MASTER

Design of decision support model for fleet scheduling in freight transportation

Raoufi, R.

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Design of a Decision Support Model for Fleet Scheduling in Freight Transportation

By

Rasa Raoufi,BSc
Student Identity Number 0788013

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Supervisors: Prof.dr.T.Van Woensel, OPAC (TUe)
Dr.E.Demir, OPAC (TUe)
A.C.Ernst (JDR)

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Department of Industrial Engineering
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Preface

This report is the result of a five month graduation project conducted at the planning department at Jan De Rijk Logistics and is written in order to complete the master degree of Operation Management and Logistics at Eindhoven University of Technology. I would like to grab this opportunity to shortly thank people who were involved during this project.

Several persons have contributed academically, practically and with support to this master thesis. Therefore firstly I would like to thank my head supervisor Tom Van Woensel for his smart advices and guidance and patience through this project. Next would like to thank Emrah Demir for his continuous support whenever I encountered with an issue. Also would like to thank Albert Ernst for his support within JDR and facilitating the requirement for this project. I would like to thank Daniel Uijtdewillegen for sharing his experience and time with me in order to incorporate all necessary operational aspects into the research .

Last but not least, I would like to thank my family and my friends for always being helpful and supportive to me, which without them I would not have been able to conduct this study as it is.

Abstract

This research study demonstrates that acquiring a transportation management system (TMS) which provides access to real time information about fleets is a necessity in todays transportation industry but still it is not sufficient to manage all scheduling operations in an optimal manner. Real time information requires each planner to decide about several variables regarding to each shipment in a limited amount of time. Considering the frequencies of planned shipments per day, decisions based only on experience can manifest as substantial cost driver for the transportation company.

The allocation model in this research study is designed to propose allocation decisions to the planners (based on a detailed cost structure) so that minimum costs for operations results. Besides, it creates an interactive opportunity with planners, so that for each shipment the planners can define different scenarios and compare decisions to select the best one. Therefore variables are logically distributed among the allocation model and the planners so that not only decision's quality but also solution time improves.

Executive summary

This research is conducted in order to design a model which could be used as a decision support tool within JPLEXS environment. This planning support model is developed to be applied by planners while planning freight requests (FTL and exclusive requests). The research is conducted in JDR's Roosendaal office (HQ) in International Transportation business group.
Currently, JPLEXS as a professional planning tool is developed and being used by planners at JDR's planning department in order to schedule all daily shipments. JPLEXS provides visibility of all elements involved in the planning such as drivers, trucks (pulling units) and trailers (pulled units) to planners with a defined status, so that each planner knows about the availability of elements to be selected for a trip.

JPLEXS is only providing real time information and very limited amount of constraints. Almost all decisions need to be taken into account by planners. Table 1 lists all decisions which need to be taken by planner(s) and JPLEXS.
As can be seen with the exception of two decisions which are supported by JPLEXS, all have

Table 1: Scheduling decision's distribution currently at JDR

Decision for FTL shipment	Planner	JPLEXS
Matching driver(s) with pulled and pulling units		✓
Matching pulled and pulling unit		✓
Driver allocation	✓	
Traveling time considerations	✓	
Freight and pulled unit matching assignment	✓	
Empty running decisions	✓	
Charter hiring decisions	✓	
Distribution of pulled units within the network	✓	

to be taken into account in a rather short time by the planner (approximately 6-8 minutes), without having visibility on costs or revenue (consequently profits associated with the planned shipment). In such a situation each planner needs to consider all variables and decide in a few minutes based on his experience and feeling. Regard to the fact that approximately 40 to 60 FTL and EXC shipments per day are being scheduled this research study is aimed to examine the impact of scheduling while using real time information and planning model on performance of International transportation group as its main research question.

In order to design the decision support model, detailed allocation assignments during the planning has identified, Table 3.1 presents new distribution of decision making among planner, planning model and JPLEXS. Compared to the previous figure planners are supported properly with most decisions without changing the way they used to work. It means that decisions are being made not only significantly faster but also aiming at minimizing costs associated with each of them (shipment costs, network costs e.g. idle costs) by applying the planning support model. It is worth to mention that as a result planners are not obliged to conduct any extra activity(s) while planning. The planning tool does not include all decision variables since it provides more flexibility considering different planning situations. Therefore

Table 2: *Scheduling decision's distribution when implementing VAPCI model*

Decision for FTL shipment	Planner	JPLEXS	Decision Support Model
Matching driver(s) with pulled and pulling units		✓	
Matching pulled and pulling unit		✓	
Driver allocation	✓		
Traveling time considerations	✓		✓
Freight and pulled unit matching assignment			✓
Empty running decisions			✓
Charter hiring decisions			✓
Distribution of pulled units within the network			✓

a logical distribution of decision variables among model and planners is created which not only prevents planners from planning pitfalls but also provides planners with the capability of testing various scenarios in order to take the best decisions with regard to each situation. Figure 1 presents a schematic view of the planning model implemented in JPLEXS and its interaction with a planner. As can be seen, the allocation model acts as JPLEXS's black

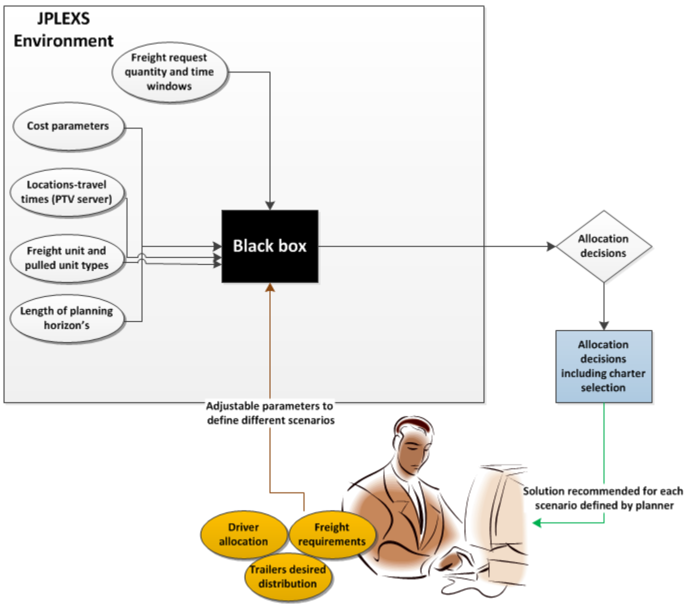

Figure 1: Schematic overview of planning model functionality within JPLEXS

box (currently JPLEXS doesnt have any decision function alike). The black box needs to receive relevant parameters as its input (which are already provided by JPLEXS in a real time manner). At the same time each planner is able to define various scenarios with regard to different situations and availability of drivers (and pulling units). As output, the model will suggest decisions regarding to using own assets or charter and also empty running decisions considering the desired distribution of assets in the network. The loop between planner and planning model can be repeated several times while new freight requests are received into the system or planner decides to change some of the parameters or both situations at the same time. The planning model has been assessed with real cases experiments and proved a saving of on average 5% costs per shipment and 12.9% as overall saving within the network compared to planners performance. Such a saving (direct saving) in the transportation industry is noticeable. Besides, applying such a decision supporting tool within the planning system (JPLEXS) will result in manpower saving and also reduction in emission level generated by own assets.

Research Findings

This study proves that taking advantage of a decision support planning model which works as systems (JPLEXS) black box could highly benefit planners and overall performance of the planning group in reducing costs associated with operation not only locally but also network-wise. Figure 2 illustrates the confirmed findings (advantageous of implementing such a decision support model).

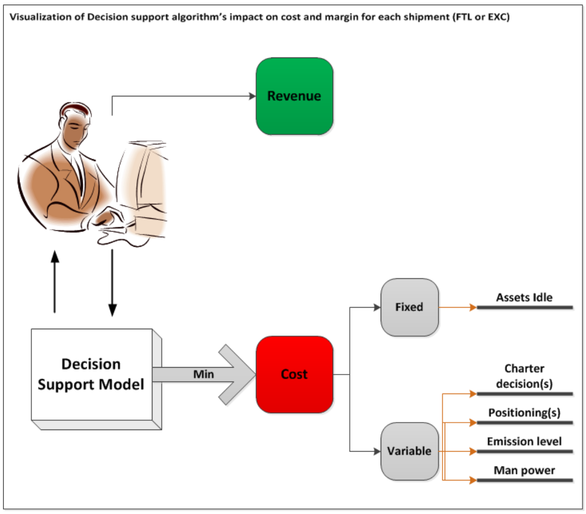

Figure 2: Role of decision support model while planning

In line with the Figure 2 the decision support model results into optimal planning with:

- Reduction in emission level generated by own assets.
- Significantly faster scheduling time (highly responsive to freight requests changes).
- Saving on man power.
- Reduction on empty running's driven kilometers.
- High quality planning (reduction in re-planning frequency per each shipment, fair allocation of freight requests among charter company and own assets regarding to network situation).

Therefore this model covers the (identified) gap in the current planning procedure (lack of attention to costs associated with each decision) which consequently derives to increase the margin for each shipment.

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Abbreviations

TPLP	Transportation Logistic service Providers
JDR	Jan De Rijk Logistics
JPLEXS	Jan De Rijk Planning, Execution and Scheduling
LSC	Logistics Service Client
LSP	Logistics Service Provider
TMS	Transportation Management System
LTL	Less Than truck Load
FTL	Full Truck Load
KPI	Key Performance Indicator(s)
CMR	Cargo Movement Request
EDI	Electronic Data Interchange
RFS	Raod Feeder Services
ITC	Information Communivation Technology
ILP	Integer Linear Programming
O.R	Operation Research
O-D	Origin Destination
TMS	Transportation Management System
APS	Advance Planning System
Webapp	Web application designed in order to track the freight unit
KMch	Hiring only pulling unit and driver from a charter company
Fch	Hiring a set (pulling unit and pulled unit) from charter company
ITG	International Transportation group
ETA	Estimated Time of Arrival
EXC	Exclusive freight requests (paid as FTL)

Chapter 1

INTRODUCTION

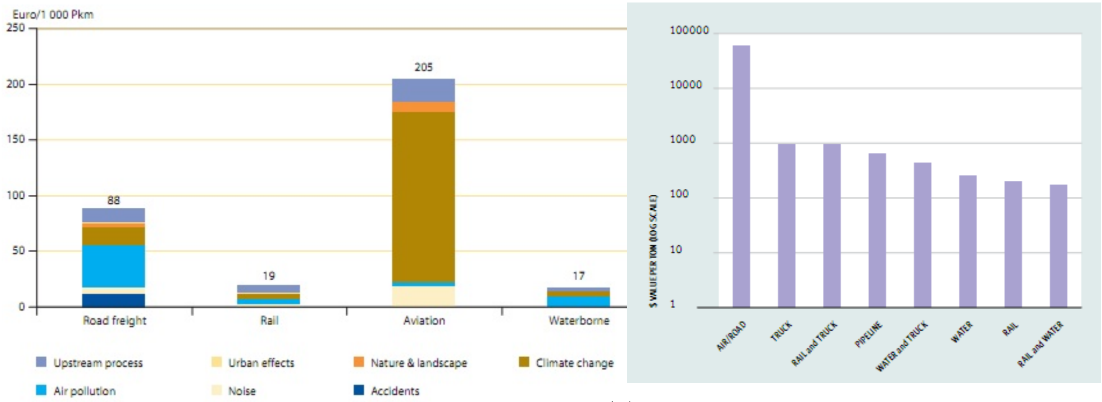
1.1 The transportation industry

The freight transportation world is moving faster and more efficiently than ever. This is mostly due to the application of new technologies such as Information and Communications Technologies (ICT), which brought services to a new level and counts as a new class of competitive advantage for transportation companies. These developments seem to be ongoing. Professionals in transportation and logistics have to keep up with the latest developments in the industry in order to make sure that they are able to compete in the fierce market.

On the other hand, changing regulations, rising transportation costs and driver shortage are just a few of the challenges in the transportation industry. Therefore transportation companies not only need to be keen to acquire the latest development in the industry but also to be flexible about dynamic behavior of regulations and market characteristics in order to survive in the competition.

1.1.1 Current situation

Regard the market characteristics, a huge amount of competitors and a thin margin in this industry, efficiency within operations is the key to succeed. Furthermore, as mentioned earlier transportation companies (especially international transportation) are highly affected by regulations. For instance, co_2 emissions are a new criteria which forces transportation companies to pay regard to the proportion of their emission level. Successful companies are those who see these new type of regulations as an opportunity to operate more efficiently by improving their network and transportation infrastructure.



(a) Road mode has the highest external costs after air mode compared with rail and water modes.

(b) Value of commodities being transported by truck (road/air) is highest compared to other modes.

Figure 1.1: Road mode special characteristics regard to its external cost and high security aspects comparing to other modes -[20]

Among all modes of transportation road is the most important mode to be focused on for improvements because of its high frequency usage, type of loads which it caries, and internal and external costs associated with using it (Figures 1.1 [20] and 1.2). Considering the aforementioned, implies the high potential of road mode to be improved, in terms of efficiency.

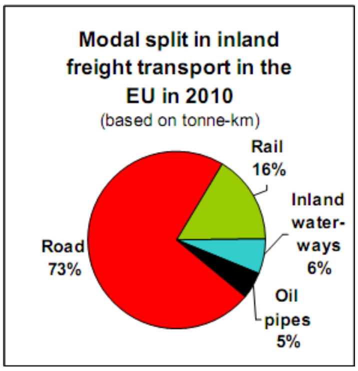


Figure 1.2: Modal split in freight transportation

1.1.2 Recent developments

As a new trend in the last decade in the transportation industry, Information Technology (IT) gained the majority of priorities, since it provides real time data and control both for transportation companies and their customers in which did not exist before. Besides IT development, horizontal collaboration is also one of the new trends. Regard to the market characteristics, transportation companies noticed that sharing their capacities/services can add positive value to their business and their target service levels. Nowadays intense cooperation among especially small and medium transportation companies is a good example of this trend.

As another popular new trends, can be called aim for maximum efficiency. Considering the thin margins in this industry, companies continuously seek for a way to cut costs; however, changes in European regulations are also one of the reasons, i.e. co_2 emissions, which force transportation companies (specially trucking companies) to reconsider on their fleets, transportation network and so on. Figure 1.3 [21] shows some of the most important areas that transportation companies have found beneficial to invest in.

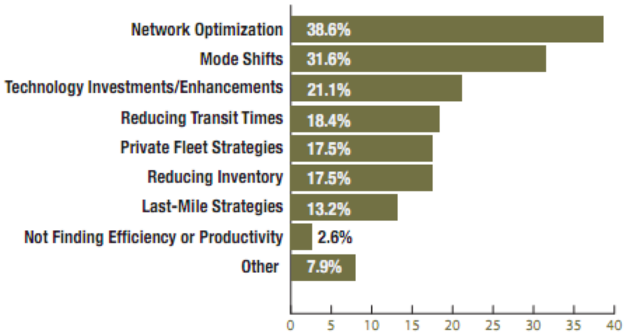


Figure 1.3: New trends in transportation companies- Network optimization and modal shifts are by far the two new trends in this industry.[21]

1.2 Jan De Rijk

Jan De Rijk Logistics (JDR) is a well-known brand in the freight transportation industry over 40 years. Possessing 26 locations in 15 countries, 650 trucks and 1,000 trailers provides an extensive transportation network throughout Europe. JDR offers various services and aligns whole supply chains as a one stop-shop service for its clients. JDR logistics business model includes four business groups:
International transportation, Benelux distribution,**Warehousing** and **Freight forwarding**. JDR's most competitive advantage is road feeder services to the emerging air cargo industry in Europe. It offers a wide range of daily schedule and flexible (FTL and LTL) feeder services in Europe. Services offered include regular daily airport-to-airport services as well as direct pick-up (door-to-airport) and direct delivery (airport-to-door) services.
Table 1.1 shows the size of JDR Logistics :

JDR serves a wide range of sectors, but has built up particular expertise in key industries such as: **air cargo road feeder services (RFS)**, **aerospace**, **automotive**, **hi-tech (and electronics)**, **fresh logistics**, **non-food retail**, **tobacco**, **pharmaceutical** and **perishables**.

1.2.1 Fleet description

As an asset-based provider of transportation and distribution services, JDR Logistics operates a huge, modern and diversified fleet of vehicles, both in international haulage and domestic distribution. Acquisition of the right type of truck and trailer is essential in order to meet customer satisfaction (service levels). JDR's international fleet supports various standards, a diversified range of trailers (including trailers and road trains, mega- and standard trailers,

Dimension	Numbers
Number of employees	Approx.1000 FTEs
Number of offices	26
number of countries	15
Vehicles deployed	+1000
Number of owned vehicles	+500
Number of owned trailers	1.200
Revenue	167 ml euros
Warehouse capacity	90.000 m^2
Certifications	ISO 9001, 14001, HACP, CCQI, TAPA compliance

Table 1.1: JDR Logistics's overview [23]

box- and curtain-sided trailers, roller-bed and flat floor. Specialized trailers such as low-loaders and trailers with slide- and adjustable roof support for out-of gauge type of cargo such as big-fan aero engines or alternative loading processes). An illustration of fleet can be seen in Figure 1.4 [23].

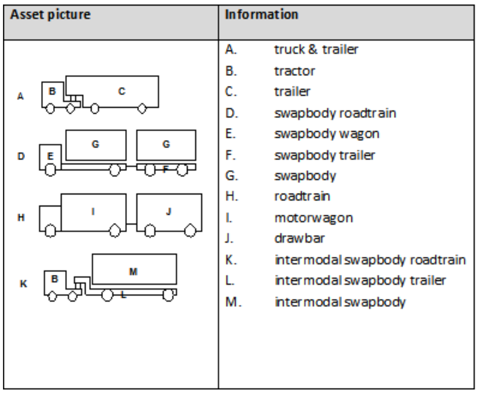


Figure 1.4: JDR fleet types

1.2.2 Transportation planning overview

Transportation planning process in JDR consists of three steps: (Re)planning, execution and completion. The stakeholders are: logistic service client (LSC), transport network manager, logistic service provider (LSP) and the transport regulator.

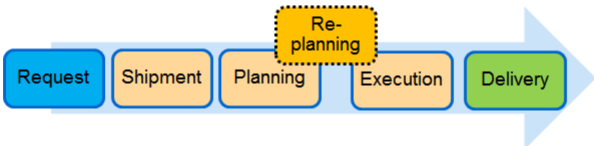


Figure 1.5: Generic transportation planning overview

1.2.2.1 Planning

In the planning stage, a freight request is determined by an order entry through customer support desk (e.g. phone) or several EDI based (email, web page, channels etc). The transport requests are being processed by the transport management system (TMS) and then the requests will be visible in the APS system (JPLEXS) so that the central planning department can start taking the request into account. Whenever a request is processed it will be visible in WEBapp (so that customers can track their shipment).

The planning process includes allocation of several freight requests to available assets (owned/charter) within the network. The availability of assets is determined by the principle of a rolling road capacity network. The rolling road capacity network in JDR means that vehicles are not only assigned to do a closed tour (serving defined locations and get back to the depot), but also open ended deliveries happen. In other words, freight requests are assigned to vehicles continuously through the network. For instance, a truck can start serving a request for a local customer and then drive (even for weeks) to the next customer due to the demand and planners assignments.

It is obvious that for different type of cargo different trailer are needed; however, sometimes one type of trailer is capable to load several types of cargo (substitutable cargos). Similar to the trailer and cargo's matching assignment, truck (pulling unit) and trailer types also needed to be matched. There are some flexibility (substitutability for matching). Currently this assignment is only being done based on hard requirement among trailers and trucks.

After allocation of right shipment on the right type of trailer (pulled unit) and truck (pulling unit), planners also should allocate driver in order to be able to execute the plan. Driving regulations (working and resting hours per day/week/month) are complex and restrictive. Therefore planner while planning a trip have to consider all these restrictions, with regard to travel time, type of commodity and type of assets to create a feasible match for execution.

Figure 1.6 [23] presents a schematic overview of the network. As it can be seen vehicles and their capacities are known, so whenever a new demand is processed into the system (JPLEXS), planners (in central planning department) attempt to assign available trucks to serve the request (considering JDR's important KPI's). Eventually this will result in a planned route with estimated times for loading and unloading, departures and arrivals, connections to ferry, split shipment handlings and pulled unit changes.

It is worthwhile to mention that currently planners decide only based on loading meters and time windows of the customers (in addition, the aim is to keep a truck moving through the network to fulfill the driving kilometers per day/month). Depending on a request, at a certain moment additional assets will be selected from transportation logistics provider(s) (TPLP- also called as charter); based on location, cost, capacity and service levels of the freight request. A transport agreement will be setup, transportation documents will be prepared and TPLP will be responsible for the delivery of CMR (cargo movement request) and the invoice of the shipment(s).

In the intentional transportation group, regions are divided among planners. Each planner

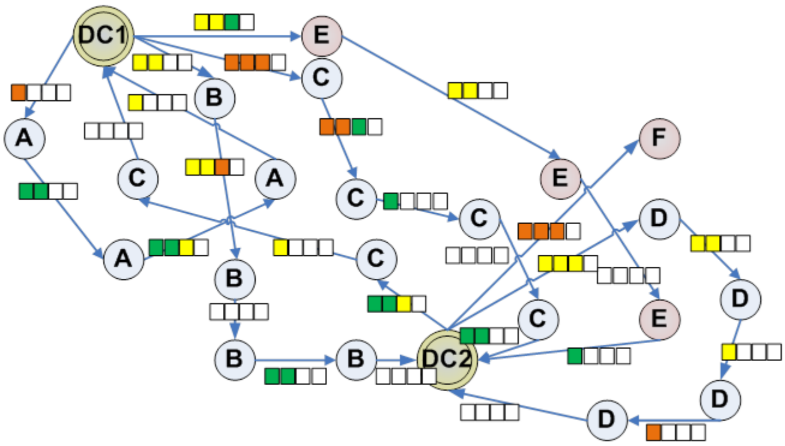


Figure 1.6: Network illustration of the international transportation group

has visibility on available (owned by JDR) fleets in a region (each region usually is a country) in which he is responsible for, and can also access freight demand from that specific region to new destination. While planning, the planner needs to take several decisions regarding to: freight loading meter(s), time windows of shipment, drivers working hours, asset allocation (e.g. decisions about type and quantity of fleet needed, positioning orders, and also charter assignment).

1.2.2.2 Re-planning

Re-planning in JDR is defined as re-allocation of shipments or drivers into assets. There are several situations in the planning system known as 'Event' which all are in the class of unexpected events and results in re-planning. These events are identified as: co-load,late report for loading, legal rest, driver overslept, delay loading, long loading, freight not ready, traffic, bad weather, accident.

Whenever one of these events occurs, planners usually receive a message from driver(s) which inform them about the event type. At that moment it is the planner's responsibility to decide about how to re-plan the current and future deliveries. As mentioned, planners only use their experience in order to make these decisions.
Re-planning in JDR is due to mainly three identified reasons (These reasons are concluded based on a survey with experienced planners at the JDR-HQ):

1. Arrival of new orders or changes in the volume of previous orders (change in volume of freight requests are mostly happening for air freight cargo as mentioned due to handling agent's way of working) which are released into the planning system (JPLEXS).

2. Poor planning of shipments which is identified by a planner and needed to be changed.

3. Unexpected 'events' which might happen during or before the execution of a shipment.

Regard the causes for re-planning, the first two are explained, but unexpected events needed more attention. Chapter two provides a comprehensive analysis regard to all recognized unexpected events.

1.2.2.3 Execution

Generally, planning at JDR starts (earliest) three days ahead of the execution. Mainly for LTL same day planning and execution happens, and for FTL orders it can be extended to two or three days ahead, depends on cargo, and equipment types. During execution of a planned trip, time dependent variables (traveling times, remaining distance, vehicle location etc.) will be adjusted by the system (every 30 minutes). However, for the third party logistics (TPLP) assets this is not possible; therefore manual interaction is needed.

1.2.2.4 Delivery and completion

After execution, and delivery of a freight request, JPLEXS will be updated automatically (status of the own asset will be changed), the asset waits for the planners to assign a new order to load. The last demand which is served will be deleted from JPLEXS (after 21 days) and stored at TMS. TMS is used to provide invoice for the delivered shipments.

1.3 Scope of this research

This master thesis is done at Jan De Rijk, focused on the international transportation group, which the transportation mode is road. All other groups are out of scope of this research. The algorithm, all experiments and surveys are anchored at this business group.

1.3.1 International transportation group

International transportation is one of JDR's business group which is clearly different from others in the sense of its network and the way this network is being managed . In this group, over 50% of freights are air cargo, and in total over 60% of freights are FTL and EXC requests. The network as explained earlier, covers 26 European countries, and has a 'rolling' flow depending on the requests. The international transportation group is JDR's most competitive

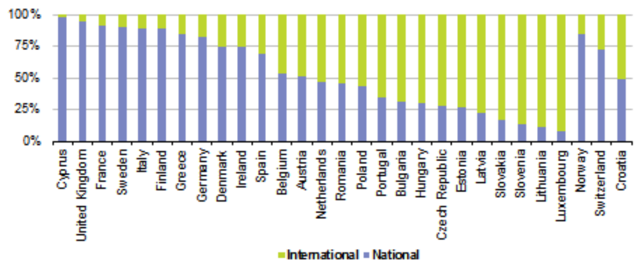


Figure 1.7: Proportion of National and International freight business in EU

advantage, which offers road feeder services to air cargo industry in Europe. Figure 1.7[21] confirms the importance of international freight in Europe for a dutch company (over 50% of the freight business for Dutch transportation companies is on the international level).

Another aspect of this planning group is the fact that assets (truck, trailer, and drivers) can flow freely in the network. This means that for example in the Netherlands there is a truck and trailer transporting a shipment with a Bulgarian driver and vice versa. Figure 1.8 [22] shows the proportion of these mix for each country in international freight transportation. As can be seen in the Netherlands, more than 50% of vehicles which are used to export a cargo are not registered in the origin country.

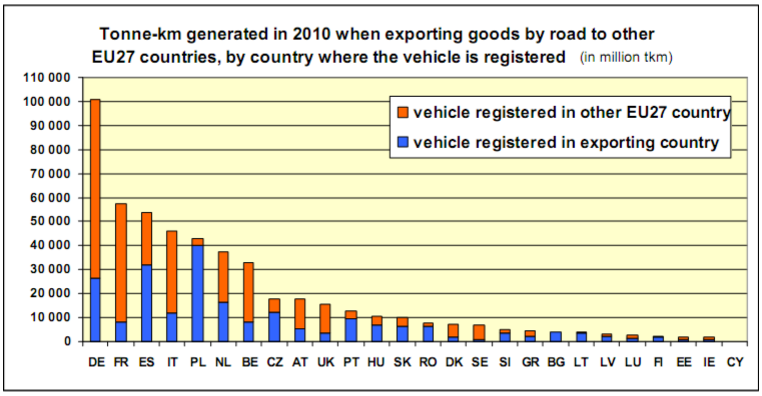


Figure 1.8: Asset registration in export cases-Vademecum 2010

1.4 Research contribution

Considering the way that planners are working in JDR and characteristics of fleets , cargo and rolling network (multi-commodity and heterogeneous fleet), this research is conducted in order to deliver an algorithm which can act as a decision support system (DSS) for the planners, to make better decisions (based on all costs associated) while planning (currently there is no function alike in the planning system). As a result of these decisions, it is expected to decrease the costs of planning. These costs are basically in two classes of fixed and variable. Fixed costs as lost sales, idle vehicle and driver cost, and variable cost are all associated with positioning orders- accepting or selling a shipment etc.

1.4.1 Problem statement

In a day to day operation, the planning department of JDR international transportation handles about 400 company's owned driving units, 500 company's owned pulled units and more than 1000 freight units. Next to the company's owned fleet, the central planning department coordinates the transport process for approximately 300 external trucks (assets from TPLP). Due to the rolling road base transport capacity network, trucks are continuously moving across Europe. Planning of drivers and assets are daily operations in JDR. Therefore these decisions act as driver for JDR's business. At the moment decisions are being taken only by experience without having any visibility on cost-revenue which have a direct impact on the company's profitability, emission level and customer satisfaction level (service level).

1.4.1.1 Research question

With regard to the way that the operations are handled in JDR and the level of complexity which planners face with (set of different decisions regarding to each shipment), the main research question of this thesis is:

"How do fleet scheduling acquiring real time data and decision support algorithm affect JDR's performance through the international transportation network?"

Therefore we are keen to see how developing a decision supporting model which aims to propose suggestions based on the cost associated with each decision can affect the current performance level based on relevant defined KPI in JDR's international transportation group.

1.4.2 Research methodology

The research methodology in this study is conducted in different steps. Figure 1.9 provides an overview of these steps and each will be explained in the following.

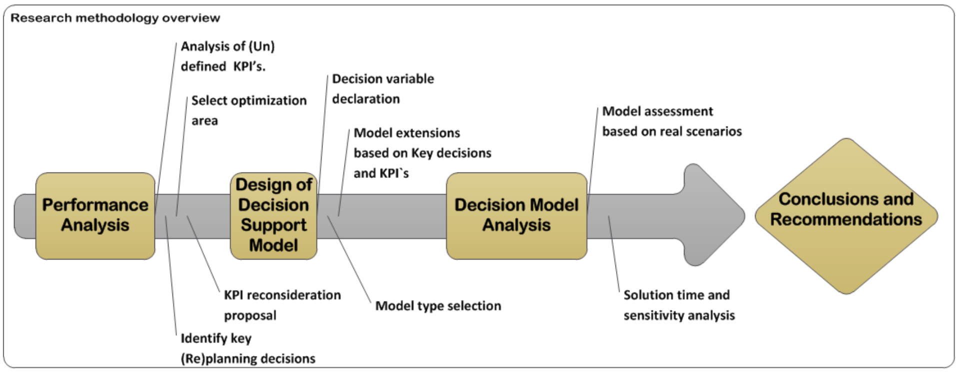


Figure 1.9: Overview of research chapters

This performance analysis includes both KPIs defined in JDR's operations and also other important transportation KPIs based on literature in order to gain enough knowledge about overall performance and to examine (defined) KPIs relative to companys business targets. As a result a reconsideration in the KPIs is proposed which is expected to have a positive effect on a companys operation performance. Besides, as a result of those analysis, areas which are potentials for improvement, and key decisions (while planning and re-planning) are identified. As a result based on the impact which can be gained by investing the identified areas, the optimization area is selected.

Following the analysis chapter, knowing the problem, decision variables are defined and type of optimization model is identified. Extensions are made to the basic model with regards to the most important variables which are identified in the previous step and also the way that operations are handled in JDR. As a result an advance algorithm is built and its application is discussed.

In the next chapter (chapter four), the advance algorithm is assessed based on some business cases which are common in daily operation and also some comparison is conducted among planners and model performance in the same situations. Consequently the research question is answered based on the analysis conclusion. The last chapter provides discussions regarding all findings, recommendations on the way to control operations, limitations of this research and also potential further research.

Chapter 2

PERFORMANCE ANALYSIS

2.1 Introduction to analysis

This chapter is dedicated to data analysis of JDR's performance in order to gain sufficient knowledge about the current performance indicators, identifying improvement areas and eventually concluding a decision for the study to be investigated. This chapter contribution to the research is as following:

First Ishikawa diagram is presented in which an analysis of re-planning and its causes are mapped, following the diagram all causes and their relevant planning KPIs are discussed in detail and eventually the chapter concludes with a choice in which area this study is conducted, in line with the analysis' conclusion.

2.2 High frequency re-plannings

In the last chapter different steps of planning a shipment from a request to delivery were discussed in detail, along with the difference between planning and re-planning. Due to the fact that from the stored data in the TMS system (and also JPLEXS) it is not possible to distinguish between planning and re-planning (since only final actions are being recorded into the system) a survey has been done with planners in order to have an impression about the planner's performance. One of the findings was that about 40% to 60% of all planned shipments are usually being re-planned.

Generally each planner plans around 100 shipments in a working day, and based on the survey it means that each planner has to re-do almost half of them again, which results in a amount of re-work for each of planners and of course extra cost for JDR. The fish bone diagram shows all reasons for re-planning a shipment in order of their importance (frequency). In the following each of these elements will be discussed and analyzed with available data.

Figure 2.1: Fish bone (Ishikawa) diagram examines main causes for Re-planning

2.2.1 Demand characteristics

As explained in the previous chapter, orders are filtered by customer service into JPLEXS, and from that time they are called shipments. All shipments are planned knowing:
Their volume (loading meter), transportation requirements (e.g, cool, secure,etc.), customer time windows and origin and destination of the shipment.

Shipments are released into JPLEXS mostly with a short time notice (e.g. 6-12 hours). Freight requests especially in the air cargo group behaves highly dynamic. This is mostly due to the way handling agents work and distribute air freight cargo for transportation companies. For instance it is very likely that a freight increases or decreases only an hour before the loading and therefore this adds to other challenges that JDR has to deal with. Figure 2.2 presents a cumulative shipment requests for the period of two years in the international transportation group. A seasonality trend in freight request can be clearly seen.

Figure 2.2 presents total presents total cumulative freight requests and their moving average for each month. Except dynamic characteristic of freight request, there is another challenge that JDR has to face low standardized freight information. It happens frequently that height and width of cargo (especially in air cargo) is not the same as it is in the request. Hence it might be the case that loading is not possible and another pulled unit is needed to be allocated which results in extra cost and delay in delivery for that particular freight unit. In order to solve this problem, it seems that more cooperation with customers and especially handling agents is a necessity. In the following a selection of findings are laid out analyzing recent data.

Figure 2.2: Cumulative freight requests data per each month from Jan 2011 to 2013 with moving average.

2.2.1.1 Time windows analysis

Time windows are one of the elements of customer service level, therefore delivering and loading on time plays a key-role to satisfy and keep customers loyal to JDR. However, not all time windows are not considered to be hard (strict), which give flexibility to JDR planners with planning shipments. Figure 2.3 illustrates some unloading delays with regards to each commodity group in JDR. As can be seen air freight cargo-which shapes the majority of commodities in the international transportation group has the highest delay, mostly due to the way handling agencies are working (a huge delay in loading and subsequently on delivery as well) and also low standardized cargo information.

Figure 2.3: Left: Mean unloading delay regard to each commodity group
Right: Mean unloading delay for 1869 freight requests with their frequencies- proves a mean of 9 hours unloading delay in average.

The histogram presents an analysis over 1869 different shipments and confirms an average of 9 hours delay in delivery for each shipment in the group. This analysis is only done based on unloading (delivery) delays (due to the fact that loading activity data are not reliable to use because of not being adjusted by the planners after a change happens with original plan).

2.2.2 Planning quality

As mentioned earlier, JPLEXS provides all different types of information regarding freight requests and assets status (drivers, pulling and pulled unit), but does not support the planners's decision on planning shipments. Therefore planners need to decide based on their experience using all information provided to them. One valid argument against the way planning is done currently is lack of visibility on cost/revenue associated with each decision that a planner needs to make which affects some KPI's negatively such as empty running and average loading meters.
Careful consideration in the planning phase can shed a light on several disadvantages which are listed here and illustrated in the data analysis afterwards:

Besides, planners have to decide in a couple of minutes for planning a shipment which increases the risk of committing and error or making a sub-optimal decision while planning a shipment and due to the fact that there are thousands of shipments being planned daily, a small 'mistake-bad decision' can derive huge cost for the company on a yearly basis. Average loading meter, empty driving (running) and kilometer driving by assets are other important KPI's related to planning;however, empty running (positioning) is not an official KPI in JDR. In the Following an analysis of each KPI is presented.

2.2.2.1 Loading meters

It can be seen that in both figures there is a high frequency of zero loading meter and utilization showed, this is due to the fact that within each location there are a lot of small movements happening without being registered into JPLEXS. For instance mounting and dismounting, maintenance check. Furthermore, in each city there are some dedicated pulling units which are only responsible for operations inside the terminal and never load any trailer. Together this results in initial high frequency in both utilization and loading meter graphs.

Figure 2.5 illustrates average loading meters based on trailer type (pulled unit). As illustrated, fast with the lowest average loading meter represent the exclusive service for

Figure 2.4: Average loading meters and utilization rates of assets with their frequencies in International transportation group.

customer. In this type of service, called exclusive, the freight requests is paid as FTL to be delivered as fast as possible. Therefore being full does not play a role in this case, on the other hand as less loading meter loaded into truck the margin for the service will increase.

Figure 2.5: Average loading meters compared regard to the trailer type (pulled unit)

2.2.2.2 Kilometers (km) driven by assets

Figure 2.6: Kilometer driven by JDR's assets in 25 days with frequency of kilometer driven by different type of trucks (pulling unit)

2.2.2.3 Positioning (empty run)

Positioning is one of the daily decisions being taken by planners in order to fulfill freight requests at a specific location in the network. Figure 2.7 shows the analysis of one and six months of data for the International group. Again worth to be mentioned is that high frequency with zero positioning resulted from activities within each city (loading/unloading/mounting/dismounting etc.) which is not registered in JPLEXS system. Regarding the average shipment distance (500 km)[1] roughly 12% empty running per shipment can be estimated. Comparison of two graphs shows that the positioning behaves normal (Close to International average) in the data set of one month. A detailed consideration, shows that most of re-positionings are being done for distances upto 30 kilometers which make sense regarding all costs associated with this decision. However re-positioning even till 600 kilometer can be seen in the data which could derive from some maintenance check or poor positioning decisions.

[1]This is the average kilometers for this set of data- on the six months data set the average travel distances are around 370 km

Figure 2.7: Comparison of empty running's (=positioning) Kilometer of one month and six months of recorded data in International transportation group-JDR

2.2.2.4 Revenue-Cost analysis

Regarding the characteristics of JDR's network, controlling cost and revenue for each shipment is highly important. This analysis is based on the second half of 2012. It is worth mentioning that, maintenance costs are not included within this data, and driver cost is included implicitly (as a fraction of total cost for each kilometer). One of the most important findings in Figure 2.8 (next page) is that huge cost can be seen without having any revenue. This cost line represents the high frequency operations being done in the same locations. The similar figure for positioning and driving activities also confirms the fact that there is a huge amount of operations being done within each terminal and this operations are equal to pure cost for JDR.

Another draw back from the data perspective is that the data is registered into system (JPLEXS) in a very blurry way. This means that different activities are treated in a same way: For example handling costs, deliveries to wrong addresses, canceled shipments etc. are all reflected as one location activities and cannot be distinguished from the data. Therefore it is not clear what the reason is for high frequency activities or how they are being managed. On the other hand, in Figure 2.8 b (next page) a comparison between productive running and activity cost is analyzed. It is needed to define what productive run means in JDR: A productive run is a loaded asset (LTL/FTL) which derives a certain amount of kilometers and productive running is therefore defined as:

Productivity of each asset is one of the main KPIs in JDR which can be seen is fully based on revenues associated with each asset. This means that costs associated with operations remained hidden. Again, it can be seen that there is high frequency with zero activity cost, all these activities are again those being done within one location. Activity cost is also defined as a cost associated with each kilometer driven by a JDR asset (in the six months set of data the rate is 1.24 euro for each kilometer).

(a) Cost and revenue associated with each activity regarding shipments-a lot of activities with zero revenues can be seen.

(b) Activity cost VS. productive run- productivity runs with zero costs are mostly within terminal operations which are not registered in JPLEXS.

Figure 2.8: Revenue cost analysis JDR

2.2.3 Delay event

Delay events are introduced as third cause for high frequency of re-planning. An analysis is provided here to have a better grasp of the proportion of top unexpected events and the classification of being within or out of control of JDR. A data analysis (Pareto analysis) has revealed the top causes of these events. Figure 2.9 shows the result of this analysis:

The analysis presents top delay events which explain 70% of all unexpected delay events.

Figure 2.9: Top events identified by Pareto analysis causing re-planning in International transportation group.

A closer consideration reveals the fact that over 30% of the events are due to poor quality of planning or client behavior which in both cases they are manageable for improvement. Therefore over 30% of the events can be controlled with more efficient planning in JDR and increased cooperation with customers/handling agents. We were also keen to know how planners cope with an unexpected event, so a survey has been designed and dispersed among planners. As a result steps which normally each planner follows have been identified. Figure 2.10 presents the results for each of the high frequency types of events.

Figure 2.10: Re-planning steps followed by planners.

2.2.4 Planners and assets

Planners and assets are the fourth and fifth identified causes for re-planning. As discussed earlier some disadvantages that can be seen in the current way of planning is lack of defined rules or structures for planners to follow while planning a shipment. Currently myopic allocation is very likely to happen since there is no specific planning horizon or waiting strategies defined. Decisions are made without a clear visibility on costs and revenues and mainly based on experience and ad-hoc decisions. Considering JDR's fleet composition (pulled and pulling units), no rule or structure is defined with regard to allocation of them through the network. This is currently being done via verbal communication of planners amongst each other.

It seems that this structure/ rules can be best applied into the planning procedure if JPLEXS supports them. Proposals based on cost (or revenue) from JPLEXS can help planners to make much better and faster decisions (cost wise) regarding freight units and asset distributions. This lack of support from the planning system can clearly be seen when observing the planning decisions made by planners in different situations. In the experiment chapter some scenarios are defined and applied to illustrate these identified gaps.

2.3 Chapter discussion

Based on the conducted analysis, a reconsideration on KPIs seems to be a necessity. Performance measures in the transportation industry can be divided into two categories : operational efficiency measures and quality of service measures. Considering quality of service, it seems that JDR is able to highly fulfill its customers expectations by acquiring a modern and facilitated fleet; however, time windows are one of quality measures which still can be improved.

In the Ishikawa diagram increasing cooperation and standardization of shipment type with handling agents and customers are proposed as an external factors to improve on-time deliveries.

On the other hand, operational efficiency measures seem to be poorly considered while (Re) planning. All performance indicators are revenue driven (loading meters, productivity factor), therefore costs associates with each operation is not only applied while planning but also for some (idle fleet costs) they are not considered even as KPI. The draw back of applying KPIs lacking a link to cost (for instance productivity factor with kilometer driven by strict lower bound for trucks) is that when there is no freight requests it just causes to extra costs and probably lost service (by wrong positioning) without being seen by managers.

Therefore applying KPIs which are only based on revenue can result in costly decisions. Cost driven and revenue driven KPIs needed to be applied next to each other in order to present real performance. With regard to JDR's rolling network and reviewed literature a set of valuable cost driven KPIs which can be added to current measures in JDR can be proposed as:

From a data perspective, lack of management and control can be seen in the way JPLEXS is being used by planners. This can lead to a situation where some operations are out of out of control (since simply those operations are not visible anymore to the managers) and makes analysis impossible (unreliability of data). There is a need to facilitate updating data into JPLEXS and train the planners about importance of this data for the company's performance level.

Reconsidering the previous analysis, discussions and Ishikawa diagram, it can be seen that decisions based on cost can play a key role in daily operations decisions in order to decrease total costs and as a result increase the margin. With regards to the fact that JDR lacks such a decision support algorithm, development of such an algorithm for the planning system (JPLEXS) is expected to have the highest impact on the international transportation group performance.

Chapter 3

DESIGN OF DECISION SUPPORT MODEL

3.1 Introduction to the model

In the previous chapter, different factors in planning and re-planning of a shipment discussed. It has been concluded that a improvement in the planning stage has the highest impact on re-planning frequency and on the performance of other re-planning causes such as planners and asset distribution. This chapter introduces the most relevant work from academia. At the beginning, a base model is introduced, followed by several extensions until the final version of the advance allocation model. Theoretical foundation of model is discussed is discussed at the end of the chapter.

3.2 Planning and its priorities in JDR

Each day thousands of shipments are released in JPLEXS and being planned by the planners in which over 70% of them are full truck load (or EXC) requests. Therefore planning is a continuous operation in JDR and other similar transportation companies. (Re)Planning decisions in particular need to be taken quickly and accurately in order to ensure the profitability for the business considering the thin margin for each shipment accepted by JDR. The decision needs to be aligned with the company's KPIs and customer service level agreements. One of the known KPIs at JDR are productivity of the assets which is a revenue driven KPI.

However there are other performance indicators which play an important role in the (cost driven indicators) final profit of each shipment. For instance, positioning and decisions regarding to charter a shipment (In JDR no shipment is rejected after it is released into the system, if service cannot be provided using own assets the shipment will be sold to another transportation company- therefore this is a smart way which indicates more collaboration among transportation companies and also saves costs for JDR, specially for destinations whom are located out of JDR network), and cost associated with idle assets are those which the current planning system does not support in a structured way.

Planners typically deal with these situations relying on their experience and ad hoc decision aids, though the competitive nature of the freight industry calls for more systematic and efficient procedures that can take advantage of real time information on vehicle positions and their status. In other words, an ideal planning system, can be defined as the one which results in agile decisions which consider all associated costs and future outcomes for the company. As mentioned before, margins in this industry are narrow: There is a rigid upper bound for revenues for any arc in the network, no matter how huge the network or extensive assets are. This rigid upper bounds is resulted by the fierce competition among transportation companies.

The key strategy to win the competition battle is to cut as many extra costs (fix and variable) as possible. Currently the philosophy is to maximize turnover per assets in a specific time period (revenue driven strategy). If this can be combined with minimizing all the associated costs (currently does not exist as KPI) one could call it an optimal planning (strategy). JPLEXS is designed in a way that planners do not decide based on cost and revenue for each shipment, therefore a gap to the optimal strategy is identified.

3.2.1 Cost-Revenue based algorithm

Based discussions on previous chapters, It is obvious that planner's decisions needs to be at least supported by either revenue or cost associated. With regards to transportation rates on the market, it can be concluded that, first market rates are highly dynamic and second, they are basically exogenous to JDR . Additionally market rates do not have a transparent structure to be analyzed accurately enough (margins are not fixed due to market situation).

Operational costs at JDR are not as dynamic as revenue rates (calculation of cost is revised every two years however revenues can change significantly from one day to another). In addition, costs for each kilometer are transparent to JDR, meaning that that elements of the costs (manpower, fuel, insurance etc.) are known, and therefore within the control of JDR. As a result The decision support model ought to be based on cost instead of revenues.

As discussed in the analysis chapter, JDR is a revenue driven company meaning that all planning KPIs (loading meters, kilometer driven by trucks, productivity factor for each asset) are revenue driven and therefore all operations are focused to maximize revenues without any visibility on cost. This is another reason why a cost based model could be highly beneficial to support planning decisions.

3.3 Literature review

The task of allocating different freight requests with regard to the fleet and shipment requirements in academia is known as Vehicle Allocation problem (VAP) or Resource allocation problem (RAP). VAP aim to find best decisions to accept/reject a shipment based on anticipation of cost and revenue associated with those decisions. Investigation in the literature shows several different attends to tackle this problem. These literature can be classified from several aspects. One of the most important criteria regard using real time data is the dynamic attribute of the model. An additional one is the application of demand forecasting in the model. Some models do not forecast freight requests and propose decisions based on known demand, others include it since they expect decisions with regard to demand forecast impact in downstream.

Powell (1986)[24] introduced a dynamic vehicle allocation model in which demands are considered uncertain and are forecasted. This model calculates the marginal value (based on the revenue and cost) of having an extra vehicle in a region in the future and decides about dispatching. Therefore there are two types of arcs in that model, deterministic (for FTL) and stochastic (LTL and empty vehicles). Crainic (2012)[19] Introduced an SND model in a time-space network to manage a fleet with limited assets. In this work different cost factors are included in the model but neither forecast function nor any stochastic application.

Topaloglu (2005)[17] presents a dynamic fleet management model with random travel times. This is a stochastic version of the dynamic fleet management problem (DFMP) which takes into account uncertainty of travel times. An extra advantage of this model to others (DFMP) is the fact that this model decomposes by locations as well as time periods, meaning the model model solves one sub-problem for each time period-location pair, and in a certain time period, the sub-problems corresponding to different locations can be solved in parallel. Advantages of this decomposition are : shorter run time and most importantly reflecting the real world decision making behavior by dispatchers, which is in-dependency in their local dispatching decisions.

Yang et al (1998)[6] introduced a truck fleet scheduling model under real time information. This model is originally vehicle routing problem with time windows (VRPTW). Time and space are considered continuous and horizon is indefinite approach which separates this model from others. The objective function is quite extensive which include all fixed and variable costs related to a probable demand. Demand is considered single commodity and fleet is considered homogeneous. Laporte and Ghiani also has introduced the basic model of VAP, this model is an ILP deterministic single commodity, homogeneous fleet which tries to maximize the revenue for each decision.

All attempts which are discussed above consider homogeneous fleet. There is one model by Powel-Carvalho (1996)[10] which cover multy-commodity cargo (with limited substitution) with heterogeneous fleet in the allocation problem. In this model problem is modeled as dynamic control problem using a logistic queuing network (LQN-this model acquires markovian queuing application) approach. The author claims that this approach is faster, more flexible in reflecting the real-world limitations and provides integer solutions to the problem.

3.3.1 Identified Gaps

In the literature reviewed above two trends can be seen. The first class of models are applicable to industry but they have some sever limitations, for instance not covering heterogeneous characteristics of the fleet or allocation assignments which are needed decisions for transportation companies while planning shipments. On the other hand, the second class models are extremely comprehensive models (for instance Powel-Carvalho (1996)[10]) but they are first of all not easy to be implemented (as author confirms) for a business application in operational level and secondly they are not agile enough for operational purposes, means that solution time is out of range for operational applications (on average each planner needs around five minutes to make all related decisions regard to a shipment and plan it).

Furthermore, in all aforementioned models the distinction among pulled, pulling units and driver and the matching assignment among them is not considered which plays a crucial role while planning. Therefore they have assumed that all units (also drivers), are equally available and attached together (matched), which is far from reality in daily operations.

Besides, Most of these models are based on revenue. As explained earlier, revenues in transportation companies are almost out of control, secondly there is high fluctuation in rates from one day to another. Therefore from the operational point of view models which are based on revenues can not be perfectly applied by planners with regard to the way that shipments are planned in JDR (it makes their work more complicated instead of supporting their decisions).

3.4 VAP basic model

The reference model of the study is the revised version of the vehicle allocation model introduced by Ghiani[19]. This model has chosen since it covers basic aspects in allocation problem, and unique extension can be developed on it in a smooth way. The revised model is based on cost instead of revenue due to the previous discussions. Consider a set of nodes representing the locations that JDR provides transportation service to/from. Let G=(N,A) in which N is the set of locations and A arcs associated in the network. This model also uses time horizon for decisions with regard to freight demand, t represents the defined time horizon for each period. Locations are indexed by i, j and k. The associated cost of departing from the location i to j is represented by f_{ij} and the penalty cost for ordering an empty vehicle from city k to city i is presented by p_{ki}. Travel time is considered to be deterministic and it is shown by τ_{ij}. Freight demand from city i to j at time t is represented by d_{ijt}.

3.4.1 Cost structure f_{ij} and c_{ki}

Costs related to each kilometer driven by JDR assets is built out of several fractions. The cost matrix in the basic model, (f_{ij}) includes around 28% for fuel and manpower each, 7% for external costs (e.g. highway tolls), and 35% of overhead costs(these percentages are calculated based on early turnover of international transportation group). As it can be seen overhead costs is the majority percentage for each kilometer driven by JDR assets, which is the case for all transportation companies. This is due to fact that on average charters are cheaper than JDR assets specially on non-regular routes, since first of all they do not have the huge overhead costs and second, different charters have higher frequencies freight on some route (destinations out of JDR network) which JDR does not service. Penalty cost of empty running (c_{ki}) is considered 30% of the normal cost for each kilometer at the same arc.

3.4.2 Assumptions

1. Travel time between two locations is non-stochastic and proportional to distance.

2. The service time within each location is set to zero.

3. There is one type of vehicle and one type of commodity.

4. All vehicles are always available to be allocated.
5. Each demand is equal to a full truck load.
6. It is assumed that initial inventory of vehicle in each location is equal to zero.
7. Driving unit (driver and its truck), and pulled unit is considered together.

3.4.3 Decision variables

In the base model there are two types of variables defined:
x_{ijt} = Number of loaded vehicle(s) to departure at time period t from location i to j.
y_{kit} = Number of empty vehicle(s) to departure at time period t from location k to j.

This model proposes decisions only using own assets, meaning that if freight demands are more than capacity the algorithm is not able to come up with an optimal answer. Also variables are not integers which means that solution might not be expected in real decisions. Planning time horizon t needs to be defined (based on experience planning every four hours works the best for JDR), and also travel time τ_{ij} among different locations with known demand for each period are the inputs that model needs to generate the optimal solution.

$$Min \sum_{t=1}^{T} \sum_{i \in N} \sum_{j \in N, i \neq j} f_{ij}.x_{ijt} + p_{ki}.y_{kit} \tag{3.1}$$

Subject to :

$$\sum_{k \in N, k \neq i, t \succ \tau_{ki}} (x_{ki(t-\tau_{ki})} + y_{ki(t-\tau_{ki})}) + y_{ii(t-1)} - \sum_{j \in N} (x_{ijt} + y_{ijt}) = y_{iit}, \forall (i,t) \tag{3.2}$$

$$x_{ijt} \geq d_{ijt}, i \in N, j \in N, t \in \{1, ..., T\} \tag{3.3}$$

$$x_{ijt} \geq 0, i \in N, j \in N, t \in \{1, ..., T\} \tag{3.4}$$

$$y_{ijt} \geq 0, i \in N, j \in N, t \in \{1, ..., T\} \tag{3.5}$$

$$y_{ii0} = 0 \tag{3.6}$$

Constraint (3.2) is a conservation constraint making sure that assets are not lost.(3.3) assures that all freight request is handled. Constraints (3.4) and (3.5) dictate that number of loaded and empty trailers in the solution cannot be negative. With constraint (3.6) it is assumed that at the beginning of planning horizon the assets inventory is equal to zero at all locations.

3.5 VAP with charter

It has been discussed in chapter one that at the very beginning some freight demands are accepted by the customer service and released into the system. Usually the volume of these freight requests is more than JDR's own capacity, therefore for some shipments hiring a charter company needs to be applied. Since the quantity of trailers is more than trucks, whenever a truck is not available JDR uses charter which uses JDR's trailers and board computer on their truck (called ‘kilometer charters’ or ‘ad hoc charter’). In a situation in which that appropriate trailer is also not available, JDR uses regular charter company which is working with JDR on a regular basis (using both truck and trailer of the charter company).

The second version of the model is an extension to also include charter decisions. In optimization the model decides based on costs between hiring a charter or using own assets (including empty running decisions). In this extended model two variables and two parameters are added to the previous model. Parameter h_{ij} is the cost associated with hiring a charter from location i to location j. Γ_{it} presents the availability and external flow (if existing) that may affects number of trailers (pulled units) into the system, for instance a trailer sometimes needs to be checked (maintenance), or extra trailers can be added to the fleets etc. Therefore all assumptions hold for this model except number four,six and seven (this model only allocates based on trailer availability, in the next chapter the reason for this decision will be explained in detail).

3.5.1 New Decision variables

The definition of added decision variables is as following:
m_{it} = Number of available trailers (pulled units) at time t in location i.
z_{ijt}= Number of needed charter(s) from origin i to destination j with departure time t.

Figure 3.1 illustrates a few nodes in the network, for which there are freight requests (FTL) from i to j and also from j to p. In fact in this example node j is both origin and destination of some freight requests. VAP model, given the freight request and costs parameters and also availability of trailers in each node (Γ_{it}) proposes a number of full truck load(s)(x_{ijt}), number of empty runs (y_{kit}) from specific nodes to origin locations and also number of charter(s) (z_{ijt}) needed. All are given for a specific pair of nodes with their departure time in a way that total costs of all operation together is the least possible.

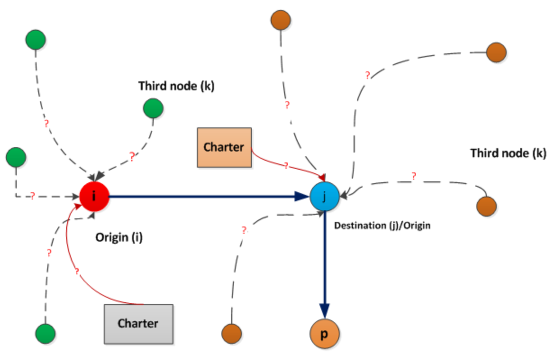


Figure 3.1: VAP model with charter

The objective function and constraints are extended as follow:

Constraint (3.8) is the new conservation constraint. Constraint (3.9) is the capacity constraint, making sure that at each location, number of full and empty trailers cannot be more than available trailers from last time horizon and those which will arrive at this location before the current time horizon (t). Constraint (3.10) assures that either own or charter trailers will satisfy the freight request at time t. Another extension comparing to the last model is that all variables are integer which makes the solution applicable to planners' decisions.

3.6 Idle and trailer type's costs and matching assignment

This section examines some detailed facts with regards to idle costs which are not taken into account. Likewise limitations while matching truck, trailer and a driver for the allocated shipments.

3.6.1 Idle costs

Considering the quantities of drivers, trucks (pulling units) and trailers (pulled units) it can be seen that number of trucks is lower than trailers and drivers. Also, comparing drivers and trailers, number of trailers are lower. Trailers are always generating costs depending on the type. For instance a cooler trailer yields the highest costs among all trailers. These idle costs are not included currently at JDR while planning.

In the new extension of VAPCI model we have incorporated this idle cost as well. Therefore the new extension forces the algorithm to prioritize using own trailers rather than hiring a charter based on idle costs of different types of trailers. It is worth to mention that planners most of the time are seeking for a truck to assign a driver and trailer to it, therefore idle costs of trucks is not a priority in the current fleet proportion.

3.6.2 Matching assignment

After shipments are allocated to a trailer (known as pulled unit) each planner needs to find a proper truck (pulling unit) and driver(s) for the trip. Therefore there are limitations for matching truck, drivers and also trailer with each other. For some type of commodities, specific trailer and (skilled) driver and truck is needed (e.g. pharmaceutical cargo). Thus, availability and matching of these combinations are counted as a hard requirement in order to execute a trip. Currently JPLEXS supports matching of drivers to shipments , and also trucks to trailer using soft and hard constraint which leads each planner while planning a trip; however, the planner still needs to match trailer type with the type of cargo depending on cargo information. In the extended allocation model this matching assignment is also considered as hard requirement.

3.7 Trailer availability; Critical element in allocation assignment

Earlier the limitation while matching trailer (pulled unit), truck (pulling) and driver in order to execute a trip has discussed. In other word if JDR aims to use its own fleet, each element of this match should be available while in daily operation this is not always the case. Thus, there are situations a planner may face with, which using only JDR assets is not possible:
For instance when an appropriate trailer is available but truck or driver(s) is not available.

Usually whenever a driver is not available the truck also cannot be used, since most of the time each driver is assigned to a specific truck. Normally drivers do not substitute their truck with each other and mostly when a driver is not available, the assigned truck to him is not also available. In such a situations the planner hires a truck and driver from another transportation company ('Charter Kilometer'- 'ad hoc charter') as a result JDR only pays only for the truck per kilometer driven and its driver and still can use its own trailer. Worth to be note that charter company not only uses JDR's trailer but also a computer board is installed in the truck, so planners can have the same visibility on the charter truck as they have on JDR's fleet.

Each planner only hires trailer and truck from another company (the second type of charter) when there is no trailer is available. It is in fact obvious that second type of charter is more costly (idle cost of trailer+ fixed charter cost). Therefore it is important to emphasize on the point that even if driver and truck are available the shipment without appropriate trailer needs to be chartered completely. This confirms that availability of the right type of trailer is the critical requirement for executing a shipment within own assets or at least partly, which results in higher service level for customers, lower costs, and real time management of freight for JDR. Figure 3.2(next page) illustrates a schematic overview of possible scenarios while planning a full truckload shipment.

3.8 VAPCI with multi commodity-heterogeneous fleet

As discussed earlier, in the new extended model costs associated with planning decisions are applied in more detail. Except considering idle costs for different types of trailers, depending on allocation of each type of trailer (or using charter) for a trip, different cost is generated on the same arc. For instance, loading a cooler trailer generates more costs than loading a tilt or box trailer, as also it generates more idle cost if it is not in use. Therefore utilization for this type of trailer becomes very important in the allocation model, as it is in daily business operations.

Considering the objective function, it compares all costs associated and using own assets, with hiring a charter, but in the constraints the availability of trailers are targeted. This is due to the fact, that if there is a trailer available, a planner still can use charter kilometer to execute a shipment (means only hiring truck and driver and pay based on kilometer, using

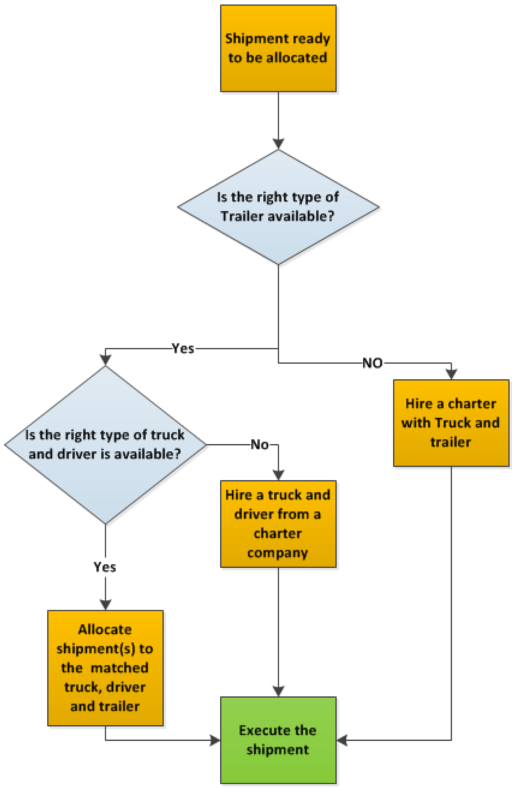


Figure 3.2: Shipments are planned based on trailers availability

JDR's trailer and also having the control over the freight unit by installing the board computer at the chartered truck) which saves both on variable (fixed rate to be payed using truck and trailer together) and idle costs (cost of a trailer being idle at one location) for JDR. On the other hand, if there is not any trailer available, or costs of using own assets are hire than charter, then it is beneficial to use charter for that specific freight request.

$$\varphi_{vp} \in \{0,1\} \tag{3.17}$$

$$t \in \{1...T\} \tag{3.18}$$

$$i,j,k \in \{1...N\} \tag{3.19}$$

$$v \in \{1...V\} \tag{3.20}$$

$$p \in \{1...P\} \tag{3.21}$$

Objective functions as mentioned have changed, in a way that idle costs for each type of idle trailer at each node is considered specifically, and also costs associated with empty or full trailers depending on the trailer type. Constraints (3.13) and (3.14) are conservation and node capacity which include the new variable m^v_{it}. (3.15) Makes the decisions to use own trailer or charter, based on availability and loading limitations defined in JDR. All variables are integer, and comparing to the previous model, two extra sets need to be defined for the model, commodity and trailer types. So then parameter φ_{vp} applies this loading limitations within the generated solution.

3.9 VAPCI with future visibility

The previous model also includes detailed costs associated regarding allocation to allocation decisions bound to origin's trailer distribution . Meaning that it does not consider the availability of trailer types in other locations in the same network . While planning a freight unit , planners always consider the number of trailer and trucks which needed to be sent to the destination, since if there is a high probability that from destination in the next time horizon there will not be any freight requests, this leads to high idle cost and also empty running for the network. As a result, planners decide based on experience and JDR's active routes to assign own fleets or hire a charter. Therefore it might be the case that there is available fleet for a specific shipment but a planner decides to charter since believes that there will not be any freight for that fleet to be back in the network.

Indeed allocation without considering the future demands affects the total network costs in specific time period. Therefore a new extension is developed in the model which provides visibility in other nodes while allocation decisions are made. It means that decisions about using own assets (including positioning orders) and hiring charter will also consider the availability of trailers in all other nodes in the network. This is implemented as a new constraint in the model which limits the number of different types of trailers in each node to a higher and lower bound defined for that node (location) for an adjustable time horizon.

In chapter two it has been shown that freight request is highly seasonal. This characteristic of demand can be used to draw a mean demand μ for each type of trailer for each specific period (based on data monthly interval is a logical choice) at each location in the network. Using standard deviation of this mean σ, provides a reasonable upper and lower bound for each type of trailer.

As a result based on historical data, there will be a bound for each type of trailer at each location, and the allocation decision is being made with regard to the average demand at all locations in the network, thus if a location has already too much (higher than the upper bound) trailer availability of one kind, or on the other hand too few (lower than the lower bound), the extended model proposes to hire a charter instead of using own assets.

Therefore the model also can support planners considering future demands based on historic data (indeed the mean and its upper and lower bounds can be updated). The bound constraint can be defined as following:

$$\mu_i^v - \sigma_i^v \leq m_i^v \leq \mu_i^v + \sigma_i^v \tag{3.22}$$

In which:

$$L_i = \mu_i^v - \sigma_i^v \tag{3.23}$$

And:

$$U_i = \mu_i^v + \sigma_i^v \tag{3.24}$$

3.9.1 Legal Driving hours regulation; another strict limitation while scheduling

Based on European regulations, drivers have to follow a restricted schedule in order to be able to drive legally. All planners need to take the regulations into consideration while scheduling a freight requests and assigning a driver for a trip. As a result for the trips with only one driver, if the traveling time is longer than legal driving hours of the driver, the trip will take longer than the defined (τ_{ki}) traveling time an becomes: Traveling time plus legal rests of driver. In the advanced VAPCI model this limitation is also included by an extra parameter ξ_{ki} which can be adjusted with the planner for each trip.

3.10 Advance VAPCI model

In the final revision of the allocation model, driver allocation also is considered in the objective function. This is due to the fact that depending on time windows of the allocated shipment (and also if there is a known freight waiting at the destination to be loaded) and travel time, planner(s) might decide to allocate two drivers into one truck, therefore the cost of drivers for that trip will be twice as high. Parameter Υ_{ij} represents the number of drivers allocated to a full loaded truck from origin i to destination j, and parameter θ_{ij} is the cost associated with wage of each driver per kilometer. Therefore f_{ij} will be fraction of costs associated with each kilometer except manpower.

This way the model is able to propose using charter or own assets in a situation when traveling time cannot be covered using only one driver or time windows of the shipment urges planner(s) to allocate two drivers on the same truck. It is worth to mention that it is assumed that for empty positioning planners are not allowed to assign more than a driver into a truck. As a result the objective function will be as follows:

$$x^v_{ijt}, y^v_{ijt}, z^v_{ijt}, m^v_{it} \in integer, \tag{3.30}$$

$$\varphi_{vp} \in \{0, 1\} \tag{3.31}$$

$$t, \xi \in \{1...T\} \tag{3.32}$$

$$i, j, k \in \{1...N\} \tag{3.33}$$

$$v \in \{1...V\} \tag{3.34}$$

$$p \in \{1...P\} \tag{3.35}$$

$$\Upsilon_{ij} \in \{1, 2\} \tag{3.36}$$

Constraints (3.26), (3.27) and (3.28) are the same as the previous model. (3.29) is the inventory constraint which assures that inventory of trailers at each type of each location is aligned with the defined upper and lower bounds. And as discussed parameter Υ_{ij} which needs to be selected by the planners based on traveling time, time windows and customer service level.

3.11 Theoritical foundation for VAPCI algorithm

In order to plan released shipments using the allocation algorithm planning horizon is defined. Thus freight requests can be released into the demand matrix d_{ijt} at each planning horizon, and the model can be (re)optimized after each freight release. The length of time horizon and also the gap from t to t+1 is totally flexible and can be changed. As in chapter one mentioned, after planning (optimization with the algorithm), there will be an execution time for the planned shipment before it actually executed. This amount of time is highly important in order to make sure that all departures will be on time. Figure 3.3 shows an illustration of this characteristics.

Regard to full truck load and exclusive freight requests, usually there are some known at the beginning of the planning horizon, but also new freight request can be released within the time horizon or even after. If we consider a known departure time based on time windows

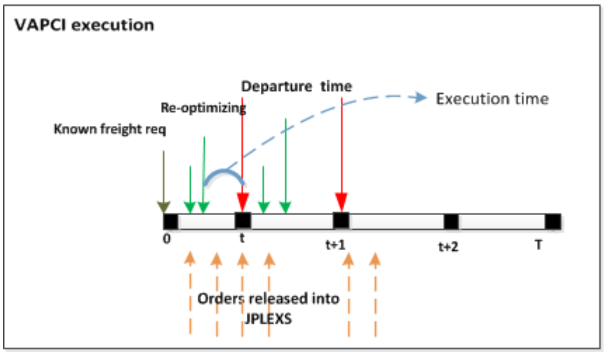


Figure 3.3: Algorithm execution illustration

and travel time of shipments, the algorithm can be re-optimized till a time horizon which is before execution time, in the Figure 3.3 re-optimization can be done till time t. This shows that defining a proper time horizon also can affect the algorithm's performance. However it is of importance that planning horizons should not be longer than freight (average) due time (time windows). For instance if the closest due time for freight requests are four hours ahead, then the planning horizon should not be shorter than four hours (which is 6 planning horizon per 24 hours) since it might lead to late departure of the freight request.

3.12 Chapter discussion

In this chapter the VAPCI advance model was introduced, this model includes all necessary variables with a highly detailed cost structure. While planning (in FTL or EXC) shipments planners can define different scenarios by altering the free parameters (number of drivers, freight requirements and desired fleet distribution) and make the best decisions based on each customer service level and optimal cost associated. Figure **??** provide a summary of all algorithms and their extension.

Table 3.1: Scheduling decision's distribution when implementing VAPCI algorithm

Allocation Model	**Extension on objective component**	**Hetero fleet** [1]	**Multi-com.** [2]	**Driver Al.** [3]	**Charte**	**Idle cost.**	**F.vis.** [4]
VAP base model							
VAPC	Charter decisions				✓		
VAPCI	Idle costs	✓	✓		✓	✓	
VAPCI Advanced model	Driver allocation costs	✓	✓	✓	✓	✓	✓

As mentioned above, using VAPCI algorithm not only planners can be sure about the optimality of decisions but also the solution time will be extremely faster compared to the current situation. Therefore it creates more room for planners to define and assess more scenarios based on cost for each shipment instead of deciding based on experience. The next chapter is dedicated to confirm the latter argument. It is worth to mention that defining the accurate costs associated with each parameter, and also the appropriate planning horizon has a direct effect on the result of this algorithm. In order to solve the VAPCI model, AIMMS solver has selected. This software uses a variety of know solver in order to solve this problem. VAPCI algorithm as an ILP problem has solved by CPLEX (12.5) solver.

[1] Heterogeneous fleet
[2] Multiple commodity
[3] Driver allocation
[4] Future visibility

Chapter 4

DECISION MODEL ANALYSIS

4.1 Introduction to the experiments setting

In this chapter scenarios based on daily operations are defined and decisions made by the VAPCI model compared to those of planners are analyzed. The analysis provides enough information about the model to be applied as a decision support algorithm to be used by planners. Furthermore a set of sensitivity analysis are conducted to give more inside into different impact that each parameter can have on the optimal answer. The last part of this chapter tests boundaries of the model and its solution time.

These cases cover different scenarios in daily plannings. For instance, the first case is one origin multiple destinations with highly relaxed assumptions, comparing freely allocation decisions between planner and model while the second case is multiple origin-destination, reflecting higher complexity level and compares planner and model decisions under situations closer to real world limitations.

4.2 Fixed origin-multiple destination planning case

Figure 4.1: Benelux distribution case study

The Benelux distribution case study contains 9 locations in the area, in which Amsterdam is the only origin, and all other locations are destinations. There are four type of commodities (multi-commodity) defined and three type of trailers (heterogeneous fleet). Further, there are loading limitations for different type of commodities for each trailer type. Three time horizons are defined in the planning case. Freight requests are released (visible to planners) at each time horizon. While planning, Planners does not have any visibility of the next horizon's demand, but in the end of the last time horizon they have the opportunity to reconsider all released freight requests and re-plan if they want to. There are some assumptions defined in order to make the experiment simpler and specifically measure allocation decisions:

1. It is assumed that the execution time is after the third time horizon.

2. Driver and truck availability is relaxed.

3. It is assumed that charter is always available.

4. Traveling time does not need to be considered while empty running decisions (relaxed time windows are assumed).

5. Costs associate with using different type of trailer units using own and charter is considered without any differentiation.

Furthermore, planners have visibility on initial inventory of trailers at each location, and also distances among different locations. In total there are 27 different freight requests in three time horizon and 31 loading units. All demands need to be satisfied. Also hiring a charter is considered to be always more expensive than using own assets (because of special origin and destination combinations) which is often not the case in the network but it makes planning decisions even easier for planners and indeed the challenge is about allocation decisions. Figure 4.2 shows the initial inventory of different type of trailers available in the network.

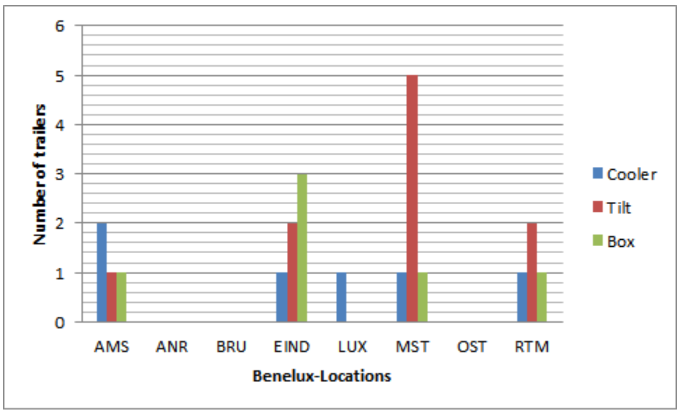


Figure 4.2: Benelux case-Initial inventory distribution

4.2.1 Case result

In the Benelux case study, the aim is to measure planner's allocation decisions considering available pulled units and hiring a charter. Therefore all other limitations have been relaxed in order to only measure allocation decisions. It should be noted that in this case cost structure is not defined in too detail e.g different trailer type have the same cost. The fact that number of freight requests are more than number of available assets distinguish this case from what mostly happens in the network. Therefore the choice between own assets and hiring a charter with regard to idle costs becomes more important.

As a result Figure 4.3 presents total cost resulted from planning using the model which is equal to 9833 €, the solution time of 0.02 second. On the other hand the average performance of planners resulted in 10225 €and average solution time of 16 minutes [1]. From the cost point of view a saving about 3.8% is achieved, besides the fact that planning time for the model is significantly faster compared to the planners average planning time. Although the cost saving can further be improved, it is worth mentioning the extremely simplified planning conditions. Even in such an artificial environment, the application of the algorithm pays off.

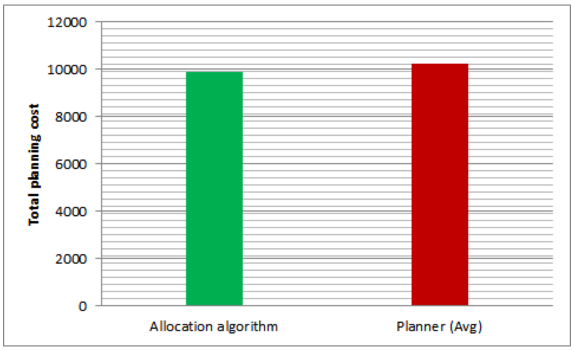


Figure 4.3: One origin- multiple destinations total allocation cost result

Figure 4.4 compares planning decisions among planners and the planning model. It can be seen that planners decisions not only have higher total costs but also higher empty running decisions (consequently higher emission levels).

[1] usually it takes for each planner 6-8 minutes to plan a shipment in the real situation

Figure 4.4: Comparison between planner and algorithm decisions

VAPCI outperforms planners performance in both total costs and solution time. It should be noted that the final costs of the algorithm and planners are sometimes very close, this is due to the fact that Benelux case has been extremely simplified in order to incorporate higher number of planners in the experiment. Although 3.8% means in average 12.76 €saving per each shipment which is almost half of average margin in a daily business (around 2% of an average margin). It is expected that in more complex and comprehensive setting this gap increases sharply.

4.3 Multiple origin-destination network

Figure 4.5: Multiple origin-destination case study illustration

The second case study differs from the first one is different in many aspects. One of the obvious differences is the multiple origin destination characteristics of the network which is also the case in daily planning. The other aspect is cost structures, in this case allocation of different types of trailer and even hiring different type of trailers associates with different costs for the model. Charter's fixed rates for each route is gathered based on real invoices, and also charters are not always available for all destinations.

Furthermore number of freight requests are increased to 48, while there are only 30 trailers of different type available to be allocated (this reflects the real situation of facing with 30% to 40% full truck shipments more than available pulled units). This is a norm regard to the locations incorporated in this case study. Many scenarios are tested within this case, for instance, the choice that planners need to make between using own or charter based on the destination's location and expected demand in the future from that location. Number of idle trailers at each location and the costs associated with them (for each trailer type being idle at a location different costs is considered based on the characteristics as price of each unit, yearly maintenance costs, insurance etc.).

It Needs to be mentioned that in this case, the number of locations increases from 9 to 11, but commodity and trailer types and their loading limitation stay the same. Compared to the last case one of the simplified assumption (while executing the case study with planners-although model considers travel times) is time windows of each shipment. Figures 4.6 illustrates initial trailer's availability at each location. In other words it is assumed that no matter how to plan the shipments, time windows will be satisfied.

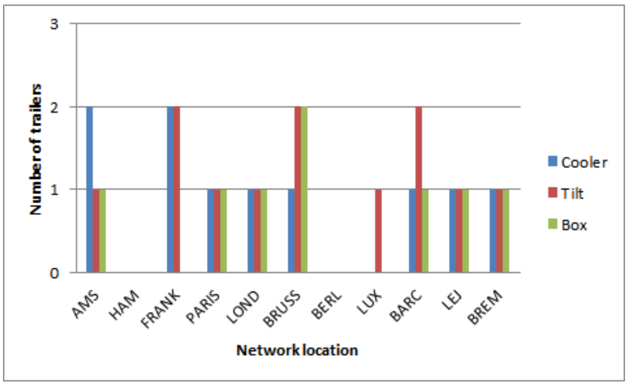


Figure 4.6: Initial trailers types at each location

4.3.1 Case result

Conducting the case with an experienced planner (without any time limitation), while solving the case using allocation model, figure 4.7 illustrates the result:

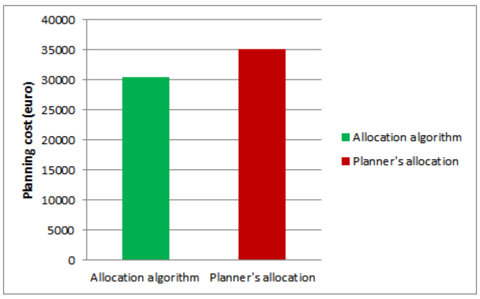


Figure 4.7: Multiple origin destination case total cost result

Alike the first case study, solution time is extremely faster than experienced planners specially due to the complexity of decisions the gap has increased exponentially. From the cost perspective final results present a saving of 12.9% in total cost for all shipments. Examining the decisions made by the planner and allocation algorithm figure 4.8 describes it as following:

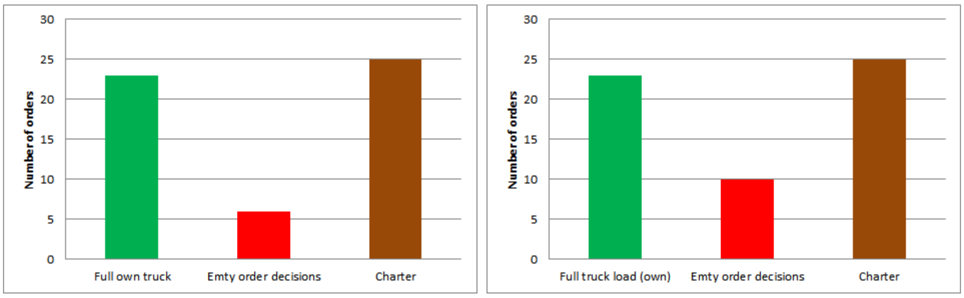


Figure 4.8: Decisions taken by planner and allocation algorithm [Left: planner Right:VAPCI]

As it can be seen the planner and VAPCI model both used the same quantity of own and charter in order to plan all freight requests, although this similarity cannot be seen in the way shipments are allocated to own and charters. Also the number of positioning orders decided by VAPCI is more than the planner's; However, the associated total cost of VAPCI is lower. Figure 4.9 illustrates planner and model's empty running decisions on the map.

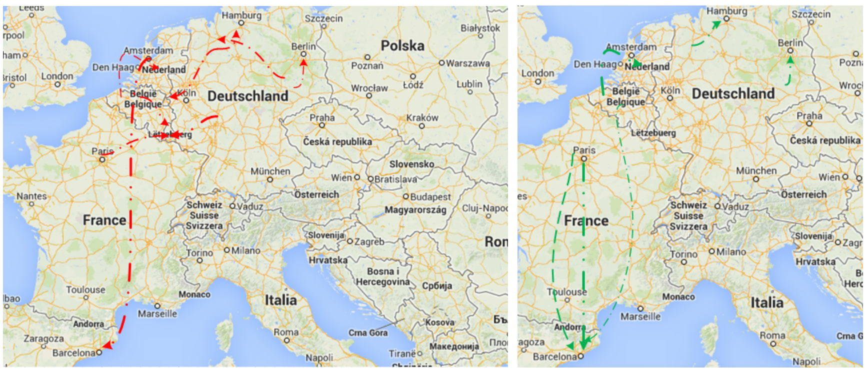


Figure 4.9: Map of positioning decisions for both planner and VAPCI model

Consequently figure 4.10 presents the differences in kilometer driven associated with positioning decisions (empty running) for each planner and VAPCI model.

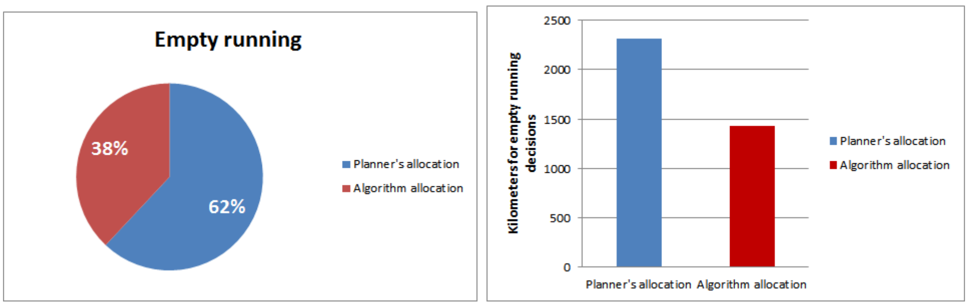


Figure 4.10: Comparison of Planner and VAPCI model positioning decisions based on number of kilometers driven

It is obvious that VAPCI model has used more positioning decisions than planners but in such a way that cumulative kilometers driven is as low as two thirds of planner's positioning decisions. The same difference can be seen considering shipments being allocated to charters and own fleet. This can be explained based on the fact that the allocation model considers costs in detail while making such decisions; however, planners do not have visibility of such a detail cost structure (they do not use any costs reference while planning) and make these decisions based on their experience.

As mentioned earlier allocation decisions should be done not only based on the current freight requests but also considering future freight requests and their impact on the network. Figure 4.11 presents the initial inventory at each location for this case.

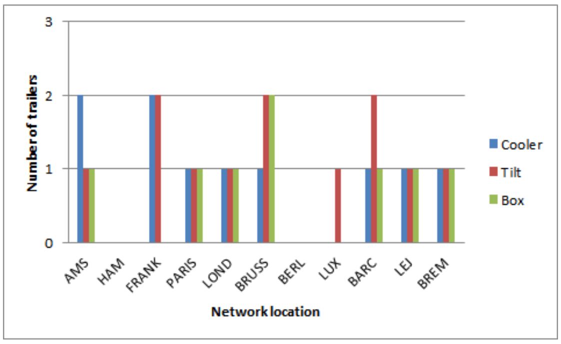


Figure 4.11: Initial fleet inventory at each location

After allocation of freight requests and assuming that all shipments are delivered to their destinations it is important to observe how assets are distributed within the locations in the network. Figure 4.12 shows the distribution of assets after planner's allocation.

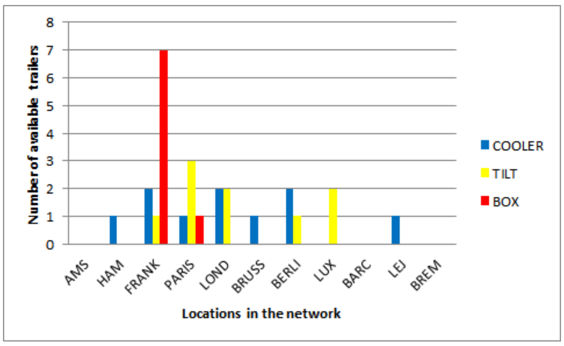


Figure 4.12: Distribution of fleets after allocation by a planner

As it can be seen some trailers did not relocate from their former positions (e.g. Assets in Lux, Lej), almost all box trailers are relocated to Frank, and there is no trailer available at AMS as one of the main locations in the network.

Figure 4.13 illustrates the distribution of trailers after being planned by VAPCI model.

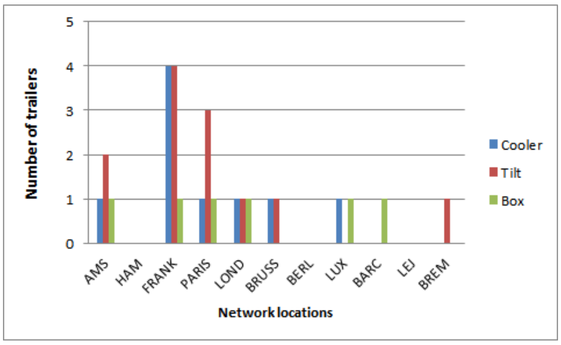


Figure 4.13: Distribution of fleets after allocation by VAPCI model

It seems that compared to the last figure, distribution of trailers is more balanced. This is due to the last constraint of the model in which availability of different trailer type at each location in the network (at each time planning for all planning time horizon can be specified). In this setting for popular locations in the network (e.g. Ams, Frank, Paris, London and Bruss) a limitation of having trailers of different type have defined.

4.4 Sensitivity analysis (p_{kit},c_{vj},U_i,L_i)

Considering all parameters in the final version of the VAPCI model. Parameters p_{ij} (penalty cost for empty running orders), c_v (idle cost associates with each trailer type at each location), L_i and U_i seem to be attractive for sensitivity analysis. Since if the cost parameters for full truckload (f^v_{ijt}) and driver wage based on each kilometer (θ_{ij}) increases , it leads to more charter decisions and if cost for hiring a charter (h^v_{ijt}) increases it will result in less. Therefore considering theses parameters to be fixed, idle costs, penalty cost assigned empty running and bounds for each location have direct impacts on y^v_{kjt}, m^v_{it} and the total costs.

4.4.1 Fixed penalty cost and variable idle cost and inventory bounds (c_{vj},U_i,L_i)

Figure 4.14 presents the result of sensitivity analysis based on fixed penalty and variable idle costs (the costs used in the second case and 50% and 10% of that cost respectively) with/without having bounds for popular locations in the network.

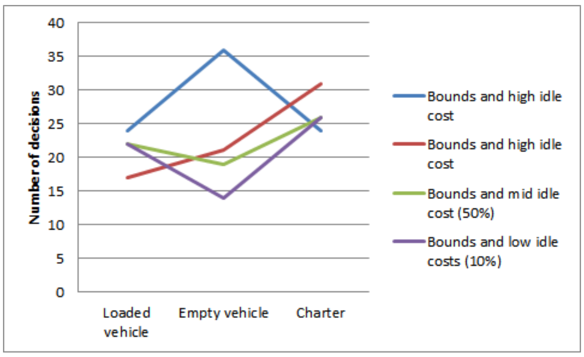


Figure 4.14: Sensitivity analysis on idle costs, empty running and bounds for each location

The impact of idle cost and boundaries can clearly be seen in the number of empty running decisions.

4.4.2 Variable penalty cost (p_{kit})

The same effect can be seen if idle costs are fixed and penalty cost for empty runs (Dec) increases with/without bounds for each asset type at each location. Therefore, setting these parameters (p_{kit},c_{vj},U_i,L_i) accurately plays a key role in decisions taken by the VAPCI model. Figure 4.15 and 4.16 illustrate a comparison of different distributions of assets by VAPCI model resulted from increasing the penalty costs while having (or not) bounds for popular locations.

It can be seen that in the case with bound on popular locations, assets are distributed more

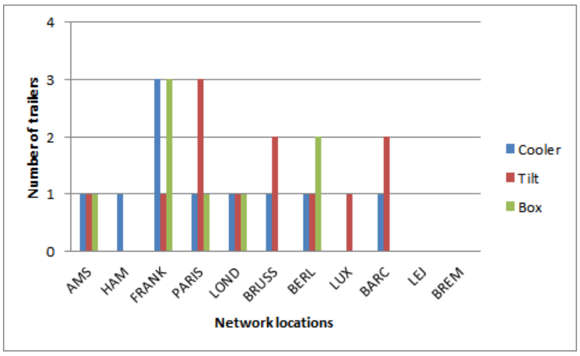


Figure 4.15: Sensitivity analysis- Penalty costs increased from 30% to 50% with inventory bounds

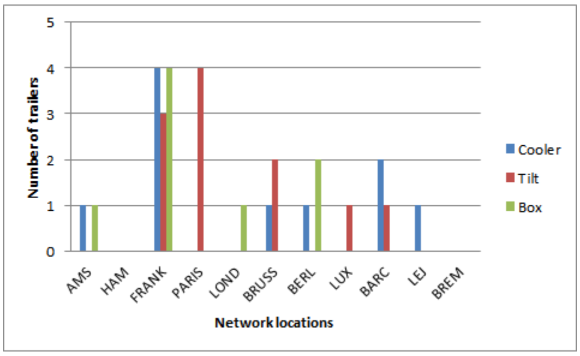


Figure 4.16: Sensitivity analysis- Penalty costs increased from 30% to 50% without bounds

uniformly than the one without bounds. This will result in availability of assets for the next planning horizons for those popular locations. This is indeed crucial part of daily planning at JDR as explained in chapter 3.

4.5 VAPCI performance in an extensive network

On a daily basis each planner plans between 40 to 60 FTL shipments in the region which he is responsible for. However, activities in each region have effects on others in a network as shown earlier in the case studies. As an important requirement for VAPCI to be implemented into JPLEXS and used by planners is the solution time, since agility while planning is crucial. JDR's current network includes 85 locations in which a freight requests can be loaded or unloaded, therefore the model has been tested in different networks with different settings. Figure 4.17 illustrates the solution time. As can be seen, even for a network with 100 locations,

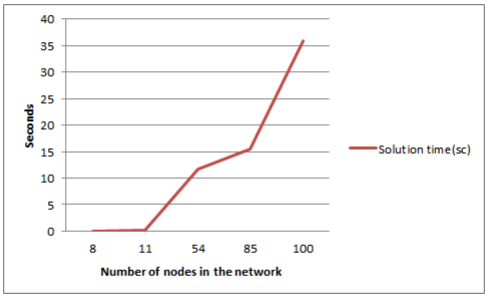


Figure 4.17: Solution time analysis for different network settings

and over 1000 freight requests while having multiple origin destinations it takes less than 36 seconds to come up with an optimal solution using CPLEX as solver.

4.6 Chapter discussion

In this chapter two different case studies have been conducted with the participation of experienced planners and the results have been compared among planners and planning algorithms decisions. As a result, it is shown that applying VAPCI model as a decision support algorithm, could be highly beneficial for planners while scheduling freight requests.

From a cost point of view using the VAPCI model results in least total cost, which consequently means lower empty runnings and lower emission levels. As mentioned previously these are cost driven measures which are lacking attention in daily business and applying such a support tool can effectively compensate the disregard. As shown in sensitivity analysis, accuracy in defining the parameters (lower and upper bounds, penalty and idle costs) plays a crucial role in the suggestion provided by VAPCI algorithm.

Furthermore, planning time using VAPCI can be decreased dramatically which first can save man hours per each shipment being planned, and also provide more time for each planner in order to assess different scenarios (by altering number of drivers, bounds and freight requirement) to make the best decision.

All aforementioned are advantageous of applying such a decision support system while real time planning, and as a result lower total cost, lower emission level while extremely faster planning procedure can be counted as elements which have direct and indirect impact on profits for each freight request.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes findings of this research study. In particular it answers the research question, afterwards limitation of research is discussed in details. Furthermore it suggests some practical recommendations that can be used in JDR's daily planning procedure, eventually future research recommendations are given.

5.2 Conclusions

This research study has started with an analysis of defined KPIs (loading meters, kilometer driven and time windows) and some hidden performance measures (empty runnings, delivery times). As a result of data and process analysis it was revealed that there is a high frequency of re-planning being done for each shipment per day. Based data analysis regard to all factors (Ishikawa diagram 2.1) leading to re-planning has and also based on improvement impact in each area it has decided to focus on the planning quality.

As a result VAPCI model has been developed in order to provide planners with decisions based on associated costs. This model minimizes costs associated with decisions (e.g. empty runnings, hiring a charter or using own assets while daily planning). Therefore this model targets all costs associated from daily allocation operations which are hidden by the definition of productivity in JDR (Loading meters * kilometer driven).

The Model's performance has been assessed with some real operational cases and proved a saving about 5% on each full (truckload or exclusive) shipment (on average) and a total network saving of 12.9% in a case which is on average ten times smaller (regard to the volume of freight requests and number of locations) compared with daily operation. VAPCI can be used as a decision support tool (implemented in JPLEXS) by planners to have allocation proposals based on optimal cost. This model is designed uniquely for JDR planning, which can be tuned by each planner to suggest allocation decisions based on different scenarios that a planner can imagine for a trip (number of drivers, loading possibilities for freight unit and trailer type). To answer the research question explicitly about the impacts of applying a decision support model while planning, The followings can be mentioned:

Saving on scheduling cost: VAPCI proposes optimal decisions based on a detailed cost structure defined for it as an input. These allocation decisions are proposed while considering desired distribution of trailer (based on historical data) through the network. As a result, VAPCI proposes scheduling decisions regard to allocation of own fleet with minimum empty running costs or hiring a charter. Therefore the gap in the scheduling process will be filled using decision support algorithm.

Emission level reduction: The decisions taken by VAPCI model aims to reduce empty kilometer driven and as a result emission level generated by JDRs asset will decrease. This impact can be counted as an important step aligned with European's new regulations which JDR can benefit from in the future.

Notable saving on scheduling time: Another advantage of this model is the capability to provide optimal solution for a network with even larger than JDR's current network using CPLEX as a solver. The agility in providing optimal scheduling proposals becomes highly important when execution time is rather short due to customer/handling agents way of working (described in the Ishikawa diagram in chapter 2 Figure 2.1). In another word, being extremely fast this model creates room for planners not only to decide more accurately about other factors while planning (drivers and truck allocation) but also to try different scenarios and comparing them together, re-optimizing with new released orders or varied parameters in order to make sure that the best decision is taken.

5.3 Limitations

This research is conducted in JDR's head quarter in Roosendaal, therefore all analysis conducted within this office and international transportation group. VAPCI model is built based on steps that planners follow in order to plan a shipment in this transportation group. This means that it might be the case that in other branches (e.g. Bulgaria) other factors have more weight with regard to re-planning but it can be said that specially in western countries the assumption of this research holds properly.

Besides, lack of access to needed data was one of the serious limitation of this research. In order to conduct simulations to measure the performance of the model and previous planned shipments, it is impossible to extract this data, because of the way they are stored in TMS system (the system only stores executed activities, therefore it cannot be distinguished in a structured way if a re-planning has happened or how empty decision are taken for a specific shipment). Due to aforementioned, it was not possible to test the model with previous data stored in the system which indeed would provide a better image about the model's performance quality.

5.4 Recommendations

Based on different analysis and discussions about the model and its variables and parameters that planners need to decide about, also examining the way that planners interact on a daily basis in order to plan shipments, following recommendations can be made:

5.5 Future research

This section provides some suggestions for future research which can result in improvement regard to the network and current planning situations at JDR. VAPCI is only focused on full truck load and is a deterministic ILP model, this model could be extended to include stochasticity regard to traveling times. Next to the planning of FTL, planning and re-planning of LTL also happens a lot due to the same reasons that has discussed for FTL, therefore a vehicle routing model (VRP) can properly take care of LTL shipments. Besides, driver and truck allocation problem is also a high potential to be investigated in. Drivers are limited with rather rigid driving regulation which makes the planning difficult in order to decide when to plan rest, driving and relocate drivers within the network in a way that it can satisfy all freight requests which are using JDR's pulled unit as an asset.

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Appendices

AIMMS output

Benelux case study

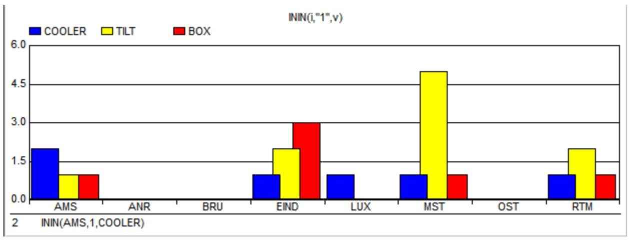


Figure 1: Initial trailer availability in all locations

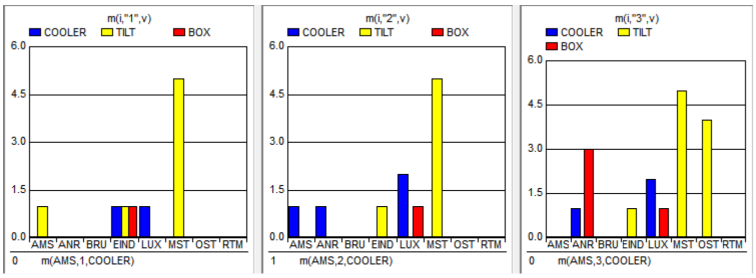


Figure 2: jjhj

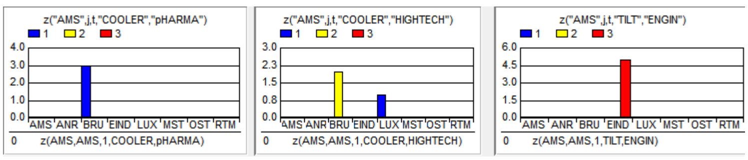


Figure 3: Distribution of trailers in 3 periods in Amsterdam

Multi Origin destination case study

Freight

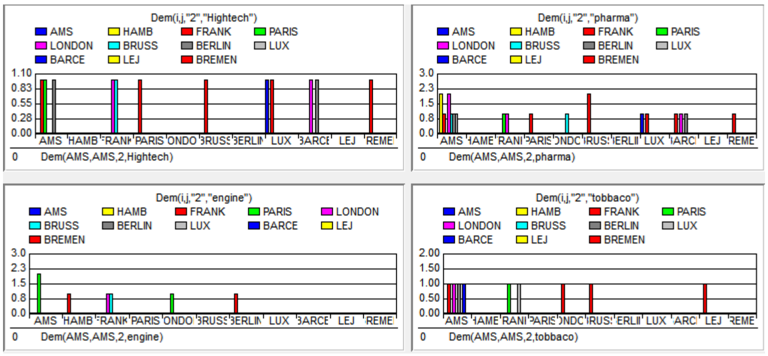


Figure 4: Freight requests for all node in the network

i	j	t	v	p	x
AMS	PARIS	2	Tilt	engine	2
AMS	BERLIN	2	Cooler	pharma	1
AMS	BERLIN	2	Box	Hightech	1
AMS	LUX	2	Cooler	pharma	1
AMS	BARCE	2	Box	tobbaco	1
HAMB	FRANK	2	Tilt	engine	1
FRANK	BRUSS	2	Tilt	engine	1
FRANK	LUX	2	Box	tobbaco	1
LONDON	PARIS	2	Tilt	engine	1
LONDON	BRUSS	2	Cooler	pharma	1
BRUSS	FRANK	2	Cooler	pharma	2
BRUSS	FRANK	2	Box	Hightech	1
BERLIN	FRANK	2	Tilt	engine	1
LUX	AMS	2	Cooler	pharma	1
LUX	AMS	2	Box	Hightech	1
LUX	FRANK	2	Cooler	pharma	1
LUX	FRANK	2	Box	Hightech	1
BARCE	FRANK	2	Cooler	pharma	1
BARCE	BERLIN	2	Cooler	pharma	1
BARCE	BERLIN	2	Box	Hightech	1
BREMEN	FRANK	2	Cooler	pharma	1
BREMEN	FRANK	2	Box	Hightech	1

i	j	t	v	p	z
AMS	HAMB	2	Cooler	pharma	2
AMS	FRANK	2	Cooler	pharma	1
AMS	FRANK	2	Box	Hightech	1
AMS	FRANK	2	Box	tobbaco	1
AMS	PARIS	2	Box	Hightech	1
AMS	LONDON	2	Cooler	pharma	2
AMS	LONDON	2	Box	tobbaco	1
AMS	BRUSS	2	Cooler	pharma	1
AMS	BERLIN	2	Box	tobbaco	1
FRANK	PARIS	2	Cooler	pharma	1
FRANK	PARIS	2	Box	tobbaco	1
FRANK	LONDON	2	Cooler	pharma	1
FRANK	LONDON	2	Tilt	engine	1
FRANK	LONDON	2	Box	Hightech	1
FRANK	BRUSS	2	Box	Hightech	1
PARIS	FRANK	2	Cooler	pharma	1
PARIS	FRANK	2	Box	Hightech	1
LONDON	FRANK	2	Box	tobbaco	1
BRUSS	FRANK	2	Box	tobbaco	1
BARCE	LONDON	2	Cooler	pharma	1
BARCE	LONDON	2	Box	Hightech	1
LEJ	FRANK	2	Box	tobbaco	1

i	j	t	v	p	y
AMS	BRUSS	1	Tilt	engine	1
AMS	BRUSS	2	Tilt	Hightech	1
AMS	BARCE	1	Cooler	pharma	2
AMS	BARCE	1	Box	Hightech	1
FRANK	LUX	1	Cooler	pharma	2
FRANK	LUX	1	Tilt	pharma	2
PARIS	LONDON	1	Cooler	pharma	1
PARIS	BRUSS	1	Tilt	engine	1
PARIS	LUX	1	Box	Hightech	1
LONDON	BRUSS	1	Cooler	pharma	1
LONDON	BRUSS	1	Tilt	engine	1
LONDON	BRUSS	1	Box	Hightech	1
BRUSS	AMS	1	Cooler	pharma	1
BRUSS	AMS	1	Tilt	Hightech	1
BRUSS	AMS	1	Box	tobbaco	1
BRUSS	AMS	2	Tilt	tobbaco	3
BRUSS	LONDON	1	Tilt	engine	1
BRUSS	LUX	1	Box	Hightech	1
LUX	FRANK	1	Tilt	engine	1
LUX	FRANK	2	Tilt	tobbaco	2
BARCE	AMS	1	Cooler	pharma	1
BARCE	AMS	1	Tilt	engine	2
BARCE	AMS	1	Box	Hightech	1
LEJ	BERLIN	1	Tilt	engine	1
LEJ	BREMEN	1	Cooler	pharma	1
LEJ	BREMEN	1	Box	Hightech	1
BREMEN	HAMB	1	Tilt	engine	1
BREMEN	FRANK	1	Box	tobbaco	1
BREMEN	BRUSS	1	Cooler	pharma	1

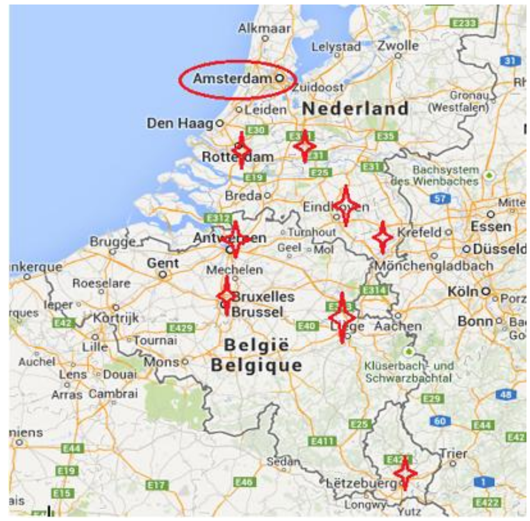
Figure 5: Shut of solution by AIMMS regarding to the proposed decisions.

Surveys and questionnaires

Appendix A : Benelux case study
Appendix B : Delay questionnaire
Appendix C : Re-planning questionnaire
Appendix D : Multi origin-destination case

Appendix A.

Planning experiment:



In the following experiment, the task is to plan full truck load shipment from Amsterdam to other cities in Benelux. There are 4 time periods in which shipments are received and needed to be planned (or Re-planned). You as JDR planner have visibility on the available assets and cities distances from each other. After each planning, there is a possibility to re-plan (re-planning frequency needs to be registered).

- Some assumption to be made in order to simplify the situation:

1- It is assumed that the first departure time will be at the end of the last planning horizon.
2- Each shipment request is equal to one truck load.
3- Charter is always available in case of need.
4- Driver allocation is not considered in this experiment.

- Table below show the loading possibilities for different freight units:

	Pharma	hightech	tobacco	Engine
Cooler	Y	Y	Y	N
Tilt	N	N	N	Y
Box	N	Y	Y	N

- Distance table between different cities:

DISTANCE TABLE (KM)

	AMS	ANR	BRU	EIND	LUX	MST	OST	RTM
AMS		936	122.6	72.8	231.8	161.2	163.1	42
ANR	936		27.9	53.4	154.3	65.6	69.3	55.6
BRU	122.6	27.8		71.3	131.1	63.1	69.4	129.6
EIND	72.8	53.4	71.3		151.1	47.6	122.5	64.1
LUX	231.8	154.3	131.1	151.1		104.4	201.2	261.3
MST	161.2	65.6	63.1	47.6	104.4		132.3	184.8
OST	163.1	69.3	69.4	122.5	201.2	132.3		77.3
RTM	42	55.6	129.6	64.1	261.3	184.8	77.3	

- Initial vehicle inventory:

Initi. Inv	Cooler	Tilt	Box
AMS	2	1	1
ANR	0	0	0
BRU	0	0	0
EIND	1	2	3
LGG	0	0	0
LUX	1	0	0
MST	1	5	1
OST	0	0	0
RTM	1	2	1

Example: 1C= one cooler , 2B= two Box trailers, 1T= one tilt trailer

- Numbers representing cities:

AMS	ANR	BRU	EIND	LGG	LUX	MST	OST	RTM
1	2	3	4	5	6	7	8	9

Planning Sheet:

Planning	From -to	From -to	From -to	From -to	From -to	From -to	From -to	From -to	From -to
Planning time	1			2			3		
Full loaded truck- vehicle type									
Empty truck-vehicle type									
Charter-vehicle type									

Re-Planning(1)	From -to	From -to	From -to	From -to	From -to	From -to	From -to	From -to	From -to
Planning time	1			2			3		
Full loaded truck- vehicle type									
Empty truck-vehicle type									
Charter-vehicle type									

Re-Planning (2)	From -to	From -to	From -to	From -to	From -to	From -to	From -to	From -to	From -to
Planning time	1			2			3		
Full loaded truck- vehicle type									
Empty truck-vehicle type									
Charter-vehicle type									

Time	1		
Origine	Destination	Freight req	
Ams	ANR	1 Pharma	
Ams	LUX	2 tobacco	1 high tech
Ams	BRU	3 pharma	

Time	2	Freight req
Origine	Destination	
Ams	OST	4 engine
Ams	ANR	3 tobacco
Ams	BRU	2 high tech

Time	3	Freight req
Origine	Destination	
Ams	LUX	2 pharma
Ams	MST	3 tobacco
Ams	EIN	5 engine

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Appendix B.

"Delay Events" Questionnaire

Dear planners,

The questionary in front, is the first step of this project in JDR. The aim of the project is to develop a ***real time Decision support system (DSS)*** to capture daily re-planning situation and provides optimal suggestions to the planners which will increase the service levels and performance of the resource allocation as well.

Regarding to the data has been analyzed; there are several situations which re-planning is needed. Making a right choice in a short time horizon considering JDR's KPI is highly important thus.

You can find some selected statuses on the next page, we are curious to know how often these time shifts are happening per month and how you usually deal with them (what steps do you usually follow to re-plan the time shift) based on your experience.

I want to Thank you very much in advance for your time, and any additional feedback from your side is highly appreciated, since every feedback helps me to have a better mind set about the problems entities, and at the end the DSS will have a better performance.

Additional feedback could be on:

- Do you know any other reasons that need re-planning of assets (e.g. Air freight shift)?
- Generally what kind of information do you need to re-plan?

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Delay Status	DelayReason	Frequency(times per month)				How to deal with the problem (steps)
		0-20	20-40	40-60	0ver 60	
101	Coload					
102	Late Report for Loading					
106	Other (due JDR)					
107	Delay loading - offloading previous address					
202	Long Loading					
209	Freight not ready					
301	Traffic Problems					
306	Ferry / Shuttle Delay					
307	Bad weather					
402	Other Beyond Control					

Appendix c.

Re-Planning Questionnaire

Dear colleagues,

Please take a look at each of these statements and confirm/reject or add extra statements based on your experience :

When Re-planning is happening at JDR?

1- A new request comes into system and there is no asset to allocate to it. (Confirm/ reject)

Add a note:

2- A new request comes into system and there is an opportunity to make a better planning (with extra loading meters, turnover etc.) (Confirm/ Reject)

Add a note:

*P. S: A new request can be an increase or decrease in the volume of initial demand (e.g. An air freight request which the demand can be increased or decrease by the customer)

3- An unpredictable event has happened (Bad weather, Traffic etc.) and the original planning should be changed (to meet customers' agreement level and JDR KPI`s) (Confirm/Reject)

Add a note:

- Can you point to any other reason for re-planning that you can think about? (If yes Add please)

- How many times re-planning do you do per day- in average? Give a fraction please. ($\frac{Re-planned shipments}{Total shipments planned}$) Per day

I want to Thank you again for your time. Any additional feedback from your side is highly appreciated, since every feedback helps me to have a better mind set about the problems entities, and at the end the DSS will have a better performance.

Yours Sincerely,
Rasa.

Appendix D.

Planning experiment:

In the following experiment, the task is to plan full truck load shipment from and to 11 different cities .

- Some assumption to be made in order to simplify the situation:

1- It is assumed that the first departure time will be at the end of the last planning horizon.
2- Each shipment request is equal to one truck load.
3- Charter availability is given.
4- Driver allocation is not considered in this experiment.

- Table below show the loading possibilities for different freight units:

	Pharma	hightech	tobacco	Engine
Cooler	Y	Y	Y	N
Tilt	N	N	N	Y
Box	N	Y	Y	N

- Initial vehicle inventory:

Trailer.tp	Cooler	tilt	Box
Ams	2	1	1
Hamburg	[redacted]	[redacted]	[redacted]
FRANK	2	2	
PARIS	1	1	1
LONDON	1	1	1
BRUSS	1	2	2
BERLIN	[redacted]	[redacted]	[redacted]
LUX	[redacted]	1	[redacted]
BARCE	1	2	1
LEJ	1	1	1
BREMEN	1	1	1

Example: 1C= one cooler , 2B= two Box trailers, 1T= one tilt trailer

- Numbers representing cities:

Ams	Hamburg	FRANK	PARIS	LONDON	BRUSS	BERLIN	LUX	BARCE	LEJ	BREMEN
1	2	3	4	5	6	7	8	9	10	11

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Planning Sheet:

Planning	From-to	From-to	From-to	From-to	From-to	From-to	From-to	From-to	From-to	From-to	From-to	From-to
Planning time												
Full loaded truck-vechile type												
Empty truck-vechile type												
Charter-vehicle type												

From-to	From-to	From-to	From-to	From-to	From-to	From-to	From-to	From-to	From-to	From-to	From-to

Demand for the first period:

origon	destination	Pharma	Tobbaco	high tech	engine
Ams	HAM	1			
Ams	FRANK	1	1	1	
Ams	PARIS			1	2
Ams	LONDON		1		
Ams	BRUSS	1			
Ams	BARLIN		1	1	
Ams	LUX	1			
Ams	BARCE		1		
HAM	FRANK				1
FRANK	PARIS	1	1		
FRANK	LONDON	1		1	1
FRANK	BRUSS			1	1
FRANK	LUX		1		
PARIS	FRANK	1			
LONDON	FRANK		1		
LONDON	PARIS				1
LONDON	BRUSS	1			
BRUSS	FRANK	2			
BERLIN	FRANK				1
LUX	AMS	1			
LUX	FRANK			1	
BARCE	FRANK	1			
BARCE	LONDON	1		1	
BARCE	BERLIN			1	
LEJ	FRANK		1		
BREMEN	FRANK			1	

Inventory after planning:

Trailer.tp	Cooler	tilt	Box
Ams			
Hamburg			
FRANK			
PARIS			
LONDON			
BRUSS			
BERLIN			
LUX			
BARCE			
LEJ			
BREMEN			

Charter is not available for these routes:

NO CHARTER AVAILABLE

origin	destination(s)
HAM	PARIS
	BARC
Paris	London
	Berlin
	Bremen
	HAMBURG
Bruss	London
	BERLIN
	LEI
BERLIN	BRUSSEL
	PARIS
	LONDON
	LUX
	BARCE
LUX	BARCE
	LEI
BARC	BERLIN
	HAM
	LONDON
	LEJ
	LONDON
Bremen	london
	BARCE
	PARIS
	LUX