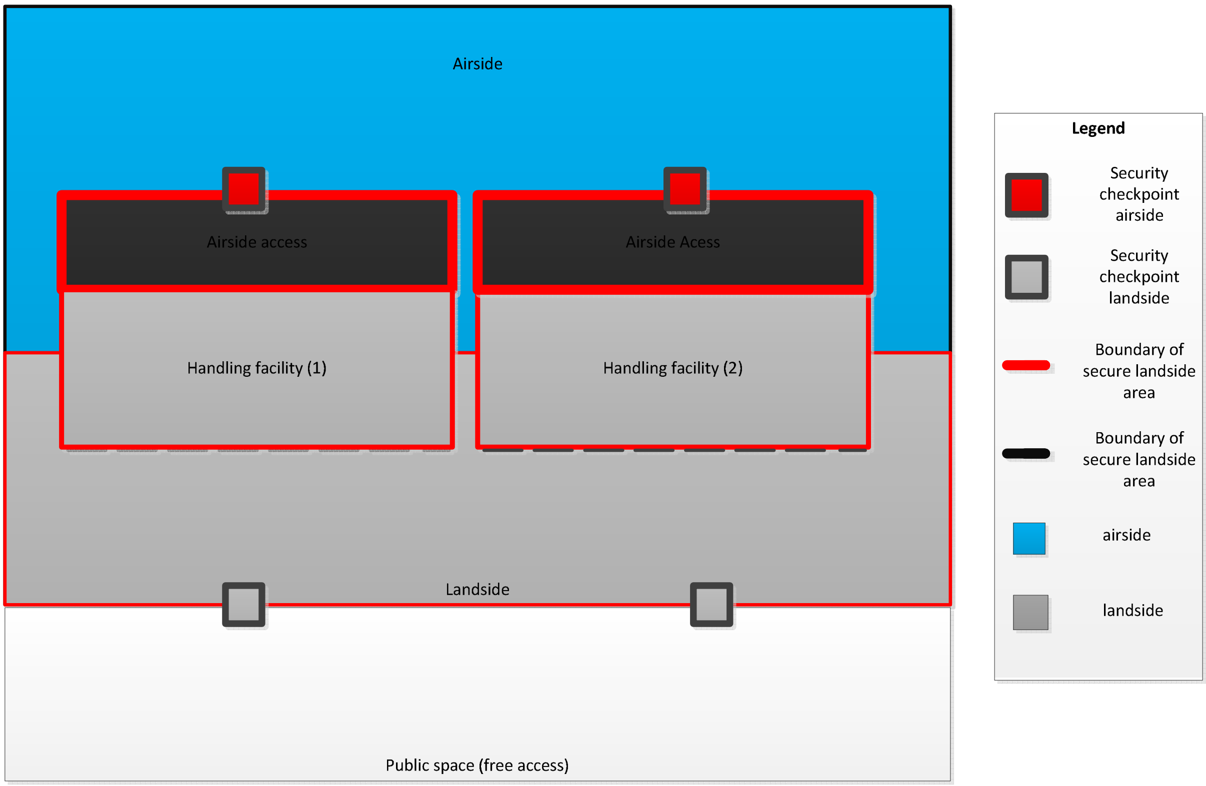

Figure 14: Airport overview cargo handling locations (airside or landside).

5.2 AIRSIDE OPERATIONS

Airside operations relate to all activities that are taking place in the area that can be directly accessed from the aircraft; this includes runways, taxiways and the apron. Aircraft at Schiphol can be parked at the apron on remote stands or at stands that are directly connected to the air cargo handling facilities, all air cargo handling facilities at Schiphol have at least on access point to the airside to be able to reach all parked aircraft at the airport which need to be loaded or unloaded. All locations of an air cargo handling facility have access to the airside operations, but are in fact not part of the airside. In this chapter the part of the handling facility that is directly located next to the airside is described either as airside location or a location with direct access to airside. All facilities of cargo handling companies at landside are separated by a fence and security check point. Before goods and staff can enter the airside from landside they have to go thru security check point, these security check points are operated by a separate organizations and staff. Therefore staff of a cargo handler that wants to access the airside, from landside, will have to undergo a complete security check before being able to travel airside from its own facility.

5.2.1 LOADING AND UNLOADING OF AIR CARGO FROM AN AIRCRAFT

Air cargo shipments arriving by air can be transported on; dedicated scheduled freight aircraft, scheduled passenger aircraft and chartered aircraft. Of the used passenger aircraft for air cargo, some passenger aircraft also have main deck cargo space (combi's), while all major passenger aircraft can load cargo in the lower deck area also called (belly space). Several types of containers/pallets are used in order to transportation cargo on both dedicated cargo and passenger aircraft, the type of container depends based on the type of aircraft and position in the aircraft. Aircraft pallets that are used on board the main deck are called unit load devices (ULD) or main deck pallet (MDP). The type of ULD that is used depends on volume/weight of cargo, the space and the type of the cargo is transported. For example a LD2 ULD can weigh about 1,2 ton including the weight of the cargo, this is smallest ULD based on load and volume and the largest ULD units is the MDP (Main deck pallet) can carry a total weight of 11,5 ton of (Boeing, 2012). For both lowerdeck as upperdeck cargo there is a large variety of different ULD's that offer different forms of protection and cooling. Loading of an aircraft in the right way for optimal take off and flying conditions is a difficult task, given the weight restrictions and space in the different compartments of the aircraft, as the weight and balance of the aircraft is not only important during loading, but also during the entire flight. Next to this air cargo shipments arrive at different times at the airport so it's not always possible to combine and load shipments in the most optimal way, based on loading preferences and volume and weight restrictions. The different cargo compartments of an aircraft have a different load limit that is based on the maximum structural load of that section of the aircraft and the weight of both cargo compartment and passenger compartment. At Schiphol airport full freighter aircraft are mostly parked close to the handling facilities for air cargo, one handling company is in charge for the loading and unloading of an aircraft that contains air cargo shipments. The handling company that is in charge of this process is linked to the airline of aircraft, as all airlines operating from Schiphol have appointed on air cargo handler for their operations on fixed or ad hoc basis for a specific flight. Right after the aircraft with cargo is parked and ready to be unloaded; the cargo that is not staying on the aircraft is transported from the aircraft. Offloaded cargo can be transferred either directly to the handling facility of the air cargo handler in charge of unloading the aircraft or the cargo transported to different handling facilities, but this transport always organized in coordination with the handling company in charge of the airline that is operating the aircraft. Cargo shipments that are offloaded from the aircraft can; directly go to the handler in charge of the loading process, it can be transported to the aircraft parking location of the next flight or it can be transported to the location of a different air cargo handler.

5.2.2 HANDLING FACILITY OPERATIONS (AIRSIDE ACCESS)

The first process at the handling facility airside when cargo arrives from an aircraft involves to the acceptance of air cargo at the air cargo handling facility, before it can be accepted the air cargo has to physically cross the boundary of airside and move into the area that is actually part of the landside of the airport. Air cargo shipments can be stored at many different locations for short durations, including the area airside access of handling facilities after coming from an aircraft and before it enters the handling facility itself. Larger handling facilities have electric powered equipment in place that can handle and store air cargo ULD's in a warehouse style system at several different levels. ULD's can stay in such systems until it either is moved to the aircraft for next flight or is accepted for processing within the handling facility itself, but since this space is actually inside the air cargo handling facility this is considered landside. Given the fact that space is limited at the storage facilities outside the handling facility (airside access area). Within the handling facility itself, the decision to move cargo from the airside to handling facility and vice versa, usually depends on variety of variables. These include the actual operation conditions, the timing for the next flight on which the cargo is transported and space both inside and in front of the air cargo handler. Often air cargo that is unloaded or transported at one facility is moved to another air cargo handling facilities at the airport before it is transported from the airport either by truck or plane again. Cargo normally first arrive at the area of the handler that is in charge of loading the aircraft and can be moved to another handler based airline that actually booked cargo space on the aircraft on which the cargo landed, another airline attached to different handler is in charge of onward transport or because of a freight forwarders request, as several freight forwarders have indirect airside access via both general and dedicated handling facilities.

5.3 LANDSIDE OPERATIONS AT SCHIPHOL AIRPORT

All cargo operations that are taking place which do not have direct airside access are defined as landside operations. The parts of the handling operations that take place, which do not have direct air side connection are considered landside activities. This means that the storage area with direct airside access is considered as part of the landside operations, as explained in the previous paragraph. Air cargo and personal active at the landside operations can however travel freely to the part of the handling facility with direct air side access but have to go to a physical check point before reaching the actual airside of the airport.

5.3.1 UNLOADING CARGO FROM NOT COMING FROM AN AIRCRAFT (FLIGHT STYLE OPERATION)

Cargo that is transported as air cargo can also arrive by truck transport, as the contract of carriage for air cargo shipments allows the use of other means of transport than transport via air based on the Montreal convention. An increasing amount of airlines are operating to/from airports without any scheduled aircraft flights and are thus operating dedicated trucks between the airport on which the cargo is flown and the airport of destination that is reached by the use of truck services. When air cargo transport comes from a trucked operated service it will always arrives at the landside part of the handling facility of the handling company that is in charge of air cargo shipments of the involved airline. The transport is either organized by the airline or appointed by a trucking company on their behalf of the airline to perform this transport. Cargo shipments that arrive as import cargo by truck can at Schiphol not be moved across the airside platform from on handler to another handler. This cargo thus has to be picked up by a truck before it can be handed over by freight forwarder and transported to its onward destination.

5.3.1 HANDLING FACILITY OPERATIONS (LANDSLIDE)

Air cargo can enter the handling facility at an airport as cargo as three different custom related types of cargo, depending on the origin and destination of the cargo. Air cargo handled as import, export, and transit cargo. The difference is important, because each type of cargo has different needs and follows other processes in order to meet legal requirements, time and operational challenges within the air cargo system. Besides the different types of the way cargo is handled based on its origin and destination, cargo is also either build up/ or broken down on ULD's of specific freight forwarder costumer or ULD's are build up / broken down for several different costumers by an specific air cargo handler when shipment volume/size of a specific forwarder is insufficient to justify the complete use of an ULD.

Build up cargo/breakup of cargo shipments (consolidation)

Both freight forwarders and air cargo handlers try to build up (export) for as much shipments as possible, in order to maximize the use of space in an aircraft related to weight and volume of shipments. Freight forwarders are trying to build up as many ULD's as possible (export) by combining shipments for other reasons. The most important reasons are to realize:

- a more controlled packing of shipments (reducing damages)
- faster processing of cargo at handling facilities (no breaking down/build up at handler)
- to utilize the bought cargo capacity
- to reduce costs the handling costs complete ULD shipments are cheaper to handle

When cargo of one freight forwarder is not completed build up on one specific ULD when arrives or it is shipped to next destination on ULD's, the handling company involved in this part of transport will consolidate shipments and build up / break up containers according to space/volume and the weight and balance of the airline involved in the next part of journey. The build and breakdown of air cargo goods is thus an important process for both the freight forwarder and handler as it can result in easier handling of the cargo and faster processing time. It does however make it more difficult for air cargo handlers to obtain revenue as charges of complete build of cargo are lower and this involves less work by handling staff. Large freight forwarders are trying to increase the amount of completely build ULD's send as air cargo shipments, as they can than breakdown/ buildup these pallets at their own facility. Also they do not have to wait for the handler to break the cargo down into smaller shipments and do not have to worry about damage that can occur during the buildup/breakdown processes. The increased use of trucking operations between airports also makes it much easier and faster to transport complete aircraft ready pallets by truck when the next onward destination is reached with the use an aircraft (export) or the previous segment was done by air (import).

Export cargo:

Airlines normally decide on the delivery deadline for export cargo often air cargo shipments have to arrive at the air cargo handler at least six hours for scheduled departure time, however it is also possible that trucking under a flight number is used for export cargo from an air cargo handler, which is organized by an airline with the use of a third party trucking company. Depending on the type of cargo and the mode of transport (truck/airplane) restrictions are in place related to the time that air cargo shipments have to be delivered at the handling facility before a flight departs. This is done to limit the number and duration of flights being delayed, because of late arrival of cargo and also to give the handling company sufficient time to build up the air cargo pallets for a flight in most efficient and effective way for next segment of the cargo journey. It also enables the handler to have prepared cargo for flight even before a flight has actually arrived. Export cargo that uses truck operations is usually much more flexibly related to delivery time restrictions than aircraft operations, as costs for delaying an aircraft operated flight is much higher than truck operated flights services. Besides this slot times for flights and arrival time cannot easily be changed by different routing or adjustment of average speed, without severe costs increases, while this is much easier to realize for truck operated services. In general export cargo arrives between about 24 and 6 hours before a flight is expected to leave, but again when the next part of the journey is known to be provided by trucking services or booking of the cargo transport is organized just before flight departure this can also be only a few hours before scheduled departure. Normally shipments do not arrive more than 24 hours before departure, as air cargo transport planned just before departure and handlers generally charge storage costs more than 24 hours before departure of flight for shipments.

Import cargo

In this research import cargo is defined as cargo that has its final destination within the European Union at which is not transported on an aircraft to onward destination from Schiphol, it can arrive as cargo by truck or plane and can also be transported further by truck under a flight number, but it will use Schiphol airport as point where import related custom formalities will have to be completed. In relation to export cargo, import cargo normally has a much lower time pressure for onward transport than export cargo, as most import cargo arriving by flight number leaves the airport by truck to its final destination, where truck services and timings of operations can much more easily be adjusted operational requirements than aircraft operated services. It may however be the case that due to customer requirements or delays in the arrival of air cargo for imports the time pressure changes during its journey, cargo can than still become time sensitive. Most freight forwarders try to deliver import cargo that arrives in the early morning on the same or next day to costumers within the Netherlands, whereas cargo that arrives in the afternoon is mostly collected at night or the next day. Again also storage costs related to import cargo shipments could influence the collection of import shipment at certain time, based on operational conditions of the involved forwarder.

Transit cargo:

Three types of transit cargo that arrives from an aircraft are defined in this research;

1) Cargo that does not leave the aircraft
2) Cargo that leaves the aircraft but stays airside
3) Cargo that is transported from and to landside.

Cargo that arrives at the airport onboard an aircraft is defined in this research, as transit cargo when it does not leave the airplane, it stays airside and continues its journey within a certain timeframe or when it is transported to the landside location and transported to a destination outside the EU customs union within a certain timeframe by an flight operated service. Air cargo can only stay at the airside for a certain amount of hours, if the connecting flight for the specific air cargo shipment leaves within a few hours it can stay airside, otherwise it has to be transported to the landside location of the air cargo handler and stored their until next flight is ready to be loaded. If these conditions are not met the cargo is handled as import or export cargo. Transit cargo can be transported directly to export facility of handler if the connecting non EU flight is to depart within certain amount of hours, it can be transported to import/export handling facility for storage until the load for the flights is transported to the aircraft parking or it can stay airside and will be transported directly to the parking location of the departing flight. Usually this means that transit cargo when it is transported to landside for storage is first moved with import cargo to the import handling facility and is transported form that location to either the export location of the air cargo handler with other cargo or is than directly moved from the import location to the parking position of the aircraft which is involved in the next flight. For this research transit cargo is actually not further researched, as the defined transit cargo does not leave the airport via landside infrastructure and does not affect the truck movements within and from the airport generated at landside of the handling facilities. It can however indirectly impact the performance of landside activities at the handler and vice versa.

5.4 TRANSPORT OF CARGO FROM HANDLER TO ONWARDS DESTINATION VIA ROAD TRANSPORT

Currently all cargo at Schiphol that leaves the airport from landside is transported by road vehicles on public road infrastructure, in the future it is expected that air cargo shipments can be transported by rail or road infrastructure from the airport, in this research the focus will be on air cargo transport from road. All cargo that is transported to its onward destination involving movement by aircraft is considered transit cargo and this thus not leave the airport by truck and leaves from the airside. The roads on the airport are actually owned and maintained by the airport authority but can be used by the general public. For this research four different types of onward transport are considered and analyzed.

The four different routes of transport from airport handler at Schiphol to next point of handling are;

1. direct transport to end costumer (consignee),
2. indirect transport via freight forwarder facility (surrounding Schiphol)
3. indirect transport via freight forwarder facility (outside Schiphol)
4. transport directly to onward other airport (shuttle service under flight number)

This different transport routes can also relate to three different types of use of trucks load capacity;

- dedicated for end costumer (shipper/consignee)
- dedicated for one freight forwarder
- combined transport for several freight forwarders/airlines

5.4 DIFFERENT TYPES OF TRUCK TRANSPORT FROM AIRPORT HANDLER TO ONWARD DESTINATION

The four different types of transport that are used from the airport handling facility will be described in this paragraph below. As the use of these different types of transport results in different use of air cargo handling facilities.

<u>Direct transport to end costumer of freight from the airport cargo handler</u>

Major cargo airlines and freight forwarders provide direct transport from to their airport hub/handling facility for large customer if; the cargo volume is sufficient and or the value of cargo justifies this type of dedicated transport. This kind of transport mainly involves around regular transport of large international companies, production launches of new products or time critical product shipments of high value. The transport needed can be undertaken by tucking companies that are either working on behalf of the airline, forwarder or independent transport company that is hired on an ad hoc basis by the shipper or consignee of the shipment. The way this transport is organized depends on the airlines, involved freight forwarder, cargo volume, value of goods, other costumer requirements and operational conditions at the airport. Sometimes even small shipments with low value are collected by a private or small company themselves at the handling facility, but this only happens for a very small part of cargo shipments as it can be costly and difficult for individual small costumers to follow all needed procedures and process all documents to obtain their cargo by themselves in comparison with using external parties on behalf of them. Large freight forwarder therefore often either have a certain amount of trucks on standby to be used for urgent deliveries and collection or can hire ad hoc transport trucks on a just in time basis from independent transport companies.

<u>Transport via freight forwarder facility within the surrounding of airport</u>

Due to cost, space and other operational limitations considerations many freight forwarders do not own or operate their own facilities within the secure area of the handling companies they use, as space connected to airside of an airport is limited and the rental prices per m² are much higher than further distant locations. Freight forwarders also often have to collect and delivery cargo shipments at many different handlers present at the airport, when the forwarder is in charge of collection of shipments (Saghir & Hoekman, 2009). Therefore the majority of freight forwarders have their own or shared warehouse facilities within a short distance from the main airport handling facilities, this makes it possible for them to offer additional services to their customers and consolidate or separate air cargo at their own facilities, without the restrictions and operational challenges that relate to operating in the secured area of a handling facility. Cargo shipments that are non-time critical or of small volume/size per shipment are often combined for collection from an air cargo handler and are transported together with other shipments to a freight forwarder location near the airport before the shipments travel to its onward destination. Transport to the warehouse of forwarder is also done to maximize the efficiency of transportation and storage of cargo with the added benefit of having a high level of operational control offer its shipments for the forwarder when shipments are in its own warehouse. Due to different type of operations of large freight forwarders around the globe, transport of goods between freight forwarding facilities around airports is also taking place more often. Freight can be collected by one freight forwarder who performs the custom procedures for a shipment and collection from the air cargo handler, while the final part of transportation is done by a competing forwarder also operating from the area surrounding Schiphol. This may also have to do with the services offered by forwarders and the agent booking the freight transport. This means that transport from a handling facility to a costumer with the use a freight forwarding company can involve the transportation between two competing freight forwarding companies in the same area around the airport.

<u>Transport via freight forwarder facility outside airports surrounding</u>

Freight forwarders can operate within a single or from multiple locations outside the airport, this often is done when freight forwarders are using different types of transport operations on frequent basis at one location, this can related to the use of other forms of transport such as rail and sea transport, this can result in need to transport air cargo from the airport to a freight forwarder location outside the airports surrounding. This type of transport is often justified based on the volumes of cargo for different modes of transport and specific onward transport requirements, but is not that common around Schiphol for major freight forwarders, given the further distance that has to be covered from the airport to such a handling facility, transport operations of this kind are often more costly to operate from. For example if the volumes of air freight shipments within a specific moment cannot be bundled effectively, longer distance transport that can't be achieved with a high load factor will result in lower economic efficiency gains. This is why most freight forwarders operate their own or shared facilities close to the airport, as trucking services between airports also provide a high frequency and can offer lower operating costs for usage than trucking services to locations outside airports. This allows freight forwarders to consolidate both inbound and outbound transport whereas this is more difficult to achieve if the distance between airport and freight forwarder facility increases and also gives them more time related control on transport. However due to operational requirement, customer request or limited use of air cargo by a freight forwarder this type of transport does exist but is not a very extensive transport flow, at least not for customers within the Netherlands. The high presence of freight forwarders in the surrounding of Schiphol can be partly explained by the drawbacks of using transport services to more distance freight forwarding facilities. This is also why in the area around Schiphol there are many companies offering truck transport and freight forwarding services.

<u>Hub to hub road transport (substitute for intra EU flight)</u>

Major airlines and trucking companies offer scheduled trucking services using truck transport between key airports at a relatively a high frequency (once a day for example) on either a fixed or ad hoc schedule; this service is offered at different continents around the world and is also available at other both major airports and secondary in Western Europe. These services offer an alternative for intra EU cargo flights and make it possible for airlines and freight forwarders to offer more choices of routes and destinations, while operating with their own facilities from only a limited amount of airports. Niche cargo airlines can offer connecting trucking services from their alternative airports for competitive prices and freight forwarders can focus on maintaining their gateway facilities and accepting both trucking and aircraft originating air cargo shipments at major gateways. Although truck transportation is used, aircraft ULD's are frequently used for this type of services, as cargo used by this service often involves large and frequent shipments of a limited amount of freight forwarders. Cargo shipments that are transported on this type of services often have the same hub destination as final location, before the shipment can be transported to the freight forwarders warehouse. This means that cargo does not have to be broken down after it offloaded from aircraft or before it is shipped to next hub airport for further handling and transport. At Schiphol a key example of an airline offering air cargo services from Schiphol that is actually not flying to Schiphol and is only using truck transport to its airport hub is Cargolux. Daily services are offered by Cargolux between its hub airport in Luxemburg and Schiphol airport, if freight forwarders book sufficient cargo volume and weight on certain flight they can even get there cargo directly delivered at their facility without it first going to air cargo handling facility.

5.4.2 TYPE OF TRUCK TRANSPORT USAGE FROM HANDLER TO ONWARD DESTINATION

<u>Dedicated for one costumer transport to freight forwarder/final destination</u>

Large cargo shipments for a specific costumer or cargo shipments that require special attention are often transported by a separate truck to its final destination from air cargo handle to avoid damage to the cargo and to ensure that cargo is picked up and transported onward as soon as it can be picked up from the handler and to deliver it as fast as possible. Large freight forwarders either hire additional trucks for such transport or have a dedicated fleet of trucks at their disposal for such transport, depending on the cargo and amount of flights which contain cargo of a single or combined shipment transport will be either organized directly to the costumers requested location or consolidation will still take place at the freight forwarders warehouse.

Shared costumer transport to one freight forwarder

As explained before, air cargo can arrive on passenger, full freighter aircraft and truck operated services, given the small average size of a shipment, shipment often cannot justify dedicated transport a single shipment. Volumes and frequency of shipments arrival may defer based on destination and airline, it is therefore not always possible to optimize the load of a truck from one handler for one costumer of a freight forwarder. As air cargo freight can arrive in small volumes during certain periods of the day especially during times when relative few full freighter cargo shipments are processed or smaller aircraft operating flight form minor cargo destinations arrive. Large freight forwarders often have difficulties to fill their trucks with sufficient cargo and to obtain cargo in a reasonable amount of time. This is why freight forwarders often try to combine as many shipments available at a certain time at one or more handlers, in order to make more effective use of their trucks, this can however be a difficult task given the time between notification that shipments are ready for pickup and the moment actual pickup can take place. Also the limited flexibility in the current system related to obtaining fast loading and unloading of cargo shipments, during peak times, makes freight forwarders often reluctant to combine cargo pick/delivery for multiple air cargo handlers in one transport planned routing. The focus is put on combining as many shipments as possible between one specific handler/ air cargo handling location and the freight forwarders own warehouse. As several handlers are located in the same secured area at Schiphol this can make it easier to combine loads when the waiting times are limited at the involved handling companies and handling process times are acceptable. So it can be that in some situation it is possible for freight forwarders to consolidate cargo of different shipments from one handler or consolidate shipments of more than one air cargo handler in one transport trip towards their own facility.

Shared transport to freight forwarder/airport hub (multiple companies)

On a limited scale shared transport of cargo shipments to multiple freight forwarders is applied at and around Schiphol, large freight forwarders tend to avoid using this kind of transport as this can mean that cargo can be delivered to the wrong freight forwarder, competitors can see the type of cargo being transported by another freight forwarder, damage can occur during loading/unloading caused by another freight forwarder and transport with multiple parties can involve much longer transportation times. Smaller and medium sized freight forwarders are however increasingly using this type of transport, as it is often the only cost effective way to obtain transport service to/from air cargo handlers within reasonable amount of time. Unlike large freight forwarders, smaller freight forwarders only use their dedicated transport to air cargo handling facilities for urgent/high value shipments. As explained before due volumes and higher frequency large freight forwarders do not have to use this type of transport in all cases, as they can combine shipments of several of their costumers and are still able to realize sufficient speed of transport. The service offered by KLM Cargo at Schiphol with the name (2door) also on occasion combines cargo for more than one freight forwarders, but this is not the general norm and is actually not allowed on the basis of the existing contract regarding this service, so this service cannot be seen as an indented shared transport service. An overview of the most common transport flows for both import and export are given in Figure 15 and Figure 16 below to visualize the different types of transport that have been mentioned above.

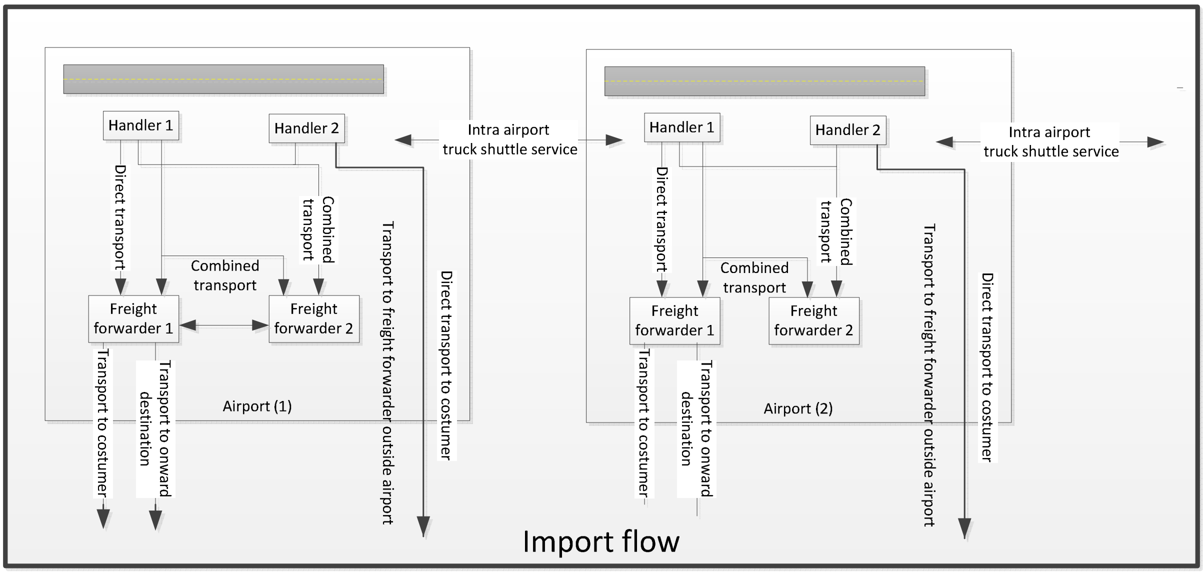

Figure 15: Import flow of goods from airport by truck transport from air cargo handler to forwarder(s) or direct customer delivery.

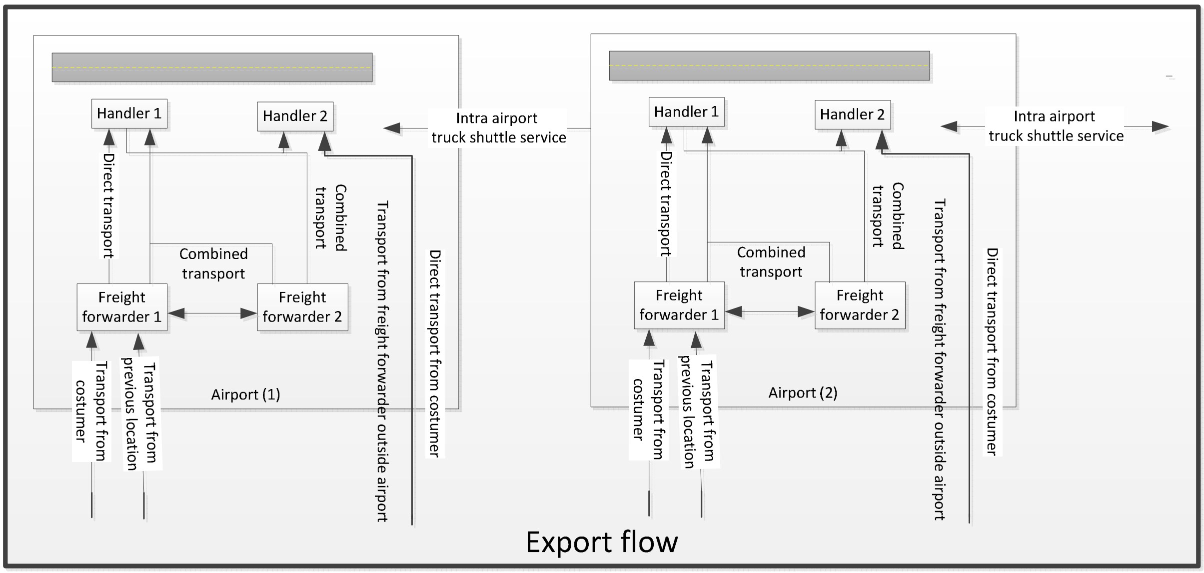

Figure 16: Export flow of goods to airport by truck from shipper via forwarder(s) or direct delivery to air cargo handler.

5.5 AIR CARGO GOODS AND RELATED SERVICES

The types of cargo shipments that are transported with the use of air cargo services are extensive, almost anything that can fit in an aircraft and does not weigh more than the maximum weight load of that specific aircraft is transported by air. Goods transported with the use of air cargo transport are often divided into different groups based on their value, service needed or their size. According to (Saghir & Hoekman, 2009). The most transport commodity products by air transport can be grouped in:

- capital and transport equipment
- computers, telecommunications equipment and other technology products
- apparel and textiles
- perishables and refrigerated goods

- intermediate goods for distributed manufacturing
- other consumer products

Airlines offering air cargo services often define different types of products/services based on the type of cargo that is transported, to some extent this includes part of the groups of products that are mentioned the research of (Saghir & Hoekman, 2009). A product that is flown as an air cargo shipment is often characterized and linked to the services the product requires during its journey from shipper to consignee. The research of (Saghir & Hoekman, 2009) defines that there are currently four such categories related to services an air cargo shipment needs: emergency freight, high-value freight, perishables and routine freight. LanCargo is a South America based cargo airline, it defines the following types of cargo product groups (LANCargo, 2012), this is slightly different from the previous types of air cargo products groups that were derived from Saghir & Hoekman . LAN Cargo defines the following groups of cargo based on their products offered:

- general cargo
- perishables
- dangerous goods
- pharmaceuticals
- live animals
- special cargo

LANcargo has also defined different type of services offered to general cargo in these different segments based on;

- the type of aircraft used
- the percentage of insurance
- the priority of the cargo for loading on an aircraft

Other airlines like KLM Cargo do this in the same way as LAN Cargo, but KLM for example has a more extensive list of product choices for specific type of products, that includes services specific to industries (aerospace, automotive, oil & gas, fashion and high-tech). For this research the focus of cargo will be on general cargo, as this type of cargo requires the least amount of attention compared to other types, it is less time critical, it has a low value for the freight forwarder and handler, it is often transported as loose cargo and does not lose its value easily due to changing conditions in the environment. This makes this type of cargo most suitable for collaboration, because; there are limited difficulties related to the handling of the cargo, the arrival time of the cargo is less sensitive and the value of the products is lower compared to other types of cargo. Besides these operation considerations, general cargo shipments are also by far the common used type of air cargo shipment flown by the major freight forwarders. This makes it also more likely for collaboration to be realized with large forwarders, as they have sufficient volume of similar cargo shipments that do not require special attention.

The following definition of **general cargo** will be used for this research:

General Cargo shipments consist of durable goods that do not require special treatment based on their value or product nature.

Within this product category many different types of products exist examples are:

- shoes
- textiles
- spare parts
- low value electronics

In essence anything that is booked as shipment for the lowest price is generally handled as general cargo, if the shipment can be handled within the general cargo product limitations. This can mean that even high value electronics are shipped and flown as general cargo, the choice of the type of service used is of course up to the shipper and the freight forwarder that are lined to air shipment, however cost considerations can lead to high value cargo being flown as general cargo. In practice air cargo handlers treat the cargo shipments they receive as general cargo unless they are notified by the airline or freight forwarder that another type of handling is required for a given shipment. To give an idea of the share of the most often flown products, the following overview is derived from (LHC, 2006) report which is presented in Figure 17 below. All of the products defined can be flown and booked as general cargo, although it is unlikely that for example perishables will be flown as general cargo.

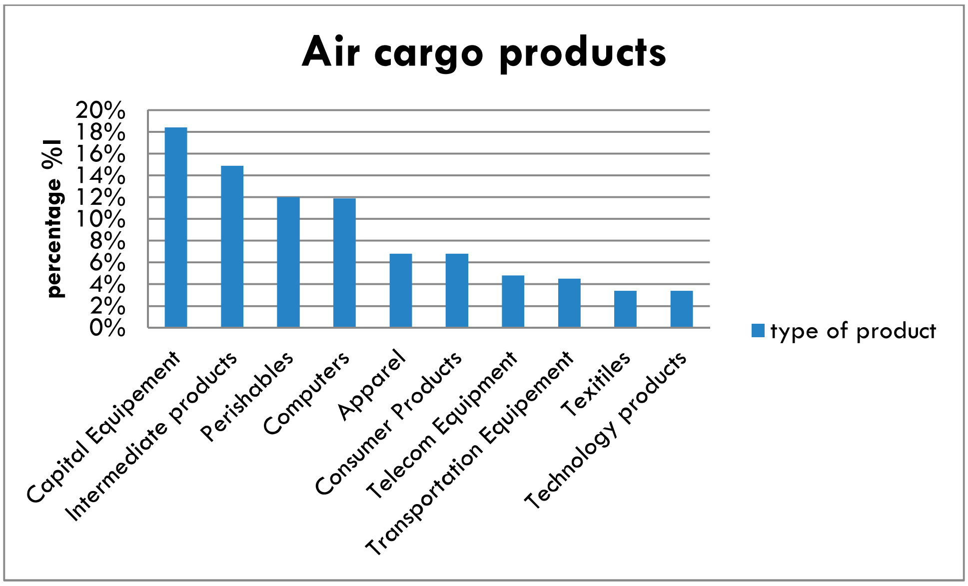

Figure 17: Main product types shipped by air derived from (Heereman, 2006, p. 8).

5.6 COLLABORATION PRACTICES APPLIED AT SCHIPHOL BETWEEN AIR CARGO STAKEHOLDERS

Most collaboration air cargo transport is currently applied in the air cargo system at Schiphol is established on vertical basis between the handler company and forwarder, the handler company and transport company or the forwarder and a transport company. Horizontal transport collaboration that currently exists between forwarding parties or handlers at Schiphol, is often either indirectly derived from vertical collaboration agreements that do not relate to collaboration on physical flows of air cargo between different freight forwarders. Collaboration thus focused more on the use of shared information systems for security related processes at handling/ forwarding locations and transport, as this can make the process for all involved parties equal, faster and more efficient, without influencing the individual companies transport ability in anyway. The most important vertical and horizontal collaboration practices at Schiphol airport in the air cargo system will now be described below based on the directly and actively involved stakeholders of each type of collaboration.

Vertical collaboration concepts between two or more different value chain companies

<u>Collaboration between freight forwarders and air cargo handlers</u>

2door delivery (import) KLM cargo handling

KLM cargo handling at Schiphol offers a 2door concept, to the freight forwarders for import cargo shipments, it is only offered to forwarders that are operating within Douane Goederen Volg System (DGVS) area. The DGVS area and system will be explained in more detail later in this paragraph. This service is offered for both lose cargo and air cargo palletized cargo, the transported cargo shipments can be both general cargo and other type's cargo depending on the freight forwarders choice. Within this concept KLM Cargo tries to offer its customers a hassle free delivery of their import cargo shipments within an agreed time after landing of the aircraft and between defined operating hours and days for a fixed price per kilo. The transport is planned by KLM cargo which hires an external transport company to realize the actual transport of shipments from their own facility to the freight forwarders warehouses. The concept is used by larger freight forwarders around Schiphol, for either cost or operational considerations. In the way this concept is offered it is currently only possible for major freight forwarders if their volume (weight) of cargo shipments is of sufficient size and the shipments are arriving is on frequent basis, otherwise the costs of transport will not be attractive and delivery frequency will be too low compared to own organized transport.

Forwarding companies that use this service of KLM Cargo pay a fixed price per kilo for cargo shipments transported to their warehouse and the costs for this service are added to the handling costs of the cargo shipments from KLM Cargo handling. KLM offers this service for each involved forwarder on individual basis, this means that there is no general agreement on the fixed allocation of truck capacity between different parties that use this concept. This also why it this concept only becomes attractive when a forwarder has sufficient import volume, as costs and volume cannot be shared with other competitors within this concept.

2door delivery via Menzies/DHL aviation/Viggo

Several air cargo handlers offer transport services from their handling facility in-house to freight forwarders to give these freight forwarders faster access and lower cost access to part of their import cargo shipments. This concept currently does not work for all freight forwarders, as only a selective few number of freight forwarders have indirect access to the airside of the airport. By utilizing part of the transport via the airports airside platform the involved freight forwarders can reduce the amount cargo transported by truck from different handling facilities and can also in some cases obtain cargo directly after landing instead of waiting for the cargo to processed at the handling facility. It also often gives them faster delivery of cargo as congestion of transport via airside does not exist in the current situation. This airside/in house delivery concept however depends heavily on the operational capability and willingness of air cargo handling companies, also not all cargo that arrives at the air cargo handling facilities can be transported via the platform, only cargo that has arrived by airplane can be transported via this way.

Slot reservation / cargo ready approach

To avoid congestion and ineffective use of cargo docking doors at handling facilities, several air cargo handlers at Schiphol have been using slot systems for their landside dock doors. This enables them for to offer faster services to their customers and also gives them a better indication when cargo shipments are collected or delivered. Currently both KLM Cargo and Aviapartner offer the use of slots for their costumers, however the way these slots are used and can be reserved is different. This system is however not applied by the other air cargo handlers. Challenges of the current slot reservation system still exist, as it is sometimes difficult on forehand to be able to assure that cargo shipments are ready for delivery/pick up and relate this to the arrival of cargo and departure of cargo based on operating flights and routes. Flights can be often delayed and operational challenges at an air cargo handling facility can result in later than expected timing for having the cargo ready for pickup. As slots have to be reserved some time before collection or delivery of air cargo shipments it can be big challenges for forwarders to make slots use as effective as they would like it to be. This is also why some forwarders prefer to use the 2door concept of KLM, as they will then outsource the challenges of finding the right slots for combining shipments within the agreed delivery deadline to the company who is actually in charge of breaking down and processing the cargo shipments. All cargo handlers at Schiphol however do notify freight forwarders when their cargo (import) is ready for pickup via the digital system, most of the air cargo handlers use the system of Cargonaut for these type of messages notifications. It is however up to cargo handler in the end to decide in which way a forwarder is notified that shipments are ready for collection. These notification messages are also important as it also defined the moment of when storage time calculation starts and it can be used by forwarders to plan combined collection of shipments at one handler. Several air cargo handlers are also using a system where freight forwarders on the basis of the shipment ready status of air cargo ULD pallets, can reserve the use of ULD dock for import and export of complete ULD cargo shipments. As explained before large freight forwarders are increasing their use of ULD pallets at major gateways, in order to avoid damage to cargo and to obtain the cargo faster without having to wait for the breakup of cargo pallets by handling company first., so this is why to be sure that cargo shipments can be delivered or picked up fast at air cargo handlers, large freight forwarders reserve the use of ULD specific docks. Collaboration on the use of ULD docks is with the increased use of buildup cargo also becoming much more important as handlers generally only have one specific dock door for import and export of ULD transport.

Freight forwarder collaboration with transport company

Outsourcing the complete transport of cargo (no direct control on truck movements)

Smaller freight forwarders that do not have the staff resources or volume of air cargo to justify the dedicated use of trucks for their transport, these companies often need to outsource their complete transport process for import and export transport to and from air cargo handlers at Schiphol. They only use their own transport vehicles (often smaller trucks/vans) for urgent and special transport and leave the transport and planning of their cargo transport needs to an external transport company. Often this types of outsourcing will result in combined transport of air cargo of several competing companies, so that the transport company can increase the load factor and to lower the costs of transport. In this sense this concept can be viewed as indirect horizontal collaboration between forwarders as they allow cargo shipments of different companies to be transported in the same trailer. However this type of transport is not fixed for certain amount of forwarders or specially defined routes and contract between involved forwarders. So this form of collaboration can be seen more as indirect acceptance of horizontal transport collaboration for costs considerations.

Using external transport company (direct control of truck movements)

Larger freight forwarders or smaller freight forwarders with frequent high value cargo shipments often need to be more in control of the movement of their cargo shipments. They cannot simple outsource their transport needs completely and allow frequent and extensive consolidation and combinations of other shipments for their transport needs. So they need to have direct control of the transport of these types of shipments, in order to achieve this, they often hire dedicated transport from an external company (truck, driver) either per hour, for a complete shift or based on fixed price per cargo kilo transported over a certain period of time. These trucks than normally run dedicated for one freight forwarder during a certain period of time and do not take cargo of other freight forwarders.

Transport company and handler (or airline)

Flight number operated truck operations

A limited amount of transport companies operating at Schiphol operate (flight style trucking) under flight numbers between other major and secondary airports and Schiphol airport, this transport is normally organized between the handling facilities of two different airports. This transport has to be organized by a transport company on behalf of an airline, but the actual organization itself and transport can be subcontracted to any party that meets the legal requirements to do so. In order to optimize this transport, several transport companies are support collaboration efforts on an individual basis with their most frequent visited air cargo handlers at Schiphol, to make sure there trucks can pick up and deliver the related air cargo on time and leave the handling facility in efficient way, without extensive waiting before loading or extensive duration of the loading/unloading process. Transport companies involved in this type of transport want to improve their reliability transport in order to better optimize their transport times and handling process at the onward destination.

Cross chain collaboration, can be defined as horizontal collaboration

ACN pas (card)

The ACN pas is a personal id card that is used at Schiphol airport by dozens of companies involved in the transport of air cargo from freight forwarding locations and air cargo handling facilities and beyond. This card gives users the ability to access secured locations around the airport without showing another form of id and having to report to person to obtain clearance to enter a secure location. Currently the card works for access at all general air cargo handling facilities and at several freight forwarders locations at Schiphol including; DHL Global Forwarding, CEVA and Rhenus Logistics. The card can also be used to transfer data from one company to other and can be used to measure the timing and location of truck driver at several points in the air cargo transport. This transfer of data can be achieved as company and personal data of the ACN pas are linked to a card(Smartlocks, 2012). So the ACN card can also be used to hand over digital documents and responsibilities of air cargo shipments between the involved parties.

DGVS system

Douane Goederen volg systeem (DGVS) makes it possible for air cargo shipments to travel without the presence of physical custom documents within a certain area around Schiphol. Companies need to be connected to the DGVS system itself, have to be located in a certain area around Schiphol and have to implement and follow procedures and processes according to customs authorities' instructions. With the use of this system no physical transit documentation is needed to transfer cargo between the involved parties that are located in the defined are around Schiphol (Cargonaut, 2012). The custom agency of Netherlands can track the movement of cargo to and from the involved companies around Schiphol and can use this information to plan checks on certain shipments based on the location of the cargo in the system. Cargo shipments that are transported under the DGVS system can already be broken down and moved to warehouses of different freight forwarders before custom authorities request or plan an inspection of cargo shipments.

E-freight

E-freight is a concept that can already be applied to part of the air cargo shipments shipped; e-freight shipments do not require the physical presence of series of documents for air cargo shipments to be transported. E-freight shipments can thus be transport completely paperless or have a reduced amount of documents included with the actual shipment. Currently up to 20 different documents for air cargo shipment are available in a digital format and are certified to be used for transport and hand over air cargo shipments across the chain by IATA in digital way. This means that truly paperless shipment of cargo is already possible for part of the shipments that arrive and depart from Schiphol airport (IATA, 2012). Custom documentation requirements related to certain type goods and destination of shipments often still require physical presence of several documents. In order to use e-freight, freight forwarders have to sign an agreement that allows the use of a digital airwaybill, without this agreement a copy of the airway bill still has to be physically attached to the related cargo shipments. Given the restrictions on goods, the limited destinations of e-freight and low support by several major airlines for this concept the amount of e-freight shipments is still low at Schiphol and other airports. However the total number of shipments is still growing and with the implementation of e-link for export and in the near future for import the use of this concept is expected to increase in the future.

E link / Airlink

E-link is a concept that utilizes the e-freight concept to further enhance the air cargo system. With E-link information about a shipment can be shared in a digital way between freight forwarders, transport companies, and involved air cargo handlers, it can however also be used to link to truck and truck driver of the selected air cargo shipments to each other. As the information from e-freight is shared and linked to the transport before the cargo shipment actually arrives in physical state at the handling facility, the handling facility can assign capacity of staff and a dock door to the transport and to offer the e-link equipped transport with a fast service from the moment of arriving at the handling facility to the moment of unloading the truck. The shipment cargo is linked to the identity card of the trucker with the use of the ACN pas this is also linked to the license plate of the used truck, this makes it possible for a driver to receive information about the assigned location where involved truck can be parked directly when driver arrives at the handlings entrance gate (export)(SADC, 2011). Without the use of E-link truck drivers have to park their truck, report first to the handling companies' office to hand over the cargo shipments documents and wait for a door to be assigned to their truck. Currently because of limited use, support and awareness of E-link concept, the full potential of the concept is not yet achieved at Schiphol, it is however expected that reduction of 25% in handling time can be achieved by full implementation and support of this concept. As shipments that will be using the e-link system in the future can be directed directly to a loading door at the handler and do not need to hand offer shipment related documents or be processed at the air cargo handlers' document desk. In the current situation E-link drivers still have to process their shipment documentation at the document desk of the air cargo handler, but do get priority over non e-link drivers their documentation process also goes much faster as all information is digitally available to the air cargo handler. E-link collaboration thus goes further than the stand alone use of e-freight shipments, as it also involves investment in ict/security system that is needed to link a truck and a driver to a specific shipment and to allow planning of the handler on the basis of this linking and assigning its dock door usage according to the information provided by the e-link concept.

5.7 COLLABORATION ASSESSMENT OF SCHIPHOL

Most collaboration applied at Schiphol in the air cargo system has been developed between companies with a vertical relationship within the supply chain. This has mainly resulted in collaboration between the largest freight forwarders, airlines, transport companies and air cargo handlers. With the exception of the use of cross chain security access to handling facilities by use of ACN card, the DGVS custom system and the digitalization of air cargo documents as these concepts offer much better efficiencies gains and support when implemented and support by the entire industry. Given the growth of cargo volumes of the last decades and the related growth of stakeholders involved in all parts of the air cargo system, collaboration practices seem to be realized when operational challenges could be best met by supporting specific types of collaboration between the stakeholders that were most affected by the operational challenges that have occurred. As the air cargo system is continuously changing when looking at the use of cargo transport, the way shipments are transported and what an average shipment consist of (volume/weight), the value proposition of both vertical and horizontal collaboration has changed within different parts of the system for major users of the air cargo system. It is even likely that value of current and future collaboration practices will change even more, as a more dynamic use of air cargo transport is being further supported by the digitalization and liberalization of key air cargo markets via direct and one stop services. It is often only when direct benefits of collaboration on a certain aspect increases or the relationships between the involved stakeholders become more long term, that more extensive collaboration will be possible than is currently in place. Collaboration between the largest stakeholders in the air cargo system can often be realized more easily, because these companies have the resources, volume of cargo and frequency of shipments to be able to collaborate on specific logistic challenges without affecting the flexibility and speed needed for certain transport of air cargo shipments. Whereas smaller stakeholders can often not support the volume and operational requirements needed to make collaboration successful. However the declining shipments sizes and weights for part of air cargo shipments and dynamics of booking shipments on different flights make it even difficult for the largest forwarders to realize effective individual transport on daily basis.

Based on the interviews that were undertaken at Schiphol airport and publications and web information on the analyzed the following factors were are defined to justify collaboration with other stakeholders that operate on the same level of the value chain:

- improving transport speed, reliability or frequency(Visser, 2009)
- improving the planning of air cargo handling (Menzies, WFS, Aviapartner, KLM, Swissport)
- reducing transport costs or related planning activities (DHL, Rhenus, Ceva, Geodis Wilson, Nippon Express, Hellman, Yusen Logistics)
- reducing the damage to shipments (many forwarders)
- reduction of document processing times (many forwarders)
- reduction of handling operations times (all handlers)
- reducing amount trucks needed for transport to handler (forwarders/handlers/transport companies)

Figure 18 below shows an overview of all major applied collaboration concepts that have been partly discussed in this paragraph for Schiphol airport. The figure tries to show too which extent improvements to the logistic operations at the involved stakeholders impact important factors that can justifying the use of collaboration. Due to the high value of air cargo, the time sensitive nature of the products and complex interaction between the different parties responsible for air cargo transport, the high costs of using air cargo transport and the high information exchange dependency between stakeholders it can be understood that collaboration relates mainly around these aspects. This is why reducing negative factors of using traditional air cargo supply chain: based on the involvement of several parties for transport, fixed use of handling facilities, challenges of reliability of ground transport facilitate the use of collaboration. Improving the factors that are key factors for using air cargo services; speed of air cargo services, high product care of shipments and frequency of service are can be key reasons to apply collaboration in the air cargo system. These factors can relate to both on ground and aircraft related operations, as operational challenges on both aspects can influence the next journey of air cargo transport. In essence the majority of measures taken in the air cargo system are supported only if they: improve speed, reliability, and frequency, while the related costs for implementing and supporting these measures are only causing a slight increase in costs. Alternatively collaboration will often be supported if the costs of process involved can be reduced, without a significant reduction in speed, frequency and reliability of the logistics operations involved. Given the use of air transport is often related to time urgency of the cargo transported, only minor reduction of reduced time performance for lower costs can be accepted. However as margins are becoming ever more under pressure, in some situations slower processes that give the ability to realize a significant costs reduction also have to be potential to be supported. With the low margins it is much less likely that more costly measures for a certain process improvement will be supported in the current air cargo system.

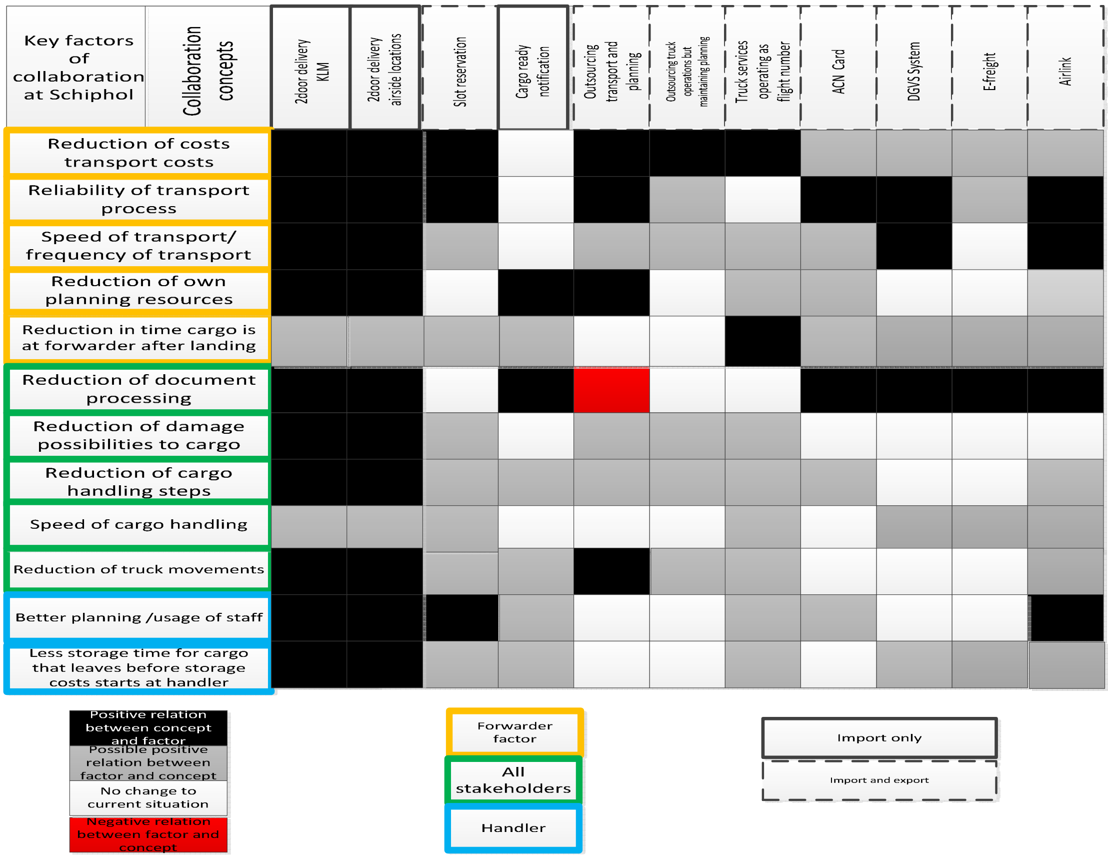

Figure 18: Relation between collaboration concepts and key factors for supporting collaboration.

5.8 UPCOMING CHANGES TO CURRENT AIR CARGO SYSTEM AT SCHIPHOL RELATED TO COLLABORATION

Future changes at Schiphol airport that can occur on the long term have been briefly discussed in chapter 4, upcoming changes that will be implemented and effect the current air cargo system and collaboration in place will be explained in more detail below in order to further analyze the collaboration potential and specifics of the air cargo system at Schiphol.

Location of export related customs checks

The main change that will impact the operations at Schiphol involves the export related transport as most of the shipments arriving at the airport need to undergo security and custom procedures at the airport. In the current system custom checks for export are mainly preformed at the air handler facilities, just before a flight departs. Custom checks for import are currently also performed for import at the air cargo handlers' facility. Given the time sensitive nature of goods exported via air cargo services and the limited space at the handler facilities, it can often be challenging process of facilitating customs checks just before a flight leaves and in the same time being able to have the cargo shipments ready for departure on time. This is also one of the reasons why shipments are currently requested to be at the handling facility at least a few hours before scheduled departure. Large freight forwarders at Schiphol are currently in the process of obtaining the option to perform custom checks for export of air cargo goods at their own facility. When this is made possible in the near future, required checks can be performed at the freight forwarders facility and also make custom process easier and quicker, as cargo will only be build up after it has been scanned and approved, this should result in faster build up/loading of air cargo shipments for export flights, less cargo to be moved, buildup again after a custom check and less handling activities at the handler. Export shipments spend a certain amount of time at the freight forwarder before they are being transported to a specific air cargo handler. Currently most of the time shipments spend in the warehouse of the forwarder is not effectively utilized, by being able to perform custom checks at the freight forwarder this time can be used in effective way and can improve the process at air cargo handlers. Certain types of cargo like dangerous goods have and will always be inspected by the customs authority to make sure that this is packed in the appropriate way for air transport, but these checks are already occurring at the freight forwarders warehouses before arriving at the handling facility so this does not affect the change in the system.

Security screening of air cargo

Another major upcoming change for the air cargo system at Schiphol will relate to security screening of air cargo from April 2013. Until 29th of April 2010 it was possible for a shipper of air cargo and air cargo agents to become a known shipper or agent for air cargo security by applying for a permit with the ACN, new security regulations in the European Union will make the process obtaining and maintaining the known status much more complex and costly. Given this change, current registered companies will have to comply with the new regulation from 29th of April 2013 or they will lose their current known status. It is expected that a large amount of companies that currently have the known status will lose this status as they do are unable for different reasons to comply with the new security rules and procedures before 29th of April 2013. Making cargo of unknown shippers or transport companies known can be done by an external company or by use of Dutch government approved equipment. Several large freight forwarders at Schiphol airport are still evaluating if they will buy their own equipment to perform checks at their own facility, use a shared location for this process together with a limited amount of competing freight forwarders to perform security and checks for custom related operations or use an external organization to perform the needed checks at their own facility (Wiertz, 2012). The reason that many companies have not made a decision on this important aspect comes from the fact that the specifications of the equipment that will be approved by the national authority in charge of security of air freight, Koninklijke Marechaussee (Kmar), still has to announce the specifications of equipment for security related checks. Companies that are considering investing in their own equipment want to make sure that that a device can be used for both security and customs related checks, because this is still not known they are waiting to make their final decision. Besides the specification and costs aspects of equipment the extent of need for scanning equipment are also unknown currently, this will be explained in more detail below. After April 29, 2013 the new European Union air cargo security regime will be enforced which will require that "known consignors" must have had their security procedures and measures validated by an officially approved inspector of the involved country. Alternatively a regulated agent, or carrier has secure air freight by scanning and inspecting the air cargo according to EU and national requirements(hktdc, 2011). These changes are being enforced on the basis of EU regulation 185/2010. To phrase it differently only air freight consignments that originate from an individual or legal entity that is registered as a Known Consignor (KC), by the appointed responsible national supervisory authority can be declared "secure". If this is not the case cargo will be declared unsecure and will have to be screened before entering the aircraft. In the Netherlands and Germany for example the amount of shippers that have obtained the known status that is applicable to the new regulation at the end of 2011 was very limited (50 in Germany) and (150 in the Netherlands). It is thus expected that many current shippers will become unknown in the end of April 2013. This will require large number of additional checks to be performed at regulated agents (handler/freight forwarder) who are likely not to have the capacity to handle such an increase. Added to this freight that has been made secure does not stay secure for a long period, after certain amount of hours air cargo shipments that have been placed in a warehouse can lose their secure status. To show this change in regard to the current situation below a flow of unknown and know shipment is shown in Figure 19 and Figure 20 below. In this figures freight forwarder one has a scan facility at its own location and freight forwarder two can only use external screening or has to call in a team of customs agency.

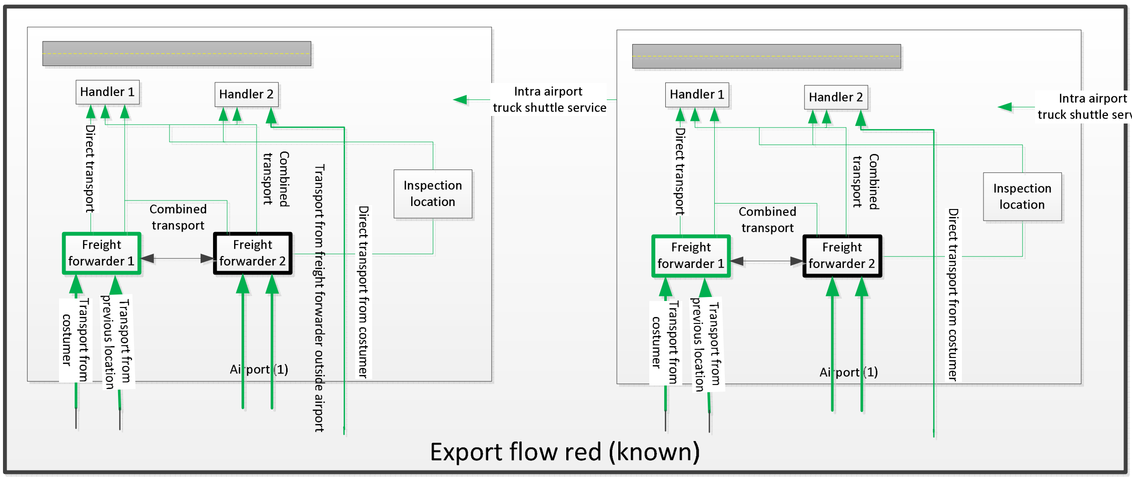

Figure 19: Transport flow of export shipments to airport with known status from shipper.

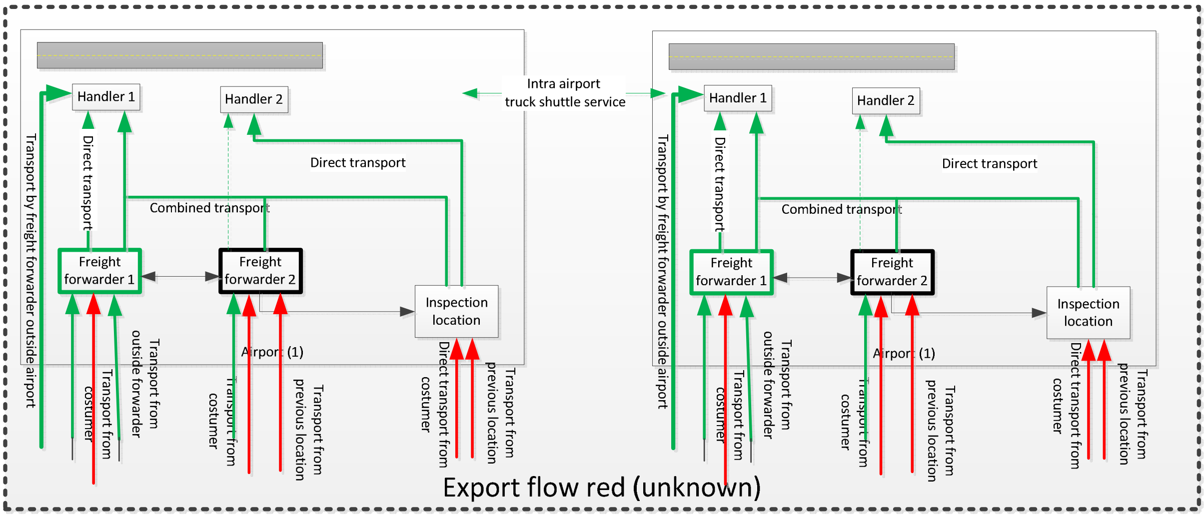

Figure 20: Transport flow of export shipments to airport with unknown shipper status (red flow) and no scan facility before arrival at airport.

Milkrun import collaboration

In the beginning of 2013 three freight forwarders that are active at Schiphol will start a horizontal collaboration transport project, which will be done for import loose cargo shipments from one air cargo hander. The cargo shipments that will be transported with this collaboration concept will general cargo that are loose and thus does not involve collaboration on ULD transport. More information about this concept will be presented in chapter 7 and the chapters that follow, as this concept will be the basis of the simulation model of this research. This concept is different from the current 2door concept offered by the KLM as the intention is not to provide individual companies with their own delivery service, but to coordinate the transport of multiple companies and thus consolidate as much cargo shipments as possible of the three involved forwarding companies. By combining the flows of several different forwarders, not only the transport planning is taken out of the forwarders hand, but also the potential to increase frequency, delivery timing and reduce transport costs are created as it involves cargo shipments of several companies.

5.9 LIMITATIONS OF CURRENT AIR CARGO SYSTEM DESIGN AT SCHIPHOL

During the system analysis of collaboration practices that are applied at Schiphol it became clear that several restrictions and limitations are currently in place that can affect the potential of further collaboration or system improvements. Some of these limitations are already being reduced by the support and priority that is given to certain transport collaboration practices and the way freight forwarders are using alternatives to traditional transport movements between handling faculties, are increasing the use ULD's and the way they are using their airside access. Also booking more cargo capacity on other airports flights with direct 2 door delivery and utilizing more extensive list of airlines make it harder to realize some collaboration.

The most discussed and pointed out limitations of the systems design in the current way are:

1. Fixed costs on import/export storage at air cargo handlers, that are based solely on weight after and certain amount of free storage hours. No extension is given in order to provide transport companies to be better able to collect shipments during non-peak times for example.
2. Fixed handling costs based on type of cargo and handling needs. Handling costs are not based on actual costs during a certain day or period of the year, the handling costs figures are defined on yearly basis and do not defer in any other way.
3. Fixed landing charges for certain periods of the day, those are not related to handler use or other potential capacity constraints.
4. General limited ability of air cargo stakeholders to charge based on actual work done (transport, storage, handling)
5. Limited support of proactive information sharing that can influence logistics flows and related performance measurement. No active use and analysis of available data on shipment processing times at the different facilities to support effective system improvements.
6. Real estate development focuses on growth and direct real estate revenue, not on sustainability of business case of companies that are involved in rent of real estate. No variable rental price related to performance of the involved companies or their contribution to the air cargo system.
7. Limited knowledge and support for system wide de-peaking strategies related to air cargo transport
8. Limited ability to support a multi airport system from Schiphol, due to no nearby comparable airport.

Air cargo handlers at Schiphol like at other major airports only start charging for storage of shipments after shipments have been processed and forwarders able to collect the their shipments, most shipments are offered for collection around the same time. Given the operation times of forwarding companies in charge of these shipments this often gives them limited ability to be able to collect the shipment within the specified storage free timing. Especially when storage free timings are being reduced by handling companies, this has actually recently happened at Schiphol without any guarantee of faster handling or more reliable handling of cargo shipments during the storage free timing. This can force transport companies to collect and deliver shipments during peak handling times, as they cannot collect the system within the storage free time in any other way. If cargo shipments arrive more than x amount hours before scheduled departure of cargo shipments flight (export), storage costs will also be charged. In some cases this can also result in delivery of more shipments during peak operations. As the competition on air cargo handling market is extensive at Schiphol and there is overcapacity at several air cargo handlers. All air cargo handlers currently cannot differentiate on costs for handling of air cargo shipments over time and relate the actual costs. This means that air cargo handlers are unable to support peak operations with needed investments in staff and equipment. Besides this handlers have been unable to not make it financially more attractive to collect or pick up cargo within the free storage allocation for cargo shipments. However the dynamics of air cargo transport make it very suitable to apply revenue management on, as has been identified in the research of (Boonekamp, 2013) Given the competition and difficulty to make the right investments for air cargo handlers, it is important that processes of the different handlers are continuously improved in the right way (Schmidberger et al., 2009). At Schiphol however currently limited performance management and bench marking between all air cargo handlers is applied, when such a system would exist ,this could help individual handlers to improve specific parts of their operations more effective without a significant cost increase. These improvements can than results in making the entire air cargo handling system more efficient and effective. Air cargo handlers will each based on their specific client base make different improvements, which will in the end hopefully also make their relation with their clients more long term. Currently information about current waiting times, average handling times and other relevant operational information from air cargo handlers is not shared with its major costumers or published in public. This does not gives a freight forwarder an incentive to wait for collection or delivery of air cargo shipments, as they cannot be assured how long transport and handling time will take. Schiphol airport as owner of large parts of the airports infrastructure should be much more involved in the future to realize and support projects and measures that force cross sector collaboration on information and transport of truck movements around the airport. Other major air cargo airports are not only involved in the rental of land space for air cargo related activities, but are also financial involved in the operations of one or more air cargo handling facilities. This is however not the case at Schiphol, in the last decades the policy of Schiphol has been mainly to facility construction of new real estate and derive as much revenues from this real estate as possible. This type of policy however only works well when growth and demand for real estate are so high that these justify new real estate developments. The airport operator of Schiphol, the Schiphol group has in the last two decades changed its focus from providing and supporting the core activities of the airport system, to development of business activities related to aviation on the landside part of the airport. The airport authority now earns more from landside activities than it does from airside activities(Jong, 2006). Policy related to real estate development and earnings have been mainly focused on attracting new businesses related to aviation, but seem to be much less focused on supporting sustainable business and adaptive real estate charges. As non-aviation revenue streams are becoming more important for airport operators, the sustainability of these revenue streams from both real estate and other developments has to be further supported (Fuerst, Gross, & Klose, 2011). Previous research of (Oderkerk, 2009) has looked into the visibility and support de-peaking of flight operations at Schiphol airport and how it has been applied at other airports. Several airports that are larger in size than Schiphol are or have been using de-peaking strategies in order to improve over airport capacity, reduce delays and limited investments. However there is limited support for such an approach from the home carrier KLM at Schiphol. Succesfull de-peaking strategies at other airports however show that de-peaking can result in large financial benefits for both airlines applying the strategy as to the airport itself. De-peaking strategies for air cargo collection and delivery of shipments have only been applied to a limited extent at Schiphol, as no incentives are given to support de-peaking in effective way by air cargo handlers way. Most large freight forwarders are also likely to be reluctant to support de-peaking, as their own as they will argue that any capacity made available by them during peak times will be used by other forwarders. Major competing airport systems in Europe op Schiphol are or will have the ability to develop multi airport systems in the near future (Frankfurt/Hann) & London (several airports), other airports in the Netherlands lack the size/growth potential to provide a similar set up for Schiphol airport and the growth of flights operations at Schiphol is also limited(Verweij, 2008). This means that Schiphol has to ensure that their single airport system out performance any developments of multi airport systems at competing airport system.

5.10 TRANSPORT FOCUS FOR THIS RESEARCH WITHIN SCHIPHOL SYSTEM

This research will focus as explained before on the transport between 1st (air cargo handler) and 2nd line (forwarder warehouse) transport at the airport, as it was already pointed out in the proposal for this research and derived from workgroups within the member group of companies involved in the air cargo industry at Schiphol that this type of transport is most suitable for optimization by using a combination of vertical and horizontal collaboration measures. The previous paragraphs of this chapter have made clear that currently the relatively larger forwarders at Schiphol use their own fleet of trucks for delivery and collection of air cargo from the handling facilities at Schiphol to their own facility within the DGVS area. Only transport from KLM Cargo handling to the largest freight forwarders or those who can afford to combine loads based on their location and or volume/frequency of freight are already using transport organized by the handler to 2nd line freight forwarder facilities. The security and custom changes that will occur from this year and onwards are likely to increase the potential for combining movements to and from freight forwarder facilities, as it is expected that more cargo will have to be screened for these two related processes and can possible be combined, as the costs for equipment for these types of scanning are high. Forwarding companies can see an advantage to invest in such equipment with competing forwarders, given the use and prices of the systems that are needed. Also the moments of security screening or customs at different facilities could directly be followed or aligned with transport to a specific air cargo handler. This could in the future enhance the support for collaborative road transport for both import and export of air cargo from freight forwarding companies in the surrounding of Schiphol airport and the handling facilities at the airport, as it cannot always be economically or operational possible to perform the needed checks in-house within a certain timeframe, but the extent and possibilities for collaboration in this area still has to be researched more and will only become more clearer after April 2013. Airside delivery and ULD transport that is trucked or transported via air is increasingly used by large freight forwarders to avoid damage and time consuming loading processes at handling facilities. However a certain amount of air cargo will still be needed to transport as loose cargo and not all of this cargo is of high value or requires special care. It is for these and reasons and for the fact that an increasing number of companies is using air cargo transport for smaller shipments, that combining loads for lose general cargo is assumed to be beneficial for major freight forwarders. As organizing single company transport for a mix of smaller shipments that are at different times in a cost effective way with the current limitations of the air cargo system at Schiphol is becoming increasingly difficult. Dozens of interviews with forwarders, handlers and transport companies combined with feedback of several workgroup sessions with the involved air cargo companies at Schiphol have made clear that best cargo to collaborate with is general loose cargo, thus this will the focus of this research. As a pilot on import collaboration for loose general cargo is expected to start in 2013 the development and ongoing process of this pilot will be used in this research to better understand the air cargo system and limitations for collaboration. It will also be used as input for better defining collaboration concepts for collaboration on export flow of lose general cargo, which will be simulated based on data of previous shipments to and from Schiphol , this will be explained in more detail in chapter 7.

5.11 KEY COMPANIES INVOLVED IN THE AIR CARGO SYSTEM`

In order to complete the system analysis of Schiphol airport, the most important stakeholders of this research will be analyzed more in depth. As a large variety of different companies are operating at Schiphol certain types of stakeholders are divided in several sub groups, as their interest, goal and challenges are different given their specific operations and the current air cargo system at Schiphol. This analysis is also done in order to further support which stakeholders are more likely to support collaboration of transport in current and future at Schiphol.

The following stakeholders are analyzed in more detail for this research in the next chapter.

- air cargo handling companies (1st line)
  - home carrier handler
  - general air cargo handler / handler with international network but local profit requirement
- governmental entities/ European
  - national government of the Netherlands
  - provincial government of North Holland
  - European Commission
- airlines
  - home carriers
  - none home carriers
- freight forwarders (with warehouse facility at or around Schiphol)
  - with (in)direct access to 1st line airside access
  - large freight forwarders with no direct to 1st line access
  - medium sized freight forwarders with no direct 1st line access
  - small sized freight forwarders with no direct 1st line access
  - specialized freight forwarders with no direct 1st line access
- transport companies
  - which offer general transport services
  - which offer general transport service, airport to airport truck services and warehousing solutions
- shippers
  - with regular cargo shipments and large volume
  - with regular cargo shipments and low volume
- cross sector organizations
  - Schiphol Airport Group
  - air Cargo Netherlands

In the next chapter a stakeholder analysis of the main stakeholders involved in this research is conducted, to understand the position, power and attitude of these stakeholders towards collaboration for truck movements between handler and freight forwarder in the surroundings of Schiphol.

6 SCHIPHOL AIR CARGO SYSTEM STAKEHOLDER ANALYSIS

6.1 GENERAL ANALYSES OF KEY STAKEHOLDERS AT SCHIPHOL AIRPORT

In this paragraph the main difference and challenges for the key stakeholders of the Schiphol system will be described below. The complete stakeholders table that defines the variables for each analyzed stakeholder can be found in **Error! Reference source not found.**. The stakeholders that are analyzed in this chapter are based on the list of stakeholders that were defined in the previous chapter. For each stakeholder the following variables are defined in relation to the Schiphol air cargo system;

- their main interest
- their main objective / desired situation
- the current or expected gap between their objective/interest and developments within the system
- causes for challenges in relation to their objective/interest and the developments within the air cargo industry
- possible solutions to reduce the faced challenges or improve their stakeholder position

Government related entities (Dutch government, Province of North Holland and European Commission)

In general the government related entities involved in the system all face the dilemma of supporting air cargo development at Schiphol or a at airports in either the Netherlands or the rest of the European Union for economic growth and job creation, while limiting the amount of negative external effects to society. For the European Commission this dilemma is also extended to the problem of by having to either support further development of existing transport hubs or providing funding and other forms of support to fast growing smaller airports in less developed member states. Besides these points, lower government budget for infrastructure at all level in general makes it harder obtain and justify large scale investments that are needed to improve the efficiency and effectiveness of profitable airport hubs like Schiphol or other major Western European cargo airports. Combined with the increased uncertainty about air cargo demand and the way of transport from major airports will develop it will be a major challenge to find other forms of support from the government entities not related to financial support that will have a big positive impact on reduction of uncertainty of air cargo development. As governments entities will have to become more selective in their commitment and support for infrastructure development, the air cargo industry as a whole should try to overcome these uncertain challenges by working together with the government entities within the air cargo related subjects and even beyond, by for example supporting projects that involve alternative forms of transport for air cargo.

Freight forwarders (airside access, 2nd line location, medium sized forwarders, small forwarders & specialized forwarders)

Due to the large amount of different type and size freight forwarders active at Schiphol their operations are optimized in different ways. This also makes it difficult to realize growth for all freight forwarders when the air cargo market is growing, as not all freight forwarders are able to offer the same products and services for the right price. However all freight forwarders are facing a declining market with lower operating margins at Western Europe airports, this means that forwarders have to find ways to optimize their processes, this can result in collaboration with competitors or take over strategies of competing freight forwarders to realize larger economics of scale are in which it is possible to improve the air cargo supply chain individually. They can also pursue collaboration with other parties in the air cargo system like; transport companies, air cargo handlers and airlines. The extent collaboration needs to be realized by freight forwarders largely depends on their scale of operations at Schiphol and their global presence, but also has to do to the extent they can realize more effective and efficient transport to and from their warehouse from air cargo handlers. In general the largest forwarders are expected to have the ability, power and economy of scale to realize more collaboration either via vertical or horizontal collaboration, as they can choose the type of collaboration with the most impact and least amount of costs. For the smaller forwarders it is much more difficult given their size/volume to achieve effective collaboration to the same extent as for big forwarders can realize, on a vertical or horizontal level, so they can be forced to support a type of collaboration that isn't the most effective given their type of operations. Given the economics of scale the larger forwarders have less need to support collaboration to achieve cost competitiveness, this can however be a big consideration for smaller forwarders to actively support collaboration practices. This also relates to the ability to integrate or exchange information flows or provide new digital based products for air cargo shipments, investments in ict can be high and complex (Schwarz, 2005). This makes it easier for larger forwarder with sufficient cargo, capital and resources to invest in these needed ict systems and ict product offerings. In Figure 21 below an attempt is made to position the relative power of the different freight forwarders at Schiphol and to assess to which extent they need to collaborate and how many different types of collaboration possibilities their operations offer.

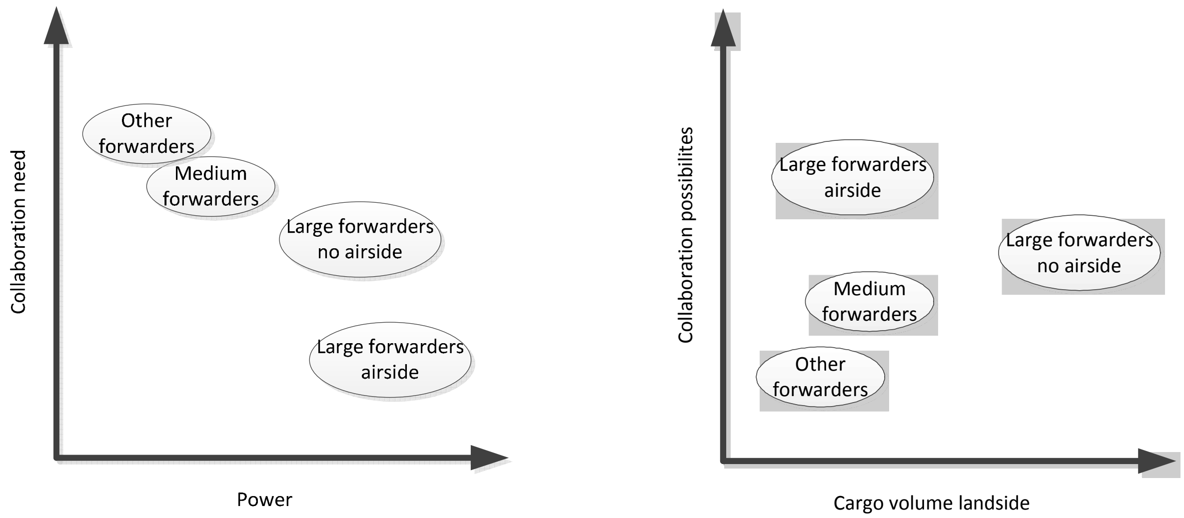

Figure 21: Power & cargo volume in relation to collaboration support/possibilities of forwarders.

Figure 21 above shows that the parties that are most eager to support collaboration either lack the power or volume to initiate collaboration in effective way, with small number of companies, as where the largest forwarders are much likely to be able to realize collaboration given their power and volume. The larger forwarders however can be more reluctant to support collaboration as this will often mean sharing revenue with other companies.

Air Cargo handlers

Air cargo handlers at Schiphol are all currently in a difficult situation, as handling charges including landing charges related to competing airports outside the Netherlands are often higher and more and more airlines are offering competitive priced trucking services from distance airports directly to freight forwarders warehouses located at Schiphol. Next to these two points a large amount of air cargo handlers have to work with excess of capacity either within their own facility or on system level, this is putting further pressure on the handling charges that can being charged at Schiphol. Previous growth of air cargo market has resulted in expansion of handling capacity at Schiphol that is currently not effectively utilized. Combined with these challenges freight forwarders are finding ways to have air cargo delivered on more complete ULD's and some have even obtained air side access locations which give them the ability to utilize different means of collection of shipments. Handlers are thus facing an increased dilemma to which extent they should be offering airside delivery (in house) or via another airside location, as this can provide them with much needed business in the current difficult times, but in the same time this type of service is also much less attractive revenue wise when compared to handling the cargo within their facility via landside. It remains to be seen to which general air handlers will support facilitate airside delivery in the future and how this will also affect the collaboration between the different handlers, as not all handlers can offer the same services. Also specialized handlers, or dedicated air cargo handlers for limited amount of freight forwarder are facing an uncertain future as import volumes of air cargo are declining and as explained before, part of the import cargo is now arriving directly at the forwarder without reaching the handling facility. Air cargo handlers at Schiphol will thus have to come up with new types of value added services at Schiphol to compensate for their higher operating costs and the excess in handling capacity in order to be able to survive in the long term. Collaboration with forwarders, airlines, transport companies and competitors will have to be improved in order support the air cargo handlers business and to be able to invest in technology and staff to support the competiveness of the air cargo system at Schiphol. Given the different size of the cargo handlers at Schiphol, collaboration possibilities and support are again different for the involved parties. This can also explain why KLM Cargo (handling) has been the most actively involved air cargo handler in collaboration concepts, as large part of the cargo shipment volume at Schiphol is handled by KLM Cargo and it is directly connected to the largest airline using the handling facility belongs to the same company. This also creates a much more stable environment for long term collaboration approach between the handler, airline and major forwarders at the airport. For other air cargo handlers collaboration can only be succesfull if the stability for collaboration can be guaranteed by involvement of biggest stakeholders for a large part of their cargo volume and it supported by stable most of airline customers it services as handling agent. Figure 22 below tries to show the different power position of the each group of handlers active at Schiphol in relation to their collaboration need and collaboration possibilities.

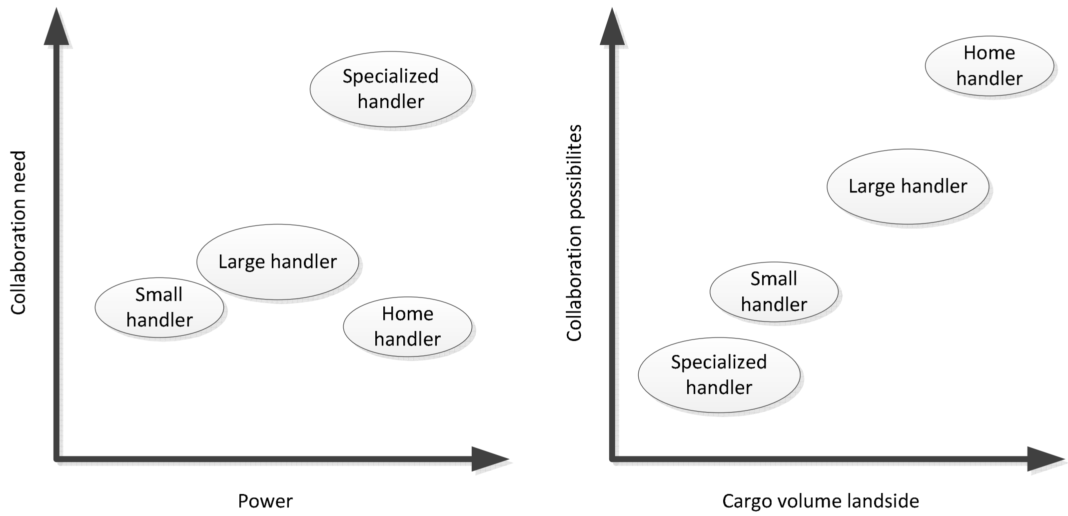

Figure 22: Power & cargo volume in relation to collaboration support/possibilities of air cargo handlers

Transport companies

More and more freight forwarders and airlines are using trucking services that are provided by a third party transport company; to reduce their fixed costs and to utilize the experience of trucking companies to provide which often results in a better services for a lower price, than their own previously operated transport division. Transport companies that are operating within the air cargo business have been growing alongside with the air cargo growth over the last decades. Given the relative small investment for truck services and the equipment needed in relation to aircraft operations infrastructure many transport companies currently have difficulty in utilizing their truck fleet in a cost efficient way, as over capacity is present at all major transport companies. This also has to do with the fact that the average cargo shipments are becoming smaller and of lower value, so truck transport operating margins are under pressure. Air cargo stakeholders that hire transport companies for air cargo are trying to obtain lower rates for truck hiring; this makes it hard for transport companies to procure business at a profitable level. In order to improve the revenue of truck services and reduction of waiting at air cargo facilities several larger transport companies are actively trying to realize more effective and efficient transport by truck with the use of collaboration via airlines, air cargo handlers and freight forwarders. Depending on the focus of the type of services provided by a transport company and the scale of air cargo operations of their most important costumers,' different strategies are possible, to improve the current position of transport companies within the air cargo system. Transport companies that offer flight number operated services and other value added services, can for example increase their collaboration with airlines, air cargo handlers and freight forwarders, in order to make their services more competitive and reliable. While transport companies that do not offer flight number services and mainly offer point to point services within the Netherlands will have to focus more with their collaboration efforts on freight forwarders, air cargo handlers and collaborate with competing transport companies, in order to realize the best possible balance of truck load, transport route and transport time for the involved stakeholders. Ofcourse given the increased use of transport companies by several different stakeholders within the air cargo system such as; airlines, air cargo handlers, freight forwarders, shippers and consignees it can make it more difficult for a transport company to define in which way it should support its collaboration efforts.

Airlines

Airlines that use Schiphol for their cargo operations are likely to face less favorable operational conditions by using the airport compared to competing airports in Europe, as the operational restrictions and environmental restrictions will become stricter in most Western European counties and especially at major hub airports. However the extensive mix of full cargo flights, passenger flights with cargo capacity and presence of major forwarders and extensive choice of handling companies still make it an attractive airport for many costumers of air freight services. Two different group of airlines have analyzed; the home carrier and non-home carrier. The main difference between these two carriers is that the first operates almost all services to and from the involved airport, were as the non-home carrier utilizes the airport as a stopover point from its own hub. Of course there are different types of carriers operating to an airport which is not their home base, as they can operate on a regular schedule, ad hoc basis or only operate trucking services to Schiphol airport. Both the home carrier and other scheduled airlines that use and of air cargo services from Schiphol will have to improve the efficiency of their operations in the future, to be able to offer competitive air cargo services to and from Schiphol, compared to utilizing alternative airports. For home carries this could be achieved by increasing the collaboration with key partner airlines, forwarders and transport companies that are active at Schiphol. With this collaboration longer term relations can be supported that make it possible to realize higher stability and investments in air cargo operations of the involved companies. As a home carrier cannot easily switch part of their operations to other airports and use truck air cargo to its own hub airport, as it needs to keep the volume and frequency of services to maintain its competitive advantage over other airlines and handling companies. Non home carriers can easily shift part of their flight operations to more favorable airports based on price and operational restrictions and truck the cargo to their customers around Schiphol. None scheduled airlines or truck only operating airlines can ofcourse more easily utilize different possibilities to improve their effectiveness and efficiency of operation to Schiphol from other airports. Longer and more extensive collaboration with key stakeholders around Schiphol will however be more difficult to be achieved as uncertainty and low volume of cargo will often not justify extensive collaboration. Collaboration from these airlines will likely be approached from their own hub environment, involved trucking partners and major costumers of cargo bookings around Schiphol. So the extent of need and support for collaboration of airlines operating at the airport depends on; their volumes, their operation flexibility regarding using other airports and type of flight operated services they offer at Schiphol. The home carrier(s), like the home air cargo handler has again the most opportunities and need to collaborate, whereas ad hoc and trucking airlines have much less power and volume of cargo shipments to support collaboration. Figure 23 below tries to show relative relation between the power/ cargo volume and collaboration need and possibilities.

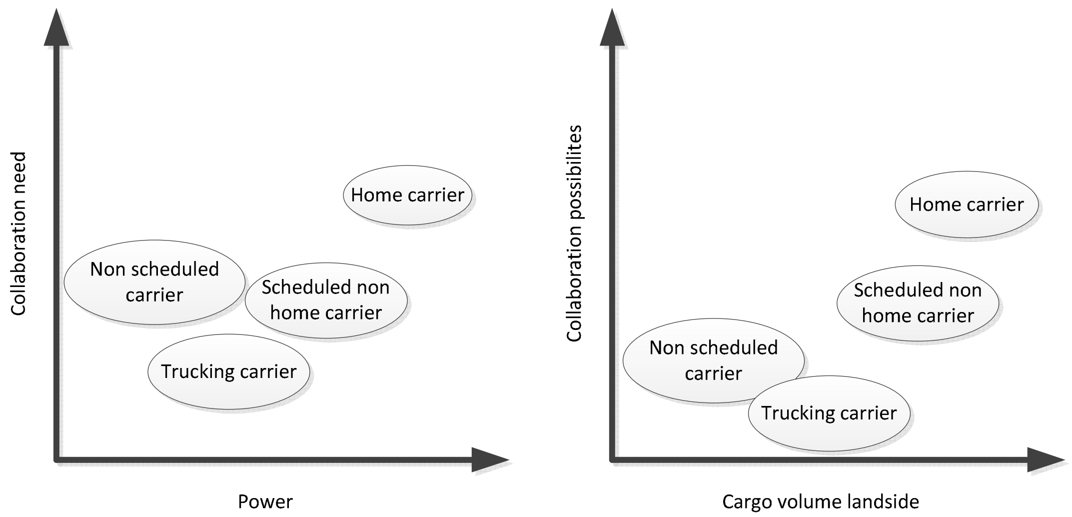

Figure 23: Power & cargo volume in relation to collaboration support/possibilities of airline (carriers)

Shippers & consignees

The amount of companies using air cargo transport is extensive and cannot easily be categorized; however the main users of air cargo are regular users. As the use of air cargo transport is often the only possible type of transport for shippers given time, value and distance the shipments have to travel. The main difference in the use of air cargo relates to the scale of operations, as a large degree of companies utilize air cargo for a small but very valuable part of their business, while other companies utilize air cargo transport for a much large part of their business. The regular large shippers of air cargo not only demand low prices for their cargo transport, but also require more flexibility when additional demand for air cargo is generated on short term notice. Given the smaller volume of shipments that comes from smaller shippers, they are mainly interested in flexibility for their cargo shipments. As more and more air cargo destinations and bookings are becoming possible without the use of a traditional forwarder, smaller shippers will have the possibility to utilize both capacity of traditional and nontraditional booking ways of air cargo shipments. Large shippers can only start utilizing new ways of booking air cargo when sufficient capacity and flexibility can be realized with these systems for the major markets they use by air transport. In the presentation of (HANKE, 2012) it was made clear that one of the biggest threats to the current business model of freight forwarders is; that shippers are becoming more aware of their booking options and real air freight prices. This means that large shippers will more and more be either doing directly doing business with airlines instead of traditional forwarders or use hybrid forms of forwarders that support a more digital environment, this was also already identified in the paper (Schwarz, 2005) which clearly states that developments in ICT will challenge it traditional business model where shipper do business mainly with traditional forwarders.

Cross sector organizations

Both Air Cargo Netherlands and the Schiphol Group have similar objectives and interest, as they want to maintain and support future growth of the air cargo sector at Schiphol airport. As the only two airports of the Netherlands that actual handle large amount of cargo are both member of ACN and Schiphol is by far the largest cargo airport in the Netherlands, the focus of growing and supporting cargo development, for both organizations is aimed at Schiphol airport. The difference of focus of ACN and Schiphol Group can be found to its current and future partners of both organizations. As the main partners of ACN are its member companies, research institutes and governmental organizations from within the Netherlands. The Schiphol Group has however both national and internal interest, as it is already involved in national and international management and investments in other airports. Besides this it is also more directly engaged with potential new airlines and real estate development at Schiphol, as owner of large parts of the land around Schiphol. So both stakeholders have the objective to support growth at Schiphol but have different opportunities and alternatives to realize this objective or alternative growth.

6.2 IMPORTANT STAKEHOLDER RELATIONSHIPS (PROCESS, INFORMATION AND FINANCIAL)

Currently airlines have an important and strong relation with freight forwarders as they book most of the cargo volume on operating flights on fixed contracted way (Koning, 2012). Air cargo handlers are responsible to unload/load aircraft based on agreements with the airlines they are operating for, they have to make the shipments ready for collection by freight forwarder within a certain time or load the aircraft of an airline according their requirements. However airlines are increasingly using direct transport to major costumers, thereby bypassing the use of handlers at final destination airport, when shipments cross more than two airports and are trucked to final destination, or excluding the use of freight forwarders in the traditional way when services are provided directly on behalf of shippers or consignees. Also the development airside connection location of freight forwarders makes airline relationships with air cargo handlers less in terms of financial contribution. Normally as explained before freight forwarders arrange transport for their costumers to and from air cargo handler, however large costumers of air freight can also arrange their own transport, let airlines arrange this transport or air cargo handlers can arrange such transport on behalf of freight forwarders. Figure 24 below gives an overview over the main processes of the different stakeholders in the air cargo supply chain and their traditional and possible contractual relationships. As the air cargo supply chain becomes more dynamic and more and different contractual relations are formed between the key stakeholders, this gives both room for new types of collaboration, but also can make it more difficult to support collaboration between certain parities as some types of collaboration to no effect other stakeholders in positive way, in the however all the stakeholders in the air cargo supply chain have to collaborate with each other on a regular basis, as the amount of forwarders and airline that are active at major airports is limited, especially when you compare this to other industries.

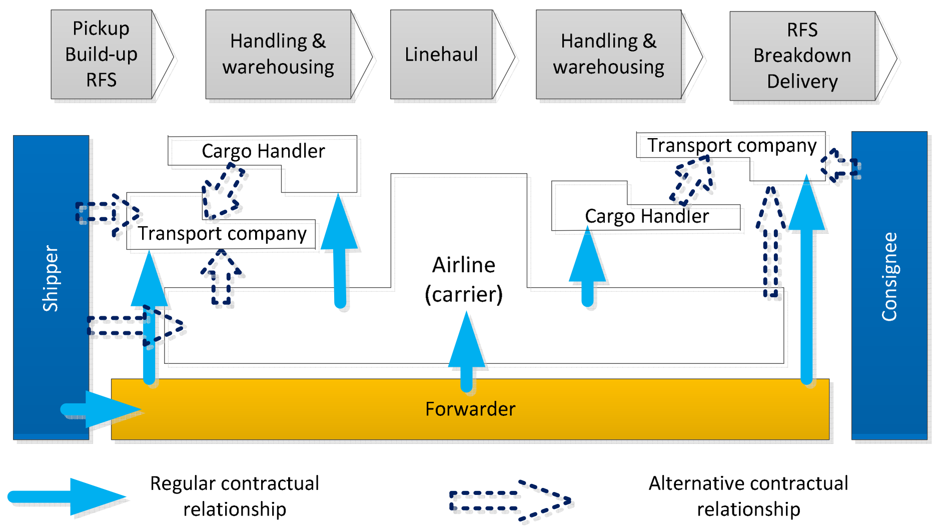

Figure 24: Value chain of air cargo between different stakeholders and contractual relationships derived from ((HANKE, 2012)

6.2.1 FINANCIAL RELATIONSHIPS OF AIR CARGO STAKEHOLDERS

The air cargo system is arranged differently compared to air passenger transport, cargo shipments are normally only paid after transport has been complemented. In air passenger transport services are paid beforehand and are often booked a long time before the actual services used. Most forwarders have made agreements about obtaining fixed capacity on certain routes with airlines, these contracts are called allotments. The rates per kilo for the booked allotments are much lower than cargo space within cargo aircraft that is offered on the free market just before flights are operated, often the prices for allotments are about 20% lower than general free market prices (Koning, 2012). However only rarely are forwarders charged differently if they utilize less or more than their defined allotment, this means that are often charged for a favorable contract prices on the actual amount of kilos that are actually transported. The forwarder can therefore earn money by charging the shipper of air cargo a higher price per kilo than he paid for in his allotment. The chargeable weight of shipment can be the same as the actual weight of shipments flown, but can also defer if the volume/weight density rate is lower than 6 cubic meters per ton cargo. The chargeable weight will then be based on volume/weight rate of 167kg/m³ (Koning, 2012). Besides obtaining capacity at a lower price forwarders can thus also earn money by consolidating high volume shipments with dense shipments to make sure they optimize the volume/weight ration of consolidated cargo. Next to the contract prices related to fixed allotments, forwarders can also buy capacity on the free market, called free sales (spot market), these sales start several weeks before flights are planned to depart. Normally the shipper is involved with financial transaction with forwarder only, however as explained above in Figure 24 new relationships between stakeholders also mean additional financial transactions either directly or via other stakeholders are possible. The amount of parties involved in financial transaction of an air cargo shipment, can widely defer based on the requirements of the costumer booking the air cargo shipment and the needed services from the moment of shipment collection to delivery. The costs of handling air cargo shipments are charged to freight forwarder by the airline, which receives information about handling costs related to all shipments from the appointed air cargo handler. The air cargo handlers often charges on an actual weight prices per kilo for handling services, but can also charge differently if it makes separate agreements with the involved stakeholders. Air cargo handlers however have to check the actual weight of shipments as they have to send this information to the airline, in order for the airline to be able to charge to the forwarder in the correct way. Part of the air cargo transport done by truck can be arranged by different parties, this can also influence the type of payment based on the shipment size, volume and distance of truck transport. It's is up to the forwarder, handler and or airline responsible for a transport segment to arrange to transport and attribute the costs made related to the transport to involved parties or not. Figure 25 below shows the key financial transactions between the different companies for the most important services provided in relation to air cargo shipment.

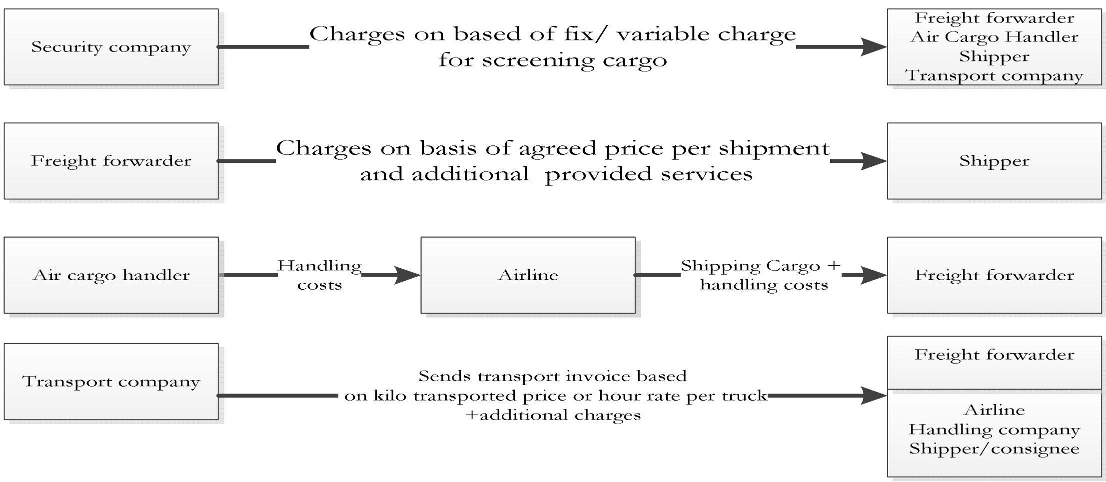

Figure 25: Most important financial transactions between key stakeholders of air cargo system

6.2.2 KEY CARGO PROCESS/INFORMATION RELATIONS BETWEEN STAKEHOLDERS OF AIR CARGO SYSTEM

Based on the figure above and the previously defined figures, it can already be derived that due to the many different ways that contractual relations are used within the air cargo system. The cargo processes and information exchange can go via several parties or directly between to the involved stakeholders. The way these key relations used depends both on legal, operational conditions and preferences of the involved stakeholders. Figure 26 below shows key information and good flows relations between the main stakeholders This figure can be used to explain why it can take time before goods, documents and other forms of information arrive at the right stakeholder and that this has resulted in use of additional or different forms of relations between parties to overcome for this indirect transfer of information and or goods. The ability of stakeholders to arrange transport via different channels, to utilize cargo screening and custom checks at different locations and to work different forwarding and ground handlers, can thus result in large benefit that can improve the systems effectiveness and operations, but can also makes it much more challenging to facilitate straight forward and simple collaboration practices, as companies can easily change the way the organize this activities and do not have to follow the traditional air transport supply chain practices in all cases.

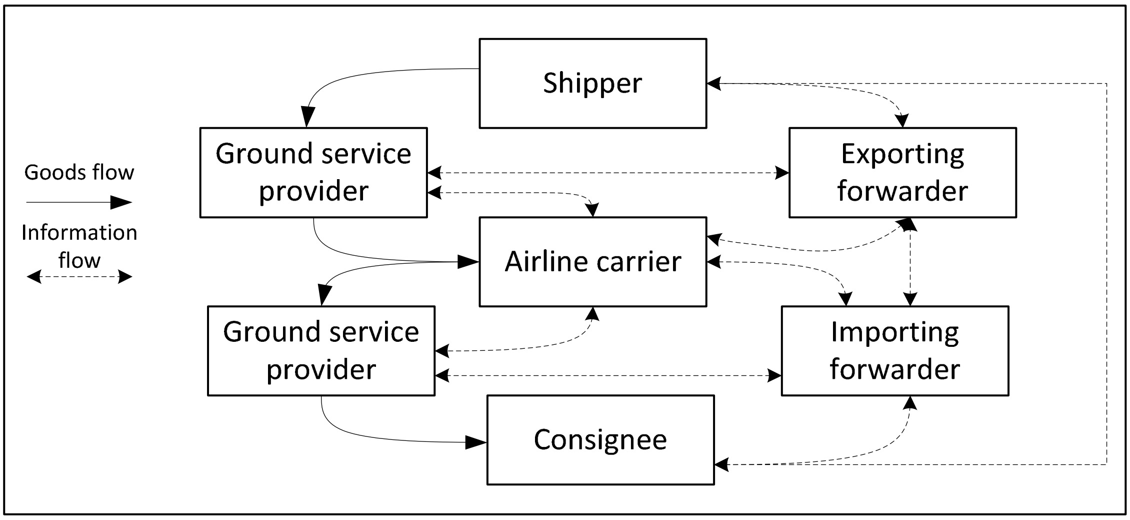

Figure 26: Key flows of shipments and information between stakeholders within the air cargo system derived from(Schwarz, 2005, p. 7)

Currently at Schiphol the different ICT systems that are in place, allow to some extent for almost any type of information to be directly shared between stakeholders directly in relation to air cargo shipments location and air way bill (AWB) information, but fear of potential miss use of this information often results in sending information with a delay or incomplete, this can than result in less optimal planning of resources for transport and handling of air cargo, this can than lead to higher transport and operational costs. However developments like e-freight and e-link are showing that more and more information is shared across the air cargo supply chain with multiple stakeholders that actually make it possible to offer a much more seamless flow of air cargo shipments between the involved stakeholders.

6.3 EFFICIENCY GAINS, COLLABORATION, NEW VALUE ADDED SERVICES AND TAKEOVER STRATEGIES

The difficult market conditions that are currently present in well-established major Western European air cargo hub airports like Schiphol are currently making it very challenging for both import and export flows of air cargo transport to be maintained at a profitable level. The uncertainty related to development and growth of air cargo is expected to become even bigger in the future as lower growth is expected for Western Europe. So efficiency and reliability gains both on the short and long term are becoming ever more needed for the air cargo system at Schiphol in order to cope with this increased complexity and uncertainty. Without any major improvements of the air cargo system at Schiphol, the system will become less competitive compared to alternative forms of air cargo transport form alternative airports or transport that does not use any of the transport services provided by the air cargo system at all. Based on the stakeholder analysis conducted in chapter it can be concluded all stakeholders in air cargo system at Schiphol are facing economic challenging times together with low operating margins. In the publication of (Cruijssen, 2006) an explanation is given why logistic service providers (LSP) are losing their competitiveness and profits, given the current market conditions. In Figure 27 below the factors that relate to the bad financial performance of LSP in general are presented and it is argued that all of these factors are also present in the air cargo system, especially in well-established air cargo systems like Schiphol, which high number of companies providing similar services. The figure can explain why stakeholders in the air cargo system on their own are currently struggling to improve financial performance.

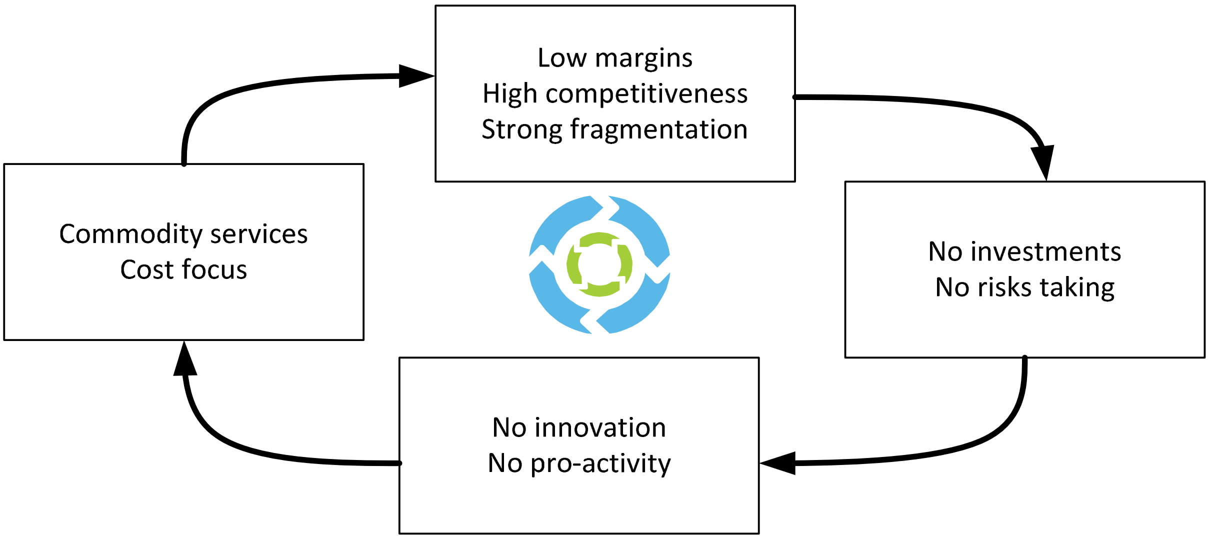

Figure 27: Vicious circle of the air cargo stakeholder system, derived from(Cruijssen, 2006, p. 7)

As the stakeholder analysis has shown the diverse operations and possibilities for the stakeholders to improve their current operations widely defer, no system wide solution for all stakeholders can be presented that positively impacts the financial and operation operations of the involved parties. This means that all stakeholders described in this stakeholder analysis and operate from at Schiphol will need to take their own specific measures to effectively face their key operational challenges. Most stakeholders will have a limited ability to face these challenges on their own, as they have a limited ability and influence within the entire air cargo system. Even the largest airlines or freight forwarders with for example airside access cannot force changes to the system to their own benefit, as they are need to work with almost all airlines and air cargo handlers to be able to offer their customers the right product at the right price. So the involved companies will need to realize efficiency gains within their own organization, with their partners (vertical) or even with competitors (horizontal) in order sustain operations at Schiphol and have the possibility to grow in the future. It is thus not surprising that the stakeholders at Schiphol have been implementing different forms of collaboration based on their current and expected future situation. However the conservative nature of the air cargo industry has often made the applied collaboration practices either of limited scale related to operations or with a limited amount of stakeholders involved. This stakeholder analysis has shown that improving the position of the key stakeholders in the air cargo system often revolves around collaboration support; in order for such collaboration to be successful it should be targeted at long term. However most stakeholders in the air cargo system at Schiphol are currently mainly focusing on short term gains and costs reductions, this can actually conflict with the way collaboration should be approached to be more effective. Figure 28 below tries to shows the relation between type of collaboration that can be applied, with the most important factors to support collaboration with the air cargo system that were defined in the previous chapters and relates them to important components of a logistic concept. Based on the individual characteristics of each stakeholder in the air cargo system a combination of horizontal, vertical and internal collaboration between departments can be utilized to a better logistic flow of goods and information. Not all stakeholders have sufficient information, power or resources to achieve the right type of collaboration some collaboration practices are not easily realized while they potentially might be very high.

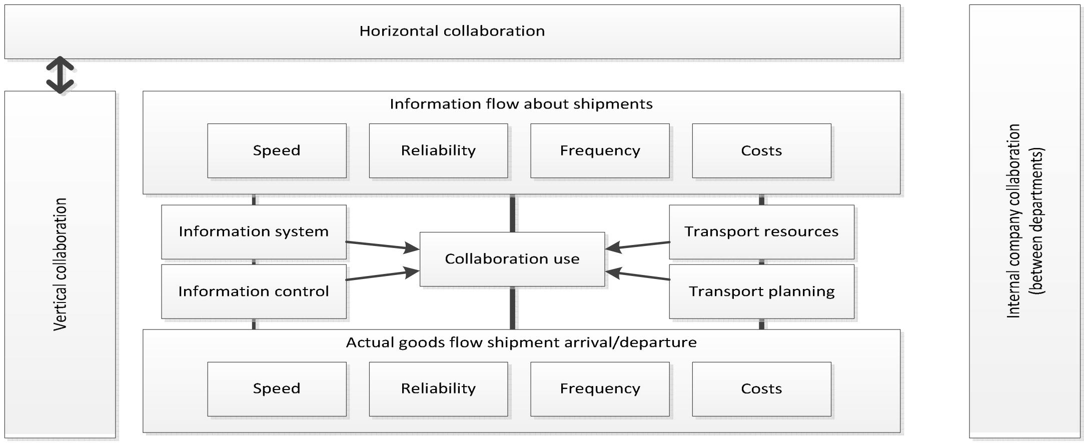

Figure 28: Important aspects and tradeoffs that define the use of collaboration in general for air cargo transport.

6.4 FUTURE POSSIBLE POWER CHANGES FOR STAKEHOLDERS IN AIR CARGO INDUSTRY

Information within the air cargo system is becoming more transparent and it is also made easier to process air cargo booking information automatically, the power and collaboration support of the main stakeholders in the air cargo system is expected to change as has been explained before. The way this change will occur and to which extent the power of the involved stakeholders will change, highly depends on which stakeholders will start to challenge the traditional air cargo collaboration model and will support new logistic concepts. Based on the literature analyzed and interviews conducted at Schiphol it is expected that shippers of air cargo will gain power as they become more aware of the actual costs and possibilities for arranging air cargo transport differently. Cross sector organizations like ACN & Schiphol Group could gain more power in the future air cargo system if they further develop their proactive role in challenging the current system and actively providing a platform or measures that will make it more attractive for involved stakeholders to focus on long term development and innovations without substantial financial and operational risks. The European Commission is currently increasing its involvement and regulation related to large transport systems, it can also be expected that this will give them more power and this changes in power should be acknowledged and taken in to account by the entire air cargo industry. As the changes related to power of key stakeholders will affect the way collaboration can and will be supported in the future. Figure 29 below tries to visualize the changes to the different involved stakeholder in the way they support collaboration and how much power they have within the air cargo system at Schiphol

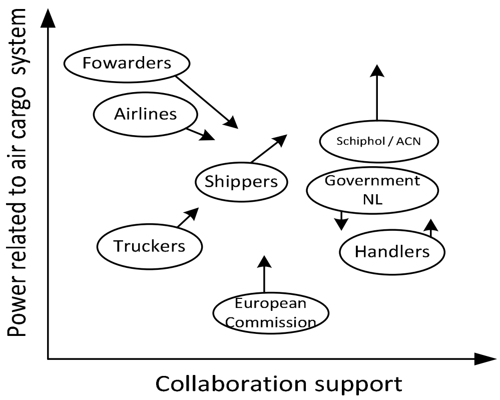

Figure 29: Possible change of stakeholder power and collaboration support in the air cargo system at Schiphol.

7 CASE STUDY OF HORIZONTAL COLLABORATION AT SCHIPHOL

7.1 IMPORT PILOT AT SCHIPHOL

In the summer of 2012 after a workgroup meeting at Air Cargo Netherland (ACN) involving air cargo handlers, freight forwarders and transport companies, common agreement was reached on the issue that waiting times and congestion at air cargo handling facilities should be improved. After the meeting in September 2012 a student of Hogeschool of Amsterdam with support of TNO started to define the pilot project for collaboration within the inner airport transport logistics to improve waiting times and lower congestion at air cargo handling facilities at ACN. In the beginning both import and export collaboration was considered for the pilot, during interviews with several freight forwarders it became clear that complexity of collaboration on export flow and time related issues made it less favorable for the pilot to start with. Therefore in October 2012 it was decided that the focus of the pilot would be on collaboration for import shipments first. After several interviews it became clear that loose general cargo had the highest potential for the pilot. The pilot was supposed to start halfway thru January 2013, but has been delayed due to several operational and procedure issues that were encountered at the end of December 2012 and beginning of 2013. At the moment of writing this report preparations for the start of the pilot are still underway. Figure 30 below gives an overview of the companies that have been contacted in relation to this research

Figure 30: Overview of companies contacted or directly involved with pilot research/workgroup.

7.2 IMPORT AND EXPORT EXTENSIONS

As stated in the previous paragraph the current pilot is aimed at loose general cargo with a limited amount of freight forwarders. Several other freight forwarders at Schiphol are following the developments of the pilot with the intention of possibly joining the current or future extended collaboration concepts. Forwarders have also stated that other types of transport might result benefits related to transport performance and costs, not only loose import transport is analyzed. The analysis of other forms of collaboration on both import and export transport is aimed at showing the business case of more extensive collaboration within the air cargo system and make Schiphol cargo system more competitive, by improving stability of cargo flows to and from air cargo handling facilities. In order to assess the potential of a different setup of collaboration, a simulation case study related to cargo shipments at Schiphol will be defined in this chapter. To limit the scale and operations involved in this simulation, the focus will be on supporting forwarding companies of the import pilot, that also have provided more detailed information about their logistic operations. As these are argued to also be most supportive in further collaboration for both import and export logistics. Next to the analysis of loose cargo transport, the transport movements of ULD cargo are also taken into account within the case study, as the amount of ULD transport is slowly gaining importance at major forwarders and for several forwarders the amount of ULD transport is already higher than loose transport in relation to total amount of cargo transport. ULD transport is also included to be able to give a complete overview of transport movements to and from a specific air cargo handlers and a set of forwarding companies.

7.3 KPI'S FOR THE CASE STUDY

The KPI's for case study are derived from several different sources; first the key factors for utilizing collaboration based on the literature review are considered, the system analysis of air cargo system is used and finally literature on logistic performance measurement is used. Two different tables for KPI measurement of the case study are constructed. The first table (Table 1) provides hard KPI factors which can be quantified, the second table (Table 2) will provide factors which should be included in evaluation of case studies alternatives but which are much harder to actually quantify. As has been pointed out in chapter (3) in the part about supply chain collaboration, horizontal collaboration, often has more difficult quantifiable KPI's that can be of great importance, to demonstrate that a collaboration project can improve the system in significant way. In the paper of (Fawcett & Cooper, 1998) five distinct groups are described for key logistic performance indicators, these groups are used to further specific KPI's that will be used to assess the system changes compared to the current system. From the literature review on collaboration practices in supply chain it can be derived that transport costs and increased demand for flexibility are key factors for collaboration. Given the fact that supply and demand for individual companies is becoming more complex it can be more difficult for companies to control the complete flow shipments and transport times on their own. This is why delivery times, handling times and waiting times are chosen as KPI's for customer service group aspects. During several interviews with stakeholders in the air cargo system, it was pointed out that the 'free' storage of air cargo at air cargo handlers is often used by other parties to reduce their own storage costs. In order to asses if changes to transport logistics effect the amount of shipments that fall within the free storage period at air cargo handlers this factor is also included, as warehouse rent costs for air cargo handlers are very high. With the current uncertainty about delivery and collection moments for air cargo utilization rates of truck, warehouse staff, planning and document staff is not optimal. It is therefore crucial to see if changes to the transport organization of goods can positively influence the utilization rates of these different resources as this can potential result in reduction of staff or better use of staff during certain periods. Related to the uncertainty of collection and delivery of also the reliability of delivery times, currently large forwarders often have to send additional trucks to ensure a given delivery time. This way the reliability of delivery times should be measured for the current and changed system. A sixth category is added related to the sustainability of transport, as several forwarders have stated that sustainability is of growing importance in the way they organize their transport.

Hard KPI's for case study		
KPI factor		Important for
	Average delivery time [hours/shipment]	Handler, Forwarder, Transport company
	Average handling time [hours/shipment]	Airline, Forwarder, Transport company, Handler
Costumer Service	Average waiting time [hours/transport]	Transport company, Forwarder
	Average transport costs per kilo [€/kilo]	Forwarder
	Total Transportation costs [€/day]	Forwarder
	Storage costs [€/day]	Handler, Forwarder, Transport company
Costs	Actual handling costs per kilo [€/kilo]	Handler
	Utilisation rate trucks [transport movement/ truck /shift]	Transport company, Forwarder
	Utilisation rate docks [trucks/day/dock]	Handler, Forwarder, Transport company
	Utilisation rate of fork truck [shipments /fork truck]	Handler, Forwarder
Asset management	Utilisation of storage system [shipments / day]	Handler, Forwarder, Transport company
	Shipments handled per warehouse staff [shipment/ staff]	Handler, Forwarder, Transport company
	Shipments planned per planning staff [shipment/ staff]	Handler, Forwarder, Transport company
	Shipments handled per document staff [shipment/ staff]	Handler, Forwarder
Productivity	Shipments transported per truck [load factor]	Transport company, Forwarder, Handler
	Reliability delivery time [% within [hours]]	Forwarder
Quality of logistics	Frequency of delivery [amount of transport visits]	Forwarder
Sustainability of	Distance travelled by transport [tonkm]	Transport company, Forwarder, Handler
transport	Waiting time with engine on [minutes/shift]	Transport company

Table 1: List of hard KPI's for transport between air cargo handler and forwarder at Schiphol.

Soft KPI's factors

During the work interviews and workgroup sessions at ACN many concerns of involved stakeholders about collaboration on transport were discussed. The establishment of criteria for selection of transport companies for the pilot and first proposed design of collaboration concepts pointed out several issues that can be related to performance factors. However many of these discussed factors are difficult to quantify, but were argued to be of great importance. This is way they are still considered for using to assess the change of the transport system. The whole idea of realizing more collaboration for the transport between air cargo handlers and forwarders was based on congestion and related waiting times at handlers. It is however hard to define when congestion is taken place. Many transport companies have publicly stated that they are often not able to charge their costumer for all costs that are made, because they will lose business if they do so. In literature review on collaboration it was stated that collaboration could improve the effectiveness of companies on their core activities, this is would be valuable to assess if changes to transport on general cargo (GC) also influence the amount of non GC shipments a forwarder and handler and transport company can handle. Two other important issues of collaboration were related to potential damage to shipments and exposure of shipments to competition, both of these factors are deemed of key importance but are very hard to quantify. Also it was often stated that collaboration should result in lower transport costs, but the effects on other organizational processes that are needed to support collaboration process should also be included to make clear what the costs of collaboration are. The sustainability category has also been added for KPI measurement of soft factors, as more effective planning both at the forwarders and handler could further reduce the amount of $C0^{2}$ produced per shipment and also reduce the amount of transport movements with the handlers' warehouse, these factors are again hard to quantify.

Soft KPI's for case study		
	KPI factor	Important for
Costumer Service	Peak congestion time per week	Handler, Forwarder, Transport company
	Missed delivery times	Airline, Forwarder, Transport company, Handler
	Extent of faster delivery possibilities	Transport company, Forwarder, Handler
Costs	Non chargeable costs	Airline, Forwarder, Transport company, Handler
	Missed handed shipment costs	Forwarder
	Collaboration costs	Handler, Forwarder, Transport company
	Exposure costs of shipments to competitors	Handler
Asset management	Utilisation rate of warehouse space	Transport company, Forwarder, Handler
	Utilisation of handling equipment	Handler, Forwarder, Transport company
Productivity	amount of non GC Shipments handled per warehouse staff	Handler, Forwarder, Transport company
	amount of non GC Shipments planned per planning staff	Handler, Forwarder, Transport company
	amount of non GC Shipments handled per document staff	Handler, Forwarder
	amount of non GC Shipments transported per truck [load factor]	Transport company, Forwarder, Handler
Quality of logistics	Damage to shipments	Forwarder, Handler, Transport company
	Amount incomplete handled shipments	Forwarder, Handler, Transport company
	amount of documents provided in incomplete way	Forwarder, Handler, Transport company
Sustainability of transport	CO^2 produced per shipment by transport [gram / shipment]	Forwarder, Handler, Transport company
	[transport movements at handler warehouse [movements/truck]	Handler

Table 2 List of soft KPI's for transport between air cargo handler and forwarder at Schiphol

7.4 CONCEPTUALIZATION

The description of the air cargo system at Schiphol in the previous chapters has given an extensive overview of process and activities that are undertaken to handle air cargo at and around the airport. In order to be able to model and simulate the relevant process of the air cargo system a conceptual models of the current air cargo system will be constructed. Figure 31 below shows an overview of the basic system components that make up the import and export system related within the air cargo system at Schiphol. As the focus of this case study will be transport between Air cargo Handlers and warehouses of forwards around Schiphol, the sub system of the shipper/consignee will not be taken into account in the case study and only limited attention is given to the logistic services providers sub system as the planning and generation of transport is considered that is mainly realized from within the air cargo handler and or forwarder.

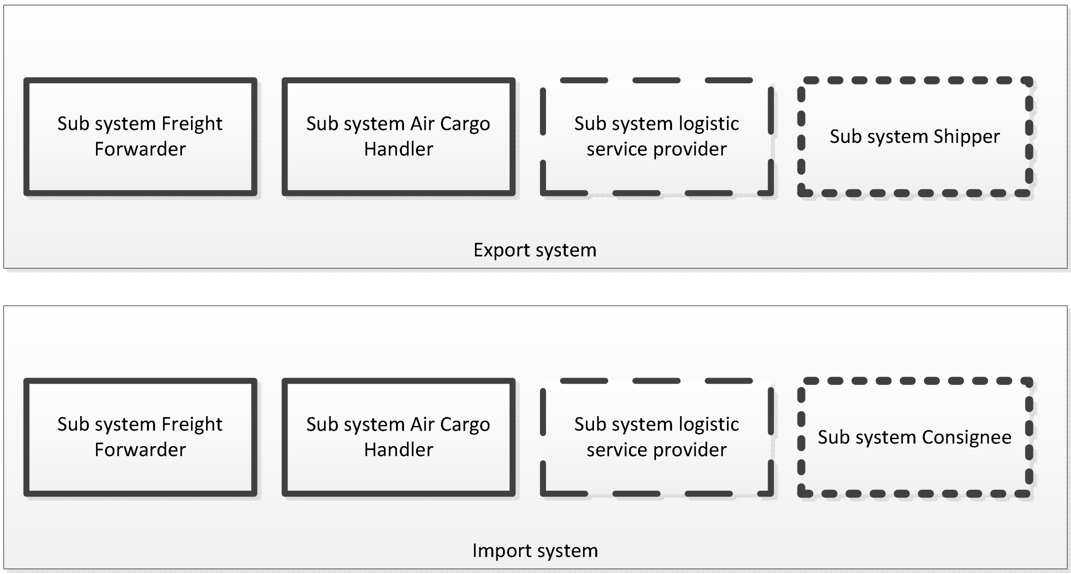

Figure 31: Overview of basic conceptual model for import and export air cargo system sub systems.

The system boundary of this research will be the companies active around Schiphol with their physical system, to further limit the boundary only companies active within the DGVS area are considered, this also has to do with the ease of transport within the DGVS area and the data availability of DGVS system related to air cargo shipments. Figure 32 below tries to visualize the different boundary levels within the airport system, in relation to the focus of this research. Before going further in detail in the sub systems a general causal relation diagram is constructed of the transport generated for processing air cargo shipments between air cargo handlers and forwarders within the DGVS area.

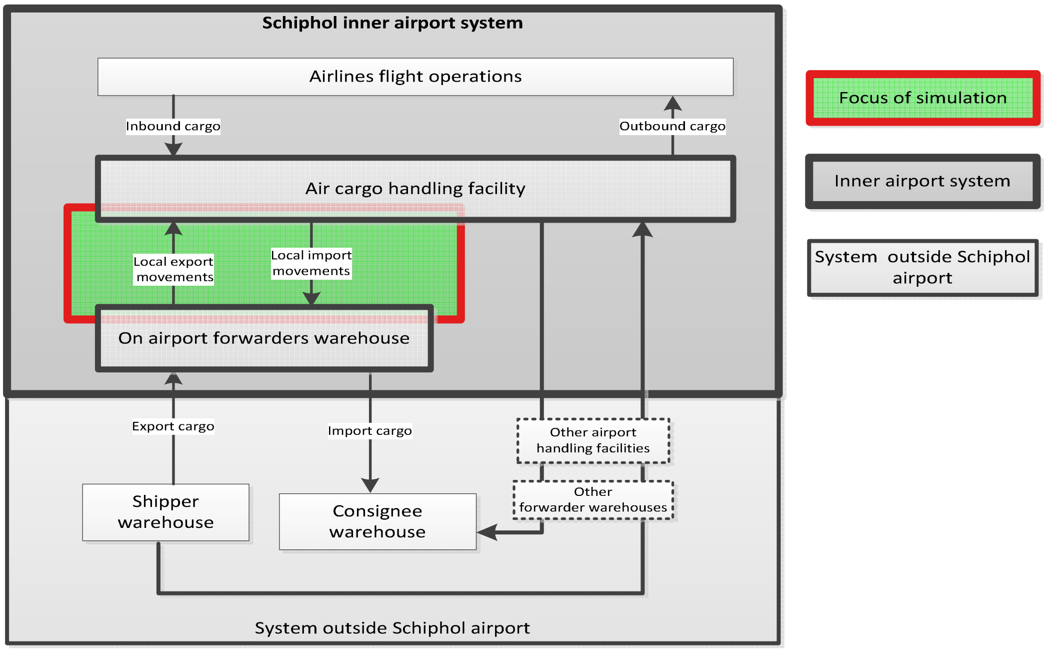

Figure 32: Focus of the study in relation to different boundary levels of air cargo system at Schiphol

7.4.1 CAUSAL FACTORS RELATIONS RELATED TO GENERATING INTRA AIRPORT TRANSPORT BETWEEN CARGO HANDLERS AND FORWARDERS

The factors that are defined for constructed causal relation diagram are mainly derived from the system analysis of air cargo system at Schiphol and are also derived stakeholder analysis en collaboration practices at other major airports. The effect of lacking of coordination and collaboration on transport movements between handlers and forwarders can clearly be seen in Figure **33** below. Long waiting times, congestions and high average handling times make it very difficult to plan transport movements effectively and this reinforces the amount of truck transport generated which than negative influences the mentioned factors again. Also the amount of shipments that are ready for both import and export flows at the air cargo handlers can be negatively influenced by the lack of coordination of transport movements, as it becomes more difficult to plan staff at the air cargo handlers and thus the average processing time for cargo shipments increases. Given the current low costs of hiring transport services both on fixed and ad hoc basis at Schiphol in the current situation, many forwarders hire more than the needed amount of trucks, which further increases the amount of transport generated and reduces the amount of shipments that can be combined with each transport movement. Finally declining average weight of shipments can make it more difficult for transport companies, to obtain sufficient cargo to operate at profitable level, when they are only paid a fixed kilo price per transport. With the current low costs of truck transport large have able up until now been able to transfer some of the inefficiency costs to transport companies, however transport companies given their bad financial situation are trying to stop forwarders from transferring this costs were possible.

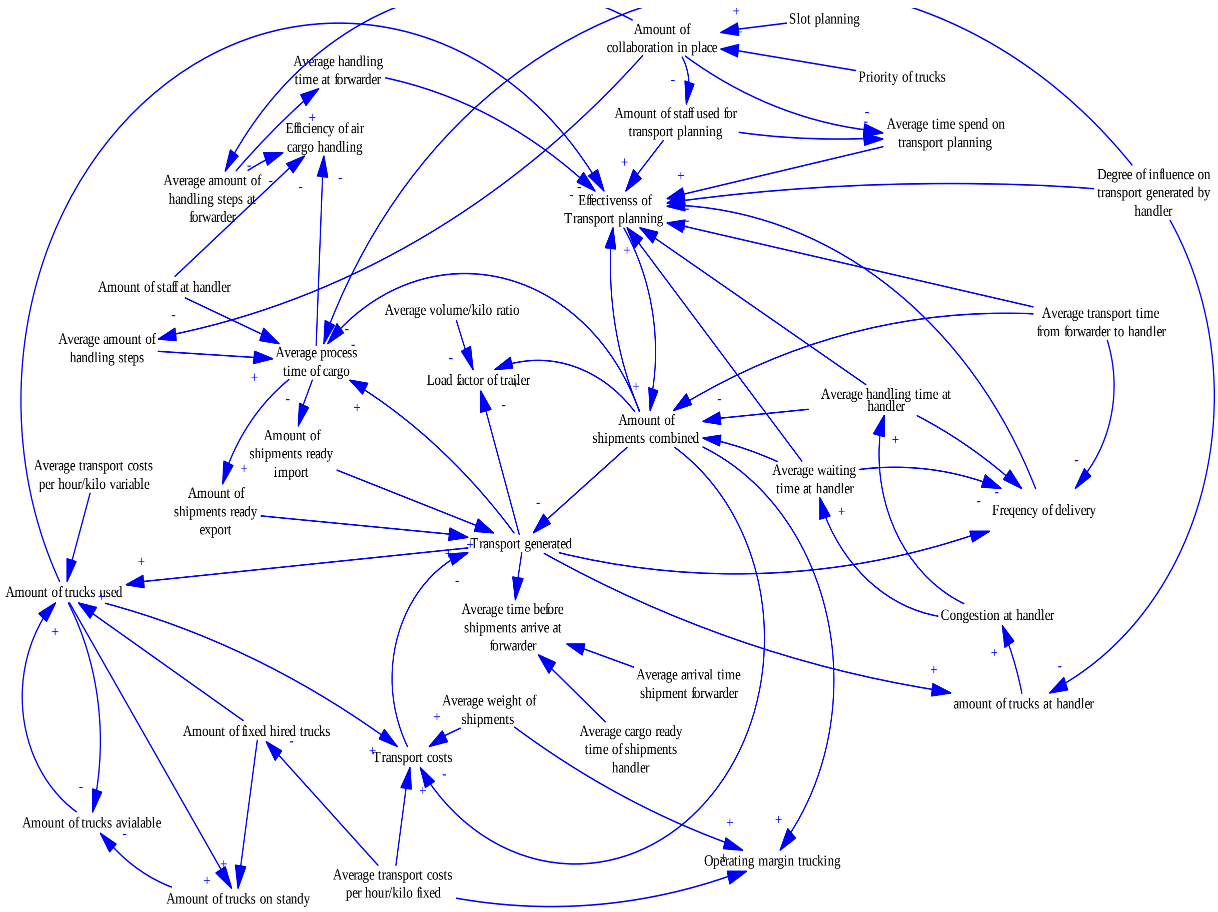

Figure 33: Causal relationship diagram of factors influencing the generation of transport between air cargo handlers and forwarders within DGVS at Schiphol

7.4.2 OBJECT ORIENTED ANALYSIS

In order to further understand and structure the relation between the main objects of the transport between the air cargo handlers and forwarders, an object oriented analysis is conducted with the use of Unified Modeling Language (UML) technique. In order to successfully realize succesfull transport of the physical flows of documents, shipments and digital information flows of transport planning has to be completed. The UML that was constructed consists of

18 different objects and their relations, for better structure of the UML the objects transport planning staff (warehouse, documentation and planning are constructed for each company that can be using these resources.

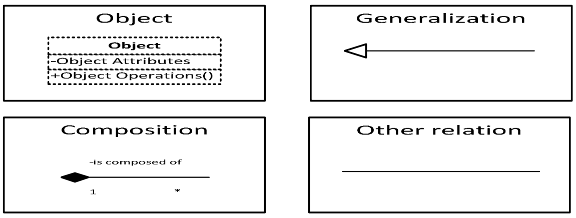

Figure 34: Object components and relationships that are used in UML construction.

Figure 34 shows the used components for the UML modeling, for each object a name is given, object attributes and object operations are defined. The relation between objects can is defined in three different ways; generalization when a certain object can be further specified in two different more specific objects, composition relation when certain object is composed of different objects and finally other types of relations which are defined on individual basis.

The objects of the model are divided in four different categories listed below:

- companies' objects are; Air cargo handler, forwarder in charge, transport company, shipper and consignee
- functional objects: transport order, transport trip, transport planning
- transport object: truck, as cargo is transported by a truck in all cases by truck between the involved companies truck is the transport objects of the system
- resources objects of the system are: staff (warehouse, planning, documentation, and drivers), handling equipment, storage system, cargo pallets, shipments and trailer

The boundaries of the system are further specified in the model as the objects only relate to cargo transport and handling between air cargo handler and freight forwarder document processing is not further specified as physical document transport and handling within the DGVS system for custom processes is not needed. The modeled UML already shows a transport planning function in relation to the air cargo handler, however currently except for KLM Cargo transport planning for landside collection and delivery is not supported by air cargo handlers at Schiphol. This is way transport planning in the model can be related to both internal transport and transport between the involved companies. All companies can offer storage of cargo, internal transport is has be facilities by each company. When new collaboration will arise with import and export flow of cargo shipments at the air cargo handlers it is likely that the air cargo handler will perform part of the intra company transport planning in order to streamline it with its internal transport planning. In the UML model drivers are only linked to transport companies as most forwarders do not have their own drivers for this type of transport. In Figure 35 the complete constructed UML model of transport between air cargo handler and forwarder is presented. The shipper and consignee are defined as objects in the model however these are not directly involved in the analyzed system in the physical flow of goods or information.

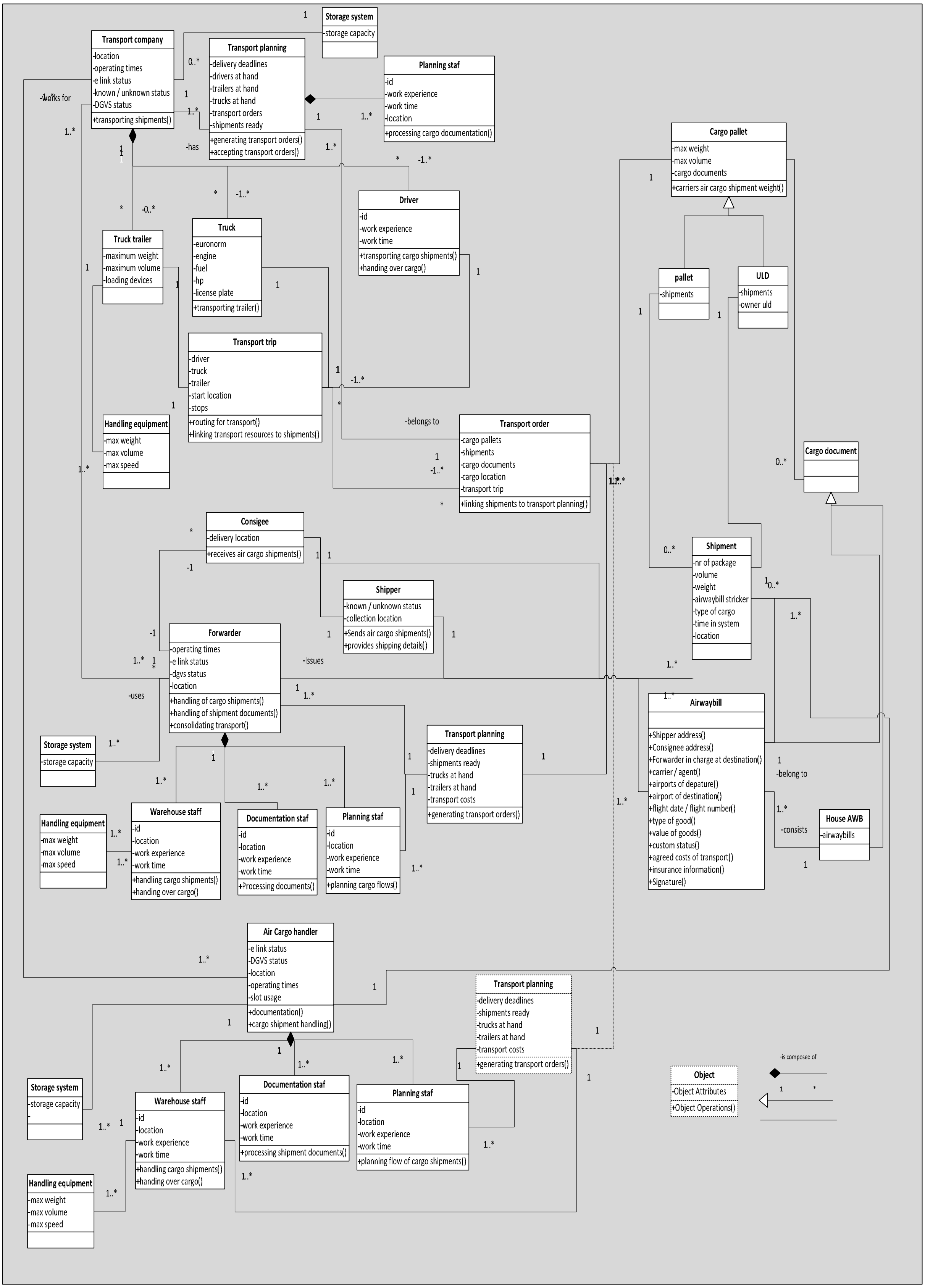

Figure 35: UML model of transport between air cargo handler and freight forwarder.

7.5 PROCESS ORIENTED ANALYSIS

Two IDEF0 models are constructed for transport between the air cargo handler and forwarder, to define all relevant processes, their relations and resources that need to be considered for realizing the transport process. As constructed model using IDEF0 of the current system allows to evaluate the present situation of the system with potential changes to the system, `as should be' system this will also part of use of construction IDEF0 model (Dorador & Young, 2000). "IDEF0 is a modeling technique based on combined graphics and text that are presented in an organized and systematic way to gain understanding, support analysis, provide logic for potential changes, specific requirement, or support system level design and integration activities. An IDEFO model is composed of a hierarchical series of diagrams that gradually display increasing level of detail describing functions and their interfaces within the context of a system(NIST, 1993, p. 7)". Another name that is frequently uses for IDEF0 analysis is; Structured Analysis Diagram Technique (SADT).

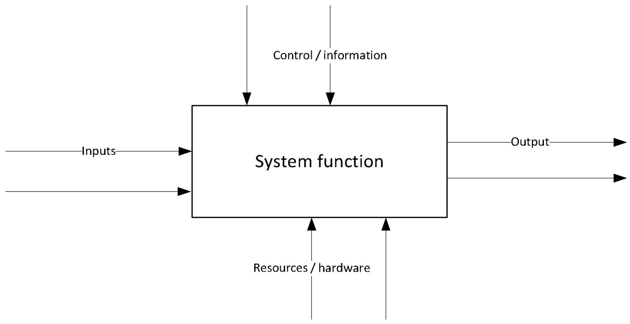

Figure 36: Main elements of IDEF0 model constructs.

The IDEF0 model will be constructed on three different levels for the transport system. The highest level construct is the A0 model, is presented first below. Two different models are made one model is made for the relevant processes at the air cargo handler and other model is made for the processes at the forwarder, both can be seen below in Figure **37**.

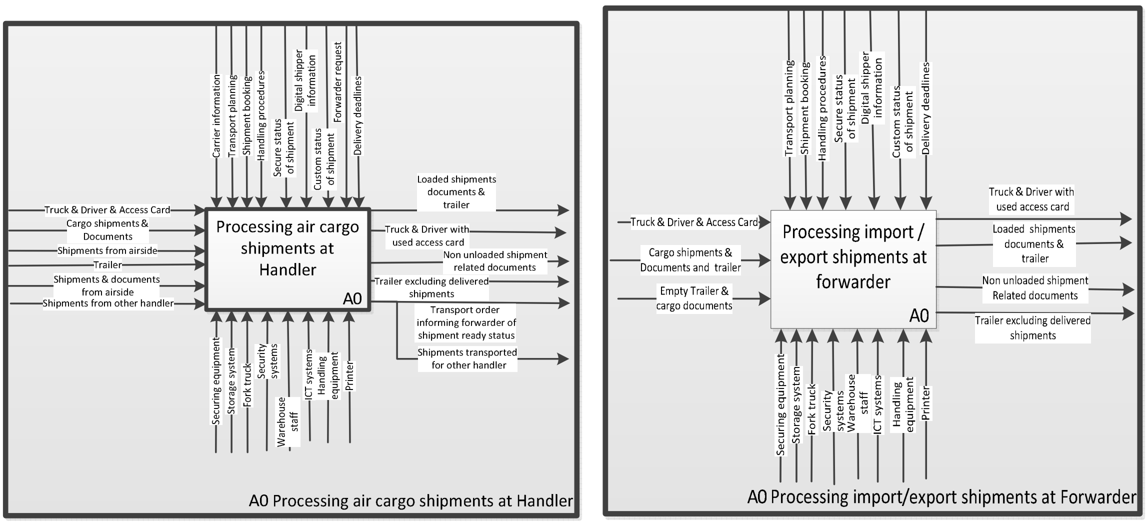

Figure 37: A0 IDEF0 models of transport generation from the air cargo handler & forwarder.

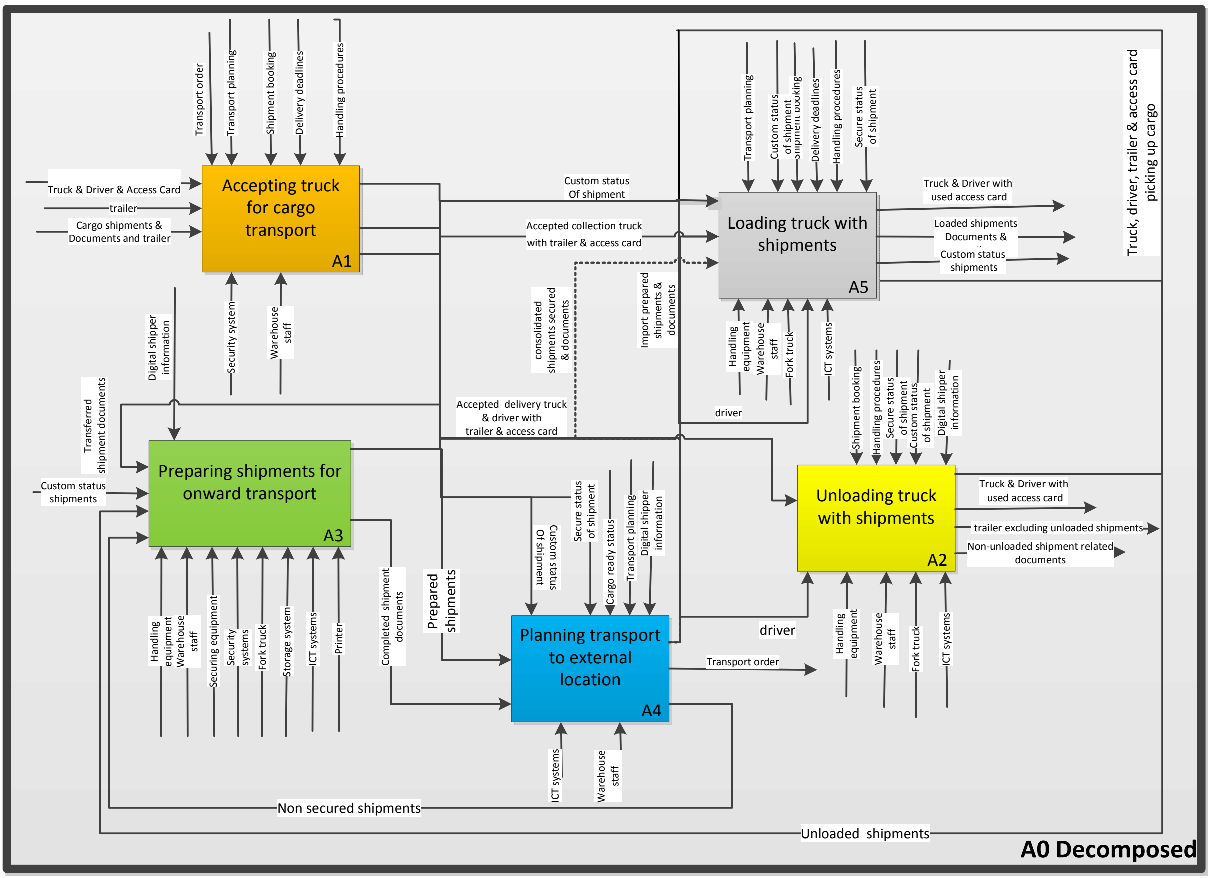

Figure 38: A1 first decomposition of A0 model for freight forwarder transport and shipment handling system.

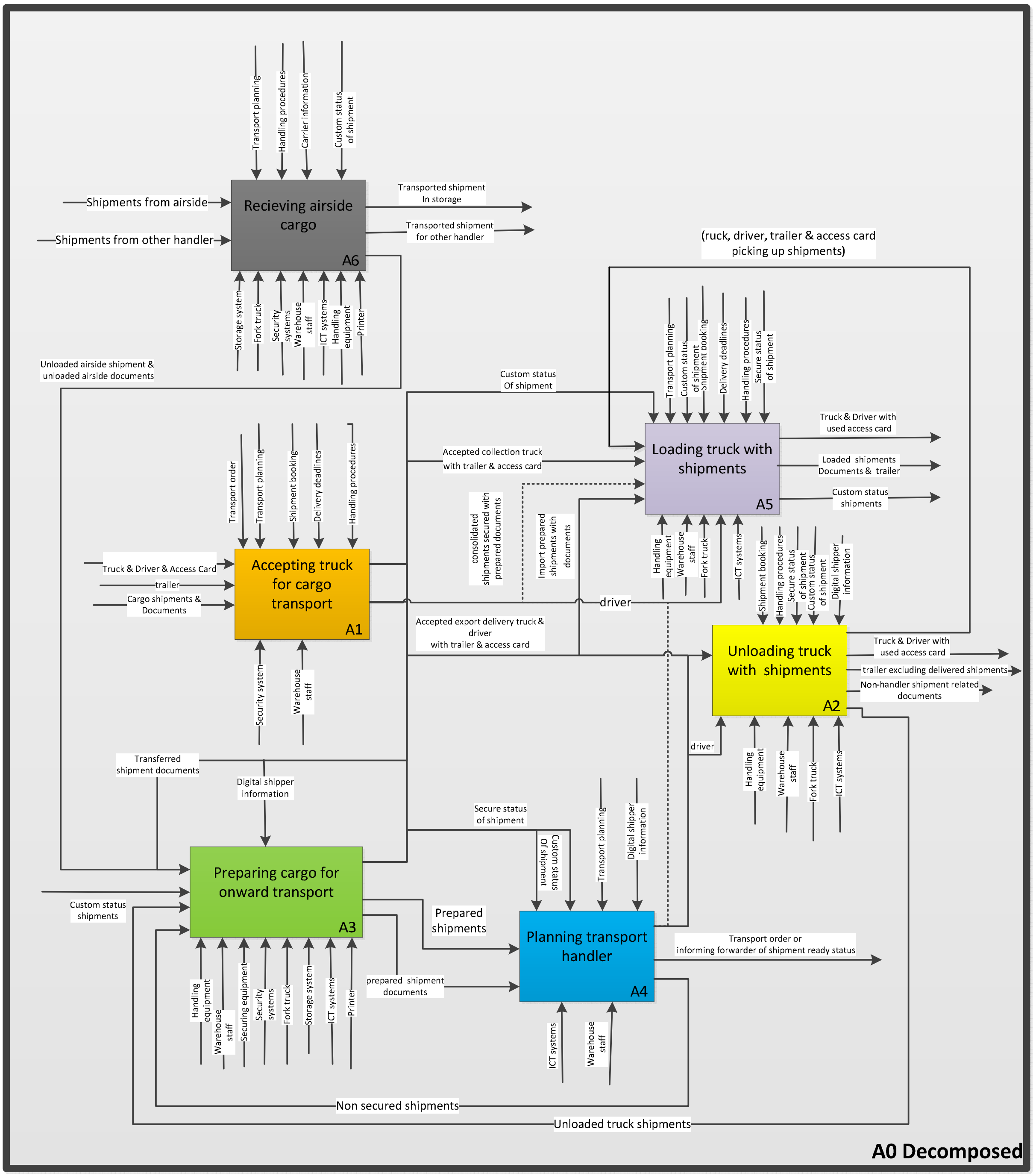

Figure 39: A1 first decomposition A0 model air cargo handler system related to handling of shipments and transport

In Appendix D, the second level decomposition of IDEF0 models is presented, again a further description will be given in the following chapters in relation to simulation model construction.

7.6 DATA ISSUES

Stakeholders in the current air cargo system lack the complete overview of data related to their logistic operations and costs, as information is available at different stakeholders that are not able or willing to share this information with other parties it is difficult to obtain an complete overview and detailed information about logistic operations around and to/from the airport related to air cargo shipments. This is further complicated by the fact that involved freight forwarders are using one or more external transport companies that provide the resources for transport of goods for import and export. Besides several air cargo handlers do not use the system that is provided to them to, notify customers of certain shipment status, but instead use their own systems. Also most forwarders higher both fixed and variable transport resources from external transport companies and use these for both inner airport as regional transport needs, making it difficult to obtain the complete information related to inner airport transport logistics. However partial data of four involved forwarders in the project and general data of cargo handlers for shipments to and from the companies within the DGVS area around Schiphol have been provided and can give an idea of the potential of collaboration. A data request was pending that would make it possible to know much more in-depth about cargo shipments timings variance at different locations in the air cargo system. This data was also vital to measure several of the KPI's that have been defined in the beginning of this chapter. However the cost of obtaining this data was too high for this research, at this moment there are still three data requests pending for the research (IATA, Handlers and Menzies) for more specific shipments information. Figure 40 below shows the potential data points that could have been derived from actual shipment data if cargonaut data would be acquired. In chapter 8, a more detailed overview will be given of which data is used for simulation model and how other data is defined.

Cargonaut data points on shipment level Figure 40 **on shipment air way bill level** (AWB)

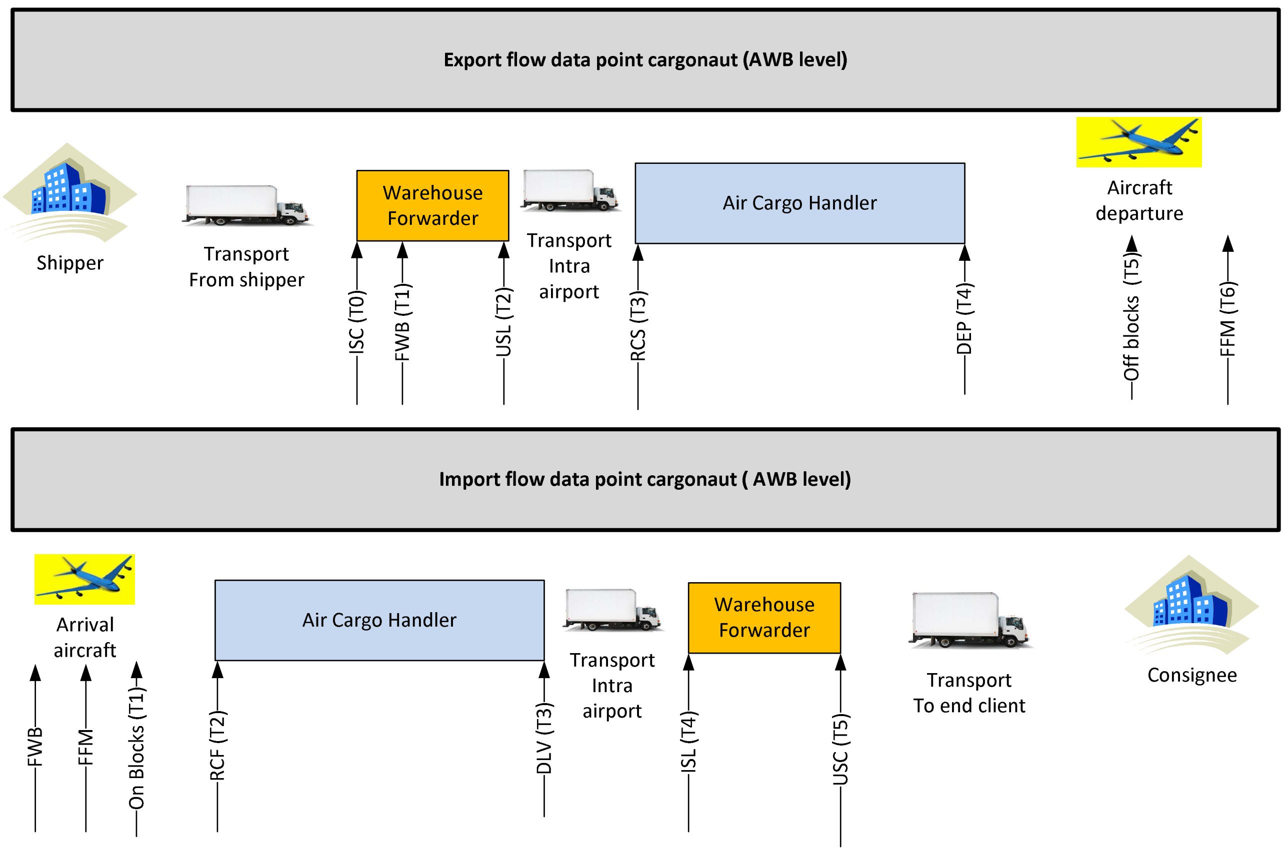

Figure 40: Cargonaut data collection moments in the air cargo transport system.

For import data points T2,T3, T4 and T5 had been requested in order to obtain better idea of how long shipments stay at different points in the system and how the timings are spread out during the day for the involved forwarders. For export T0,T1, T2, T3 and T4 are valuable points of measurement as they can give insight on how long shipments stay within the warehouses of the forwarder and handler and when they arrive. Besides the information on time moments for all shipments of the involved freight forwarders in the pilot, the following information per shipment had been requested.

- shipment weight in kilo
- shipment volume (m3)
- nr of coli/package per shipment

Data was requested for a period of 3 months, as the pilot will for import collaboration would be January and February 2013, but these two months do not represent a ‘normal’ cargo month at Schiphol March is also included. Data was also requested for the same period in 2012, in order to compare of flows or processes times for the involved companies change to great extent or stay relatively the same. Data was requested for the following parties:

Handlers: Menzies / Aviapartner

Forwarders: DHL, Geodis Wilson, Rhenus

Figure 41 below gives a brief overview of how different data will/ or was supposed to be used for the simulation model, in order to generate shipments, transport, collect/deliver shipments and processes shipments at the different analyzed warehouses.

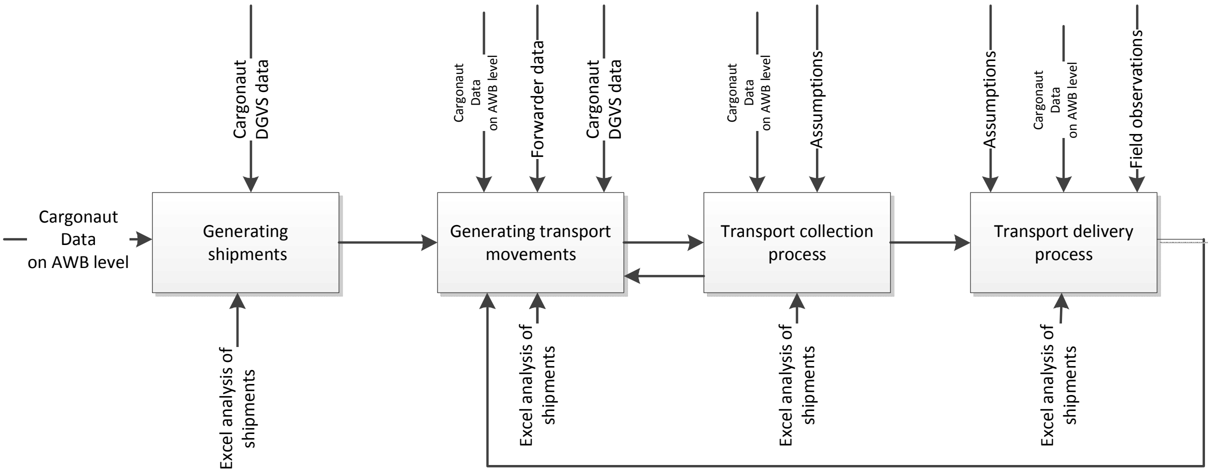

Figure 41: Overview of simulation process based on IDEF0 models and which sources will be used to provide the model with input data and process times

8 SIMULATION OF TRANSPORT MOVEMENTS OF AIR CARGO TRUCKS WITHIN SCHIPHOL

8.1 INTRODUCTION INTO DISCRETE MODELING OF INNER AIRPORT CARGO TRANSPORT SYSTEM

Currently most freight forwarders active at Schiphol have limited insight into the effectiveness of their current transport organization and do not know how their current organization can support horizontal collaboration of shipments next to their current own transport. Or even how it can be used as a complete replacement for both all their import and export shipments form one or more air cargo handlers at Schiphol. At this moment there is no major forwarders at Schiphol that is in involved in combination single and combined transport on regular and structured basis, currently therefore there is lack of knowledge about the difference between utilizing combined or single transport for inner airport transport. For this research a software program called Arena, made by Rockwell Software will be used to simulate the effects and differences of utilizing combined, single or both types of transport. This will be done by looking at the transport between three specific forwarders at Schiphol and one air cargo handler. The decision to use Arena rock software has been made on several factors, which relate to the application of the software within the air cargo system, the usability of the software and nature of process within the inner airport cargo transport system.

Application of Arena software within the air cargo system

Several researches have been found in the field of air cargo system simulation on different subjects that have been successful applied the use of Arena to assess current and future operations of processes within the air cargo system (Franz & Stolletz, 2012b; Nsakanda, Turcotte, & Diaby, 2004; Van Amstel, 2009). These research has shown that simulations can generate results that are in line with actual processes at major air cargo systems.

Usability of the software

Arena software is also very user friendly, the arena software does require any specific programming knowledge and offers a wide range of building blocks that can be used to construct specific modeling logic. Besides these positive aspects Arena software also has the ability to display animations of simulated processes, which can be used to easily visualize the results and effects of certain changes to simulation model.

Nature of process within the inner airport cargo transport system

The processes within the inner airport transport system can be best defined by using process and modeling logic that is based on stochastic distributions that defer over time and for certain processes. The whole process of shipment creation, collection and delivery in the air cargo system is based on a set of sequential discrete events, this is why it can argued for to model the system with software that is specially designed for discrete processes, Arena software has been specially constructed to model and analyze systems that are discrete. The model will be constructed on the basis of general cargo data of three specific freight forwarders in relation to their operations at one specific air cargo handler at Schiphol. As specific data relating the operation of the three modeled companies on detailed level is missing to and from the modeled air cargo handler. This means that the model cannot be completely specified according to actual realtime operational parameters of involved companies at Schiphol. Instead general parameters that can be validated on the basis of companies operating at Schiphol will be used to construct the simulation model.

The model goal of the simulation model is to: demonstrate under which conditions transport of shipments with the use of horizontal transport collaboration can provide similar or greater benefits than single company organized transport. Next to this the model should be able to give an indication on related processes that are linked to transport movements and how they can affect both the individual company's single or combined transport performance and the system performance as a whole.

The simulation model will try to answer the following question(s):

The main question that for this simulation is;

Under which conditions organizing horizontal transport can be an effective and efficient alternative to own organized transport for freight forwarder inner airport transport needs?

The simulation model will thus explore the limits in which horizontal collaboration can be used effectively compared to own individual transport for two or more companies sharing fixed transport capacity for both import and export transport between their own warehouse and a specific air cargo handler at the airport.

In more detail, an attempt is made to answer the following questions with the simulation model:

- To which extent does the use of horizontal transport have an impact on transport costs en quality compared to own transport by each individual company?
- Can all transport for import/export be organized in such way by horizontal collaboration that it in effect out qualifies the use of own dedicated transport both on transport costs and quality?
- Under which transport conditions does horizontal transport realize the most effective outcome given a certain transport demand allocated to the concept for import and export flows?
- Which operational and transport decision variables have the highest impact on the effectiveness of horizontal collaboration?

Important decision variables for the outcome of the simulation that will be assed in further detail are:

- the amount of shipments available for own and shared transport
- the type of shipments that use single or shared transport (weight and type of shipment)
- the conditions under which shipments are moved from one type of transport to another (weight or type restrictions)
- the way allocation of transport capacity to different shipment flows (ULD, Loose, combined) (capacity management)
- the operational differences in handling of shipments based on type of transport
- the amount of capacity at hand for shipments to be transport by single or combined transport (variable or fixed limitations)
- the arrival pattern of shipments for import/export flows
- operational hours of transport (single/combined)

On which basis the variables above have been defined will be discussed later in this chapter.

Highest level conceptual model of transport system

At the highest aggregation level a conceptual model of the simulated system is represented by Figure 42 below. This figure can be used from the perspective of both single company or system perspective:

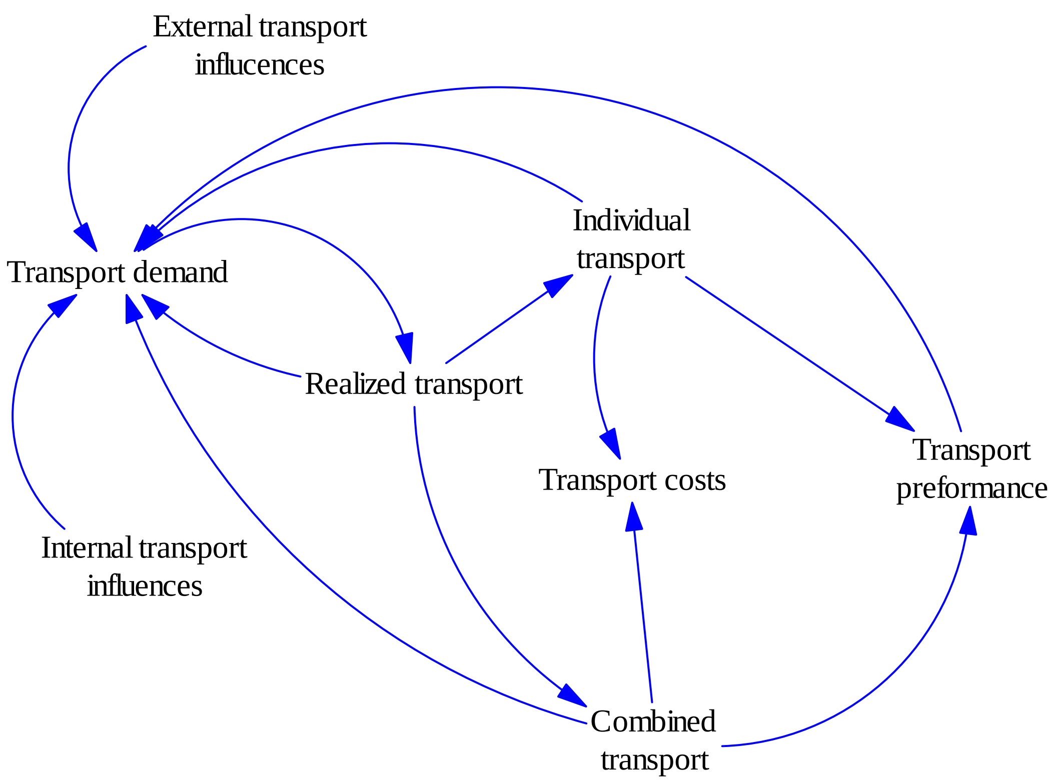

Figure 42: Relation between transport demand and actual conducted/planned transport simulation basis.

Transport demand depends both on internal and external influences which can have a positive or negative effect on the actual transport demand. Based on transport performance and transport costs, given a certain amount of transport demand, choices are made for realizing either single (individual) transport or using combined transport. As stated before this simulation model will try to asses to which extent realized transport, transport costs and transport performance can be positively influenced by defining conditions for combined transport that can be supported by the involved forwarding companies. It will also try to show what effect the use of combined transport can have on utilization of single transport and the total amount of transport movements within the system.

Lower level aggregation of the transport system

On a more detailed level the defined variables of Figure 42 can be split up into different types of transport and operational aspects related to transport and shipment variables. The to be constructed simulation model will attempt to include most defined variables of Figure 43 and relate for each of the different types of transport if changes and uncertain to these variables will have a big impact on the realized transport of the system. The different types of transport that is generated can also be organized separately or can be supported by combining both import and export transport. Figure 44 below shows the different of options of transport that were considered for this simulation model. Combining different types of transport can reduce the amount or distance that is traveled without (any) shipment(s) and could also improve the collection time and delivery of shipments. It is however not always be a straight forward task to decide if transport can be better utilized by combining import and export flows or leaving them separate. This is why in the simulation model transport is always send back to base location before checking if there is demand for import or export flows, this is thus checked only after a transport journey is completed. Figure 43 below shows a distinction between express and non-express transport demand, in the simulation model this distinction is not modeled separately, as decision logic related to one shipments becoming express and in need for different transport are based on company specific operation parameters that are currently unknown. Shipments waiting for transport will in all transport related queues be ordered on the basis of their deadline time, this means that shipments with a urgent delivery will always be transported on the next available transport. Finally in the figure below ULD and loose cargo shipments can generate combined transport that includes both ULD and loose cargo, this is type of transport is technically possible, but involves operational procedures that in general make this type of combined transport not attractive transport solution. Therefore this type of combined transport is not included in the simulation.

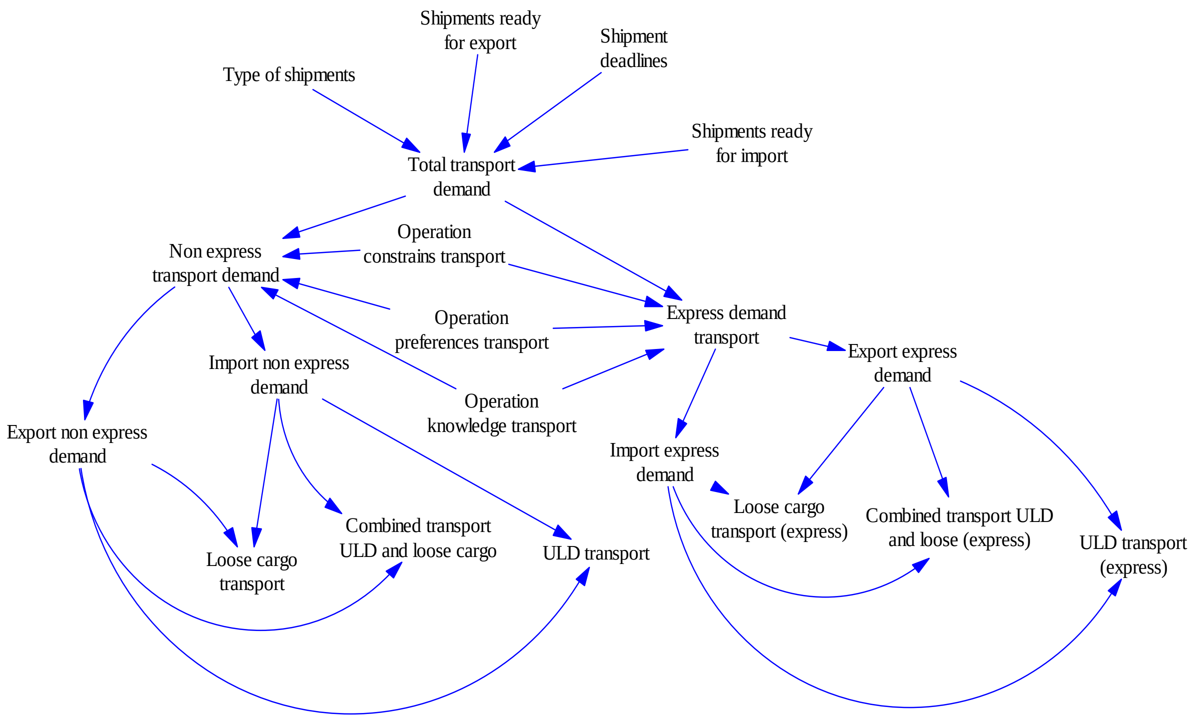

Figure 43: More detailed overview of transport system variables that define the actual realized transport for specific shipment flows.

<u>Simplified model of transport</u>

In the to be constructed simulation model there thus will be no separate express or combined (ULD, loose) transport for both individual and or shared transport between the different companies. All types of transport will therefore be specifically assigned to either loose or ULD cargo for import or export flows and will only be used for different transport flows after the transport comes back to its base when transport shipments have been unloaded at the final destination and the transport resources has returned to its base.

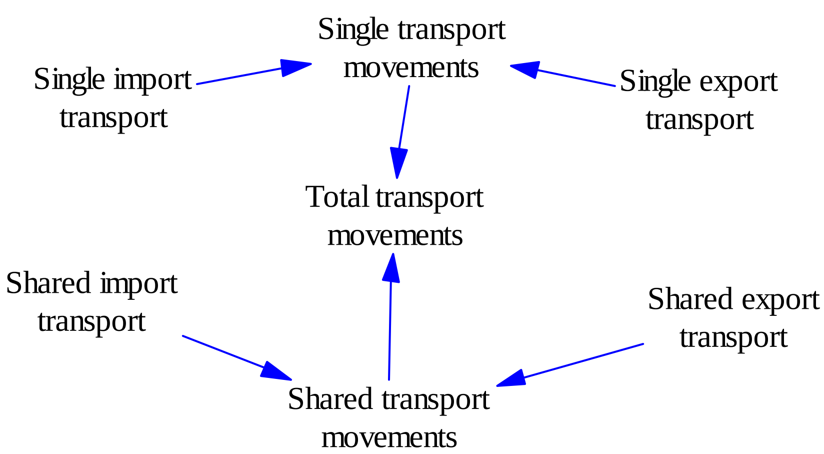

Figure 44: Relation between combined transport of single company or multiple companies combined transport.

System overview of transport demand and transport generation

Figure 45 below gives an overview of the important variables and their relations that influence the transport demand and generated transport based the operational conditions of a freight forwarder and transport costs and performance for the different types of transport that can be utilized.

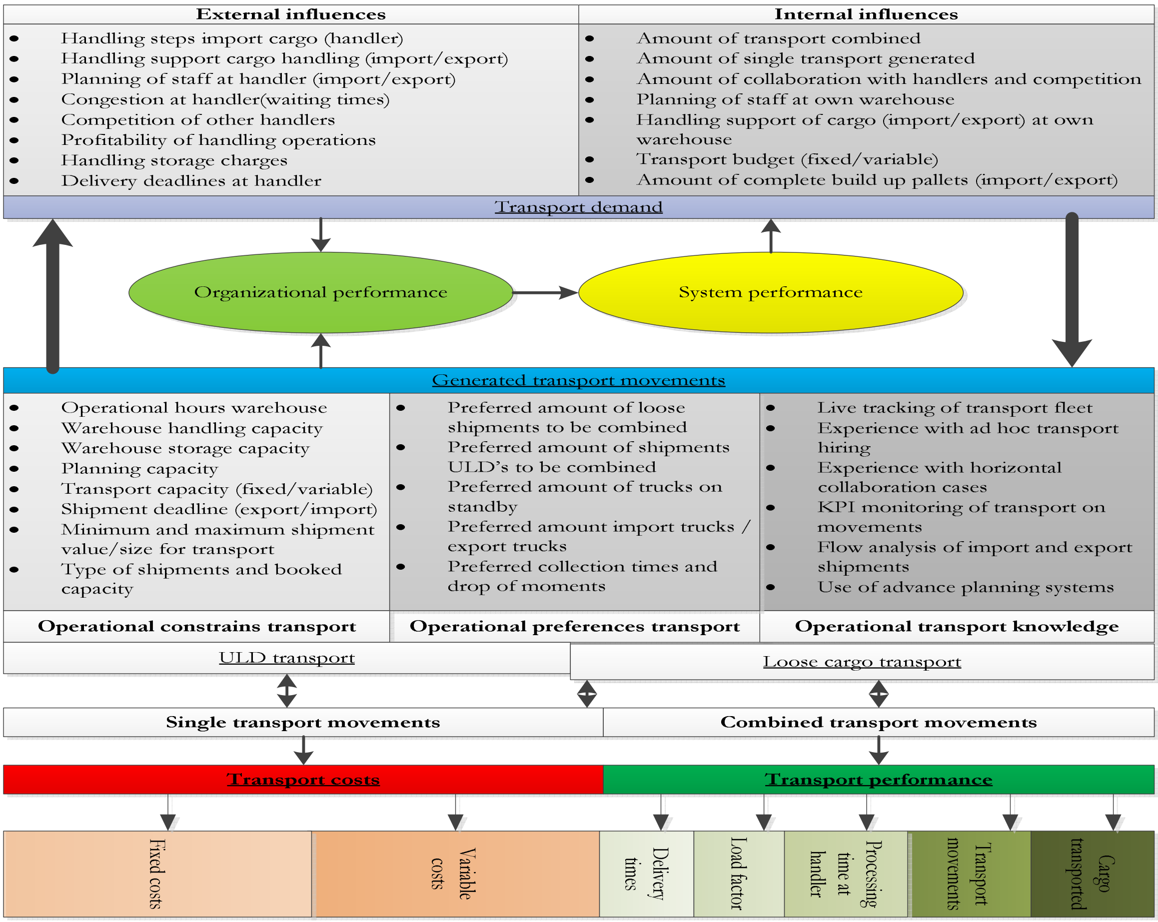

Figure 45: Relation between transport demand aspects and generated transport aspects for a freight forwarder.

The organizational performance of freight forwarder depend on the way it plans its transport, this can be based on both internal and external influences. Operational constrains, preferences and transport knowledge are three aspects that impact the way and amount of transport that is generated. The type of transport movements that are realized can be decided on the basis of transport performance, transport costs and to which extent the involved company has fixed and variable transport capacity at hand.

8.2 SIMPLIFYING CONCEPTUAL MODELS FOR SIMULATION MODEL

The conceptual models that have been defined in previous chapter contained level of details that are either not relevant in relation to the research question defined for this simulation or cannot be realistic modeled due to lack of data or uncertainty about the involved process times and or modeling logic that needs to be applied. This is why the simulation model will focus on a specific part of the system and will simplify the conceptual models in such a way that modeling complexity is only added when it can be justified, is need and can be modeled or supported in the correct way. The simplification of the different processes that have been defined in chapter 7 using SADT modeling technique will now be discussed for each process that will be used in the simulation model. First the processes at the forwarder will be described followed by the main processes at the air cargo handler.

Processes at forwarder facility

Accepting truck for air cargo transport

Three sub processes were described in the conceptualization in relation to acceptance of a truck for air cargo transport at the forwarding facility, this included the sub process of documentation. As all intra airport movements to analyzed forwarders are with DGVS system, document free transport is possible. As document process both for import and export can defer for each company and limited information in relation to shipment generation and processes is known in general. The documentation process will not be constructed for the simulation model. All transport carried out for intra airport transport assumed to be occurring with drivers that have an ACN card, this makes the gate process for both single transport import/export at the gate of each forwarder equal. It should however be noted that not all forwarders have a secured facility that can only be accessed with a card. It is however expected that this will become the norm in the future as more and more transport will be linked to digital process and gate check in moments to further enhance the speed of import and export at both the handling and forwarding facility. The gate arrival moment is thus modeled as separate process and the docking of truck is modeled as transfer object which takes a fixed amount of time.

Unloading truck with shipments

The unloading of shipments at forwarding facility had been separated in three different (sub) processes; the unloading of the shipments, the handover of the shipments and the transport away from the dock to further location in the warehouse. For the transport related research of this simulation the handover moment and further transport within the warehouse are less relevant, as these processes do not in general affect the transport process for both single and combined transport. Forwarders have sufficient docks and staff at hand to support the unloading process and can perform the other two sub processes according to their own preferences and operational situation. Therefore in this model the most relevant process for transport is modeled only for unloading of shipments, as transport will be able to depart again as soon as the unloading has been completed. The difference between single and combined unloading will be defined in the time it takes to unload the shipments. Current collaboration concept (2door concept) of KLM has shown that priority is given to unload shipments of this concept in relation to own transport at the forwarding facility.

Preparing shipments for onward transport

The preparing of shipments for onward transport (import) is not a relevant process for the defined simulation goal. As the simulation focuses on intra airport transport and further transport import is supported by different pool of transport truck that are normally not included in intra airport transport system. As stated before the sub processes related to documentation are not included in this simulation model, so will also be left out in relation to this process. Recent developments will make it possible for forwarders to perform checks for export shipments within their own warehouse, so for the simulation model it is assumed that all shipments that are created either have already completed documentation, custom procedures and security procedures or these do not cause a delay onward transport process. For export process shipments at the forwarder facility are thus directly ready to be transported when they are created in the simulation model.

Planning transport to external location

The planning of transport from a forwarder location to external location to either delivery or collect shipments is crucial process for the simulation model. As the logic that will be applied can have a high impact on the effectiveness of single and combined transport. Planning capacity for trucks is the same for single and combined transport, several objects in the model will check if transport has been allocated for next planned transport. For each company two different holds are created that can have shipments waiting for collection (import) or delivery (export). As their currently is to limited information about the effects of the new security regulations that will be implemented in April 2013, processes related to securing cargo (export) will not be included in the model. Shipments will be combined in the model as long as transport has not been linked to a specific hold and the maximum transport weight has not been reached. Transport will only operate during specified operating hours which have been based on information that has been provided by the involved forwarders, transport can only leave for to collect new shipments if time is before closing time. As soon as transport is allocated to set of shipments, new arriving shipments have to either wait for new transport to arrive for free hold or will wait in central hold before transport is completed. Based on interview information the generally export transport is given priority above import transport. However to ensure that import transport is also collected a module based on change is included that will at certain moments also give priority to import shipments. As this planning process can defer from company to company, a more complex way of decision logic is not applied to the model as it cannot be validated for each simulated company. Individual transport planning does not have a current minimum level in the model, as most companies higher there transport at fixed basis, there currently is little or limited gain to send less trucks to the handler as fixed transport capacity has been paid for anyway (fixed hiring of trucks).

Loading truck with shipments

Forwarders can have their shipments ready at their facility before transport arrives or only afterwards, as it impossible to define supported simulation logic for when shipments will be ready or not, with the limited information at hand a more simplistic process of loading will be used. In the model it is assumed that when truck transport is requested at a forwarding facility that the related shipments are already at a location close the docking of the truck for transport. Again similar to unloading of import shipments single transport loading will have a different loading process compared to the use of combined transport export loading. The handover process again is not modeled in this simulation model, it is included in the time it takes to load the shipments.

<u>Processes at transport company</u>

The forwarding companies that are included in this simulation model hire external transport company to perform their transport needs. However the planning of the transport is still mostly done by forwarding company. This is the case for single company transport, in the case of combined transport it is not defined yet which company will take the role of transport planning. Or if this is combined planning between handler, forwarder, transport companies that are involved. In the model this decisions and planning are done at the base of transport company, but the real decisions could be done at other locations, this however should not affect the way transport is generated.

Transport planning of forwarders combined

In the conceptualization of the previous chapter no specific processes were defined for transport company as this is assumed to be done by the forwarder. However important decision logic has to be defined for transport planning of combined transport, which is currently not being applied for such a concept as it does not exist at Schiphol. The model demand will be checked for import/ export shipments that are offered for combined transport, with priority given for export shipments in the same way as for individual transport. One crucial model process is the decision logic in the sequence of both combined import and export transport. The same sequence will be followed for all transports as long as there is demand for transport or shipments of companies are included. This sequence will be the same for all transport in order to model it simplified way. The way a transport company is paid also greatly effects the way transport is planned. This will however not be one of decision variables of the model, however the transport will either be set free or will be limiting it, based on time and amount of cargo waiting. This can be done both for import or export combined transport movements in order to ensure that a sufficient load factor is achieved with a reasonable amount transport per movement.

<u>Process at air cargo handler</u>

Accepting truck for air cargo transport

In the conceptualization the acceptance of truck for air cargo at the handling facility is modeled in four different sub processes. The documentation part will not be modeled as separate process in the simulation model. As for import documentation will have already been collected before shipments are collected or will not taking longer than the loading of shipments. The other three processes defined for expecting a truck will be modeled. Processing of truck will only occur for single transport truck, as the combined transport will have dedicated dock door and does not have to be processed. In the future however export single transport that meets all e-link requirements will also be able to skip this process, but this is not the case in the current system. Docking of the transport is modeled as routing object that takes a fixed amount of time. And the accepting process at the entrance is modeled as a process with a fixed resource that is the same for single and combined transport. Single transport arriving at the handler will have a change of being delayed before docking due to congestion change, this relates to the limited ability of air cargo handler to plan their resources effectively during peak and non-peak times. Also single company transport needs to go to process of obtaining a dock and delivery the related documents to the handler which is modeled as delay process. This process is not applied to combined transport as docks are defined before and documentation is not part of process.

Unloading truck with shipments

In the same way as unloading of shipments at the forwarder has been defined in three sub processes at the forwarder, this has been defined for the handler in the same way. Again the handover moment at further transport of shipments away from the dock are not modeled and are only partly included in the unloading time of shipments which has to be completed before the truck can leave the dock for further transport. Similar to the processes of loading at the forwarder, at the handler the process times of loading is different for combined and single transport.

Preparing shipments for onward transport

At the handler three processes are defined for preparing shipments for onward transport. These are the same as at the forwarder, again the custom related process and documentation processes are not modeled as separate processes. Shipments that are generated at certain time have already gone thru this process or will not be delayed for transport by this. Shorting of shipments is this model only relevant for import movements as is included in process that defines the time it takes for air cargo handler to prepare the shipment from arrival from the aircraft to be ready for collection. These processes are defined for both loose and ULD cargo, difference between combined and single transport cargo cannot be made as there is no influence by the importing handler on how these shipments are loaded onto the aircraft at the export location. The possibility that part shipments arrive on different flights or containers (import) is not modeled, as more information about the actual amount of part shipments is not at hand. So shipments that are created and processed at air cargo handler are assumed to be ready for onward transport to the warehouse of the involved forwarders.

Planning transport process at handler to forwarder

A process related to planning transport from handler to forwarder was defined in the conceptualization, because it was stated by a handler that they would like to such planning processes in the future. In the model however this process are defined at the transport company that will perform the combined transport as explained before above. It can be however that part of the planning is done by transport company within the warehouse of handler.

Loading of truck with shipments at handler

The loading of shipments is defined as two different processes at handler that take different times according to the facto if transport is combined or carried out for a single company. These different timings come from the support for loading and the distance that shipments need to the dock. Loading of shipments will start directly for combined transport whereas this will only start for single transport when it is known by the warehouse staff which shipments are collected. Again the documentation process and custom procedures are not accounted for in this process. For single shipment process however the truckers will first need to provide the correct documentation and be assigned to a door in order to start collecting shipments, which is not the case for combined transport. This has been taken into account at docking process of single transport, where a delay is included to obtain a dock door.

9 SIMULATION MODEL SPECIFICATION

After having defined the simplified model structure based on the conceptualization in the previous chapter, the simulation model will now be specified in this chapter. Important data that will be used in the data will be explained for both the construction of the model as how to validate and verify that the model actual performance in line with reality.

9.1 DATA COLLECTION FOR SIMULATION MODEL

As described in chapter 7 collection of data for the simulation model was not an easy task as companies with in the air cargo system at Schiphol either didn't have the needed data or were unwilling to provide the data. A combination of data was therefore used to be able to define the input for the variables of the model. Several different sources of information were used in order to construct the model which were:

- forwarder specific data (transport movements/costs/type of cargo (ULD/Loose) and amount of cargo)
- cargonaut DGVS systeem data (amount of cargo/ amount of shipments to and from all handlers for all DGVS members of certain period)
- Schiphol Group year data (data on movements of flights/ import and export flows)
- literature on air cargo system and transport on airports (average ULD shipment size)
- case observations at handling and forwarding facilities (process times of cargo loading/unloading/ transport times)
- expert input during presentations, meetings and company visits (average amount of transport per shift/ amount of shipments carrying per transport, load factor, shipment distribution etc.)

9.2 MAIN INPUT VARIABLES OF THE MODEL

Due to the extent of the model not all input variables of the model will be discussed in this chapter, the most important input variables of the simulation model are briefly explained in Table 3 below and a more detailed explanation can be found in the tables following Table 3. Not all of the defined values could be based on actual data, so some value are derived from literate, based on observations at handler facilities or based on a mixture between other logic and common sense. More additional information regarding the definition of input variables can also be found in Appendix E. All facilities that are constructed in for this simulation have been assigned one entrance and departure check point The transport distances haven been derived from using Google maps distance between the forwarders and one specific handler of which data has been used to construct this model (Table 4) . The transport timings have been assessed on the basis of using car transport between the involved facilities. Operating hours of the involved companies (Table 5) have been based on information obtained during interviews of several forwarders during their week day's operations. A standard trailer has been said to be able to take up 20000 kilo of cargo as maximum weight, however this not include any volume or special care restrictions, this is why given the fact that no volume aspect is included in the model a lower maximum weight is used in this model. For combined transport it can even be hard to realize loading 10000 or more kilo's as shipments of competing companies still have to be separated and cannot be stacked on each other. The weight limitation that will be used of 10000 kilo has been based on general rule that cargo 1m³ of cargo volume equals 166 kilo of cargo, an average trailer can take between 70 to 80 m³ in the most optimal loading, when 10000 is defined as limit this relates to 60m³ of volume, 75% of the maximum volume. Given the challenge to combined cargo of different companies more strict limitations to the maximum weight of a shipment are defined for combined transport which can be found in Table 6. For single transport a maximum of 10000 is defined for shipments which limited by the capacity of trucks. In default scenario a limit of 2500 kilo is set to be the maximum of combined shipments, this is done for two reasons; first shipments larger than 2500 kilo can already justify the use dedicated transport and it will also make more difficult to combine shipments of other companies. The strength of combined transport will mostly come from combining smaller shipments of several companies that would otherwise not be combined with sufficient volume. The base scenario of the simulation model should represent the current situation for three forwarding companies; in the base scenario none of the companies combines transport of shipments with other forwarders. This is why the default value of combined transport on all flows is set to 0%.

	simulation parameter	description	default value
1	transport distance	distances between facilities and transport bases	See table 4
2	*number of transport*	amount of transport per company and type of transport	See table 5
3	operating hours transport	operating hours of transport per company and for combined transport	See table 5
4	**weight capacity transport**	maximum weight for transport single and combined and types of shipments	10000 kilo
5	*weight limitations transport*	weight limitations for different transport flows	See table 6
6	*percentage of cargo offered for collaboration*	percentage of cargo offered for collaboration	0%
7	**transport costs per hour truck**	average hourly rate for rental of airport truck	€45- €50
8	**docks at facilities**	amount of docks at hand for involved parties at facility	see table 7
9	*handling times cargo at dock*	handling times at facilities for unloading and loading cargo shipments	see table 8
10	**Process time cargo (import) before**	How long it take before shipment is processed at handler	see table 8
11	minimum amount of shipments to start	The amount of shipments before transport is released	1
12	*maximum amount minutes before departure*	How long will transport be delayed after shipments are waiting	0
13	*amount of fixed capacity per truck*	The relation between fixed and variable capacity of transport	0
14	*Delay for transport check when transport or shipment cannot be allocated*	amount of time to wait for next transport or shipment hold check	5 minutes
15	**Arrival of export shipments**	arrival pattern and distribution of weight export shipments	See table 9
16	**Arrival of import shipments**	arrival pattern and distribution of weight import shipments	See table 9

Table 3: Overview of key input variables that are used for simulation, parameters that are marked as cursive are changed later in the model.

base (combined)	c1	c2 (imp)	c2 (exp)	c3	h1
distances in (km)	0,2	0,1	1	1	0,6
c1		0,2	0,9	0,9	0,5
c2 imp	0,1		1	1	0,6
c2 exp	0,9	0,9		1,9	1,4
c3		1			1,1
routingtimes in	c1	c2 (imp)	c2 (exp)	c3	h1
(minutes)	2	1	4	6	3
c1		1	4	5	3
c2 imp	1		4	6	3
c2 exp	4	4		5	5
c3		6			5
import in (km) single		h1	h1 and back		
c1	0,5		1		
c2	0,6		1,2		
c3	1,1		2,2		
import transport in (minutes		h1	h1 and back		
c1	1		2		
c2	3		6		
c3	5		10		
export in (km) single		h1	h1 and back		
c1	0,5		1		
c2	0,9		1,8		
c3	1,1		2,2		
export transport in (minutes)		h1	h1 and back		
c1	3		6		
c2	4		8		
c3	5		10		

Table 4: Transport distances and minutes of travel between facilities.

Transport costs are crucial parameter for the simulation, however they are not directly calculated in this model itself but are calculated on the basis of the amount of transport used and the operating hours of the involved companies.

As no specifics were provided related to hourly rate of transport by interviewed forwarding companies an estimation of hourly rates is used that has been validated on basis of actual hourly rent rates of truck transport at Schiphol. It is assumed that the larger forwarder will lower transport costs than smaller forwarders as it will hire more transport capacity on a regular basis. More about transport costs assumptions and calculation can be found in Appendix H.

forwarding company single	operating times	amount transport	ULD transport	loose transport	specfic for loose import	specfic for loose
c1	24 hours a day	4	2	2	0	0
c2	from 0600 to 0200	2	1	1	0	0
c3	from 0600 to 0200	2	1	1	0	0
combined	from 0600 to 2200	4	2	2	1	1

Table 5: Amount of transport used for model, operating times and specifics of transport allocation to flows.

weight restrictions	single (kilo)		combined (kilo)		trailer capacity restrictions	maximum weight (kilo)	amount of shipments taken	
Loose	50	10000	50	2500	Loose	10000	1	∞
ULD	1800	2500	1800	2500	ULD	10000	1	4
	min	max	min	max		maximum	min	max

Table 6: Weight restrictions of single and combined transport used in simulation model

The amount of docks Table 7 below, have been defined on the basis that the simulation model was first defined for use of more than 1 transport unit for a specific flow, this meant that two or more docks were defined for loose single and combined transport. As combined transport should not be stopped at the handler due to lack of docks. Also at the forwarders facilities it was stated by all interviewed companies that it would be no problem capacity wise to have dedicated dock for combined transport so again two docks were defined for both import and export faculties. Defining the amount of docks for single transport at handler was however difficult as the relation between the involved companies and other companies could not be supported with actual numbers. This why sufficient docks were defined for all transport that was defined for the base scenario.

amount of docks	H1 import export	c1 facility		c2 facility		c3 facility	
		import	export	import	export	import	export
ULD	1	1	1	1	1	1	1
Loose (single)	4	2	2	2	2	2	2
Loose (combined	2	2	2	2	2	2	2

Table 7: Amount of transport docks at different facilities within the simulation model.

Table 8 below shows the handling / (un)loading times at the 8 different facilities that have been defined for processing air cargo shipments. The timings of these processes have been defined on the basis expert judgments of several forwarders and have been verified by actual observations at handlers and interviews with warehouse staff and transport truck drivers at different facilities at Schiphol. Handling times in minutes that have been defined in the table below are the same for export, so in essence the loading and unloading of shipments takes the same amount of time. Given the relative high uncertainty about process times of loose cargo at a given handling facility, these processes times were based on exponential distribution. The exponential distribution seems to be the most suitable distribution for defining the process times at the handling facility, as an exponential distribution has the following characteristics; values are independent of previous value, there is a large range and a variety of different values occur with certain randomness. Also the research of (Franz & Stolletz, 2012a) uses an exponential distribution of the process times of trucks at an air cargo handling facility based on actual observed data. The main values of exponential distributions have been based on actual observed timings for single company transport and on expected values for combined transport. The defined distribution also gives maximum process times that are in line with the actual situation at the analyzed handling facilities at Schiphol. The handling times of ULD cargo at the handling facility and at forwarder for ULD and loose shipments have based on triangular distribution, as process times for these processes are much more stable and known.

times in minutes			
Handling times (un)loadingof	single loose	combined loose	ULD shipments
c1	TRIA(5,7,20)	TRIA(3,7,15)	TRIA(2,5,7)
c2	TRIA (5,7,20)	TRIA(3,7,15)	TRIA(2,5,7)
c3	TRIA (5,7,20)	TRIA(3,7,15)	TRIA(2,5,7)
h1	exp(8) +10	expo(4) +5	TRIA(4,6,10)
Processing import cargo at handler		**system wide (hours)**	
ULD shipments		TRIA (1,3,4)	
Loose cargo shipments		TRIA (3,6,10)	

Table 8: Handling times at all facilities for loading and unloading shipments for ULD and loose (single/loose) transport

It was very challenging to define the weights, the distribution of weights, the amount of shipments and the arrival moments of these shipments based on average weights that were not specified for ULD and loose cargo nor was the percentage of ULD or loose provided specified for the specific handler that was simulated. Several revenue management researches use lognormal distribution to simulate the arrival of air cargo shipment, this is why a log normal distribution was used (Boonekamp, 2013; Huang & Chang, 2010) Several experiments were conducted for each company on basis of the know amount of shipments at handler and average unspecified weight for ULD and loose in order to come up with a specific number of shipments that would fit with provided loose cargo percentage and amount of shipment arriving over time. Based on average arrival and departure schedule for Schiphol per hour for one day, three different time slots during the day were defined and for each of these slots the percentage of shipments in relation to the number of flights during that period was allocated. A poison process was used to simulate the arrival process of shipments with exponential distribution for the time between arrivals in order to have different arrivals of shipments over the day and between days, while in the same time be able to come with average over longer period that would be in line with the actual provided data. Shipments that were generated which were larger than 10000 kilo or smaller than 50 kilo were disposed and adjustments were made to amount of shipments arriving in order to process amount of cargo that represented the actual value obtained for each forwarder.

arrival shifts		daily	weight distribution import					
			ULD	Loose	ULD	Loose	ULD	Loose
arrival block	%	nr flights	c1	c1	c2	c2	c3	c3
early morning	6%	11,7	NORM (2300,100)	LOGNOR (350.600)	NORM (2300,100)	LOGNOR (150.400)	NORM (2300,100)	LOGNOR (310.600)
day peak	63%	162,9						
eveing peak	31%	21,2						
shipments per arrival			2	6	1	7	1	6
depature shifts		195,8	weight distribution export					
arrival block	%	nr flights	c1	c1	c2	c2	c3	c3
early morning	2%	3,4	NORM (2300,100)	LOGNOR (390.600)	NORM (2300,100)	LOG.NOR (180,400)	NORM (2300,100)	LOGNOR (330.600)
day peak	79%	153,9						
eveing peak	19%	38,5						
shipments per arrival			1	4	1	7	1	2

Table 9: Arrival of shipments in system based on flight arrival/ departure schedule of Schiphol airport.

9.3 MODEL CONSTRUCTS USED

The constructed model has been specified with limited amount of model constructs as information on resources related to the different processes was not available, this meant that several process were modeled as a delay instead of also allocating a certain amount of resources to a specific process. Given the situation that multiple shipments can be transported by one transport, the transported object in the simulation software was not used. As the transport constructs that are normally used to transport entities can have difficulties with transporting multiple entities. This is why transport is actual done by using a specially created entity as transporters in this model. This why in this model only one type of resources is actually defined for entrance check at each facility and the other constructs that flow thru the system are only entities. Entities can be split up into shipments or transporters. Each company has its own shipment entities for both loose and ULD cargo and this is the same for transport entities. For combined transport there are also two different entities are created for both ULD and loose combined transport.

- entities
  - Shipments (ULD [import/export] & loose [import/export])
  - Transport (C1 [loose/ULD], C2 [loose/ULD], C3 [loose/ULD], Combined [loose/ULD])
- resources (check in staff at gate (c1/c2/c3/h1)

9.4 DESCRIPTION OF MODEL STRUCTURE

The simulation model consists of several sub models that each represent distinctive location for handling air cargo shipments or relate to generation of transport. Each forwarding company has its own transport base, were transport is generated and all forwarders have a warehouse with an import facility that handles incoming cargo shipments from an air cargo handler. Next to the import warehouse there is an export facility that handles export shipments that are transported to an air cargo handling facility. All facilities that handler air cargo has the same arrival and departure points for transport and shipments, but they handle combined and single transport in relation to ULD and loose cargo at different location and with different process times. For combined transport a separate transport base is created that works that can collect and delivery air cargo shipments to all three forwarder warehouses.

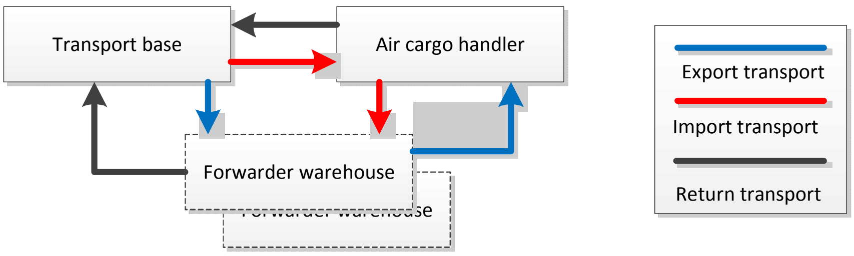

Figure 46: Simplified simulation model structure of inner airport transport movements.

Transport system logic

Given the limited information at hand regarding the actual transport logic of involved forwarding companies will be explained below, more detailed information regarding the transport logic is given can be found in Appendix E.

<u>Transport entities</u>

All transport entities in the model are generated at the start of simulation and are than placed in hold that only allows transport to operate during operation times. When transport can operate transport will be placed in next hold were demand for transport is checked, when there are shipments waiting for transport the transport model will check if other transport entities are already on route to collect the shipments, when this is not the case the transport entity will be assigned to collect and delivery the a specific set of shipments and will be assigned a transport route based on the location of the shipments.

<u>Import process of air cargo shipment</u>

Import shipments that are generated at handler are after creation first processed at the air cargo handler, the process time depends on the type of shipment (ULD/Loose), after this process shipments can be allocated to combined or single transport, when shipments are allocated to combined transport a check is made to ensure that the shipments are not too large. Afterwards shipments are transported to a specific area within the handling facility, from this point import shipments are allocated to the next transport or wait in a specific hold when capacity for next transport is available. When transport arrives for collection of import shipments it loads the shipments and based on which types of shipments it its carrying it will start transport to one of the involved forwarders. A sequence of transport is defined for this simulation, which means that fixed route is followed when shipments are loaded for different companies. Shipments are first delivered to company c1, than to c2 and finally to c3.

Export process of air cargo shipment

Export shipments are generated at the different forwarding companies, this means that shipments have already undergone all other processes needed before being cleared to be transport to handler. In the model therefore there are no processes after creation of the shipments before transport allocation. So after the creation export shipments are allocated to combined or single transport and are transported to a specific location in the warehouse of the forwarder, from this point export shipments are allocated to the next transport or wait in a specific hold when capacity for next transport is available. When transport arrives for collection of export shipments it loads the shipments and based on which types of transport has been requested the collected shipments are either directly transported to the air cargo handler or will check if more shipments are waiting collecting at other forwarders. A sequence of transport is defined for this simulation, which means that fixed route is followed when shipments are loaded for different companies. Shipments are first loaded at company c1, than at c2 and finally at c3 before going to the involved air cargo handler. At the air cargo handler shipments are unloading with different processes times based on if the transport involves combined transport or single company transport and which type of shipments has to be unloaded.

9.5 REPLICATION & SIMULATION RUN SETTINGS

Replication settings

At the start of the construction of the simulation model a simulation period of 10 days was used, which should represent two work weeks, 5 runs were defined as well and warm-up period of the model of two days was defined. In order to ensure that randomness of each run is not related to previous simulation run, different starting seed values were defined for each run. Six of the main processes at the handling facility were selected to ensure that average of each run didn't change too much and were sufficient entities going thru the processes at each run. This was however not the case with 5 runs of 10 days, so the model run length time was lengthened up to 30 days and the amount of replications was increased to 10. Based on decreased variance between the simulations run the replication settings of 10 runs and run length of 30 days were assumed sufficient, the values and calculations of the variance, average and confidence interval can be seen in Appendix F. The length of the simulation could have been shorted than defined but has also been increased to 30 days, to allow fast comparison of simulation results with provided data of companies that were analyzed.

9.6 VERIFICATION OF BASE MODEL

Several methods were used to verify that the constructed model actual functions as its intended and does it in right sequence and order for the different flows of shipments within the model. Four different methods of verification are used which are

- input verification
- structural verification
- scenario verification
- variable verification

Input verification

The creation of shipments for both import and export flows was first defined in a separate model in order to test different settings of arrivals, times between arrivals and weight distributions. In this separate part of the model the amount of shipments, the total weight per flow and average weight of cargo shipments that had been generated and fell within accepted cargo size range was first verified with weight limits that were set and amount of shipments that were created. Afterwards the creation modules of shipments were added to complete simulation model and it was checked that the amount of shipments and weight that was generated for a specific destination in line with what had been defined for specific period of arrivals in the separate model.

Structural verification

The simulation model consists of 6 import and export flows that that should be handled by either single company transport or combined transport, in order to asses if these flows are handled by the right transport and are delivered by to the correct company and location within the involved company all six flows were simulated individually for import and export first and later together for both combined and single company transport. Testing the model showed that all shipments were transported with right type of transport and followed the defined sequences of process on the basis of their shared or individual transport attribute. Also entities that were defined as transport were moved back to correct transport base awaiting next transport after completing either the delivery of export shipments to handler or to the last company of which the transport company was carrying import shipments. Also several holds were created in parts of the model were shipments and transport were separated in order to ensure that the correct shipments and transport were involved, as only entities that were expected at that given location were moved onward and other were put in infinite hold. After simulation no entities were found to be located in any of the defined holds.

Scenario verification

In order to assess if the model could work with multiple transport entities for both single and combined transport, different amounts of transport entities were created for each forwarding company. When the model was simulated for long period (30 days) and was simulated 10 times, the amount of transport entities arriving back and leaving for shipments was not found to be higher or lower than the total amount of transport entities that had been created at the beginning of the simulation. This means that during the simulation no shipments or entities were lost.

Variable verification

Several variables have been defined in the model to ensure that the amount of cargo allocated to a combined transport is in total does not reach more the maximum defined limit. For all of these variables counter were introduced to monitor the amount of capacity (fixed/variable) used by each company and how much of the total capacity was used. It was observed that the total capacity used was not more than what would be allowed by the model. Also several variables were created to ensure that no more than 1 transport entity could be on the way for collection of cargo shipments, for these type variables counters were also created to ensure that the value of each hold could only be 0, 1 or 2, the number two was later defined for transport as for ULD import only one hold was used, so two transport entities could be send to collect ULD's if there were more ULDs waiting than that could be transported by one transport entity

9.7 VALIDATION OF SIMULATION MODEL

Validating the constructed model on base current operations data was very difficult as the companies that were used for the simulation did not provide specific information related to their transport movements and shipment throughput for the different flows of transport that had been defined. Most of the model was therefore validated on the based on observations at the different facilities, information obtained from experts and information derived from formal and informal interviews with industry professionals.

Most important validation parameters related to transport movements are:

- average company load factor (LF) (Table 10)
- average amount of transport movements per truck per shift (Table 11)
- average amount of shipments for loose import and export transport (Table 11)

Based on observations at air cargo handling facilities, expert options and interviews with forwarders it was concluded that the much formulated average LF of 30% was quite high and that a minimum of 20% could be possible to validate the simulation for the involved companies. Load factors here are calculated for total amount of cargo and transport movements, as company specifics can mean that LF for either loose or ULD transport inbound or outbound can be much higher than average. A transport movement is defined as movement that is generated to either collect or deliver cargo shipments.

30 days(imp/exp)	c1	c2	c3	system total	observed
Load factor	29%	21%	21%	25%	20 to 40%
Transport movements	1483	463	821	2767	n/a
Cargo processed [ton]	4301	985	1691	6977	within actual range
1 day (imp/exp)	c1	c2	c3	h1	
Load factor	29%	21%	21%	25%	20 to 40%
Transport movements	49	15	27	92	n/a
Cargo processed [ton]	143	33	56	233	within actual range

Table 10: Transport movements, cargo processed and LF of companies and system.

ULD transport movements / shipments total						uld shipments per transport				uld transport
ULD	import	export	shipments	import	export	import simulation		export simulation		company wide
c1	349	384	c1	518	574	1,5		1,5		1,5
c2	25	23	c2	26	23	1,0		1,0		1,0
c3	171	203	c3	224	254	1,3		1,3		1,3
loose transport movements / shipments total						loose shipments per transport				loose transport
loose	import	export	shipments	import	export	import sim	actual data	export	actual data	company wide
c1	475	316	c1	2240	2105	4,7		6,7		5,5
c2	206	208	c2	1418	1765	6,9		8,5		7,7
c3	155	201	c3	918	682	5,9	3 to 10	3,4	5 to 10	4,5

Table 11: Amount of shipments on average related to type of transport for each company's flow.

In order to assess if the amount of shipments that are transport on average fall within the current situation on basis of data provided by one forwarder is used, to assed if transport movements fall within the given range. The range was given for loose transport both for import and export transport. All companies in the simulation fall within the average for import shipments, for export company c3 has a lower average, however this lower average can be explained as this company has a ULD percentage that is about 2 times higher than company c2, as both companies have one dedicated transport unit for loose cargo this can explain why company c3 has a lower average amount of shipments on export loose transport.

Next to the aspects above the model was also validated on basis of maximum expected values of actual processes and delivery of cargo shipments (Table 12)

- process times (un)loading cargo at handler/ forwarder
- process time after landing shipments import (ULD/Loose)
- throughput time shipments (minimum, average/ maximum)

time unit [hours]	c1	c2	c3	c1	c2	c3	c1	c2	c3	max
transport part	average			minimum			maximum			
shipment througput import ULD	0,82	0,73	1,46	0,36	0,41	0,4	2,14	1,46	7,81	<10
shipment througput import loose	1,25	2,7	3,12	0,45	0,41	0,5	3,84	14,88	18,23	<30
shipment througput export ULD	0,91	0,69	1,21	0,39	0,48	0,5	2,74	1,55	7,74	<10
shipment througput export loose	1,47	2,18	2,1	0,7	0,54	0,6	6,88	13,18	15,37	<18
entire system time	average			minimum			maximum			
entire import time	6,78			1,76			25,94			<30
entire export time	1,71			0,39			15,37			<18
Unloading before transport	average			minimum			maximum			
Process ULD at import h1	2,67			1			3,99			<4
Process loose at import h2	6,32			3,0092			10			<10
(Un)loading at transport h1	average			minimum			maximum			
Single loose cargo unloading	0,29			0,16			1,32			<2
Combined loose cargo unloading	0,15			0,083			0,595			<1
ULD unloading	0,11			0,067			0,16			<1/3
Single loose cargo loading	0,29			0,16			1,52			<2
Combined loose cargo loading	0,1494			0,0083			0,58			<1
ULD loading	0,1			0,05			0,169			<1/3

Table 12: Process time and throughput time of shipments in base model for involved companies import / export.

Table 12 above shows that all process times fall within the defined maximum of process times in hours, these limits have been defined on the basis of actual observations, points made during interviews and other meetings and in relation to storage free limit for export and import 18 hours that is started after shipments are checked in at the facility. Based on the validated data of the simulation on key simulation parameters it can been concluded that the model can represent actual transport operations to and from one specific air cargo handler for three different forwarders situated around the airport.

9.8 MAJOR LIMITATIONS OF THE CURRENT MODEL

The simulation is made on the basis of cargo transport demand to and from one handler involving three forwarders active around Schiphol, however there are currently six general handling facilities and most forwarders try to combine transport (import/export) when suitable between and within specific handling facilities. This model does not make this combination possible as there is insufficient data available on the decision logic regarding the combination of shipments and the way certain handlers operate. This is why export and import flows are separated in the model and also combing ULD and loose cargo shipments is not supported in the model. This again not supported as insufficient data is at hand about under which conditions forwarders would decide to combine loose and ULD cargo as it can have major drawback regarding loading/unloading of cargo. Also in the current model forwarders send transport out to handler or own warehouse as soon as there is more than 1 shipment at hand, again this is modeled in this way as no industry standard approach has been found that shows which is the minimum amount of shipments or weights that is used to start a transport. It is for example possible that the uncertainty about shipments arrival and deadlines will force forwarders to start transport even for one shipment of low weight, but this has not been validated on basis of actual data. Other major limitations of the simulation model are discussed below in more detail separately.

<u>Arrival of shipments/weight of shipments / amount of shipments that arrive each time</u>

The arrival of import/export shipments has been based on general distribution of flight arrivals/departures during average day over the year at Schiphol, this has been done as no more specific data was provided for the analyzed companies. It could however be that one or more of the analyzed companies has very different arrival or departure pattern of shipments. Difference in arrival patterns of shipments (import/export) could be absorbed by difference of other involved companies, but this can be supported by actual data. It can be assumed that large forwarders (which have been studied) all obtain their shipments at similar timings as they use similar fights and have costumers operating in a similar way, however this cannot be supported with actual data. Weight distribution and average shipment weight of the involved companies have been based on both actual data from Cargonaut, company provided average and likely values based on other research. In order to get amount of shipments with a total weight that can fall within the data provided by involved companies the amount of shipments that arrive and the time between arrivals has to be modified for each company. Next to this difference in arrival of shipments per week/day for inbound/outbound flows for certain forwarder have not been provided, this potential difference are crucial in order to asses in which way fixed capacity and variable capacity for transport collaboration have to be defined. If transport demand for import/export shipments to one air cargo handler from three forwarders is very certain and stable most of transport can be planned by using fixed capacity, were as very unstable and uncertain shipment flow of shipments will justify the need of more variable transport capacity.

<u>Deadline times of shipments</u>

As timing of shipments for air cargo shipments is important aspect deadline times have been defined for each type of shipment and flow (import/export) for all involved companies. These deadlines have not been based on actual information but were based on the transport performance of the involved companies. Deadline times for export were defined in such a way that for all companies with transport capacity at hand less 1% of the export shipments would arrive later than the defined deadline and for import <10% of the shipments would arrive after the defined deadline. These deadline times are seen as useful as they will show out that using slower transport for export will have a high impact on the amount shipments that arrive late, in the case that deadline times are not changed. It can also be used to show the importance of having more specific actual information of deadline in order to effectively compare single and combined transport. If slower combined transport will in for example 99% of the time still meet the import and export deadlines of the involved companies that the extent that combined transport is slower does not have a negative impact on transport performance.

<u>ULD / loose cargo shipments percentage</u>

In this simulation model transport has been defined in fixed way for ULD and loose transport based on fixed percentage of ULD and loose cargo for each forwarder (import/export). However it could very well be that this average percentage changes for each forwarder to great extent during the week, again stability or variety in percentage of ULD and loose cargo would demand another why of organizing transport. The model does ofcourse have some variety of shipments arrival (ULD/loose) based on the fact that it's based on poison process, however the arrival process and its similarity for each day cannot be validated or supported by actual data.

<u>Resources at handling facility</u>

Large air cargo handling companies often serve more than 100 different forwarders a day, this why it wasn't possible to define specific resources to handling process of the involved forwarders at the analyzed handling facility. Also combined transport as is planned in the pilot has not been organized yet by any handler at Schiphol, therefore the amount of resources that would be allocated to the concept are currently unknown. Resource planning and utilization is one of the main challenges of air cargo handlers therefore it would have been very valuable if analysis would be possible on comparing current resources usage with combined transport resources usage at forwarding facility. The model therefore cannot provide any information on the effect of resources usage by applying combined or single transport.

<u>Relation between other transport movements</u>

Currently very limited information is available on the transport movements to and from handling facilities at Schiphol, especially on the handling facilities they visits and what are actual waiting and loading times are. Even the check point data at the handling facilities is incomplete as trucks sometimes don't have to use their card on the way our and not all truckers have an ACN card. Also at Schiphol South-East several handlers are located after one checkpoint so there is no clear overviews on the amount of transport that actual combined collection/delivery of import & export. This makes it difficult to state to which extent the actual movements that are generated by this model are representative for the whole of Schiphol. Also the use of docks for single transport and ULD transport at the handlers has in the model not been able to take into account the usage of other forwarders during the day, as there is no data at hand about the utilization of these docks and the extent of congestion or extra process time during peak times.

10 SIMULATION TESTING & RESULTS

Before results of the simulation can be presented the current validated simulation model will first be assessed related to sensitivity of the most important used simulation parameters.

10.1 MODEL SENSITIVITY

In order to assess which values have the highest impact on key simulation parameters, a selected number of simulation parameters are assessed in detail on their sensitivity. The parameters that will be further analyzed in this chapter have been selected on basis of their expected impact and uncertainty and also on the ability within the model to change the analyzed parameter in an appropriate way. The parameters that were selected influence single, combined or both types of transport, this is why for the parameters concerning combined transport, a base scenario of combined transport is defined. This is not needed for the parameters that only involve a process of single transport. The ranking of parameters and selection of parameters for the sensitivity analysis can be found in Appendix G. In order to limit the amount factors to judge the sensitivity of the model on only six different parameter changes are assessed in the sensitivity analysis, as these are the most important for both the handler and forwarder in relation to their own performance and operational costs.

KPI's used for sensitivity analysis are:

- amount of import / export transport generated
- amount of import / export cargo processed
- load factor of transport system wide
- amount of shipments late / on time
- amount of shipments late after define deadline
- average throughput time of shipments

Sensitivity of single transport system

For the single transport system two parameters are tested within the sensitivity analysis as their potential impact and uncertainty justifies further analysis.

Process time of (un)loading loose cargo shipments at handler for single company transport

The process time of loading and unloading shipments at the handler for single loose cargo had been changed by +/- 50%. It shows that there is limited effect on the amount of cargo that is transported/processed and the load factor does not change that significant, but the impact on the amount of transport and the amount of shipments that arrive late for both important and export flows of loose goods is extensive. If (un)loading process is faster than has been defined a much stronger increase of transport movements is observed than the decreases that is realized when (un)loading process increases by 25% or 50%

un(loading) of single loose shipments	-50% **expo (4) + 5**	-25% **expo (6) + 7,5**	base case **expo (8) + 10**	25% **expo(10) + 12,5**	50% **expo (12) + 15**
import movements loose	955,8	890,8	837,4	791,6	722
export movements loose	768,4	749,2	725,9	711,8	675,7
import cargo	1661449,4	1685102,1	1615299,9	1663249,2	1640358,3
export cargo	1643334,2	1660559	1642338,7	1654107,2	1663115,7
LF	1916,705487	2040,037256	2083,82179	2206,569376	2363,50719
import shipments late	250	277,4	281,1	328,7	368,8
export shipments late	11	10,7	15,3	20,7	26,1
import shipments late loose	6	12,5	12,4	23,7	40,2
export shipments late loose	2,6	2,9	4,4	6,9	9,5
throughput time import	8,15	8,36	8,49	8,7	9,03
throughput time export	1,71	1,79	1,84	1,94	2,07

Table 13: Sensitivity of (un)loading process at handler for single loose cargo shipments on selected KPI's.

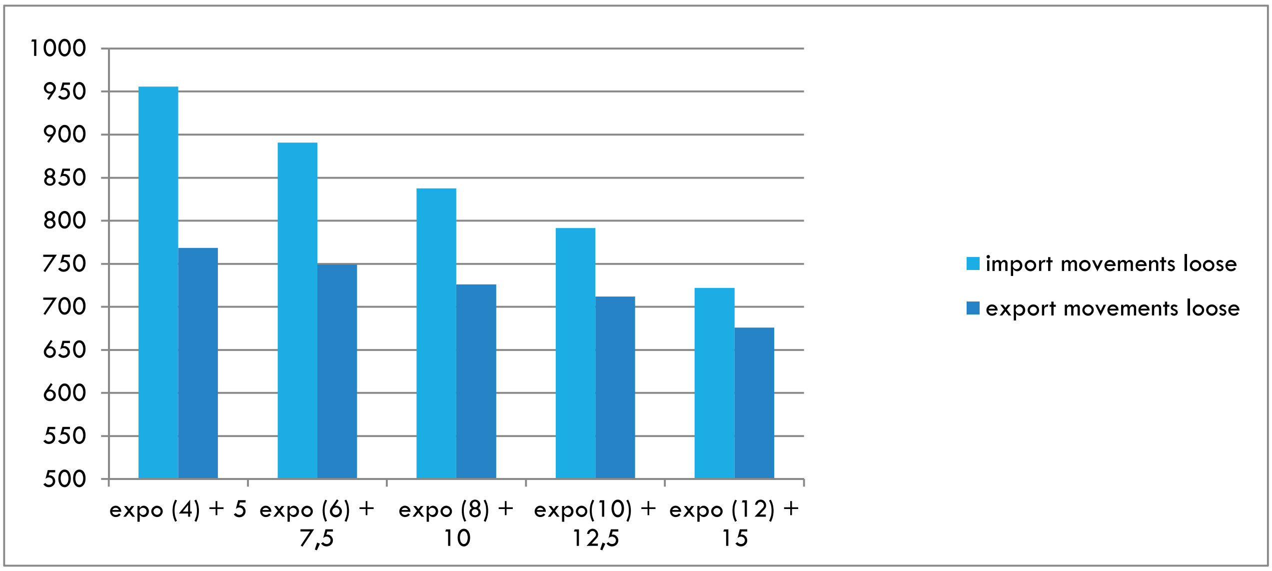

Figure 47: Relation between (un)loading process at handler and amount of transport movements for singe loose transport.

Figure 47 above shows that the amount of transport is negatively influenced by loading times at the handler however import transport affected differently before base level of expo (8) +10, as the transport first decreases faster than around expo (8) and then afterwards decreases faster again for higher (un)loading process at the handler for single loose cargo transshipment.

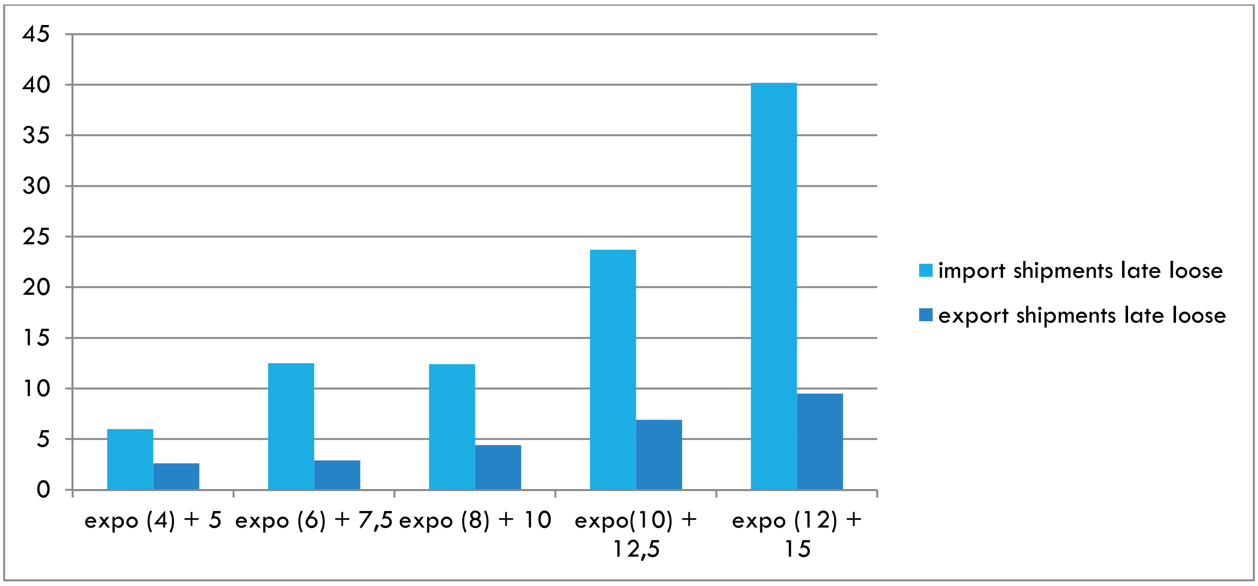

Figure 48: Relation between shipments arriving late at destination and (un)loading times at handler for single loose transport.

Figure 48 above shows that the amount of shipments that arrive late after changes to (un)loading time are made are stronger after base loading time and affect important shipments more than export. This can partly be explained by the preference of transport system for checking export transport demand more often than import demand. With longer average (un)loading times at the handler less capacity will be at hand for single import transport loose shipments, this increases the change that import shipments have to wait for collection.

Maximum capacity truck trailer single loose cargo

Volume of shipments or restrictions on loading could have a high impact on the actual amount of kilo's that can be transported by a truck for each given transport. In order to asses if changes to maximum weight of trailer have a large impact on the define KPI's a reduction and increase of 20% is analyzed for trailer capacity of single transport. Table 14 below shows that the effect of changing capacity of a trailer is minor on all defined KPI's as LF, shipments late and cargo processed only result in slight reductions on movements and increases in LF.

Single loose transport (30 days)	maximum weight of transport single loose	-20%	0%	20%
		8000	**10000**	**12000**
transport movements	import movements loose	749,3	837,4	726,4
	export movements	684,7	725,9	670,2
cargo processed	import cargo	1650093,3	1615299,9	1665152
	export cargo	1641475,9	1642338,7	1652607,3
Load factor of transport	LF	2295,376011	2083,821787	2375,59738
Amount of shipments late	import shipments late	405,6	281,1	373
	export shipments late	28,9	15,3	23,8
Amount of shipments later than defined time	import shipments late loose	75,7	12,4	33
	export shipments late loose	9,6	4,4	7,1
throughput time loose transport	throughput time import	9,2	8,49	8,97
	throughput time export	2,11	1,84	2,01

Table 14: Sensitivity of trailer weight restriction process at handler on selected KPI's.

Figure 49 below actually shows a minor reduction in import loose transport movements when capacity is reduced to 8000, which can partly be explained by the fact that shipments larger than 8000 can be generated that will not be transported. Next to this the amount of shipments awaiting when transport comes back to its base for export could be higher than the capacity at hand, this why reduction in export movements is less as shipments size is on average also higher. The effect of additional capacity from 10000 to 120000 stronger for import than export transport, this can have to do with again the effect that export transport is checked more often, so there is more time for import shipments build up at the handler before transport arrives, with the increase in capacity fewer import transport is needed. The effect of capacity change is however minor as increase in capacity of 20% only results in 5% reduction of export transport movements and less than 2% for import.

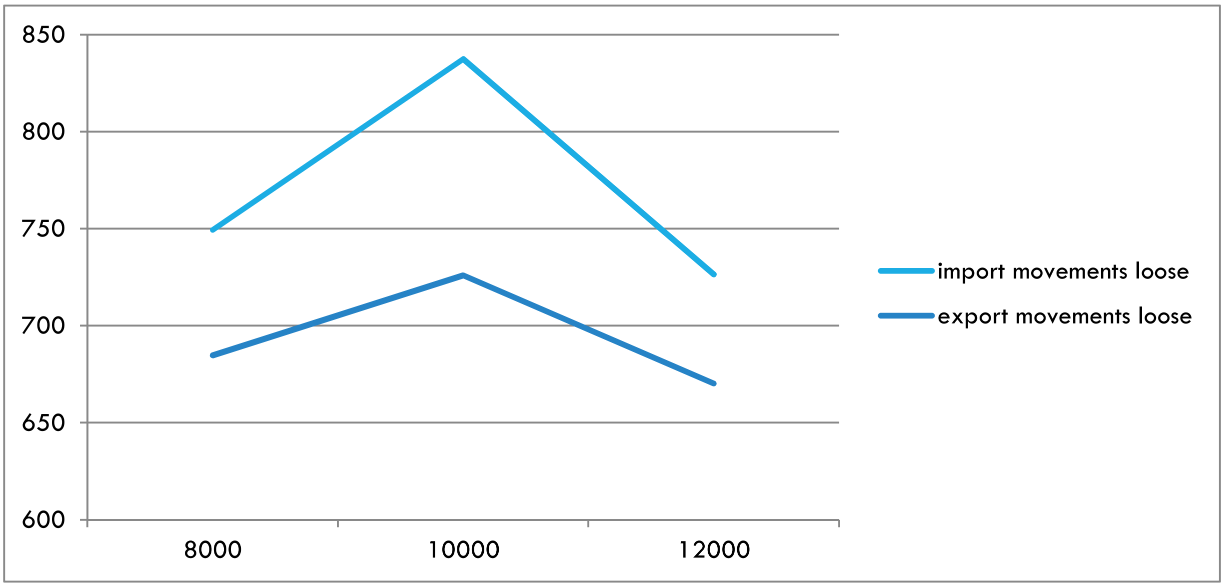

Figure 49: Relation between transport movements and trailer capacity of trucks for loose single transport systems.

<u>Sensitivity of combined transport system</u>

For the combined transport system five parameters are tested within the sensitivity analysis, as their potential impact and uncertainty justify further analysis. Parameters regarding ULD transport have been recorded in all simulation, but are however not studied more in depth as the process and combing of loads is more stable compared to loose cargo transport. Also the amount of ULD's that arrive late and the load factor of transport shows significant improvement over individual transport when combined for ULD without extensive negative effects. The tested parameters are:

- weight acceptance level for loose combined transport
- share between fixed and variable weight for involved forwarding companies on combined loose transport
- desired weight and waiting policy for combined loose transport
- (un)loading time for combined loose transport of shipments at air cargo handler
- the amount of companies that are involved in the collaboration

However before starting the analysis on these four parameters, first different levels are tested for to define the base scenario for collaboration. Several extreme scenarios were tested first. First 90% of all cargo flows was allocated to combined transport with combining both loose import and export transport. This however resulted in a very high number of both export and import shipments being late, especially later than 2 hours for export or more than 12 for ULD import and 18 hours for loose import. When loose combined transport was separated for import and export the performance of transport improved regarding the amount of shipments that were late and the extent of shipments missing their deadline time. However there were still more than 500 shipments late for import and 200 for export. This simulation showed that it is possible to transport 90% of the shipments with the fixed capacity that had been defined, however as many shipments arrive later than their deadline and it likely that in such a case less shipments will be allocated to combined transport. Therefore combined transport was reduced to lower level which could be more in line with the actual amount of shipments that will be allocated to the combined transport means and which also gives some more flexibility to test other parameters effect on combined transport. After analyzing the different flows and looking at the individual volumes of the involved companies the following allocation of combined transport has been defined in Table 15 below. These levels also still give a significant costs reduction potential compared to single transport systems for all involved companies, based on calculation of transport costs of the single transport base system, even if part of shipments cannot be allocated to combined transport due to weight restrictions.

flow	export		import	
type of shipment	ULD	Loose	ULD	Loose
c1	80%	70%	80%	70%
c2	80%	70%	80%	80%
c3	80%	70%	80%	80%

Table 15: Proposed base level of cargo shipment allocation to combined transport.

Max weight for combined loose and transport movements

In order to make combined transport work effectively and make sure that shipments of multiple companies can be loaded into one truck, the maximum weight of shipments for combined transport is restricted. Also when shipments are larger than a certain size they will often justify direct delivery to the end costumer or handler and are therefore also less suited for collaboration. In order to assess if changes to maximum weight of combined have large impact on the performance of combined transport the max weight of shipments is changed. Reducing the maximum weight size shows to have a positive effect on the amount of shipments that arrive on time for import, but not for export. When shipments of up to 3000 kilo are accepted, there is increase in amount of cargo offered for the collaboration concept, it makes more challenging for all shipments to be transport by the fixed transport capacity and that is why throughput time and the amount of shipments that arrive late increase for both import and export flows.

Combined transport loose	max weight shipments loose com	-20% 2000	0% 2500	20% 3000
Total transport movements combined	import movements	350,9	346,1	348,7
	export movements	305,4	308,5	307,7
Total amount of cargo processed by combined	import cargo	1056475,3	1068987,1	1063378,7
	export cargo	977022,3	1014436,3	1039012,7
Average load factor of transport	LF	3098,42694	3182,74274	3202,91194
Amount of shipments late	import shipments late loose	417,8	431	442,7
	export shipments late loose	157	152,6	155,3
Amount of shipments later than defined time	import shipments late loose	21,7	24,4	25,8
	export shipments late loose	90,6	88,5	91
throughput time loose transport [hours]	throughput time import	9,72	9,03	9,76
	throughput time export	3,34	3,36	3,37

Table 16: Sensitivity of max shipment weight restriction process at warehouses for combined loose transport on selected KPI's for combined transport.

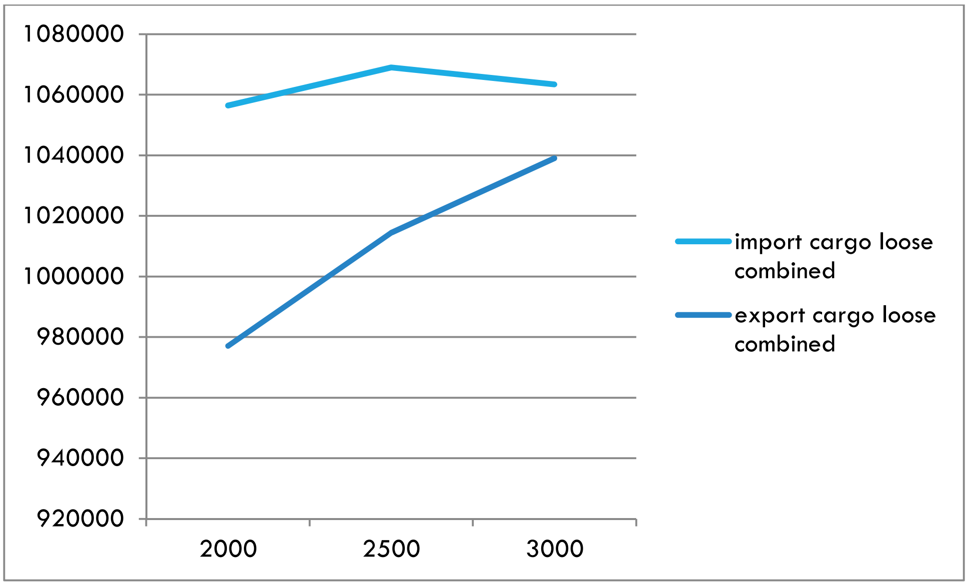

Figure 50: Relation between weight restrictions for combined loose transport and amount cargo that is transported.

Figure 50 above shows the relation between weight limit and the amount of cargo that is transported by combined loose transport system. Loose import shipments have an average weight that is lower, the amount of cargo that is transported is much more affected by increase in the limit for export cargo than for import cargo. A further increase to 3000 kilo's makes the combined loose import system not been able to carry more cargo were as this is still possible for export. The amount of transport generated for the cargo transported does not really change, a big change in the throughput time of shipments was expected however that is not really the case, contrary to what would be expected does an increase in shipment limit actually have a positive effect on throughput of import shipments on average as can be seen in **Figure** 51 below, the throughput time for export shipments is not affected that much, but the impact in reduction is larger when shifting to smaller shipments from 2500 as when it is increased to 3000 as limit for export shipments.

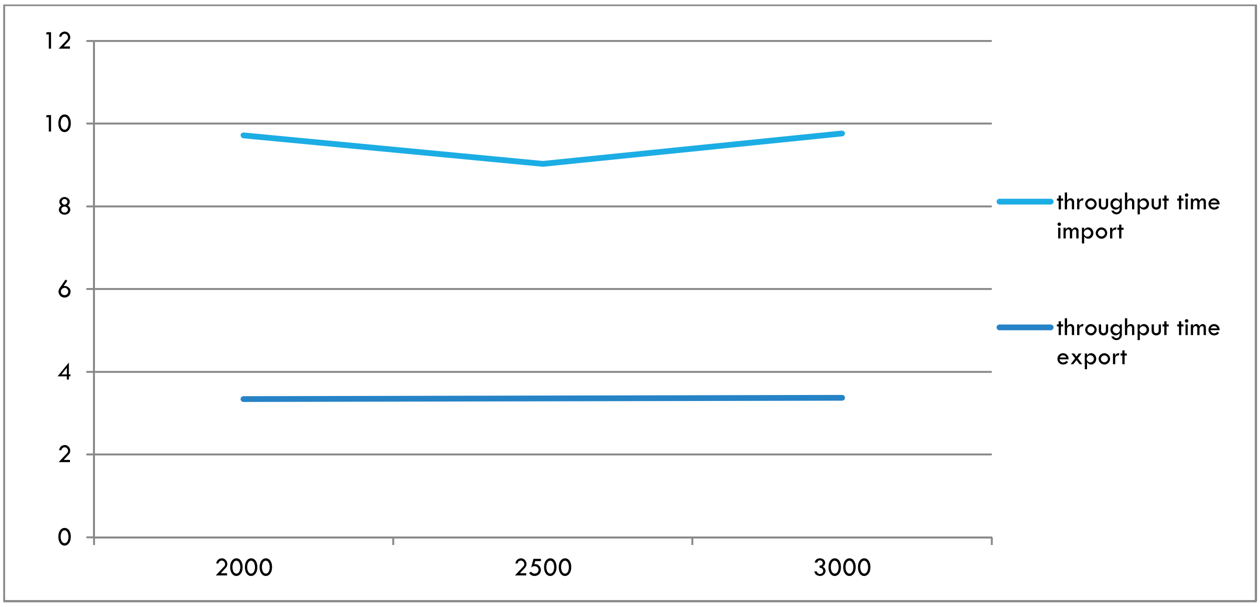

Figure 51: Amount of cargo processed by combined loose transport system with changing weight restrictions.

Fixed capacity use for combined loose transport

Companies that are collaborating on transport movements have actively stated that being offered a fixed ensured capacity on a transport is desired as it makes it possible for them to allocate shipments on a transport beforehand. This seems even more necessary for export transport, given the time sensitive nature, but also for combined import transport allocating shipments to transport automatically can be attractive option for forwarding companies, as it ensures them that shipments that are ready and fit within the fixed capacity will be transported with next transport. In order to see if applying a fixed part of capacity for each company improves or reduces the performance of combined transport two changes are made. First adding fixed capacity of 1250 for each company and finally adding 1250 extra capacity for company c1, given its size in relation to company c2 and c3 on loose cargo. It shows that adding fixed capacity can reduce the amount of shipments that are late for export and import, but slightly increases the amount of import shipments that arrive later 18 hours. Adding more than 1250 fixed capacity however increases the performance in relation to the amount shipments that arrive later and increases the amount of cargo that can be transported for export as, however this is not achieved for import movements. Although the average throughput time of combined loose transport import shipments is negatively influenced by adding fixed capacity for the involved forwarding companies and is only positively influenced for export until a variable capacity of 6250 kilo, as can be seen in Figure 53.

		-50%	-38%	0%
Combined transport loose	variable weight combined loose	**5000**	**6250**	**10000**
Total transport movements combined	import movements	357,3	357,3	346,1
	export movements	295,1	297,6	308,5
Total amount of cargo processed by combined	import cargo	1077277,7	1081459,8	1068987,1
	export cargo	1031616,8	1010974,9	1014436,3
Average load factor of transport	LF	3232,51763	3195,04459	3182,74274
Amount of shipments late	import	421,6	422,7	431
	export	149,9	147,6	152,6
Amount of shipments later than defined time	import shipments late loose	20,4	25,1	24,4
	export shipments late loose	82,2	84,7	88,5
throughput time loose transport	throughput time import	9,72	9,744	9,03
	throughput time export	3,28	3,2249	3,36

Table 17: Sensitivity of variable fixed weight restriction for combined loose transport selected KPI's for combined transport.

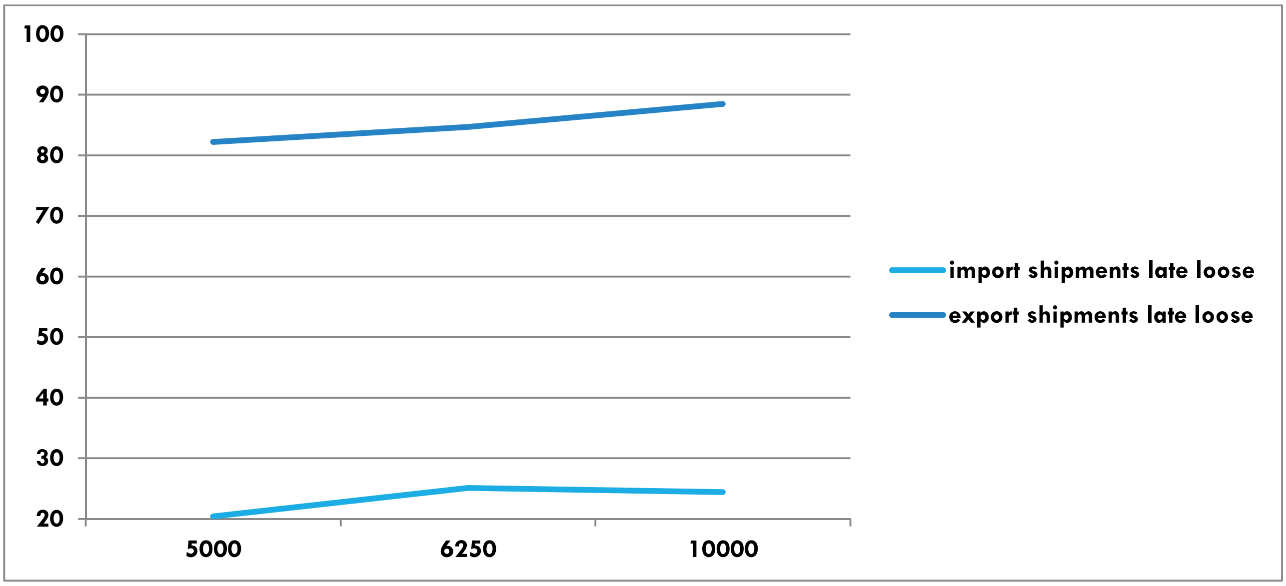

Figure 52: Relation between use of fixed capacity for involved forwarders on combined loose transport and the amount shipments that arrive late than specified deadline (18 hours import) more than (2 hours) after deadline export.

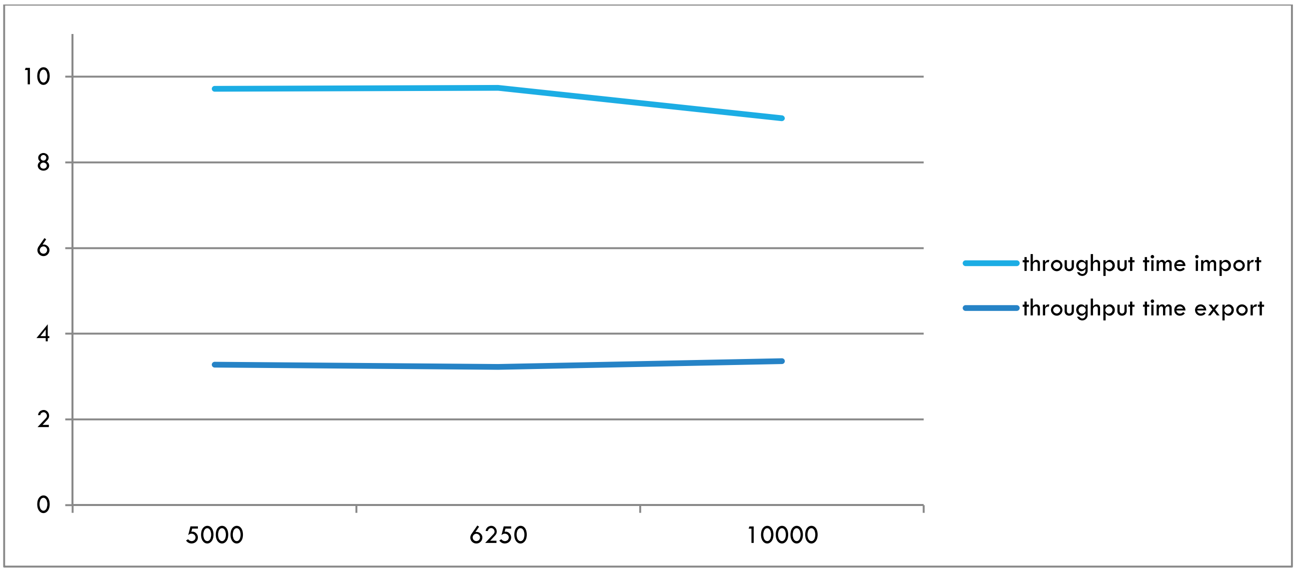

Figure 53: Relation between use of fixed capacity for involved forwarders on combined loose transport and average throughput time of involved shipments.

Process time un(loading of loose cargo shipments at handler combined

Process time of (un)loading combined loose shipments has an impact on the amount of transport that is used for combined loose transport, it can actually improve the amount of cargo that is handled and reduces the amount of transport for both import and export flows. It does however increase the amount of shipments that are late. The increases of process time even with doubling times compared to base scenario shows handling of loose shipments the performance of combined loose transport has only a minor impact. Nevertheless the average throughput time of import shipments increases with more than an hour and only slightly increases for export transport.

Combined transport loose	un(loading) combined loose	0% expo (4) + 5	50% **expo (6) + 7,5**	100% **expo (8) + 10**
Total transport movements combined loose	import movements	346,1	328,8	294
	export movements	308,5	292	273,6
Total amount of cargo processed by combined loose	import cargo	1068987,1	107445150%	1073832,4
	export cargo	1014436,3	1014583	1034884,2
Average load factor of transport	LF	3182,742744	3365,06846	3715,14553
Amount of shipments late	import	431	438,9	476,2
	export	152,6	168,4	183,9
Amount of shipments later than defined time	import shipments late loose	24,4	30,5	43,9
	export shipments late loose	88,5	94,3	101,5
throughput time loose transport	throughput time import	9,03	9,98	10,22
	throughput time export	3,36	3,5	3,65

Table 18: Sensitivity of (un)loading process for combined loose transport at handler for loose cargo on selected KPI's for combined transport.

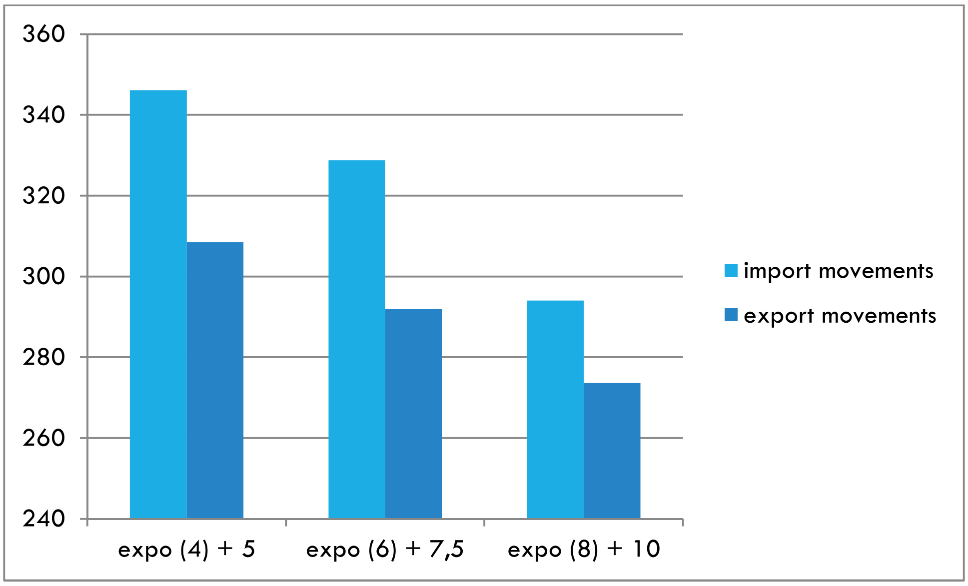

Figure 54: Relation between (un)loading times at handler for combined loose shipments and the amount of transport movements that are generated over time.

Minimum weight before start of combined transport or waiting time after demand

In order to improve the load factor of combined transport, several suggestions were made during the pilot about offering only a minimum amount of transport per day and only increasing the amount of transport if there would be sufficient demand. In order to assess the impact of such decision variables both the waiting time and desired weight for combined loose transport are changed in the model. The changing of weight preference and waiting times has a very high impact on the amount of transport that is generated. Only after large increase in waiting time and desired weight and waiting time for import transport are great negative effects occurring, for export however this already starts 2500 kilo or 30 minutes of waiting. This shows that defining minimum weights and waiting times for combined transport can significant reduce the amount transport needed, until u certain level with a limited effect.

Combined transport loose	weight | time hold	0 | 0	1250| 15	2500 | 30	3750 | 45	5000 | 55	6000| 110
Total transport movements combined loose	import trans movements	392,5	346,1	306,5	265,7	239,9	166,8
	export trans movements	333,8	308,5	279,4	248,2	223,2	177,4
Total amount of cargo processed by combined loose	import cargo	1073407,7	1068987,1	1061666,6	1056967,5	1091194,6	1078233,1
	export cargo	1031210,7	1014436,3	1030693,8	1028889,2	1030164,3	1010159,8
Average load factor of combined loose transport	LF	2897,73	3182,74	3571,19	4058,88	4580,78	6067,38
Amount of shipments late	import late shipments	443,3	431	419,2	419	433	532,9
	export late shipments	147,6	152,6	155,8	183,3	214,6	418,7
Amount of shipments later than defined time	import shipments late loose	26,2	24,4	26,4	23,7	22,2	57,8
	export shipments late loose	87,8	88,5	87,9	100,3	114,5	241,4
throughput time loose transport	throughput time import	9,83	9,03	9,81	9,86	9,9158	10,61
	throughput time export	3,187	3,36	3,49	3,85	4,401	5,83

Table 19: Sensitivity of desired weight and holding times combined loose transport for loose cargo on selected KPI's for combined transport.

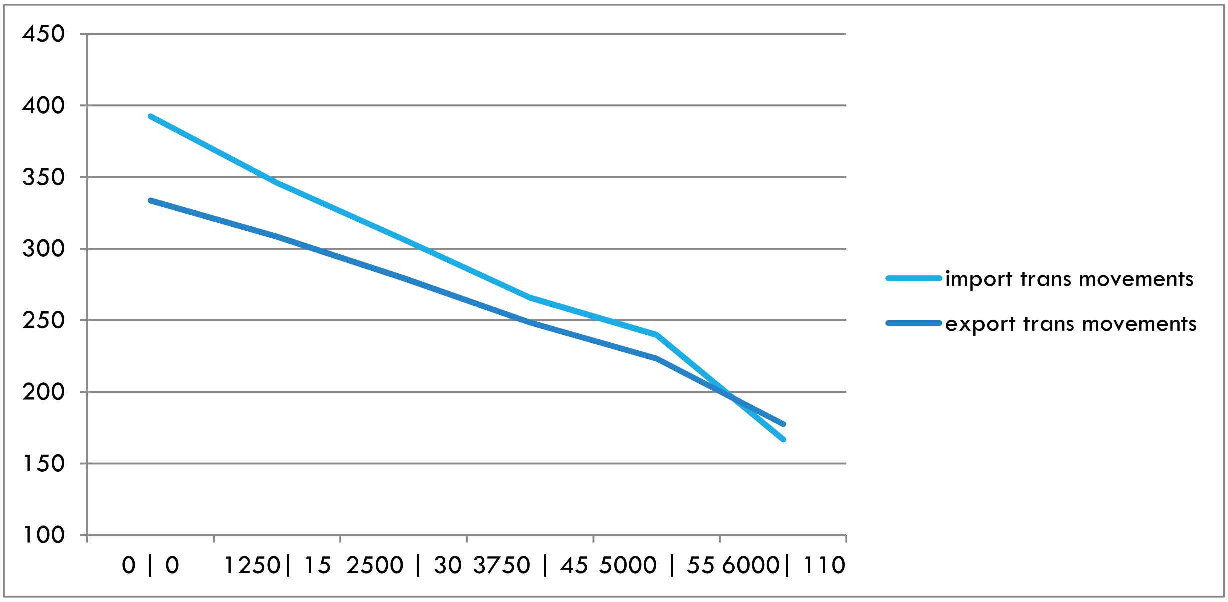

Figure 55: Relation between weight and transport hold times for combined loose transport generation and transport movements in system..

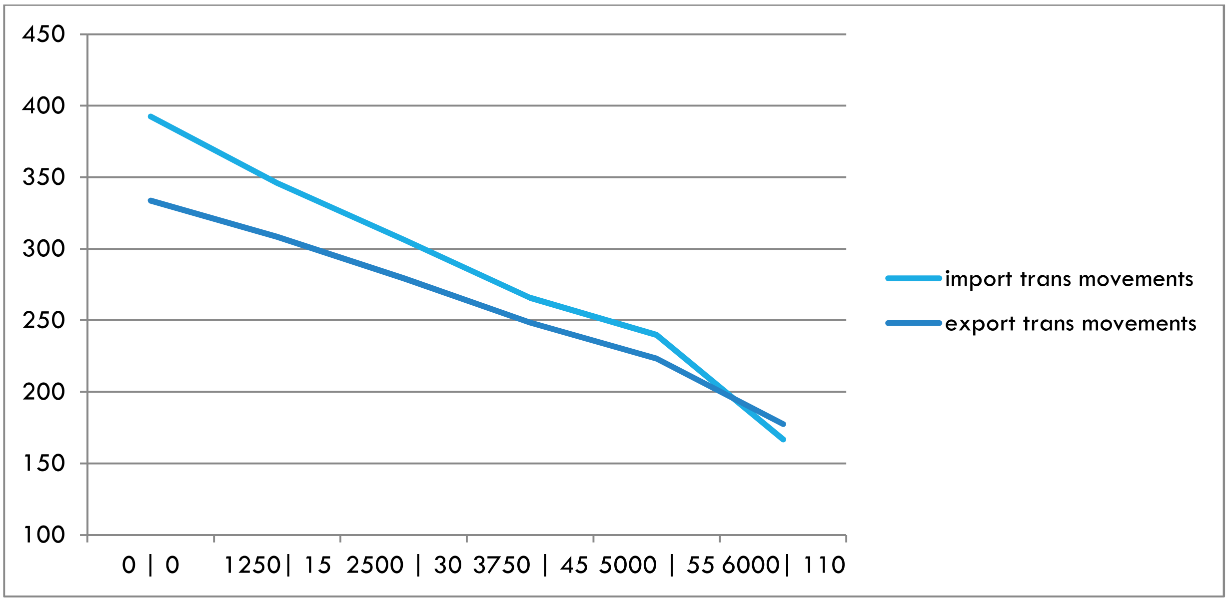

Figure 55 above clearly shows that in relation with Figure 56 reduction of transport movements only starts to negatively affecting the amount of late shipments on import and export after significant increase of waiting time and desired weight for combined loose transport. Only after 30 minutes wait or more than 3750 kilo desired does it start reducing the amount of transport so strongly that it starts increasing the negative effect on the amount of shipments late for import and export flow of combined transport.

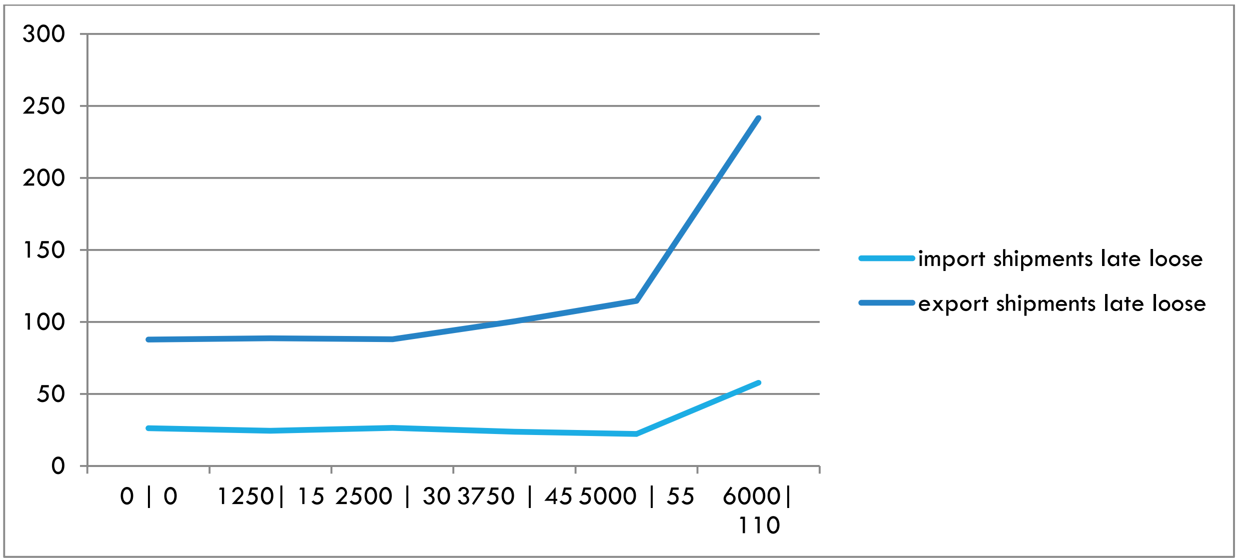

Figure 56: Relation between weight and transport hold times for combined loose transport shipments late on import and export flow

Amount of companies involved in the collaboration

In order to assess if the performance of combined transport is significantly influenced by the amount of companies involved in transport the companies with the highest flow for ULD/Loose are selected for collaboration leaving out the smallest company of combined transport. As a sufficient level of cargo is needed for collaboration in order to be costs effect the sensitivity is only tested for 90% shared flow of shipments on either ULD or loose transport system. As company c1 and c2 have the biggest loose flow and c1 and c3 have the biggest ULD flow on both import and export the following situation is assessed.

collaboration	c1	c2	c3
ULD	90%	90%	0
Loose	90%	0	90%

Table 20: Import and export flows allocation for combined transport with two specific companies.

Combined transport loose	only two collaborating parties	[90%] 2 **c1 | c2**	[80/70] 3 **c1 | c2 | c3**
Total transport movements combined loose	import movements	431,4	332,4
	export movements	319,7	290,7
Total amount of cargo processed by combined loose	import cargo	1097845,4	1053779,7
	export cargo	1097845,4	1012523,8
Average load factor of transport	LF	2923,300226	3316,166747
Amount of shipments late	import	460,2	420
	export	137,2	162,3
Amount of shipments later than defined time	import shipments late loose	14,3	12,4
	export shipments late loose	75,4	4,4
throughput time loose transport	throughput time import	9,46	8,49
	throughput time export	2,86	1,84

Table 21: Sensitivity of selective collaboration with only two forwarding companies combined loose transport for loose cargo on selected KPI's for loose combined transport

Table 21 above shows some suppressing results as the amount of shipments that arrive late for import and export and throughput average time of combined loose transport shipments increases when only two forwarding companies are collaborating, this could have to do with the fact that transport is generated more often which results in transport arriving for collecting of shipments when fewer shipments are waiting and the effect of longer transport runs when collaborating with three forwarders actually seems to have a positive effect on the utilization of combined transport both on import and export flows in relation to transport movements, throughput time and shipments that arrive late. Next to this collaboration with two companies needs a higher level of committed cargo to the concept in order to become financially attractive, it questionable if high level of commitment can actually be achieved and supported by the involved companies in relation to the performance of single transport system. It therefore can be argued that collaboration with two instead of three forwarding companies requires either more demand stability or higher amount of cargo for specific flows in order to justify the collaboration, next to that different starting conditions should be set for the combined transport in order to ensure that the right balance between amount of transport and performance is realized for only two collaborating companies.

10.2 POSSIBLE COLLABORATION SCENARIO'S

Based on the results of the sensitivity analysis above three combination scenario are discussed in more detail by combining positive changes to key parameters. The transport costs for combined transport for ULD and loose for each flow will be calculated for the scenarios below, as will be shipment throughput time average, the amount of shipments that arrive later and also later than set deadline and finally the amount of transport that is generated. These scenarios will give an insight in difference that can occur if a; low, medium or high level of collaboration is supported.

Low level collaboration [60% for all flows]

With low level of collaboration it can be necessary for loose cargo to accept larger shipments, in order to ensure costs effectiveness of combined loose transport. Fixed capacity of 1250 kilo had a positive impact on shipments that arrive on time for both import and export this will also be set for this scenario. Besides this to increase the load factor due to low level of cargo collaboration, waiting until 45 minutes or 3750 is also applied for import and 2500 and 30 minutes for export. This will result in some undesired effects with more cargo collaboration, but given the fixed capacity and lower amount of cargo it will be tested in this scenario.

Medium level collaboration [80% ULD (imp/exp), 70% loose [imp/exp] all companies

Fixed capacity is added for both import and export until 1250 as this had a positive result in previous scenario analysis, waiting for cargo is set 2500 and 30 minutes for import and export flows and shipments as in the previous is not increased further for import. The 2500 max weight for combined shipments is kept at 2500 as was defined in the previous scenario.

High level collaboration on small shipments [90% ULD (imp/exp), 0% loose [imp/exp] all companies]

Other than in the previous scenario, only fixed capacity is added for export loose cargo, shipments are only accepted for collaboration under 2000 kilo. Also holding and waiting for transport demand is increased from 1250 to 2500 and from 15 minutes to 30 minutes before transport only for import and not for export loose cargo, as more export cargo demand more frequent transport.

<u>Transport costs allocation</u>

Previously it was stated that several different forms of transport cost allocation would be assessed, regarding the allocation of both variable and fixed capacity and the actual use of freight forwarders in the transport in relation to the total transport costs. However the dynamics of the air cargo transport and limited conditions under which lower transport can be realized for all involved forwarding companies make the value of such an analysis not justified. As changes to costs based on fixed or variable use of transport could have high impact on how forwarding companies would utilize the concept. Variable prices for transport will make the decision logic for using combined transport complex, without adding any value to the use of the combined or single company transport system itself. The argumentation does not only come from personal experience and practices applied in the air cargo industry, large horizontal coloration projects that are currently operational within Europe have not seen the actual use of costs distributions according to certain mechanisms such as for example the often used Shapley value(ELUPEG, 2013). Even when these large current projects are related to much more stable flows and frequencies between different warehouses, they often do not add value to the support or justification for using combined transport.

It is however up the forwarding companies to use a more sophisticated allocation method to allocate transport costs to the involved companies. The research of (Naber, 2012) compares five different types of allocation methods to allocate $C0^2$ of transport that is used by several companies. Based on its findings it seems that Shapley method is most suited type of cost allocated method, as it ranked the fairest of all methods, has been used in other horizontal transport project(co3-project, 2012) and is relativity easy to understand and calculate. However for cost calculation in following parts of this research, the transport costs will be calculated by dividing the total transport costs by the amount of cargo that is transported by the analyzed transport flow.

10.3 RESULTS OF DIFFERENT LEVELS OF COLLABORATION SCENARIO'S FOR LOOSE CARGO TRANSPORT

Table 22 below shows the differences of the combined transport outcome for loose cargo collaboration, between the defined types of collaboration. Which collaboration type will be supported depends on the preferences of the companies that are involved, based on acceptable levels of throughput times and shipments that arrive late. Transport costs will ofcourse be of less importance for export shipments when other parameters are impacted in a negative way, as where for import a longer throughput time with significant reduction in transport costs can be acceptable. It is therefore likely that a higher level of collaboration will be supported for import loose transport than for export transport. All collaboration scenarios' show an improvement in costs for the involved companies and increase in throughput time, for all involved companies the throughput time of export shipments increases between 1 to 1, 5 hours, as can be derived when comparing Table 22 with Table 23 which shows an overview of average throughput times of single loose transport shipments. It is difficult to assess what impact collaboration will have on the total amount of transport visits to the involved warehouse, as the change to single transport cannot be calculated. It can however be expected that smaller companies will be able to gain more frequent delivery and reduction in costs, whereas the largest company c1 is likely to see reduction in the frequency of deliveries and should seek the benefits of collaboration on costs aspect and the easy of combined transport. In Appendix H the potential of transport movements by supporting combined transport is calculated based on a defined formula, which results are shown in table below. When looking at the transport costs and comparing them to the assumed transport costs of the involved forwarders, all forwarders can gain reduction in transport costs for import of minimum 22%, however for export there is one forwarder which could see an increase in transport costs 19% compared to its calculated own average loose transport costs. This is however only the case if low level of combined export transport is achieved, when the base scenario is applied for collaboration on loose export the minimum benefit for most cost effective company on loose export transport is 13% reduction in transport costs.

Combined transport loose	collaboration extent	low	medium	high	base
	import movements loose	270,7	313	321	346,1
Total transport movements combined	export movements loose	257	266,5	300,1	308,5
	import cargo loose	871752,6	1025973,3	1329016,9	1068987,1
Total amount of cargo processed by combined	export cargo loose	881576,1	1008500	1241788,2	1014436,3
Average load factor of transport	LF loose collaboration	3322,586128	3510,739085	4139,11625	3182,7427
	import	335,1	402,1	555,3	431
Amount of shipments late	export	135,3	165,2	196,6	152,6
	import shipments late loose	15,5	20,7	35,3	24,4
Amount of shipments later than defined time	export shipments late loose	84,5	91,4	112,2	88,5
	throughput time import	9,71	9,8	9,91	9,03
throughput time loose transport	throughput time export	3,6	3,55	3,43	3,36
	transport costs per kilo import loose	€ 0,02787	€ 0,02368	€ 0,01828	€ 0,02273
Transport costs	transport costs per kilo export loose	€ 0,02756	€ 0,02410	€ 0,01957	€ 0,02395
	import movemments	181,231946	218,882681	367,985836	208,08179
	export movements	132,6492794	179,248584	248,760022	139,87238
Amount of potential reduction of movements	% of total movements loose	-20%	-25%	-39%	-22%

Table 22: Overview of differences on key KPI's for selected combined transport scenarios for loose shipments.

Throughput times average of single transport [hours]	c1	c2	c3
loose import transport	7,6	9,11	9,53
loose export transport	1,47	2,2	2,1
ULD import transport	3,58	3,51	4,28
ULD export transport	0,91	0,69	1,21

Table 23: Average throughput times of single transport system with no collaboration.

10.4 RESULTS OF DIFFERENT LEVELS OF COLLABORATION SCENARIOS FOR UDL CARGO TRANSPORT

Table 24 below shows that it is much harder to achieve effective collaboration for ULD transport in comparison to loose cargo transport. This can be explained by relatively short process times at both the handling and forwarder facility for ULD transport and the limited amount of ULD's that can be combined. In certain scenario's using combined ULD transport will actually result in more transport generation than when companies would individually collect their ULD's, also the throughput time of ULD's for both import and export collaboration on this type of transport increases, with higher increase for export collaboration than import. The reason why this type of collaboration for ULD transport should be applied should mainly be derived from costs savings, as the negative impact on throughput times of transport is extensive both for import and export. Also only a minor reduction in transport movements can be realized, which have been calculated based on formula that can be find in Appendix H. It can therefore be questioned if sufficient collaboration on ULD on regular basis can be achieved by only collaborating with the three analyzed companies with the use of two ULD trucks for both import and export ULD transport.

Combined transport ULD	collaboration extent	low	medium	high
Total transport movements combined	import movements ULD	315,7	357,9	365,1
	export movements ULD	405,8	489,5	514,9
Total amount of cargo processed by combined	import cargo ULD	1061039	1425046,8	1173912,9
	export cargo ULD	1165930	1582302,9	1739519,7
Average load factor of transport	LF ULD collaboarion	3086,582121	3548,913972	3310,71886
Amount of shipments late	import ULD combined	5,1	9,3	14
	export ULD combined	16,8	25,2	26,2
Amount of shipments later than defined time	import shipments late uld	3,7	10,2	16,9
	export shipments late uld	7,7	12,8	17,2
throughput time loose transport	throughput time import ULD [hours]	4,43	4,63	na
	throughput time export ULD [hours]	1,65	1,79	na
Transport costs	transport costs per kilo import uld	€ 0,0229	€ 0,0171	€ 0,0207
	transport costs per kilo export uld	€ 0,0208	€ 0,0154	€ 0,0140
Amount of potential reduction of movements	import movemments	9,844419494	79,32806914	-4,92398991
	export movements	-42,79874483	3,135011335	26,682972
	% of total movements loose	3%	-7%	-2%

Table 24: Overview of differences on key KPI's for selected combined transport scenarios for ULD shipments.

10.5 IMPORTANT ASPECTS OF USING COMBINED TRANSPORT

Several insights were gained from simulation different collaboration settings on systems performance, which should be discussed in more detail in order to understand the positive and negative impact of supporting collaborative transport and its relation with single transport. After discussing the different collaboration issues below the simulation questions of chapter 8 will be answered.

Transport distances traveled within inner airport transport system

One key reason why companies have stated that they want to collaborate within Schiphol airport, relates to the inefficient use of their trucks and the negative external effects this causes. When for example a truck has to wait for a long time or extra transport has to be generated to collect a limited amount of shipments, when planning could not be optimized. Collaborative transport can theory reduce the negative effects of transport, by reducing the amount of transport movements to and from a specified air cargo handler, however as the distances between the involved companies are similar length to the distance of the individual warehouses to air cargo handler, the positive effects for environment may actually be expected to be either low or even negative. Only when conditions are defined that reduce the amount of transport extensively for combined transport and do not increase the use of single transport, could it be that the negative environmental impact would be reduced. Given the expected restrictions on collaboration transport by the involved companies it will however be difficult to achieve costs reduction and suitability improvements for the complete system.

Rationalizing the use of combined transport

In the current model shipments are allocated to combined transport based on change and not on actual operational conditions or time restrictions of the shipments, this is done in order to compensate for the fact that logic regarding the allocation of shipments for combined transport can be complex and defer from company to company. This means that when combined transport use is rationalized, the throughput times of shipments can be decreased and the amount of late arriving shipments should be further reduced.

Changes to single loose shipment (un)loading processes at handler

In the current simulated situation the average throughout times of single loose transport are lower than combined transport, however when analyzing longer loading times for single transport 100% increase combined transport average throughput times can be even lower for import and similar to single transport export loose shipments. This can reveal additional benefits of combined transport when single transport is less reliable than defined in the simulation model.

Lack of single transport adaptation after horizontal collaboration is supported.

When no change is made to the way single transport is used to collect shipments that are not collected or delivered by combined transport, additional transport movements are expected to be generated as fewer cargo shipments will be available at any given time for single transport. This means that true reduction of transport movements within the whole system depends on the way single transport is or can be utilized. More about the importance between single and combined transport will be given in the next chapter.

Fixed and variable capacity allocation and extra truck hiring

In the current model the combined transport is operating for 18 hours but only departs between 16 hours, this means that there is some potential for using combined transport that is not used within the model. It has been stated by expert involved in the pilot that combined transport should be able to perform one transport roundtrip in an hour, so there is actually extra capacity paid for in the model that is not been used. When looking at amount of shipments that arrive late, with average weight for loose cargo ranging between 300 and 400 kilo, the extra capacity needed to delivery these shipments within defined deadline without extra costs can be effectively realized. The used of fixed and variable capacity within the model showed to certain extent some impact on key KPI's however the use of this capacity very much depends on the stability of cargo flow shipments for certain period to and from an air cargo handler with the analyzed forwarders. When the demand of involved companies changes on daily basis, the use of fixed capacity can result in higher negative effects than which were observed in the model

Weight distribution of shipments

The weight distribution of loose and ULD shipments of the involved forwarders has not been analyzed in depth, due to lack of data, this does however have crucial impact on the performance of combined transport and to which extent fixed or variable capacity should be applied. It also directly relates to the way weight limitations of combined loose transport should be set, as setting these limits can have a high impact on the amount of cargo that is handled within the combined transport system and also increasing the limit could result in high increase in shipment throughput with fixed use of transport capacity.

10.6 INTERIM CONCLUSIONS BASED ON TRANSPORT SIMULATION MODEL

In order to support conclusions on the base of analyzed simulation model the simulation question defined in chapter 8 will now be answered and further augmented for.

Under which conditions organizing horizontal transport can be an effective and efficient alternative to own organized transport for freight forwarder inner airport transport needs?

In order for horizontal collaboration to be an effective and efficient alternative for single transport collaboration sufficient volume of cargo has to be allocated to the concept and the involved companies have to support certain restrictions and conditions that defer from single transport. Based on the cost aspects a minimum amount of 50% of cargo volume should be allocated to combined transport for each of the analyzed flows of the given forwarding companies. Combined transport cannot operate under same operating times as single transport for all companies, this means that companies will have to accept that certain shipments can arrive later 18 hours after the shipment arrived on an aircraft for loose cargo and 12 hours for ULD or will have to be collected with individual organized transport. Companies should understand and accept that the average throughput of combined transport shipments will be higher than individual transport, which will give them benefits in cost reduction of potentially between (20% to 75% compared to current transport costs) and it will gives them the ability to better use their own transport means for more urgent transport needs. Besides the reduction in costs a reduction of transport movements has seen on basis of selective collaboration scenario's has shown that a reduction of transport is possible for loose shipments 40% and for ULD transport up 8%. This does however result in an even large amount of shipments arriving later than the specified deadline, so it requires more flexibility of the forwarder in preparing shipment for transport or on receiving shipments for onward transport (import). When the involved companies can accept throughput times that are between 1 to 4 hours longer on average than individual transport, up 90% of shipments both on ULD and loose cargo can be transport for significant reduction in costs and amount of transport movements needed. It is crucial that the process time at the handler for combined loose shipments (un)loading is significantly lower than single transport, in order to compensate for the longer average transport time and the involvement of different deliveries.

The smaller collaborating companies will have a potential increases in deliveries, whereas a slight reduction is expected for the biggest involved company. Limitations on shipment weight for combined loose transport and demands for fixed capacity per transport movement can in some cases result in negative performance of the combined transport. The specifics will be discussed in more detail for the two types of transport below. Tradeoffs have to be made between costs, frequency of delivery, and security of capacity, desired throughput times and acceptable deadlines for deliveries. The smaller involved companies can in some cases depending on amount of cargo allocated to the combined transport not only receive costs and frequency increases but also a lower average throughput time. This has to do with the fact that the smaller companies in this simulation have only one transport truck at hand for both import and export flows, where the largest forwarders constantly has two trucks at hand. In this simulation model a fixed sequence for delivery and collection was used, this fixed use can be beneficial for both operational reason and contributions to the collaboration. When such a sequence of delivery and collection is linked to the desires of the largest collaboration contributor on a specific transport flow. It can give the largest contributor to combined transport more time to prepare shipments for export and receive the combined import shipments with a lower average throughput time than average, which can be closer to its own single transport throughput time. Looking at indirect costs and potential to reduce transport resources or use them more effectively, it can be reasonable to expect that a larger forwarder can still be able to better consolidate shipments with its remaining transport or is able to reduce the amount of fixed transport trucks that are needed by allocating a certain amount of cargo to combine transport.

<u>ULD transport:</u>

Combing ULD transport and achieving higher benefits that use of individual transport has been found to be limited in the simulation model, as the limited process times of handling ULD shipments and the limited amount of ULD capacity per truck often make it difficult for the involved companies to achieve a situation where costs benefits are in line with other operational benefits. The throughput time of combined ULD transport is almost double compared to single transport time on average for all involved companies on export, while the increase in throughput time for import only slightly increases. ULD's are often completed close before flight departure (export) and are requested as soon as possible within the warehouse for import, in order to facilitate check procedures and breakdown of cargo consignments, so the increase of throughput time is undesired. Besides this the model showed that it difficult to reduce the amount of transport that is generated for collection of ULD's when the transport is combined, especially for the export flow which results in additional congestion potential at the air cargo handler. It therefore seems much more likely to support ULD transport on an ad hoc basis, which means that when sufficient ULD are within the system combined transport can be offered, however organizing this may be much more difficult compared to the use of dedicated fixed capacity. In the current system at most air cargo handlers' coordination with forwarders on the use of ULD dock for delivery and collection could therefore often be sufficient to maintain certain level of stability and resource planning. However when the amount of ULD's will increase not only for larger forwarders, but also for smaller forwarders it may be better to and more effective to organize both single and combined transport from one handler to a limited amount of forwarders.

Loose transport:

Combined transport of loose cargo can both on import and export results in lower costs and reduction of the amount of transport to the analyzed forwarder. For import setting less strict restrictions on the average throughput time of shipments can improve the costs of transport and reduce the amount of transport that arrives at the handler. Use of fixed capacity for involved companies can improve the throughput average time of loose shipments for export, but at some point has a negative impact on import throughput times. Limiting the weight accepted for loose combined transport can improve speed of combined transport, but can also make it more difficult to realize sufficient volume of cargo weight to make the combined transport more cost effective than single transport. If the value of combined loose transport can be higher indirectly by transport only small shipments than the forwarders will have to in some cases accept a higher prices than their average own transport costs price. As with own transport much larger shipment are often transported which reduce the cost per kilo significantly. A trade of therefore in some cases has to be made on higher per kilo costs, for a large amount of small shipments or longer throughput time with the inclusion of some larger sized shipments, that will reduce the average transport costs per kilo of combined transport. In some cases supporting combined loose transport can reduce the amount of transport visits to a specific forwarder, this can make the amount of cargo arriving for each transport higher, but may have undesired effects on how much time there is between arrival or collection and planed onward transport. It can therefore not be stated to which extent a reduction of movements can be accepted by the involved forwarders. In the next chapter more about the restrictions, costs and performance of both combined and single transport will be discussed.

11 AIR CARGO HANDLING SYSTEM AT SCHIPHOL RELATION BETWEEN PILOT AND SYSTEM POTENTIAL

The previously chapters on transport collaboration and basis of pilot on transport collaboration can combined with the system analysis of air cargo system at Schiphol give an good oversight of potential of transport collaboration at Schiphol airport. However in order to quantify the system potential of transport collaboration this chapter will use findings of the simulation model and relate them to general share of loose shipment cargo transport at Schiphol, the analysis will try to point out which air cargo handlers are most likely to be able to support transport collaboration on loose cargo, based on amount of shipments and cargo volume. Due to limited data on ULD transport and ULD shipments, this analysis is only aimed at 'small' loose cargo shipments. The analysis in the chapter is not only intended for the current situation for transport collaboration is assessed but also possible future growth scenarios are assed in relation to collaboration on transport.

11.1 LOOSE CARGO SHIPMENTS AT SCHIPHOL

In previous chapters statements have been made that average shipment sizes within the air cargo market are declining, but no statements were made about the share of these small size shipments in relation to the total volume of air cargo at Schiphol. Most large forwarders at Schiphol have stated that collaboration on loose cargo shipment is most suitable it is therefore important to be able to quantify in some way how much of these so called 'loose' shipments are actually processed at Schiphol and to which extent these shipments can be allocated to forwarders that are active around Schiphol. Information that has been derived from several different sources, actual data regarding amount of shipments and weight is used to define the estimated amount of loose shipments and their related weight which ranges that are most suitable for transport collaboration of loose cargo. This is also why the share of freight forwarders around Schiphol for loose cargo shipments is assessed, given the relative short distance of their warehouses to all air cargo handlers and their competitors these companies are deemed to be most suited for transport collaboration on loose cargo. Also legal and custom related restrictions make it more interesting to focus on transport collaboration within the DGVS area, as has been explained in previous chapters.

11.1.1 LOOSE CARGO SHIPMENTS AT SCHIPHOL DATA SOURCE #1

In order to assess the share of loose cargo shipments, all AWB's that have a chargeable weight of less than 1000 kilo are considered loose cargo shipments. This has also been done as the data source that had been provided specified shipments in three groups, the second group being shipments with a weight between 1000 and 5000 kilo, many of shipments within this range could actually already be ULD's, therefore the limit is set at 1000 kilo in order to ensure that is more likely that all shipments within the first weight range can be assumed to be loose cargo shipments.

weight range		ton	AWB's	ton / AWB	% CW	% AWB
import	0 - 1000 kilo	**141000**	**378365**	**0,37**	**19%**	**81%**
	1000 or more	609750	91654	6,65	81%	20%
export	0 - 1000 kilo	**99000**	**329000**	**0,30**	**13%**	**66%**
	1000 or more	651000	171000	3,81	87%	34%

Table 25 Weight breakdown of AWB's at Schiphol for import and export based on total AWB's and % of weight and AWB's for import and export shipments at Schiphol.

Table 25 above shows that shipments up to 1000 kilo are related to a very significant share of the total amount of shipments that are processed at Schiphol airport. It also shows that import shipments on average within the first weight range, weigh more than export shipments and that there are significant larger shipments for export on average than for import. However the average chargeable weight of larger shipments is much higher for import than for export shipments. This might have to with the fact that many perishables such as flowers are imported and flown to the Schiphol, such shipments have very big volumes but low weight, thus their chargeable weight would be much higher than an average general cargo shipment, high volume cargo can easily restrict the amount of other cargo that can be transported within an aircraft. The average weight ratio to AWB of shipments that has been calculated for all shipments at Schiphol, for loose shipments, is similar to the average weights that have been used in the simulation model. The low average weight for shipments until 1000 kilo and the amount of shipments can clearly support why it is difficult for freight forwarders to realize a high load factor while using trailers that can take up to 20000 kilo or 80 m³, given the extensive amount of shipments that are needed to fill a truck, as to completely fill a truck you will need between 30 and 50 loose cargo shipments. Based on information provided by forwarders at Schiphol, currently forwarders on average are only transporting about 5 to 20 shipments in one truck trailer.

11.1.2 LOOSE CARGO SHIPMENTS AT SCHIPHOL DATA SOURCE #2

The second data source that has been obtained just before the end of this research is much more extensive than the previous data source, as it contains a total of more than 360000 AWB's with destination Netherlands and 575040 AWB's that are exported from the Netherlands. The first interesting finding that come from the second data set is that there is extensive amount of AWB's that weight less than 50 kilo and also very few large shipments are present for both for import and export, as can be seen in

Import NL			Import NL range 50 to 10000			
weight range	nr # AWB's	% of total	weight range till	1000	2000	3000
0 - 50	55369	15%	AWB's in range	187411	241580	267489
50 - 10000	304824	84%	percentage %	61%	78%	87%
10000 or more	3314	1%				
total	363507	100%				

Table 26: Import NL AWB"s weight amount of AWB's in different weight ranges.

Error! Reference source not found. below show the share of different weight ranges of shipments for both import and export shipments in 2012 based on dataset 2 that was obtained. These same tables show that there is clear difference in total amount of AWB's that weigh less than 1000 or 2000 kilo for import and export, only at the limit range until 3000 kilo is the amount of AWB's within the weight range more or less the same for both import and export shipments. Unlike the pervious data set, this data set does not specify CW related to actual weight of shipments. Also the second data set is based on all AWB's to and from the Netherlands and not related to Schiphol only, which was the case for data set one. It is however difficult to define which part of the shipments that arrive or depart from the Netherlands cannot be defined as Schiphol based or are actually are linked to another airport, this is why for this dataset all shipments are used regardless if they are defined as Schiphol destination or origin location. For both import and export more than 93% of the weight and AWB's have their origin or destination defined as Schiphol airport, most of the AWB's that will not start or end with Schiphol on the AWB will also be transported via AMS, as other airports expect for Maastricht airport lack a sufficient number of direct cargo related flights or capacity on key cargo routes.

Export NL			Export NL range 50 to 10000 kilo			
weight range	nr # AWB's	% of total	Weight range till	1000	2000	3000
0 - 50	166050	29%	AWB's in range	307221	354679	374468
50 - 10000	403137	70%	percentage %	75%	87%	92%
10000 or more	5853	1%				
total	575040	100%				

Table 27: Export NL AWB"s weight amount of AWB's in different weight ranges.

In order to compare the data first data set with the second data set, the average weight range of shipments between 50 and 1000, 1000 and 2000 and 2000 and 3000 are shown in Table 28 below. The average weight of AWB's within the range of 50 to 1000 are only slightly different from the calculated average of Table 25 for both import and export, there is less than a 5% difference. This difference could be explained by the fact that shipments smaller than 50 are excluded from the second data set for this analysis or that the period of data that was collected was different. The table below also shows that for both the shipments ranges between 1000 – 2000 and 2000 to 3000 the average shipment weight is close to the middle value of these ranges both for import and export, therefore the main difference lies in the average weight of shipments until 1000 kilo and the amount of shipments that fall within this range in relation to the total amount of shipments that are processed at Schiphol during a year.

Export shipment ranges 50 – 3000			
Total weight	94482470	67220885	48528786
AWB's	307221	47458	19789
Average weight	307,54	1416,43	2452,31
range	50 - 1000	1000 - 2000	2000 - 3000
Import shipment ranges 50 – 3000			
Total weight	73256415	77450464	64891867
AWB's	308138	54169	25909
Average weight	390,89	1429,79	2504,61
range	50 - 1000	1000 - 2000	2000 - 3000

Table 28: AWB specifics for defined weight ranges import / export based on average weight within ranges up to 3000 kilo.

For import transport the importance of accepting large shipments, compared to export, can be clearly supported by the data that has been analyzed in tables above. The data above shows that in general accepting large shipments for collaboration above 1000 or more kilo, as also has been analyzed for three specific forwarders based on the simulation model for accepting shipments larger than 2500 or 3000 kilo, will have a bigger positive impact for the amount of shipments and cargo that can be allocated to combined transport for import than for export. This can be supported by fact that the amount of shipments in relation to the total amount of shipments for import that are smaller than 1000 kilo is significantly smaller for import than for export, increasing the allowed shipment size for combined transport will therefore likely have more impact for import flow of shipments than for export flow, as there are many more larger shipments for import than export in general.

11.2 LOOSE CARGO ORRIGIN / DESTINATION ASSESSMENT

During the pilot several forwarders and other parties suggested that one way to realize effective collaborative transport for export would be to base the transport collaboration on either destination or airline. In order to assess this potential DATASET #2 can also be used, as is also shows the origin and destination of AWB's. For import transport collaboration their less need to limited collaboration on basis of origin, however as data is available the most suitable destinations based weight and amount of shipments this will be also included in the analysis of this paragraph.

11.2.1 KEY IMPORT DESTINATIONS TO NL BASED ON AWB'S (IMPORT)

The by far biggest import destination for Schiphol airport is Mariscal Sucre Airport (UIO) of Ecuador, both regarding the amount of shipments and total weight that is imported, in order to better compare the other airports, shipments from UIO will however be excluded. As most shipments coming from UIO will be perishables and these types of shipments are less suitable for horizontal collaboration, due to critical time and handling conditions vertical collaboration is would be more suitable. In order to assess the remaining inbound destinations, these will be only selected with a sufficient amount of cargo weight and number of shipments.

The basis for setting the value that includes or excludes an origin has been done by assessing the largest origins both on amount of shipments and total weight of shipments. The following minimum has been used to select a limited amount of key import destinations.

- More than >5000 amount of AWB's per year
- Higher weight than >5000000 kilo, total shipment weight from a specific origin

There are 18 origins that fall within the defined minimum amounts for AWB's and total weight of shipments, the 18 origins are shown in Figure 57 and Figure 58 below. However not all origins are the same given the different minimum values that have been defined based either the amount of shipments, or the total weight of cargo.

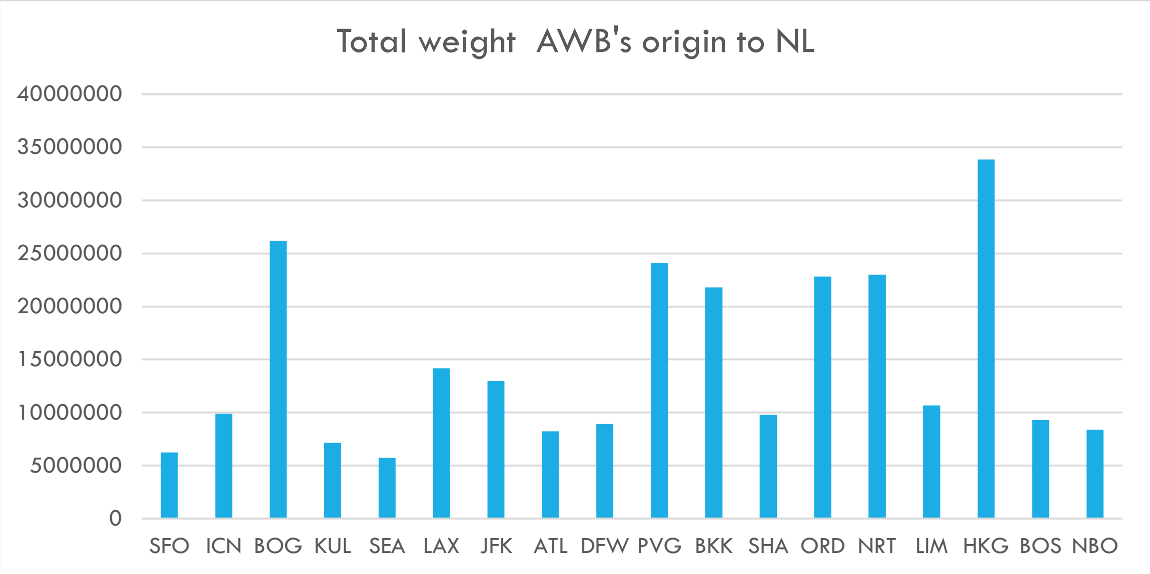

Figure 57: Total import weight to Netherlands from biggest import markets (excluding UIO) (year total).

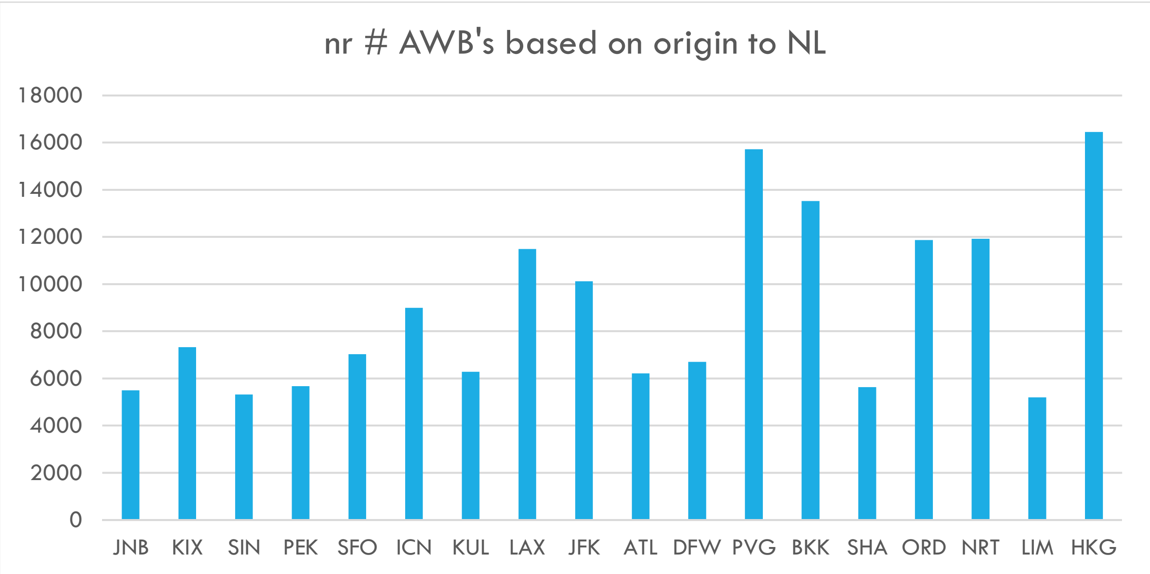

Figure 58: Total import AWB's to Netherlands from biggest import markets (excluding UIO) (year total).

Given the notion that collaboration can be best realized for smaller shipments another important factor determining import collaboration is the average weight of shipments, this why based on the origins that have more 5000 shipments the average weight from these origin is also shown in Appendix J, it is however difficult to conclude anything on the basis of these three different values, as the origins with high amount of AWB and weight are also the origins that have both regular passenger and full cargo services to Schiphol airport. This can mean that many different airlines and flights can be linked to one defined origin. Based on the figures above there are several origins that can be however defined as most suitable based on the amount of shipments and the amount of cargo that come from the analyzed origins:

- HGK (Hong Kong)
- BKK (Bangkok)
- PVG (Shanghai)
- NRT (Tokyo)
- ORD (Chicago)

The difficulty however is that these shipments are not related to one airline or handler, there it could be the case that origins with high amount of cargo and shipments are spread over several airlines/flights and thus also over different air cargo handlers, making it more difficult to facilitate collaboration on these flights. It does however give indication of the size of the largest markets over the year, this 'only' represents about 60 to 50 shipments per day on average, with the given amount of forwarders at the airport this directly reveals again how difficult it would be to collaborate with a limited amount of forwarders based on a single origin. Next to this, the breakdown of one flight can take up to 10 hours, making it often much more attractive to collaborate on multiple origins, to realize more stable amount of shipments over time. Therefore this further supports the already defined concepts to collaborate for import shipments not on airline/origin but on all shipments related to a specific forwarders of certain type of cargo shipments.

11.2.2 KEY EXPORT DESTINATIONS FROM NL BASED ON AWB'S

Unlike import the difference in total weight for major export destinations and amount of shipments, this is less present for export shipments coming from the Netherlands. Dubai airport (DXB) is the largest export destination based on weight and second largest based on amount of shipments. In order to assess the remaining outbound destinations, the airports in dataset will be only selected with a sufficient amount of cargo and shipments. The basis for setting the value that includes or excludes destination has been purely done by assessing the largest origins both on amount of shipments and total weight of shipments. The following minimum values have been used to selected suitable export destinations from the Netherlands.

- More than >5000 amount of AWB's per year for a specific destination airport
- Higher weight than >5000000 kilo, total shipment weight for a specific destination airport

There are 25 destinations that fall within the defined minimum amounts for AWB's and total weight of shipments. In the figures Figure 58 Figure 59 below, the most important export destinations based on amount of shipments and total exported weight are presented. However not all destinations are the same based either the amount of shipments, or the total weight that is exported from the Netherlands to a specific airport over the year.

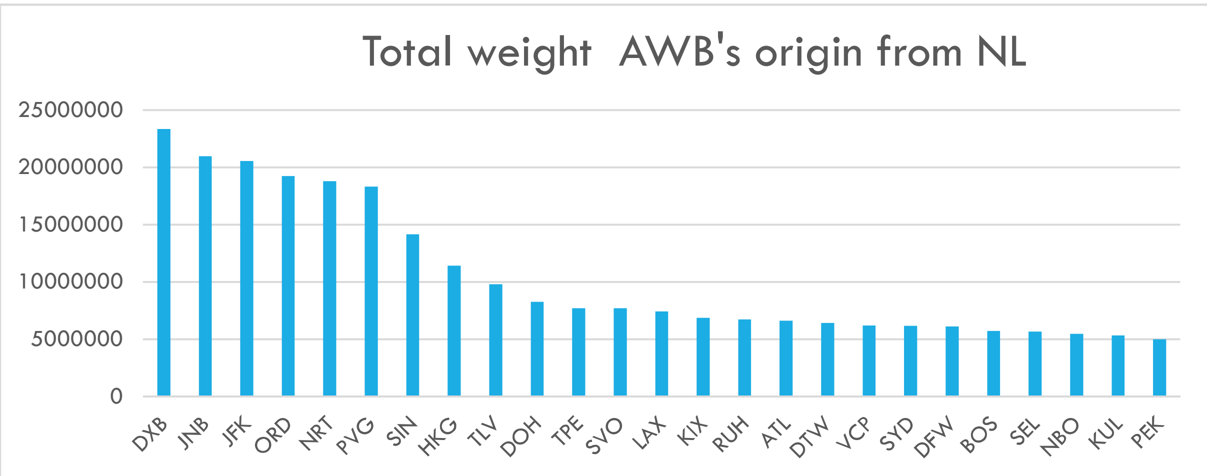

Figure 59: Total export weight from the Netherlands to biggest export markets (year total).

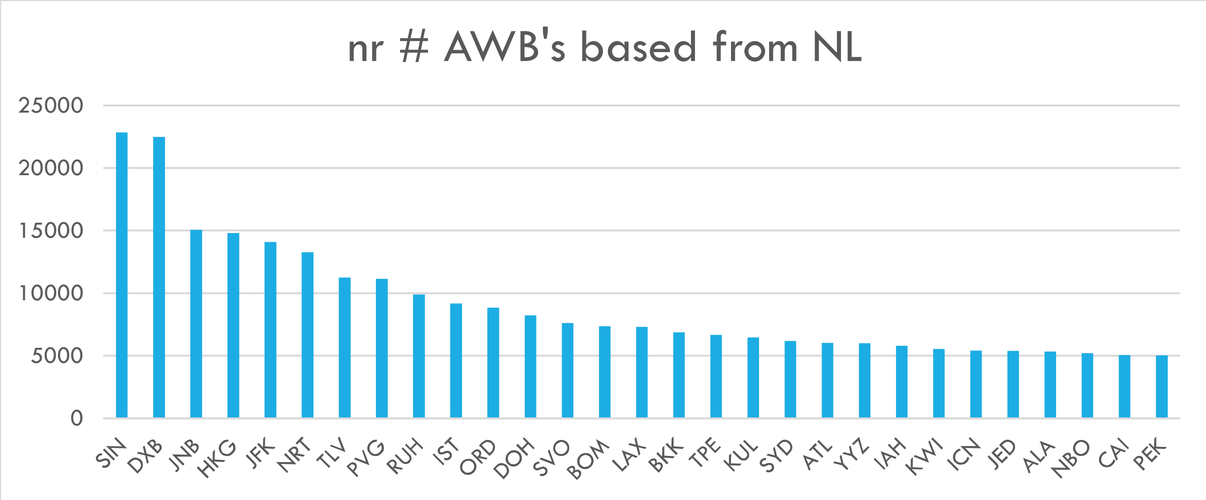

Figure 60: Total number of AWB's from the Netherlands to biggest export markets year total.

Given the notion that collaboration can be best realized for smaller shipments another important factor determining export collaboration is the average weight of shipments, this why based on the destinations that have more 5000 shipments the average weight from these origin is also shown in Appendix J, it is however again (similar to import origins) difficult to conclude anything on the basis of these three different values, as the destinations with high amount of AWB and weight are also the airports that have both regular passenger and full cargo services from Schiphol airport.

Based on the figures above there are however several destinations that are most suitable based on the amount of shipments and the amount of cargo the destinations for export transport collaboration these are:

- DXB (Dubai) [based on volume and weight]
- JNB [based on volume]
- SIN (based on volume)
- JFK (based on average shipment weight and volume)
- HKG (based on volume and weight)

Difficulty however again (similar to import analysis) is that these shipments are not related to one airline or handler, there it could be the case that destinations with high amount of cargo and shipments are spread over several airlines and different handlers, making it more difficult to facilitate collaboration on one specific or more flights of a given airline. The analysis does however give indication of the size of the largest markets over the year, this 'only' represents about 60 to 80 shipments per day, with the given amount of forwarders at the airport this directly reveals again how difficult it would be to collaborate with a limited amount of forwarders based on one export airport destination. Next to this it can several hours to buildup of shipments for one flight it often more attractive to collaborate on multiple destinations, to realize more stable amount of shipments over time and increase the amount of shipments that are delivered to a specific handler. A higher potential would be achieved when flights of a specific handler or airline that depart around the same time are combined, as this will make the amount of shipments at any time higher that can be collected. This can however not be analyzed on the basis of the provided dataset.

11.3 CARGO HANDLED AT THE SIX GENERAL AIR CARGO HANDLERS AT SCHIPHOL

Several attempts had been made during this research to obtain specific data on the actual amount of cargo that is processed at the six main air cargo handlers at Schiphol for different flows and forwarders. The air cargo handlers have not responded to my data request after several attempts, the share and amount of cargo handled by the different air cargo handlers therefore has been based on expert judgment alone. Table **29** below shows the estimated values for cargo processed, the share of DGVS forwarders and the share of import and export at a given air cargo handler.

- % of cargo that is handled [import/export]
- % of cargo that is handled for [Schiphol based forwarders (DGVS)]

Air cargo handler	Cargo processed [ton/year]	DGVS forwarders share of cargo	import share of total cargo processed
KLM	500000	50%	[50%]
Avia	400000	80%	[50%]
Menzies	400000	80%	[50%]
Swissport	100000	60%	[50%]
WFS	70000	70%	[50%]
Skylink	30000	70%	[50%]

Table 29: Total amount of cargo processed at cargo handlers at Schiphol [ton/year], share of DGVS forwarders on total and share of import and export on total cargo processed at each handler.

Currently no information was at hand to define the import/export share of each air cargo handler therefore the share of import and export has been defined as being equal. This has been based on current system shares of import/export, which are about the same on total level of cargo handled at Schiphol over the last few years. The share of DGVS forwarders on the total and the amount of cargo processed has been based on partial data that have been derived from various sources, including expert judgment. With the information provided in Table 25 & Table 29 combined with findings of simulation model, an estimation is made on the potential system contribution combined loose cargo transport, which can be seen in Table **30** below.

Air cargo handler	loose ton DGVS		loose AWB's DGVS	
	import loose	export loose	import loose	export loose
KLM	16500	23500	109667	103091
Avia	21120	30080	87733	82473
Menzies	21120	30080	87733	82473
Swissport	3960	5640	21933	20618
WFS	3234	4606	15353	14433
Skylink	1386	1974	6580	6185

Table 30: Estimation of amount of cargo related to DGVS forwarders on yearly basis with <AWB's of less than 1000 kilo

With a simple calculation based on the simulation model LF of 2000 kilo per truck and the assumed potential reduction of 30% of truck movements is realized in relation to the total movements for loose cargo transport, there could be potential to reduce the use of 55 truck transport movements a day at Schiphol for import and around 80 movements of trucks for export transport, for freight forwarders that operate at around the airport alone. When the validated with average of 4 transport movements per shift is taken for an inner airport transport truck use, one transport movement will relate to 2 hours transport time in total. When average costs of truck hiring of €50/hour is used this means around €5000 could be saved on the basis of truck hiring alone for import and around €10000 for export for one day. Therefore their seems to be a system potential to reduce the transport costs at Schiphol of almost €5 million a year, when all forwarders could combine loads in same way as the pilot companies that has been analyzed for both import and export transport. As explained before ofcourse not all handlers and forwarders operate in the same way, so the actual reduction that can be achieved is expected to be lower, as the smaller air cargo handlers and forwarders might not be able to realize the same reductions in movements as larger forwarder at the biggest forwarders..

11.4 AMOUNT OF AIR CARGO HANDLERS AND COLLABORATION POTENTIAL SCHIPHOL

In order to assess the current and future air cargo system at Schiphol and its air cargo handlers this paragraph will analyze both the current air cargo handling system and potential changes to current volume and capacity handled at the airport.

11.4.1 CURRENT AIR CARGO HANDLING SITUATION

Three air cargo airports, including Schiphol, have been analyzed in more detail in order to better argument what the optimal amount of air cargo handlers would be for Schiphol. However the comparisons which can be found in Appendix I, does not directly explain what an optimal amount of handlers or capacity could be. Hong Kong airport currently has two and will soon have three handling facilities that can handle more than 4 times the amount of cargo that is handled at the largest facility at Schiphol. Paris airport's (CDG) largest facility handles double the amount of the largest facility at Schiphol, but Paris on the other hand has three general handlers that are of very small size compared to Schiphol airports average handling facility size. Given the uncertainty of major cargo flows and the decreasing size of loose cargo shipments, it can be assumed that larger handling facilities would be able to offer a more reliable demand and supply of cargo that can either support vertical or horizontal collaboration. Both the largest facilities at Paris airport and Hong Kong are often seen as extremely efficient cargo transshipment facilities based on their own remarks and other literature. With the fact that Schiphol currently 'only' handles about 1,5 million tons of cargo, it can be assumed that two facilities the size of largest handling facility at Paris airport (capacity of about 1,2 million) would possible make the efficiency and potential for both horizontal or vertical collaboration much higher than in the current system. Currently the three smallest handlers at Schiphol (WFS, Skylink and Swissport) lack the volume or frequency of supply and demand to support specific collaboration with a limited amount of large forwarders on a vertical or horizontal level, based on the data calculated in table 30 regarding the amount of loose shipments and total amount of kilos of loose cargo that is processed at the six different air cargo handlers.

11.4.2 FUTURE SCENARIOS OF AIR CARGO HANDLING AT SCHIPHOL

In the previous chapters allot has been said about the increased dynamics of air cargo system at Schiphol, smaller shipment sizes and lower expected growth rates, however the difference in growth related to handling at Schiphol and collaboration has not been further specified. In this section several different growth rates will defined for air cargo system at Schiphol and these will be related to the amount cargo handled/available capacity. It is important to consider the different growth rates, as they are likely to impact the collaboration potential and the way of air cargo system at Schiphol will be used/ how many air cargo handlers will be operating at the airport.

<u>Growth scenarios of cargo processing at Schiphol</u>

In order to understand the different growth trend, current market and future growth potential three figures are constructed below. **Figure 61** shows the extensive growth of air cargo volumes at Schiphol airport between 1972 and 2007, in this period an average yearly growth rate of 6,2% was achieved. The second figure (**Figure 62**) shows the negative growth that has occurring in the last 5 years and finally **Figure 63** below shows the expected amount of cargo handled at Schiphol for the next 20 year based on three different growth rates that have been defined.

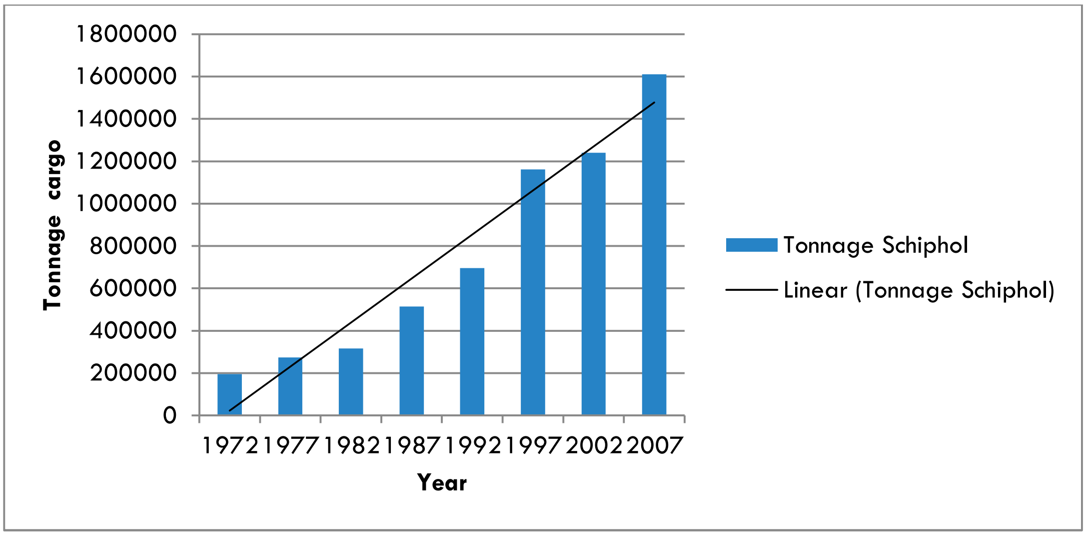

Figure 61: Previous high growth of cargo processed at Schiphol period (1972 – 2007).

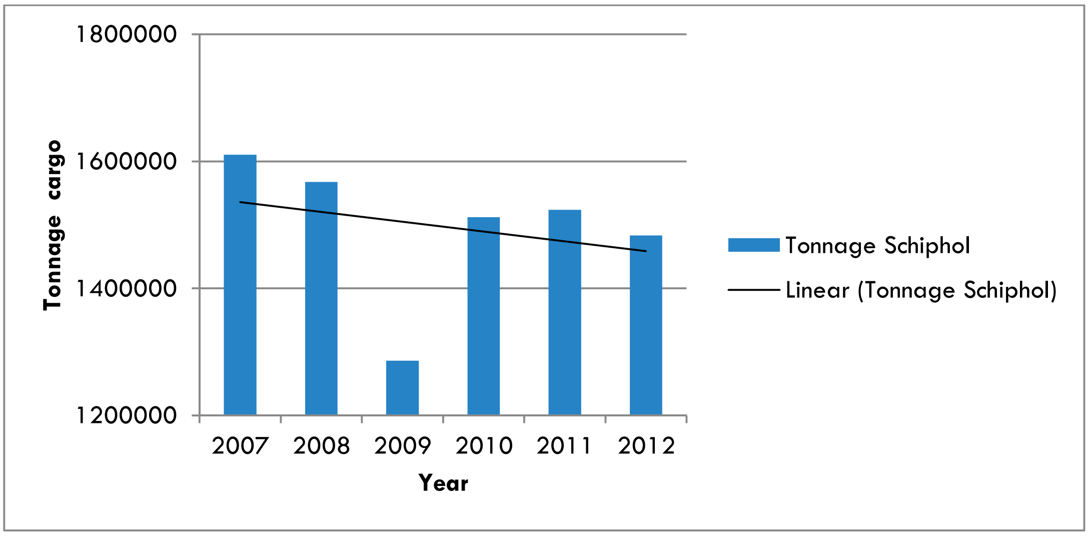

Figure 62; Negative growth rate trend of cargo processed at Schiphol period (2007 – 2012)

In period between 1972 and 2007 there has been growth of cargo processed at least every two years, in the period of 2007 to 2012 two years of negative growth in a row were observed that had not happened before 2007 and after 1972, also the amount of cargo processed in the last five years did not recover to previous levels after the decline has started. This shows that the growth trend of the previous period is not likely to return to its previous 6,2% growth rate a year.

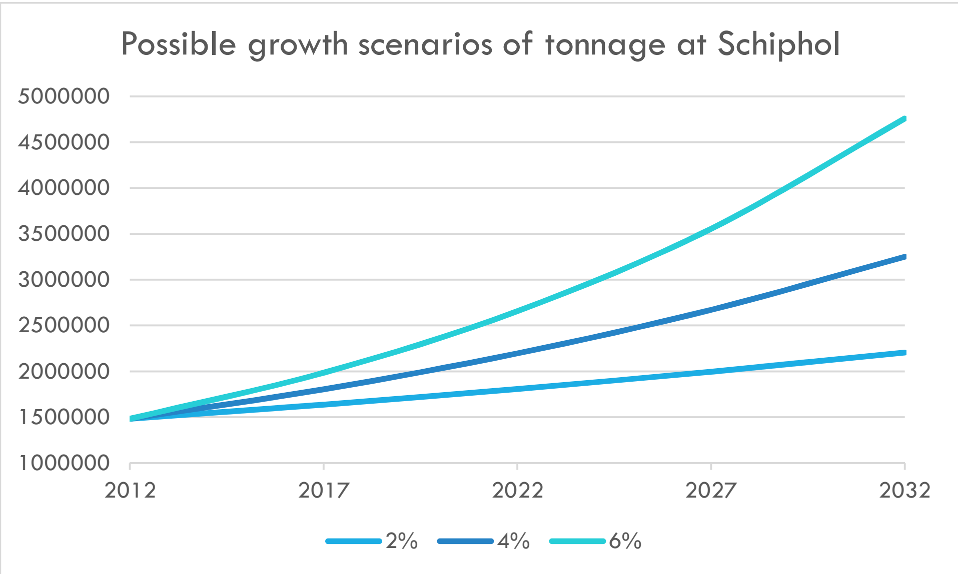

Figure 63: Amount of cargo processed at Schiphol in future based on three growth scenarios of 2, 4 and 6%.

Figure 63 above shows the outcomes for the amount of cargo that is estimated to be handled at Schiphol based on three different growth rates. When the amount of cargo is compared to the estimated current handling capacity of cargo at Schiphol it reveals that even in highest growth scenario, there should be sufficient handling capacity for the next 10 years and for the lowest growth scenario no additional capacity would be needed at all until 2032. This is important notion given the lower expected growth rates and negative growth rates of the past few years, it is therefore much more likely that that therefore no additional capacity will be realized in the coming years

<u>Changes to the use and development of air cargo system airside warehouses at Schiphol</u>

Based on previous growth rates of cargo processed at Schiphol, the excess in current capacity and the expected lower growth rates, changes regarding the use air cargo system with airside access on short term (next 10 years) can be expected to take place, in order increase revenue or reduce costs of the involved stakeholders that are currently owning/renting airside access warehouse at the airport. Some of these developments have already been pointed out in chapter four and five. On the long term both with low and high growth rates of cargo volume handled changes compared to the current system are also likely, given the increased number of small shipments and amount of both direct and indirect delivery and collecting at both airside access and non-airside access warehouses. The main difference will be regarding the level of automation, the amount of different air cargo handling companies and the way warehouse capacity is used. These difference are based on the lack of warehouse space this means that automation needs to take place after a certain level of cargo has to be processed in order to be able to process a higher level of cargo. Next to this lower growth rates will force air cargo handlers to look for ways to reduce costs which can be achieved by renting our part of their warehouse space that is not effectively utilized or providing additional services to their customers, such as the organization of their transport needs. Three different scenarios of growth are described below in relation to the use and potential of transport collaboration. After that the potential of both vertical and horizontal transport collaboration is defined on the basis of growth and the amount of air cargo handlers for three different sizes of forwarders.

High growth scenario long term developments

With a high growth rate investments in new more automated and advanced warehouses can be expected given the lack of space to realize sufficient handling capacity for high growth scenario, after 10 years of growth with the current capacity of air cargo handling. Due to the low margins and high amount of handling companies' active at Schiphol, this will likely results in limited number of air cargo handlers, up three handlers can be expected to stay operation on the long term at Schiphol, this based on the largest highly automated handling facilities that can handle more 1 million on of cargo a year. When three facilities would be in place that can handle on average about 1 million tons of cargo, they can handle all expected cargo for the next 20 years and would outclass any other smaller air cargo handler. It can be assumed that as soon as a handler would invest in automation with a certain size, competing handlers would either have to follow or aim for a niche in order to either compete on price or quality in the same way. When larger more automated warehouses would be constructed at Schiphol this could change the potential of combined transport for large forwarders in negative way, as their volume could become sufficient to realize single transport collection and delivery comparable cost way as combined transport without the restrictions and limitations of combined transport. However it could increase the potential of combined transport for smaller or medium sized forwarding companies to collaborate with smaller number of competitors. With a high growth rate and expected automation it can therefore be expected that collaboration both on vertical level for large forwarders with the involved air cargo handler and collaboration on horizontal level for smaller and medium sized forwarders will increase. With the current overcapacity it can be however be safe to say that for the coming next than years the current facilities at Schiphol will have sufficient capacity and that investments in major new facilities are not expected anytime soon.

Low growth scenario long term developments

With low growth rates it is also likely that a smaller amount of handlers would be active at the airport, however a similar amount or less warehouse space would be used by these handlers than in the current situation, for additional revenue, individual handlers or several handlers could either rent out part of their warehouse space to forwarders, to give them airside access as has been done in the current system at a limited scale, or a company could manage airside warehouse space for more than one forwarder to jointly realize transport, security or other procedures in more efficient way. With a low growth rate it can therefore be much difficult to assess the potential development of both vertical and horizontal transport collaboration, as increase of airside access warehouse use by selective number of forwarders can reduce the potential of combined transport, but on the same time make the vertical collaboration between the handler and forwarder stronger and more long-term. Only when the amount of handling companies is reduced in such a way that the average amount of cargo at the remaining air cargo handlers for landside collection and deliveries stays the same or increases it can still positively affect the potential of combined transport on horizontal level.

Greenfield desired situation for collaboration potential

Given the expected lower growth rates and the limited amount of companies that want to collaborate a further situation can be described which would result in highest potential of both vertical and horizontal collaboration. In such a situation a limited amount of large forwarders would be located at the airport (2 to 3) which all process a large amount of cargo 500000 or more. Large forwarders that do not want to collaborate with competitors would in most cases use airside access warehouses in order to optimize their own collection form different handlers. Forwarders that are supportive of horizontal collaboration would be in a situation that air cargo handlers will support both horizontal and vertical collaboration wherever it realize desired results for a limited of forwarders that sufficient in size and volume for a specific forwarder. For smaller forwarders that lack the size and volume a dedicated warehouse could be used that combines loads for collection (airside) and delivery (landside) in more effective way than is currently possible. If this scenario would be possible it would result in high collaboration potential for all sizes forwarders and also would support the desired type of collaboration based on forwarders preference and its ability to collaborate.

Potential of both vertical and horizontal transport collaboration

The potential of transport collaboration as has been explained in the previous section relates to; the amount of cargo at a handler, the growth of cargo at Schiphol and the amount of air cargo handlers. These three variables will in general define the potential of transport collaboration for freight forwarders on horizontal or vertical level based on their size. Table 31 below tries to reveal the potential of different sized forwarders, in relation to the growth and amount of air cargo handlers active at Schiphol.

		High amount of handlers		Small amount of handlers	
		High growth	Low growth	High growth	Low growth
Large forwarders	horizontal	Mixed potential	**High potential**	Limited potential	Mixed potential
	vertical	**High potential**	Limited potential	**High potential**	Mixed potential
Medium forwarders	horizontal	**High potential**	Mixed potential	**High potential**	Mixed potential
	vertical	Limited potential	Limited potential	Mixed potential	Limited potential
Small forwarders	horizontal	Limited potential	No direct potential	Limited potential	No direct potential
	vertical	No direct potential	No direct potential	No direct potential	No direct potential

Table 31: The potential of transport collaboration on vertical or horizontal level based on the growth of air cargo and the amount of air cargo handlers.

12 MANAGERIAL IMPLICATIONS OF HORIZONTAL TRANSPORT PROJECTS

12.1 HORIZONTAL TRANSPORT FORWARDER POTENTIAL

The previous chapters have analyzed the collaboration that takes place at Schiphol and have quantified the differences between single company transport and combined transport based on a case study and shown the potential of combined transport on a system level. Given the limited amount of forwarding companies involved in the case study and extensive amount of factors that either directly or indirectly influence the potential of combined transport from a managerial perspective, this chapter will be used to define the most important challenges and opportunities for the use of combined transport from a managerial perspective. This is done by looking at different literature regarding collaboration and the ability of certain companies to utilize these advantages based on; cargo volume and organizational structure/culture. In order to support this analysis, the partnership model introduced in the introduction of this research (Lambert et al., 1996) is used to explain the main partnership elements for transport collaboration within the air cargo system, the model will be combined with the conceptual framework of the research (Rezaei & Ortt, 2012) to point out the value and need for continuous assessment of companies within the collaboration. The use of a more segmented approach to collaboration and to add additional considerations for managing complex transport collaboration, from selection to operational phase of projects will also be pointed out. Technical aspects related to transport system performance, processing of cargo shipments and measurement are assessed afterwards and this chapter will end with additional advice on setting up, maintain and reviewing combined transport based on both hand on experience from the pilot project and suggestions from the previous part of this research. This chapter is aimed mainly at the freight forwarder, given the fact that the forwarder will have to pay for transport collaboration and is also the company that supplies the concept with shipments either directly (export) or indirectly via air cargo handler (import). However most of the points that are pointed out in this chapter can also be used by transport company and or air cargo handling companies that are involved in collaboration projects, as it will give them a better insight on how to support and adapt their own operations to make it both efficient and effective in regards to transport collaboration concepts, with the least amount of effort and costs for all involved stakeholders. Besides this in most cases it can be expected that the air cargo handler will together with one or more transport companies arrange and support the horizontal transport concepts on behalf of a group of forwarders, so their rule is also very important in the management of horizontal transport projects.

12.2 HORIZONTAL TRANSPORT FORWARDER COLLABORATION RELATIONSHIP ASPECTS

The research of (Lambert et al., 1996) defines different level of relationships between companies, where several of these levels can be defined as partnerships. The first important remark based on this article is that horizontal transport collaboration relationships within the air cargo system for large forwarders, as has been analyzed in this research should in general be based defined as partnership. The main reasons to define it in this way are:

- Dynamics of shipment demand/supply for each forwarding company involved, require frequent direct and indirect changes to the actual combined transport use.
- Direct and frequent communication has to take place between all involved companies in order to ensure that combined transport, can handle and process as much cargo shipments as possible, within the least amount of time between the involved locations.
- In order to ensure fast processing of cargo shipments at the different facilities both transport planning and warehouse department have to be included in the collaboration, there thus has to be cross department coordination regarding the collaboration in order to ensure its effectiveness.

A higher level of relationship between stakeholders than a partnership is not desired, as this will result in joint venture / or vertical integration, large forwarders at Schiphol are currently not seeking such integration and still want to control part of transport with a certain extent of freedom. A lower level of relationship will often not work, as transport collaboration in air cargo system in order to be effective needs to be adaptive and supported by several different departments of the involved companies, to be able to cope with the dynamics of shipment supply on daily basis and realize sufficient use of transport capacity for all involved companies. Given the proposed extent of collaboration as a partnership, it becomes very important to justify why a combined transport partnership with competing forwarders, that operate on the same level of value chain is needed.

The partnership model of Lambert defines two different elements that relate to the initial support for a partnership, these elements are:

- drivers (compelling reasons to start/support a partnership)
- facilitators (supportive environmental organization factors that can enhance collaboration potential)

Drivers for partnerships

Four different categories are used to relate to drivers for realizing/supporting a partnership based on the partnership model. For each category below the most import justifications for a partnership are given related to this research. The number of the driver category and identified reasons for a partnership are presented in Table 32 below. The table shows that several drivers for transport partnership can positively impact more than one category. The numbers in table are linked to the four different categories.

1. **cost/asset efficiencies**
2. marketing advantages
3. **customer service improvements**
4. **profit stability/growth**

Of the four categories that are defined in the partnership model, marketing advantages are assumed to be valued the least. This is due to the sensitivity of applying combined transport and the potential negative reaction of customers towards it, marketing advantages however can arise when for example also customer service can be improved or costs can be reduced while also improving sustainability of transport. Most forwarders state that it is challenging to make money on import bound shipments, as most profits stay within the exporting forwarding agent. Therefore there is a strong tendency to reduce transport costs on import shipment processing and this might be less apparent for export shipment transport, where the focus is of more on customer service and profit growth. The table below shows that most of the defined drivers' impact affect both on customer service improvements and or profit stability/growth these categories can therefore be seen as important drivers for realizing partnership regarding transport collaboration in the air cargo system.

driver	1	2	3	4	positive driver for support partnership (stakeholder(s) affected)
1	x	x	x	x	Frequency delivery / collection increase of shipments (forwarders) [supported by model]
2	x				Reduction of trucks queuing at or before facility without planned dock [supported by model]
3	x				Prior knowledge on arrival location of truck movements (forwarder / air cargo handler)
4	x			x	Direct influence on arrival of truck time (forwarder) / increased stability of arrival or departure of trucks
5		x		x	Low transport costs per kilo (forwarder/consignee) [supported by model]
6	x		x	x	Increased transport delivery/collection reliability (forwarder/consignee)
7				x	Better resource planning / utilization (forwarder/ air cargo handler)
8			x		Better relationship long term with import stakeholders (transport company/ air cargo handler/ forwarder)
9		x			Increased load factor average LF for part of shipment transport [supported by model]
10			x	x	Ability to use two different transport resources and therefore also offer own costumer two options (air cargo handler / forwarder)
11			x		Faster response to shipment collection messages, holding time base (forwarder) [supported by model]
12		x	x		Showing efforts to reduce congestions and improve sustainability by collaboration (air cargo handler/ forwarder)
13			x	x	Increased holding time of single transport can give opportunity for additional revenue (forwarder) [supported by model]

Table 32: Main drivers for transport collaboration both for forwarder and air cargo handler based on pilot case / simulation model.

Facilitators

Four different categories are used to explain the most important aspects for facilitating a partnership based on the partnership model of Lambert research, the categories are:

- **corporate comparability (business objectives and culture)**
- managerial philosophy and techniques (long term strategy based approach)
- mutuality (willingness to give up part of own identify)
- **symmetry (process, size, efficiency)**

Based on this research it is argued that not all of these aspects are of the same level of importance for horizontal transport partnerships. Due to specific focus of transport collaboration on limited part of the forwarders operations, therefore the own identify of the companies can remain and the long term strategy does not have to be aligned extensively. The most important aspects for transport partnerships are cooperate comparability and symmetry. It became clear from the assessment of forwarding companies within the airports surroundings that there forwarding companies can have very different business objectives and cultures, in relation to the way they organize and maintain their supply chain. When companies have a strong desire to control all steps of shipment processing, it can be much more difficult to support collaboration in an effective way. In order to support effective collaboration transport companies' objectives and their business culture should be supportive in regards to the use of combined transport and the objective that companies want to achieve by supporting combined transport should also be similar between companies. If companies are only interested in a reduction of total transport costs, this can for example limit the potential of combined transport, whereas if companies would also support collaboration if other organizational factors are improved this can increase the potential of combined transport. A very important aspect related to this is the extent of trust between companies, often forwarders are reluctant to share shipments based on potential use of booking information by other forwarders. When trust between companies is limited, the collaboration potential becomes much more restricted as the ability to allocate shipment to a concept with a low level of trust is likely to put extensive restrictions in the way combined transport will be executed and supported. This will also be become more clear in next part of this section were the main components of the partnership will be explained in more detail.

<u>Outcomes of partnership (components)</u>

Outcomes of the partnership are influenced by the identified drivers and facilitators of the partnership, however in order to produce the actual outcomes of partnership, certain activities and processes have to be undertaken to realize the intended effect of the partnership. The partnership model of Lambert defines these activities as components, eight different components are defined in the model. Not all of the defined components are however of same level of importance related to air cargo collaboration, this is why only the components that were defined in introduction are discussed in more detail below.

- joint operational control
- communication
- scope
- trust and commitment
- risk and reward sharing

Due to the dynamics of arrival of shipments, it is crucial to make effective use of available capacity over time within the partnership. The components above have a strong impact on the usability of combined transport and the support that will be given by the involved companies. Companies involved in transport partnership should find the right combination and level of support for these components, to realize the most desirable result of combined transport performance. Therefore it is vital to not only state fixed levels of transport capacity for companies for each transport but also have adaptive policies in place to better utilize capacity. Given the fact that possible longer process times of shipments can occur, a more dynamic approach of capacity use should be considered to further enhance the success of the partnerships transport use. In order to achieve this it would be a good idea to have a join operational control system in place. An example of this could be a system where fixed capacity for certain truck can be transferred between forwarders between two or more transport trips, this can give the forwarders more control of transport movements and actual usable capacity. Besides a joint operational control system can also be used to define and measure KPI's of the combined transport based. Currently most forwarding companies are only interested in reducing transport costs by supporting different transport operations, in order for this to be realized commitment should be high regarding the amount of kilos of shipments that will be allocated to combined transport. If the involved forwarders are not committed to using combined transport on a regular basis, it will not perform as desired, this will result in higher costs and less favorable transport performance. This is why commitment of the involved forwarder should be predefined and of sufficient level. Effective communication between the different parties is also very import, not only given the dynamics of the operations, but also because most companies use shifts for warehouse and transport operations. Therefore it is important that communication during and between shift changes is set up in the right way to adapt shipment transport to the actual situation and make combined transport preform as intended. The extensive amount of shipment requirements in relation to transport also makes it important to scope the partnership in the right way, the partnership regarding transport should be aimed at collaboration on shipments that have similar requirements and are most suitable for collaborative transport. Combined transport can be more succesfull if the involved companies value it in such a way that they are committed to using it, which depend mostly on both; trust and fair risks and reward sharing. Forwarding companies can be more reluctant to support collaboration that would see high increase in costs or does not reward a higher contribution in either financial or ways based on the share of shipments allocated to the transport. In general most forwarding companies would support transport collaboration when transport costs would be lower than individual transport and risks of transport related operations and financial commitment are limited, more on this aspect will be discussed in the technical part of this chapter.

12.3 HORIZONTAL TRANSPORT COLLABORATION FORWARDER ORGANIZATIONAL ABILITY AND WILLINGNESS (SEGMENTATION)

The case study of transport collaboration revealed that transport collaboration on certain flows is much more suitable than others. The research of (Rezaei & Ortt, 2012) points out the importance of segmentation supplier and buyer relationship, in order to manage and develop relationship more effectively. It reveals a set of important variables that are used in research for defining both capabilities and willingness of suppliers to collaborate effectively with a buyer. These are based both on the capability and wiliness of suppliers companies to collaborate with one or more other companies on certain segments, as the potential of collaboration is strongly related these aspects. For air cargo shipments transport collaboration transport as has been defined in this research, it would be organized by a specific air cargo handler for a limited amount of forwarders. Given the fact that the forwarder controls the export shipments before delivery to the air cargo handler and for import the air cargo handler controls the shipments, the willingness and ability for supporting collaboration transport is different for export and import transport for the involved stakeholders. Supporting the different types of transport organization depends both on the ability and willingness of forwarders/air cargo handlers to support segmented transport collaboration based on the advantages that can be gained by applying collaboration for all parties. It is therefore vital to understand and quantify the main benefits and drawbacks of certain collaboration for all involved parties in relation to capabilities and willingness each organization, before a long term transport collaboration is started and supported. When this is done, collaboration on a specific flow (segment) can be defined for a limited amount of forwarders that will be more suitable for all involved parties in relation to their willingness for collaboration and their organizational capabilities. If these aspects are not assessed in the right way or before collaboration is started in relation to segment on which collaboration is applied, the transport and processing of shipments involving combined transport could be less effective/efficient and this could reduce the potential of transport collaboration both on the short and long term. With the extensive amount of forwarders active at different handlers and low operating margins of most companies, it is therefore vital to start with collaboration of transport regarding not only forwarders that handle/transport similar products or volumes, but also to relate the collaboration to their capabilities and willingness to support transport collaboration. By applying such an approach, collaboration potential can be increased with least amount of additional costs and highest desired outcome for all parties. Figure 64 below shows the different steps that should be followed in order to define, support and maintain effective transport collaboration, these steps are based on the research of (Rezaei & Ortt, 2012), which also defines four different phases related to effective management of supplier and buyer relations, the four steps are:

- selection
- segmentation
- management

- development

Figure 64 below uses these four steps for company collaboration transport development. The first step selection is based on each of the individual companies' capabilities and willingness to collaborate (based on its own shipment and transport assessment). In order to apply effective segmented collaboration, the companies that want to collaborate should be jointly assessed be on own capabilities and willingness and in order to come up with best possible segmented collaboration with a limited amount of companies involved. After the segment for collaboration is clear, a suitable strategy should be defined for management of collaboration, when this phase is defined to a sufficient level, the development/start of collaboration can take place. During this phase efforts should be made to further improve the segmented collaboration, which also relate to frequent evaluation of the transport collaboration. The evaluation could results in further assessment of transport and shipment flows, which could have an impact on the selection, segmentation, management and development of combined transport again. In many more stable demand/supply industries the evaluation of collaboration and assessment might not have to be applied that frequently, however given the dynamics of the demand of transport based on shipments between a forwarder and specific handler, for air cargo transport collaboration it is important to frequently evaluate and adapt the collaboration based on changes regarding to shipment flows and transport for selected shipment flow segments. This means that individual companies, should be open to changes to the amount of companies involved in collaborations in order to improve to actual performance and costs the combined transport system.

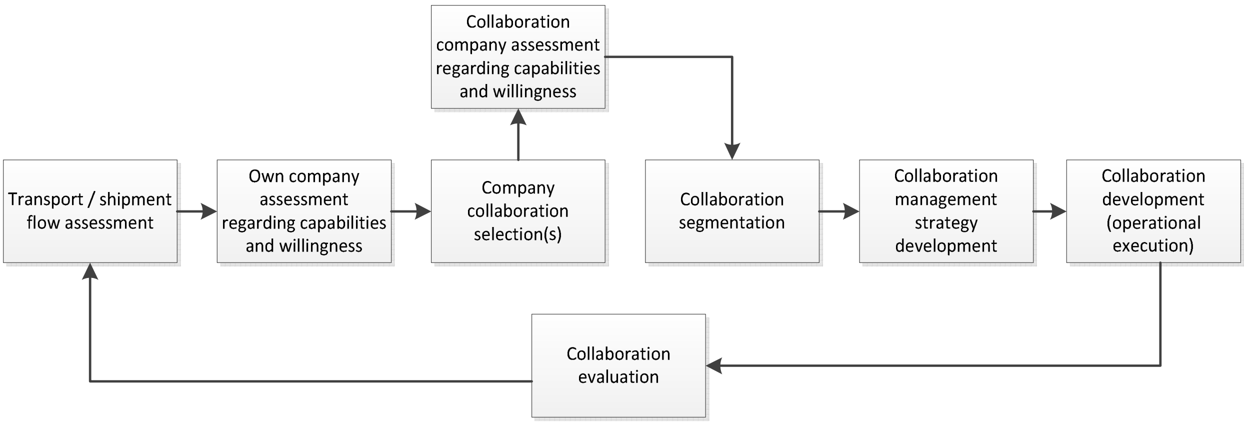

Figure 64: Proposed transport collaboration phases for transport and shipment flow assessment, based on conceptual framework of (Rezaei & Ortt, 2012).

12.4 HORIZONTAL TRANSPORT COLLABORATION FORWARDER TECHINICAL ASPECTS

The ability of companies and willingness of companies to support transport collaboration strongly relates to how technical requirements, use and measurement on shipment transport are applied.

Technical aspects

When a certain amount of cargo is allocated to combined transport, this will ofcourse negatively influence the amount of cargo that can be allocated to single transport, with the use of fixed transport this could increase the single transport cost per kilo cargo, but may also increase the performance of single transport on other aspects. When single transport performance can be increased by the use combined transport, less transport capacity on fixed basis might be needed. However this all will depend on the restrictions and capacity that is at hand at a specific forwarder in relation the actual amount of shipments that have to be delivered and collected. Given the importance of these technical considerations regarding the use and measurement of organizational performance in relation to transport use, a separate section on key aspects and considerations of using horizontal transport in relation to single transport use and other possible organizational impacts is presented in the section. Part of the technical aspects could also have been defined within the ability/willingness of company to collaborate, but due to the specific importance and time/value sensitive aspects of air cargo shipment transport this is analyzed and defined separately. Figure 65 below tries to show the most important challenges and opportunities for using and restricting both combined and single transport. Allocation of shipments to certain type of transport, will influence the performance and costs both single and combined transport. Restrictions regarding the transport of shipments by combined or single company transport also influence the amount of shipments that can be transported. Based on the figure below it may become more clear that is it challenging to support both combined and single company transport in such a way that their performance and costs base are both acceptable, without having reducing desired restrictions on transport of shipment to extensively.

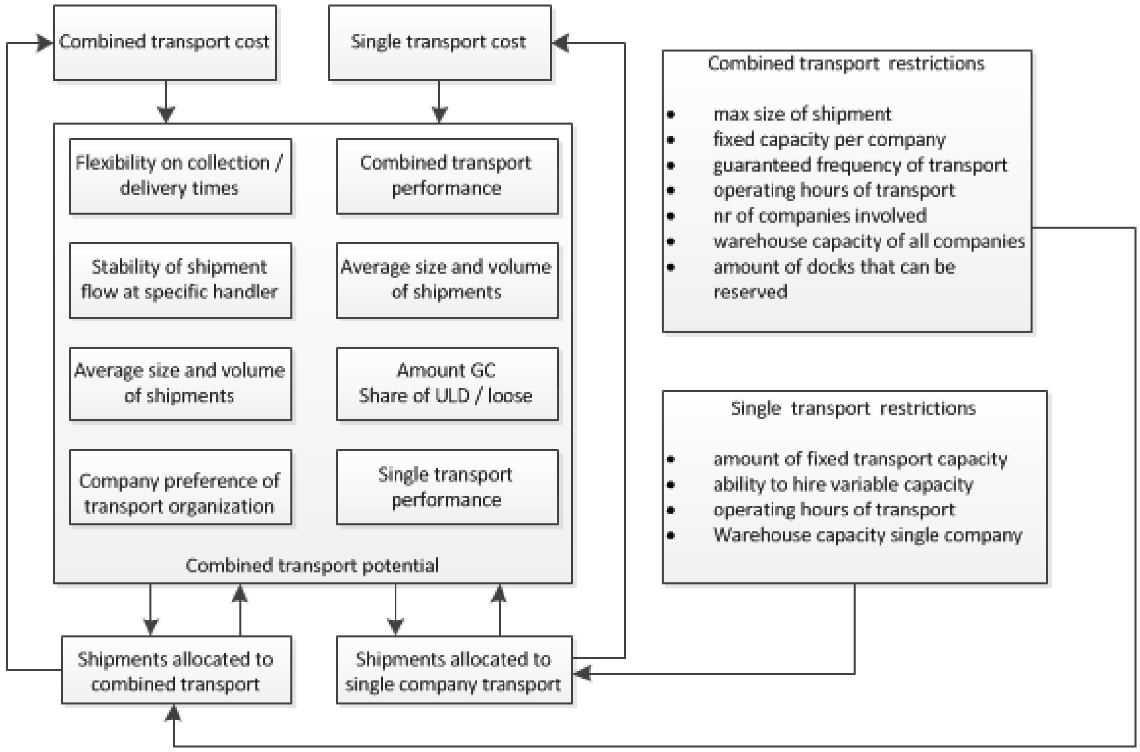

Figure 65: Overview of combined transport potential and impact of allocation of shipments to single or combined transport.

12.4.1 TRANSPORT SYSTEM USE AND MEASUREMENT

In order to understand the difference between the use of combined and single transport the defined KPI in chapter 7 can be already be used as, these clearly defined several different types of performance measures of both direct and indirect nature related to transport use. Based on the simulation model and the information obtained by interviewing several forwarding companies at Schiphol the most frequent used single company transport measurement KPI's are presented below in Figure 66. The current amount of KPI's that are often used to assess the performance of single transport limited. Currently most major forwarders see the fixed hiring of transport, as the most suitable solution to supporting their transport needs, due to high fixed cost aspects of current transport few KPI's are measured in relation to transport use. The use of combined transport can however not only positively impact costs and the limited amount of KPI's that are generally used it can also have a positive impact other KPI's such as;

- transport reliability (ability to reduce the combined transport for several different air cargo handlers)
- resource usage (ability to control and utilize certain resources
- transport visits (between own warehouse and air cargo handler)
- transport flexibility (choice of transport use)
- transport revenue (ability to offer customer multiple types of transport)

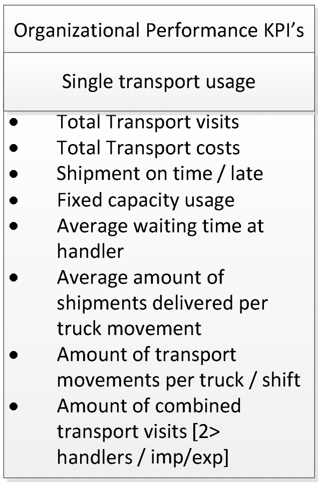

Figure 66: Overview of different KPI's that are often considered for single transport performance assessment.

Assessment on more KPI's than is currently applied by major forwarder companies for single company transport is advised, when combined transport is used, in order to fully show the benefits, drawbacks and actual performance of both combined and single transport. This is especially important for forwarders that are unable to directly obtain a reduction in total transport costs by applying combined transport and even more for companies that have to maintain the same level of single transport fixed capacity. These companies will have to quantify benefits other than reduction in transport costs to support the use of combined transport based next to the use of single company transport. The use of both combined and single transport will demand a more specific focus on organizational and transport performance, in order to justify and quantify the most important effects of using and supporting combined transport on whole organization. When companies are able to charge their costumers according to the specifics of the transport that will be used, they may be able, for example justify the use of single transport for less cargo and can also make combined transport use more affordable (this only applies if prices differentiations on transport will be accepted). With the current low margins within the air cargo industry it however remains to be seen however to which extent forwarders can charge their costumers differently for either faster services at a higher price or slower services at a lower price. The direct and indirect positive impacts use of combined transport could have both on the single company transport and resource usage in other parts of the organization is an important aspect that each company evaluating its own single company transport should consider when combined transport is included as potential alternative.

12.4.2 FORWARDER POTENTIAL FOR COMBINED TRANSPORT BASED ON TRANSPORT COSTS

A forwarder based on the previous analyses and figures above should therefore only support combined transport if the following conditions are met:

- It can allocate sufficient demand to combined transport that can be combined with the shipments of other forwarding companies, to realize a costs effective alternative to single company transport use.
- Shipment demand of a specific forwarder has some form regularity and for most part not extremely time sensitive.
- The difference in distance between warehouses of forwarders and involved air cargo handlers in the collaboration is not too large.
- Similar operational requirements / restrictions in relation with other forwarders can be accepted for combined transport.
- Organizational flexibility to accept longer average shipment throughput times can be supported
- Sufficient warehouse and transport planning resources are in place at the forwarder to support dedicated and proactive support of combined transport.

If one or more of these conditions are not met it way become very difficult to effectively combine loads, accept simple cost allocation methods and will make the collaboration processes for loading/unloading more complicated, which can reduce the efficiency and effectiveness of combined transport to great extent. The difference between transport costs and shipments throughput of companies that has been identified on the basis of the simulation model, shows that in order to realize transport that is more cost effective for all involved companies increased throughput times will have to be accepted to make it possible for the combined transport system to transport and processed sufficient volume of cargo with limited operation times and the amount of transport resources that are used. Next to the potential for making combined transport work in both an operational and costs effective way it is also important to relate the impact to single transport, as has been pointed out in Figure 65 above. Given that most forwarders use fixed capacity for their daily transport needs on airport, using combined transport will lead to potential of reducing fixed transport costs, but this is not always the case. To point out this difference three different forwarder examples are given that are impacted by the use of combined transport.

group one (highest potential)

- forwarders who can reduce the amount fixed single transport hired by using combined transport (direct reduction in total transport costs)

group two (medium potential)

- forwarders who can reduce part of their transport use costs by reducing the amount of fixed transport, but will have to hire more variable transport (reduction in fixed transport cost, increase in variable transport costs)

group three (low potential)

- forwarders that can reduce the amount of variable transport hired but have to maintain same level of fixed capacity (possible reduction in variable transport costs)

Given the dynamics of arrival of shipments for collection and delivery, it can be expected that only a small number of forwarding companies could reduce their fixed used transport on basis of supporting certain amount of cargo by combined transport at one specific air cargo handler. It is therefore much more likely that companies can either only reduce their fixed capacity if they will hire additional variable capacity, or still have to maintain the same level of fixed capacity and can only reduce their variable hiring capacity. This may cause the total transport costs to rise in many types of transport collaboration. However when companies would be able to apply segmented revenue management based on the use of combined or single transport use, this could be compensated by additional revenue that could be generated by different use of single and combined transport. Besides this the direct costs considerations companies who apply combined transport should focus on a much wider number of KPI's as this will reveal both the direct and indirect effects application of either only combined or combined use of combined and single transport. Cost reduction in other parts of the organization could possible also be achieved, therefore the focus should not only be on cost reduction in transport but on other possible cost and revenue potential as well that can be derived from the use combined transport.

12.5 CONCEPTUAL FRAMEWORK OF ASSESSING COMBINED TRANSPORT PARTNERSHIP IN THE AIR CARGO INDUSTRY

Based on the research of (Lambert et al., 1996) and (Rezaei & Ortt, 2012) combined with the technical aspects of transport collaboration, a conceptual framework is defined below in Figure 67, that shows the most important factors and aspects that will influence the actual amount of transport collaboration that can be realized in an complex and dynamic transport system such as a large airport cargo system as Schiphol. The technical, organizational (ability and willingness), facilitators and drivers all influence each other and together define the potential and actual realized amount of transport collaboration.

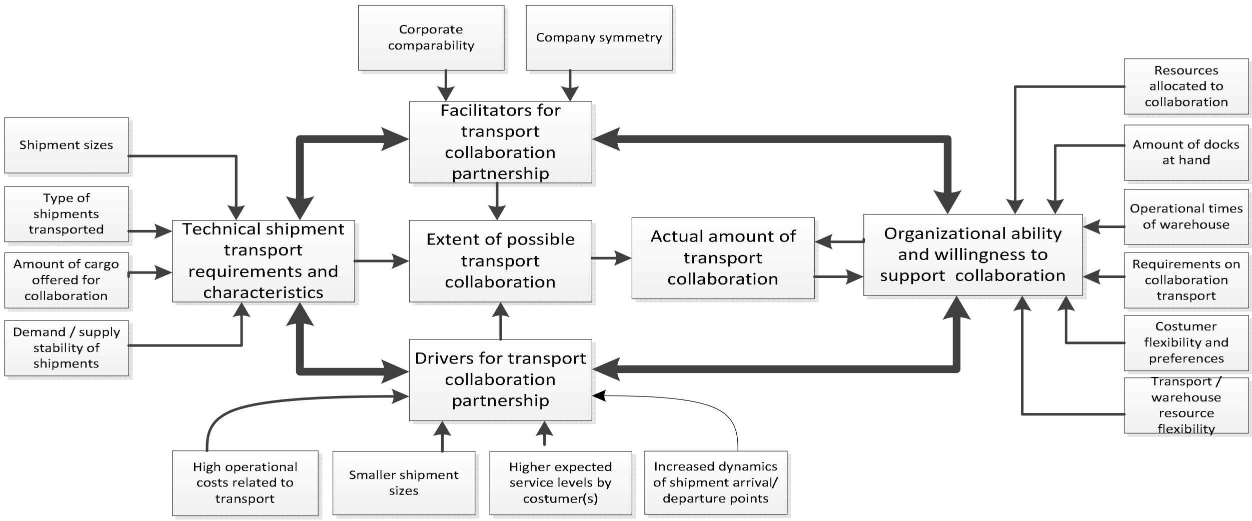

Figure 67: Conceptual framework of air cargo inner airport transport collaboration based framework of (Lambert; Rezaei) and air cargo specific shipment issues.

12.6 HORIZONTAL PROJECT MANAGEMENT & LEGAL ISSSUES

The main stakeholder management implications for developing, starting and maintaining collaborative transport will be briefly described below based on the experience during development of the pilot project. One of the most important aspects given the limited amount stakeholders that can support horizontal collaboration with small number of competitors is, analyzing the Europeans Commission Guidelines on horizontal transport agreements (COMMISSION, 2011), in order to ensuring that the conditions with EU law and national law are within the boundaries of competition law or are exempted on the basis of defined criteria will ensure that no legal action will be successfully taken against the proposed collaboration. This is essential because it can be expected that several companies which are not able to support transport collaboration, for whatever reason will try to block or challenges projects that can potentially give competitors a competitive advantage. To reduce delays on horizontal transport projects even before a pilot phase is started several points should be already addressed in development phase in order start pilot project as soon possible with the right level of support.

Developing horizontal transport collaboration project

The most relevant points that should be considered during the development of transport collaboration project will be pointed out below, afterwards a short explanation will be given for all points that are described.

1. agree on an open platform for horizontal collaboration projects
2. use a platform that can be only limitedly be impacted by dominate stakeholder behavior
3. use a platform that is long term and that will continue with or without success of transport project
4. include a data analysis trustee
5. include research and transport collaboration expertise within the project

6. start the transport collaboration on specific flow with simple requirements
7. discuss future collaboration scenarios in relation with developments that are ongoing in regards of current collaboration plan
8. define how benefits/risks of combined transport will be shared
9. gain approval of data collection during before pilot and for after pilot
10. gain financial backing for data analysis, monitoring software and other startup costs

Given the dynamics of the air cargo industry and users of air cargo in relation to a specific forwarder and airline, it is of crucial importance that an open platform [point 1] is used to develop the project at hand, as during the development phase changes can easily occur that affect the suitability of one or more companies to collaborate at a given handler. This is also why further collaboration scenarios should also be included during the pilot project [point 7]. During the setup of the pilot, differences in the use of Martinair operated flights at Menzies caused a significant decrease in import volumes for the analyzed companies for example, that was not expected but has had high impact on the amount of cargo that can be allocated to combined transport for certain shipments. Having an open platform that also includes potentially interested parties, it can be helpful to adapt the pilot project in later phase or speed up the process for the establishment of new pilot projects. When an open platform is used, (new) possible candidates can join the project at different stages, when for example a starting company leaves. When a platform/organization is used [point 2] during the development phase, it is advisable to ensure that dominate stakeholders cannot use their power to modify or delay the project within the used platform. This can be realized by using a platform that can only be influenced to limited extent by strong potentially opposing parties. Priorities of companies involved in new collaboration projects can change overnight, therefore it can take a long time before a new project is realized [point 3]. To ensure support for development stage a platform should be chosen that either can support a project for long period of time, or extension of the support period is highly likely. Given the lack of collaborative transport that has been applied and the reluctance to share data with key competitors within the air cargo system, it is also import to include; research, collaboration and data trusty analysis stakeholders in the development stage [point 4/5]. This will make it possible to analyze flows and different setups of collaboration in more structured and supported way (both on knowledge and trust). Also issues regarding completion law could be avoided if an external part, such as a trustee is charge of analyzing data and also defines the costs of collaboration in objective way. Adding complex requirements to combined transport will make it more difficult to optimize combined transport and will also reduce the potential to make easy tradeoff [point 6], therefore a collaboration project should start with simple requirements that are easily accepted by all involved parties, even the parties that might not directly join the intended collaboration at the start. With current low operating margins of most stakeholder in the air cargo industry any project that is started should clearly define how risks and benefits are shared between parties [point 8]. This should also be further supported in order to gain the right level of commitment of the involved parties. Data analysis approval take an extensive amount time especially when large companies are involved, there when starting discussing about collaboration already approval should be requested to analyze relevant data, before, during and after collaboration pilot has started [point 9]. It is important to analyze data regarding this three different periods in order to analyze the way combined transport preformed compared to single company transport before, during and after the pilot. In order to assess how further project on combined transport can be improved and to reveal which companies supported to project as intended. Finally with limited financial resources that are currently available for a new project and the relatively high of project management and possible also for data acquiring, financial support should be acquired as soon as possible [point 10]. It can take very long to acquire new funds to support projects financially, this is way it should be realized preferably before the start of the pilot.

Starting Pilot

In order to make sure that the pilot will be succesfull in demonstrating the potential for transport collaboration several points have to be considered which are explained in the same way as the points above.

11. using monitoring systems for pilot transport performance
12. gain commitment of involved companies for a certain period
13. define clear communication for pilot between companies
14. assign project manager during pilot and weekly assessment to improve project even during pilot if needed

Due to the relative short transport times between warehouses and the relative time long time loading/unloading of shipments can take in relation to transport, it is important to monitor pilot performance, to ensure that the key challenges that occur during the pilot can be identified and improved for post pilot phase collaboration [point 11]. Air cargo transport is highly dependent on several routes, both seasons and external influences, therefore a pilot project should be run for a long period, in order to gain feedback on both low and high volume of combined shipment transport [point 12]. Due to the large size of the companies that are involved and the amount of parties involved it is very important that a clear communication is set up, to ensure that all parties can act and react on the use of combined transport based on the shipments that are ready for collection/delivery [point 13] and operational challenges that may occur. Depending on the complexity and scale of the pilot project it might be advisable to assign a project manager during the pilot in order to react and adapt the pilot project in the best way during the limited pilot period [point 14]. However hiring such a project manager externally or using a manager from one of the involved companies could be costly and it might be sufficient and less expensive to have several staff members assigned to supporting the project.

Maintaining collaboration project after pilot phase

In order to make sure that after the pilot, transport collaboration will continue in a succesfull way, several points have to be considered which are explained in same way as the points above.

15. assessment of pilot project in-depth with all stakeholders
16. scheduled assessment of collaboration transport performance (for onward collaboration)
17. scheduled possibility of trustee party to assess better alignment of flows of current and potential forwarders within or on other shipments segments at the airport

In order to improve the collaboration project after a pilot, it is essential to assess the pilot project with all involved stakeholders [point 15]. Due to the dynamics of shipments flows between a specific handler and a given forwarder over time, it is important to have regular scheduled assessments of transport performance [point 16] of combined transport in order to update transport collaboration according to changes transport performance, to ensure that collaborative transport is operating as intended. The dynamics of transport flows between forwarders around Schiphol and a specific air cargo handler could change dramatically over time, therefore it's important that independent party such as a trustee, can on regular basis assess transport flows of current and interested forwarders in collaborative transport to adapt and improve the potential of combined transport by including new forwarders or types of shipments [point 17].

12.7 COLLABORATION PILOT MAIN EVALUATION FINDINGS

Just before the end of this research the evaluation of the pilot project was conducted, the most important findings of the evaluation are pointed our below in this paragraph.

- The fixed capacity use over the day should be more adaptive, cargo that is checked-in before 1200 has a high priority for delivery, whereas later checked in cargo shipments can be transported more slowly or even the next day.
- Several important regular cargo flights with extensive amount of loose cargo, where moved from the pilot handler to other handlers, this had a high impact on the amount of loose cargo shipments for all forwarding parties.
- The extensive amount ULD shipments for two of three forwarders in the pilot at the pilot handler, resulted in low amount of loose cargo being over to the pilot concept (only about 90000 kilo in 9 days)
- Communication about shipments and the capacity for next transport were successful, due to fast response and proactive suggestions by staff of the involved handler during all shifts of combined transport.
- Several shipments consisted of being part loose cargo and containerized items, due to restrictions on transport of containerized items therefore less shipments could be transported.
- Preloading of trucks was not needed during the pilot as amount of shipments for the three forwarders companies could be handled without preloading and still transport all cargo during the pilot that was allocated.

- Transport costs based on the amount of kilo that had been transported was too high in the pilot , about (€ 0,06 / kilo), target was costs that would be half of his, therefore either including additional forwarders for combined transport or also transport ULD's will be considered.

Figure 68: Photo of pilot evaluation session at Menzies world cargo Schiphol.

The points above show that the fixed capacity use of transport for only loose cargo shipments that is not adaptive over the day or does not also including both containerized and loose cargo shipments, makes it very difficult to offer a concept for combined transport that can compete with single transport based on costs for the involved forwarders. It may is therefore important to not only asses the comparability of shipments (ULD/loose and combined shipments), but also the amount/kilo of certain shipments on specific flights, the arrival times of shipments and the flexibility for forwarders for delivery of shipments before and after 1200. The importance/restrictions related to these aspects for the different forwarders can influence the attractive on costs and operational performance of combined transport, when based on requirement and characteristics of these aspects measures can be applied to improve combined transport performance and costs attractiveness, it can make the involved stakeholders more supportive in regards to the use of combined transport. This means that offering combined transport with limited amount of companies on a specific transport flow, needs more adaptive use of transport and more flexible requirements regarding shipment delivery times.

13 CONCLUSIONS, DISCUSSION & FUTURE RESEARCH

In this chapter the conclusions, contribution, limitations of this research findings and further research are described, based on the combined analysis that were conducted for this research

13.1 CONCLUSIONS

This research has analyzed the most important internal and external developments within the air cargo industry and other related transport systems in regards to horizontal transport collaboration in order to answer the main questions of this research. The type of collaboration that was specifically analyzed in depth for this research has been horizontal collaboration, which means that companies on the same level of the value chain collaborate on their transport needs and capacity. The research questions which have been defined in chapter two will now be answered, starting with the main research question:

To which extent can the logistic operations of truck movements between the freight forwarders and air cargo handlers at Schiphol be improved, through application of one or more (new) horizontal transport collaboration concepts?

Given the extensive amount of air cargo handlers, freight forwarders and transport companies that are active at Schiphol and the current limited ability of even the largest forwarding companies around the airport, to realize effective utilization and a reasonable load factor of their inner airport transport movements, there seems to be a very high potential for improving the truck transport operations at Schiphol, with the use of one or more horizontal collaborative logistic concepts. The single company transport approach that is currently being used, has been reinforcing the challenges that forwarders currently faces related to the time to process truck transport and shipments at handling facilities, both on the average length of processing and the reliability of the process time. Due to longer average process times and the decreased reliability of processing the transport of forwarders also becomes more unreliable, which reinforces the need to generate additional transport movements in order to be able to collect/deliver shipments on time.

Besides this, the share of small sized shipments in relation to the total amount of shipments that are collected/delivered in general for forwarders at general air cargo handlers is also expected to stay high or even become larger due to;

- different use air cargo transport for both import and export shipments in general by key users shippers of air cargo
- the amount of flights that offer cargo capacity for key cargo trade lanes (both on passenger and full cargo aircraft)
- the type of aircraft that are used (less large full freighters / more passenger aircraft)
- the increased use of both on-airport and other airport for air cargo transport by large forwarders at a gateway

With average smaller booked shipments sizes it will also become harder for forwarders to combined shipments for export delivery and will be more difficult to collect a sufficient amount of shipments at any given time at a specific handler, as it can take up to 10 hours for all shipments to be processed of one flight. Therefore the dynamics of shipment flows between key air cargo handling facilities at Schiphol will also increase, as it will become increasingly difficult for forwarders to organize their own transport needs with reasonable costs and performances. This makes it more attractive for competing companies (forwarders) on the same level of the value chain to support either direct or indirect collaboration of truck transport at Schiphol. Especially when individual company collaboration, on a vertical level, related to transport movements, cannot be justified or supported based on the frequency, volume or value of shipments transported between a given forwarder and air cargo handler. To which extent logistic transport operations can be improved by horizontal transport collaboration does however not only depend on the difficulty of organizing its own transport in an effective way and the volume of shipments of a specific forwarder. Other internal or external developments can make it even more difficult/ easier to collect and delivery shipments in an individual way, which has a big impact on the actual potential for horizontal transport collaboration. Several different aspects have a big impact on the potential for improving logistic operations by the use of horizontal transport collaboration, the most important aspects that have been identified are;

- the freight forwarders involved in collaboration, to which extent effective partnerships can be established and managed
- the specific characteristics cargo flows of the forwarders at the air cargo handler which are involved in collaboration
- the ability and willingness of all the collaborating parties to support horizontal transport collaboration
- the current use and performance of own transport systems of involved companies
- the ability of forwarding companies to rationalize or improve their single transport use after supporting horizontal collaboration
- existing and further drivers that support/demand improvements for on airport transport for a given forwarder
- the flexibility and restrictions that are set on the use of both single and combined transport by the involved companies

Figure 69 below tries to define the main aspects described above for a specific forwarder in relation to the real potential of combined transport for a general air cargo system, that were identified in this research based on; actual observations, literature and a simulation model results.

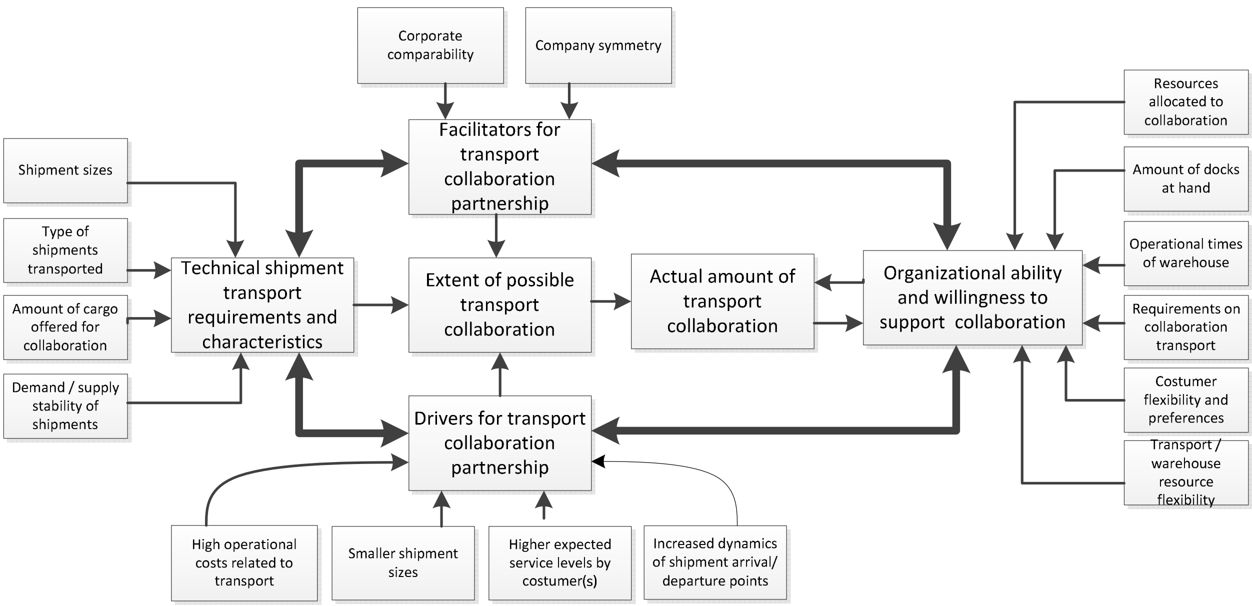

Figure 69: Conceptual model for transport collaboration between two or more forwarders and one air cargo handler.

Potential costs and congestion savings by applying combined transport (simulation model)

Transport collaboration of three large forwarders on loose general cargo for import shipments only can already result in total savings of up to €300000 a year, based on calculations of actual historic data of the three analyzed companies compared to single company transport costs that were analyzed for the pilot on basis of the simulation model. This relates to a potential costs reduction of between 10 to 40% of the involved forwarding companies on a specific transport flow (export/import) for either loose or ULD shipments based on the results of the simulation model. When a substantial amount of the largest freight forwarders active around Schiphol would jointly organize their loose cargo transport, a reduction of up to 25000 truck movements a year could be realized based on the findings of the simulation model and the analysis of loose cargo shipments at the different handlers at Schiphol for forwarders that operate around the airport. This would result in potential savings of up to 5 million euro a year related to inner airport transport costs for loose cargo transport alone. From a system perspective costs and transport movement reductions for ULD or loose shipments to the air cargo handler are ofcourse different than the effects for single company on a specific transport flow for ULD or loose shipments. The potential cost reductions are even higher than described above when transport of export and import flows are combined, however this has not been analyzed in this research with the constructed simulation model. Figure 70 below shows the potential reduction on transport movements and transport costs from a system level for three used levels of collaboration that were simulated. Based on these reductions it might seem that a high level of collaboration is desired as reductions on both costs and movements can continually improve for almost all types of shipment transport. When throughput times on a company level are also included in the analysis the attractiveness of combined transport will be reduced extensively. Given the fact that average throughput times of shipments can increase between 1 to 4 hours for loose cargo shipments and are almost doubled compared to single company ULD transport, not all companies involved in combined transport benefit in the same way. This means that it is very likely that forwarding companies that have better preforming single transport will often allocate less shipments to combined transport than forwarding companies which have a worse preforming single company transport system. Therefore, it is difficult to say to which extent horizontal transport collaboration will be supported and results in low costs or better transport performance, as this differs for each company and is also impacted by the companies that are collaborating.

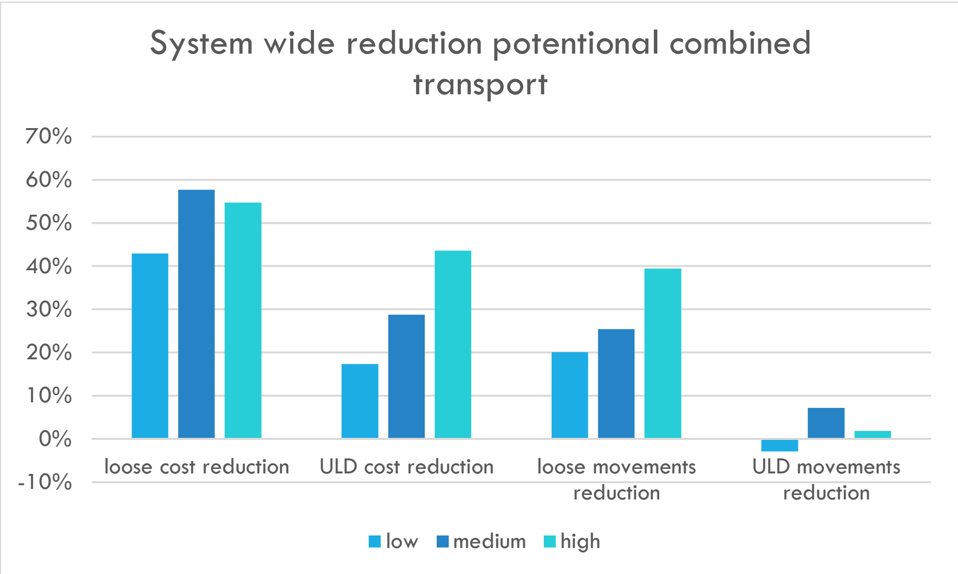

Figure 70: Overview of system wide reduction potential by using combined transport compared to single transport on costs and movements.

Besides the extent of costs reductions that can be achieved also depend on the actual collaboration potential at a certain air cargo handler, which differs between the air cargo handlers based on;

- different types of air cargo shipments that forwarding companies generate to and from the involved handler (ability to support combined transport with the given shipments)
- the degree of support to collaboration transport that can be given by the air cargo handler

At any large airport like Schiphol, there are big differences between the average amount of different types of cargo shipment handled at each air cargo handler, as these can be dependent both on airline, aircraft and route of operations which will influence the type of shipments that are processed by a given handler for a specific forwarder. The type of shipments that are processed can have a big impact on the suitability of applying combined transport, as certain shipments require faster or different type of handling that cannot be easily be used for transport that combining shipments of more than one forwarder. The general share, regarding the total amount of shipments/weight a forwarding company has for specific import or export flows of shipments, at a given air cargo handler and the stability of the flows of shipments that arrive and depart for each forwarding company is also very important. These three aspects influence both the ability to combine shipments and to have sufficient volume of shipments to allocate the combined transport, in order to reduce transport costs and maintain a certain level of required transport performance. Besides these aspects, the possibility of airlines to quickly switch between the air cargo handler that is in charge of handling their air cargo shipments and to start (new) operations to Schiphol or other nearby airports, within a short period of time, can also have a direct influence on the potential for transport collaboration between different freight forwarders at Schiphol and a specific handling facility. The impact can especially be extensive when the airline operates on high frequency, uses high cargo capacity aircraft and has a high share of booked shipments for the forwarding companies that wish to collaborate. Therefore it is much more likely that horizontal transport collaboration will be realized and supported over a long period of time, by one of the largest air cargo handlers at Schiphol that also handle a variety of shipments that are suitable for combined transport. Based on the amount cargo processed and the normally higher number of airlines operating at a given facility, which reduces the impact of individual airline/route on potential of collaborative transport on one or more different shipment segments. Unfortunately even if favorable conditions regarding the transport collaboration potential exist at a handler, not all freight forwarding companies at Schiphol believe that collaboration on truck movements is necessary, given their operational preference and restrictions, it can therefore not be expected that all forwarding companies operating at the airport, with their own truck movements at Schiphol, will fully support more extensive collaboration in the near future on a horizontal level. This can reduce the potential contribution of more collaborative transport the near future on a system level. Different strategies for collaboration should therefore be suggested for certain forwarders, in order realize transport performance, which may improve the support for collaboration, if new concepts offer added value over the existing situation. This could mean that certain non-horizontal collaboration concepts, such as vertical transport collaboration concepts, should also be assessed in more detail. The fact that extensive horizontal transport collaboration by large forwarders is non-existing at Schiphol, the extent to which truck movements' transport can be improved has thus not been proven at Schiphol. That is why most forwarding companies, which are willing to support collaboration and coordination of their transport, will not allow all of their cargo shipments to be transported in a completely shared combined transport way, which will often mean that even these companies will still have their own transport capacity at hand, that will be used for collection and delivery of part of their shipments. The system analysis of cargo shipments at Schiphol has shown that large amount of shipments are related to the forwarders around Schiphol and that loose cargo shipments of relatively small size are important to the flow of shipments, based on the amount of shipments that are processed and their limited weight. Based on the data analyzed and the estimations that were calculated, this further supports the fact that there is a high potential to realize combined transport for several forwarders in a coordinated way, that can both outperform single company transport on costs and also improve other direct and indirect operational performance indicators, which are currently non performing due to the unreliability and uncertainty of single company transport.

Besides that in the near future it can be expected that after succesfull implementation of one or more collaborative horizontal transport concepts that either reduce; transport costs, shipment throughput times or stability of shipment flow. More companies will be willing to support and implement collaborative transport logistics on a horizontal level. This could mean that most large forwarding companies will transfer a substantial part of their cargo demand between the main air cargo handlers and their warehouse, by using shared transport. However given the time sensitive nature of air cargo shipments and often the sensitivity of the products itself, due to customer requirements or value, forwarders will still be a certain amount of single organized transport, even if combined transport can be organized in such a way that is will outclass single transport on all key transport performance aspects. Besides this there are also several forwarding companies that will do whatever they can to keep full control of all their transport needs and they might be able to find a customer base that is willing to pay for such air cargo transport. The use of dedicated single company transport can however also be improved by shared use of a pool of trucks for different forwarders for their transport needs that cannot be combined, when this would be fully supported this could reduce both the combined transport and single company transport needs.

Collaboration concepts at Schiphol

Which concepts for truck movements have logistic operators at Schiphol currently considered for improving their operations and how have they selected them? [sub question 1]

Most concepts that have been supported at Schiphol by large forwarders regarding transport collaboration focus on improvements at the landside transport of large handlers or airside transport, and these concepts have resulted in lower transport costs on landside or faster delivery of shipments, by collaborating with a specific air cargo handler for a forwarder specific shipments. These types of collaboration either focus on shipments that involve special cargo or complete pallets, there is currently no specific collaboration on loose general cargo at Schiphol that involved two or more large forwarders. Therefore all collaboration concepts that are applied at Schiphol relate to a large share of the cargo processed at the airport for one specific costumer, most collaboration is aimed at vertical level between individual companies that are not operating on the same level of the value chain.

The main three air cargo handler collaborative concepts that are used to improve logistics and are successful to some extent in the current system are;

- the use of slots for collection and delivery of shipments for both loose and ULD transport
- airside delivery of shipments (import)
- 2door delivery for single forwarder (KLM)

The way these concepts are currently organized however do not always make it an attractive way to improve transport logistics, as forwarders for import are dependent on ability of the air cargo handler to ensure and support the provided concepts. Regarding the use of slots, forwarders depend on the ability of air cargo handler to ensure that the shipments are placed at selected slot on time or are delivered on time to their own airside location. Added to this all three main collaborative concepts that are currently used, do not include any form of direct or indirect form of revenue sharing, either the concept is provided free of charge, a fixed charge per kilo is defined. The limited ability of current collaboration concepts to charge based on actual costs and benefits can make it less attractive to support collaboration on a regular basis. Also with the average size of shipments that are decreasing and which are linked to a specific forwarder, it can become difficult to meet minimum requirements for use of slots or to ensure that transport capacity is at hand at a given slot time. Added to these challenges, the reduction of storage free hours at all major air cargo handlers both for import/export shipments, make it more difficult for forwarders to effectively use slots times in all cases. Due to the growing importance of costs reduction focus of air cargo handling facilities at Schiphol, the uncertainty about air cargo (un)loading times go up and with the reduction of free storage time limited, the ability of forwarders to deliver/collect shipment in non-peak transport times is therefore becoming more challenging. This further supports the potential of horizontal transport collaboration when the challenges of current collaboration are overcome by supporting organized transport on behalf of two or more forwarders.

<u>Changes to air cargo system at Schiphol</u>

How do the expected changes in the coming decade of infrastructure for logistic operations at Schiphol airport effect the application of logistic collaboration on a horizontal level? [sub question 2]

It is very difficult to generalize for which specific type of forwarder or air cargo handler horizontal transport collaboration change the future will occur at Schiphol, due to the dynamics of the air transport market and the changes that are expected to take place at airports like Schiphol. However, with the current low operating margins and slow air cargo growth outlook for air cargo processing at major Western Europe airports, it can be expected that the amount of handling facilities at Schiphol will be reduced in the future or at least will not increase. This will make it possible for more forwarders to realize effective collaboration with either the involved handling companies (vertical collaboration) or key competitors (horizontal collaboration), as the amount of cargo that is processed on average for a specific forwarder at a given handler could increase, this could justify either the use of one of the defined types of collaboration. At Schiphol there are currently three large air cargo handlers, which could support more extensive collaboration based on their size (amount of kilo processed) and frequency of loose cargo shipments (based on the amount of shipments) and thereby make a potential succesfull business case on organizing and or supporting transport on behalf of the forwarders to and from their facility with a limited amount of participating forwarding companies. The current overcapacity of the handling facility warehouse space, will even with large growth rate not require additional handling space in coming decade, this will make (new) or existing handling companies reluctant to invest capital intensive handling resources, that could improve handling operations. Therefore low capital investments that could improve operations at handling facilities are much more likely to be supported. Horizontal transport collaboration organized/supported by handling companies has a high potential to realize a more stable flow of cargo processing at major handling facilities, which could help the handling facilities to better plan and use its most costly resources (people), without the need to invest in capital intensive resource improvements. Depending on the growth of the air cargo market at Schiphol, the type of shipments that are processed and the amount of handling facilities, horizontal collaboration can provide high potential for forwarders, which lack the volume of shipments and resources to justify transport planning on an individual basis to improve transport performance and costs. It can therefore be very likely that further expected changes to the logistic operations at Schiphol will have a positive impact on the suitability and potential of supporting horizontal transport collaboration for either medium or large sized forwarders. Finally, changes to security and custom procedures for export processes at air cargo handlers, can and will likely impact the way transport is organized from major freight forwarders, these changes could result in coordinated custom/security processed that are linked to transport to a specific handler, when this is applied in the correct way this could improve the future transport collaboration for export transport.

Use of KPI"s to analyze transport & organizational performance

How can the most important KPI"s used both in the aviation sector and other industries be best compared and assessed? [sub question 3]

In other analyzed industries the use of collaboration on transport is often used also due to the potential for costs reduction, increase in frequency of deliveries and to improve sustainability aspect of transport. The frequency of delivery is often differently valued and could often be improved more by supporting horizontal transport collaboration in other industries, than what can be realized within the air cargo system, given the limited demand stability during the week for a specific forwarder and the different volume of shipments flow of import and export shipments over a specific period of time. Forwarding companies within the air cargo transport system are often more concerned about deadlines than frequency of delivery, as most shipments are planned for onward transport, that takes place either later the same day or even the next day. For forwarding companies receiving shipments before a certain time and being ensured that shipments arrive on time at the air cargo handler is crucial, because it could otherwise mean that shipments will not be accepted for the booked flight and new costly arrangements have to be made, to ensure onward transport. Transport is currently a lot less valued on the way it is effectively used related to its actual costs, or to which extent extra flexibility can be realized when single transport system becomes more reliable, by the use of for example combined transport. This has to do with the fact that the airport transport costs are only a fraction of the total costs of a freight forwarder and KPI measurement on other organizational processes it not applied that extensively. In other industries the longer distance truck transport is often a much higher part of the involved organization transport costs and can therefore on that basis alone already justify the use of combined transport. Given the rather short distance between the air cargo handlers and the forwarders at Schiphol the use of combined transport can negatively impact the amount of shipments that arrive after a set deadline. The combination of transport between different forwarders and (un)loading process will in most scenarios make combined transport slower than single transport, even with lower process times at forwarders and handling facilities for combined transport. This can make it difficult for most forwarders to support collaborative transport when only a limited amount of KPI's are used to assess the performance of transport related to cost and amount of shipments that arrive late.

Difference between current use of KPI"s and combined transport

How does the current logistic system for truck movements compare with the (new) collaborative logistic concepts on key logistic KPI's both on individual company level and system level? [sub question 4]

In order to assess both direct and indirect value differences of combined transport in relation to individual transport, forwarding companies will have to include certain KPI's to assess their transport performance, which is currently not used that often in the air cargo system. These relate to both direct and indirect factors that change as result of applying horizontal transport collaboration. In this research six different KPI categories have been used and the most important aspects are;

- the way application of transport collaboration allows for better use of its own assets within the company
- how productivity of staff is affected by different transport use
- to which extent the reliability of transport delivery times for both single and combined transport cane improve the overall organization performance and attractiveness of a forwarder for its customers
- how additional revenue can be realized by using existing single transport resources in different way, either for new transport demand or by being able to charge more for dedicated costumer transport

Sustainability related to an airport transport had been defined as KPI for this research as combined transport, as in other industries horizontal transport had often improved the sustainability of transport. However, given the short distances between the handling facility and the forwarders, it can be very difficult to improve sustainability of the transport, as combining loads means more shared deliveries; the distances traveled is expected to increase even with higher loads and fewer visits to the air cargo handling facility. Only when the amount of transport movements is strongly reduced and the visits to forwarding facilities can also be linked to a high minimum level of shipment (weight) for each forwarder, will it be possible to improve the sustainability of inner airport transport. Applying collaboration on transport results in improvements on either transport and other organizational improvements that are greater than realizing this on an individually level, which often cannot be derived from only looking at actual transport costs or average throughput time of shipment. This is why a more extensive analysis on a more broader list of KPI's is needed that show the difference of single and combined transport to its full extent, as impact on other parts of the organization can be different based on the actual use transport. The simulation case study of transport collaboration involving three forwarding companies and one air cargo handler, has shown that under certain conditions collaboration can reduce transport costs and increase the frequency of delivery for two the three of the analyzed companies. A reduction of between 10 to 40% of the transport movements to air cargo handler is possible if when combined transport to its full potential. This means that the single company transport use after applying combined transport should be further rationalized. However the average throughput time of shipments will increase when combined transport is used extensively, this way the impact of this longer average throughput on other transport and organization KPI's should be assessed in great detail. It could very well be that the increase in longer throughput times of shipments can be justified based on the possible positive impact it has on other KPI's and the limited negative consequences it causes.

Management of collaboration transport concepts

What are the most important stakeholder management issues related to the different collaborative logistic concepts that can be applied to Schiphol air cargo truck movement operations? [sub question 5]

Often a fair distribution of costs in relation to the contribution of involved companies is deemed of major importance when looking at traditional supply chain collaboration projects. In horizontal collaboration projects however, case examples have shown that companies are mostly interested in achieving lower transport costs while maintaining an acceptable level of transport performance, much less value is placed on the amount of benefits that other collaborating parties realize. The most important preconditions for succesfull horizontal transport collaboration therefore is, that the transport costs of the involved companies can all be reduced, to a lower level than current transport costs of the cargo flow on which collaboration is applied. In order to support more collaborative transport concepts it is crucial to start the process of stakeholder consultation at an open platform, in order to limit the restrictions for participating and get as much needed feedback to set up the project in the right way. Potentially interested companies that can be involved in the collaboration should be consulted individually before group meetings are started, to ensure that companies with the same interest and goal can be linked together from the start. This can help with to maintain progress and use regular meeting to focus on the most challenging aspects of realizing combined transport. Given the dynamics of the air cargo industry, reliance on a too small group of potentially interested companies should be avoided at all costs, as changes during the definition phase of the project could result in a negative business case for one or more of the involved parties. When sufficient parties are included in the consultation phase, this will give more room to be able to select the right companies for the realization phase that actually share the same beliefs and support the concept on a wider set of KPI's. These points also relate to the ability and willingness of companies to support transport collaboration in a way that it will result in benefits for all involved stakeholders. With the different flows of shipments between forwarder and specific air cargo handlers, a segmented approach should be applied to transport collaboration. Collaboration should start with shipments that can be easily combined and do not require additional processes, to ensure fast processing and limited requirements for combined transport. Currently many interested forwarding companies in supporting more extensive transport collaboration have been identified, often these companies have limited knowledge of the benefits and drawbacks of collaboration, that is also why it is also vital to include clear examples of a set of succesfull collaboration projects, support the proposed projects with experts on transport collaboration and analyze the logistic system of the involved companies in great detail. This is needed to find out to which extent the operations of the proposed forwarding companies and air cargo handler can be managed more effectively, by using collaborative transport and which positive effects can be derived other than reduction in transport costs both regarding the operational performance and the remaining single transport use. Companies are often reluctant to share company sensitive information regarding their operational and financial performance with key competitors, a good way to organize this, is to involve a trustee in horizontal collaboration projects. A trustee will act as guardian of information of all parties that will potential collaborate and will only use the provided data to analyze the best solution for all involved companies, given the requirements and preferences of the involved parties. The trustee will not share these data with external parties, it will solely use the gathered data to define the best transport potential and to allocate costs and revenues of the combined transport to the involved parties in most suitable way. Due to the dynamics of the air cargo transport, its frequent assessment of transport collaboration, regarding the segment of collaboration and the involved parties should be planned, in order to maintain a competitive combined transport system.

13.2 Major contributions of this research

Scientific contributions

Most research on horizontal transport collaboration that has been identified relates to research on collaboration for specific stable and large transport flows on relative long distances to key customers markets. This research has attempted point out the key differences between existing transport collaboration in several industries in relation to horizontal transport collaboration in the air cargo system. It further supports the notion of several other researches that supply chain management will become more complex and dynamic in the future, which would justify the use different types of both vertical and horizontal transport collaboration in order to improve existing supply chains in a costs effective way. In most of the analyzed industries it can be possible to realize both a reduction in transport costs and performance, due to the long transport distances, stability of shipment flows and relatively few shipment requirements. However all of these aspects are more complicated and challenging for inner airport air cargo transport collaboration. Therefore this research has tried to contribute to understanding and management of horizontal transport by analyzing a more dynamic transport system than is currently been analyzed in literature. This research has pointed out the need and justification for analyzing combined transport on a wider range of KPI's related to both transport and organizational performance in order support the use of combined transport. A conceptual model has been constructed on basis of existing literate and findings of the case study on collaboration that could be used in the further to assess the potential and actual use of combined transport in a dynamic transport system. Based on an actual case study a simulation model has been constructed that shows the difference and main impact variables for using combined transport, given the fact that simulation has not been used previously for analyzing horizontal transport collaboration in literature next to single company transport, this research also contributes to the way simulation can be used to analyze and compare different transport systems within the air cargo system with the use of actual data. The simulation model of transport system within the airport was constructed for this research based on fixed capacity use, the research has shown the main challenges of applying and using fixed capacity, which can be used by further research to assess the use of variable transport capacity. This research has shown that it is vital for dynamic transport collaboration to also asses transport reliability improvements that could be realized by supporting collaborative concepts, however this has to be proven in further research.

Sociality contributions

The development of the air transport industry at major airport like Schiphol depends on many different factors, having an attractive and sustainable air cargo system, has a major impact on the development of air transport system. Increased competition and changes of air cargo transport markets flows are and will impact the competiveness of Schiphol airport and this will influence the development of the air transport market at Schiphol both on short and long term. This research has shown that Schiphol airport will have to make its own airport system more competitive in the future, to face the current and future challenges that will impact its competitiveness compared to other airport systems. Using horizontal transport collaboration could make the airport more competitive and efficient in regards to air cargo transport, this could increase the long term sustainable use and development of the airport. With the high amount of people that work directly or indirectly within the air transport sector at Schiphol, improvements to the competiveness of air cargo system of Schiphol directly influences the economic developments that are linked to supporting and realizing air cargo transport. Besides this air cargo transport developments could also support further economic development, as new products and high tech industries use air cargo transport on frequent basis.

Industry contribution

Currently most stakeholders in the air cargo industry lack the knowledge or support of their own organizations to start, maintain and extend horizontal transport collaboration projects. This research has tried to identify the current and future importance of improving the competitiveness of air cargo transport system with the use of horizontal transport collaboration. It has defined based on pilot case, what are important steps to develop, support and maintain effective horizontal transport collaboration, and to which extent combined transport influences single company transport. Key variables that impact the potential of combined transport have been analyzed and the suitability of changes to these variables have been described in different collaboration scenarios. The simulation model has shown that in theory extensive reductions of transport movements to air cargo handler, reduction in transport costs and increase in frequency of transport deliveries is possible based on actual data of forwarders active at Schiphol. This research therefore can be seen as a guide on horizontal transport collaboration in air cargo system at major cargo airports, it can help all involved stakeholders to assess their own transport needs/demands in relation to the use of both single and combined transport and it points out the some important aspects that should be taken into account to succesfull develop and maintain combined transport in a dynamic transport system such as the air cargo system. Finally it points out current and future challenges for air cargo systems at major developed airports in Europe and to which extent horizontal transport collaboration can be used to overcome part of these challenges and reduce the dynamics and unreliability of the current transport by supporting selective long term collaboration projects with key stakeholders within the air cargo system.

13.3 DISCUSSION & LIMITATIONS

During this research several import limitations were discovered in relation to the usability and validity of this research the most import points will be discussed below.

Data limitations

A major limitation of this research can be found with the used data that was used to support the input and validation of both single and combined transport simulation model, companies within the air cargo system currently, either lack the data to support more extensive analysis or are legally or financially not able to provide the needed data for research purposes free of charge or without restrictions. Given the expected challenges the air cargo system at Schiphol faces, analysis based on real data are vital to improve the system with limited investments. The use of actual detailed data can also make the selection, segmentation and management of combined transport more succesfull and will also make it possible to better adapt single company transport. Cargonaut is the company at Schiphol that is used by most stakeholders in the air cargo system to; support efficient and effective digital transactions air cargo related handling operations and transfer of documents between stakeholders. However this company currently does not support efficient data analysis for the stakeholders within the system in a cost effective way. In order to realize that the research is actually in line with the actual situation it is vital that future research can use specific and actual data of the air cargo system at Schiphol. Without such data, research will be less supported and valuable. As it resulted in simplified decision logic for part of the constructed simulation model, due to lack of detailed data regarding transport and shipment. Besides this the increased use and benefits of benchmarking certain air cargo processes at other airports have shown, that the air cargo system at Schiphol will become less competitive if it cannot support such benchmarking analysis that are based on more detailed data. Therefore it is argued that a much more structured and supported approach to extensive data analysis should be in place at Schiphol airport. Schiphol has many different systems in place that can support such analysis, however companies involved in the air cargo system should adapt and support the use of data analysis in order to improve the air cargo system, with the use of both vertical and horizontal collaboration in an effective way.

Similar projects horizontal transport projects in air cargo transport

Unfortunately, during this research, no comparable project could be assessed in great detail in the air cargo industry at other airports around Western Europe, regarding the use of horizontal transport collaboration for major air cargo forwarders. Several attempts were made to compare and asses the way horizontal transport collaboration that is currently applied at Paris Charles de Gaulle airport, but the involved handlers in Paris (WFS), airport authority (Aéroports de Paris) and Schiphol Group (co-owner of the airport in Paris) could not help with getting either more detailed information on the collaboration project in Paris or provide us with hands on experience of the concepts. It is understandable that competing airports would be reluctant to share such information, but in this case handling companies are active at both airports and both airport authorities are actually shareholders of the involved airports it is less understandable. Therefore it would be advised that the Schiphol Group and the handlers that operate at both airports will play a more active role in supporting collaborative projects, such as the milkrun project, by actively working together with their colleagues at other airports, when they have already set up and defined a similar collaboration projects. This can create support for further collaborative projects and easier to realize with less effort and both airports can benefit from the development of the collaborative projects, which often are applied for forwarders that are active at both airports.

Forwarder similarity research and general forwarder attributes

This research has been based on information of limited amount of globally active forwarders that operate from Schiphol, all of companies regarding the simulation have had a high share of general cargo. A limited amount publications have found that support to some extent the assumption that large forwarders around the globe all have extensive share of general cargo. This can however not be fully validated, in order to generalize the findings and similarity of the analyzed companies in this research compared to other forwarders at Schiphol or other major airports more information about the share of loose cargo shipments that can be defined as general cargo. This is important as it becomes clear from this research and the interviews that loose shipments that are general cargo, are most suitable for combined transport, given their limited requirements for processing and relatively low value and priority for users of air cargo transport.

Generalization of Schiphol in relation to other major airports

Schiphol airport is one of the largest air cargo airports in Europe, it can easily be compared to other major airport based on cargo volume, forwarders and the amount of air cargo handlers. However this research has not been able to analyze the type of shipments or the share of loose cargo at one or more comparable airports, as this has a big impact on the potential for horizontal transport combined with the existing type of collaboration that is supported at other airports, it remains to be seen to which extent the results of this research can therefore be applied to other large air cargo airports. It might be that other flows or types of shipments are more suitable for collaboration on either vertical or horizontal level at different airports around Europe.

Stakeholder behavior

Besides the data related challenges and limited research that had been found related to air cargo transport collaborations on a horizontal level, there are also several stakeholder challenges that currently often limit the realization or extent to which new innovative projects can be realized. Certain market players at Schiphol airport have much more power and ability to block or support projects than the smaller players, who often want these new projects to be realized. It is therefore crucial that innovative projects that could improve the logistic system at Schiphol are supported/managed by an organization that can limit or exclude the use of dominate organization to either block or delay projects, with no or limited argumentation. Future projects that are likely to face opposition from one or more key stakeholders should therefore not be assigned to other projects that can be used by opposed parties to block or limit the development of new projects. Developing, managing or supporting collaborative transport projects is currently not a key focus area of the airport authority at Schiphol, however due to ability of airport authority to support long term projects, ways to further increase the facilitation or support of potential stakeholder sensitive projects that could improve the competitiveness of the airport should be given a more attention.

13.3 FUTURE RESEARCH

Based on the findings and limitations of this research several subjects have been identified that are suitable for further research

More complex and dynamic use of combined transport

Given the limited data and the dynamics of the air cargo industry it is vital to actually understand how dynamic or stable demand for large forwarders is over a given period for certain types of shipments between their own warehouse and that of a specific air cargo handler. This is why future research should be aimed at analyzing the actual demand stability over time for a selective amount of forwarding companies at one or two large handlers at Schiphol. This is needed to assess if future research should be aimed at analyzing the benefits of variable capacity use for combined transport. Dynamic planning with both a fixed and variable set of trucks might further improve the effectiveness of combined transport, but such an analysis should first be justified on the actual dynamics of shipments arrival and collection times in the current system. Segmented transport collaboration for certain type of shipments should also be assessed in more detail, this could improve the transport collaboration and organizational performance at certain periods of time. Future research should identify the potential of not only providing shared transport within the use dedicated trucks, but also look at the shared use of 'express' dedicated trucks between different forwarders within the airport, that only transport shipments of one company at the time. It can be argued that organizing single company express transport by one company for several companies who now use their own transport resources can be done more effectively, especially given the dynamics of shipment arrivals for both import and export flows. In order to further support the value of combined transport in relation to single transport organization on inner airport transport, the constructed simulation model of this research should be further expanded on the basis of actual data that has been gathered in more detailed. This could be helpful to support further if the defined potential of transport costs reduction and movements are actually in line with the operations of forwarders at Schiphol and to which extent the defined reduction in transport movements can be achieved.

Benchmarking of key transport related processes at forwarders and handlers

Given the limited use and knowledge about the potential of benchmarking air cargo handling processes and transport handling activities currently applied at Schiphol, future research should try to identify the need and value of such an analysis relation to Schiphol air cargo system and come up with a cost effective way of improving the benchmarking capabilities of both the forwarding agents and air cargo handlers at Schiphol. Only when companies are able to fully capture the most important direct and indirect changes in their organization when using either combined or single company transport, will they be able to fully give it the support and attention it needs to fulfill its maximum potential. Given the fact that not all companies are willing to support certain types of collaboration and not all types of shipment transport are suitable for combined transport, more detailed information on the impact of supporting different types of collaboration is vital for all involved stakeholders to focus on the transport collaboration with the highest potential for all involved stakeholders. Without detailed information, collaboration projects will start on less supported basis and could encounter startup problems that could have easily been overcome or reduced when more information about related processed and flows was used. Future research should therefore also asses the possibility of establishing a (new) separate organization that can support and realize effective data analysis management based on existing and future air cargo systems, which can help to point out the challenges and benefits of applying combined and single company transport in efficient and effective.

Revenue management analysis on transport collaboration

The complexity and dynamics of air cargo transport make the air cargo industry very well suited for applying revenue management techniques, this has however not been applied to great extent in relation to handling collection and delivery of shipments. Future research should therefore analyze if and under which conditions using different prices and services can be offered by air cargo handlers to improve both their own revenue and the transport performance of their costumers (forwarders). Currently most of the measures that are imposed to increase revenue for one specific stakeholder, significantly reduce the potential for other stakeholders to maintain a certain level of profit. This is why a more integrated approach should be used that assesses both the internal and external impacts of changes to air cargo transport for all involved stakeholders. When this is done in the right way changes to costs of transporting and delivery shipments at the involved stakeholders will be more supported and understood. This could improve the relationship between stakeholders and therefore make it easier and faster to realize further necessary changes that involve support of multiple different stakeholders.

Security and custom changes

Current and further changes to the custom and security processes at major European airport will have a big impact on the ability of both forwarders and air cargo handlers to effectively organize transport and processing of cargo shipments, therefore further research should assess how these changes will impact the transport and organizational performance of major forwarders and air cargo handlers. Research on this subject could be used to further improve the use and suitability of collaboration on transport movements between forwarders warehouses and air cargo handlers at a major airport.

Comparison of air cargo transport collaboration at major airport

This research focuses mainly on the collaboration concepts that have been applied at Schiphol and has related the potential for collaboration to the specifics of air cargo handling at Schiphol, in order to be better supported and generalized, the results of this research in relation to horizontal transport collaboration at other major air cargo airport. Future research should assess the key difference and similarities of shipment flows/processing and the related transport collaboration both on vertical and horizontal level in order to better understand how major air cargo airport cargo systems can be compared and assessed.

Stakeholder management on horizontal collaboration projects

The air cargo industry is known to be a very conservative industry, which can make it difficult to realize complex projects that challenge the existing status quo. Generally the air cargo industry consists of relatively small amount of stakeholders that have a large influence. It can therefore be extremely difficult to convince and obtain commitment of key stakeholders in the industry to realize potentially high value innovative concepts, especially when these concepts are differently compared to the current way system is organized. Also the difficult operating conditions and low margins make it more challenging to realize new collaborative concepts that require both financial support and long term commitment. This research has tried to support the development of new types of collaboration, by clearly stating the value and benefits of such collaboration in comparison to single company transport approach and defined a conceptual model to analyze the potential of collaborative transport, however more needs to be done to improve the commitment and involvement of stakeholders in (new) and challenging projects within the industry. Therefore future research should try to support a more structured and effective way of how innovative project that challenge the status quo can be better realized within the air cargo industry. This could also relate to research regarding the best way to organize financing and support of complex transport project in air cargo system via current cross channel platforms or by establishing separate organizations that can reduce the influence of dominant stakeholders.

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