MASTER

The effects of lightweight workflow management systems and its functions
a case study at Jan de Rijk Logistics

van Vught, C.N.M.

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The effects of lightweight workflow management systems and its functions: A case study at Jan de Rijk Logistics

by

Casper van Vught

B.Sc. Industrial Engineering and Management Science – TU/e (2011)
Student identity number 0629521

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Supervisors:
dr.ir. R.M. Dijkman, TU/e, IS
Prof.dr. T. van Woensel, TU/e, OPAC
A.C. Ernst, Ernst Opus V
R. Ridderhof, Jan de Rijk Logistics

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ABSTRACT

In this master thesis the effects of lightweight workflow management systems and its functions are researched. The effects are measured on four KPIs: service time, data accuracy, operation margin, and data availability. This project is executed at Jan de Rijk Logistics in Roosendaal, the Netherlands. In order to gain insight into the effects a lightweight WfMS and the WfMS function were developed and both a pre- and post-test were performed for each of the KPIs. The results show that the lightweight workflow management systems and its functions have a positive effect on service time, data accuracy, and data availability.

MANAGEMENT SUMMARY

Workflow management systems (WfMS) are becoming more popular over the years. Due to the increasing complexity of business processes several issues with traditional WfMSs arise: weak support for changes, complex exception handling mechanisms, limited openness to integrability with other systems, and limited extensibility (Muth, Weissenfels, et al., 1999) (Agostini and Michelis, 2000). To overcome such issues lightweight workflow management systems are introduced, however, the effects of lightweight WfMSs are still unclear. Measuring the effects of a lightweight WfMS and its functions in this study is done based on four key performance indicators (KPIs): service time, data accuracy, operation margin, and data availability. In this master thesis the effects of lightweight WfMSs are researched. The research question is formulated as follows.

WHAT ARE THE EFFECTS OF A LIGHTWEIGHT WORKFLOW MANAGEMENT SYSTEM AND ITS FUNCTIONS ON SERVICE TIME, DATA ACCURACY, OPERATION MARGIN, AND DATA AVAILABILITY

With the lightweight WfMSs and functions, this research question covers two aspects of enterprise modeling, process and function. Enterprise modeling also contains other aspects, namely data, structure, and resources, however, in this study the focus will be on the process and function aspects.

The research is performed at Jan de Rijk Logistics (JDR). Jan de Rijk Logistics (JDR) is a logistic service provider (LSP) that operates in several business areas, including transportation. For transportation, JDR uses both their own fleet of trucks and the services of third party LSPs, or charters. In the charter process several issues occur. The issues center around the problem of a misalignment of data. One misalignment is between the charter confirmation, which is a document containing the agreement of a trip being executed by a charter, and the invoice of the charter. This misalignment can be caused by either a change in the shipment, which has not been documented correctly, or there is information missing on the charter confirmation. The second misalignment is between the charter confirmation and the waybill (CMR). Since the waybill is often received late because of the physical travel time, the process is paused or continued with possible incorrect data, which could cause several other issues, i.e. wrong amounts credited. The main issues are thus missing information, both price and shipped amount, and missing documents.

The main issues can be measured based on data accuracy and data availability in a pre- and post-test. First, the missing price information, which is based on data quality, can be measured on data accuracy. To obtain accurate price information a cost/gain calculation is necessary. Also the data flow should be controlled to ensure the accuracy of the data. Second, the missing information on shipped amounts, which is concerned with the timeliness of the data, can be measured on data availability. A change in obtaining the shipment data or the changes of shipped amounts will affect the data availability. Third, also the missing documents can be measured by the data availability. Therefore the changes of transport need to be documented. Furthermore, the operation margin can be measured by measuring the increase of the costs or by performing a cost/gain calculation. The service time not related to the issues at JDR.

To solve the issues concerning missing information on shipped amount the process should be changed so that the communication of such important data is mandatory. This communication should be facilitated by a workflow management system. The issue concerning missing price information, which is mainly caused by a lack of a cost/gain calculation, can be resolved by developing a WfMS function that facilitates such a cost/gain calculation. Furthermore, this WfMS function should also make the documentation of the agreed price, as well as other important data, mandatory. The issue concerning missing documents is solved indirectly. The physical travel time of the waybill is not changed by the lightweight WfMS or the WfMS function, however, since the important shipment data is communicated via the lightweight WfMS, all relevant shipment data is available within JDR at the moment the transport is finished. Therefore, no incorrect invoice will be send anymore, since the invoice can be made based on accurate shipment data, for which the waybill is no longer necessary since the data it carries is already present within JDR.

In order to determine whether the lightweight workflow management system and the WfMS function increase the data accuracy and data availability and to measure the effects on service time and operation margin a pre- and post-test are performed for each of the KPIs.

Due to the highly interchanging tasks of JDR planners, not only the actual time spend to finish a task, task time, is relevant but also the startup times of tasks, because the tasks in the shipment feedback process are currently initiated by phone calls, which disturbs and intervenes other tasks. Therefore, the service time is measured in both task time and startup time. To measure the task time, the time spend by a JDR planner changing shipment statuses was timed with the current system and with the WfMS. The difference that was observed is negligible. To measure the startup time, the time that was measured is the restarting time of the original task after the disturbance of the intervening task. For the post-test the startup time result is zero, since the WfMS is designed to eliminate disturbances by shipment notifications. The pre-test resulted a startup time of 15 seconds on average. Thus 15 seconds could be saved per notification. Due to the large number of ad hoc charter trips per month this adds up to 46.35 hours per month, which is slightly more than 0.25 FTE.

Data availability is based on the issue of missing price information, this can be measured in two way. Either by the percentage of requests for additional information or by the percentage of invoices sent before receiving the waybill. In the pre-test, the former only contributes to 1.50% of the cases while the latter results in 35.16%. This corresponds to a data availability of 63.34%. Since the WfMS is designed to deliver a data availability of 100%, the increase in data availability is 36.66%.

To test the data accuracy, historic data was analyzed for the pre-test. However, due to a lack of accurate historic data at JDR, a measurement of the missing agreed price data was used for data accuracy. For the first quarter of 2013, 18.76% of the agreed price data was missing, which corresponds to a data accuracy of 81.24%. The WfMS function is designed to eliminate missing data, thus the post-test results of data accuracy is 100%. This is an increase of 18.76%.

To measure the operation margin in the pre-test historic data is necessary, however, there is no historic data of the operation margin present at JDR. Therefore, no pre- and post-test comparison could be made. Nonetheless, the WfMS function was tested to gain insight in the functionality. The results of the operation margin center around zero. Negative margins indicate that the agreed price is too low and operation loss, positive margins indicate an operation profit. Aside from the operation margin and the composition of the agreed price, the WfMS function saves all relevant trip information, however, these were not relevant to the KPIs of this study.

Below, in Table 1, the results are summarized. Looking at the table it can be observed that there is a decrease in service time, more specifically startup time, and an increase in both data accuracy and data availability. Based on this the effects of a WfMS and the WfMS function can be stated. First, a lightweight workflow management system and its functions decrease the startup times. Second, a lightweight WfMS and its functions increase the data accuracy. Third, a lightweight WfMS and its functions increase the data availability. Therefore, it can be stated that a lightweight workflow management system and its functions have a positive effect on service time, data accuracy, and data availability.

Table 1: Summary of results

	Service time		**Data accuracy (%)**	**Operation margin (%)**	**Data availability (%)**
	Task time (sec)	Startup time (sec)			
Pre-test	58	15	63.34	-	81.24%
Post-test	60	0	100	0	100%

The results also indicate that the internal and external communication issues are solved due to the increase in data accuracy and data availability, respectively. It is therefore recommended to implement a workflow management system for the shipment feedback process. This system will solve the external communication issue. Also, it is recommended to implement the workflow management system function, or charter selector. This tool will solve the internal communication issue. It also allows for monitoring the performance of planner, which could positively influence the operation margin. An additional recommendation for this tool is to set a JDR standard price. This standardization makes it possible to filter and sort charters based on a mix of price and quality, while in the current model only quality measures are used to sort charters.

PREFACE

This master thesis is the result of a graduation project performed at Jan de Rijk Logistics, in order to receive the Master's degree in Operations Management and Logistics at Eindhoven University of Technology. This last semester was both challenging and a great experience.

I would like to thank Remco Dijkman, my first university supervisor, who helped me to keep on track and provided me with help in our meetings. I also would like to thank Tom van Woensel, my second university supervisor, for his support and feedback. Furthermore, I would like to thank Shaya Pourmirza for his help in developing the lightweight workflow management system.

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Finally, I would like to thank my family for the support during all my years of studying. And I would like to thank my girlfriend for her support and lending me her ears when I had something on my mind.

Eindhoven, September 2013

Casper van Vught

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1. INTRODUCTION

This chapter gives an introduction into the research performed in this thesis project. First, in section 1.1, the motivation for doing the research is discussed. Second, a lightweight workflow management system is defined in section 1.2. Third, the research question is presented in section 1.3. Finally, in section 1.4 the methodology is discussed.

1.1. MOTIVATION

Workflow management systems (WfMS) are becoming more popular over the years, however, due to the increase in complexity of business processes traditional WfMSs face several issues; weak support for changes, complex exception handling mechanisms, limited openness to integrability with other systems, and limited extensibility (Muth, Weissenfels, et al., 1999) (Agostini and Michelis, 2000). Lightweight workflow management systems are introduced to overcome these issues. The idea behind lightweight WfMSs is that they are simpler systems, that are more adjustable and extendable. These attributes are the key to solve the issues traditional WfMSs face. However, the effects of lightweight WfMSs are not yet studied, therefore it is unclear what the effects of lightweight WfMSs are on business processes. In this master thesis the effects of lightweight WfMSs are researched.

Measuring effects on business processes is done by performing a pre- and post-test and measuring the differences in key performance indicators (KPIs). In literature and practice a wide variety of KPIs are used, therefore a selections needs to be made. In general, literature suggests that WfMSs increase the quality of communicating important information and thus increasing the efficiency, in both lead time and service time (Fischer and Workflow Management Coalition, 2001) (Reijers and van der Aalst, 2005). Furthermore, software improvements can have various effects on quality, time, cost, or flexibility (Reijers and Liman Mansar, 2005) (Shtub and Karni, 2010). Additionally, the problem analysis in this case study reveals issues with data accuracy and data availability, this is discussed in more detail in section 2.3. of this report. Therefore, the KPIs used to measure the effects of a lightweight WfMS in this research are: service time, data accuracy, operation margin, and data availability.

1.2.WHAT IS A LIGHTWEIGHT WORKFLOW MANAGEMENT SYSTEM

A lightweight workflow management system can be define as: a workflow management system that only support basic functionality and is characterized by a short implementation phase and larger involvement of business users during the implementation and configuration phase (Sonnenberg, 2007).

In this definition there are a two key elements. The first key element is that a lightweight WfMS only supports basic functionality. The possibilities of a lightweight WfMS are thus more limited than a traditional WfMS. However, the extensive functionality of a traditional WfMS is caused by a more rigid system, which is the reason for several of the problems it faces: weak support for changes, complex exception handling mechanisms, limited openness to integrability with other systems, and limited extensibility. The basic functionality of a lightweight WfMS allows for more flexibility. The second key element is that a lightweight WfMS has a short implementation phase and larger involvement of business users during implementation and configuration. This implies a more user friendly system, which also increases the support for changes. The issues a traditional WfMS faces can thus be overcome by using a lightweight WfMS.

1.3. RESEARCH QUESTION

The research question of this study is:

WHAT ARE THE EFFECTS OF A LIGHTWEIGHT WORKFLOW MANAGEMENT SYSTEM AND ITS FUNCTIONS ON SERVICE TIME, DATA ACCURACY, OPERATION MARGIN, AND DATA AVAILABILITY

With the lightweight WfMSs and functions, this research question covers two aspects of enterprise modeling, process and function. Enterprise modeling also contains other aspects, namely data, structure, and resources, however, in this study the focus will be on the process and function aspects.

The research question focusses on four KPIs. For each of the KPIs a hypothesis is constructed. For each of these hypotheses a pre- and post-test will be performed to measure the effects of a lightweight WfMS and its functions on the individual KPIs.

The first hypothesis will test if a lightweight WfMS and its functions decrease service time. Literature states that traditional WfMSs increase efficiency by decreasing service time (Reijers and van der Aalst, 2005). It is expected that a lightweight WfMS has a similar effect on service time.

HYPOTHESIS 1: A LIGHTWEIGHT WFMS AND ITS FUNCTIONS WILL DECREASE THE SERVICE TIME

The second hypothesis tests if a lightweight WfMS and its functions have a positive effect on data accuracy. The problem analysis in this case study shows an issues with the data accuracy. Furthermore, literature suggests that a traditional WfMS has a positive effect on the quality of communicating of important information. Therefore it is expected that a lightweight WfMS and its functions have a positive effect on data accuracy.

HYPOTHESIS 2: THE DATA ACCURACY WILL IMPROVE USING A LIGHTWEIGHT WFMS AND ITS FUNCTIONS

The third hypothesis will test if a lightweight WfMS and its functions have a positive effect on operation margin. It is expected that the increase in efficiency suggested by literature has a positive effect on the operation margin. Furthermore, it is expected that the lightweight WfMS and its functions reduce the costs and therefore increase the operation margin.

HYPOTHESIS 3: THE OPERATION MARGIN WILL IMPROVE USING A LIGHTWEIGHT WFMS AND ITS FUNCTIONS

The fourth hypothesis will test if a lightweight WfMS and its functions have a positive effect on data availability. The problem analysis in this case study shows an issues with the data availability. Also, literature suggests that a traditional WfMS has a positive effect on the quality of communicating of important information. Thus, it is expected that a lightweight WfMS and its functions have a positive effect on data availability.

HYPOTHESIS 4: A LIGHTWEIGHT WFMS AND ITS FUNCTIONS WILL INCREASE THE DATA AVAILABILITY

1.4. METHODOLOGY

To answer the research question a research methodology is followed. This methodology is based on the model that was proposed by Mitroff et al., here the implementation of the solution is not present (Mitroff, Betz, et al., 1974). Figure 1 below shows the research methodology.

The research methodology consists of three phases: analyzing, modeling, and verification. During the analysis the problems that are observed in the process are identified. Based on the observed problems a scope is set to determine the focus of the research. During the modeling phase the workflow management system and the WfMS function are developed, these are based on the requirements set in the analysis phase. During the verification phase a pre- and post-test is performed for the WfMS and WfMS function to measure the effects on the KPIs.

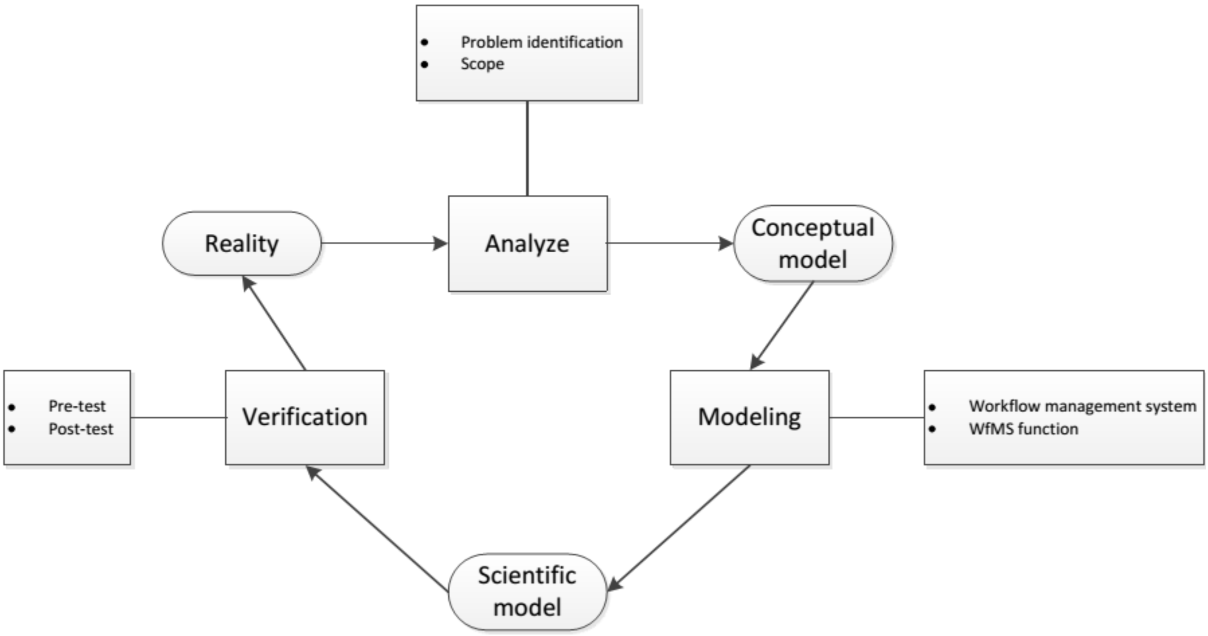

Figure 1: Research methodology

Now that it is clear which steps need to be taken, the structure for this report can be discussed. Figure 2 shows the report structure graphically. First, in chapter 2, the business process is discussed, problems are identified, and an analysis is performed. Based on this analysis the research scope is determined. Second, in chapter 3, the lightweight workflow management system is introduced and the impact of the proposed solutions are discussed. Third, in chapter 4, the conceptual model is discussed, then the workflow model is discussed, and as last the development of the WfMS function is discussed. After the development of the lightweight WfMS and the WfMS function the effects on the KPIs can be measured in a pre- and post-test. In chapter 5, the WfMS test is discussed, then the results of the WfMS tests are presented, the WfMS function test is discussed, and as last the results of the WfMS function test are presented. Finally, in chapter 6, the conclusions of this study, the recommendations, the study limitations, and possibilities for future research are discussed.

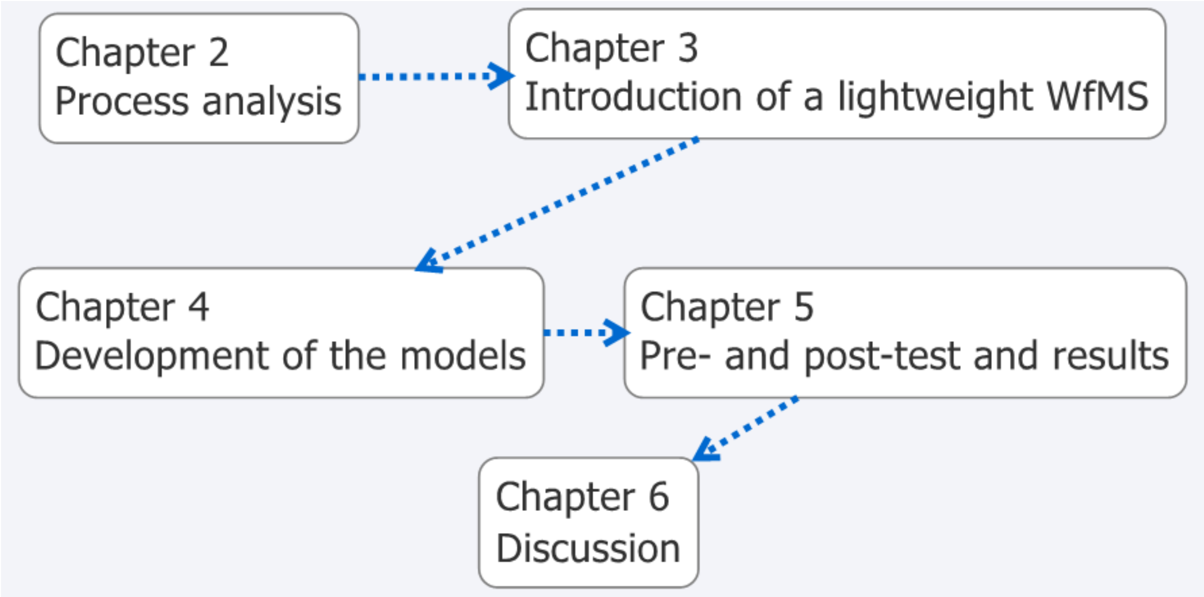

Figure 2: Report structure

2. JAN DE RIJK LOGISTICS

In this chapter, first a short description of the organization is given in section 2.1. Second, in section 2.2 the charter process is discussed. Third, in section 2.3 the problem analysis is discussed. Finally, in section 2.4 the research scope is presented.

2.1. ORGANIZATION

Jan de Rijk Logistics (JDR) is a logistics service provider. JDR was founded in 1971 and currently employs around 1000 employees, operates out of 26 offices and 15 countries, has a fleet of over a 1000 vehicles, and has a warehouse capacity of 90.000 m2. The headquarters is located in Roosendaal. JDR consists of 4 lines of business: International Transportation, Benelux Distribution, Warehousing, and Freight Forwarding.

Aside from using its own fleet, JDR also outsources a part of their shipments when their capacity is not sufficient for a specific route and moment in time. The company where the shipments are being outsources too is referred to as a charter.

2.2. THE CHARTER PROCESS

At JDR the charter process is special case of a normal transportation process. An ordinary transportation process starts with a demand for transport from a customer, an order. For this order it is checked whether all necessary data is present, i.e. price, amount of the shipment; full truck load or number of pallets or kilos. After this, it is checked whether the capacity required for this shipment is available for that route in that time frame, this is performed by a planner. If the capacity is available the shipment is handled by own trucks, else the planner has to outsource this transport to a charter. This is where the charter transportation process starts. Figure 7 in Appendix A. shows the charter transportation process. Below a description of the process will be given.

There are a large number of charters, either fixed or on ad hoc basis, connected to the company. Only the fixed charters are connected to the IT bus of JDR via a board computer in the truck. Although the benefits of using fixed charters, still a lot of ad hoc charters are used. The ad hoc charter are not connected to the IT bus of JDR and therefore have to communicate the trip and shipment information via telephone. In Appendix B. the number of ad hoc charter trips in 2013 is presented.

When a charter has to be selected for a supply of transport, a list of possible charters is obtain from the system. The charter is then selected based on the locations of the shipment, amount of the shipment, and other restrictions like atmospheric goods. The planner contacts charters until a charter is available for the shipment. Then an agreement is made on the conditions and price of the shipment, if no agreement can be achieved the planner contacts another charter. After agreement is achieved, an order confirmation is send to the charter.

The charter can then plan the transport. At the load address, the driver communicates he starts loading. He checks whether the shipment matches the order, if the shipment differs from the order than the driver communicates this also. After he signs the waybill (CMR) and notifies that the loading is finished and starts driving, either to another load address or an unload address. All notifications are communicated via telephone to JDR. At the unload address, the driver unloads the shipment and he and the receiver sign the necessary documents. After the final unloading the shipment is completed and the administration process starts.

The billing of customers is based on the original order, corrections can be applied based on the CMR. There are three types of customers with respect to the necessity of the CMR; customers that always request the CMR, customers that occasionally request the CMR as a sample test, and customers that request the invoice within 10 days after delivery. For the customers that always request the CMR, the invoice is sent when the CMR is received. For the customers that occasionally request the CMR, the invoice is sent without the CMR and upon request the CMR is sent. For the customers that require the invoice within 10 days, the invoice is sent with CMR if the CMR is received from the driver in time, else the invoice is sent without the CMR.

The charter also sends his invoice. The invoices of charters are sorted and then checked by the charter department. If the invoice is not OK additional information is requested from the charter. Since the actual shipment often misaligns with the ordered shipment, this results to delays of the process. However, for the customers could require an invoice in 10 days and the customers that just occasionally request the CMR the invoice is sent without confirmation with the CMR, which then could be based on incorrect information. Consequently, corrections are necessary, which cost more time and money.

After the problem has been solved or if the charter invoice is OK, the invoice can be processed. This processing entails registering the invoice in the system and transferring it to a payment system. When the CMR is received from the driver, the CMR can be processed. After all information is received and processed, the charter can be paid. Finally, the invoice can be archived and the process is finished.

2.3. PROBLEM ANALYSIS

In the charter transportation process there are several issues. An initial attempt to structure these issues resulted in a fishbone diagram. Figure 9 of Appendix C. shows this fishbone diagram. The process was decomposed into three sub processes; the charter selection process, the transport execution process, and the administration process. For each of these sub processes the causes and effects were related to create the fishbone diagram.

By looking at the fishbone diagram you can see that the main problem is an increase in costs of administration handling. The main issue relating to this increase are two misalignments between data. On the one hand there is a misalignment between the charter invoice and charter confirmation can occur, while on the other hand there is a misalignment between the waybill and the charter confirmation can occur. These misalignments come apparent in the administration sub process. In this sub process the charter confirmation is compared with both the charter invoice and the waybill. The waybill is the document which surely contains the accurate shipment data, however, due to the frequent lateness of the waybill the process of checking the correctness of the invoice can come to a hold. Here the restricting factor is the availability of the correct data, which is an information issue. Also, a client invoice has to be sent based on the shipment information. For the customers that require the invoice within 10 days after delivery and the customers that just occasionally request the waybill, the sent invoice could be based on incorrect information, which then results in requests for credit notes to resolve the misalignment. This both increases handling and costs. All these administrative issues are caused by the misalignments of data and the availability of the waybill.

The misalignments can be caused by three events. First, the actual amount that was transported is more than what is on the charter confirmation and this difference was not communicated or documented at JDR. Second, the charter sends an invoice with a different price than was agreed on. Third, there is information missing in the charter confirmation which makes it impossible to check the correctness of a charter invoice. Quite often the missing information is the agreed price, either there is no price agreement or the agreed price is not documented. For all three events the frequent lateness of receiving the waybill is another problem, since this is the document which contains the correct shipment data.

The three events have several causes and effects on the process. Most effects are concerned with additional administrative tasks. The first event is caused by a miscommunication or not documenting changes during transport execution. The second event can a result of the first event since a change in the actual transport changes the price, however, it can also be caused by poorly documented price agreements. The third event is caused by either a lack of price agreement or a lack of documentation of the agreed price. The causes of the three events can be summed up into the main issues; missing information, both price and amount, and missing documents.

Since several causes and effects in this process are interrelated, the fishbone diagram fails to give an accurate view on causes, effects, and their connections. Therefore, different cause-and-effect diagram is used; the problem mess. In Figure 10 of Appendix D. the problem mess is shown. By looking at the problem mess it is clear to see the connections between the different causes and effects. The misalignments are colored red and the main issues are colored blue.

The problem mess shows the causes for the main issues. The missing price information is caused by a lack of control of data flow and not negotiating or documenting the agreed price. The latter is mainly caused by a lack of a cost/gain calculation. The missing amount information is caused by not documenting changes in the transport at JDR, thus accurate shipment data is not present within JDR. The missing documents is caused by the physical travel time of the waybill. All problems in the problem mess result in the requirement of a credit note due to a wrong invoice and/or an increase in handling in the administration sub process. Both of these increase the costs of the charter transportation process.

2.4. RESEARCH SCOPE

This thesis only has a limited amount of time, thus it is not possible to solve the full range of problems shown in the problem mess. Therefore the scope of this research must be defined.

The scope of this research is based on the main issues and the four KPIs. The main issues, missing information and missing documents, are the center of the problems at JDR. Furthermore, the research question centers around four KPIs: service time, data accuracy, operation margin, and data availability. The main issues can be measured based on data accuracy and data availability in a pre- and post-test. First, the missing price information, which is based on data quality, can be measured on data accuracy. To obtain accurate price information a cost/gain calculation is necessary. Also the data flow should be controlled to ensure the accuracy of the data. Second, the missing information on shipped amounts, which is concerned with the timeliness of the data, can be measured on data availability. A change in obtaining the shipment data or the changes of shipped amounts will affect the data availability. Third, also the missing documents can be measured by the data availability. Therefore the changes of transport need to be documented. Furthermore, the operation margin can be measured by measuring the increase of the costs or by performing a cost/gain calculation. The service time not related to the issues at JDR. Table 2 shows the relation between the issues and the KPIs. This defines the scope of this research. Figure 11 of Appendix E. shows the resulting problem mess that remains after the research scope is defined.

Table 2: Relation between issues and KPIs

Issue	KPI
Missing price information	Data accuracy
Lack of cost/gain calculation	Operation margin
Missing amount information Missing documents	Data availability

3. INTRODUCTION OF A LIGHTWEIGHT WORKFLOW MANAGEMENT SYSTEM

In this chapter the lightweight workflow management system is introduced. In section 3.1 the development steps of a lightweight workflow management system are discussed. In section 3.2 the impact of the lightweight WfMS and the WfMS function are discussed.

3.1. SETTING UP A LIGHTWEIGHT WORKFLOW MANAGEMENT SYSTEM

In order to set up a lightweight workflow management system several steps need to be performed. A workflow management system consists of five aspects: control flow, data, resources, work assignment rules, and exception handling. Thus in order to develop a WfMS, each of these aspects needs to be defined and modeled.

The control flow aspect is basically the process model of the WfMS. Below in Figure 3 an example of a simple process model is shown. This process models shows a sequential flow, task A will be performed before task B. The control flow aspect of a WfMS usually concerns a more elaborate process model and a more complex routing from begin to end. Also, since the WfMS is a system executable by software, the process modeling usually requires more details and the resulting process model should be more unambiguous. The start of the control flow aspect is normally a conceptual process model. This conceptual process model is then transformed into a workflow process model. Depending on the complexity of the process routing, this transformation can be either fairly simple or very difficult.

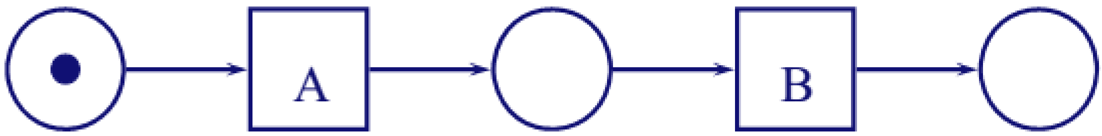

Figure 3: Control flow (Reijers, 2011)

The data aspect of the WfMS is concerned with what data flows through the WfMS, how data is interrelated, and how data is affected by process tasks. The data aspect is modeled by a data model. In Figure 4 below an example of a data model is shown. In this data model there are two data classes: Client and Product. The client has two attributes, name and ClientNumber, the product also has two attributes, name and an ProductID. This model shows the relationship between a client and a product that a client can order. The numbers indicate the multiplicity. A client can order an arbitrary number of products. A product can either be ordered by one client or cannot be ordered. The data model for a WfMS usually contains more data classes, attributes, and relations, but follows the same modeling principle as the example.

Figure 4: Example data model (Angelov, 2011)

The resource aspect is concerned with the resources necessary to perform the tasks in the WfMS. A resource can be a human or a system. The resource aspect is usually modeled in the process model. This can be done by making a swim lane for each resource, in which all tasks within the swim lane are performed by that resource, or by indicating the resource for each task separately. Figure 5 shows a process with swim lanes. Here the administrator performs task 1 and the checker performs task 2. Figure 6 shows a process with resources stated per task. Here the administrator performs the first task and the checker performs the second task. The resource aspect of a WfMS usually contains more different resources.

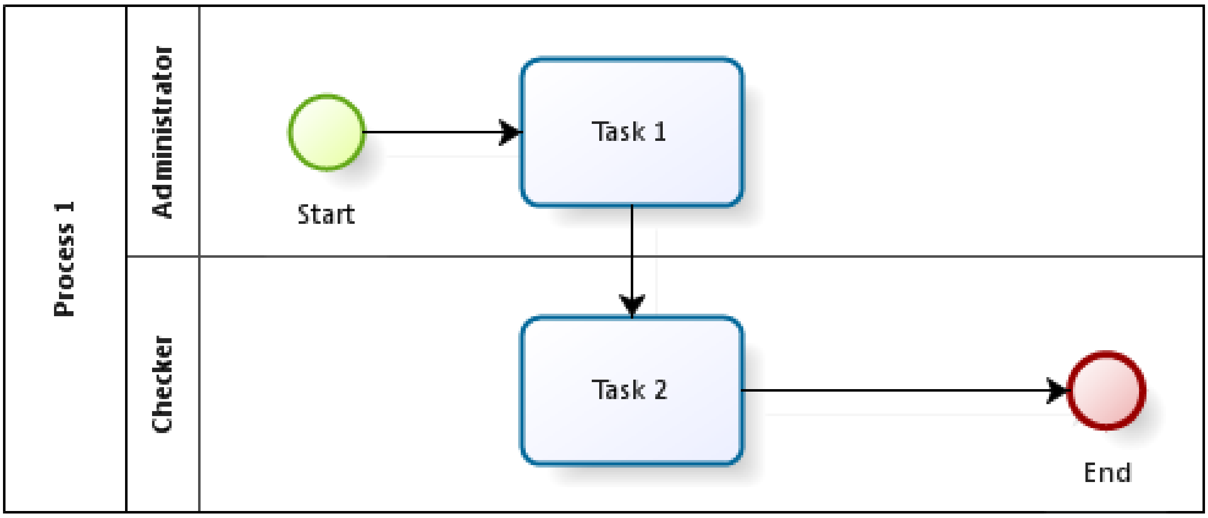

Figure 5: Resource per lane

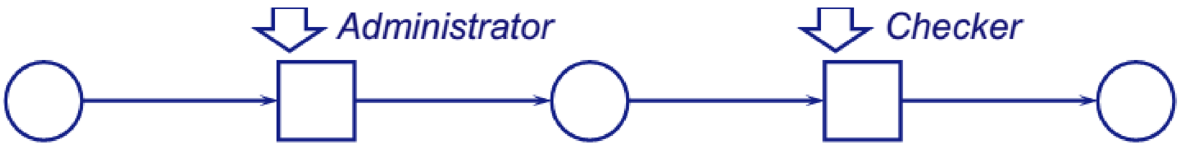

Figure 6: Resource per task

The work assignment rules for a WfMS indicate to which resource a task is assigned. Work can be assigned to specific resources or to resource roles. In Figure 5 and Figure 6 the tasks are assigned to resource roles.

The exception handling aspect in a WfMS is used for workflow models where unexpected events can occur during the execution. In such types of models the deviations from normal execution should be processed by programmatic procedures. Depending on the range of unexpected events the procedures can be simple or complex.

3.2. IMPACT OF A LIGHTWEIGHT WFMS AND ITS FUNCTIONS

The research goal of this study is obtain an understanding of what the effects of a lightweight WfMS and its functions are on service time, data accuracy, operation margin, and data availability. The lightweight WfMS and the WfMS function are expected to solve issues concerning missing information and missing documents, however, to measure these effects the existing process needs to be changed so the process incorporates a lightweight WfMS and a WfMS function.

To solve the issues concerning missing information on shipped amount the process should be changed so that the communication of such important data is mandatory. This communication should be facilitated by a workflow management system. Literature states that ‘WfMSs increase the quality of communicating of important information and thus increasing the efficiency’ (Fischer and Workflow Management Coalition, 2001) (Reijers and van der Aalst, 2005). The process scope of the WfMS is set by the issue it’s solving and thus covers the actual transport; from the sending of the charter confirmation to the receiving of the charter invoice and waybill. This sub process is referred to as the shipment feedback process.

The issue concerning missing price information, which is mainly caused by a lack of a cost/gain calculation, can be resolved by developing a WfMS function that facilitates such a cost/gain calculation. Furthermore, this WfMS function should also make the documentation of the agreed price, as well as other important data, mandatory.

The issue concerning missing documents is solved indirectly. The physical travel time of the waybill is not changed by the lightweight WfMS or the WfMS function, however, since the important shipment data is communicated via the lightweight WfMS, all relevant shipment data is available within JDR at the moment the transport is finished. Therefore, no incorrect invoice will be send anymore, since the invoice can be made based on accurate shipment data, for which the waybill is no longer necessary since the data it carries is already present within JDR.

The impact of the proposed solutions is graphically illustrated in Appendix F. , Figure 12. Here the direct impact of the lightweight WfMS is colored dark green, thus there will be a control on the data flow and the changes of the transport will be documented. The indirect impact of the lightweight WfMS is colored light green, no credit notes are necessary because of incorrect invoices sent by JDR, since the shipment data present within JDR is accurate. The direct impact of the WfMS function is colored dark brown, which shows that the WfMS function will facilitate a cost/gain. The indirect impact of the WfMS is colored light brown, thus the agreed price is always documented. Furthermore, the selection of charters can be made objectively due to the cost/gain calculation, which will optimize the charter selection and decrease costs.

The relationship between the KPIs, issues, and proposed solutions is summarized in Table 3. The issue of missing price information is measured on data accuracy and solved by the WfMS function, which facilitates a cost/gain calculation. The cost/gain calculation also allows for a measurement of the operation margin. The issues of missing information on shipped amount and missing documents are measured on data availability and solved by the lightweight WfMS. Furthermore, effect of a lightweight WfMS is also measured on service time.

Table 3: Relation between, KPIs, issues, and proposed solutions

KPI	Issue	Proposed solution
Data accuracy	Missing price information	WfMS function
Operation margin	Lack of cost/gain calculation	WfMS function
Data availability	Missing amount information Missing documents	Lightweight WfMS
Service time		Lightweight WfMS

4. DEVELOPMENT OF THE WFMS AND FUNCTION

In this chapter the development of the lightweight workflow management system and the WfMS function are discussed. First, in section 4.1 the conceptual model is presented. Second, in section 4.2 the workflow model is discussed. Finally, in section 4.3 the development of the WfMS function is discussed.

4.1. CONCEPTUAL MODEL

To develop a conceptual model for the WfMS, the current business process and proposed solutions are used as input. The process description of section 2.2 is broader than the scope of the WfMS, however, gives enough detail for the conceptual model.

The changes in the process basically entail the automation of the communication of shipment details before, during, and after the transport. These details consists of the charter confirmation, actual load and unload times and changes of the shipment. The communication will be facilitated by a WfMS. In this study BPMN is chosen for the conceptual model, since it is the industry standard for conceptual process modeling.

The conceptual process model starts when the charter confirmation is sent to the charter. The charter then performs the execution of the transport. In Appendix G. the initial design of the conceptual model is presented. In this model the control flow and resource aspects are modeled. This model describes the shipment feedback process. It starts when the JDR planner sends the charter confirmation to the charter and changing the status to zero. When status notifications are received, the JDR planner changes the status of the shipment. The third party LSP planner receives the charter confirmation, plans the transport, and sends a status notification. The driver, upon arriving at the load location, checks the shipment, loads the transport, obtains a signature for loading, and sends a status notification that the shipment is loaded. Then the driver drives, for this another status notification is sent, to the unload address where he unload the shipment, obtains a signature for unloading, and sends a status notification of unloading. When all necessary documents are signed another status notification is sent and the driver hands the waybill over to the third party LSP planner. The third party LSP planner sends the waybill and an invoice to JDR. These documents are received at JDR and processed, which is the end of the process.

The development of the lightweight WfMS was based on the idea that the communication of the shipment details during transport would be performed by the driver, however, this resulted in several, mostly practical, issues. The most imminent issue was that the driver needed to be able to communicate the shipment details to the WfMS. To solve this, the use of a smartphone app that would work as a portal for the WfMS. This, however, required all drivers to have a smartphone. Due to the high geographic diversity of the drivers a small digital survey was performed to gain insight in the smartphone usage of the drivers. Although the 63% of the participant owned a smartphone, this was still considered as a low result as the target area of the survey was The Netherlands, England, and Ireland. Extrapolating these results to all drivers, which include increasingly more eastern Europeans, the expected ownership of smartphones will be much lower than 63%. One solution for this is that JDR would facilitate smartphones to the drivers, however, obvious practical problems and investment costs prevented this. The survey questions and results are in Appendix N. Another way to solve this is to change the process so that the drivers were not required to communicate the shipment details straight to JDR, but instead the office of the charter company should communicated these. This is a change in the resource aspect. In Appendix H. the resulting model is shown, this is the final conceptual model. As can be seen when comparing the initial and final conceptual models, the change in the process is that the driver is removed as resource in the final conceptual model. The tasks of the driver are now executed by the third party LSP planner, for the rest the models are the same. This final conceptual model shows the changes in the process, however, before it is implementable in software several steps need to be taken.

4.2. WORKFLOW MODEL

Since a workflow process model needs to be implementable by software, it requires more detail and unambiguity. First of all, the conceptual model focusses more on the steps of the driver, since this was originally one of the resources. The focus of the workflow model, however, should be on the communication of shipment details. Appendix I. shows the workflow model, also in this model the control flow and resource aspects are modeled. The resources involved with the shipment feedback process are the JDR planners, third party LSP planners, and the drivers. The driver, however, is not part of the WfMS, since the driver removed from the conceptual process model due to practical reasons, as was discussed above in section 4.1. This leaves the JDR planners and third party LSP planners as human resources and the WfMS as a system resource. In this study YAWL (Yet Another Workflow Language) is chosen because of the high similarity with BPMN and therefore an extensive support in the transformation process. Since the conceptual model only consists of simple modeling constructs or patterns, similar modeling constructs or patterns can be used in the workflow process model. (van Vught, 2013)

For the control flow aspect, the workflow model starts when the JDR planner sends the charter confirmation to the charter after which he changes the status to released. The third party LSP planner receives the charter confirmation, assigns a driver to the transport, and sends the shipment details to the driver. If a notification is received of a change in the shipment or delay, the notification is filled in the WfMS. Otherwise the process continues when the driver notifies the third party LSP planner that he started loading, which is registered in the WfMS, and after that he receives a notification that the shipment is loaded, which is also registered in the WfMS. When data is registered in the WfMS the JDR planner is notified of the changes and performs necessary actions if necessary. If a delay in the transport occurs the third party LSP planner receives a notification from the driver, which the planner then registers in the WfMS. Otherwise he receives a notification of start unloading and after that a notification of end unloading. Both are registered in the WfMS. After the driver hands over the waybill, the waybill and invoice are sent to JDR. These are received, which is the end of the workflow model.

The workflow model differs from the conceptual model in several ways. First, the tasks of the third party LSP planner don’t reflect the drivers’ tasks, but only his own tasks. During transport, this comes down to receiving notifications of the driver and communicating notifications to the WfMS. Second, more detail is added in this model, since it is specified which shipment details are required in which task, i.e. start load time or end load time. Third, the process of the JDR planner shows an actual flow instead of separate tasks. Not only does this clarify the process, it also a clear start and end of the transport phase. Fourth, the communication of data as shown in the conceptual process model, i.e.

charter confirmation or waybill, is not shown in the workflow process model. The workflow process model is only concerned with the process flow, data forms are modeled in the data aspect in a WfMS.

The data aspect covers an essential part of the WfMS, therefore a detailed data model was developed. In Appendix J. the data model is presented. The data model describes how the data objects are related to each other. The data classes in the data model are: charter company, driving unit, document, drivingunitshipment, shipment, status, change, good, and activity. Furthermore, there are several enumeration classes: document type, activity type, status type, and change type. Also, all links between the data classes are shown. All data classes have attributes, which are the variables for which the data is stored. The first attribute in every data class is an attribute that gives the data an ID/primary key, i.e. charter ID or shipment number. These IDs also link the different data classes and therefore appear in other data classes, as secondary key.

The workflow process model already showed a clear separation of tasks between the two resources that are in the workflow model. This separation states the work assignment between the JDR planners and the third party LSP planners, each performing their side of the process. The work assignment is based on resource roles.

Based on the process description it can be concluded that there are no unexpected events likely to occur in the process. Furthermore, the workflow process model is fairly straightforward thus the number of unexpected events is likely be low. Therefore, for the exception handling aspect no programmatic procedures are developed. A full trial of the WfMS will give more insight into the possible unexpected events.

4.3. THE WORKFLOW MANAGEMENT SYSTEM FUNCTION

The WfMS function is developed to resolve the internal communication issue by supporting the planner with a cost/gain calculation and also requiring the planner to document all relevant trip information. During the development of this WfMS function at JDR it has named charter selector.

The charter selector tool was developed in Excel and is based on the requirements of JDR. To solve the issue of internal data inaccuracy the tool needed to capture and store all relevant trip information. To assure that all relevant data is actually filled in, the tool doesn’t allow the charter selection to be saved before certain data is filled in. This includes the agreed price, driver information, and date and time of loading and unloading.

The model is based on several parameters, most of these are cost parameters. The trip prices from all from and to locations need to be present for the cost calculation. Also the additional cost parameters are stored in the cost worksheet. All these prices should reflect the market price and therefore be updated frequently.

Charters can be blocked from showing up in the list. This can be desirable in the case of bad past performances or if JDR becomes too dependable on this charter by using it too much. Furthermore, charter locations indicate from which location a charter operates. This list should be well updated because it filters the charter list. Currently it only filters on from locations, but could also filter on to locations.

Figure 17 of Appendix K. shows the front of the tool, which operates all options of the tool. Besides the front worksheet, the tool consists of 4 worksheets with data, that includes cost parameters, charter data, charter locations, and charter quality measures. All worksheets except the front sheet are password protected and show no data, also the macros are password protected. Thus planners don't have access to the data and macro's.

The layout of the front and the charter quality measures were already defined by JDR (Ernst, Heeren, et al., 2013). These measures are reliability and timeliness, skilled drivers, waybill accuracy, security, safety, and flexibility. Furthermore there is a worksheet that stores all finished charter selections as a log file and another worksheet that uses this log file to search price history both for a specific trip and also specific for a charter on a specific trip, which can assist by future charter selections. The tool works with excel functions and macros. In the current version only a limited number of locations are added, to reduce the number of data that needs to be stored. Figure 18 of Appendix L. shows the locations graphically.

The tool works as follows. First, a from and to location have to be chosen, the 'from' location is used for filtering charters based on areas they often load shipments. The locations are currently cities, but can be converted to any area. Then it should be indicated whether or not it concerns a roundtrip. Then using the button 'get charter list' the macro filters the list of charters and sorts them based on the sum of the quality measures. This sum also includes the number of trips driven by this charter, which makes more popular choices to rank higher. Then a charter can be selected from the list. If this charter is available a price can be negotiated. The price depends on several factors, the base trip price, additional costs, and if it's a roundtrip. The additional cost concern if it's a cooled shipment, if there's a fuel surcharge, and if there are additional stops. Additionally you can also indicate whether or not JDR books a ferry or tunnel passage. A price indication will be given as base trip price and trip price. Furthermore, if there is historical data about the trip and/or about the charter it will show the lowest, average, and highest trip price as information for the planner.

When the planner reached an agreeable price for the trip this should be filled in the as the price agreement. The tool then indicates the purchase margin, which is the margin of the agreed trip based on the trip price. Depending on the value of the margin, it will either be red, yellow, or green, indicating if it's a low, medium, or high margin. If the margin is very bad, the tool doesn't allow the charter to be selected for this price. This lock can be overruled with a password by a manager.

Before the information can be saved, there is still extra information required. Information about the driver(s), the truck, and the date and time of loading and unloading. When this is filled in, the button 'save & clear sheet' activates a macro to save all information in the log and clear the sheet to the initial state.

5. TESTS AND RESULTS

In this chapter, first the workflow management system tests are discussed in section 5.1. Second, in section 5.2 the results of the workflow management system test are presented. Third, the workflow management system function tests are discussed in section 5.3. Finally, in section 5.4 the results of the workflow management system function tests are presented.

5.1. WORKFLOW MANAGEMENT SYSTEM TESTS

The lightweight workflow management system was developed to resolve the issues concerning missing documents and missing information on shipped amount. The increase in performance due to the use of a lightweight WfMS will be measured on data availability. Furthermore, the performance of the lightweight WfMS will also be measured on service time, since traditional WfMS decrease the service time and thus it can be expected that a lightweight WfMS also has a positive effect on service time. Testing the lightweight WfMS will determine the extent of these effects.

The work of JDR planners can be described as a highly interchanging tasks, therefore not only the actual time spend to perform the task itself, but the time spend on other elements of a task can be relevant to measure. There is no indication in literature what the elements of a task are. Therefore, here an attempt to specify the elements of a task is given.

In general a task has the following elements: startup, gather necessary data, perform task, document performed actions. In a factory environment these elements can look as follows. The startup phase can be for example starting up a machine necessary to perform a task. The gathering of necessary data can include the parameters and machine settings to perform the task. Performing the tasks is executing the task. Documenting the performed actions can be writing done the performed task and used parameters in a log file.

In the case of the WfMS process for JDR planners the startup phase is opening the correct case. This case already contains the relevant data, so gathering data does not take time for JDR planners. The tasks of JDR planners is, aside from planning and managing the shipments, documenting the relevant data in the system. Therefore, the performing task phase includes the documenting phase. Thus the two elements for tasks of JDR planners in the WfMS process are the startup phase and execute task phase. Service time in this research will therefore be measured on two aspects, startup time and task time. Therefore, the effect of the WfMS on service time can be measured both on task time and on startup time.

To measure the influence of the WfMS on the service time both a pre- and post-test were performed. The WfMS test was set up as two parts; the first part measures the task time and the second part measures the startup times.

Measuring the task time of the JDR planner was done by timing the JDR planner performing his regular tasks of changing shipment statuses after a notification or time expiration for the pre-test and timing the JDR planner performing the tasks assigned to him by the WfMS for the post-test. Since the JDR planner performs regular tasks in the pre-test, the task time should not vary significantly, only four status changes were measured; the same number of status changes that the WfMS has. Because the WfMS is new to the JDR planner the system is first explained by walking through the steps. After the explanation the task times will be measured, however, because a higher time variance could be expected, the tasks times of two shipments will be measured, each containing four status updates. Both the practice run and tests were performed by following a script, which contains a description of the shipment and the tasks that need to be performed. Appendix O. shows the scripts of the practice run and two tests. Because only the task time of the JDR planner is relevant, the tasks of the third party LSP planner were not timed and performed by the researcher.

The second part of the test measures the startup time that planners need after being disturbed by a shipment update. The time that is measured is the restarting time of the original task after the disturbance of the intervening task. The startup times can only be measured for the pre-test, since the WfMS was developed to not disturb the JDR planner with status updates during his work, therefore no tasks need to be restarted because of shipment status disturbances. This, however, does not mean there is no comparable value for the post-test, the post-test result for the startup times is simply zero. The pre-test was performed by measuring the restarting time after the JDR planner was disturbed by a phone call or co-worker, which is comparable to a shipment update by phone in the current situation.

The descriptions of the pre- and post-test indicate an important difference. The pre-test, of both task time and startup time, is performed with actual work data. The post-test of task time, however, is performed in a simulation of the workflow management system. Due to some research limitations, among which time, only a simulation of the workflow management system was performed, instead of a full test of the WfMS. Although this may affect the observed results, the test is performed nonetheless.

The planning of the WfMS test is shown below in Table 4.

Table 4: Planning of the WfMS test

Time (in minutes)	
1-10	Explanation and description of workflow test
11-15	Perform practice run task time
16-25	Perform real tests task time
25-40	Measuring pre-test task time
41-90	Measuring startup times after disturbances of work tasks

To measure the effect of a lightweight WfMS on data availability a test is performed. Since the WfMS test was merely an experiment, without actual data, no performance data on the data availability could be obtained from the WfMS test. However, pre-test data could be obtained from historic data of the current situation. Data availability is based on the issue of missing price information. Currently in the case of missing price information either additional information is required to complete the case or the case is handled with incomplete data. To obtain a value for the data availability in the current situation, the number of requests for additional data can be used. Additional data is requested when the invoice doesn't correspond to the charter confirmation and the shipment data is not present, which corresponds with a lack of data availability. Another way to measure of the data availability in the current situation is comparing the date of invoicing with the date of getting the waybill. If the invoice is sent before the waybill is received there was missing information. Thus the data availability can be measured on two ways, by the number of additional data requests and by the number of invoices sent before receiving the waybill. The WfMS was developed to increase the communication of data by making the communication tasks mandatory tasks in process, therefore the use of the WfMS ensures a data availability of 100%.

5.2. RESULTS OF WORKFLOW MANAGEMENT SYSTEM TESTS

Table 5 and Table 6 show the result of the pre- and post-test of the service time. Looking at the averages of the pre- and post-test, only a marginal difference between the pre- and post-test can be observed. Also between the two runs of the post-test a small differences was observed, but also this difference is negligible.

Table 5: Results pre-test task time

Pre-test	
Task	
1	0:01:03
2	0:00:48
3	0:01:18
4	0:00:41
Average	0:00:58

Table 6: Results post-test task time

Post-test			
Task	Run 1	Run 2	
Set Status Loaded	0:00:51	0:01:28	
Set Status Driving	0:01:15	0:01:46	
Set Status Unloaded	0:00:44	0:00:21	
Set Status Complete	0:00:49	0:00:49	
Average	0:00:55	0:01:06	0:01:00

Below, in Table 7, the results of the pre-test of the startup time are shown. As stated earlier, the post-test result for the startup time is zero, since the WfMS would remove any disturbances caused by shipment notifications because the WfMS will remove the need for telephone communication which disturbs the JDR planners. The values of the pre-test vary 9 to 30 seconds, this variation can be related to the length and importance of the disturbance, however, this was not documented. The startup time for a task is on average 15 seconds. These times were measured after a disturbance by timing how long it took to continue to task prior to the disturbance. These results show that the WfMS would save on average 15 seconds per notification. The average number of notifications handled by the WfMS is 11,124 per month. This is calculated by multiplying the average number of ad hoc charter trips, which can be found in Appendix B. , with the number of notifications in the process, which is four. With 11,124 notifications and an average of 15 seconds saving per notification, the saving adds up to 166,860 seconds, or 46.35 hours per month on average.

Table 7: Results pre-test startup time

Restart time (sec)	
	10
	30
	10
	9
	11
	18
	12
	20
	15
	17
	12
Average	14.91

For the pre-test on data availability the performance is measured by both the number of additional information requests and the number of invoices sent before receiving the waybill. The results of the pre-test are shown in Table 8. In the current situation for around 500 cases per year additional information is requested, which is around 2 cases per day. Comparing this to the number of trips, it only adds up to 1.50% of the cases. In the first quarter of 2013 the number of invoice sent before receiving the waybill occurs in 35.16% of the cases. Since the two ways of handling cases with missing information are mutually exclusive, the percentages add up to 36.66%. Thus the pre-test performance of data availability is 63.34%. As stated before, the post-test performance of data availability is 100%. This is a 36.66% increase in data availability.

Table 8: Results pre-test data availability

Data availability	
Additional information requests	1.50%
Invoice sent before receiving waybill	35.16%
Data unavailability	36.66%
Data availability	63.34%

5.3. WORKFLOW MANAGEMENT SYSTEM FUNCTION TESTS

The WfMS function, or charter selector, was developed to resolve the issues of missing pricen information and the lack of a cost/gain calculation and therefore increase the performance of two KPIs; data accuracy and operation margin. The extent of this increase will be determined by testing the WfMS function. Measuring the effect of the WfMS function on the data accuracy and operation margin was done by performing a pre- and post-test.

To perform a pre-test on data accuracy the historic data should be analyzed or compared with accurate data, however, no accurate historic data is present at JDR. An extensive analysis of the data is beyond the scope of this study due to time limitations. The internal communication issue is concerned with missing data, in particular the agreed charter price, and a quick look of the historic data reveals a high number of missing values of the agreed charter price. Therefore, the data accuracy will be determined by measuring the completeness of the shipment data, specifically the data of the agreed charter price. For the pre-test the historic data will thus be analyzed on the completeness of agreed charter price information. The WfMS function was developed to resolve the issues of missing information and therefore requires the planners to fill in all relevant data. Although some data is optional to fill in, the agreed charter price is a mandatory requirement. Therefore, the performance of data accuracy in the post-test will be 100%.

In this study the operation margin, within JDR referred to as purchase margin, is defined as the margin of the agreed charter price to the charter price. The charter price is the set price by JDR for a certain trip including all extra options, i.e. fuel surcharge or extra stops. Due to the lack of a cost/gain calculation, there is not historic data of the operation margin. Thus there was no possibility to compare the pre- and post-test. Nonetheless, a post-test of the WfMS function was performed to gain insight into the functionality. In this test two employees were assigned to use the WfMS function. During the time of this trail, which ran for 1.5 months, feedback from the users was used to optimize the functionality to user requirements.

5.4. RESULTS OF WORKFLOW MANAGEMENT SYSTEM FUNCTION TESTS

The pre-test on data accuracy concerns a data set of historic data of shipments of JDR of the first quarter of 2013, since the data set contains too much data it is not added as an appendix. To test the data completeness, the percentage of non-blank values was calculated. The results of the pre-test are shown in Table 9. The blank values in this data set are all cost values, which refer to the agreed charter price. For the first quarter of 2013 18.76% of the cases have missing values. Further analysis shows that it is likely that a high percentage, 31.60%, of the filled in price data is most likely false, since it concerns invoice values of less than 1 euro. Although it is likely to be false data, it requires a more detailed data analysis and thus is out of the scope of this study. Therefore, the pre-test value for data accuracy is 81.24%. As stated before, the post-test performance on data accuracy is 100%, because of the WfMS function design. Thus the increase in data accuracy is 18.76% when the WfMS function will be used.

Table 9: Results pre-test data accuracy

Data accuracy	
Missing price values	18.76%
Data accuracy	81.24%

Below, in Table 10, the results of the post-test on operation margin are shown. This table only shows the operation margin, Appendix M. shows the complete results of the post-test, in this table the operation margin is referred to as realized purchase margin. The results of the operation margin center around zero. Negative margins indicate that the agreed price is too low and operation loss, positive margins indicate an operation profit. Aside from the operation margin and the composition of the agreed price, the WfMS function saves all relevant trip information, however, these were not relevant to the KPIs of this study. As stated before, the lack of a cost/gain calculation is the reason why there is no historic data to which the post-test operation margin can be compared with.

Table 10: Results post-test operation margin

Trip	Operation margin
1	-11,11%
2	-11,11%
3	-11,11%
4	-11,11%
5	15,38%
6	15,38%
7	0,00%
8	0,00%
9	15,38%
10	15,38%
11	11,76%
12	15,38%
13	8,45%
14	0,00%
15	0,00%
16	0,00%
17	8,33%
18	0,00%
19	0,00%

6. DISCUSSION

In this chapter, first in section 6.1 the conclusions are discussed. Second, the recommendations are presented in section 6.2. Third, in section 6.3 the limitations are presented. Finally, in section 6.4 propositions for future research are discussed.

6.1. CONCLUSIONS

The objective of this research was to gain insight into the effects of a lightweight workflow management system and its functions. During this study a lightweight workflow management system and a WfMS function were developed. Four hypotheses were formulated to answer the research question.

HYPOTHESIS 1: A LIGHTWEIGHT WFMS AND ITS FUNCTIONS WILL DECREASE THE SERVICE TIME

Service time was split into task time and startup time, the former indicating the actual time spend on a task and the latter indicating the time required to restart a task from the point the employee previously was before a disturbance. For the task time no significant difference was observed between the current way of working and working with the developed workflow management system. For the startup time, however, 46.35 hours per month on average can be saved when using the developed workflow management system. This is slightly over 0.25 FTE. Thus it can be concluded that a lightweight workflow system decreases the service time.

HYPOTHESIS 2: THE DATA ACCURACY WILL IMPROVE USING A LIGHTWEIGHT WFMS AND ITS FUNCTIONS

The data accuracy was measured by calculating the percentage of non-missing values of agreed charter price, which is the most important data of the charter process. With a pre-test result of 81.24% and a post-test result of 100%, the data accuracy thus increases by 18.76% when using the workflow management system function.

HYPOTHESIS 3: THE OPERATION MARGIN WILL IMPROVE USING A LIGHTWEIGHT WFMS AND ITS FUNCTIONS

Since there was no historic data present of the operation margin, no pre- and post-test comparison can be made. However, the development of the workflow management system function does facilitate the monitoring of the operation margin. The monitoring of performance can improve performance (Irving, Higgins, et al., 1986). Nevertheless, this study cannot conclude that a lightweight workflow management system and its functions increase the operation margin.

HYPOTHESIS 4: A LIGHTWEIGHT WFMS AND ITS FUNCTIONS WILL INCREASE THE DATA AVAILABILITY

Data availability was measured by calculating the percentage of additional data requests and cases handled with incomplete data. For the pre-test, the result of the former was only for 1.50% of the cases while the result of the latter was 35.16%. The data availability of the current situation is 63.34%. The post-test result was 100% data availability, which is an increase of 36.66%. Thus the data availability will increase due to the use of a lightweight workflow management system and its functions.

Below, in Table 11 the results of the tests are summarized. Based on the results and conclusions of the hypotheses, the research question can be answered.

WHAT ARE THE EFFECTS OF A LIGHTWEIGHT WORKFLOW MANAGEMENT SYSTEM AND ITS FUNCTIONS

First, a lightweight workflow management system and its functions decrease the startup times. Second, a lightweight WfMS and its functions increase the data accuracy. Third, a lightweight WfMS and its functions increase the data availability. Therefore, it can be stated that a lightweight workflow management system and its functions have a positive effect on service time, data accuracy, and data availability.

Table 11: Summary of results

	Service time		Data accuracy (%)	Operation margin (%)	Data availability (%)
	Task time (sec)	Startup time (sec)			
Pre-test	58	15	81.24	-	63.34
Post-test	60	0	100	0	100

6.2. RECOMMENDATIONS

The results and conclusions of the tests indicate the possible gains that could be obtained by implementing a lightweight workflow management system and the WfMS function. The issues concerning missing documents and missing information on shipped amount are solved due to the increase in data availability. The issue of missing price information is solved due to the increase in data accuracy. Both data accuracy and data availability have a performance of 100% when implementing a lightweight WfMS and the WfMS function.

It is therefore recommended to implement a workflow management system for the shipment feedback process. This system will solve the issues concerning missing documetns and missing information on shipped amount. Furthermore, it sets a basis for a track-and-trace system to be developed. However, in the current model the third party LSP planners communicate the shipment updates. This allows for delay in the notifications and thus influences the reliability of a track-and-trace function.

Also, it is recommended to implement the workflow management system function, or charter selector. This tool will solve the issue of missing price information. It also allows for monitoring the performance of planner, which could positively influence the operation margin. An additional recommendation for this tool is to set a JDR standard price. This standardization makes it possible to filter and sort charters based on a mix of price and quality, while in the current model only quality measures are used to sort charters. In general, for a WfMS function that facilitates the data documenting and makes this a mandatory task for the users similar results can be expected on data accuracy. The extent of the increase of the data accuracy depends only on the pre-test results, thus on the current performance. The mandatory task of documenting data ensures that the data accuracy will increase up to 100% after implementation of a such a WfMS function.

6.3. LIMITATIONS

The process of this research and the results of the tests are influenced by several factors. These factors have limited the outcomes of this study.

The first limitation is the lack of key performance indicators and performance data at Jan de Rijk Logistics. Currently at JDR key performance indicators are not used. This is mainly caused by a lack of accurate data on shipments and trips. The workflow management system and the WfMS function help solve this issue for future research, however, it caused issues for measuring the effects of the WfMS and the WfMS function in this study. This is especially clear for operation margin, since a lack of accurate data prevented the performance of a pre-test based on historic data. Furthermore, the analysis on price data showed that it is likely that a high percentage, 31.60%, of the filled in price data is most likely false, as it concerns invoice values of less than 1 euro. This influences the results of the pre-test on data accuracy, since now only missing price data was used for measuring the data accuracy. Additionally, the erroneous data makes data analysis impossible for a study with this amount of time. Finally, the lack of performance data made additional research efforts impossible. Since either the data was not available or the data was not reliable to use for analysis. This prevented additional research efforts to extent the presented tests and results.

The second limitation is not being able to perform a full test of the workflow management system. Because there are multiple third party LSPs involved in this process, a full test of the WfMS with the external parties was not possible. Instead, a small experiment was done within JDR. It is likely that the difference in testing, with a pre-test in a work environment and a post-test in an experiment, affected the results on task time. Another problem is the size of the experiment, both on task time and startup time. The low number of results makes it impossible to perform a statistical analysis. A full test of the WfMS would also have helped gaining insight into possible issues relating to the implementation of the WfMS. The main problem is 'outsourcing' several of JDR's administrative tasks to the third party LSPs.

The third limitation is the distorted image of the shipment feedback tasks. The changing of shipment updates by planners at JDR are done differently than what was claimed by the operation manager. Instead of having contact with the charters about the shipment updates, the JDR planners change the statuses when the expected activity time is passed by one or two hours without any communication. This has great impacts on the amount of time spend for changing status updates and would have resulted in different results for the task time. The current way of working operates on assumptions, because important shipment data is not present. The WfMS ensures the availability of the shipment data and does not increase the task time of JDR planners.

6.4. FUTURE RESEARCH

Future research should expand the research into the effects of lightweight workflow management systems and its functions. In this study the effects were only measured on four key performance indicators. Future research should focus on more KPIs in order to gain insight into the full range of effects of a lightweight workflow management system and its functions.

Future research should also deepen the research of the effects of the four KPIs studied in this research. For service time, and especially for task time, the effects of a lightweight workflow management system are likely to be larger than the effects found in this study. As discussed in the limitations, this study was hampered by a distorted image of the shipment feedback tasks. A fairer comparison with the measured WfMS task times would be to compare it with a pre-test that performs equally on data availability. Furthermore, the tests in this study were based on a limited amount of data. Even more so, the reliability of the data is questionable. Research with more reliable data would give better and more powerful results.

Finally, future research should also perform a full test of the workflow management system with third party LSPs. This study only performed a small experiment within JDR. To gain insight into the possible issues relating the implantation of a the WfMS, a full test of the WfMS with third party LSPs should be performed. Also, such a test would gain insight into the exception handling aspect of the WfMS, which was not worked out in detail in this study.

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Appendix A. CHARTER TRANSPORTATION PROCESS

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Figure 7: Charter transportation process (AS-IS)

Appendix B. NUMBER OF AD HOC CHARTER TRIPS

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Table 12: Number of ad hoc charter trips in 2013

Figure 8: Number of ad hoc charter trips in 2013

Appendix C. FISHBONE DIAGRAM

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Figure 9: Fishbone diagram

Appendix D. PROBLEM MESS

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Figure 10: Problem Mess[1]

[1] The main problems are colored red and the key issues are colored blue.

Appendix E. RESEARCH SCOPE

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Figure 11: Research scope[2]

[2] The main problems are colored red and the key issues are colored blue.

Appendix F. IMPACT OF PROPOSED SOLUTIONS

Confidential

Figure 12: Impact of proposed solutions[3]

[3] The impact of the lightweight workflow management system is colored dark green, the indirect impact is colored light green. The impact of the WfMS function is colored dark brown, the indirect impact is colored light brown.

Appendix G. INITIAL CONCEPTUAL PROCESS MODEL OF REDESIGN

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Figure 13: Initial conceptual process model of redesign

Appendix H. FINAL CONCEPTUAL PROCESS MODEL OF REDESIGN

Confidential

Figure 14: Final conceptual process model of redesign

Appendix I. WORKFLOW PROCESS MODEL

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Figure 15: Workflow process model

Appendix J. DATA MODEL

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Figure 16: Data model

Appendix K. WORKFLOW MANAGEMENT SYSTEM FUNCTION

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Figure 17: View of the WfMS function

Appendix L. LOCATIONS IN WFMS FUNCTION

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Figure 18: Locations in WfMS function

Appendix M. RESULTS POST-TEST OPERATION MARGIN

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Table 13: Results post-test operation margin complete table

Appendix N. SURVEY QUESTIONS AND RESULTS

Table 14: Survey questions and results[4][5]

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[4] Questions about contact information not shown.
[5] Dutch and English answers mixed because survey was available in both languages.

Appendix O. WORKFLOW TEST SCRIPTS

Third party LSP planner (practice case)

Charter confirmation

Shipment 1

From: Nike
Address: Grotekerkplein 103, Rotterdam
Telephone: 0104131645

To: Footlocker
Address: Demer 19, Eindhoven
Telephone: 0405132645

Load date: 15-08-2013
Load time: 09:00:00
Unload date: 15-08-2013
Unload time: 12:00:00

Colli: 24

Tasks

Receive charter confirmation
ApplyChange: no
StartLoading: Shipment 1 Start load time: 09:15:00
EndLoading: Shipment 1 End load time: 09:30:00
ApplyChange2: no
StartUnloading: Shipment 1 Start unload time: 12:00:00
EndUnloading: Shipment 1 End unload time: 12:20:00
ReceiveWaybill: Cost: 300
SendBillToJDR
SendWaybillToJDR

JDR planner (practice case)

Charter confirmation

Shipment 1

From: Nike
Address: Grotekerkplein 103, Rotterdam
Telephone: 0104131645

To: Footlocker
Address: Demer 19, Eindhoven
Telephone: 0405132645

Load date: 15-08-2013
Load time: 09:00:00
Unload date: 15-08-2013
Unload time: 12:00:00

Colli: 24

Tasks

For every task check if the data is correct or if additional tasks need to be performed

SetStatusAllLoaded: Loaded
SetStatusDriving: Driving
SetStatusAllUnloaded: Unloaded
SetStatusComplete: Complete

<u>Third party LSP planner</u> (Test 1)

Charter confirmation

<u>Shipment 1</u>

From: Nike
Address: Grotekerkplein 103, Rotterdam
Telephone: 0104131645

To: Footlocker
Address: Demer 19, Eindhoven
Telephone: 0405132645

Load date: 15-08-2013
Load time: 09:00:00
Unload date: 15-08-2013
Unload time: 12:00:00

Colli: 24

<u>Shipment 2</u>

From: Nike
Address: Grotekerkplein 103, Rotterdam
Telephone: 0104131645

To: Intersport
Address: Rechtestraat 32, Eindhoven
Telephone: 0403442786

Load date: 15-08-2013
Load time: 09:00:00
Unload date: 15-08-2013
Unload time: 12:30:00

Colli: 18

Tasks

Receive charter confirmation
ApplyChange: yes
Change: Loadtime: <u>Shipment 1&2</u> 10:00:00
StartLoading: <u>Shipment 1&2</u> Start load time: 10:15:00
EndLoading: <u>Shipment 1&2</u> End load time: 10:30:00
ApplyChange2: yes
Change: Unloadtime: <u>Shipment 2</u> 13:00:00
StartUnloading: <u>Shipment 1</u> Start unload time: 12:30:00
EndUnloading: <u>Shipment 1</u> End unload time: 12:50:00
StartUnloading: <u>Shipment 2</u> Start unload time: 13:00:00
EndUnloading: <u>Shipment 2</u> End unload time: 13:20:00

ReceiveWaybill: Cost: 500
SendBillToJDR
SendWaybillToJDR

<u>JDR planner</u> (Test 1)

Charter confirmation

<u>Shipment 1</u>

From: Nike
Address: Grotekerkplein 103, Rotterdam
Telephone: 0104131645

To: Footlocker
Address: Demer 19, Eindhoven
Telephone: 0405132645

Load date: 15-08-2013
Load time: 09:00:00
Unload date: 15-08-2013
Unload time: 12:00:00

Colli: 24

<u>Shipment 2</u>

From: Nike
Address: Grotekerkplein 103, Rotterdam
Telephone: 0104131645

To: Intersport
Address: Rechtestraat 32, Eindhoven
Telephone: 0403442786

Load date: 15-08-2013
Load time: 09:00:00
Unload date: 15-08-2013
Unload time: 12:30:00

Colli: 18

Tasks

<u>For every task check if the data is correct or if additional tasks need to be performed</u>
SetStatusAllLoaded: Loaded
SetStatusDriving: Driving
SetStatusAllUnloaded: Unloaded
SetStatusComplete: Complete

<u>Third party LSP planner</u> (Test 2)

Charter confirmation

<u>Shipment 1</u>

From: Nike
Address: Grotekerkplein 103, Rotterdam
Telephone: 0104131645

To: Footlocker
Address: Demer 19, Eindhoven
Telephone: 0405132645

Load date: 15-08-2013
Load time: 09:00:00
Unload date: 15-08-2013
Unload time: 13:00:00

Colli: 24

<u>Shipment 2</u>

From: Adidas
Address: Havenweg 23, Rotterdam
Telephone: 0104131645

To: Footlocker
Address: Demer 19, Eindhoven
Telephone: 0405132645

Load date: 15-08-2013
Load time: 10:00:00
Unload date: 15-08-2013
Unload time: 13:00:00

Colli: 12

Tasks

Receive charter confirmation
ApplyChange: no
StartLoading: <u>Shipment 1</u> Start load time: 09:00:00
EndLoading: <u>Shipment 1</u> End load time: 09:30:00
StartLoading: <u>Shipment 2</u> Start load time: 10:00:00
EndLoading: <u>Shipment 2</u> End load time: 10:20:00
ApplyChange2: yes
Change: Unloadtime: <u>Shipment 1&2</u> 13:30:00
StartUnloading: <u>Shipment 1&2</u> Start unload time: 13:30:00
EndUnloading: <u>Shipment 1&2</u> End unload time: 13:50:00

ReceiveWaybill: Cost: 400
SendBillToJDR
SendWaybillToJDR

<u>JDR planner</u> (Test 2)

Charter confirmation

<u>Shipment 1</u>

From: Nike
Address: Grotekerkplein 103, Rotterdam
Telephone: 0104131645

To: Footlocker
Address: Demer 19, Eindhoven
Telephone: 0405132645

Load date: 15-08-2013
Load time: 09:00:00
Unload date: 15-08-2013
Unload time: 13:00:00

Colli: 24

<u>Shipment 2</u>

From: Adidas
Address: Havenweg 23, Rotterdam
Telephone: 0104131645

To: Footlocker
Address: Demer 19, Eindhoven
Telephone: 0405132645

Load date: 15-08-2013
Load time: 10:00:00
Unload date: 15-08-2013
Unload time: 13:00:00

Colli: 12

Tasks

<u>For every task check if the data is correct or if additional tasks need to be performed</u>

SetStatusAllLoaded: Loaded
SetStatusDriving: Driving
SetStatusAllUnloaded: Unloaded
SetStatusComplete: Complete