Validated Requirements for a Smart Logistics Application

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ABSTRACT

Logistics companies want to move towards smart logistics, but currently they do not have any suitable application to do so. Research in this field has already delivered many requirements for an application to help planners with smart logistics [17]. This research provides a consolidated list of requirements for an application which enables LSPs (Logistics Service Providers) to perform smart logistics, a mapping of these requirements to functionality, an implementation of a number of them, and a validation of the implementation by experts. This research will provide a step in the direction of performing smart logistics.

Keywords

Smart Logistics, Synchromodal Transport, Smart Planning, Requirements, Application, Information System, Logistics Service Provider (LSP), Fourth Party Logistics (4PL)

1. INTRODUCTION

Every day new customers are in need of transportation and in some parts of the worldnew markets are emerging [18]. Since Logistics Service Providers (LSPs) are commercial, profit has to be made. They want to be as efficient and effective as possible to increase their profitability and competitiveness.

Lately, extensive research has been conducted regarding modern concepts of transportation. From 2008 on, LSPs started to increase cooperation. By this time, the concept of multimodal transportation (making use of at least 2 different modes of transportation) was introduced [18]. Further research determined other concepts for multimodal transportation. The most recent concept of transport is called synchromodal transportation, which turned out to have a considerable overlap with *smart logistics* [17][18][20].

Smart logistics involves using data about roads, weather, traffic jams, train delays, congestion on waterways and other sources of available data. Furthermore, smart logistics creates the possibility to change the planning in real time (dynamic switching) [19]. The use of dynamic switching is only relevant for big disruptions, because only then switching could make the transport more efficient [8]. Big disruptions regards disruptions of several hours, and not minutes. How much exactly, depends on the customer. Cooperation between many LSPs is needed to achieve the best transport offer. It can be viewed as a large logistics network, which has already been proved to be way more profitable [7].

At the University of Twente research on smart logistics has been conducted, the project is called SynchromdalIT. The three main reasons for this research are (I) the need for an European logistics network, (II) the need to increase efficiency and sustainability of logistics services and (III) the ambition to trigger companies towards a synchromodal way of working [8].

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2. PROBLEM STATEMENT

Currently, LSPs are using applications for planning, however, they are not able to perform smart logistics. One of the main reasons is that these applications are only focusing on their own business and are not connected to any extra data at all [8]. To involve this extra data, SynchronmodalIT suggests a new comprehensive application usable for planners to perform smart logistics. The majority of LSPs do not have a tool for this purpose. This tool should have an automated planning functionality (to plan transportation by using several transportation modalities from more than just one LSP) and also adjust the planning dynamically (during transportation) [8]. The problem is that there does not exist any literature which describes what should be the functionality of such an application.

Requirements from various stakeholders have already been defined to make sure how existing processes can be improved and which new processes are required [17]. A first demo version of the application has been developed, but there was no structured method to do so: the entire requirement analysis was missing. It is very likely that requirements and functionality are disjoint from each other. Furthermore, the test application has not been validated yet.

Developers of the existing test application are aware of the fact that the application is still incomplete and that part of the functionality is missing. The goal of this research is to map the consolidated requirements from different stakeholders to functional and non-functional requirements for the application. These new requirements will be implemented and validated by experts. This research provides a consolidated list of requirements and an improved and validated implementation.

2.1 Research Question

From the Problem Statement the following research question has been derived:

RQ: How can an application aid in smart logistics?

In order to answer this research question, the following

subquestions have to be answered:

SQ1: What is smart logistics and what are the requirements for a smart logistics application?

SQ2: What functions are needed to satisfy the requirements?

SQ3: How effective is the new implementation compared to the current state of work?

The sub questions help to clarify the requirements for smart logistics, find functional requirements for the application, and validate these requirements with experts.

SQ1 will be answered in Section 4, *SQ2* in Section 5 and *SQ3* in Section 7.

3. METHODOLOGY

To achieve the goal of this research, the Design Science Research Methodology [26] has been used. The research exists of several steps, which are shown in Figure 1.

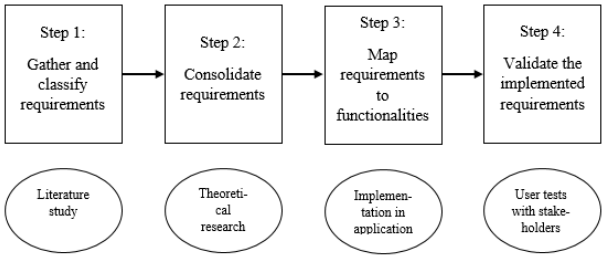

Figure 1. Research method based on Design Science Research Methodology [26]

3.1 Method

The steps described in Figure 1 can be mapped to the steps shown in Figure 2. As shown in Figure 2, this research is a closed chain of actions which follow up each other. Requirements are gathered, consolidated and mapped to functionality, implemented, and validated. The validation can yield new or improved requirements for the next version of the application. The four steps of Figure 2 are explained in sections 3.2–3.5.

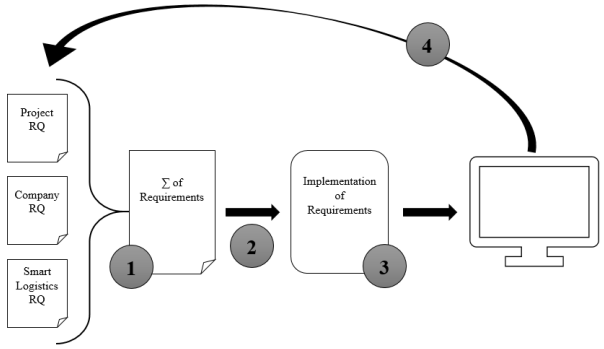

Figure 2. Research method

3.2 Literature Study

The literature study is about gathering all requirements for the smart logistics application. A complete list of requirements takes into account the following information:

- SynchromodalIT project [8]
- LSPs [13]
- Smart logistics [17]
- Optimal process of handling disruptions [19]
- Development of a smart logistics dashboard [21]

Furthermore, 2 relevant papers [3][6], which were not included in the already existing research and are about not yet considered aspects regarding smart logistics, have been taken into account as well.

Next to these requirements, previously conducted interviews for the SynchromodalIT project with several companies [4][5][15][16][22][23][24][25] were used as well. The companies which were interviewed before are shown in Table 1 (4PL means 'Fourth Party Logistics' and is an enterprise which offers customers the services of several LSPs).

Table 1. Companies which were interviewed before

Interview	Company
LSP	Bolk Transport
4PL	Seacon Logistics
Logistics Institute	TKI DINALOG
Software Provider	CAPE Groep
Software Provider	OV Software

The combined list of requirements was completely unclassified. A new classification was made by using the method of writing down all requirements on small cards and distributing them on a table. While reading them one-by-one, a classification was made.

This classification is an improved version of the classification made by Singh et al. [17], due to including more requirements. Additionally, the classification made by Singh et al. does not explain the method of classification while in this paper the method is explained.

The literature study will be discussed in Section 4.

3.3 Theoretical Research

Consolidation of the requirements was made after classification. Overlapping requirements (requirements which describe the same functionality in the application) were combined into one clear requirement. Taking into account the classification, a new list of requirements was made.

Finally, the consolidated requirements were mapped to the four levels of requirements engineering of Lauesen [10], the levels are explained in Table 2. This classification has been used because of the clear distinction of functional (F) and non-functional (NF) requirements, and further hierarchy in the functional requirements. The design-level requirements were not taken into account since the design of the application is not part of the functionality. Furthermore, no research in this field has been done and doing this is out of scope for this research.

Table 2. Four levels of requirements [10]

Level	Description
Goal-level	Business goal (NF)
Domain-level	User tasks to be supported (F)
Product-level	System functions to be supported (F)
Design-level	Specification of interface (F)

After acquiring the complete list of requirements, the application can be improved. However, with just the general requirements from all stakeholders, a developer is still not able to improve or develop an application. Thus, an extra

step between requirements and implementation is necessary.

To get a clearer insight into the boundaries and the needs of the system, a context diagram and different scenarios per requirement were specified. This will help the developer to implement the requirements [2].

The theoretical research will be discussed in Section 5.

3.4 Implementation

After having gathered all requirements, the context-diagram and the scenarios, the application can be developed. Due to the time-constraint for this research, it was not possible to implement all requirements. Therefore, a list of requirements to be implemented for this research was made.

The to-be-implemented requirements were implemented in the already existing application. This application is made using Mendix [11].

The implementation will be discussed in Section 6.

3.5 Validation

The implemented requirements were validated by conducting qualitative research by the use of expert reviews. An expert review can be well-used in both formative (how to improve) and summative (whether it answers the question) validation [14].

The participants of the validation are guided through the application to show the implemented requirements. When they are on the right page, they can use the application themselves and check whether it is a good implementation according to the scenarios of the functional requirement.

Their opinion about the implementation and recommendations regarding the scenario will be asked in a semi-structured interview, right at the time they are using the application.

The validation will be discussed in Section 7.

4. REQUIREMENTS ANALYSIS

The requirement analysis is the literature study in this research. First, requirements were obtained and processed from all available data sources (Section 4.1), after that, the classification (Section 4.2) was made.

4.1 Obtaining requirements

The first list of classified and consolidated requirements from literature has already been made by Singh et al. [17]. In this research, this list have been appended with the requirements from 8 relevant interviews and 2 relevant papers, both from the industry perspective.

While retrieving requirements from the literature, many requirements were linked to already documented requirements. In 10 new information sources, a total of 60 requirements were found. 57 of these could be linked to or combined with already existing requirements. The other 3 are new requirements, which will be discussed in subsections 4.1.1–4.1.3.

Next to adding new requirements, overlapping requirements were removed. The original list of Singh et al. [17] contained 55 requirements. 5 pairs of overlapping requirements were found, so the list has been decreased to 50. By adding 3 new requirements, the new list consists of 53 requirements.

4.1.1 Security and roles

Security and roles is a requirement mentioned by the SynchromodalIT project researcher. Different users (e.g. customers, LSPs and 4PLs (the actual planner and owner of the application)) should all be able to use the same application, but with different authentications. Therefore, security and different user roles should be considered as an important requirement.

4.1.2 Create awareness

To make sure that the stakeholders are going to use the application to perform smart logistics, they should become aware of possibilities of improvement in the network's performance, including a reduction in their costs [6].

4.1.3 Mode-free booking

Smart logistics can improve the current logistics chain the most, if the customers are booking mode-free transportation [3]. The customer books a transport from A to B, without specifying a particular mode of transportation. This ensures that the planner using the smart logistics application can search for the best integration of modalities and that they can switch modalities in real time in case of a disruption.

4.2 Classification

Having the list of 53 requirements is not convenient to work with or to implement, because some requirements are still vague when read separately. This can be improved by a classification. Three different classifications were made using the method explained in Section 3.2. The final classification contains 7 groups, which can be found below. In Appendix A, one can find the classified requirements.

Pre-requisites. Successful implementation of the application requires pre-requisites. Without these pre-requisites, using the smart logistics application will not lead to its potential.

Unscheduled activities. Every planning has to deal with unscheduled activities. This category includes requirements regarding (handling) delays and uncertain circumstances in the supply chain.

Coordination. Requirements show that for smart logistics it is important to have a central point of coordination. Requirements in this group are related to this coordination or the visibility of the supply chain, which is necessary for coordination.

Logistics combination. The demand of the customer should be offered as a complete logistics combination of different modalities and services.

Bundling. A planner should be able to bundle freight in order to make the best offers for the customers. These requirements are about freight aggregation and the synchronization of the customer's demand.

Dynamic planning. All requirements regarding the planning are classified in this group. Aspects such as real-time adaption, switching, and planning decisions can be found in this group.

Effects. All effects of the smart logistics application are classified in this group. These are all non-functional requirements for the system, describing what the system eventually should contribute.

5. REQUIREMENTS TO FUNCTIONS

The theoretical research will be discussed in this section. First, the consolidation of the classified requirements was carried out (Section 5.1). Then, a context-diagram (Section 5.2) and scenarios (Section 5.3) were made.

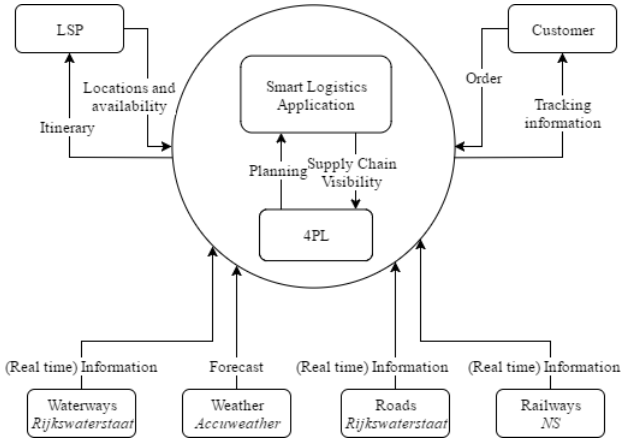

Figure 3. Context Diagram

Table 3. Actors in Context Diagram

Actor	Description
4PL	Owner of the application and planners of the enterprise
LSP	Logistics Service Provider
Customer	Customer with transport demand
NS	Dutch Railways
Rijkswaterstaat	Dutch road institute
AccuWeather	Weather forecast
Rijkswaterstaat	Dutch waterway institute

Table 4. Implemented functional requirements

Requirement	Scenario(s)
Security and roles	[1][2][3][4]
Supply chain visibility	[5.2]
Coping with disruptions	[11]

5.1 Consolidation

The consolidation of requirements is needed for a clear overview. Many requirements could still be combined into one requirement, because A exists out of B and C, e.g. *bundling freight, consolidation of load, aggregate demands* and *synchronization of demand* all refer to the same concept.

The classification of requirements made the consolidation easy. All groups of requirements except for *Pre-requisites* and *Effects* are functional requirements. The functional requirements were consolidated the most. The new list of consolidated requirements can be found in Table 5. The origin of the requirement refers to the original requirement in Appendix A.

After the consolidation, all requirements were mapped to one of the four levels of requirement engineering of Lauesen [10] (Table 2). It became clear that requirements categorized as *Pre-requisites*, could not be mapped to one of the four levels. This is obvious, since these are not requirements for the application itself, but requirements for the circumstances in which the application is able to work. This supports the categorization and thus the consolidation which was made.

The domain-level and product-level requirements are functional requirements and are therefore translated into normal English functional requirements, which are in Table 6.

5.2 Context Diagram

In order to get a better understanding of the boundaries, stakeholders, interactions and the data input and output of the system, a context diagram is a very helpful method [2]. The context diagram can be found in Figure 3.

The *4PL* can be seen as the owner of the *Smart Logistics Application*. Planners of this company will use the application to do smart logistics. A short description of the actors in this diagram can be found in Table 3.

5.3 Scenarios

Alexander and Beus-Dukic (2009) claimed that *"A scenario is a story adapted and structured for engineering use. (...) Scenarios communicate requirements very effectively (...) as storytelling is such a natural and powerful way of explaining needs in human terms."*.

The application will be used by different stakeholders, having different roles. Administrators, 4PL planners, LSPs and customers want to use the system to plan or to get insight into the logistics process. The application should make sure that it offers different functionality to different roles (e.g. a customer should not be able to plan a route).

Scenarios were made to explain the functional requirements and the context diagram towards the programmer of a software enterprise. The entire list of scenarios in consecutive order can be found in Table 7.

6. IMPLEMENTED FUNCTIONALITY

The scenarios in Table 7 are written in consecutive order. After comparing this list to the first demo version of the application, the conclusion was that many scenarios are not present in the existing demo application.

The implemented requirements can be found in Table 4. Because of the time-constraint for this research, not all scenarios can be implemented. The chosen scenarios are expected to be the most important, since these are the first five in the list of consecutive scenarios (5.1 is already present). Except for scenario 11, which is already partly implemented. It will be extended by the weather forecast. The explanation of each implementation is written in the subsections below. The screen captures are in Appendix B.

6.1 Security and roles

For the requirement *Security and roles*, 4 different user roles were defined:

- Administrator
- Planner (4PL)
- LSP
- Customer

The administrator is the only one who can create accounts and assign roles. The planner of the 4PL as well as the administrator have got access to all other functionality of the application. According to the scenarios in Table 7, the customer and the LSP can just see their own orders, however, the LSP can also see disruptions.

Up until this current research, no implementation regarding security has been considered. The first step to establish security is a log-in mechanism. After, the landing pages for every role were made and connected to the roles (Figure 4 and 5).

Security settings were set for every page and every role. Furthermore, constraints for orders were given in case a customer or LSP is logged in. This means that a customer or LSP can now only see the orders where they are customer or LSP respectively.

Table 5. Consolidated List of Requirements

		Origin	Level
	Pre-requisites		
1	Integrating governance	P1, P4	
2	Cooperation	P2, P3, P5, P6, P7	
3	Create awareness	P8	
4	Mode-free booking	P9	
5	Data	P10	
6	Sharing real time information	P11	
	Functional requirements		
	Coordination		
7	Central logistics coordination	C1, C2, C3	Domain-level
8	Supply chain visibility	C4, C5, C7	Product-level
	Smart Planning		
9	Dynamic planning	D1, D2	Product-level
10	Real time decisions	D3, D6, D9, D10, D11	Domain-level
11	Real time switching between modes	D4, D5, D7, D8	Domain-level
12	Bundling freight	B1, B2, B3, B4	Domain-level
13	Integrated transport system	L1, L2, L3	Product-level
14	Synchronized combination of modes and services	L4, L5, L6	Product-level
15	Coping with disruptions	U1, U2, U3	Product-level
	System		
16	Security and roles	C6	Product-level
	Effects		
17	More efficient	E2, E3, E8, E9, E10, E11	Goal-level
18	Environment friendly	E1, E5	Goal-level
19	Reliable	E4	Goal-level
20	Sustainable	E6	Goal-level
21	Flexible	E7	Goal-level

To make sure that the last function is working properly, the domain model and the page for creating an order were slightly changed. Now it is also possible to connect LSPs to an order (the relation 'customer to order' was already present), which is needed to show the LSP's orders once logged in.

This functionality is implemented according to functional requirement 16 in Table 5 and 6. According to scenarios 1, 2, 3 and 4, the requirement is completely implemented.

6.2 Supply chain visibility

For the functional requirement *Supply chain visibility*, the pick-up and drop-off locations of an order (scenario 5.2) were visualized on a map. The Google Maps Widget [9] made for Mendix [11] was used.

Showing markers on the Google Maps Widget is possible with latitude (lat) and longitude (lon) combinations of the to-be-displayed location. The translation from pick-up/drop-off location to lat/lon has been implemented by using a REST-service (method of communication between computers), called Nominatim by OpenStreetMaps [12]. This translation process has been made in such a way, that it can be re-used for every situation and entity inside the application.

The feeded Google Maps Widget is displayed on the order overview page (Figure 6) and the order new/edit page (Figure 7). This ensures that the planner can immediately see from where to where the order needs to be transported. The process of feeding the application with the correct data has been done in a way that the widget could be placed on every page with just some minor changes in the background.

This functionality is implemented according to functional requirement 8 in Table 5 and 6. According to the scenarios (Table 7), the requirement is not completely implemented yet. However, the implementation made for this requirement is a good starting point to continue developing the application.

6.3 Coping with disruptions

For the functional requirement *Coping with disruptions*, real time information about the weather was implemented.

First, the location where the planner wants to know the forecast should be translated into lat/lon. In the previous implemented requirement, the function for doing that have already been made. The API of AccuWeather [1] can be used as a REST-service, which changes the lat/lon combination to a numerical code for each location. Subsequently, the weather forecast can be retrieved by using the same API.

Currently, the weather forecast can be retrieved on order-level on the order page. Using the corresponding button in this page displays real-time information regarding the first possible disruption due to weather conditions (e.g. rain, thunderstorms, snow, and ice; see Figure 7). Because of the free API version, this forecast can just retrieve data up to five days ahead.

This functionality is part of functional requirement 15 in Table 5 and 6. According to the context diagram (Figure 3), the requirement is not completely implemented yet, since the diagram shows that the APIs of the railways, waterways and roads should be implemented as well. The incompleteness is supported by the scenarios in Table 7, since the application should also automatically add the disruption to the orders (scenario 15). Nevertheless, the implementation of the weather API is a new and required function for the application and is a step in the right direction for completing the requirement.

7. VALIDATED REQUIREMENTS

The three (partly) implemented requirements were validated by experts. These experts are active in the logistics domain and are aware of information systems.

The three implementations were rated as *good* by all three experts, which means that scenarios 1, 2, 3, 4, 5.2 and 11 (regarding weather) from Table 7 are implemented well in the application.

Besides the approval of the implementation, the experts suggested many recommendations for future work. The recommendations regarding the validated implementation are as follows.

The application should:

- show the route between stoppages.
- show all stoppages of a consolidated transport.
- show route alternatives and terminals/hubs along the route.
- show real time information about the transport.
- process a delay to the orders itself.
- focus weather forecasts on transport over sea.

Most of the recommendations were already present in the list of scenarios in Table 7. However, scenarios 5.3 and 6.4 were added to the scenario list and minor changes to some other scenarios were processed.

In a meeting with the supervisor of this research, the recommendation of creating an extra page for the weather forecast to see the forecast for each individual day came up. This recommendation was implemented in the application, which means that the user can now see a weather forecast for each individual day (Appendix B, Figure 8).

One participant of the validation recommended a change in the application disregarding the new implementation. The suggestion was to change the disruption information on order-level. Right now, the application just saves *true* or *false* regarding a disruption. According to the participant, it is almost impossible to state that 'yes there is a disruption' or 'no there is not'. Furthermore, a customer will be interested in the probability of a change in the estimated time of arrival.

The summary of the expert reviews are in Appendix C.

8. DISCUSSION AND FUTURE WORK

This research offers a list of consolidated requirements for applications to aim in the field of smart logistics. Requirements were derived from the literature and interviews with stakeholders. To provide developers with useful information, a context-diagram and scenarios were made, according to the list of consolidated requirements. This is all based on information which is available in this stage. As soon as there is new information regarding smart logistics, the requirements could need changes.

Due to the time-constraint for this research, not all scenarios were implemented. Implementation of all requirements will be an extensive process, since all stakeholders should be highly involved in order to make an application which would include each stakeholder's demand.

The implemented and validated scenarios are a next step in the direction of having one application for 4PLs, LSPs, and customers. The security and landing pages are implemented, as well as showing markers on a map and getting a weather forecast from a specific location. The last two functions are made possible by having a connection with an API to retrieve lat/lon combinations by addresses as data input. This is a useful feature in the further development of the application, since it can be re-used.

Furthermore, the application is able to process a weather forecast of more than five days, but the usage of the free API version limits the forecast data to five days ahead. In order to offer valuable information to the users of the application, the API version should be extended. The improvement after validation regarding the view of the forecast per day is not validated again, but since it is implemented according to a recommendation, it can be seen as a valid improvement.

According to one participant of the validation, the data the application saves about a disruption on order-level, is not the information a customer needs. They need to know the probability of a change in the estimated time of arrival. Therefore, research of the customer's side is recommended.

The list of scenarios as well as the implementation made for this research was validated by experts from the University of Twente in the logistics domain, and not by companies, the future users of the application. Validation of scenarios and implementation with companies becomes possible and should be done after implementing more requirements, due to the lack of benefits for these companies in this stage. This new validation can result in new requirements which are unforeseen right now.

9. CONCLUSION

In the introduction, the following research question together with its subquestions were posed.

RQ: How can an application aid in smart logistics?

SQ1: What is smart logistics and what are the requirements for a smart logistics application?

SQ2: What functions are needed to satisfy the requirements?

SQ3: How effective is the new implementation compared to the current state of work?

Each subquestion and consequently the research question will be answered below.

SQ1. The criteria for a smart logistics application have been captured and a list of consolidated requirements for a smart logistics application was made by taking into account various stakeholders and literature (Table 5).

SQ2. Functional requirements were derived from the list of consolidated requirements. To make a developer able to develop the application, a context diagram (Figure 3) and several scenarios per requirement (Table 7) were made.

SQ3. Some composed scenarios (Table 4) were implemented in the already existing demo application. This implementation was validated by experts in the logistics domain as *good*, thus the implementation is an improvement. Recommendations are processed in the scenario list.

RQ. In order to achieve the benefits of smart logistics, an application is required. By using the list of consolidated requirements, the context diagram, the list of scenarios and the improved version of the application, a developer is able to implement all known requirements from stakeholders and literature in the domain of smart logistics into one system which supports smart logistics. This research can be used as a reference for developing a smart logistics application.

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[26] R. J. Wieringa. *Design Science Methodology for Information Systems and Software Engineering*. Springer Verlag, London, 2014. ISBN 978-3-662-43838-1.

Table 6. Functional Requirements

No. Table 5	Functional Requirement
1–6	*Non-functional requirements (Pre-requisites).*
7	The product should support the user to act as a central logistics coordinator/planner.
8	The product should be able to show the entire supply chain to the planner.
9	The product should be able to plan dynamically.
10	The product should support the user to change the already made planning real time.
11	The product should support the user to switch between modes while planning.
12	The product should support the user to bundle freight in order to get the best transport offer.
13	The product should be able to give the planner, LSP and customer an integrated transport system.
14	The product should be able to make a synchronized combination of modes and services to the planner, LSP and customer.
15	The product should be able to cope with (unplanned) disruptions regarding every transport mode.
16	The product should be able to distinguish user roles and their rights to see, add, edit and delete data.
17–21	*Non-functional requirements (Effects).*

Table 7. Scenarios

	Situation				**Response**	
	Scenario	**Cause**	**Interface**		**Actor**	**Task**
1	Log in	Customer	Application		Application	Show orders from just this customer.
2	Log in	LSP	Application		Application	Show all disruptions and only orders from this LSP.
3	Log in	Planner	Application		Application	Show all functionality except for user administration.
4	Log in	Admin	Application		Application	Show all functionality
5.1	New order	Demand	Email/Call/ Website		Planner	Make new order and include into the planning.
5.2					Application	Show pick-up and drop-off locations on a map.
5.3					Application	Show route between start and end locations including possible stoppages.
6.1	New route	Planner	Application		Planner	Make new route of orders.
6.2					Application	Communicate route to the customer and LSP.
6.3					Application	Show start and end locations on a map
6.4					Application	Show route between start and end locations including stoppages.
7	Tracking order	Customer/ LSP	Application		Application	Show available tracking information about their order(s).
8	Stoppage unavailable	Unknown	Email/Call		Planner	Change the schedule.
9	Freight unavailable					
10	Truck unavailable	Unknown	Email/Call		Planner	Change vehicle or mode.
11	Check disruptions	Interest	Planner's		Planner	Check road/rail/water/weather APIs.
12	Disruption from API	Unknown	API		Application	Check order whether they use the disrupted transport leg. If so, add disruption to the order(s).*
13	Truck breakdown		Call		Planner	
14	Traffic jam		Call		Planner	
			API		Application	
15	Heavy weather		Call		Planner	
			API		Application	
16	Exceeding driver's time		Call		Planner	
17	Accident road/rail/water		Call		Planner	
18	Delay at customs		Call		Planner	
*	Disruption for order	Disruption	Application		Planner	Switch vehicles or modes if that is more efficient and show alternative routes on a map.

APPENDIX

A. CLASSIFIED REQUIREMENTS

Table 8. Classified list of requirements

Pre-requisites (P)	
P1	Legal [17][23]
P2	Cooperation [3][5][17][23]
P3	Decision Making [17]
P4	Integrating governance [17]
P5	Integrating policies [17]
P6	Integrating technology [4][5][17][23]
P7	Integrating infrastructure [17]
P8	Create awareness [6]
P9	Mode-free booking [3]
P10	Data [3][5][15][17][23]
P11	Sharing real time information [3][5][15][16][17][23]
Unscheduled activities (U)	
U1	Coping with delays [15][17][23]
U2	Handling uncertain circumstances [3][17]
U3	Coping with disruption [16][17][23]
Coordination (C)	
C1	Central network orchestrator [3][17][23]
C2	Coordination of logistics chains [17][23]
C3	Advanced information systems [17][23]
C4	Supply chain visibility [17]
C5	Holistic view of transport network [17][23]
C6	Security and roles
C7	Traceability [17]
Logistics combination (L)	
L1	Integrated solution [17]
L2	Integrated transport system [17]
L3	Aggregation of different modes into a coherent service [17]
L4	Synchronized combination [17]
L5	Structured combination [17]
L6	Integrating services [17]
Bundling (B)	
B1	Bundling freight [3][17][23]
B2	Consolidation of load [16][17]
B3	Aggregate demands [17]
B4	Synchronization of demand [3][17]
Dynamic planning (D)	
D1	Better planning [3][15][17]
D2	Dynamic planning [17]
D3	Real time adaption [3][17]
D4	Switching between modes [17]
D5	Intermediate transfers [3][17][23]
D6	Possibility of last minute changes [17]
D7	Dynamic switching [17][23]
D8	Real time switching [3][17][23]
D9	Ability to decide at real time [3][16][17][23]
D10	Best mode selection of all time [17]
D11	Choice based on current circumstances [3][17][23]
Effects (E)	
E1	CO2 decrease [17]
E2	Better utilization of resources [3][17]
E3	Reducing empty container routes [17]
E4	Reliable [3][17]
E5	Environment friendly [17]
E6	Sustainable [17]
E7	Flexible [3][17]
E8	Reduce costs [3][17]
E9	More efficient [3][17]
E10	Optimal alignment [17]
E11	Minimal buffer time [17]

B. SCREEN CAPTURES

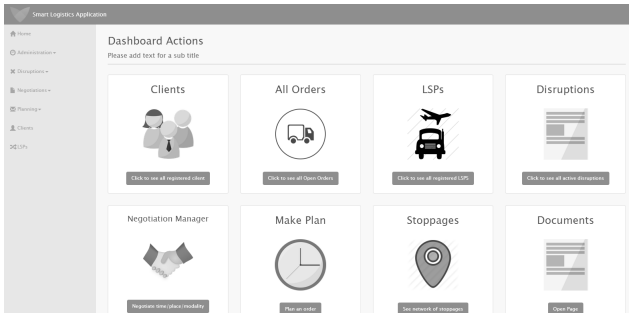

Figure 4. Landing page Administrator role (all functionality)

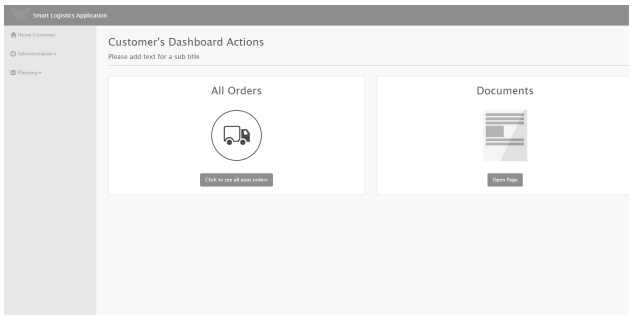

Figure 5. Landing page Customer role (limited functionality)

Figure 6. Order overview page including map

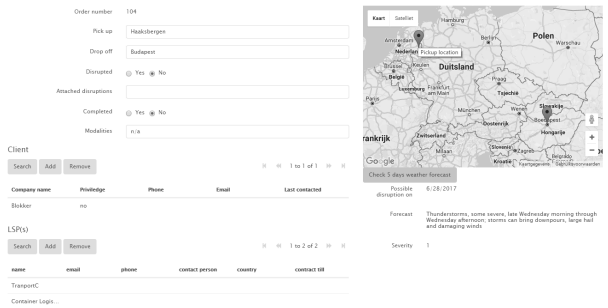

Figure 7. Order new/edit page including map and first possible disruption due to weather

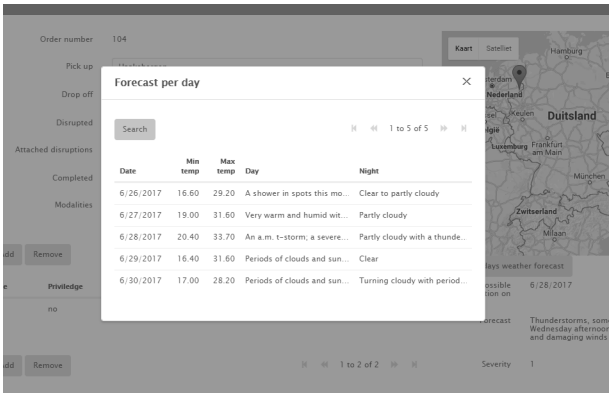

Figure 8. Pop-up forecast per day

C. VALIDATION SESSIONS

Validation was carried out with the help of three participants. All of them are working at the University of Twente and are active in the logistics domain and are aware of information systems.

C.1 Participant 1

C.1.1 Requirement 16; Scenarios 1, 2, 3, 4

Opinion Participant's opinion about the implemented scenarios is that all scenarios have been implemented well. The application is able to process all scenarios in the way they are described.

Recommendations None.

C.1.2 Requirement 8; Scenario 5.2

Opinion Participant's opinion about the implementation is that the scenario has been implemented well. The application is able to process the scenario in the way it is described.

Recommendations Participant sees that this is a first step in the right direction of showing entire routes on the map. In the future, the map should also show stoppages where a freight can switch modes and all possible routes to get to its destination. Furthermore, if an order is in the process of transportation, the real time location should be visible as well.

C.1.3 Requirement 15; Scenario 11

Opinion Participant's opinion about the implementation is that the scenario is implemented well. However, the participant is questioning whether this functionality would be useful to the planner. The planner could also use its own web browser to search for this information and manually change the order.

Recommendations In the future, the application should automatically give a delay to orders which are using a disrupted transport leg.

C.2 Participant 2

C.2.1 Requirement 16; Scenarios 1, 2, 3, 4

Opinion The application is good regarding these scenarios. It is just focused on the login, role-based views, and its authentication, which are implemented well.

Recommendations None.

C.2.2 Requirement 8; Scenario 5.2

Opinion Okay, first step towards the final product.

Recommendations What if there are multiple clients? That is one goal of Smart Logistics: bundling freight from different customers. The map should also show the other stoppages and not just start and end point.

C.2.3 Requirement 15; Scenario 11

Opinion The possible disruption can be seen. OK.

Recommendations It is very unlikely that the weather is going to influence trucks. However, weather can influence shipments, so focus on the terminals and ports, and not on roads.

C.3 Participant 3

C.3.1 Requirement 16; Scenarios 1, 2, 3, 4

Opinion A customer does not see more than they already know. They placed an order so they know the information about it.

Recommendations Even though it is not about this scenario, the participant was questioning how an order can have a disruption in a yes/no way? In the participant's opinion it is not so black/white as it is stated here. There can be a disruption which does not influence the ETA (Estimated Time of Arrival), is it a disruption for the customer then? There might occur disruption which have minor or major impact, in reality you cannot state that 'yes there is' or 'no there is no' disruption. There are always disruptions. Try to drive from Enschede to Rotterdam and arrive exactly at the ETA the TomTom is telling you when leaving. This is not going to work. In the participant's opinion, a customer is more interested in the probability that a time window of the delivery is going to change.

C.3.2 Requirement 8; Scenario 5.2

Opinion Scenario is implemented well.

Recommendations The map should show routes of consolidated transports, e.g. all transport legs should be visible. The participant has worked on a similar project some years ago and also suggests to show route alternatives, nearest terminal/hub along the route, and real time information about the location of the freight. Furthermore, some customers have strict delivery time slots, which should be taken into account.

C.3.3 Requirement 15; Scenario 11

Opinion Participant saw many LSPs but he thinks they are not interested in the weather. However, if the weather is going to change the ETA, it might be useful for the customer to know that there might be a disruption.

Recommendations There are many more sources for disruptions than only the weather.