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Optimisation of Intermodal Transport Using Satellite-based Services

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The European Space Agency (ESA) is currently funding a number of projects in order to develop services for the optimization of transport and logistics processes using satellite assets. One of these projects is I-PORT, especially addressing intermodal container transportation through European ports. In this context, one of the major challenges is the alignment in planning the arrival and departure of different modalities, e.g. vessels and trucks, such that the containers can be transferred without delays. In addition, unproductive waiting times of transport vehicles should be avoided.

To support this, an integrated solution was defined and developed, which utilizes the added value of satellite assets, in particular GPS and Satellite-based AIS (Automatic Identification System). By using these services, the positions of transport vehicles are tracked and the estimated time of arrival (ETA) is calculated and regularly updated. If the I-PORT system detects a deviation from the planned schedule, e.g. a delay in arrival of a vessel, all involved actors are informed pro-actively. Consequently, the related vehicles can be re-scheduled at an early stage and waiting times and unsuccessful attempts to deliver or pick up a container can be reduced. The I-PORT solution was developed based on the elaboration of user needs as well as existing technologies and services.

Keywords: Intermodal Container Transport, Satellite-based Services, Optimisation, ETA Prediction

1 Introduction

Intermodal container transport today still suffers from various bottle-necks (Witte, 2012), which are often caused by the intransparency of logistics processes and the fact that information is not forwarded to all relevant partners in the supply chain. The efficiency of transport processes can primarily be enhanced by a more intelligent disposition of vehicles (ten Hompel, 2014). In addition, it is one of the challenges for container ports to optimize their facilities in order to be prepared for the growing demands concerning the spatial and time aspects of cargo handling related to the increase in vessel size (UNCTAD, 2014). Especially in case of modal changes, e.g. the pick-up of an import container by a truck in a sea port terminal, avoidable delays occur. If the vessel which delivers the container has a deviation in its arrival time from the planned schedule, this information is in general not forwarded to the haulier, who is scheduling the container pickup according to the planned arrival time. If the vessel arrives late, the truck has to wait accordingly or has to leave without the container.

The I-PORT project funded by the European Space Agency (ESA) aims at improving this situation by developing a system for end users which optimises the handling of intermodal freight transport through European ports. The optimisation is realised by providing more visibility to the different actors involved in freight transport. One of the project's key issues is the management of access to ports, which in general have limited information about arrival of trucks, barges and vessels, inhibiting the ability to optimize port throughput. In addition, I-PORT addresses the topic of schedule reliability. Vessels currently use weather-routing systems and sophisticated naviga-

tion equipment, but not earth observation equipment or techniques to assist in vessel routing optimization. Furthermore, inland transport movements can be better predicted by using satellite-based services as the organisation of hinterland transports relies on sharing information across many organizations and processes which can be optimized. The latter will also lead to predictable turnaround times as access to ports especially in the UK is managed by a vehicle slot booking process; transport providers can only access those ports if they have booked a respective time slot. This is likely to become a more rigid process, as ports strive to manage internal resources.

Besides I-PORT, a project named Smart SC (e-business standardisation in the maritime supply chain) (Smart SC, 2015) is currently funded by the German Ministry of Economics and Technology as part of the German government initiative on e-business standards. Smart SC looks at the improvement of the data visibility along the container supply chain and includes support systems for truckers for the truck/sea port interface with a regional focus on the German sea ports of Bremerhaven and Wilhelmshaven. Within I-PORT, a link between the Smart SC and I-PORT platforms was developed, enabling the use of synergies between the two projects and establishing added values from interoperability and data exchange between these two platforms.

2 Users and Their Needs

A study addressing the optimization potentials through more intelligent disposition processes of vehicles enabled by an improved visibility (INFORM, 2012) identified the following key benefits: decreased congestion of access roads, reduced unproductive waiting times, improved utilisation of resources, and reduced transport costs. The users targeted in this demonstration project are those which could benefit from optimising intermodal freight transport, including e.g. shipping lines, ports, container terminals, hauliers, railway operators, inland waterways, and storage facilities. In addition, stakeholders include (local) authorities, Customs, Port Community Systems, and other partners who benefit from an optimised visibility of the logistics and transport processes. The users have expressed a number of high level needs for improving freight transport through ports. For instance, hauliers expressed a need to have further information on deviations from the vessels' schedules, which results in early or delayed release of import containers or changes in cut-off times for export containers. Furthermore, there is a need to remove the paper side of vehicle slot bookings in ports to improve efficiency. In addition, ports and terminals expressed a need to improve the visibility of incoming vehicles, e.g. by geofencing.

3 Space Added Value

Space technologies, and above all satellites, have an enormous potential in many areas such as logistics, amongst others. Currently the respective potentials are still underestimated and largely underutilized (Perrin, 2013).

Consequently, I-PORT can be seen as a pioneer project in this area. It integrates space-based information delivered by satellites into an intermodal freight transport system. The use of navigational systems enables improved visibility of the truck fleet by using respective GPS signals. The visibility of vessels is improved by using the vessels' AIS (Automatic Identification System) data which is captured by respective receivers which are both shore-based and satellite-based. Merging these data sources together leads to improved synchronisation between port and supply chain actors, reduces delays and waiting times and thus optimises the throughput and the efficiency of sea port terminals and hinterland transport. Because it is not feasible to equip the complete vessel and truck fleets with additional technology, it is critical for the proposed services to exploit existing technologies to integrate diverse information sources and provide a unified interface to improve visibility and standardise communication. Most importantly, the location data must be used to provide estimated time of arrival (ETA) information of vessels and trucks to the relevant stakeholders. The service must be able to capture the location data from existing tracking systems and/or mobile devices and mobile applications, e.g. using smartphones.

4 Technical Background

The Automatic Identification System (AIS) was developed in the 1990s as a short range identification and tracking system for seagoing and inland vessels (Easyais, 2015). It is a maritime transponder/receiver system defined by the IMO (international maritime organisation) and operates in the VHF

frequency band. The purpose of AIS is to assist identifying vessels when not in sight (e.g. at night, in radar blind arcs or shadows or at distance) by transmitting and receiving vessel ID, position, course, speed and other relevant data to and from other nearby ships. During the time of development, it was not foreseen to be detectable from space. Nevertheless, since 2005, experiments were performed detecting AIS signals using satellite-based receivers. Since that time, several commercial companies have started to offer respective services which in combination with the terrestrial AIS receiver network will allow a truly global AIS coverage. The latest development are very little satellites like AISat-1 which is a nano-satellite measuring only 20 x 20 x 20cm (Norsk Romsenter, 2015) or the 1U cubesat AAUSAT3 weighing only 800 grams (AAUSAT3, 2015). These satellites can carry AIS receivers at very limited costs for construction and launch, which makes the installation of an adequate fleet of AIS satellites feasible.

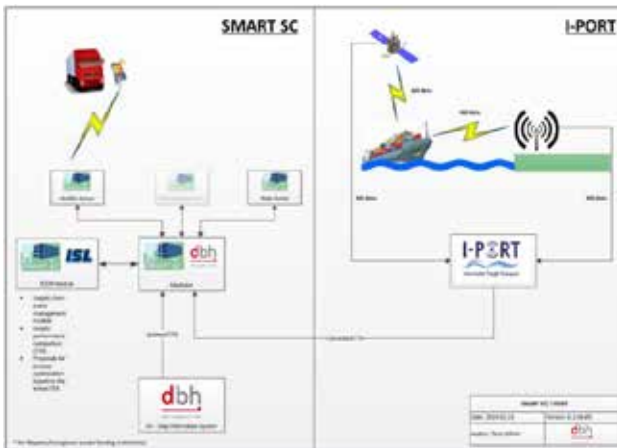


Figure 1 Interaction between the Smart SC and I-PORT systems

5 System Concept

As mentioned above, within I-PORT a link between the Smart SC and I-PORT platforms was developed, establishing added values from interoperability and data exchange between these two platforms. The combination of these two systems as shown in fig. 1 addresses the information requirements of the receivers of containers routed through the ports of Bremerhaven and Wilhelmshaven. These stakeholders need to be informed pro-actively about delays in vessel arrival and receive an updated estimated arrival time of the vessel in order to re-schedule the on-carriage supply chain.

In addition, ports and Shipping Companies require as accurate vessel ETA data as possible; within 2 hours tolerance if practical. However, the current situation is that ETA information (plus destination) contained in a ship's AIS message transmissions is manually entered by a crew member; i.e. it is not derived automatically from the ship's navigation equipment. As well as potential inaccuracies in a crew member typing in the ETA information, it is often also not subsequently updated once the ship is underway. Its entry is also solely at the Captain's discretion, i.e. it is not mandatory. All of this means that any additional information on potential ETA that is derived separately from the AIS message content will be of benefit to ports and Shipping Companies and as such, I-PORT end users.

Shipping companies would ideally like to have any changes reflected in estimated ETA updated in a real time basis. The port companies need to plan in relation to tidal windows (6 hours) and in relation to shift work patterns. The ports would need to know from 24 hours in advance of any changes to the scheduled ETA.

In Smart SC a component named “SCEM (Supply Chain Event Management) tool” was created aiming to compare plan and schedule data with actual status messages (such as vehicle positions) automatically detecting deviations from the plan at an early stage.

The following scenario describes the linking of the Smart SC and I-PORT platforms in detail. The basic precondition is that the I-PORT platform provides the vessels’ AIS location data and ETA to the Smart SC system. In the case of importing containers to the ports of Bremerhaven and Wilhelmshaven, the receiver of the goods enters the shipping order into the Smart SC system, which provides the relevant container number(s) and the port of destination (Bremerhaven or Wilhelmshaven). Based on the data available in Smart SC, the information about the vessel transporting the container(s) is derived from the container number(s). The planned date and time of arrival of the vessel at the port of destination, obtained from the SIS system operated by the port community system dbh, serves as to-be data for the SCEM module of the Smart SC system. Based on the AIS vessel tracking data and ETA provided by the I-PORT system, the SCEM module will compare it with the planned time of arrival. In case of deviations from the plan, the SCEM module will pro-actively inform the relevant partners involved in the on-carriage of the container about the delay in order to allow an efficient re-scheduling of the supply chain processes.

Hauliers who deliver export containers to the ports of Bremerhaven and Wilhelmshaven require to automatically receive updates of the closing time for container delivery in order to be in time for the booked vessel. This is especially important in case of deviations from the plan, e.g. delayed arrival

of a vessel. For this case, it was investigated whether the calculated estimation of the vessel arrival time at the port of destination can be used to predict an updated closing time for container delivery, i.e. the time from which on delivered containers are considered as delayed and will not be loaded on the vessel. The updated closing time will be provided back to the I-PORT platform to be made available to I-PORT users.

6 Conclusions

The I-PORT project demonstrates the expected benefits of utilisation of new satellite technologies within freight transport, providing better visibility of a freight's positioning, to all stakeholders. This clarity and precision allows for accurate status of delivery through the duration of the process and greater security, because all freight is traceable at all times. This allows for greater optimising when utilising resources and alleviating congestion at the busiest periods. Considering traffic data and live positioning of freight allows for live updates of ETAs and live scheduling and optimisation of hauliers' processes.

With the specified linkage between the I-PORT system and the Smart SC system, the following benefits are anticipated:

- Better utilisation of port resources, optimisation of efficiency (as an example, between 5%-20% of booking slots are currently wasted due to delays);
- Better planning of truck resources with ETA data available in real time, leading to a reduction of unproductive waiting times and

unsuccessful attempts to deliver or pick up a container and consequently to a reduced impact on the local community and the environment (reduced emissions and reduced traffic on access roads);

- Automatic rebooking of slots and advise to the driver in the event of late or early arrival, saving wasted journeys and/or waiting time;
- Reduced administration time managing slots and missed slots;
- React to the growing demands concerning spatial and time aspects of cargo handling related to the increase in vessel size;
- More capacity for growth.

The systems were developed and are currently in the phase of implementation and integration in the port community system. The expected benefits mentioned above will be validated during the subsequent demonstration phase in a real-life environment.

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