

# THE CONCEPT OF TRACKING AND MONITORING SYSTEM FOR SENSITIVE CARGOES IN THE INTERMODAL TRANSPORTATION

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**Abstract.** The paper proposes a novel concept of the system that can be used for tracking and monitoring whereabouts and condition of sensitive cargoes in the intermodal transportation. The main aim of the proposed system is tracking and monitoring of several selected parameters of the container cargoes from the moment of placing them in a container and afterwards during the whole voyage, until container unloading in the destination place. Thus, the proposed system can be classified as a door-to-door type of solution. The aim of the suggested system is also to assure a rich functionality for monitoring sensitive cargoes for all stakeholders in the supply logistic chain through designing user friendly and wide analytical interface. As a base for further design steps a review of the selected existing systems for tracking and monitoring sensitive cargoes in the sea transportation is included in the paper. Next, technical and functional assumptions for the novel proposed system are described.

**Keywords:** sea transport, sensitive cargo, tracking and monitoring systems

## 1. Introduction

Transport and logistics is a vital part not only of the global economy. From the European perspective it leverages export of European goods and increases their competitiveness. This is especially true for maritime transport which allows to reach global economy with products made in European countries.

Maritime transport plays particularly important role in Polish, German and other EU countries economies. European countries including Poland and Germany have long and successful history of shipbuilding and shipping. However during the last two decades shipbuilding activities have diminished due to the competition of the Far East shipyards. According to several renowned economists presently we are facing a turning point where the existing experience and resources should be redirected towards more advanced products and items. Such an innovative approach could assure a stable growth of the European maritime economy. The proposed project belongs to an very innovative IT and automation sector combining it with a strong shipping background and therefore using the available know-how in a novel domain. The project is seen as a tool for creating added value for its stakeholders and positively influencing the maritime economy.

Transport of condition-sensitive cargoes is gaining an importance due to the technology advances and growing global demand for condition-sensitive products as well as a constant growth of the average transportation distance. Furthermore, what can be observed recently, the additional factor for closer tracking and monitoring is the growing value of the transported products. Development of wealth in Far East countries (especially in China) resulted in a necessity of maintaining strict transport conditions for upmarket, high-value products (e.g. gourmet food, wines, haut-couture products etc.) [5], [6], [7].

Long distance transport of sensitive cargo is usually carried-out using the refrigerated containers (reefer containers) of standard sizes (20', 40' or 45'). These containers allow for maintaining the required degree of condition standards (usually meeting restrictions on temperature but for some cases assuring also other parameters such as humidity inside a container). Furthermore modern containers allow for a local monitoring of the cargo conditions (conditions inside container) and in certain cases local monitoring parameters can be accessible through a parent system (located usually in a container terminal or on a container ship). Parent systems use the existing infrastructure (in a terminal or on a vessel) to provide access to the most important parameters of the cargo condition inside a container. Obtained data can be compared with known standards and in case cargo parameters deviate from the required ones an alert information is generated. Some systems offer external access to the condition monitoring functionality e.g. for cargo owner [8].

There are several systems for tracking and monitoring cargoes, including sensitive cargoes, but no one is ready to provide monitoring functions from the moment of loading the cargo into a container and afterwards during the whole voyage, until container is unloaded in the destination place. Constant access to the monitored parameters throughout all phases of

the transportation chain is currently not available for the maritime transportation stakeholders. The objective of the paper is to present a concept of the system for tracking and monitoring sensitive cargoes in the sea transportation addressing the above issue. The idea of the system based on integration of functionality and some technical solutions (including communication protocols) from the existing systems for monitoring cargoes in the transportation thus creating a complex solution (system) of the door-to-door type.

The paper is organized as follows. In Section 2 the state-of-the-art in research and development of tracking and monitoring systems for sensitive cargoes in the sea transportation is included. Section 3 presents concept and assumptions of the proposed system, with overview on the research and development process which has to be carried out to design and implement the suggested system. Finally, the last section concludes the paper with final remarks.

## **2. State of the art in research and development**

Reefer containers monitoring and tracking systems do not constitute an extremely competitive market. There are only few vendors offering monitoring systems but their solutions cover only part of the logistics chain (container terminal and/or vessel). Some of the leading solutions are briefly reviewed below.

GRASP 3.0 system [1] offered by US company RTE Inc. is a comprehensive tool for monitoring and control of conditions inside the reefer container. It includes both software and hardware solutions. Hardware includes both - dedicated solutions designed to be attached to a reefer container and, alternatively, some modifications of the third party hardware of selected brands. Software is developed as a desktop application (i.e. requires installation on the user terminal) and therefore does not offer cloud flexibility. Main features of the system are summarized below:

- Recording precise connecting and disconnecting times in order to reduce likelihood of container being not powered,
- Electronic storage of information (claim reports),
- Alarm functionality,
- Remote control of selected parameters.

ReeferConnect system [2] is offered by another US company ORBCOMM. System combines dispersed hardware (installed on a container) with on-demand software which is tailored for the purpose of the user. With this approach user interfaces are built in a case-by-

case method. Therefore there is no general interface available as a cloud solution. Main features of the systems are following:

- Tracking and monitoring of each container in a system,
- Providing status of the vital reefer container parameters,
- Alarm messages in case of exceeding set boundaries of selected parameters
- Integration with existing reefer container systems.

REEFCON 6 developed by the global company Emerson is an advanced monitoring and control system for reefer containers in a container terminal and on board containership [3]. System does not provide functionality for monitoring containers during their road or rail transportation leg. However for the vessel and terminal transport phases system provides specialized graphical interfaces. System focuses on the whole terminal or vessel rather than on each separate container. Main features of REEFCON include:

- Monitoring container conditions during storage in terminal and transportation on board,
- Real-time status and alarm functionality,
- Conditions reporting on request,
- Data centralization with use of the Global Monitoring Server.

Reefer Container Monitoring System [4] provided by German Intershalt has been designed with the goal of monitoring the reefer containers onboard a container vessel. System uses data transmission through the power cable or allows semi-automatic data logging with use of handheld terminal in case of containers not equipped with modem.

Concluding the review Section one should note the following:

- The reviewed systems offer different functionalities and capabilities. However, some of their functions are common to all of them.
- The reviewed systems are based on different ICT technologies.
- There are no data available on their dependability and reliability.
- None of the discussed system can offer the door-to-door service.

### **3. Conceptual assumptions and requirements for the proposed system**

#### **3.1 General assumptions**

Main reason for proposing a new approach for tracking and monitoring sensitive cargoes is the need to respond to challenges from increasing volume of cargoes transported by the sea, increasing number of the specialized sensitive cargo containers used, increasing

value of the transported cargoes and a growing demand for a door-to-door services assuring better effectiveness of the transportation chain. The proposed solution therefore fits well into the current trends in offering global, innovative, dependable and value-generating solutions to the intermodal transportation systems.

The main design assumption for the proposed system is its ability of tracking and monitoring the selected parameters of the container cargoes from the moment they are loaded inside a container and afterwards during all the transportation phases including land, water and sea legs, until a cargo transported in a container is unloaded in the destination place. Hence, the proposed system would offer the door-to-door service capabilities.

Another important assumption is that the system, including its communication protocols, should be open allowing for a speedy and flexible adaptation of the dataset required to be monitored during transportation depending on the requirements of the sensitive cargo and/or its carrier or owner. Consequently, a flexible sharing of different kinds of the measured and monitored parameter values, which the transportation process stakeholders would like to record, should be offered. To implement such a system, a new and innovative set of the controllable sensors allowing for typical parameters monitoring through discrete reading, as well as monitoring of the required spectrum of such parameters over the whole container space is needed. Results of such measurements registered over the whole container space, will form an input for spectrum analysis allowing for a complete evaluation of conditions in which cargo is transported. Subsequently, evaluation results should trigger eventual alarm functions.

To realize such system it is also needed to design, develop and implement a new telemetric solution allowing for transmission of the measurements from inside a container during all transportation legs (including storage and waiting for loading/unloading in container and logistics terminals). Communication and data transmission subsystems should be flexible allowing for changing the tele-transmission medium through the ground GPRS as well as through the satellite telecommunication systems. One of the required system functionalities should be also ability to integrate through specially designed interface with the parent container terminal systems as well as with the ship infrastructure systems.

As it has been mentioned, the system should be based on a dedicated telemetric and analytical solutions. From the ICT technology point of view the proposed system should use a cloud processing tools and techniques which will increase accessibility to system functions for all potential users. The graphical user interface should be an important part of the system designed to allow for customization and personalization with respect to category of users and

their particular expectations. Flexible access to system functions should be guaranteed through modular structure of the software component.

In addition, it should be considered to implement the analytical module allowing for the predictive processing and identification of the short-term and long-term changes of the observed parameter values. This should extend functionality of the system allowing for evaluating eventual physical and economic consequences which might be critical from the point of view of quality and value of the transported sensitive cargoes. Such solution could aid decision-making processes of the logistic chain stakeholders. From the research point of view, an open question remains methodology of induction based on spectral analysis applied to spectral data collected under the above described assumptions.

General structure and components of the proposed system are shown in Fig. 1.

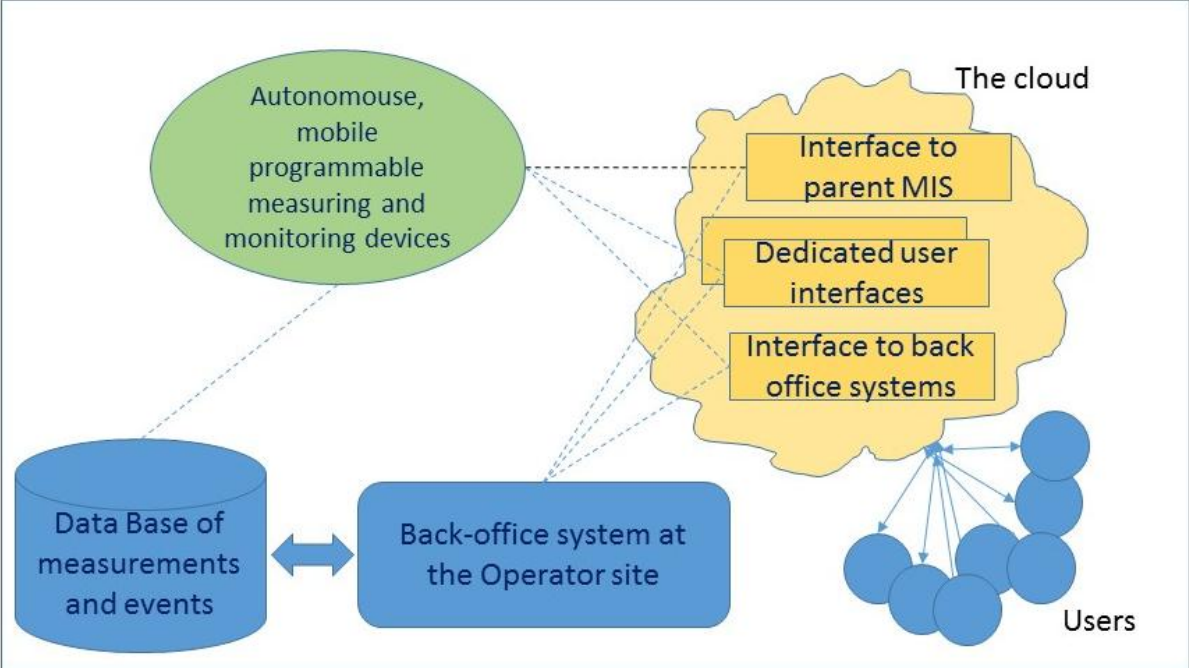


Fig. 1. General structure and components of the proposed system

Thanks to the module functionality the system will be flexible and provide, through dedicated interfaces, different services to different users. Overall impact of the system on logistic chain effectiveness should be positive. Services such as micropayments and subscriptions will make the access easy and affordable. Increased dependability of the main service, that is multimodal transportation of sensitive cargoes achieved through monitoring and tracking, could decrease uncertainty on the part of shippers and insurers leading to decrease of the insurance costs. Eventual alarms raised by the system will allow for timely

reactions due to the real-time property of the system information flow. In case of alarms there subscription systems. The system will aid managing sensitive cargoes transportation chain through on-line real-time monitoring and assurance of meeting standards and requirements. Decreasing risks of damage to cargoes should be considered as an important factor for reducing probability of environmental pollution as a result of improper cargo handling.

### **3.2 Research and development challenges**

The paper reports on idea of the R&D project presently at its early phase. To develop and implement the proposed system a number of research and development tasks need to be carried-out. In particular, the following milestones have to be reached:

- Designing AMTM (autonomous mobile tracking and monitoring) devices through finding new technological solutions and validating functionality of emerging solutions as well as assessing their properties with respect to the expected application area, which is transportation of the sensitive cargoes,
- Proposing adequate telematics solutions including standards, sensors and respective protocols,
- Designing robust and flexible sensors for both continuous and discrete recordings,
- Finding adequate telemetric solutions,
- Proposing and validating new specialized methods and tools for spectral data analysis, and spectral data processing,
- Proposing and validating tools and techniques for knowledge extraction from the recorded data which will be a typical “Big Data” problem.
- Solving system analysis task for making possible integration of the system with the parent stakeholder MIS (management information systems

There are also engineering tasks that require skilful application of the existing technologies. Among them one should mention the following:

- Designing communication subsystem,
- Designing a power supply solutions for system components, including sensors and mobile devices,
- Integrating all components into a working system,
- Proposing adequate system configuration,
- Designing databases structure and functionality with consideration of user needs,
- Designing the required interfaces assuring ease and low costs of access,

- Designing and validating set of the system users roles including tools for providing functionality “on demand”,
- Designing cloud computing part considering availability, costs and ease of access.

#### **4. Concluding remarks**

The review of currently available solutions shows that in the field of tracking and monitoring sensitive cargoes transported in containers there are no door-to-door services available on the market. The proposed system aims at providing a novel alternative for all of the chain stakeholders providing for monitoring of the sensitive cargo conditions over all intermodal transportation legs.

Probably such a capability could be achieved through improving the existing solutions by adding a new telematics mechanisms to the parent systems and increasing they functionality. Such an approach would be equally costly as developing a new system and will probably not assure the required universality and flexibility. The proposed system aims at creating an innovative system based on newest ICT technologies. Its implementation will create added value for shipping and intermodal transportation chains community through better utilisation of the transportation infrastructure, reduced damages to the sensitive cargoes and reduced probability of damages to environment.

Potential system users include logistic chain stakeholders such us ship owners and transportation companies, container terminal operators, transit operators, cargo owners, cargo senders and receivers, and insurance companies. Currently, there are no systems of the proposed or similar functionality offered on the market, so the proposed system would be considered as an extension of the existing solutions with a wide range benefits.

Finally, the authors would like to stress that the concept of the system is a part of the early stage of the research and development project, aiming at offering the emerging product on the market by one of project partners.

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