RTF - Using ferry real time information to optimise intermodal transport chains in the Baltic Sea Region

WP 3.4

Monitoring parallel development activities with relevance for ferry real time data generation

Annual ferry real time generation trend report No. 2

May 2019 – November 2019

prepared by

A'TUIN, KSRC, RISE, ZUT, University of Rostock

EUROPEAN REGIONAL DEVELOPMENT FUND

EUROPEAN UNION

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It´s time to get visible!

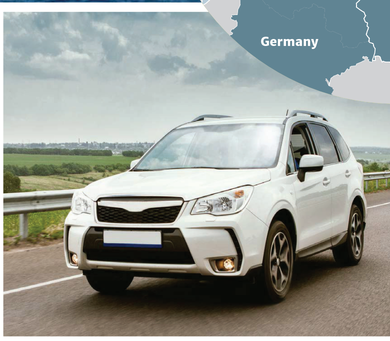
Real Time Ferries – sharing real time departure and arrival times for ferries in the Baltic Sea Region to facilitate passenger and goods transport.

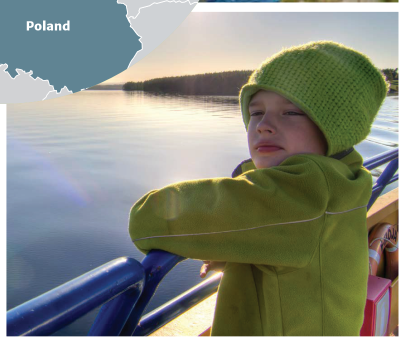
The RTF-project connects ferry-lines to hinterland and public transport making ship voyages a connected part of the transport chain.

• Official partners: 22

• Duration: 3 years (May 2017-September 2020)

• Budget: ~€5 Million (~€3,9 Million from European Regional Development Fund)





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List of abbreviations

AIS	Automatic Identification System
CEF	Connecting Europe Facility
CORDIS	Community Research and Development Information Service
ETA	Estimated Time of Arrival
GTFS	General Transit Feed Specification
IT	Information Technology
NeTEx	Network Timetable Exchange
NN	Neural Networks
NOPTIS	Nordic Public Transport Interface Standard
OJP	Open Journey Planne
Ro-Ro	Roll on Roll off
RTF	Real Time Ferry
R & D	Research and Development
Pax	Passengers
SIRI	Standard Interface for Real-time Information
STM	Sea Traffic Management
SVR	Support Vector Regression
TMS	Transport Management System
TRIMIS	Transport Research and Innovation Monitoring and Information System

Abstract

In the framework of the RTF project, it is aimed for the development of an RTF platform. This platform will provide real time information from the ferries for the example of the Baltic Sea region. Therefore, the generation of real time information is an important part of the project. To support the implementers of the data generation tools, continuous monitoring of developments in the field of real time data generation is required, which will be documented in annual ferry real time data generation trend reports. Subsequently to the first report, scientific papers, research projects and IT-solutions developed by companies are reviewed and summarised in the following. Moreover, pros and cons are discussed.

1 Introduction

1.1 Introduction and scope of the project

Real time information from ferries in the Baltic Sea region is hardly available and currently the information exchange is executed by conventional information transfer (e.g. phone and email). This is a restriction for logistics service providers e.g. to establish just-in-time concepts, and also reduces the planning ability of passengers. The scope of this project is mirrored in the collaborative development and installation of a real time data management system (data hub/platform) for the ferry traffic in the Baltic Sea Region, which provides ferry real time information from ferries to the different stakeholders in the public transport and to the stakeholders along the maritime supply chain.
This system will enable the improvement of related processes for the logistics companies, for the ports, for the public authorities and for the passengers at land and on board of the ferries.
Therefore, a data generation tool will be developed. This toolset generates and provides real time data to the RTF platform. This annual report supports the implementer of data generation toolset by finding new data generation methods or confirming the used methodologies.
Twelve ferry real time demo lines will be implemented and tested under real world conditions (see Figure 1).

Figure 1: Collaborating ferry lines in the Baltic Sea Region

1.2 Monitoring parallel development activities with relevance for ferry real time data generation

The field of real time traffic information and digitalisation of logistics and port processes is very dynamic at the moment. One of the issues, which a lot of different initiatives and actors are dealing with, is the data generation. As a consequence, it could be possible that new methods for generating real time data could be found during the lifespan of the RTF project.
For noticing and taking advantage of these new methods, it is important to continuously monitor and track the developments in the area of generation of real

time information and data. Whenever new solutions are found that add value to the project, they have to be investigated and analysed. Through continuous reviewing of relevant scientific papers and journals, scanning of research projects and monitoring of developed/implemented IT-solutions by companies, this report presents a comprehensive review of parallel developments in the area of real time data generation.
Therefore, different sectors such as public transport (includes bus, train, public ferries and tram), logistics (road, rail, air and sea) and other relevant areas were considered to get an overview about the methods to generate real time information. The findings with relevance to the generation of real time data are presented in this report. Applicable solutions are assessed by collecting and comparing the pros and cons.
This report could help the implementers of the real time data generation tools through new real time data generation approaches or could confirm the currently applied methods.

1.3 Structure of the annual ferry real time generation trend report

The annual ferry real time generation trend report is divided into the following sections:
The methodology to monitor parallel developments to generate real time information is explained in section 2. This section is followed by the review of the scientific papers in section 3. The reviewed research projects are presented in section 4. Section 5 shows the review of IT-solutions developed by companies. A conclusion is given in section 6.

2 Methodology

The methodology consists of the following steps (see Figure 2):

1. Scope of analysis
2. Identification of publications
3. Selection and evaluation

In the first step, scientific data bases, R&D Information Services and search engines and in a later stage company IT-solutions are selected.
The second step includes defining appropriate keywords related to the field of real time data generation and setting different search criteria such as the period of analysis. The period of analysis is limited to the last twenty years (2000-2019). This is followed by the search for papers and research projects. In this report, articles in peer-reviewed journals and conference proceedings which are related to real time data generation are considered. The third step is represented by filtering search results based on title and abstract followed by reviewing and analysing them. After full-text reading, the classification takes place and the results are integrated into the annual report. Finally, the related IT-solutions developed/implemented by companies are scanned and discussed.

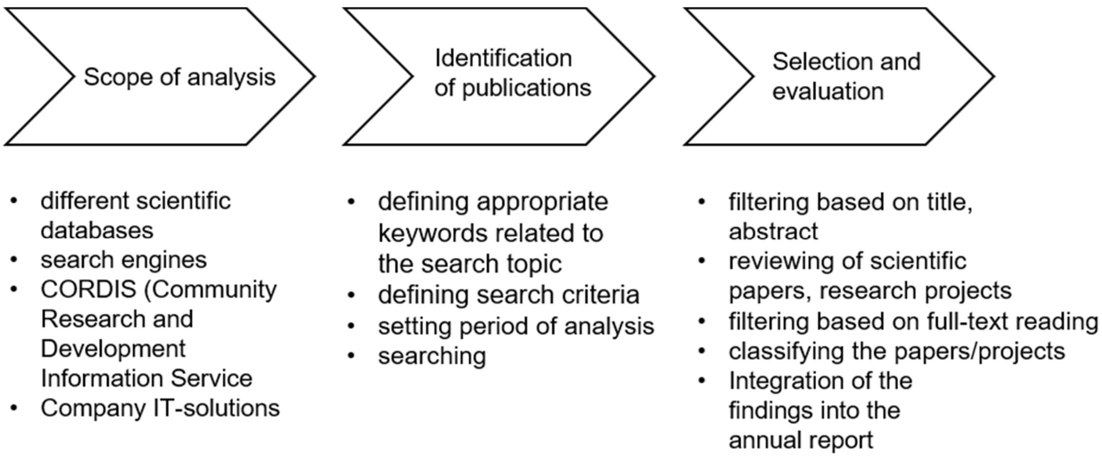

Figure 2: The steps of the methodology

A limitation was the accessibility of the papers. The chosen databases are not accessible for every institution. This means, that there will be an exchange between the project partners, as they may have different access to different databases. As a result, a variety of databases are used for the annual ferry real time generation trend report. To limit the error quote, topic-related papers were considered to get the crucial information. [Konovalenko 19]

2.1 Databases and Search Engines

The considered scientific databases of journals and papers are listed in the Table 1. The used scientific databases were Science Direct, Emerald Insight, Taylor & Francis, IEEE Explore and BazTech.
For the second part of this report, the review of projects, CORDIS (Community Research and Development Information Service) was used. It gathers all information about EU-financed projects in one database. It is created by the European Union. These findings will be complemented by the search results, which were found by "Interreg" and "TRIMIS" (Transport Research and Innovation

Monitoring and Information System). Both databases also include projects funded by the European Union, but focus on different topics.
For the monitoring of IT-solutions a different approach was applied. Therefore, instead of using scientific databases, general search engines (e.g. Google) were used. Additionally, IT-solutions presented at conferences and exhibitions were included.

Used Scientific Databases
Science Direct
Emerald Insight
Taylor & Francis
IEEE Xplore
BazTech
Scopus
Web of Science
Google Scholar
ResearchGate

Table 1: Different science databases for the review of scientific papers

2.2 Keywords

The determination of the topics and keywords is important for the execution of the research process. To increase the benefits for the stakeholders, it is important to keep track of the latest developments in the field of real time data generation. The identified topics e.g. transport, ETA, logistics, supply chain, real time data generation, help to find papers. The keywords were selected as part of the brainstorming process of the research group members. At the beginning, the most generic keywords have been used for the search process. For using the keywords in different databases various approaches are possible for example the using of keywords strings. Therefore, the using of OR and AND strings is an efficient way. To generate these strings, it is important to find keywords that can be combined and to know the string codes of the database websites. It is also important to define the position where the keyword should be searched in e.g. only in the title or abstract. For this report the search for keywords will take place in the title, abstract and keywords list of the papers.

The following keyword combinations have been defined:

- Data generation AND
    - Real time OR
    - Arrival time

(TITLE("real time") OR TITLE("arrival time")) AND data generation
("real time" OR "arrival time") AND data generation

- Estimated time of arrival AND
    - Prediction OR
    - Calculation

(TITLE("prediction") OR TITLE("calculation")) AND estimated time of arrival ("prediction" OR "calculation") AND estimated time of arrival

- Real time data generation AND
  - Public transport OR
  - Logistics OR
  - Ferries

(TITLE("public transport") OR TITLE("logistics") OR TITLE("ferries")) AND real time data generation
("public transport" OR "logistics" OR "ferries") AND real time data generation

The above shown search strings are for the search on science direct. They are used in the advanced search.

In addition to the mentioned keywords and search method, following keywords are used:

- Calculation Arrival Time
- Vessel Arrival Time
- Estimated Vessel Arrival Time
- Real Time Information Arrival
- Transport Real Time Information
- Multimodal Transport Freight Monitoring
- Real Time Multimodal Freight Transport
- Ferry Transport
- Modern Systems Used in Ferry Shipping
- Real Time Intermodal Transport
- Real Time Public Transport

2.3 Selection and evaluation

The entire selection of the results has been divided into a preselection part, an extended search part and finally a part about the selection and integration of the selected results.
Using the previously defined keywords and databases / search engines, a large amount of results was compiled. To make an appropriate selection, the process was divided into two rounds. In the first round, papers, projects and IT-solutions were evaluated by their titles and abstracts / short summaries in relation to RTF. Therefore, the first results found were briefly read and rejected if they were not relevant for the project. A paper was relevant if it met the following criteria:

- Main topic is the transport of goods and / or passengers
- It is about real-time data and its generation
- The research question is considered in the paper
- The keywords are mentioned in the paper
-

The second round includes reviewing and filtering the results of the preselection based on full-text reading. Finally, the results are analysed, classified, summarised and integrated into the report.

3 Review of scientific papers

The following section presents the review of scientific papers. The reviewed papers are divided into different areas. Table 2 to Table 6 give an overview of the reviewed papers.

Public transport	
Public transportation (bus) - ETA	
[Wang 14]	Bus Arrival Time Prediction Using RBF Neural Networks Adjusted by Online Data
[Liu 13]	Social Sensing Enhanced Time Ruler for Real-Time Bus Service
[Rong 03]	Estimated Time of Arrival (ETA) Based Elevator Group Control Algorithm with More Accurate Estimation. Turku Centre for Computer Scienceo. ISBN 952-12-1289-6. 21 2003
Public Transportation (bus) - system	
[Kale 14]	Real Time Passenger Information System
[Monzon 12]	Real Time Passenger Information systems and quality of bus services
[Bruglieri 15]	A real-time information system for public transport in case of delays and service disruptions
[Fagan 11]	Intelligent time of arrival estimation Proc. IEEE Forum Integr. Sustain. Transp. Syst. (FISTS), 2011 pp. 60–66
[Hjalmarsson 15]	Mind the Gap: Exploring Stakeholder Values with Open Data Assessment.
[Koutsikouri 18]	Extending Digital Infrastructures: A Typology of Growth Tactics
[Smith 18]	Barriers to innovating with open government data: Exploring experiences across service phases and user types

Table 2: Overview of the reviewed papers - Public transport

Maritime transport	
Transportation (vessel) - ETA	
[Parolas 16]	Prediction of Vessels' Estimated Time of Arrival (ETA) Using Machine Learning – A Port of Rotterdam Case Study
[Hillerström 18]	Arriving on time using uncertainty aware deep learning
[Paulauskas 19]	Ro-Ro and Ro-Pax vessels ETA and ATA analysis
Transportation (vessel) - Emission	
[Ceder 06]	Planning and evaluation of passenger ferry service in Hong Kong
Transportation (vessel) – Berth scheduling/simulation/routing	
[Pallotta 13]	Vessel Pattern Knowledge Discovery from AIS Data: A Framework for Anomaly Detection and Route Prediction
Transportation (container)	
[Findley 18]	Evaluation of wait times and queue lengths at ferry terminals
[Wawruch 18]	Development of the Polish Harbours Information and Control System (PHICS)
[Hanssen 19]	Determinants affecting ferry users' waiting time at ferry terminals
[Jurdziński 15]	Pilot navigation planning
[Watson 15a]	Green Steaming: A Methodology for Estimating Carbon Emissions Avoided
[Chrysostomou 19]	Ports of the Future: Bringing Emissions in Port Visits to a Minimum by Collaboration and Data Sharing
[Michaelides 19]	Port-2-Port Communication Enhancing Short Sea Shipping Performance: The Case Study of Cyprus and the Eastern Mediterranean.
[Lind 19]	Boosting data-sharing to improve Short Sea Shipping Performance: Evidence from Limassol port calls analysis
[Watson 15b]	A Research Agenda for Self-Organizing Ecosystems: The Case for Maritime Informatics.
[Watson 17]	Physical and digital innovation in shipping: seeding, standardizing, and sequencing.
[Lind et al. 15a]	Enabling Port Efficiency by increased Collaboration and Information Sharing – Towards a Standardized Port Call Message Format.
[Lind et al. 15b]	Port collaborative decision making – closing the loop in sea traffic management.
[Christodoulou 19]	The integration of RoRo shipping in sustainable intermodal transport chains: the case of a North European RoRo service. Sustainability

[Chung 11]	The critical factors: an evaluation of schedule reliability in liner shipping
[Jørgensen 18]	Determining optimal frequency at ferry crossings
[Mohd Salleh 17]	Predicting a containership's arrival punctuality in liner operations by using a Fuzzy Rule-Based Bayesian Network (FRBBN).
[Paulauskas 13]	Ships entering the ports
[Pani 14]	Managing Vessel Arrival Uncertainty in Container Terminals: A Machine Learning Approach
[Kaizer 13]	The concept of modernization works related to the capability of handling e class container vessels in the Port of Gdynia
[Tomczak 08]	Safety evaluation of ship's manoeuvres carried out on the basis of integrated navigational system (INS) indications
[Zalewski 08]	Navigation safety assessment in an entrance channel, based on real experiments

Table 3: Overview of the reviewed papers - Maritime transport

Rail Transport	
[Poznański 12]	Application of the simplified calculation method for the determination of the running time of a train on the open line
[Šakalys 17]	Research on intermodal terminal interaction in international transport corridors

Table 4: Overview of the reviewed papers - Rail Transport

Air Transport	
Public transportation (airplane) - ETA	
[Di Ciccio 16]	Detecting flight trajectory anomalies and predicting diversions in freight transportation
[Suzuki 00]	The relationship between on-time performance and airline market share: a new approach
[Achenbach 18]	prescriptive analystics in airline operations: Arrival time predicition and cost index optimization for short-haul fights

Table 5: Overview of the reviewed papers - Air Transport

Road Transport, logistics and other topics	
Time of Arrival	
[Li 07]	Event Stream Processing with Out-of-Order Data Arrival
[Sahay 08]	Real time business intelligence in supply chain analytics
Intermodal ETA	
[Vera-Baquero 16]	Real-time business activity monitoring and analysis of process performance on big-data domains
[Gunasekaran 04]	Information systems in supply chain integration and management
[Keller 14]	Classification models for RFID-Based real-time detection of process events in the supply chain
[Behdani 16]	Multimodal Schedule Design for Synchro modal Freight 533 Transport Systems
Real-Time Information systems – Real time information acquisition	
[Harmony 17]	Evaluation of Real-Time Transit Information Systems: An information demand and supply approach
[Bruglieri 15]	A real-time information system for public transport in case of delays and service disruptions
[Harris 15]	ICT in multimodal transport and technological trends: Unleashing potential for the future
[Bast 14]	Real-time movement visualization of public transit data
[Tarrant 17]	Romanse: a road management system for Europe
[Vickery 10]	Supply chain information technologies and organisational initiatives: complementary versus independent effects on agility and firm performance
[Salo 06]	IT—enabled supply chain management
[Angeles 05]	RFID technologies: supply-chain applications and implementation issues
[Yan 09]	Supply chain information transmission based on RFID and internet of things
[Hinkka 15]	Supply chain typology for configuring cost-efficient tracking in fashion logistics

[Helo 05]	Logistics information systems: An analysis of software solutions for supply chain co-ordination
[Iakovou 07]	An analytical methodological framework for the optimal design of resilient supply chains
Impact of real time information system	
[Pronello 17]	The effects of the multimodal real time information systems on the travel behaviour
[Hasiewicz 16]	Network management system on roads in Poland
[Prajogo 12]	Supply chain integration and performance: the effects of long-term relationships, information technology and sharing, and logistics integration
[Engler 18]	Trajectory-based multimodal transport management for resilient transportation
[Xue 13]	Risk mitigation in supply chain digitization: system modularity and information technology governance
[McFarlane 03]	The impact of automatic identification on supply chain operations
[Werthmann 17]	Towards a standardised information exchange within finished vehicle logistics based on RFID and EPCIS
[Werner 10]	Correlating distributed RFID-based event data for logistics process monitoring
[Conforti 12]	Real-time risk monitoring in business processes: a sensor-based approach
[Cimino 11]	Autonomic tracing of production processes with mobile and agent-based computing
[Kang 16]	Performance prediction of a MongoDB-Based traceability system in smart factory supply chains
[Soroor 09]	Initiating a state-of-the-art system for real-time supply chain coordination
[Chauhan 09]	Fuzzy state noise-driven Kalman filter for sensor fusion
[Paulauskas 15]	Jūrų transporto plėtra
[Web site 19]	www.marinetraffic.com. 2019
[Konovalenko 19]	Event processing in supply chain management – The status quo and research outlook
[Murphy 12]	Physics-based and parametric trajectory prediction performance comparison for traffic flow management
[Curtis 10]	An implicit representation of chordal comparability graphs in linear time
[Finbow 10]	On well-covered triangulations

Table 6: Overview of the reviewed papers - Road Transport, logistics and other topics

A master thesis with the title “ETA prediction – Predicting the ETA of a container vessel based on route identification using AIS data” by Ricardo Meijer from 2017 was also considered. As the title refer, it is about the ETA prediction and therefore, it could be significant for this project.

In the following, an in-depth analysis of the papers presented in Table 2 to Table 6 is carried out as well as a suitability check concerning the RTF-Project.

3.1 Papers concerning public transport

A solution for the estimation of the bus arrival time in China based on an artificial neural network is presented in “Bus Arrival Time Prediction Using RBF Neural Networks Adjusted by Online Data” by Wang et al. The method is divided into two phases. In the first phase a Radial Basis Function Neural Network (RBFNN) trained to learn the historical datasets. The method includes different factors: travel time, dwell time, distance, number of passengers (getting on or off), delay, travel speed and congestion index. In the second phase an online filter with real time information is used to calculate the arrival time. A Kalman Filter is used to determine the actual travel speed of the objective bus. During an experiment phase, both methods, a MLR (Multiple Linear Regression) and a BPNN method have been tested. As results the second phase (RBFNN with online adjustment) was the most accurate method with the lowest MAPE (Mean average percentage error). [Wang 14]

Suitability check for the RTF:
Four different approaches to predict the arrival time of buses are presented and compared in the paper and a recommendation for one method is given. Nevertheless, it has been applied to the bus transport which is different to the ferry transport, because of the stops at which passengers go on and off of the bus.

The paper “Social Sensing Enhanced Time Ruler for Real-Time Bus Service” by the authors Liu et al. deals with an innovative solution to predict e.g. arrival times and delays of buses. Social Sensing is used to improve the service quality and estimate the arrival time of public transport busses. The developed system considers the speed of the travelers and the speed of the buses. Social Sensors are the individual people, which report about the real time condition in social networks. The support vector machine classifies events and enhances the service quality. A case study is presented and an artificial neural network is used to estimate the speed of the buses and to calculate the time of arrival based on the report in social networks, which are related to the traffic. This system helps to identify unpredictable events like traffic jams, bad weather and temporary road-work. The Figure 3 gives a simplified overview of the system structure. [Liu 13]

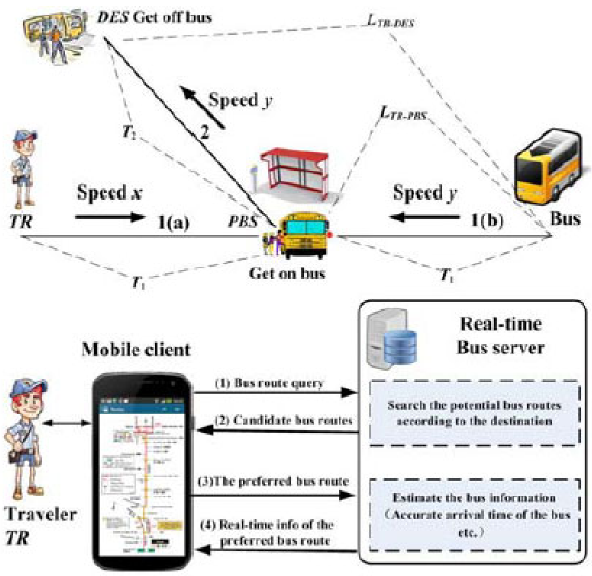

Figure 3: Simplified depiction of the social sensing structure [Liu 13, p. 166]

Suitability check for RTF:
The aspect to use social media interaction to improve the service quality and to predict the arrival times is a new approach. Service quality motivates the passengers to use the service again. It must be examined if the system is applicable to ferries and if the conditions for buses are given for ferries as well.

The paper “Real Time Passenger Information System” by Kale provides means by which the transport industry can develop innovative near-term solutions to meet demands placed on it. The main objectives of this design paper are:

(1) RTPIS display at bus stops – showing time of arrival of buses in real time.

(2) Web based interface for admin control room to monitor buses in real time.
(3) RTPIS display in the bus-showing next and previous bus stops, time to reach destination, advertisement based on location.
(4) Future scope of designing mobile application for home users to find out bus schedules and RTPIS. [Kale 14]

Suitability check for RTF:
This paper focuses on systems that facilitate the operation of urban transport by introducing interactive boards at stops that would inform travellers in real time about the arrival of the bus. Similar proposals have been proposed in the RTF project. Figure 4 shows the way of exchanging information in real time described by Kale.

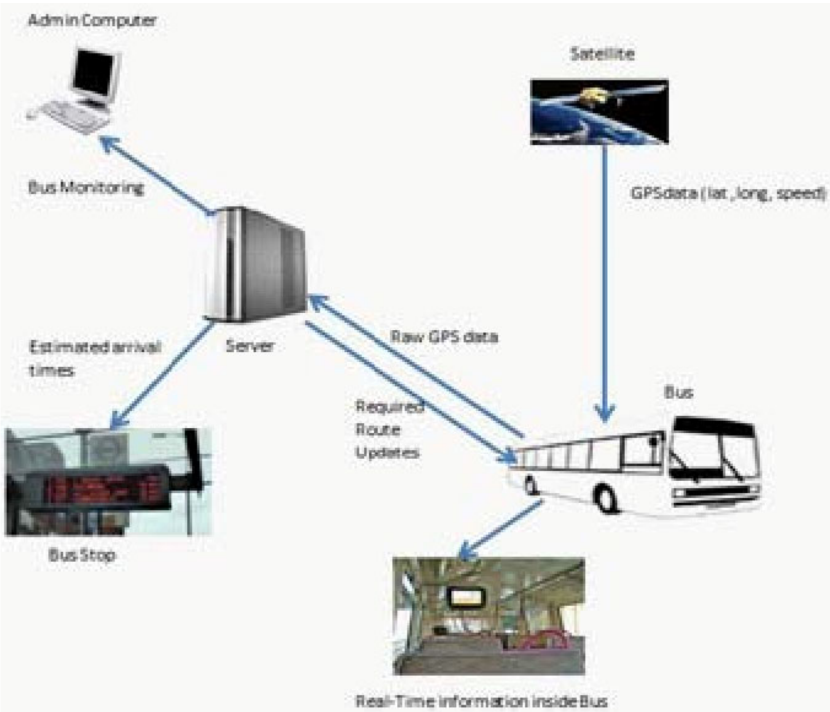

Figure 4: System Architecture [Kale 14]

Monzon et al. in their paper "Real Time Passenger Information systems and quality of bus services" pay attention that one of the key problems in urban areas is the steady growth in car ownership and traffic levels. It will be achieved much by moving from individual transport to public transport. The challenge of sustainable development is focused on growth of the demand for public transport means through improvement of the quality and availability. For this reason, Real Time Passenger Information (RTPI) systems are key elements of the helpful for citizens change of their travel preferences towards more efficient and environmentally friendly transport modes. This paper presents a methodology of assessment which evaluates how RTPI systems improve the quality of bus services in selected European cities. [Monzon 12]

Suitability check for RTF:
In order to minimize the number of motor vehicles on the roads, which results in heavy traffic, the authors proposed to strive for sustainable development of public

transport. Therefore, they drew attention to improving the quality and access to public transport by introducing real-time RTPI information systems. The RTF project also analyses the use of information boards at stops, route and terminals. In addition, the paper presents a methodology for assessing the quality of bus services that could be considered within the project.

The paper “A real-time information system for public transport in case of delays and service disruptions” written by Bruglieri et al. is about an information transport service in form of a travel planner in Milan/Italia. The information service is related to the project “MOTUS” (Mobility and Tourism in Urban Scenarios). The aims of MOTUS are to create systems for mobility of tourists and citizens and integrate data from different data sources. Additionally, an information service for the end user will be available. The paper describes a solution for the information service as travel planner, which considers disruptions and accidents for the calculation of the optimal route. A modified version of the Dijkstra algorithm is used. Data format of the travel planner is the “General Transit Feed Specification”. Compared to well-known travel planners like Google Transit and Moovit, MOTUS shows different and good alternative routes in case of disruptions. A screenshot of MOTUS can be seen in Figure 5. [Bruglieri 15]

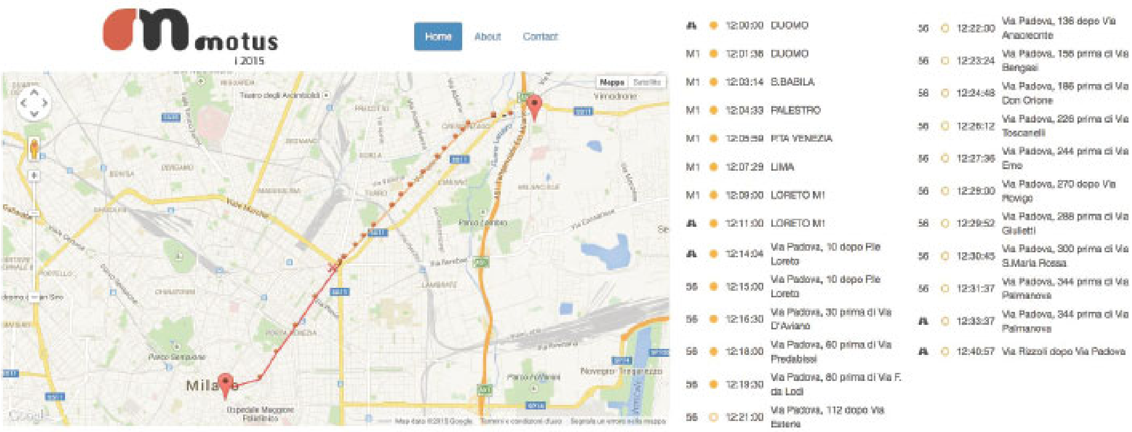

Figure 5: Screenshot of the integrated travel planner in MOTUS [Bruglieri 15, p. 500]

Suitability check for RTF:
This paper and the mentioned project can be referred to the RTF project as another example of public transport service system. Also, the data format GTFS is mentioned, which is investigated in the RTF project as well. The consideration of disruption is interesting for the RTF project relating to the pre- and on-carriage of the passengers. This will make it easier to plan the trip and also to enhance the punctuality to reach the ferry port. The use of Dijkstra’s algorithm is a good approach, but not applicable for the RTF project, because of the missing stops / (bus) stations during the ferry trip.

The paper “Mind the Gap: Exploring Stakeholder Values with Open Data Assessment” written by Hjalmarsson, A., Johansson, N., & Rudmark, D. discusses the importance of understanding the challenges that users of open transport data face as they are developing new services. More specifically, the paper investigates what dimensions (access, support, license terms, cost, technical format and data quality) of the open data that is necessary to meet sufficient standards. [Hjalmarsson 15]

Suitability check for RTF:
This is highly relevant for RTF as the paper's findings are quite likely to be a support for WP3 and WP4 when designing their platform and onboarding tools to facilitate service development within the RTF project.

The paper "Extending Digital Infrastructures: A Typology of Growth Tactics" written by Koutsikouri, D., Lindgren, R., Henfridsson, O., & Rudmark, D. talks about how open data can be used to substantially grow the digital infrastructure of an organization. The study is a 10-year longitudinal study of Stockholm public transport (SL) and how they have increased their customer reach through open data. [Koutsikouri 18]

Suitability check for RTF:
This is highly relevant for RTF since especially ferry companies might be reluctant to disclose their data openly. As the RTF seeks to recruit new actors beyond its project members, the paper offers empirical support for the benefits of opening up internal data to outsiders.

The paper "Barriers to innovating with open government data: Exploring experiences across service phases and user types" written by Smith, G., & Sandberg, J, analyses the different barriers to service development on open transport data. The paper identifies three archetypes of users and the different impediments they face during digital service development. [Smith 18]

Suitability check for RTF:
The results could be considered by designing their platform and onboarding tools to facilitate service development within the RTF project.

3.2 Papers concerning maritime transport

Ioannis Parolas deals in his master thesis "Prediction of Vessels' Estimated Time of Arrival (ETA) Using Machine Learning – A Port of Rotterdam Case Study" with the calculation of the ETA of vessels by using Support Vector Machine and Neural Network. To predict this key indicator, a case study was carried out in Rotterdam, in which information about container vessels (in form of AIS data) and weather forecasts were considered as implementing methods. The dataset consists of 600 voyages. Mean errors were calculated to validate and compare the two prediction methods. Both methods outperform the actual state without an ETA prediction and the Support Vector Machine predicts the ETA better than the Neural Network. The Figure 6 visualizes the created Neural Network with the input variables. Most of the data is monitored and transmitted by the AIS of the container vessel. The result is an ETA prediction.

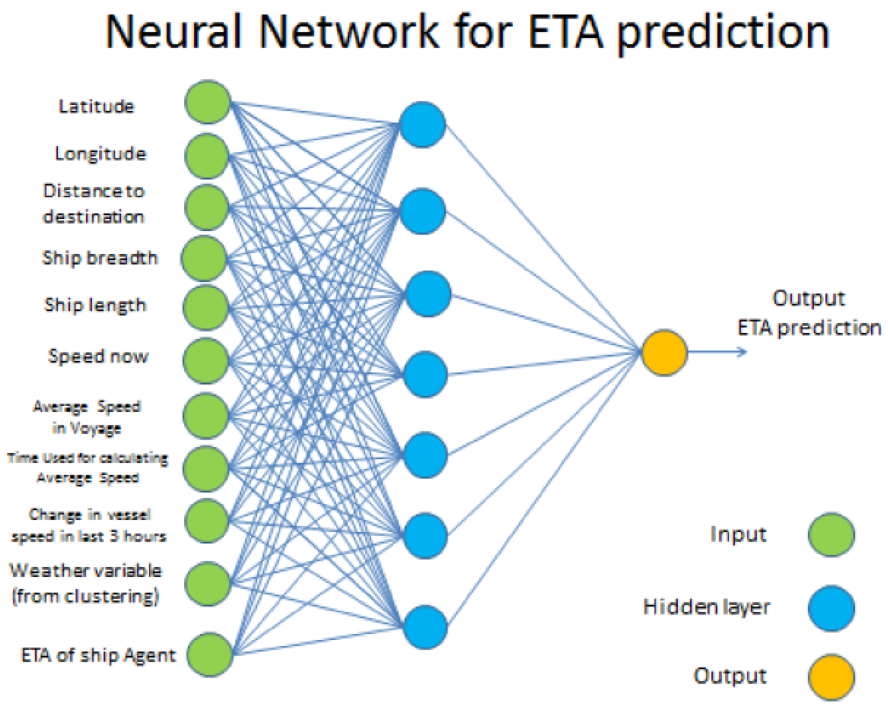

Figure 6: The developed Neural Network [Parolas 16]

Weather data is not relevant for the Support Vector Machine or Neural Network. The author thinks, that the explanation can be varied. For example, the AIS data could be influenced by the weather data. This means that weather is still an important factor for the arrival of container vessels, but can be removed in the prediction using the Neural Network and the Support Vector Machine. [Parolas 16]

Suitability check for RTF:
The ETA prediction using artificial intelligence is a modern solution for the issue. There are other papers that have taken a similar approach for calculating the ETA for the different stakeholders. It may be possible to adapt the approach and to calculate the ETA if there is enough data about the ferry. The voyages of the container vessel are much longer than the travel distance of a ferry voyage. So the prediction has a larger permissible deviation than the prediction of a ferry transport.

"Arriving on time using uncertainty aware deep learning" is an article from Hillerström et al. and is part of the proceedings of the 5th International Physical Internet Conference that took place in the Netherlands in 2018.
The regarded voyages are from the Mediterranean Sea to the port of Rotterdam. A deep learning network is developed and the necessary uncertainty is built by another network. The input parameters are the information about the vessel voyage which are transmitted by the AIS (such as length, speed, width…) or provided by the shipping companies. Wrong data was removed with the help of the expertise of operators to grant the reliability and validity. Comparing a physical model to deep learning methods shows that the networks performs better. [Hillerström 18]

Suitability check for RTF:
The application of a deep learning network can be adapted for the project, but needs further research, if this approach is suitable for the project. The prediction model performs better than currently used methods especially if the prediction is given at lower distances to the destination ports. This also applies to the ferry transport, which makes the presented ETA prediction applicable for the RTF project, even if it was originally developed for container vessels.

In order to ETA and ATA calculation Article performed by V. Paulauskas, L. Filina-Dowidowicz and D. Paulauskas “Ro-Ro and Ro-Pax vessels ETA and ATA analysis” (Transport Means 2019), proposed ETA and ATA (RTA) calculation used “Cascade”, maximal distribution and dispersion methods for the increase accuracy and possibility have more accurate results.
Possession of information about actual time of arrival (ATA) of the Ro-Ro and Ro-Pax ships is very important for the freight transportation and passenger voyages planning, organization and execution. Estimated time of arrival (ETA) of ships, obtained from automatic identification system (AIS), port information systems and other sources, differs very often from ATA. The Article presents the way to calculate and evaluate ETA time band, based on AIS and port information system data sources, to make it be as close as possible to ATA. The Klaipeda – Kiel shipping line serviced by Ro-Pax vessels is analyzed in detail. The mathematical analysis methods such as Kalman filter, dispersion and maximal distribution methods for ETA time band calculation and evaluation are implemented. The improvement of ETA calculation methods will be useful for different users of Ro-Ro and Ro-Pax ships services in various ports. [Paulauskas 19]

The paper “Planning and Evaluation of Passenger Ferry Service in Hong Kong” elaborated by Ceder presents a planning approach combined with a multi-objective evaluation method in order to assess the ferry routes with scientific, practical, and simplified analyses for future use. Evaluation procedure is applied both to the existing ferry routes and candidate routes. [Ceder 06]

Suitability check for RTF:
Regarding the RTF project, this article can serve as an example of planning approach design for ferry service combined with a procedure to evaluate the way to use existing water infrastructure resources and ensure the cost-effectiveness of offering ferry services.

“Vessel Pattern Knowledge Discovery from AIS Data: A Framework for Anomaly Detection and Route Prediction” by Pallotta et al. is a paper about the determination of vessel routes by an automatic and self-learning method. The objective of the paper is to create a technique that is capable of handling the increasing amount of information and data available to maritime operators via AIS. A method called TREAD was created that is an abbreviation for “Traffic Route Extraction and Anomaly Detection”. This method is able to determine the future trajectories and routes for vessels. Also, it is adjusted and well fitted for situations when the AIS data is not complete and has gaps, which is common for AIS data according to the authors. Anomalies and outliers can be identified and excluded for the analysis and to grant the learning aspect of the method. The algorithm can explain unexpected behavior of the ships e.g. a course and speed change due to a collision avoidance maneuver can be considered. Figure 7 shows the presented architecture of TREAD. [Pallotta 13]

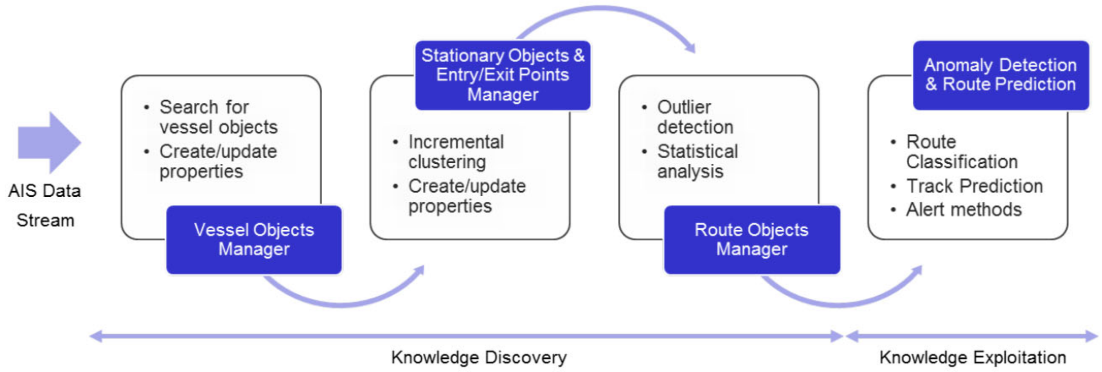

Figure 7: The architecture of the TREAD method [Pallotta 13]

The key services are the classification, the prediction and the detection of anomalies. [Pallotta 13, p. 2223]

Suitability check for RTF:
The papers provide a solution for a well-known problem of the processing of increasing available information. The paper concentrates on the processing of AIS data. AIS data is an important data source, which will be also used in the RTF project. The presented method can help to understand unexpected travel changes and consequently ETA changes.

Findley et al. in their paper “Evaluation of wait times and queue lengths at ferry terminals” payed attention that transportation systems often require travellers to wait for service. Observational data from a wait-time study at ferry terminals demonstrate that the amount of time a vehicle waits to board a ferry is highly dependent on that vehicle's position in line. Queue psychology suggests that unexplained waits, uncertainty, and anxiety make wait times for individuals seem longer. Thus, the vehicle position and wait time relationship can be used to equip ferry service providers with the knowledge to inform and pacify passengers waiting to board a ferry. Transportation systems often impose a delay to travellers in the form of waiting for service. For instance, motor vehicle drivers wait during the red indication at a traffic signal and transit passengers wait at boarding locations. The extent of the wait time often varies extensively by the time of day, day of week, and supply of the infrastructure or system. In this paper, the wait times and queue lengths of vehicles at a ferry terminal are examined. [Findley 18]

Suitability check for RTF:
This article indicates problems arising from the queue of travellers waiting for the ferry. It covers the issues that the RTF project considers. Research conducted in the article shows the possibility of analysing and managing the waiting time of travellers, which is also analysed as part of the RTF project.

Wawruch in his scientific paper „Development of the Polish Harbours Information And Control System (PHICS)“ refers to the issues of increasing control over the safety of maritime transport and the environment and reducing the administrative burdens of shipping companies, as well as ship owners and shippers. The paper presents reasons for establishing of the Polish Harbours Information and Control System (PHICS) and the analysis of its four constituent components: IMO - FAL, HAZMAT, PAS - REG and PSC. [Wawruch 18]

Suitability check for RTF:
The article [Wawruch 18] refers to topics related to safety, control of maritime transport and its environment. In Poland, there is a PHICS system that could be extended in future to include real-time data exchange in Polish seaports, using solutions to be developed by RTF project.

The paper “Determinants affecting ferry users’ waiting time at ferry terminals” written by Hansen et al. deals with the development of a model to examine how different factors influence ferry users’ waiting time at the terminals. The estimations are based on interviews of 10,952 Norwegian ferry travellers just after they boarded the ferries. The interviews were conducted in 2013 at 16 of the most important ferry connections in Norway. The average headway and waiting time at the terminals were 52 and 15 min, respectively. By comparison, average sailing time at the services in question was 38 min, indicating that waiting-time costs at the terminals make up a large proportion of ferry users’ time costs. The model’s results show that the users’ waiting time at the terminals increases concavely with the ferries’ headway and distance travelled to the terminals, that is, the marginal effects of these factors diminish when their values increase. The first result indicates that the proportion of ferry users arriving randomly at the terminals decreases with the ferries’ headway. The model also reveals that a large proportion (20%) of the waiting times at the terminals is due to the travellers being unable to board their desired departure because of the ferries’ capacity restrictions. Other variables, like the mode of transport travellers used to get to the terminals, their income, and how often they used the service, influence waiting time significantly in the hypothesised directions, even though some (e.g. income and trip frequency) have very moderate influences on waiting time. [Hanssen 19]

Suitability check for RTF:
This article refers to a model that allows to examine the factors affecting the time the users wait for the ferry in the terminal. The research was carried out in Baltic Sea Region, in Norway. With regard to the RTF project, the analyses contained in the article can be helpful in carrying out the process analyses, including determining the ways to reduce travellers’ waiting times and factors affecting these times.
According to Jurdziński (paper title: “Pilot navigation planning”), the estimated time of arrival (ETA) to a specific destination is calculated by an officer on the ship planning a trip. The navigation plan includes the exact distance of the ship's arrival between port A and B. The speed of the ship is determined on the basis of weather conditions and the speed of the ship on a given section. The example of route calculation proposed by Jurdziński for set conditions is shown below:

– length of the route 496.2 Nm,
– speed for different conditions: V1 - 15.0 kn, V2 - 16.0 kn, V3 - 17.0 kn,
– the sections of the route: d1 - 100 Nm, d2 - 200 Nm, d3 - 170 Nm (Figure 8).

Additional episodes:

- 10 Nm after leaving port A for acceleration from 5 to 15 kn - 1 hour,
- 16.2 Nm for releasing from 17 to 5 kn in port B - 1.5 hours.

The above time to change the speed of the ship is necessary due to the main engine operation regime.

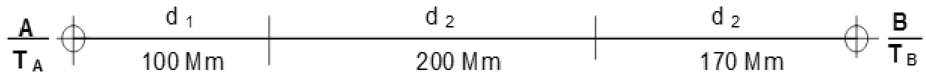

Figure 8: Distance between port A and B [Jurdziński 15]

ETA calculations for determined conditions:
T = Tb – Ta,
T = ∆T1 + ∆T2 + ∆T3 → Total travel time,
∆T1 = d1 / V1 → 6,4 hours,
∆T2 = d2 / V2 → 12,5 hours,
∆T3 = d3 / V3 → 10,0 hours,
T= 29,2h = 1 day 5 hours 12 minutes,
ETA = Ta + 1 day 5 hours 12 minutes → The moment of arrival at the port B. [Jurdziński 15]

Suitability check for RTF:
The paper presents a method of calculating the estimated time of arrival (ETA) at a specific port by a ship. Using the given ETA calculation method, calculations can be performed within the RTF project.

Watson R.T., Holm H. & Lind M, elaborates in their paper “Green Steaming: A Methodology for Estimating Carbon Emissions Avoided” on the environmental opportunities of recommending times for just-in-time arrivals of ships to ports. The paper identifies sweet spots of which a recommended time of arrival would be to the ship given the distance and speed bumps applied for the ship. [Watson 15a]

Suitability check for RTF:
This is highly relevant for the RTF project as the communication between the ferry and the port is essential to make the sea transport environmentally sustainable.
In this article “Ports of the Future: Bringing Emissions in Port Visit to a Minimum by Collaboration and Data Sharing”, Chrysostomou A., Lind M. and Bergmann M, bring forward the introduction of market-based regulations is not necessary to reduce the emissions coming out of shipping. It is identified that there are so much of efficiency gains to get out of the maritime sector that allows for different actors to engage for sharing the benefits coming out enhanced collaboration and data sharing. [Chrysostomou 19]

Suitability check for RTF:
This is relevant for the RTF project due to the fact that its scope aims at looking into how sea transports can be made more environmentally sustainable following the societal expectations and requirements.

The two articles, where the first one is “Port-2-Port Communication Enhancing Short Sea Shipping Performance: The Case Study of Cyprus and the Eastern Mediterranean” and is written by Michaelides M., Herodotou H., Lind, M., and Watson R. T and the article “Boosting data-sharing to improve Short Sea Shipping Performance: Evidence from Limassol port calls analysis” and written by Lind M., Michaelides M., Ward R., Herodotou H. and Watson R.T both of the articles provide foundations for understanding the role of short-sea shipping for the purpose of enabling that ports collaborate and expand their planning horizons. Special emphasis is put on the role of the shipping agent to suppler the coordination of the port call. [Michaelides 19], [Lind 19]

Suitability check for RTF:
This is relevant in relation to the RTF project due to that many of the ferry lines would be conceived as short-sea shipping lines.

The paper “A Research Agenda for Self-Organizing Ecosystems: The Case for Maritime Informatics” written by Watson, R. T & Lind, M, present a research agenda for maritime informatics building upon that the maritime sector is conceived as a self-organized ecosystem and how digital solution may glue the different actors together. This paper is foundational for the understanding the role of digitization of the maritime sector. [Watson 15b]

Suitability check for RTF:
This is highly relevant for the RTF project as it provides basis for understanding the drivers behind the opportunities coming out of digitizing maritime sea transports.

The paper “Physical and digital innovation in shipping: seeding, standardizing, and sequencing” looks into seed innovations affecting the maritime sector using the development of the physical container and the AIS data feed as seed innovation trying to understand what there is to be expected from the further development of the maritime sector due to digitization. [Watson 17]

Suitability check for RTF:
This is highly relevant for RTF as it builds upon new innovations coming out of the maritime sector.

The following two papers where the first one is “Enabling Port Efficiency by increased Collaboration and Information Sharing – Towards a Standardized Port Call Message Format” written by Lind, M., Haraldson, S., Karlsson, M., Holmberg, P.-E., & Watson, R. T, and the second paper “Port collaborative decision making

– closing the loop in sea traffic management." Written by Lind, M., Haraldson, S., Karlsson, M., & Watson, R. T, elaborates on the necessity to connect what happens at sea and what happens in ports in order to enable efficient and environmentally sustainable sea transports. Inspired by the aviation sector's efforts in coordinated airport operations through AirportCDM the concept of PortCDM is introduced to enable the coordinated port as a driver for just-in-time arrivals and shortened turn-around times. [Lind et al. 15a], [Lind et al. 15b]

Suitability check for RTF:
These articles are relevant as the RTF project aims at supporting the integration between the sea transport as such and the service quality delivered upon departure and arrival from the port connected to hinterland transports.

The paper written by [Lind et al. 15a] with the title "Enabling Port Efficiency by increased Collaboration and Information Sharing–Towards a Standardized Port Call Message Format" elaborates on the port call message format coming out of an ontology derived for port call operations and its related events. [Lind et al. 15a]

Suitability check for RTF:
This is highly relevant for the RTF project due to that the different actors engaged in the ferry transports do have a need to communicate in a standardized message format about time stamps associated to events associated to the port visit.

3.3 Papers concerning rail transport

According to Polish authors, J. Poznański and D. Żebrak (paper title: "Application of the simplified calculation method for the determination of the running time of a train on the open line") it is possible to use the simplified calculation method, which allows to estimate the approximate time of train travel using a few basic patterns. It should be noted that the conditions for uniformly accelerated and delayed movement at the start and stop of the train are close to real data (they do not correspond to the actual conditions of trains). A way to calculate the time from point P to point P1 is shown below:

Tpp1 = tr + tj + th [s],
tr – waste of time needed for starting the train at the starting point P [s],
tj – time train uniform motion on the trail P – P1 [s],
th – waste of time needed for braking the train at the final station P1 [s]. [Poznański 12]

Suitability check for RTF:
The article refers to the method of calculating the approximate ETA for trains. The approximate travel time for trains is significant in the case of multimodal transport and synchronizing it with the ferry schedule. This is a fairly important problem because of the need for better integration of intermodal transport modes. The article shows a simplified method of ETA calculation, which can also be considered when estimating the arrival times of transport means within RTF.

3.4 Papers concerning air transport

In „prescriptive analystics in airline operations: Arrival time predicition and cost index optimization for short-haul fights" by Achenbach et al. A machine learning method for the gate arrival time of airplanes is proposed. The algorithm is based on a gradient boosting and linear regression methodology. To calculate the arrival time the actual speed of the aircraft, weather forecasts, time related features and airport congestion data is used. The cost index is also considered, because the flight speed and the fuel costs of an aircraft are in a direct relation. By using a dataset of 200 European continental fights, the results of this method are the optimisation in delay costs and fuel savings. [Achenbach 18]

Sutatbility check for RTF:
The presented solution is developed for aircrafts. The authors propose an arrival time prediction by using a machine learning algorithm. The used variables speed of the aircraft and weather conditions can also be used for ferries. The coherence between arrival time (speed) and cost (fuel consumption) could be applicable for ferries as well.

3.5 Papers concerning road transport, Logistics and other topics

The study "Evaluation of Real-Time Transit Information Systems: An information demand and supply approach" elaborated by Harmony and Gayah assesses current needs in the implementation of Real-Time Transit Information Systems. In light of this, the goal of this research is to examine more closely what real-time information transit passengers want and what real-time information agencies provide to identify ways to improve RTTISs. [Harmony 17]

Suitability check for RTF:
The study identifies the needs for implementing real-time transit information systems and identifying the agencies that provide this information. Ferry shipping is currently focused on truck servicing. The study can be useful in an RTF project because it relates to the same issues raised within the project.

Bast et al. in their paper "Real-time movement visualization of public transit data" introduce a framework to create a world-wide live map of public transit, i.e. the real-time movement of all buses, sub- ways, trains and ferries. Their system is based on freely available General Transit Feed Specification (GTFS) timetable data and also features real-time delay information (where available). The main problem of such a live tracker is the enormous amount of data that has to be handled (millions of vehicle movements). The authors present a highly efficient back-end that accepts temporal and spatial boundaries and returns all relevant trajectories and vehicles in a format that allows for easy rendering by the client. The real-time movement visualization of complete transit networks allows to observe the current state of the system, to estimate the transit coverage of certain areas, to display delays in a neat manner, and to inform a mobile user about near-by vehicles. The system can be accessed via http://tracker.geops.ch/. The current implementation features over 80 transit networks, including the complete Netherlands (with real-time delay data), and various metropolitan areas in the US, Europe, Australia and New Zealand. It continuously integrates new data.

Especially for Europe and North America almost full coverage is expected soon. [Bast 14]

Suitability check for RTF:
This article presents the framework for creating a global map of public transport, enabling the integration of all modes of transport within one information system. It should be emphasized that this project covers 80 transit networks in Europe and worldwide. This project, like RTF, provides real-time information sharing.

Tarrant et al. in their paper “Romanse: a road management system for Europe by Tarrant” discuss a feasibility study for the ROMANSE, a road management system, which is to be implemented in Southampton. The purpose of ROMANSE is to provide a comprehensive, real-time, multi-modal information centre which will collect, evaluate, co-ordinate and disseminate both real-time and forecast information on networks and service conditions for travellers by road, bus, train, ferries and air. [Tarrant 17]

Suitability check for RTF:
The ROMANSE project aims to create a multimodal center for real-time information exchange. Like the RTF project, it deals with the sharing and dissemination of real-time data for public transport, ferries, trains, air transport to create a multimodal exchange of information that can facilitate the planning of supply chains.

The book performed by Hasiewicz “Network management system on roads in Poland” presents the problem of road traffic management projects with particular emphasis on traffic organization. It presents interpretations regarding procedures and rules for traffic organization designing, considering opinions and approving traffic organization and implementation, supervision over traffic management on the road and other organizational aspects. This publication presents the issues of road traffic management in terms of administrative practice of road traffic authorities in Poland. The book is a compendium of knowledge for public road managers, road traffic management bodies, road traffic and construction engineers. [Hasiewicz 16]

Suitability check for RTF:
The book presents interesting issues dealing with road transport, its organization and infrastructure. In relation to the RTF project, these issues do not exactly relate to the operation of ferry shipping, but they indicate the ways to improve the functioning of road transport, as a part of multimodal transport.

Prajogo and Olhager in their paper “Supply chain integration and performance: the effects of long-term relationships, information technology and sharing, and logistics integration” pay attention that information technology capabilities as well as information sharing have substantial impacts on integration process of logistics. This paper presents study investigating the integrations of key flows of supply chain, namely information and material flows, between supply chain partners and their impact on operational performance with particular attention to the role of the long-term supplier relationship as driver integration. [Prajogo 12]

Suitability check for RTF:
Logistic integration and real-time data exchange are very important elements in the efficient functioning of transport nowadays. This article focuses on exploring the integration and exchange of data and materials between supply chain partners and is thematically similar to the issues raised within the RTF project.

Engler et al. in the paper “Trajectory-based multimodal transport management for resilient transportation” highlight that profitability of multimodal transport chains depends not only on the cost-effectiveness of the transport carriers involved but also on the capability of transport management. The major difficulties to comprehensive multimodal transport management are differences with regard both to the technical equipment used and infrastructural facilities available and administrative as well as public organizational structures. This research presents a trajectory-based concept, as tool to facilitate multimodal transport management for future Intelligent Transport Systems (ITS), which considered as suitable approach to perform the smart and adaptable planning, operation, and management of systems with dissimilar structures, processes, applications, and stakeholders. [Engler 18]

Suitability check for RTF:
The article may be suitable for RTF project, showing the trajectory-based concept to perform the smart and adaptable planning, operation, and management of systems that can be used within RTF.

4 Review of research projects

The second component of this annual ferry real time generation trend report is the review of research projects. The projects were chosen and evaluated by the main issue “transport”. According to the approach of Harris, Y. Wang and H. Wang [Harris 15] databases which consist EU-financed projects were selected. The Table 7 shows an overview of analysed research projects.

The following databases are used for this review:

- CORDIS (commission database of EU-funded research and innovation projects)
- TRIMIS (transport research and Innovation Monitoring and Information System project database)
- Interreg project database
- General search engines

				Mode of transport						Kind of transport		
Projects	Project abbreviation	Programm/Financed	Multi-modal	Maritime	Road	Railway	Inland waterway	Aviation	passenger	freight	Security
Strengthening Combined Transport in Baltic Sea Region	Combine	Interreg Baltic Sea Region	x	x	x	x	x	x		x	
Intermodal Transport Real-time Information Platform	INTRATRIP	TRIMIS – European (4th RTD Framework Program)	x		x	x		x		x	
Navigational System for Efficient Maritime Transport	NAVTRONIC	TRIMIS – European (7th RTD Framework Program)		x					x	x	
River Service for Improving the Integration Waterway transport into Intermodal Chains	RISING	TRIMIS – European (7th RTF Framework Programme)	x		x	x	x			x	
Collaborative Information Services for Container Management	COMCIS	TRIMIS – European (7th RTD Framework Programme)	x	x	x	x				x	
Vessel Traffic Monitoring and Information System	VTMIS	TRIMIS – National (Croatia)		x					x	x	x
Preventing Incident and Accident by Safer Ships on the Oceans	PICASSO	TRIMIS - European		x						x	x
Real-time information applications and energy efficient solutions for rail freight	FR8HUB	TRIMIS - European (Horizon 2020)	x			x				x	
STM Validation Project		Trimis - European		x						x	
Real time Technologies for Maritime Security	MaFo	TRIMIS – National (Germany)		x					x	x	x
Safety Enhancements in transport by Achieving Human Oriented Resilient Shipping Environment	SEAHORSE	CORDIS - 7th RTD Framework Programme		x							x
Autonomous Surveillance in Public transport Infrastructure Systems	ASPIS	CORDIS - 7th RTD Framework Programme	x	x		x	(x)		x		x
European Bus System of the Future	EBSF	CORDIS - 7th RTD Framework Programme			x				x		
Management of weather events in transport system	MOWE-IT	CORDIS - 7th RTD Framework Programme							x	x	x
Maritime Unmanned Navigation through Interlligence in Networks	MUNIN	CORDIS - 7th RTD Framework Programme		x							x
Wide Scale network of E-systems for Mulitmodal Journey Planning and Delivery of Trip intelligent personalised data	WISETRIP	CORDIS - 7th RTD Framework Programme	x						x		
Door to Door Information for Airports and Airlines	DORA	CORDIS – Horizon 2020-EU.3.4.						x	x		
Vessel Traffic – Vorhersage Informationsdienst	Vestvind	IFB Hamburg		x						x	
Development of an efficient method to create a robust airplane timetable	ROFL	LuFO V-2						x	x		
Improving Transport and Accessibility through new Communication Technologies	ITRACT		x		x	x			x		
Sustainable Social Network Services for Transport	SUNSET	CORDIS			x				x		
Göta Älv River Information Services	GOTRIS II		x		x	x	x			x	
	FEDeRATED		x	x	x	x	x	x		x	
	e-Impact		x	x	x	x				x	

Table 7: Overview of analysed research projects

In the following, an in-depth analysis of the research projects presented in Table 7 as well as a suitability check concerning the RTF-Project is carried out.

Combine - Strengthening Combined Transport in the Baltic Sea Region
Database/program: Interreg Baltic Sea Region
"Combine" is an on-going (January 2019 – June 2021) Project about the Combined Transport in the Baltic Sea region. The project is partly financed by the European Regional Development Fund with an amount of 2.72 million €. Combined Transport has many advantages which shall be implemented. The main objectives are increase of combined transport in the Baltic Sea Region. This project deals with combined/intermodal transport, but does not consider the development of a system providing real time ferry information. Also, the execution region will be the Baltic Sea Region and the partners of the project are settled along the Baltic Sea and in the different Baltic States (Denmark, Germany, Poland etc.). [COMBINE 19]

Suitability check for RTF:
Strengthening the combined Transport in the Baltic Sea Region are directly related to the RTF-Project. Unfortunately, the project is on-going, so there are no results, which can be included in this literature review.

INTRARTIP – Intermodal Transport Real-time Information Platform
Database/program: TRIMIS – European (4th RTD Framework Program)
INTRATRIP is the abbreviation of "Intermodal Transport Real-time Platform" and is an old project about the creation of an intermodal information system. The time period of INTRATRIP is indicated from January 1998 to December 1999. This system is able to provide real time data. A pilot system was created. The project deals with the intermodal transport problem and about the use and implementation of real time data. But it does not consider ferry transport. [INTRATRIP 19]
An amount of thirteen information services were developed and implemented. The Figure 9 shows every offered information service of INTRATRIP and the relation to the other services. [Palumbo 13]

Suitability check for RTF:
The project showed an approach to create an intermodal real-time information platform. The focus is not ferry real-time information.

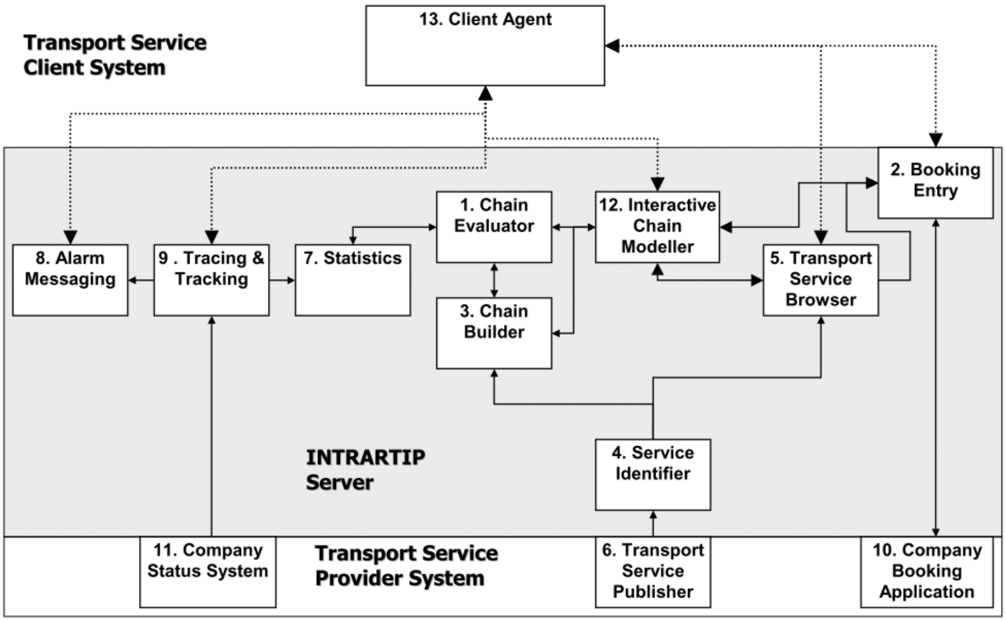

Figure 9: Designed transport service client system [INTRATRIP 00, p. 41]

NAVTRONIC – Navigational System for Efficient Maritime Transport

Database/program: TRIMIS – European (7th RTD Framework Program)

NAVTRONIC (Navigational System for Efficient Maritime Transport) was an EU co-financed project from 2009 to 2013 with the objective to "optimise sailing time (expected time of arrival), reduce fuel consumptions and greenhouse gas emissions and minimise maintenance cost". Solving this objective, a planning system was developed to gather real time ship data. During the project a fully operational prototype was developed and tested for 12 months. Benefits for the freight and passenger transport in the EU are the results. [NAVTRONIC 13]

Suitability check for RTF:
The project did not consider the specials of the ferry transport. But it invented an algorithm that helped to optimise the ship transport in general. The system architecture may be similar to the RTF project.

RISING – River Services for Improving the Integration of Inland Waterway transport into Intermodal Chains
Database/program: TRIMIS – European (7th RTF Framework Programme)
RISING started in February of 2009 and finished by the January of 2012. These projects deal with the development of a transport system for the inland waterway transport. The system is called "River Information Services (RIS)" (see Figure 10). Besides providing crucial voyage information, RISING makes estimated time of arrival for the terminals available. The project website www.rising.eu is not valid anymore and a mere progress report can be downloaded. [RISING 13]
Objective of the presented projects "RISING" is the spreading of useful information for the freight transport on rivers using e.g. river information systems [Gehlhaar 10, p. 28]

Figure 10: River Information System [Gehlhaar 10, p. 28]

COMCIS – Collaborative Information Services for Container Management
Database/program: TRIMIS – European (7th RTD Framework Programme)
The project "COMCIS", which extended over a time period from September 2011 to August 2013, concentrates to make the different logistics chains more reliable and optimise the delivery times. The focal logistic chain is the container transport between water transport and the concerned hinterland. Unused data sources (e.g. data from container security devices) are used and integrated to achieve these objectives. The compatibility between different e-freight systems is also a key point granting the aim of COMCIS. [COMCIS 14]

Suitability check for RTF:
This idea to integrate different system and use unused data to improve the processes is interesting and can be considered in the project of RTF. But the objective of RTF is to create an own system proving crucial information to every operator along the logistic chain.

VTMIS – Vessel Traffic Monitoring and Information System
Database/program: TRIMIS – National (Croatia)
The project "Vessel Traffic Monitoring and Information system" was conducted in 2008 for 6 months. The execution field was the Mediterranean Sea region of Croatia. [VTMIS 16]
An information system was developed monitoring and tracking the vessels to ensure the maritime safety. The focus of this project is safety. The Automatic identification system (AIS) is an important data source. [Linić 10]

Suitability check for RTF:
One of the main objectives was the building of the infrastructure to grant the use of the different data sources for the maritime safety. 75% of the project cost was used to buy the hardware (e.g. radar) [Linić 10]. On this account, this project isn't important for the realization of RTF. One interesting similarity is the use of AIS data to achieve the particular objectives of each project.

PICASSO – Preventing Incident and Accident by Safer Ships on the Oceans
Database/program: TRIMIS - European
PICASSO is a European funded project, which was executed between May 2016 and June 2018. The official project website is not available anymore. The project is built on the results of the Monalisa 2.0 and enhance the safety and sustainability in the maritime sector. [PICASSO 17]
https://ec.europa.eu/inea/en/printpdf/11285

Suitability check for RTF:
Safety and sustainability are important indicators for the maritime transport. This is the reason why other projects concentrates also on these topics and can be included and considered in the execution of the RTF project. Additionally, RTF is also based on “Mona Lisa 2.0”.

FR8HUB – Real-time information applications and energy efficient solutions for rail freight
Database/program: TRIMIS - European (Horizon 2020)
This project was funded by the EU, which started in September 2017 and will be ended in August 2020. The focal transport mode is the transport on rails. The objective is the improving of the railway system including e.g. the nodes and the hubs. [FR8HUB 17] Reliability of the operation, capacity, efficiency and punctuality shall be increased through the execution of this project. Also, the life cycle cost of railway system, emissions and noise will be decreased. “FR8HUB” is a part of the innovation program 5 organized by Shift2Rail, which consists of many other projects. Figure 11 shows the vision of the mentioned innovation program 5 after the execution of all related projects. [FR8HUB 19]

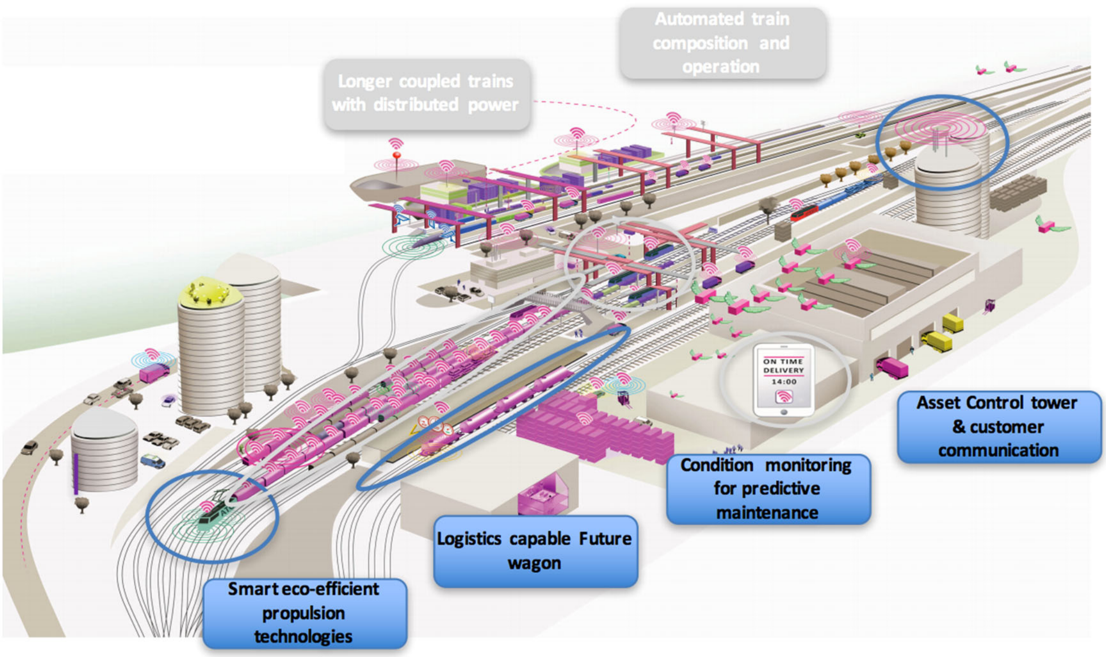

Figure 11: Hub components of FR8HUB-project. [FR8HUB 19]

Suitability check for RTF:
FR8HUB concentrates on trains as main transport vehicle and the system will fit for these special requirements. Project RTF deals with the intermodal transport problems handlings processes between different transport modes and vehicles.

STM Validation Project
Over the last couple of decades and specifically in the last few years, various initiatives have been launched in the maritime domain to overcome the traditional narrow view of focusing exclusively on optimising individual actor-specific processes. However, since most processes are shared among several actors, it is necessary to share information to support collaborative decision-making, and for efficiency reasons, exchange of information has to be in a standardized format. [STM 17]

Secondly, it has become increasingly clear that, as in the aviation sector and more generally across commerce, it is necessary for the maritime sector to go through a digital transformation. Digitalisation will enable collaboration and better-informed decision-making in the maritime industry which, in turn, will substantially improve the overall efficiency, effectiveness and innovation in the international transport and logistic supply chains. [STM 17]

Prior initiatives, including BLAST, MONALISA and MONALISA 2.0 promoted digitalisation to enable data sharing to create improved situational awareness thereby enhancing safety and efficiency of the maritime transport sector. The Sea Traffic Management (STM) Validation project was the logical result. The STM validation project aims to validate the envisioned concepts through sea trials and simulation. [STM 17]
The aim STM Validation Project to validate and further refine the strategic enablers of sea traffic management. The enablers were Voyage Management, Flow Management, Port Collaborative Decision Making (PortCDM), Maritime Service Infrastructure (SeaSWIM). The purpose of STM was to enable efficient, safe and environmentally sustainable sea transports. [STM 17]

Suitability check for RTF:
STM Validation Project is relevant for RTF due to that the project aimed to enable information sharing between involved stakeholders in sea transports and port operations, through standardized formats. One deliverable of the project was a standard for sharing of time stamps (S-211), relevant to align to formats for public transportation (as applied in RTF).

MaFo – Real time Technologies for Maritime Security
Database/program: TRIMIS – National (Germany)
MaFo is an ongoing German maritime project and the acronym stands for “Maritime Forschungsstrategie” and extends between 2018 and 2022. The objective of the project is the improvement of the maritime safety by the use of real time maritime security systems. This shall prevent crucial errors and accidents. An aspect to be called is the multi sensor fusion to validate the data and enhancing the reliability. [MaFo 18]

Suitability check for RTF:
As an ongoing project, there is no result, which can be analysed. It will be considered in the next annual report.

SEAHORSE – Safety Enhancements in transport by Achieving Human Orientated Resilient Shipping Environment
Database/program: CORDIS - 7th RTD Framework Programme
SEAHORSE is a maritime project which coordinated by University of Strathclyde. The project started in November of 2013 and ended in October 2013. The main objective of project "SEAHORSE" is the transfer of the gained knowledge about the safety of the air transport to the maritime transport sector. A crucial point is the human factor, which is able to trigger an error. Solving these problems for example, guidelines were evaluated and introduced to the different shippers. Next step was the development of training modules by maritime and aviation experts, which are presented on this list:

- Standard operation procedure Development Training Module
- Just culture Training Module
- Checklists Training Module
- Human Factors Training Module
- Mandatory Safety Reports Training Module
- Safety Bulletins Training Module

The different training modules are available at the website http://seahorse.smt.strath.ac.uk/PublicDeliverables. You need to register to download it. [SEAHORSE 19]

Suitability check for RTF:
Safety is an important point and can be included. However, this subject area is not the main subject area of the RTF project. It is possible to consider the findings of SEAHORSE to complement the RTF in the matter of safety.

ASPIS – Autonomous Surveillance in Public transport Infrastructure Systems
Database/program: CORDIS - 7th RTD Framework Programme
The project "Autonomous Surveillance in Public transport Infrastructure Systems" is a closed project, which took place from June 2008 to March 2012. ASPIS developed a system to improve the safety of passenger transport on-board and support the crisis management. The devices monitor the condition and are used as black boxes after a critical incident to sustain important information. The results were successfully demonstrated at two kind of transport vehicles: subway and ship. [ASPIS 14]

Suitability check for RTF:
The objective of RTF is also to develop a system. However, the key point of RTF is an information system to share information of ferry for the passengers or the terminal operator on shore. The project ASPIS mentioned the usage of its surveillance system on ferries to detect e.g. wrecks. So, it is possible to adapt the

findings because the implementation and validation of results were already tested on ferries.

EBSF – European Bus System of the Future
Database/program: CORDIS - 7th RTD Framework Programme
The project "European Bus System of the Future" develop a bus system to enhance the popularity of the bus in urban and suburban regions. The time period of the project extends from the September 2008 to February 2013. Every stakeholder of the public bus transport shall be satisfied with the help of an intelligent system. To achieve these objectives, the vehicles and the infrastructure was reworked and modernised. [EBSF 14]

Suitability check for RTF:
The application of EBSF to RTF is questionable, because it regards only transport mode on shore. Buses will be a link in the intermodal transport chain the RTF. So, it could be additionally considered in the executive process of the project. But it is not the main subject area.

MOWE-IT – Management of weather events in transport system
Database/program: CORDIS - 7th RTD Framework Programme
"MOWE-IT" is the acronym for the Management of weather events in transport system, which took place from October 2012 to September 2014. It was coordinated by TEKNOLOGIAN TUTKIMUSKESKUS VTT OY from Finnland. The objective of the project "MOWE-IT" is the provision of knowledge and guidelines for companies in passenger and freight transport and schielding them against extreme weather or natural disasters, travel delays, cancellations and/or distruptions. [Mowe-IT 15]

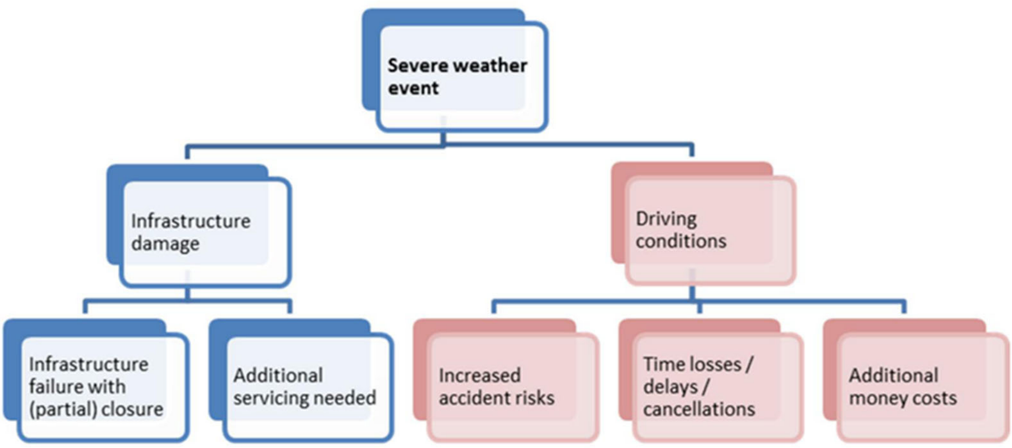

Figure 12: Different impacts of the weather event "MOWE-IT" [Nokkala 14, p. 46]

The Figure 12 shows the different impact of the weather events regarded in the project their effects on the transport chain. The project usees the findings of other projects in this subject area about the weather event management (EWENT, WARTHER, ECCONET). The user of the system is able to determine the time (present or future) and different transport modes offering alternatives for the transport. An interactive visualization tool was developed that is shown in the following Figure 13 [Nokkala 14].

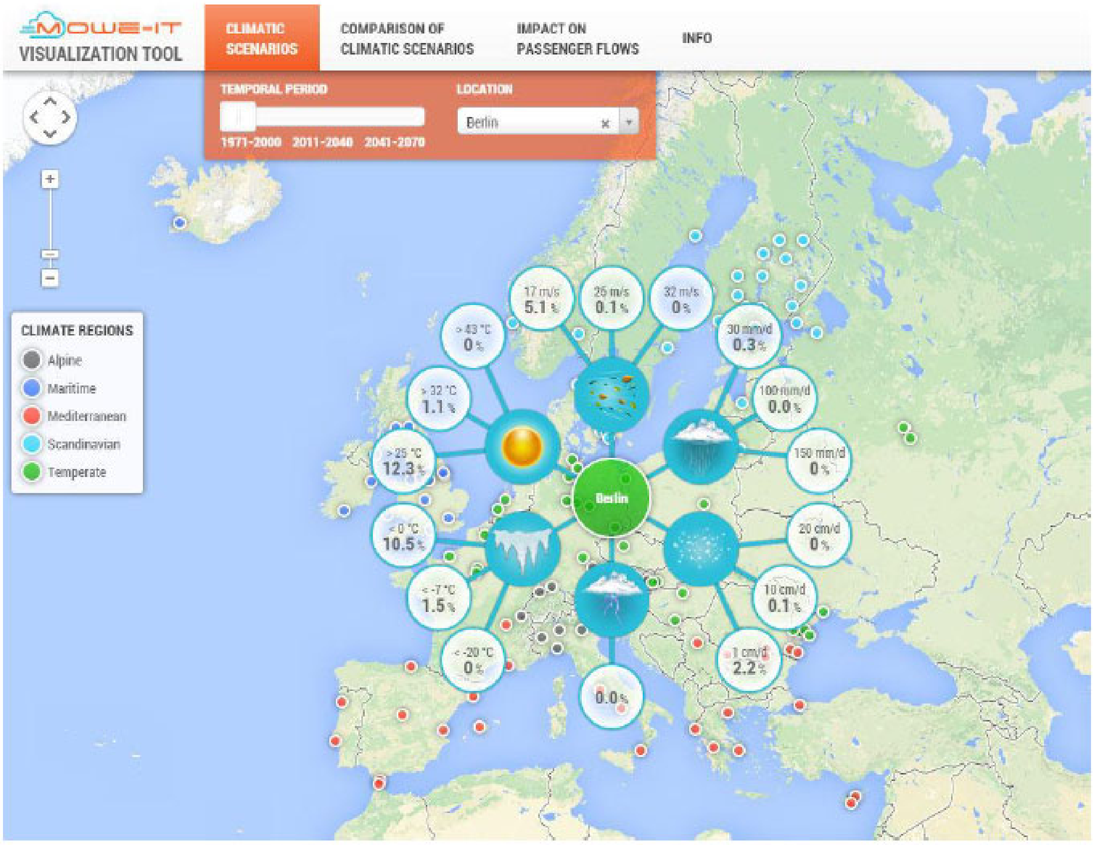

Figure 13: Screenshot of the interactive visualization tool [Nokkala 14, p. 13]

Suitability check for RTF:
Ferries are highly influenced by the weather events because they can cause delays or even cancellation of the shipping. This will affect the different stakeholders in a negative manner and trigger dissatisfaction. In the further research, it shall be examined if there is a need for this kind of weather management or maybe there is already an own developed system by the ferry operator.

MUNIN – Maritime Unmanned Navigation through Intelligence in Networks
Database/program: CORDIS - 7th RTD Framework Programme
The project "MUNIN" examined the use and practicability of unmanned merchant vessel. The components of the project were an advanced sensor module, autonomous navigation system, autonomous engine and monitoring control system and a shore control centre.

Suitability for RTF:
The implementation of sensors to monitor the vessel can be interesting for the project. The practicability of the concept to the ferry transport needs to be further analysed. [MUNIN 19]

WISETRIP – Wide Scale network of E-system for Multimodal Journey Planning and Delivery of Trip Intelligent Personalised data

Database/program: CORDIS - 7th RTD Framework Programme

Project “WISETRIP” combined different data sources of various transport modes to improve the journey planning for the international travellers. A network of journey planners through digital integration of the participating engines was built. With WISETRIP a user-friendly and easy-to-use transportation information system was developed. The system is able to get request from travellers and provide them with multimodal trip answers and travelling information.

Suitability check for RTF:

WISETRIP could be interesting for the project because of the realisation and implementation of a travelling information system for multimodal trips. One aim of RTF is the provision of journey information and the development of application for ferry passengers.

DORA – Door to Door Information for Airports and Airlines

Database/program: CORDIS – Horizon 2020-EU.3.4.

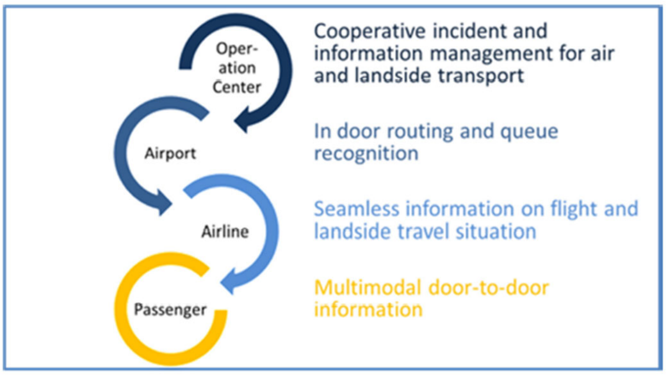

Figure 14: The benefits for the different operators [DORA 19]

DORA optimises the lead time of the passenger transport chain. The focal transport mode is the air traffic. The whole transport from the origin to the airport to the destination airport is covered. Every operator gets benefits as shown in Figure 14. Also, an information system including the platform and the end user application was created and tested. Figure 15 shows the developed information system divided in different parts. The project was carried out from June 2015 to September 2018. [DORA 19]

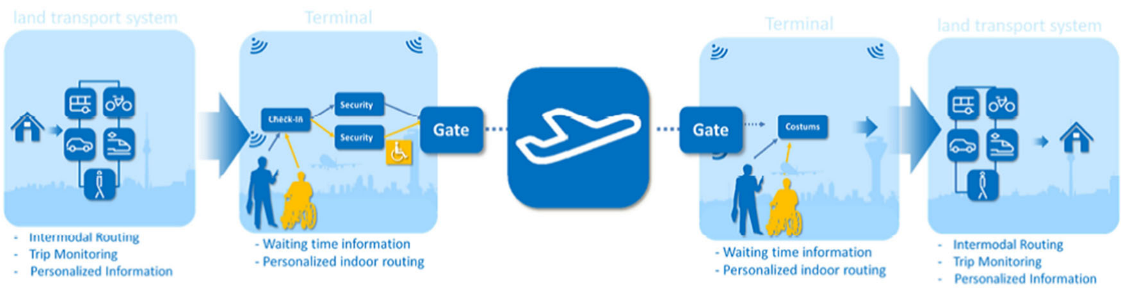

Figure 15: The presented information system for the passengers [DORA 19]

Suitability check for RTF:
This project is relevant and interesting for the RTF-Project because there are some parallels to the project. DORA considers also an intermodal transport chain. The differences are the transport modes and the kind of transport. (RTF – ferry transport of passengers and freight; DORA – use of airplanes for passenger transport)

Vestvind – Vessel Traffic Vorhersage Informationsdienst (Vessel Traffic Information Service)

Vestvind is a project of the Fraunhofer CML and the enterprise TRENZ AG that was realised from 2015 to 2017. A part of this project was financed by the IFB Hamburg (Invenstionsförderbank). The main focus of the project was the ETA calculation of ships by using artificial neural networks. This ETA calculation will enhance the efficiency and the possibility of planning for the different port operators in the Baltic Sea and North Sea. The created product is distributed at the website www.real-eta.com.
An artificial neural network needs many information and data. The most important information for the ETA-calculation are the ship movements, weather information and tide information. The Automatic Identification System (AIS) provides some of these information and it is possible to transmit this information in the ANN. The goal is the precise calculation of the ETA of a ship 72 hours before the ship arrives in the port. [Jahn 18]

Suitability check for RTF:
The project “Vestvind” acts in the same region as the RTF project. The regarded transport vehicle are the container vessels. The project operators are using a Neural Network to forecast and to estimate the arrival time. As written in the suitability checks of scientific paper that also solve the problem of the estimation of arrival time by neural network, this approach can be regarded and adapted for ferries. The main difference between container ships and ferries is the long transport duration which changes the requirements of the ETA prediction.

ROFL – Development of an efficient method to create a robust airplane timetable by [Kölker 19]
Program: LuFo V-2

The objective of the project ROFL is the creation of a schedule for airplanes which are constant robust against the delays in collaboration with Lufthansa System and the German Aerospace Center. Delays are in transport a huge factor that produce immense costs. The project classified delays in two different classes: the primary and the secondary delays. The primary delays cannot be directly influenced by the airlines’ operators. So, the secondary delays are an interesting point to optimizing the lead time and to compensate the overall delay. The Figure 16 shows the relation between the primary and the secondary delay.

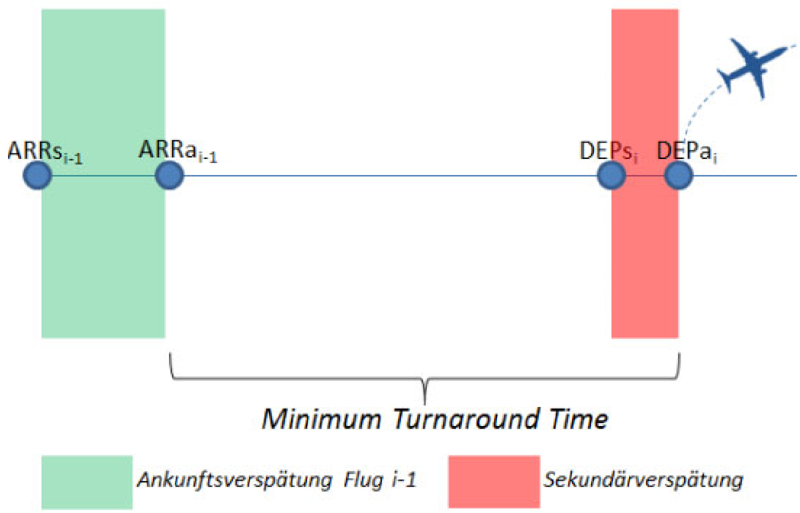

Figure 16: Visualization of secondary delays followed by the primary arrival delay [Kölker 19, p. 32]

To create a robust flight schedule, the secondary delays need to be minimal. Different methods are considered to create an optimal result e.g. simulation, linear optimization, decision tree and Binary Particle Swarm Optimization. The Binary Particle Swam Optimization is a heuristic method to find an optimal result for a problem. The Figure 17 shows the optimization process with this method. The arrival delays are reduced by 19%. [Kölker 19]

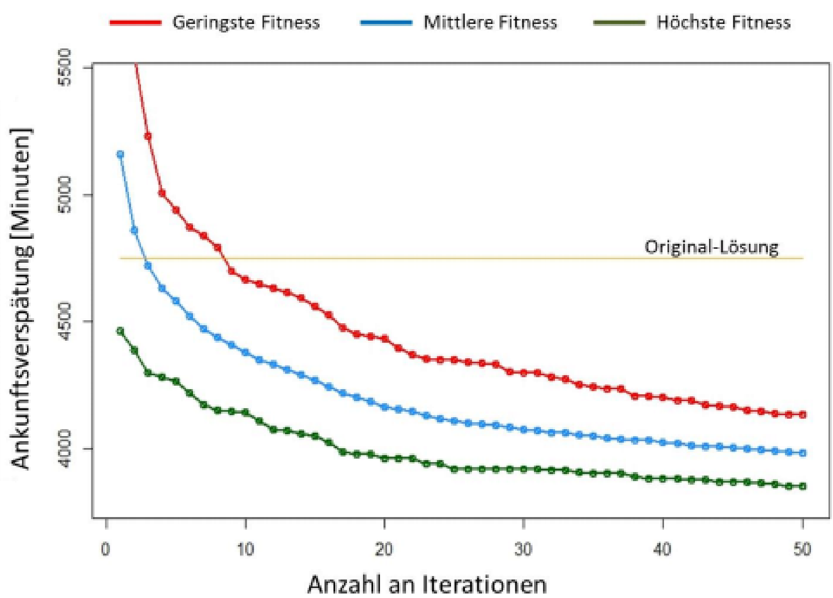

Figure 17: The result of the Binary Particle Swam Optimization through 50 iterations [Kölker 19, p. 63]

Suitability check for RTF:
The findings and the execution of the project “Rofl” is interesting for the RTF-project. The different methods could be evaluated and regarded in the further process. It is possible to adapt the approach of the classification of two different delay types because the ferries have similar characteristics. But the “Rofl”-project did not consider the intermodal or combined transport, which could limit the adaptation possibility.

ITRACT Improving Transport ans Accessability through new Communication Technologies

Database/program: keep.eu

Improving Transport and Accessibility through new Communication Technologies (ITRACT), was a project, conducted between January 2012 and December 2014, focusing on the development and use of ICT applications to boost efficient, environmental- and user-friendly transport concepts in order to reverse the spiral of decline in remote areas. The focus area was a number of areas within the North Sea Region that are located at a distance from the main economic agglomerations of their countries and lag behind in terms of socio-economic development. In accordance with the Gothenburg agenda, the aim was to create sustainable and inclusive regional economies and communities throughout the North Sea Region by improving the virtual and physical modes of transport through innovative technologies.

The project wanted to foster the success of the sustainable communities' policies by contributing to a more effective interaction of spatial planning, transportation, economic and environmental policies, social policy, finance and governance – all strategic policy EU interventions in the 2007 – 2013 and 2014 – 2020 European Union programs.

The transnational partnership brought together technology experts - in the fields of novel ICT, satellite, wireless broadband and sensor technology - with experts in social, economic, and spatial development, and transport operations. Within the triple helix of business, governmental, and knowledge institutions aimed to develop an information architecture and run pilot actions in order to create standardized technical procedures for efficient and user-friendly transport services.

The objectives for ITRACT was:

- Set up a transnational research program to assess and identify the transport needs of various target groups in remote areas
- To develop virtual and physical services for selected target groups in all participating regions
- To contribute by pilot activities linking governmental, educational and knowledge institutes with private business to a powerful cluster of shared knowledge, innovative tools and best practice on ICT and transport
- Demonstrate the effectiveness and efficiency of shared expert knowledge within a transnational partnership and with various cross-border and cross-sectoral stakeholders
- To promote transnational activities on innovative transport models as a tool for territorial integration and the European Commision's strategy for sustainable development

The outcome of the project was a report on policy recommendations and the implementation of innovative strategies for improved transport and accessibility in the North Sea Region and wider Europe [ITRACT 19].

Suitability check for RTF:

There are some similarities with RTF and those are that the project is a transnational partnership and with various cross-border and cross-sectoral stakeholders, to promote activities on innovative transport models, which in RTF is done by getting ferry operators to share time tables and real-time data about departure and arrivals for a better logistic flow and smoother travels for passengers and goods. Like ITRACT RTF is targeting the North Sea Region and improving the virtual and physical modes of transport through innovative technologies.

SUNSET

Database/program: CORDIS

Sustainable Social Network Services for Transport (SUNSET) was a research and innovation project financed by the European Commission's Seventh Framework programme Smart Cities & Sustainability (CONNECT.H.5) under DG Connect.

The project aimed to explore and develop new digital services that stimulate a more sustainable everyday life. Social media and incentives were essential components of the services. The project ran from 2011 to 2014, and several user studies took place in three European cities: Enschede (NL), Leeds (UK) and Gothenburg (SE).

The yearly growth of personal mobility results in increasing safety, economic and environmental concerns. SUNSET addressed these concerns by taking a new approach to urban mobility management using the latest ICT technologies.

The information was targeted on individual travel behavior, and thus allowed road authorities to fine-tune their transport policies and individuals to meet their personal objectives. The personalized approach could also help to alleviate other societal problems as social safety, social exclusion and even personal health.

SUNSET used four mechanisms:

- Web 2.0 technology to create communities that was involved in mobility
- ICT technology to collect individual travel patterns and to distribute information
- Positive incentives to encourage and help travelers to adopt a more sustainable mobility behavior. Incentives may stem from all parties involved and may contain information about the current and future status of the transport infrastructure and about travel alternatives. Also, feedback information of individual travel behavior or financial incentives was involved.
- Living labs was conducted to evaluate the SUNSET system under well-monitored conditions. In the Enschede Living Lab two releases of the full system was evaluated. Two other locations were used to benchmark the SUNSET results. [SUNSET 19]

Suitability check for RTF:

SUNSET is relevant for RTF because the project aimed to use positive incentives to get people to travel more sustainable and stimulate a more sustainable everyday life. This is also in line with the RTF project hence time table and real-time arrival and departure time from the ferries will be provided and can then be integrated with public transportation travel planners. Also, SUNSET provided information about current and future status of travel alternatives.

GOTRIS II

Göta Älv River Information Services (GOTRIS II) was a research and innovation project, which were to design and develop a platform for allowing various stakeholders involved in transports on and over the River Göta Älv to share information. [Holmberg 14]

The project was to demonstrate how this platform would support traffic management between different modes of transport. By bringing together all the actors and let Rail, Maritime and Road to share information and services in a RIS (River Information Services) for the Göta River, the project demonstrated how vessels on Vänern (The biggest lake in Sweden) and the River Göta Älv could be controlled and guided at the passages of the bridges and locks. This enabling so that disturbances to road and rail transport could be minimized, while the vessels voyage was optimized. [Holmberg 14]

The project developed a pilot version of a GOTRIS platform where information sources from the railway, the City and shipping were integrated. Models for control and optimization, as well as functions for ships, traffic management and road system were also developed. The project aimed to:

- Provide opportunities for increased freight train traffic across the river
- Create social benefit by reducing interference in the conflict between opposing national interests
- Coordinate freight traffic over the river to and from the Port of Gothenburg with the traffic on the river, requiring bridge opening
- Coordinate information about bridge openings with road and tram traffic in Gothenburg
- Provide for a developed inland and regional growth in Värmland and Västra Götaland
- Provide opportunities for green growth – transfer of freight volumes from road to sea

The technology, system and applications were tested in a demonstration where vessels, operators and users were involved. 120 vessels performed about 500 voyages during an 8-month living-lab were the platform could be tuned, optimized and the effects evaluated.

Some of the conclusions from the project was that a fully developed GOTRIS platform could be designed to create a well-functioning freight traffic over the river that facilitates expansion of the Port of Gothenburg, while traffic is optimized and can expand. From a societal perspective is efficient environmentally friendly transport can be achieved (rail and shipping rewarded) by minimizing waiting time and ship fuel use. From a state perspective, a well-functioning attractive city with minimal interference from bridge openings achieved. [Holmberg 14]

Suitability check for RTF:

In the GOTRIS II project a platform was created to handle the information exchange between different modes of transports, like in the RTF project. Also models for calculating when a ship where to arrive at a certain location and to communicate that to other modes of transport are something RTF could learn from when looking into how ETA and ATA to certain locations are to be exchanged between different modes of transport and how to coordinate delays and early arrivals.

e-Impact Project is implemented under the CEF (Connecting Europe Facility) program. The project involves 11 partners from Portugal, Italy and Poland. The aim of the project is to adapt and pilot implementation of the eFreight standard for information exchange in European ports, including the use of the eFreight standard for information exchange in three corridors of the TEN-T network: Atlantic, Mediterranean and Baltic/Adriatic. Pilot application of the eFreight standard will cover various IT solutions, including:

- IT system enabling/improving multimodal transport as well as planning and management of logistics integrated with transport management systems,
- multimodal route planning for freight transport,
- tracking tools,
- intelligent cargo applications
- tools for implementing transport documents,
- IT infrastructure for information exchange, authorization and authentication of users: eFreight connectivity infrastructure,
- support for interoperability between standards.

The ports involved in the project are: Trieste (Italy), Leixoes and Lisbon (Portugal), Gdańsk, Gdynia, Szczecin and Świnoujście (Poland). [e-IMPACT 19]

Suitability check for RTF:
The project implemented in Europe introduces the solutions related to the eFreight system. This system may be interesting for the RTF project, as it will serve to exchange information in seaports and within three TEN-T corridors, including the Mediterranean/ Baltic/ Adriatic corridor. For implementing an RTF project, e-IMPACT may be considered as another example showing the solutions of information exchange.

The **Logicon** project aims to develop, test and prepare to adopt simple and inexpensive solutions that allow the electronic exchange of commercial and logistic data. The solutions developed will enable especially small and medium-sized enterprises to exchange information electronically, reduce errors and time, and increase their credibility and competitiveness on the market. [Logicon 19]

Suitability check for RTF:
This is another project concerning simple solutions regarding electronic exchange of information and data. This project will be very popular in small enterprises related to logistics and transport. The transfer of information will be easier, which means that goods transported in the supply chain will be safe and delivered on time. This project is not directly related to RTF project, but it shows the way of documents exchange, support for small enterprises and improvement of the supply chain.

FUTURE AIRPORTS

This was a project about developing global sustainable mobility, Viktoriainstitutet (RISE Viktoria), together with Swedavia / Stockholm-Arlanda airport and the Swedish Transport Administration, the project, Future Airports, was a project based on the traveler's journey from door to door, where scalable innovations were to be developed and evaluated with Stockholm-Arlanda as a node to act as the experimental arena and showcase.

The unique door-to-door perspective involved processes, from booking a trip to completing a journey. This included synchronized multi-modal transports with different means of transportation as well as activities at airports. This was enabled by multi-organizational innovation related to one of the airports that has the toughest requirements on environmental sustainability in the world, Stockholm Arlanda Airport. Active collaboration integrated and balanced performance, mobility management, digital solutions for coordination and management as well as digital solutions for the well-informed and well-prepared passenger became keys for success. The project was initiated in 2010 where the parties aimed to establish a world-class multimodal transport system intended to spread to the world.

By building a door-to-door perspective on the traveler's journey, the performance of various organizations is regarded as part of the sustainable traveler process. In order to achieve such a seamless integration of process steps and thus contribute to increased passenger satisfaction, an active collaboration between the actors involved is required based on a common situation picture. The project was unique through its door-to-door perspective on the traveler process, which means that airports are part of a multimodal transport system. This is regarded as the future of airport operations.

Some examples of the scalable innovative solutions that the project was to develop, implement and evaluate was:

- Forecasting and Simulation tools for environmental impact
- Management Dashboard and Passenger Dashboards
- Model and Method for Active Collaboration
- Measurement systems and Process Optimization tools [Future Airports 19]

Suitability check for RTF:

An interesting approach that was taken in Future Airports was the traveler's journey from door to door, which is something that RTF could do when it comes to integrate the ferries time table and real-time information about departure time and arrival time and creating incentives for public transportation to use that information in their travel planner and to give the ferry companies the possibility to do the same with public transportation (This includes synchronized multi-modal transports with different means of transportation). Like RTF Future Airports want to achieve seamless integration of the process steps and to contribute to increased passenger satisfaction.

5 Review of IT-solutions developed by companies

The importance of IT-solutions in the transport sector has increased over the last couple of years. Furthermore, software and systems are a crucial component for optimising the transport and planning processes. A central point of the RTF project is the determination, calculation and transmitting of the estimated time of arrival of ferries. The objective of this part of the report is to research for related IT-solutions which are offered and provided by different companies. At the end, a suitability check for the RTF project will be conducted and an overview of the solutions found will be given.
To identify IT-solutions developed by companies search engines were used (see also website www.predictiveanalyticstoday.com). [NN 19]
A limitation is the availability of information. In some cases, the available information on the websites are not complete and give just an overview of the different functions of the respective IT-solution. The additional materials besides the website (e.g. flyer, presentations, white paper) need to be considered in the future. Moreover, the software providers prefer to have direct contact with the customer to present the software e.g. on a web seminar. These meetings can also be held in the future to get more information about the solution.
The found IT-solutions are categorized in different topics. The key terminology "Estimated time of arrival" or just the acronym "ETA" are used by different providers in the name of their product. Examples are "ETAtransIT" or "Real-ETA". Others have their main focus on the calculation of the ETA like "Synfioo". Many different providers of transport management software offer a schedule planer and consider the multimodal aspect of the transport management. It is possible that these providers and their IT-solution are able to fulfil the requirements, but there are not enough information on their websites about that. So, they will be included in an own category. The number of providers and the aspect that they concentrate on different areas shows the diversification on the transport management system market and a high density on the market. In the following, different IT-solutions are discussed.

These IT-solutions focus on the determining of the ETA.

- ETAtransIT
- Real-ETA
- Synfioo
- PTV Group with their product "PTV Drive&Arrive"

ETAtransIT:
The company ETAtransIT enables the complete tracking of the ETA of different transport modes. It includes the public transportation, private shuttles, trains and streetcars. The arrival times are predicted in real time and provides passengers in apps and on displays reliable information. [ETA-Transit]

Suitability check for RTF:
ETAtransIT is a company that focuses on the generation of ETA for different transport modes. They have developed products for the public transport and for trains and streetcars. They are ETA generators for the passenger transport. There are no solutions for the ferry transport right now.

Real-ETA:
Real-ETA is a German company that is specialised on the calculation of the ETA of ships. Therefore, geographic lines (near the ports) are defined. Whenever a ship crosses one of the defined lines, the customer receives a notification that the certain ship is close by and will arrive soon. The ships are tracked by AIS data. A machine learning algorithm is developed that uses historical data to calculate the ETA. A speed reduction of the ship is considered when calculating ETA. [Real-ETA]

Suitability check for RTF:
In the RTF project the ETA of the ferries will be calculated by using AIS data as well. The proposed methodology could be considered for the project.

Synfioo:
Synfioo calls themselves the ETA experts. They develop real time information systems for intermodal supply chains. These systems include the ETA calculation for many transport modes e.g. trucks, trains, airplanes and ships. Synfioo provides a solution that combines all data in one system. [Synfioo]

Suitability check for RTF:
Synfioo has a lot of experience on the field of real time data generation. To get further information how they generate and supply the data, it is required to book a demo.

PTV Group with their product “PTV Drive&Arrive”:
The IT solution “PTV Drive&Arrive” calculated the ETA of trucks and can be integrated into most transport, fleet, yard and dock management software solutions. The ETA is calculated by using the tour information and the data of the position of the truck. It informs all stakeholders (shipper, haulier and ramp operator) about delays and the expected arrival times. The algorithm for the calculation of the ETA is done by using i.a. following variables: position data, truck attributes, truck traffic patterns, driving and rest periods, live traffic information and traffic predictions, ongoing road closures, waiting times at tollbooths, road matching and time windows and service times. [PTV]

Suitability check for RTF:
On the websites of PTV detailed information about the ETA prediction of trucks is given. It is possible to adjust some of their variables for the ferry transport, but most of them cannot be transferred from the street to the sea transport.

Following descriptions deal with IT-solutions in the field of vehicular traffic, public transport, port management and port operating, shipments and transport planning:

- General Transit Feed Specification [GTFS 19]
- Romanse [Romanse 19]
- Bydgoszcz System IST [Bydgoszcz 19]
- Wrocław System IST [Wrocław 19]
- Translink [Translink 19]
- Tramwaje Warszawskie [Tramwaje 19]
- Garmin [Garmin 19]
- Atrax4 [Atrax4 19]
- InterLan mSPEED [InterLan 19]
- Optilo [Optilo 19]
- iCargo [iCargo 19]
- ZDiTM Szczecin [ZDiTM 19]
- Raben Group [Raben 19]
- RailNetEurope [RailNetEurope 19]
- RIGAS SATIKSME [RIGAS 19]
- WAZE [WAZE 19]
- HOGIA [HOGIA 19]
- ShipLog [ShipLog 19]
- Inport [Inport 19]
- Seamless [Seamless 19]

A Bydgoszcz System IST implemented in Bydgoszcz (Poland) improves the general conditions for vehicle traffic at intersections, guides drivers on alternative routes, gives information about traffic conditions and weather conditions, and also about the delays. The ITS System in Bydgoszcz is equipped with a number of elements, which include:

- ITS for public transport, e.g. dynamic information for travellers, vehicle fleet management, monitoring punctuality and traffic safety of public transport vehicles, dissemination of various forms of ticket purchase,
- network optimization, e.g. prioritizing public transport, adapting traffic light programs to forecasted traffic flows (area analyses and according to the importance of traffic routes), directing vehicles to routes with less traffic, recommending alternative route drivers,
- parking management (dynamic analysis of parking space and parking facilities to provide information about the occupancy of parking spaces and directing vehicles to other parking lots and urban spaces),
- supporting public transport planning by obtaining current information on traffic intensity.

The multifaceted aspects of the ITS System in Bydgoszcz can be presented within four subsystems:

- motion control with video monitoring,
- public transport management with dynamic stop information,
- parking information,
- guiding vehicles to alternative roads.

The ITS Bydgoszcz system provides road users with up-to-date information and guides vehicles to alternative roads, via information on variable content tables, on variable content signs placed in front of intersections, and through dynamic passenger information at public transport stops and a dedicated internet portal. [Bydgoszcz 19]

Suitability check for RTF:
The described system aims to improve public transport. Thanks to the Bydgoszcz System IST, travelers receive real time information, while being able to monitor and control a specific vehicle. In addition, the ITS system manages, controls, monitors and organizes transport traffic so that its flow is as smooth as possible. In relation to the RTF project, the ITS system in Bydgoszcz shows the way of real time data exchange between transport means and passengers in large urban agglomerations, the usage of systems supporting data exchange and improving traffic.

The Intelligent Transport System (Wrocław System IST) in Wrocław, Poland is a wide range of innovative technological solutions using telecommunications, IT and measuring tools. Among others: cameras, intersection sensors, stop boards, complicated communication systems and specially dedicated software. All this is used to manage and improve the quality and efficiency of Wroclaw's transport system. It mainly affects the flow of traffic and improvement of road safety. [Wrocław 19]

Suitability check for RTF:
Similar as Bydgoszcz System IST.

Real-time information is also available for Translink bus, train, ferry and tram services in South East Queensland and buses in Cairns. Real-time information provides accurate predictions for the next services departing from your stop or station. Using real-time information, it is possible to check when your next bus, train, ferry or tram is predicted to depart from your stop or station. This means there is a possibility to make public transport choices based on actual travel time, not just scheduled times, which may vary depending on traffic or weather conditions. [Translink 19]

Suitability check for RTF:
The described system is based on real-time information exchange. This system integrates multimodal connections. Its purpose is similar to the RTF project because it mainly integrates various branches of urban, suburban and national transport (ferries, trains) by informing users precisely about specific transport services.

Tramwaje Warszawskie (Warsaw, Poland) has implemented a platform enabling passengers have the opportunity to check the actual time of departure of the tram from each stop in Warsaw using the Internet. It is enough to scan a special QR code placed next to traditional timetables, posted at the bus stop or enter the website www.tw.waw.pl/sip and select the appropriate tram line or stop. The system will automatically redirect you to the page with a virtual departure board presenting information about the time and order of trams departures. In addition, information will be displayed about tram accessibility to disabled people (i.e. whether it is low-floor). The Passenger Information System (SIP) operates based on an IT system that calculates the time forecast of the departure of the tram based on the GPS position of the tram, timetable, vehicle speed and current events on the route. A special algorithm calculates the time the tram will leave the given stop and displays this information on the electronic board in the form of the remaining number of minutes. Giving the possibility to use the SIP on wide scale, information about times is also available on displays in trams, at bus stops, leaflets with QR code, at ZTM Passenger Service Points and on the websites of the Public Transport Authority and Warsaw Trams. [Tramwaje 19]

Suitability check for RTF:
Similar as Bydgoszcz System IST.

The website of the Roads and Public Transport Authority in Szczecin, Poland (ZDiTM) in the tab for the passenger, allows to find a map of stops and vehicles. It is possible to check on it whether the bus we want to go to is on time and in what location. In addition, at each of the virtual stops you can see information about the lines that stop on it and the scheduled time of the next five vehicles. Passengers can check timetables by line or stops, or can use the search engine to determine the route based on addresses. In addition, it is possible to download the application on a smartphone. ZDiTM allows checking in real time the current state of urban transport (buses, trams). Electronic boards are also installed in Szczecin at bus stops (tram and tram stops), which are the part of the Dynamic Passenger Information System. The boards cooperate with the vehicle location system, and with the auto-computers installed in 270 buses. Some vehicles are equipped with real-time monitoring. The implementation of the system is aimed at improving the functioning of public transport in Szczecin, making it more attractive and increasing the safety of travellers. Thanks to the system, the supervision over the operation of buses and trams will also be improved. [ZDiTM 19]

Suitability check for RTF:
Similar as Bydgoszcz System IST.

Raben Group, in order to meet the expectations of its customers, has developed an innovative system for monitoring shipments based on the ETA parameter. It uses information about the current position of the driver based on the GPS location provided by the mobile device. Customers of Raben Group can monitor the delivery time in real time on the platform myRaben.com. In the event of a situation that may affect the delivery time (earlier / later than originally calculated), resulting e.g. from road or accident situations, the system automatically updates the estimated delivery time and sends updates to the myRaben.com platform. At the same time, the customer at the time of submitting the transport order has the possibility to activate electronic notifications of the estimated delivery time, sent by e-mail to the e-mail addresses indicated by him. It is enough for the driver to have a mobile device in order for the customer to receive reliable and precise information about the delivery time of his shipment. It does not have to remember about specialized packaging, RFID labels. The new IT solution developed by the Raben Group together with the leaders of the telematics market (TIS GmbH and PTV) enables ongoing monitoring of the location of cars and parcels located within the cargo area of cars. Raben Group has implemented the ETA solution in 11 countries in which it operates. [Raben 19]

Suitability check for RTF:
Raben Group focused on developing an innovative system to monitor ETA parameter. This system is available via a supported load receiver to track the truck. In addition, it facilitates the operation of supply chains, route planning and inventory management. This system is related to RTF project and shows the way for real time information exchange.

HOGIA
Hogia is Swedish company with its head quarter in Stenungsund outside Gothenburg. Hogia Group operates in three business areas: Business and Accounting, Human Resources and Payroll and Transport

Hogia, Terminal, is a Terminal operating system (TOS), which is a software product supporting all different operations in a terminal and keep track of those so the client can invoice their customers. It also keeps track of all the different unites in the terminal and provides a web based service desk for the terminals clients. According to Hogia they can provide their customers with API's for real-time integrations with different systems used by the terminals clients such as hauliers, customers, shipping companies, customs and border authorities. Furthermore, Hogia provides a solution for different types of cargo such as: Intermodal solution, Container solution and RoRo solution

Hogia has developed a Data hub for public transportation called Hogia PubTrans. The Hub combines and quality assures data from different modes of transport like busses, metro, trains, trams and ferries. The output from the PubTrans provides a complete public transport picture that is updated in real time. The solution can provide operators and passengers with direct access to relevant and accurate information, before, during and after the journey. A real-time complete overview of the traffic situation, Hogia Instant View gives you an unparalleled overview of the public transport network and shows you detailed traffic data right down to vehicle level.

Hogia has developed a system called BOOKIT Reservation System for ferry- and sea freight operators. It is a reservation system targeted for maritime transportation services. BOOKIT handles the booking process from the capture of passenger, vehicle and freight details to follow-up activities as invoicing and reporting. The system is suitable for ferry and sea-freight services and contains services such as: flexible route, capacity, price and yield management functionality. According to Hogia they also provide open API's through which external systems can interact with the reservation system. This could be integration to external web booking sites, ticket machines, smartphone apps and mobile check-in.

Hogia has developed a cloud based series of products for transport planning called Hogia Moveit, which is designed to help the haulier with a more efficient planning of its transport assignments to and from the terminal. By integrating it into the terminal system, it provides real-time information on when vessels arrive at the terminal. The transports to the terminal are pre-notified, which means that the driver can go to the terminal on time and avoid unnecessary waiting times and the driver gets information in the app and does not have to leave the vehicle. Information about when a unit arrives at the terminal is also updated in real-time and in case of delays the assignment can be rescheduled and the driver can take other assignments [Hogia 19].

Suitability check for RTF:
Hogia have several different services, terminal, rail, ferries, passenger and trucks picking up goods. Those services align in a good way when it comes to what RTF wants to achieve, even doe RTF takes a little bit more open approach then a private owned system manufacturer. Hogia is building an application for the port of Trelleborg, which is based on Hogia's different system modules that can interact with the haulage contractor and inform delays of the ferry and information of when the cargo is ready for pick-up. Furthermore, Hogia also develops systems for the public transportation operators and it could be interesting to see which standards they are using when it comes to communicating timetables and real-time information to passengers, on board screens and screens in terminals.

ShipLog
ShipLog is a Norwegian company with its head quarter in the city of Kristiansund. ShipLog provides tools allowing supply bases, port authorities and others working with port operations, to plan and manage their port of calls by following the vessel traffic. This is done via their own infrastructure of AIS base stations, their cooperation with the Norwegian and Swedish coastal administration providing their customers complete information on vessel and vessel movements along the Scandinavian coast. According to ShipLog their customers can experience increased earnings through a better reliable registrations and invoicing to customers, improved and increases customer service. ShipLog also have two other services:

- Shiplog Fleet, a service that provides ship-owners real-time tracking of their fleet. Where their customers can set events triggers, based on an array of criteria, so they can set clients alerts.
- Shiplog Traffic is a service ShipLog has developed together with ferries and high-speed vessels ship owners. The service offers an automated notifications system on board each vessel, including passenger safety information and alerts on the bridge for the navigators if pre-defined control procedures are not followed. Fairway and Speed warnings is presented live in the Shiplog administration client, together with a real-time overview of the vessels movements, number of PAX and HAZMAT cargo. According to ShipLog the system also provides travellers at sea real-time ETA route information and operational messages directly from the vessels. The system provides both public authorities and ship owners with customized statistics and historical movements solutions [ShipLog 19].

Suitability check for RTF:
ShipLog uses AIS data displayed on a Sea chart to visualize where the vessel is and the users can set pre-defined notifications of when a ship is at a certain location, they also seem to have real-time ETA route information directly from the

ships and real-time tracking the ships, which could be interesting for RTF to look more into as another mean of providing the platform with real-time data of arrival and departure times of ferries.

InPort

InPort Intelligent Port Systems is a Swedish company with its head quarter in Karlstad. They products such as logistics systems for port authority, terminal operators, other actors in the port as well as to ship owner companies. Their product suit is called POTRIT.

PORTIT target for the port, is a solution target towards port authorities handling vessel and berth administration.

PORTIT targeted for terminals is according to InPort a complete suite for terminal operators, with all necessary modules for a terminal operator. The customers can choose from one or more modules depending on their needs. Each module can work together and can be added if the client realize they need more modules

PORTIT targeted for shipping is a module targeted for liner shipping companies like ship agents and for ship owners, the door – to – door traffic is covered by their "PROSHIP" application. For ships agents they have modules for e.g. administrating manifests, B/L's, disbursements account etc. The Shipping solution is based on their EDI Handler and the EDI motor will take care of all electronic messages to and from ship agents, ships operators etc.

POTRIT Rail, RAILIT, is a solution for complete administration of wagons and containers and where system bookings and rail set of wagons can be managed. Some of the key features are:
Involved actors

- Route planning
- Automatic receiving of bookings from container operators through EDI or via Internet web site
- EDI messages for load and discharge order to terminals
- Automatic receiving of Gate in / Gate out messages from terminals
- Parameters for capacity planning
- Handle export and import flow
- Status on the internet [InPort 19]

Suitability check for RTF:

InPort has several different products in their portfolio based on their port system PORTIT, modules that are handling berth management, port calls and terminal operations which could be of interest for RTF to check which standards they are using for communicating Estimates and Actuals of ships arrivals, departures as well as operations of when goods are ready for pick up.

Seamless

Seamless is a Norwegian company with its head quarter in Kristiansand and they are a part of the Grieg Logistics business group. Seamless provides port operating systems that, according to themselves, ensure god data management, work procedures and effective communication between systems and actors. Their Portwin system is built for handling port calls, cargo handling and pricing of services. Portwin also handles reporting requirements to government agencies. According to Seamless, Portwin reduces the workload for anyone working in port, terminal or supply. Portwin can be integrated with other modules developed by Seamless as well as several other external systems to meet the individual customer's needs. These modules are:

- PortTools is a module developed to collect statistics and presentation of reports related to port management
- PortTools XML to present port information on the port's own website
- PortTools WIE tool for exchange and sharing of port and ship documentation between shipping company, ship agent, port and terminal
- PortTools SIE is a module that ensures integration and exchange of data with external system [Seamless 19].

Suitability check for RTF:

Similar to Hogia and InPort, Seamless has several different product modules in their portfolio based on their port system Portwin, modules that are handling berth management, port calls and terminal operations which could be of interest for RTF to check which standards they are using for communicating Estimates and Actuals of ships arrivals, departures as well as operations of when goods is ready for pick up.

Klaipeda city public passenger transport (busses) information system

This system is implemented in Klaipeda city. It works in internet pages and on bus stops on the screens. (see Figures 18 to 20))

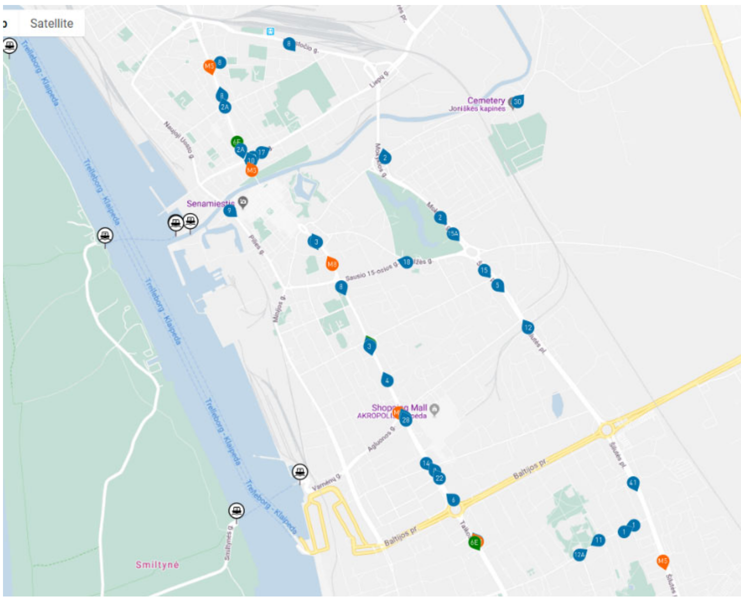

Figure 18: Busses location in Klaipeda city in internet

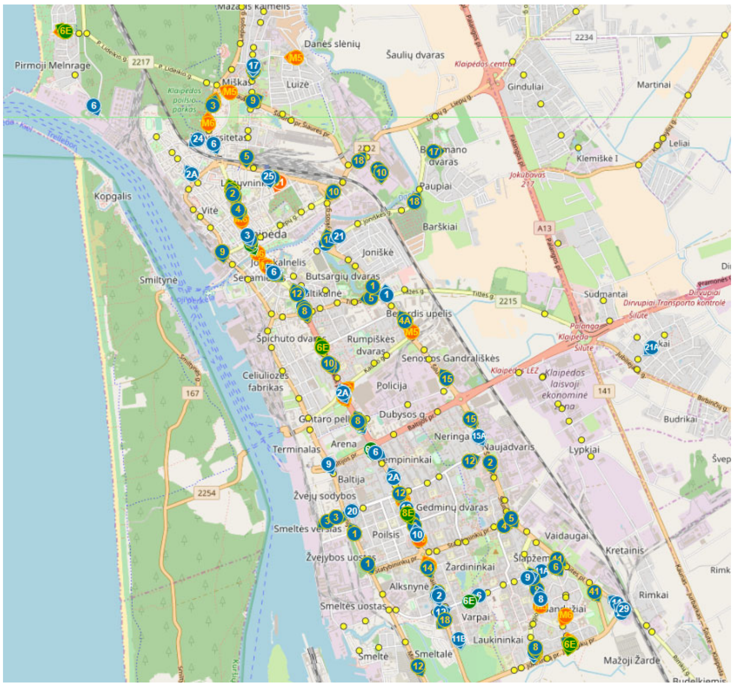

Figure 19: Busses location in real time in Klaipeda city on web site https://m.stops.lt/klaipeda/#klaipeda/map

Figure 20: Information screens at bus stops (Klaipeda)

DFDS Freight Terminals (working program for clients) website https://play.google.com/store/apps/details?id=com.dfds.driverapp&hl=en_GB. System, which implemented and used freight transport companies and drivers inserted in SMART telephones and provide information about trucks arrival time to terminal, parking place in terminal, as well work as ticket to terminal and ferry.

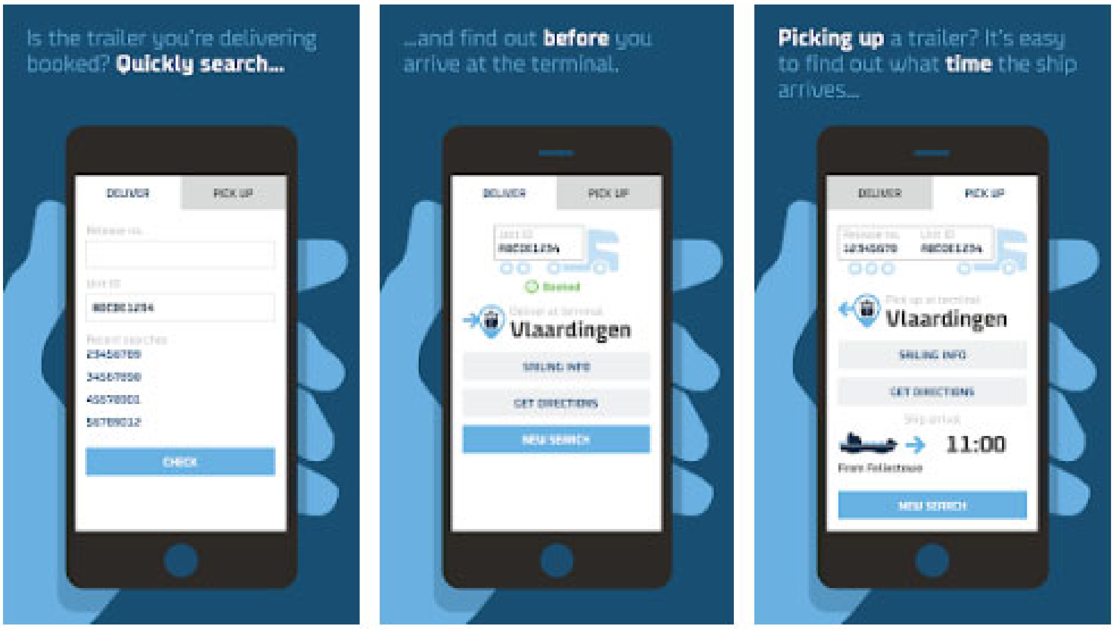

Figure 21: DFDS TERMINALS APPS system (a)

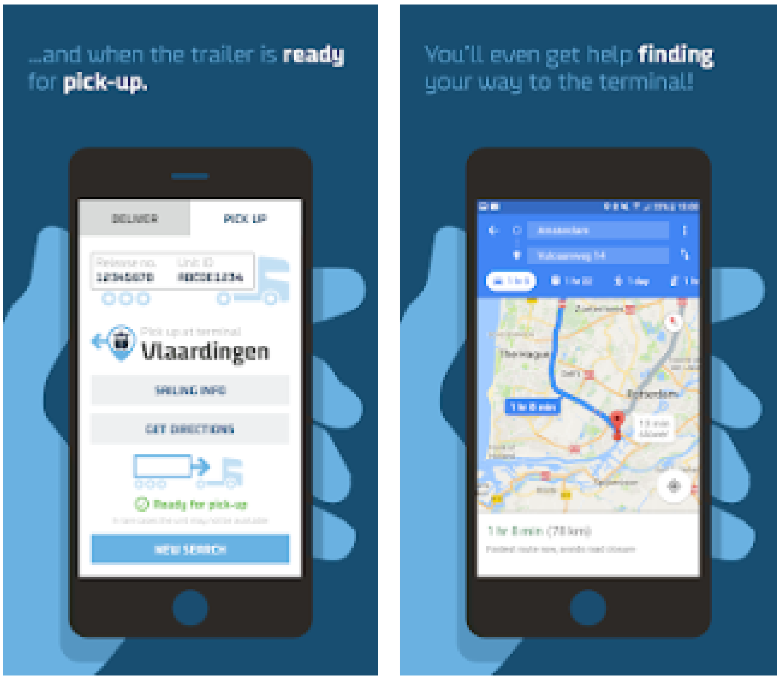

Figure 22: DFDS TERMINALS APPS system (b)

Other Transport Management Systems:
These transportation management systems are difficult to classify in different categories. For identifying their features and characteristics, additional material needs to be requested.

- Inform-software
- Kratzer Automation
- BNS-Software
- Logistiqo
- Sauer Software
- Initions with their product "OPHEO"
- Manhattan (Manhattan Acitve – Supply Chain)
- Allotrac
- Jda
- One Network Enterprise
- Trimble
- Mercury Gate
- Oracle
- Eyefreight
- Cerasis
- Descartes
- AscendTMS
- BluJaySolutions
- AlpegaGroup ("RANSWIDE TMS)
- Infor (Nexus Transportation Management)
- 3Gtms
- Kuebix
- Leogistics
- Transpereon

The following data standards and data specifications were discussed in project meeting with developer team:

NeTEx
[NeTEx 19] NeTEx is the chosen standard for exchanging data on timetable, infrastructure and networks in RTF.

NOPTIS
[NOPTIS 19] NOPTIS is a standard used by many public transport authorities in Sweden, Denmark and Norway, among these are Skånetrafiken in RTF.

NORDNETEX
[NORDNETEX 19] The Nordic NeTEx as a focused representation of NeTEx constructs, officially sanctioned by Sweden, Norway, Finland and Denmark, and the NeTEx profile used in RTF

OJP
[OJP 19] Open Journey Planning is a set of interfaces used for travel planning purposes. It is a European CEN standard on officially used in the RTF platform for travel planning purposes.

SIRI
[SIRI 19] SIRI is the chosen standard for exchanging real-time data on ETAs, current position etc. in RTF

TRANSMODEL
[TRANSMODEL 19] is common data object model used by NeTEx, SIRI and NOPTIS. As such, knowledge on Transmodel is pivotal to the RTF project.

GTFS
The General Transit Feed Specification (GTFS) is a data specification that allows public transit agencies to publish their transit data in a format that can be consumed by a wide variety of software applications. Today, the GTFS data format is used by thousands of public transport providers. [GTFS 19]

6 Conclusion

In the report No. 2, a general overview of real time data generators in different transport and logistics sectors is given. For the development of a data generation tool, it is important to keep track of the IT-solutions developed and the algorithms and methods used. Therefore, various scientific papers and research projects have been examined so far.

6.1 Evaluation of the results

In order to evaluate the results, it is important to consider all findings and how they may affect the data generation in the RTF project. Therefore, a suitability check was carried out for each finding. An overview of the suitability of each finding is given in Table 8. This table compares the pros and cons of each scientific paper to give an overview of the most relevant findings.

Papers	Short description	Pros	cons
[Findley 18]	Waiting Queue psychology, wait times and queue lengths are examined	How to analyse and manage queue times	
[Wawruch 18]	Polish Harbours Information and Control System	PHICS could be extended to include real time data	
[Hanssen 19]	Which factors influence ferry users waiting time at terminals by interviewing passengers	A model that allows to examine the factors affecting the time users wait for the ferry in the terminal	
[Poznański 12]	Train travel time calculation	Simplified formula for calculation ETA of trains that can be adapted to ferries	Developed for trains, must be checked if adaptation is possible
[Jurdziński 15]	ETA of ships calculation by using speed, weather conditions within a formula for each section of the route	Formula to calculate the whole travel time of a ship to get the ETA	Calculation for long distances, must be checked if applicable for ferries as well
[Ceder 06]	Approach in Hong Kong to evaluate existing and potential ferry route for the future	An approach how to design potential ferry water infrastructures	
[Watson 15a]	Evaluating the environmental opportunities for just-in-time arrivals of ships. Recommendation of arrival times	Shows off the communication between the ferry and the port for making sea transport environmentally sustainable	
[Chrysostomou 19]	How to reduce the emission of ships	Shows off how sea transport can be made more sustainable for the environment	
[Michaelides 19], [Lind 19]	Explanations about the role of short-sea shipping	Relevance because many ferry lines are considered as short-sea shipping lines	
[Watson 15]	Paper considers the maritime informatics and how digital solutions may glue the different actors together	Give a basis for the understanding of the role of digitalization in the maritime sector	
[Watson 17]	Looks into maritime innovations like physical containers and AIS data feed to understand what can be expected in the future	Builds up new innovation coming out of the maritime sector	
[Lind et al. 15a]	Elaboration of necessity to connect what happens on sea and what happens in ports to enable efficient and sustainable sea transports	Knowledge about the connection between sea transports and the ports and hinterland	
[Lind et al. 15b]	Investigation of the port call message format for the port call operations and its related calls	The communication in the RTF project between the different actors needs a standardized message format about time stamps associated to events and port visits	
[Parolas 16]	By using machine learning algorithms, the ETA for container vessels is predicted	Comparing of different machine learning algorithms (NN, SVR) to	The calculation is for container vessels which have a longer trip duration

		see which performs better for the prediction of the ETA	
[Hillerström 18]	A deep learning network is developed for the container transport from the Mediterranean Sea to the Port of Rotterdam	The prediction model performs better for short travel distances and is a solid ETA prediction method	The calculation is for container vessels which have a longer trip duration
[Pallotta 13]	The TREAD method was developed to identify and exclude anomalies in the AIS data like gaps	The self-learning and automatic algorithm identifies gaps in the AIS data and can explain the unexpected behavior of the ship and consequently explains the ETA changes	
[Kale 14]	Real Time Passenger Information systems were examined for bus stop displays and home users	The bus stop displays / monitors inform the passenger by using real time data	
[Monzon 12]	Paper presents methodology how Real Time Passenger Information Systems can improve the quality of bus services in European cities	Presentation of RTPIS and their benefits	
[Hjalmarsson 15]	Discusses the dimensions of open transport data that is necessary to meet sufficient standards	Important information for platform designing and service development	
[Koutsikouri 18]	A study of Stockholm public transport how they have increased their customer reach through open data	The paper gives benefits and reasons for opening internal data to outsiders	
[Smith 18]	Analyses the barriers to service development on open transport data	Information how to facilitate service developments	
[Paulauskas 19]	Shows off how to calculate ETA based on AIS information and port information systems	ETA calculation methods for RO-RO and RO-PAX ferries	
[Bruglieri 15]	A transport information system was developed to give passengers real time information about disruptions. Works like a travel Planner and uses GTFS	Approach of a real time information system that shows disruptions and uses the GTFS format	Uses the Dijkstra algorithm that is not applicable to ferries because of the missing (bus) stops
[Wang 14]	In this method artificial neural networks are used with and without online data to predict bus arrival times	Two different approaches are examined, one with historical and online data and one with historical data. The approaches use travel time, distance, delay, travel speed etc. to predict the ETA	The bus transport considers stops at which passengers go on and off of the busses
[Liu 13]	Improving of the service quality and estimating the arrival time of busses by using the Social Sensing method	New approach that improves service and ETA calculation by using social sensors of the passengers	Applied to busses, must be checked if the conditions for ferries are equal
[Achenbach 18]	A machine learning method is used to predict the arrival time of aircrafts at the gate. Therefore, the actual speed, the weather forecast, airport data etc. is used.	Predicting the ETA by using machine learning algorithms, also creating a coherence between arrival time (speed) and costs (fuel consumption)	Developed for aircrafts, conditions must be checked
[Hasiewicz 16]	Issues of road traffic management in terms of administrative practice of road traffic authorities in Poland	Improve the functioning of road transport as part of the multimodal transport chain	
[Bast 14]	A world-wide live map for public transport networks is developed. All movements will be implemented and is based on freely available GTFS data and real time information	The handling of a huge amount of data is shown in this system and the data is freely available and may be used for ferries as well	
[Tarrant 17]	A road management system is implemented in Southampton and provides real time and forecast information for	It aims to exchange multimodal information of many transport modes to enable the planning of supply chains	

	travelers by road, bus, train, ferry and air		
[Harmony 17]	The study examined what real time information transit passengers want and what real time information agencies provide	Shows off the needs for implementing real time transit information systems	
[Prajogo 12]	Shows studies that information capabilities and information sharing have substantial impacts on logistics processes	Focuses on exploring integration and exchange of data and materials between supply chain partners	
[Engler 18]	The research presents a concept that facilitates multimodal transport management for future Intelligent Transport Systems	Shows how perform smart and adaptable planning, operation and management of systems	
[Harris 15]	Describes information and communication technologies advances for multimodal transport	Shows off the benefits of using the most recent information and communication technologies	

Table 8: Overview of the findings - pros and cons

Table 9 presents an overview of the scientific papers with regard to real time data and ETA prediction.

	Real Time Data					**ETA prediction / calculation methods**			
Paper	Study/ survey	Information system	Service Plan	Environ-ment	Communi-cation Systems	Support vector machine	Neural Networks	Manual calculation	Route predic-tion
[Findley 18]	X								
[Wawruch 18]		X							
[Hanssen 19]	X								
[Poznański 12]									
[Jurdziński 15]								X	
[Ceder 06]			X						
[Watson 15a]				X					
[Chrysostomou 19]				X					
[Michaelides 19], [Lind 19]					X				
[Watson 15b]					X				
[Watson 17]		X							
[Lind et al. 15a]					X				
[Lind et al. 15b]					X				
[Parolas 16]						X	X		
[Hillerström 18]							X		
[Pallotta 13]									X
[Kale 14]		X							
[Monzon 12]		X	X						
[Hjalmarsson 15]					X				
[Koutsikouri 18]	X								
[Smith 18]			X						
[Paulauskas 19]								X	
[Bruglieri 15]		X							
[Wang 14]							X		

[Liu 13]									x
[Achenbach 18]									
[Hasiewicz 16]									
[Bast 14]									
[Tarrant 17]		x							
[Harmony 17]		x							
[Prajogo 12]		x			x				
[Engler 18]		x							
[Harris 15]		x			x				

Table 9: Overview of the findings - Real Time data and ETA

6.2 Outlook for the future

The methodology will be refined in the next report. Further scientific papers, research projects and IT-solutions developed by companies will be reviewed and the results will be included in the upcoming report.

7 References

[Achenbach 18] Achenbach, A.; Spinler, S.: *Prescriptive analytics in airline operations: Arrival time prediction and cost index optimization for short-haul flights*. in Operations Research Perspectives, 5, 2018, pp. 265–279.

[ASPIS 14] ASPIS: *Final Report Summary - ASPIS (ASPIS - Autonomous Surveillance in Public transport Infrastructure Systems) | Report Summary | FP7 | CORDIS | European Commission*. https://cordis.europa.eu/project/rcn/92011/reporting/en, 2014. accessed: 06.08.2019.

[Angeles 05] Angeles, R.: RFID Technologies: Supply-Chain Applications and Implementation Issues. In Information Systems Management, 2005, 22; pp. 51–65.

[Bast 14] Bast, H.; Brosi, P.; Storandt, S.: *Real-time movement visualization of public transit data.* In: Conference Paper Association for Computing Machinery, 2014.

[Behdani 16] Behdani, B.; Fan, Y.; Wiegmans, B.; Zuidwijk, R. 2016. Multimodal Schedule Design for Synchromodal Freight 533 Transport Systems, European Journal of Transport and Infrastructure Research 2016 (3): pp. 424-444. Available 534 online: https://doi.org/10.2139/ssrn.2438851.

[Bruglieri 15] Bruglieri, M.; Bruschi, F.; Colorni, A.; Luè, A.; Nocerino, R.; Rana, V.: *A Real-time Information System for Public Transport in Case of Delays and Service Disruptions*. in Transportation Research Procedia, 10, 2015, S. 493–502.

[Chauhan 09] Chauhan, S.; Patil, C.; Sinha, M.; Halder, A. 2009. Fuzzy state noise-driven Kalman filter for sensor fusion. Proc. IMechE: J. Aerospace Engineering, 223, pp.1091-1097.

[Christodoulou 19] Christodoulou, A.; Raza, Z.; Woxenius, J. 2019. The integration of RoRo shipping in sustainable intermodal transport chains: the case of a North European RoRo service. Sustainability, Vol. 11, 2422; doi:10.3390/su11082422.

[Ceder 06] Ceder, A.: *Planning and evaluation of passenger ferry service in Hong Kong.* Transportation, March 2006, Vol. 33, Iss. 2, pp. 133-152.

[Cimino 11] Cimino, M.; Marcelloni, F.: *Autonomic tracing of production processes with mobile and agent-based computing*. Pisa, 2010.

[Chrysostomou 19] Chrysostomou A., Lind M., Bergmann M. (2019). *Ports of the Future: Bringing Emissions in Port Visits to a Minimum by Collaboration and Data Sharing, Paper presented at International Conference on Marine Engineering and*

Technology, 5-7th of November 2019, Military Technological College, Muscat, Oman

[Chung 11] Chung, C.C.; Chiang, C.H. 2011. The critical factors: an evaluation of schedule reliability in liner shipping, International Journal of Operations Research, Vol. 8, No. 4, pp. 3-9.

[COMBINE 19] COMBINE: *Strengthening Combined Transport in the Baltic Sea Region - Project Outline*. https://www.combine-project.com/sites/ default/files/content/resource/files/combine_project_outline_1.pdf, 2019.

[COMCIS 14] COMCIS: *Collaborative Information Services for Container Management*. https://trimis.ec.europa.eu/project/collaborative-information-services-container-management, 2014. accessed: 07.08.2019.

[Conforti 12] Conforti, R.; Rosa, M.; Fortino, G.: *Real-time risk monitoring in business processes: A sensor-based approach*. Queensland, 2012.

[Curtis 10] Curtis, A.; Izurieta, C.; Joeris, B.; Lundberg, S.: *An Implicit Representation of ChordalComparabilty Graphs in Linear-Time*. Colorado, 2010.

[Di Ciccio 16] Di Ciccio, C. et al.: Detecting flight trajectory anomalies and predicting diversions in freight transportation. In Decision Support Systems, 2016, 88; pp. 1–17.

[DORA 19] DORA: *Door to Door Information for Airports and Airlines | DORA Project | H2020 | CORDIS | European Commission*. https://cordis.europa.eu/project/id/635885, 2019. accessed: 06.08.2019.

[EBSF 14] EBSF: *Final Report Summary - EBSF (European Bus System of the Future) | Report Summary | FP7 | CORDIS | European Commission*. https://cordis.europa.eu/project/rcn/89933/reporting/en, 2014. accessed: 06.08.2019. [Engler 18] Engler, E.; Gewies, S.; Banyś, P.; Grunewald, E.: *Trajectory-based multimodal transport management for resilient transportation*. Transport Problems, Vol. 13, Iss. 1, 2018, pp. 81-96.

[Fagan 11] Fagan, D.; Meier, R. 2011. Intelligent time of arrival estimation Proc. IEEE Forum Integr. Sustain. Transp. Syst. (FISTS), pp. 60–66.

[Finbow 10] Finbow, A.; Hartnell, B.; Nowakowski, J.: *On well-covered triangulations: Part III*. in Discrete Applied Mathematics, 158, 2010, S. 894-912.

[Findley 18] Findley, D.J.; Anderson, T.J.; Bert, S.A.; Nve, T.; Lerchworth, W.: *Evaluation of wait times and queue lengths at ferry terminals*. In: Research in Transportation Economics, ELSEVIER, Vol. 78, Iss. 71, pp. 27–33, 2018.

[FR8HUB 19] FR8HUB-Website: *Objectives of the project "FR8HUB"*. https://projects.shift2rail.org/s2r_ip5_n.aspx%20hp=FR8HUB, 2019. accessed: 03.09.2019.

[Gehlhaar 10] Gehlhaar, A.: *The Rising Project: 1st Advisory Committee Meeting*, 2010.

[Gunasekaran 04] A Gunasekaran, E.W.T Ngai, Information systems in supply chain integration and management, European Journal of Operational Research, Volume 159, Issue 2, 2004, Pages 269-295,

[Hanssen 19] Hanssen, T.-E.S.; Jørgensen, F.; Larsen, B. 2019. Determinants affecting ferry users' waiting time at ferry terminals. Transportation, 2019, pp 1–22.

[Harris 15] Harris, I.; Wang, Y.; Wang, H.: *ICT in multimodal transport and technological trends: Unleashing potential for the future*. in International Journal of Production Economics, 159, 2015, S. 88–103.

[Helo 05] Helo, P.; Szekely, B.: Logistics information systems. In Industrial Management & Data Systems, 2005, 105; pp. 5–18.

[Hillerström 18] Hillerström, F.; Kruithof, M.; Oggero, S., 2018: *Arriving on time using uncertainty aware deep learning*. in 5th International Physical Internet Conference, S. 205–218.

[Hinkka 15] Hinkka, V. et al.: Supply chain typology for configuring cost-efficient tracking in fashion logistics. In The International Journal of Logistics Management, 2015, 26; pp. 42–60.

[Harmony 17] Harmony, X.J.; Gayah, V.: *Evaluation of Real-Time Transit Information Systems*: *An information demand and supply approach*. in: International Journal of Transportation Science and Technology, Vol. 6, Iss. 1, pp. 86-98, January 2017.

[Hasiewicz 16] Hasiewicz, J.: *Network management system on roads in Poland*. publishing house C.H. Beck, 2016 (in Polish).

[Hjalmarsson15] Hjalmarsson, A., Johansson, N., & Rudmark, D. (2015). *Mind the Gap: Exploring Stakeholder Values with Open Data Assessment*. Paper presented at the 48th Hawaii International Conference on System Sciences

[Holmberg 14] Holmberg, Per Erik, et al. "CO-modal adaption between modes of transport-River information services for river GÖTA ÄLV." *21st World Congress on Intelligent*

Transport Systems: Reinventing Transportation in Our Connected World, ITSWC 2014, 7 September 2014 through 11 September 2014. Intelligent Transport Systems (ITS), 2014.

[Iakovou 07] Iakovou, E.; Vlachos, D.; Xanthopoulos, A.: *An analytical methodological framework for the optimal design of resilient supply chains*, 2007

[Jahn 18] Jahn, C.; Scheidweiler, T.: *Port Call Optimization by Estimating Ships' Time of Arrival*., in: Freitag, M.; Kotzab, H.; Pannek, J. *Dynamics in logistics: Proceedings of the 6th International Conference LDIC 2018, Bremen, Germany.* (Lecture notes in logistics). Cham, Switzerland: Springer, pp. 172–177, 2018.

[Kaizer 13] Kaizer, A.; Formela, K.: The concept of modernization works related to the capability of handling e class container vessels in the Port of Gdynia, "Marine Navigation and safety of Sea Transportation", Edited by: Weintrit, A.; Neumann, T.; Taylor & Francis Group, Gdynia 2013. P. 201-205

[Kale 14] Kale, R.: *Real Time Passenger Information System*, International Journal of Advanced Research in Computer Science & Technology, Vol. 2, Iss. 3, 2014, pp. 153-155.

[Kang 16] Kang, Y.; Park, I.; Youm, S.: *Performance Prediction of a MongoDB-Based Traceability System in Smart Factory Supply Chains*. Sungkyunkwan, 2016.

[Keller 14] Keller, Th.; Thiesse, F.; Fleish, E.: Classification Models for RFID-Based Real-Time Detection of Process Events in the Supply Chain: An Empirical Study. ACM Transactions on Management Information Systems 5 / 4(2014): Art. 25

[Kölker 19] Kölker, K.; Wenzel, S.; Radde, M.: *ROFL DLR Schlussbericht Entwicklung eines effizienten Verfahrens zur Erstellung eines robusten Flugplans*, 2019.

[Konovalenko 19] Konovalenko, I.; Ludwig, A.: *ROFL DLR Schlussbericht: Event processing in supply chain management – The status quo and research outlook*, in Computers in Industry, pp. 229-249, 2019

[Koutsikouri18] Koutsikouri, D., Lindgren, R., Henfridsson, O., & Rudmark, D. (2018). *Extending Digital Infrastructures: A Typology of Growth Tactics*. Journal of the Association for Information Systems, 19(10), 1001-1019. doi:10.17705/1jais.00517

[Jorgensen 18] Jørgensen, F.; Solvoll, G. 2018. Determining optimal frequency at ferry crossings. Transport Policy 63, 200-208.

[Jurdziński 15] Jurdziński, M.: *Pilot navigation planning.* in: Zeszyty Naukowe Akademii Morskiej w Gdyni, Iss. 92, pp. 54-70, 2015 (in Polish).

[Li 07] Li, M. et al.: Event Stream Processing with Out-of-Order Data Arrival: 27th International Conference on Distributed Computing Systems Workshops (ICDCSW'07). IEEE, 2007 - 2007; p. 67.

[Lind et al. 15a] Lind, M., Haraldson, S., Karlsson, M., Holmberg, P.-E., & Watson, R. T. (2015). *Enabling Port Efficiency by increased Collaboration and Information Sharing – Towards a Standardized Port Call Message Format*. Paper presented at the Special Interest Group 2 (Ports and Maritime) of the World Conference on Transport Research Society (WCTRS-SIG2) of the World Conference on Transportation Research, Antwerp, Belgium.

[Lind et al. 15b] Lind, M., Haraldson, S., Karlsson, M., & Watson, R. T. (2015). *Port collaborative decision making – closing the loop in sea traffic management*. Paper presented at the 14th International Conference on Computer Applications and Information Technology in the Maritime Industries, Ulrichshusen, Germany.

[Lind 19] Lind M., Michaelides M., Ward R., Herodotou H., Watson R.T. (2019). Boosting data-sharing to improve Short Sea Shipping Performance: Evidence from Limassol port calls analysis, Article No. 35 [UNCTAD Transport and Trade Facilitation Newsletter N°82 – Second Quarter 2019] (https://unctad.org/en/pages/newsdetails.aspx?OriginalVersionID=2102)

[Linić 10] Linić, R.; Grce, C.: *Establishment of the Croatian vessel traffic monitoring and information system (CVTMIS)*. https://trimis.ec.europa.eu/sites/default/files/project/documents/Establishment of the CVTMIS.pdf, 2010.

[Liu 13] Liu, J.; Gong, C.; Li, J.; Li, J.; Cui, X., 2013: *Social Sensing Enhanced Time Ruler for Real-Time Bus Service*., *2013.Ninth International Conference on Semantics, Knowledge and Grids (SKG)*, Beijing, China: IEEE, 3-4 October, p. 165–172.

[MaFo 18] MaFo: *Real-time Technologies for Maritime Security - MaFo*. https://trimis.ec.europa.eu/programme/real-time-technologies-maritime-security-mafo, 2018. accessed: 07.08.2019.

[McFarlane 03] McFarlane, D.: *The Impact of Automatic Identification on Supply Chain Operations*. Massachusetts, 2003.

[Michaelides 19] Michaelides M., Herodotou H., Lind, M., and Watson R. T. (2019). *Port-2-Port Communication Enhancing Short Sea Shipping Performance: The Case Study of Cyprus and the Eastern Mediterranean*. Sustainability Journal, Vol. 11, No. 7, pp. 1912-34

[Mohd Salleh 17] Mohd Salleh, N. H.; Riahi, R.; Yang, Z.; Wang, J. 2017. Predicting a containership's arrival punctuality in liner operations by using a Fuzzy Rule-Based Bayesian Network (FRBBN). The Asian Journal of Shipping and Logistics Vol. 33, Iss. 2, pp. 95-104.

[Monzon 12] Monzon, A.; Hernandez, S.; Cascajo, R.: *Real Time Passenger Information systems and quality of bus services.* Proceedings of the 12th International Conference "Reliability and Statistics in Transportation and Communication" (RelStat'12), 17–20 October 2012, Riga, Latvia, pp. 1–10. ISBN 978-9984-818-49-8.

[Mowe-IT 15] Mowe-IT-Cordis: *Optimised passenger transport during disasters and extreme weather | Result in Brief | FP7 | CORDIS | European Commission*. https://cordis.europa.eu/project/rcn/104378/brief/en, 2015. accessed: 04.09.2019.

[Murphy 12] Murphy, J.; Reisman, R.; Clayton, J.: *Physics-Based and Parametric Trajectory Prediction Performance Comparison for Traffic Flow Management*. 2012

[NAVTRONIC 13] NAVTRONIC: Navigational System for Efficient Maritime Transport. https://trimis.ec.europa.eu/sites/default/files/project/documents/9039/final1-final-report-public-navtronic-2013-12-19-final.pdf, 2013

[Nokkala 14] Nokkala, M.: *Project Final Report: Management of weather events in transport system (MOWE-IT)*. https://cordis.europa.eu/docs/sults/314/314506/final1-final-report-mowe-it-final.pdf, 2014.

[Pallotta 13] Pallotta, G.; Vespe, M.; Bryan, K., 2013: *Vessel pattern knowledge discovery from AIS data: A framework for anomaly detection and route prediction*.

[Palumbo 13] Palumbo, G.; van der Zweep, C.; Kessel, R.; Chryssakis, C.; Davies, H.: *Navigational System for Efficient Maritime Transport (Final Report)*, 2013.

[Pani 14] Pani, C.: Managing Vessel Arrival Uncertainty in Container Terminals: A Machine Learning Approach. 2014

[Parolas 16] Parolas, I.; Tavasszy, L.; Kourounioti, I., 2016: *Prediction of Vessels' Estimated Time of Arrival (ETA) Using Machine Learning - A Port of Rotterdam Case Study*.

[Paulauskas 13] Paulauskas, V. 2013. Ships entering the ports. N.I.M.S publish house, Riga, 240 p. ISBN: 9984-679-71-3.

[Paulauskas 15] Paulauskas, V. 2015. Jūrų transporto plėtra. KU leidykla, 240 p. (in Lithuanian)

[Paulauskas 19] Paulauskas, V, Filina-Dawidowicz, L. and Paulauskas, D.: Ro-Ro and Ro-Pax vessels ETA and ATA analysis. Proceedings of 23rd International Scientific Conference – TRANSPORT MEANS, 2-4 October 2019, Palanga Lithuania, Part II: 852–855

[PICASSO 17] PICASSO: *Preventing Incident and Accident by Safer Ships on the Oceans*. https://trimis.ec.europa.eu/project/preventing-incident-and-accident-safer-ships-oceans, 2017. Abrufdatum: 07.08.2019.

[Poznański 12] Poznański, J.; Żebrak, D.: *Application of the simplified calculation method for the determination of the running time of a train on the open line.* in: Prace Naukowe Politechniki Warszawskiej, Iss. 87, pp. 69-83, 2012 (in Polish).

[Prajogo 12] Prajogo, D.; Olhager, J.: *Supply chain integration and performance: the effects of long-term relationships, information technology and sharing, and logistics integration.* International Journal of Production Economics, Vol. 135, Iss. 1, 2012, pp. 514-522.

[Rong 03] Rong, A.; Hakonen, H.; Lahdelma, R. 2003. Estimated Time of Arrival (ETA) Based Elevator Group Control Algorithm with More Accurate Estimation. Turku Centre for Computer Scienceo. ISBN 952-12-1289-6. 21 p.

[Sahay 08] Sahay, B. S.; Ranjan, Jayanthi: Real time business intelligence in supply chain analytic. 2008

[Šakalys 17] Šakalys, R.; Batarlienė, N.: Research on Intermodal Terminal Interaction in International Transport Corridors. In Procedia Engineering, 2017, 187; pp. 281–288.

[Salo 06] Salo, J.: IT—Enabled Supply Chain Management. In Contemporary Management Research, 2006, 2; pp. 17–30.

[Smith 18] Smith, G., Sandberg J. (2018). *Barriers to innovating with open government data: Exploring experiences across service phases and user types*. Information Polity, 23(3), 249-265. doi:10.3233/IP-170045

[Soroor 09] Scroor, J.; Tarokh, M.; Shemshadi, A.: *Initiating a state-of-the-art system for real-time supply chain coordination*. in European Journal of operation Reasarch, 169, 2009, S. 635-650

[Suzuki 00] Suzuki, Y.: The relationship between on-time performance and airline market share: a new approach. In Transportation Research Part E: Logistics and Transportation Review, 2000, 36; pp. 139–154.

[Tarrant 17] Tarrant, D.; McDonald, M.; Turner, J.D.; Alessandrini, A.: *Romanse: a road management system for Europe by Tarrant.* In: Conference Paper, Publisher by IEEE Xplore, Stevenage, United Kingdom, pp. 11-14, 2017.

[Tomczak 08] Tomczak, A.: Safety Evaluation of Ship's Maneuvers Carried Out on the Basis of Integrated Navigation Systems (INS) Indications. In Journal of Konbin, 2008, 4.

[Vera-Baquero 16] Vera-Baquero, A.; Colomo-Palacios, R.; Molloy, O.: Real-time business activity monitoring and analysis of process performance on big-data domains, Telematics and Informatics, Volume 33, Issue 3, 2016, Pages 793-807

[Vickery 10] Vickery, S. K. et al.: Supply chain information technologies and organisational initiatives: complementary versus independent effects on agility and firm performance. In International Journal of Production Research, 2010, 48; pp. 7025–7042.

[Wang 13] Wang, Q.; Wang, Q., 2013: *Study on Real-time Bus Arrival Information System Based on Bluetooth.*, *2013 IEEE Third International Conference on Information Science and Technology (ICIST), 2013 IEEE Third International Conference on Information Science and Technology (ICIST)*, Yangzhou, Jiangsu, China: IEEE, 23-25 March, pp. 93–97.

[Wang 14] Wang, L.; Zuo, Z.; Fu, J.: *Bus Arrival Time Prediction Using RBF Neural Networks Adjusted by Online Data*. in Procedia - Social and Behavioral Sciences, 138, 2014, pp. 67–75.

[Wawruch 18] Wawruch, R.: *Development of the Polish Harbours Information And Control System (PHICS).* in: Autobusy Bezpieczeństwo i Ekologia, No. 6, pp. 276-282, 2018.

[Watson 15a] Watson R.T., Holm H., Lind M. (2015). *Green Steaming: A Methodology for Estimating Carbon Emissions Avoided*, Thirty Sixth International Conference on Information Systems, Fort Worth 2015

[Watson 15b] Watson, R. T., & Lind, M. (2015). *A Research Agenda for Self-Organizing Ecosystems: The Case for Maritime Informatics. SSRN*.

[Watson17] Watson, R. T., Lind, M., & Haraldson, S. (2017). *Physical and digital innovation in shipping: seeding, standardizing, and sequencing*. Paper presented at the HICSS.

[Werner 10] Werner, K.; Schill, A.: *Correlating distributed RFID-based event data for logistics process monitoring*. Dresden, 2010.

[Werthmann 17] Werthmann, D.; Brandwein, D.; Ruthenbeck, C.: *Towards a standardised information exchange within finished vehicle logistics based on RFID and EPCIS*. in International Journal of Production Reasarch, 55, 2017, S. 4136-4152.

[Xue 13] Xue, L.; Zhang, C.; Ling H.; Zhao, X.: *Risk Mitigation in Supply Chain Digitization: System Modularity and Information Technology Governance*. in Journal of Management Information System, 30, 2013, S. 325-352

[Yan 09] Yan, B.; Huang, G.: Supply chain information transmission based on RFID and internet of things. In (Luo, Q. Ed.): 2009 ISECS International Colloquium on Computing, Communication, Control, and Management. CCCM 2009 ; Sanya, China, 8 - 9 August 2009 ; [including the 2009 IITA International Conference on Communication Systems, Networks and Applications (ICCSNA 2009). IEEE, Piscataway, NJ, 2009; pp. 166–169.

[Zalewski 07] Zalewski, P.; Montewka, J.: Navigation safety assessment in an entrance channel, based on real experiments: Proceedings of the 12th International Congress of the International Maritime Association of the Mediterranean (IMAM 2007), 2007; pp. 2–6.

[Zappia 14] Zappia, I.; Cianchi, P.; Adembri, G.; Gherardelli, M.; Giuli, D.; Paganelli, F., 2014 - 2014: *SITMar project: An integrated platform for goods monitoring in multimodal transport*., *2014 Euro Med Telco Conference (EMTC), 2014 Euro Med Telco Conference (EMTC)*, Naples, Italy: IEEE, 12-15 November, p. 1–6.

Internet links:

[Atrax4 19] http://tronik.pl/atrax4/ (from: 11.06.2019).

[Bydgoszcz 19] www.zdmikp.bydgoszcz.pl/pl/inwestycje-i-projekty/2305-o-systemie-its, (from: 04.08.2019).

[CLOUD 19] https://no.linkedin.com/in/cloud-project-745334141 (from:16.09.2019).

[ETA-Transit] https://www.etatransit.com/solutions/, retrieved 15.11.2019

[e-IMPACT 19] https://www.eimpactproject.eu/documents/20543/55670/02-e-IMPACT+Project-Trieste-APL+Overview-Final+Meeting-May29_2018.pdf/2464d7c0-9dd1-4082-bcf0-67e7a39d4c61 (from: 16.09.2019).

[Future Airports 19] https://www.viktoria.se/projects/future-airports (from 12.10.2019)

[Garmin 19] https://www.garmin.com/pl-PL/software/express

[GTFS 19] https://gtfs.org/ (from: 17.08.2019).

[GOTRIS II 19] https://www.viktoria.se/projects/gotris (from 15.10.2019)

[Hogia 19] https://www.hogia.com/hogia-group/about (from 17.10.2019)

[iCargo 19] https://www.icargo.pl/ (from: 11.06.2019).

[InPort 19] https://www.inport.com/ (from 28.10.2019)

[INTRATRIP 00] INTRATRIP: *Intermodal Transport Real-time Information Platform (Final Report)*. https://trimis.ec.europa.eu/sites/default/files/project/documents/intratip.pdf, 2000

[INTRATRIP 19] INTRATRIP-Trimis: *Intermodal Transport Real-time Information Platform*. https://trimis.ec.europa.eu/project/intermodal-transport-real-time-information-platform, 2019. accessed: 07.08.2019.

[InterLan 19] https://www.interlan.pl/system-speed/interlan-mspeed (accessed:11.06.2019).

[ITRACT 19] Website: https://www.viktoria.se/projects/itract-improving-transport-and-accessibility-through-new-communication-technologies (from 12.10.2019)

[Logicon 19] http://www.logicon-project.eu/ (from: 11.08.2019).

[Marine traffic 19] www.marinetraffic.com. 2019.

[NeTEx 19] CEN TC278 Working Group 3 Sub Group 9. (2019). Network Timetable Exchange. Retrieved from http://netex-cen.eu/

[NOPTIS 19] NOPTIS. (2019). Nordic Public Transport Interface Standard. Retrieved from http://www.noptis.org/

[NORDNETEX 19] Nordic NeTEx Profile CCB. (2019). Nordic NeTEx profile. Retrieved from https://enturas.atlassian.net/wiki/spaces/PUBLIC/pages/728891481/Nordic+NeTEx+Profile

[OJP 19] CEN TC278 Working Group 3 Sub Group 8. Open API for distributed journey planning. Retrieved from http://www.transmodel-cen.eu/standards/ojp/

[Optilo 19] https://optilo.eu/pl/drivers-application/ (accessed: 11.06.2019)

[PTV Group] PTV Group Website, https://www.ptvgroup.com/en/solutions/products/ptv-driveandarrive, retrieved 15.11.2019

[Raben 19] https://polska.raben-group.com/aktualnosci/news/eta-od-stycznia-w-grupie-raben/ (accessed: 20.05.2019).

[RailNetEurope 19] Website: http://www.rne.eu/tm-tpm/estimated-time-of-arrival/ (from: 15.09.2019).

[Real-ETA] Real-ETA Website, https://www.real-eta.com/, retrieved 15.11.2019.

[RIGAS 19] https://www.rigassatiksme.lv/en/e-services/ (from: 28.09.2019).

[RISING 13] RISING: *RIS Services for Improving the Integration of Inland Waterway Transports into Intermodal Chains*. https://trimis.ec.europa.eu/project/ris-services-improving-integration-inland-waterway-transports-intermodal-chains, 2013. accessed: 07.08.2019.

[Romanse 19] https://www.romanse.org.uk/ (accessed: 06.02.2019).

[Seamless 19] Website: https://seamless.no/blog/core/havneadministrasjon/ (accessed 29.10.2019)

[ShipLog 19] https://www.shiplog.no/about/ (from 14.10.2019).

[SIRI 19] CEN TC278 Working Group 3 Sub Group 7. (2019). Service Interface for Real-time Information. Retrieved from http://www.transmodel-cen.eu/standards/siri/

[STM 17] STM: *STM Validation Project*. https://trimis.ec.europa.eu/project/stm-validation-project, 2017. accessed: 07.08.2019.

[SUNSET 19] https://www.viktoria.se/projects/sunset (accessed 09.10.2019).

[Synfioo] Synfioo website, https://www.synfioo.com/de/, retrieved 15.11.2019.

[Tramwaje 19] https://warszawa19115.pl/-/system-informacji-pasazerskiej (accessed: 28.08.2019).

[Translink 19] Website: https://translink.com.au/plan-your-journey/real-time

[TRANSMODEL 19] European Committee for Standardization (CEN). (2019). Transmodel. Retrieved from http://www.transmodel-cen.eu/model-visualisation-html/

[VTMIS 16] VTMISs: *Vessel Traffic Monitoring and Information System*. https://trimis.ec.europa.eu/project/vessel-traffic-monitoring-and-information-system, 2016. accessed: 07.08.2019.

[WAZE 19] https://www.waze.com/ (from: 16.09.2019).

[Wrocław 19] http://its.wroc.pl/ (accessed: 28.08.2019).

[ZDiTM 19] https://www.zditm.szczecin.pl/pl/pasazer/rozklady-jazdy,mapa-przystankow-i-pojazdow (accessed:15.04.2019).

8 Appendix

IT-solutions Links

PTV-Group - https://www.ptvgroup.com
Synfioo - https://synfioo.com/de/
Real-ETA - https://www.real-eta.com/
ETA-Transit - http://etatransit.com/solutions/
Paris - https://www.parisoptimalplanning.com/
Transplace - https://www.transplace.com/
AlpegaGroup TMS system - https://www.alpegagroup.com/de/tms/
Kuebix - https://www.kuebix.com/
Grieg Logistics - https://grieglogistics.no
Inform-Software - https://www.inform-software.de/
Kratzer Automation - https://www.kratzer-automation.com/logistics/en/software-solutions/ym-yard-management/arrival-board/
BNS-Software - https://www.bns-software.com/
logistIQo - https://www.logistiqo.de/
Sauer Software - https://sauer-os.de/
Initions - https://www.initions.com/transportmanagement/
Manhattan Associates - https://www.manh.com/de-de/produkt/transportation/ubersicht
Allotrac - https://allotrac.com.au/
Jda - https://jda.com/solutions/manufacturing-distribution-solutions/intelligent-fulfillment/transportation-management
One Network - https://www.onenetwork.com/supply-chain-management-solutions/intelligent-logistics/transportation-management-systems-tms/
Trimble - https://enterprise.trimble.com/solutions/transportation-management
MercuryGate - https://mercurygate.com/
Oracle - https://www.oracle.com/de/applications/supply-chain-management/solutions/logistics/transportation-management.html
Eyefreight - https://eyefreight.com/deutsch/
Cerasis - https://cerasis.com/
Descartes - https://www.descartes.com/de
AcendTMS -
https://inmotionglobal.com/?_ga=2.47146599.1104159948.1566204215-1083364176.1566204215
Transplace - https://www.transplace.com/
BluJay-Solutions - https://www.blujaysolutions.com/de/
Infor - https://www.infor.com/products/supply-chain-management/transportation-management
3gtms - https://www.3gtms.com/
Leogistics - https://www.leogistics.com/
Transporeon - https://www.transporeon.com