LOAD CARRIER MANAGEMENT ON RO-RO TERMINALS

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ABSTRACT
The transparency of location and status of loadings and load carriers is particularly important for efficient warehouse management on seaport terminals. Today detection of load carrier movement processes and modified status information is insufficiently supported by software systems. An automated IT-based load carrier management system offers a wide range of opportunities for tracking and tracing positions and status information of loadings and load carriers. A permanent monitoring of changes regarding location and status allows the usage of innovative stock-keeping strategies, search time reduction, decrease of relocation processes and overall an improvement of the traffic flow on the seaport terminal area.

This article addresses the design and modelling of a system that enables automated detection of location and status of load carriers on seaport terminals combining innovative information and communication technologies for identification, communication and localisation tasks. Superior objective is the improved process monitoring in the context of Ro-Ro traffic.

Keywords: load carrier management, Ro-Ro terminals, track and trace

1. INTRODUCTION

In relation to globally increasing trade flows of goods the role of sea harbours for unobstructed cargo handling is gaining in importance. The amount of goods traded via the German sea ports alone increased from 224 million tons in 1999 to 302 million tons in 2006. The sea traffic prognosis passed by the German federal government in May 2007 forecasts a continuing growth of cargo shipping from German sea harbours to reach 759 million tons in 2025. Next to container traffic the Ro-Ro (Roll on / Roll off) traffic in particular is regarded as a main driver of this development with high potential for growth. The mentioned prognosis forecasts that Ro-Ro traffic of the German Baltic range sea harbours will grow over-proportionally with average growth rates of 4.8% and thusly increase by more than a factor of three from 27 million tons in 2004 to 71.7 million tons[1] in 2025 (ZDS 2007). In order to successfully manage the challenges related to this growth, next to increasing harbour capacities by expanding harbour infrastructure and connection to the hinterland, better use of existing capacities is required. In this conext process improvements using intelligent storing position management systems and automatic freight or load carrier identification systems have been proposed (Oppel 2007).

A substantial part of the goods in Ro-Ro traffic is transported with specialised load carriers. Load carriers are defined by the German industrial norm DIN 30781 as carrying means for combining loadings to a loading unit and fulfilling transport, aggregation and handling functions as well as protective functions for these goods (Arnold 2002, Pfohl 2003).

The transport function for bridging spatial differences requires optimised size for efficient usage of transport spaces, e.g. fitting into ship hull spaces. Additionally load carriers fulfil a storage function for bridging timely differences and, in some cases, a handling function for assembly, picking and finishing processes (Heimbrock 2001).

The protective function or quality keeping function of the load carriers includes protection of the loadings against external strains from the surrounding (e.g. cold, humidity, electromagnetic fields) and also protection against damages resulting from inept or accidental handling (e.g. hits, scrapes etc.). Finally, load carriers also serve to mark and identify the loadings they contain (Pfohl 2003).

Load carrier management as a logistics function involves on the one hand load carrier life-cycle management, which includes the design of the load carriers, the development of the load carrier cycles, the maintenance of the load carriers during their life-cycle phases and their disposal at the end of the life-cycle, taking into account cost, time and quality aspects. During design of the load carriers the optimised size, handling and space efficiency as well as minimal manufacturing, maintenance and repair costs have to be considered. During operation the load carrier quality

[1] Data without own weight of load carriers

and functionality has to be monitored and maintenance or repair actions have to be initiated.

The second main function of load carrier management comprises operational planning and control of the load carriers during their use within logistic and supply chains. This means the continuous tracking and tracing of the load carriers during the related processes, including documentation and filing of the process data, and disposition of the load carriers (Gudehus 2004).

This contribution focuses on the second task of load carrier management. Operational planning and control depends on a permanently up-to-date overview of load carrier inventory sizes as well as state and position of the load carriers. In this context innovative technologies like radio frequency identification and satellite based positioning offer potentials for improved load carrier processes and management (Fleisch 2005).

2. OBJECTS OF INVESTIGATION

Load carriers that are used particularly in Ro-Ro traffic are roll-trailers (mafis) and their prime movers (tug masters). They are used to transport high and heavy loadings. The so-called high and heavy segment is a niche market dealing with the import and export of trucks, busses, and construction or agricultural vehicles. In addition to self-propelling vehicles, heavy goods such as large boats or machines are placed on roll-trailers, which can be moved inside the Ro-Ro ships (Mattfeld 2006). The benefit of this technical solution results from the low conception of the trailer-chassis and the flexible connection through a z-shaped, hydraulically driven part of the tug master which can be raised and lowered.

Voluminous charges can be transported even into shipping spaces where ceilings are low. Acute angles can be negotiated during the loading and unloading of ships which induces an optimal utilization of shipping space.

The German MAFI Transportsysteme GmbH in Stuttgart developed these Systems, which are now enforced in the worldwide Ro-Ro system. Roll-trailers are property of the shipping companies who call at a port or are rented by them for a period of time. The trailers are partly denoted with standard alpha-numeric identities.

In the section “High & Heavy” of German automotive logistics provider BLG LOGISTICS AUTOMOBILE, 16 tug masters are used to move loaded and empty trailers, while ships are discharged and loadings are stored, externalized or charged. In 2006 approx. 330.000 tons of high & heavy goods were handled. For this task approx. 5.500 roll-trailers were used. Approximately 450-550 empty roll-trailers have been used on the seaport terminal in average. In the year 2007 the volume grew to approx. 380.000 tons of high & heavy goods, which were transported by approx. 6.300 roll-trailers. 500 to 650 empty roll-trailers have been the average of this year.

Figure 1 shows the essential processes of current load carrier management on a Ro-Ro terminal and the weaknesses in the process chain. Cargo-loaded roll-trailers are drawn down the ship and placed onto the terminal’s high & heavy areas. If the cargo is carried on quickly, the loaded goods will remain on the trailers.

After moving the cargo onto trailers that are usable for road traffic, empty trailers are stocked on disposable surfaces. The roll-trailers are put on top of each other by fork lifts to form stacks and thus reduce storage space.

Directed storage on specific fields occurs – if at all – only on the basis of information concerning place or status that is collected via a barcode system or keyboard entry. As manual data input bears risks concerning faulty or fragmentary collection of data, significant costs of following blemishes are expected e.g. through unknown and wrong captured positions of roll-trailers which causes costly actions to look for them.

Furthermore, generally missing and insufficient integration of information regarding status and position of load carriers into existing inventory management systems does not allow consideration of the load carriers in the context of planning inventory allocation.

This results in an intermediate storage of load carriers on temporary areas which leads to time-consuming and resource-expensive processes of relocation.

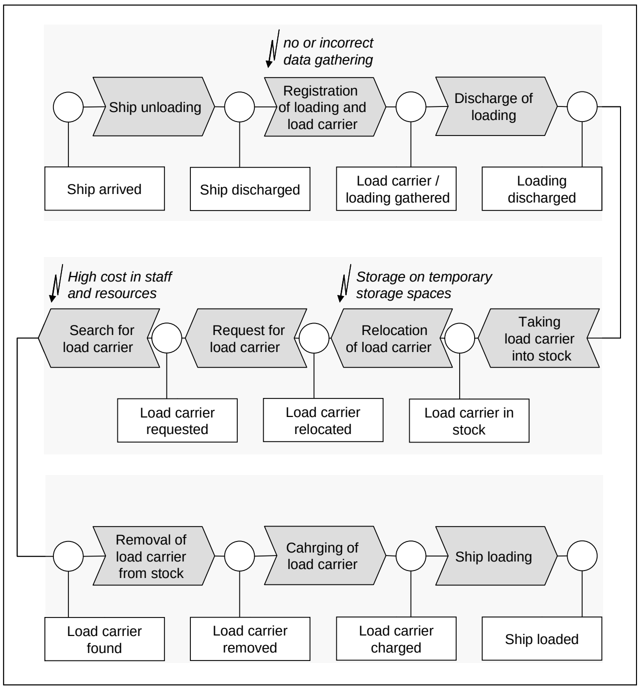

Figure 1: Current load carrier management processes

A similar problem to the use of mafi and tug master is handling sport boats on trailers. Every trailer is affixed by a number that referrers to the boat number as a rule. This way of attaching an identification mark is restricted due to inconsistent weather. Capturing the boats is very disaffected.

Movements or changes of state (load carrier loaded, load carrier stocked etc.) of load carriers are currently not captured by IT systems.

Roll-trailers are not captured or captured manual via keyboard entry or barcode systems in which different standards to label goods (e.g. barcode, barcode-labels and identification plates) are used which complicates the process of capturing.

Locations of logistic objects are not often known due to missing or blemished capturing. Many inventory management systems do not consider load carriers which causes their storages on temporary surfaces. This causes rearrangements of the load carriers and position-tracing is hindered additionally.

Figure 2 shows the weaknesses and requirements of current inventory management systems regarding planning and control of load carrier processes as well as the deduced requirements to an effective inventory management. The lack of transparency concerning the whereabouts and condition of logistic objects affects uncertainties of planning such as absent correlation of load carriers and loadings. Otherwise it is necessary to bring in expensive arrangements such as searching on the huge seaport terminal to reduce disturbances.

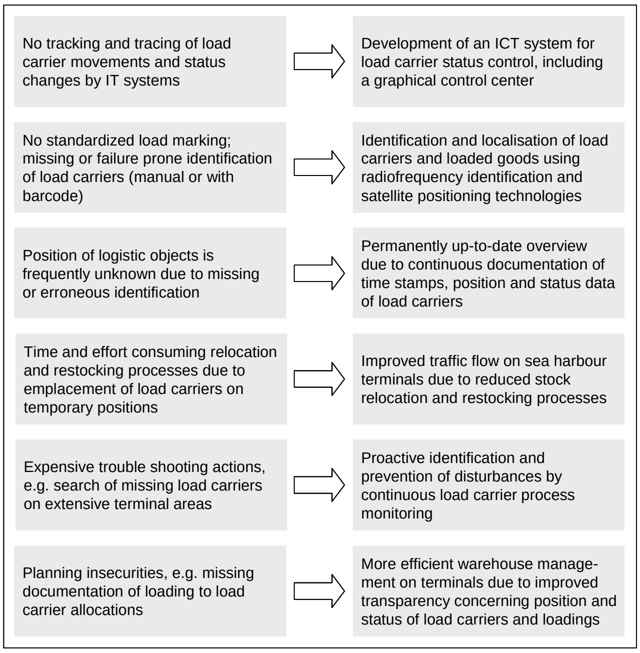

Figure 2: Weaknesses and requirements

Due to missing integration into inventory management systems a complete observance of all objects is not possible although it would be possible to plan the inventory management measures. This situation leads to an inefficient administration of inventory surface areas overall.

3. PROCESS IMPROVEMENT

The super-ordinate objective of the concept consists of improved transparency concerning position and status of load carriers and loadings in sea harbour Ro-Ro terminals by combination of innovative technologies like radio frequency identification and satellite positioning as well as control center approaches. The continuous identification and localisation results in a permanent overview of load carriers and loadings concerning time, position and status information. This allows to realise potentials for added value logistic processes like e.g. permanent allocation of load carriers to their owners, and thus exact storage fee calculations.

Automatic documentation of load carrier storage positions allows to significantly reduce time and effort, spent searching load carriers or goods. Additional potentials are offered by improved capability to control storage relocations and stock transfers, prevention of loading errors and acceleration of stock inventory taking processes. Integration of load carrier position and status information into existing warehouse management systems allows to improve storage allocation planning and to use new intelligent storage strategies like e.g. chaotic storage allocation.

The time stamp, position and status data can be used to monitor terminal processes. Such a process monitoring, combined with the capability to analyse the data, which has previously been documented over longer periods, using adequate data analysis and business intelligence methods, allows to better capture longer term developments related to the load carrier processes. This offers further potential for lasting and effective improvements in process planning and execution.

In the prospect of logistic potentials for improvement several effects can be identified and formulated as objectives for implementing the concept, which has been described in this paper:

- *Improved traffic flow on sea harbour Ro-Ro terminals due to reductions of storage relocation and restocking processes:*
  The overview of Ro-Ro terminals which the system can provide enables improved, proactive planning of the terminal processes, allowing to reduce time consuming and capacity fixing storage relocation and restocking processes of the load carriers which are currently necessary due to planning inconsistencies.

- *Reduced search efforts to find missing load carriers:*
  Due to localisation and tracking and tracing of also individual load carriers, losses of load carriers and resulting searches for missing load carriers on the extensive terminal areas can be prevented almost completely. This will allow to reduce fuel consumption during searcing activities and thus operating costs of the Ro-Ro terminals.

- *Reduced fuel consumption:*
  As implementing the system allows to reduce erroneous dispositions during removal of the

load carriers from storage positions, fuel consumption of the tug masters (towing machines for the load carriers) may be significantly reduced. One example might be the allocation of a tug master for dissolving the different load carriers stacked onto each other in order to get to the single load carrier required.

- *Proactive identification and prevention of disturbances:*
  An IT-based graphical control centre allows a real-time monitoring of the load carrier processes and thus enables improved planning and control within load carrier management.

Additionally, in the medium term it will be possible to reduce over a mid term horizon the amount of trailers on the terminals by using exact storage fee calculation and accounting, which will free storage areas for other terminal processes. Generally an increased throughput may be achieved on sea harbour terminals and such in the respective sea harbours as a whole.

4. TECHNICAL IMPLEMENTATION

The adoption of innovative information and communication technologies for identification, communication and localisation tasks offers a wide range of opportunities for tracking and tracing positions and status of loadings and load carriers. In this context localisation systems as well as automated identification technologies are of particular importance. Via satellite positioning systems such as GPS (Global Positioning System) or the upcoming European Galileo system any object can be localised at anywhere in the world with an accuracy of several meters. This means that the exact position of an object can be determined in an appropriate frame of reference, e.g. in a geodetic graticule. The main purpose of automated identification systems is fast and reliable identification of several objects. In addition to identification technologies such as barcode and OCR (optical character recognition), especially radio frequency technologies are currently within the centre of attention. A radio frequency system consists of at least one storage medium fixed to the corresponding object (a transponder) and a reading / writing device, which communicate with each other via radio signals. A transponder contains an unique identification number and possibly additional data. These data stored onto the transponder is transmitted to the reading device in the form of an electromagnetic signal responding to a request impulse. Both the transponder as well the reading device have an integrated transmitting and receiving antenna. The reading / writing devices are connected to the operational planning and control software system via suitable network and communication interfaces. Due to the fact that the data acquisition is done automatically at the moment of emergence by the reading / writing devices, the data inventory of the logistic planning and control system is always up-to-date, which allows real-time planning and control of logistic order processing.

Regarding the logistic objects suited for adoption of the described technologies, several layers and levels of aggregation respectively can be distinguished, which range from loading via load carrier to means of transportation. At the bottom layer loadings and load carriers are equipped with transponders containing a unique identification number and possibly additional order data. The middle layer includes mobile and stationary reading / writing devices at specific locations in order processing recording relevant status information of loading and load carrier. The logistic backend software system represents the upper level of the considered load carrier management system.

As illustrated in figure 3, the technical implementation of the designed system for tracking and tracing load carriers on seaport terminals is based on innovative information and communication technologies for identification (RFID, mobile character recognition), communication (WLAN) and positioning (GPS, Galileo) tasks including necessary hard- and software components. The adoption of existing technologies for automated detection of seaports is the basis for the development of comprehensive process improvements which results from new opportunities for communication between logistic objects, handling equipment and seaport systems.

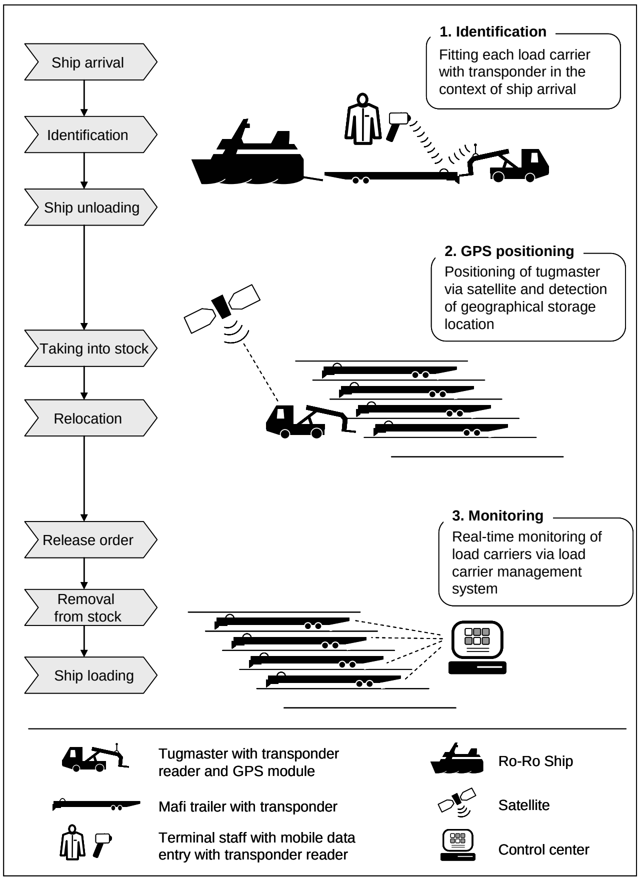

Figure 3: Technical implementation

The combination of these technologies in the form of a so-called hybrid solution with appropriate interfaces to warehouse management systems allows the identification and localisation and consequently the ongoing position and status monitoring of load carriers and loadings. The last mentioned aspect is an essential condition for the comprehensive and efficient storage allocation planning based on current planning data.

The focus of the designed system is directed onto stationary and mobile detection of position and status information of load carrier on seaport terminals as well as on ships in the harbour. For this purpose, roll-trailers are fitted with passive UHF transponder. Tug masters and fork lifts are equipped with combined data terminals, which contain each an UHF reader to identify the related roll-trailers, a positioning component for locating the current position as well as a communication component for transmitting transport orders, positioning and status data. The position of the tug master or fork lift determined by GPS or Galileo in the near future is assigned to the roll-trailer identified by its RFID tag. So a detection of the specific position of the roll-trailer can be achieved both in the case of moving the roll-trailer with a tug master from one location to another and in the case of taking into storage or stack building by a fork lift. An appropriate combination of the described technical components allows a continuous monitoring of position and status of the roll-trailers (loading status, current allocation of roll-trailer to tug master, movement status etc.) on the huge terminal area. As a result, the main stock keeping processes of load carriers such as taking into stock, removing from stock and relocation can be tracked. For each process step (ship loading / unloading, taking into stock / removal from stock / relocation of roll-trailers, unloading of roll-trailers etc.) a timestamp as well a location stamp is documented. The identification number of the roll-trailers and loadings as well as the voyage numbers are documented in the corresponding software system and are assigned to the related ships and shipping companies in their function as invoice recipient for storage charge. At neuralgic points of the seaport terminal area (ship ramp, storage gates etc.) additional stationary reader devices can be implemented, which complete the monitoring of roll-trailer movements by identifying passing roll-trailers fitted with passive transponders.

By means of the designed IT-based load carrier management system described above, the process chain in the field High & Heavy of the BLG LOGISTICS AUTOMOBILE (ship unloading, taking into stock, relocation of load carrier, removal from stock to ship loading) can be permanently observed and therefore significantly improved. Further sub processes are primary data collection and receiving inspection in the context of the ship arrival process. On the seaport terminal of the BLG LOGISTICS AUTOMOBILE the RFID system represents a temporary closed loop solution with main focus on the time periods, during which the roll-trailers are staying on the terminal area. Transponders, which are tagged to the roll-trailers in the context of the ship unloading process, are read by stationary RFID reader devices at the ship ramp. When a roll-trailer leaves the seaport terminal area, the transponder is read again by the RFID reader at the ship ramp and after that removed from the roll-trailer. Another field of application of the described system is the inventory of load carriers, which can be significantly accelerated using a mobile data entry device (MDE) with integrated RFID reader and GPS component.

5. CONCLUSION AND OUTLOOK

Central aspect and aim of the present article is design and modelling a system that captures position and status of load carriers to achieve an improved load carrier management in Ro-Ro traffic on sea harbour terminals.
Whereas information and communication systems are used in several areas of harbour logistics, similar technological support does not occur in collecting changes of load carriers' status and positions.

The described analysis points out weaknesses in the process steps. Rearrangement of mafi trailer load carriers ccauses high effort and use of temporary stocking areas. Searching for load carriers is expensive in terms of time and resources (e.g. additional employment of staff, additional fuel consumption, additional motor tractors etc.) and results in increased costs.

Weaknesses as demonstrated particularly result from faulty or completely missing collection of data, while load carriers are collected or used as the ship is unloaded. Based on detailed inventory and documentation of actual-processes on the harbour terminal of BLG LOGISTICS AUTOMOBILE an analysis of critical points could be enforced. It uncovered different potential for advancements. Requirements on an IT-based load carrier management system have been developed on the analysis results. The described method of resolution regarding the technical implementation was also developed in adopting the results.

System implementation includes the development of software for load carrier management and as the selection of appropriate hardware components. The developed theoretical model adjoins limits in its practical use. Therefore further steps of work will be implementation of software and hardware according to the model.

A prototypical system based on the shown model and system concept will be implemented on the Ro-Ro terminal of the BLG LOGISTICS AUTOMOBILE. Beside the identification of load carriers also changes of location and time will be recorded and monitored by a IT-based control center.

The phase of implementation is followed by field tests within an installation for testing. Logistic and economic benefits regarding the rollout of implemented hardware and software prototypes for load carrier management are explored under commercial aspects.

The designed system can be seen as an exemplary system that raises different expectations. Beside real time monitoring of load carriers it is the aspect of up-to-date transparency that shows at what place and in what kind of state a load carrier stands in a certain moment. Planning and control processes are to be improved which will result a significant impact on the logistic performance of Ro-Ro terminals.

It is expected that sea harbours will be increasingly frequented in the future. Considering this aspect, the profitability of Ro-Ro traffic in sea harbours cannot be disregarded.

6. ACKNOWLEDGMENTS

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