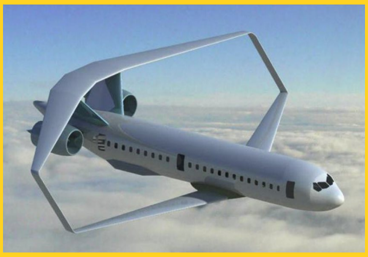

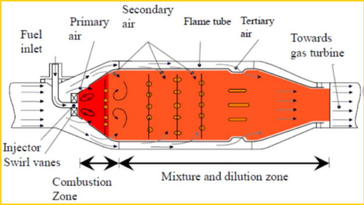

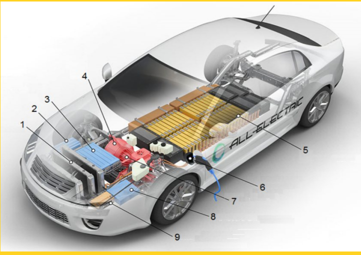

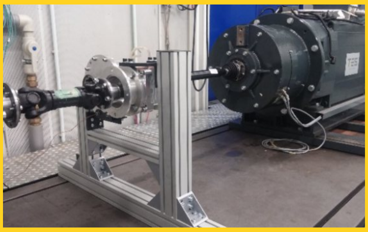

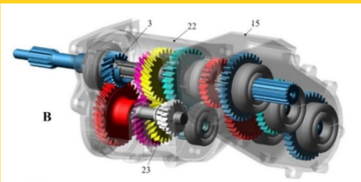

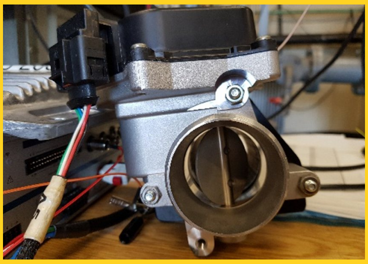

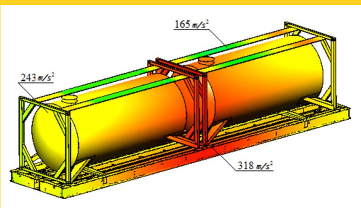

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ФАКУЛТЕТ ПО ТРАНСПОРТА

НАУЧНА КОНФЕРЕНЦИЯ
С МЕЖДУНАРОДНО УЧАСТИЕ
по авиационна, автомобилна и железопътна техника и технологии

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От секция: **Мениджмънт и логистика в транспорта**
From section: **Transport Management and Logistics**

System for automated management of the logistic process through control points

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Abstract. The paper is about a system for automation the processes for reporting the execution of incoming and outgoing requests in a production company. It is described the basic structure of the system and the principal logic of the processes through which it functions. The system allows to be automated the processes connected to organizing, reporting and controlling the logistic activities for supply, storing and transportation of raw and ready materials. The system management is done automatically in real time through constant monitoring of the location of the transport vehicles and network of control points situated throughout the factory. The system is intelligent and allows resetting when the conditions of the processes are changed. It is applicable for processes for supply and transportation of different in type, quantity and state raw and ready materials with different modes of transport in factories with variable and dynamic activities. The system allows data exchange with other systems and can be used in remote production facilities or subsidiaries.

1 Introduction

The System for automated management of the logistic process through a network of control points and real-time positional tracking of road vehicles in the zone of a logistics' enterprise yard comprises of three main interconnected subsystems: "Logistics – Road Transportation", "Logistics – Loading/Unloading Services and Warehousing" and "Personal Navigation Devices". The System can be integrated in enterprises which specialize in supply, manufacturing and expedition by rail or by road of production that could vary in type, physical state and quantity. The System functionally interconnects contemporary hardware and software technologies. It is suitable for application when uninterrupted automated control of the logistic process is necessary, and when the latter is organized according to the principal logic of movement of the means of transport shown in Fig. 1. The logistics process is organized in the following stages: entry of the truck (or freight car) into the enterprise; control measurement of the mass (tare or gross) of the vehicle by means of a car or a freight car scale; loading and unloading activities; control measurement of the mass (gross or tare) of the vehicle; leaving the enterprise. Each of those stages is simultaneously accompanied by preparing the corresponding documentation. The latter is not covered in this paper.

The main subsystems ("Logistics – Road Transportation", "Logistics – Loading/Unloading Services and Warehousing" and "Personal Navigation Devices") are designed to automate the processes of organizing, reporting and controlling logistics activities related to delivery, loading, unloading, storing and removing materials in and from the enterprise. The system is based on the use of information and communication technologies and is in line with the guidelines of the EU Directive 2010/40 [1] related to the development of Intelligent Transportation Systems. Process modelling and the description of system logic are based on the use of integrated information systems (ARIS - Architecture of Integrated Information Systems).

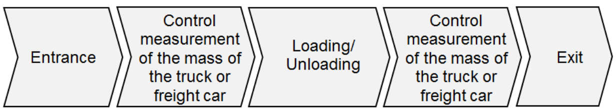

Fig. 1. Stages of movement of the truck or freight car.

Continuous control over the process is necessary in order to provide automated management of the logistics process. Monitoring the locations where inaccuracies are likely to occur is advisable for any logistical system in which processes related to the physical processing of products and/or goods are carried out. For logistic systems operating according to the principal logic of Fig. 1, inaccuracies are most commonly emerging on the executed request. Those may be inaccuracies related to the type of product being loaded or unloaded, its quantity or size, or the place where it is handled. They are most often caused by: inadvertent handling, related to the type and/or quantity of the order being executed; lack of up-to-date and systematic information on the state of stock

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availability and the free capacity of the warehouses in the enterprise; or errors made when manually entering data.

2 Logical consecution of the process

The operation of the system is based on the continuous automated control of the logistics process when executing requests in the yard of the enterprise. Any activity of supplying and/or repositioning products and/or goods inside the enterprise is regarded as a request. The control of the logistic process when processing a request is carried out in two main directions:

- monitoring the loading and unloading activities at the control points when supplying or repositioning raw materials, products and commodities by rail and or by road transport;
- continuous control of truck traffic in the enterprise from the entrance to the exit. The control covers the movement of trucks, supplying or transporting materials and/or products from the moment they enter the enterprise until they leave.

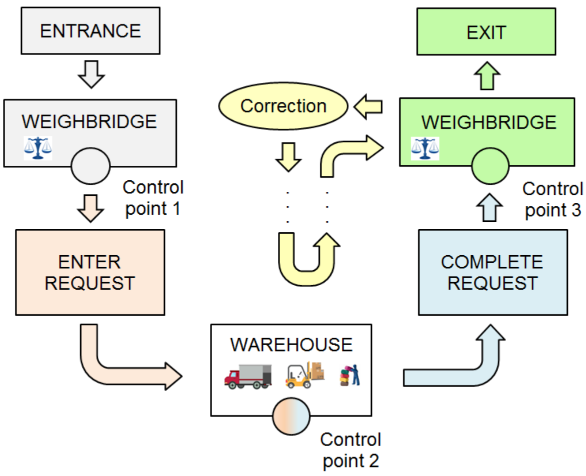

Fig. 2. Logical consecution of the process.

Control points (Fig. 2) are the places where physical handling or control of the cargo and/or vehicle is performed. Often, control points are places where there are prerequisites for inaccuracies in the processing of executed requests. In the automated management system of the logistics process control points are the areas for carrying out loading and unloading activities, the weighbridges for controlling the mass of the trucks or the freight cars, etc. The number of control points can vary depending on the type of requests and processes. A basic principle for the proposed system is that the physical handling of the load and the controlling are displayed in real time after request execution at each control point. The registration in the system is done by identifying the truck drivers and the operators of the loading and unloading machines (LUM) with their personal identification cards (PIC) and readers (validators) located at the control points, the entrance and exit of the enterprise. The LUMs are equipped with identification cards (ICs) through which they are been registered in the system at the control points.

The chain of events for automated management of the logistics process (Fig. 2) when executing orders with a truck is: when the truck arrives in the company to execute a request, the driver of the vehicle registers in the system and is assigned a truck driver's personal identification card (PIC) and a personal navigation device (PND). All data related to the respective request (type of cargo, quantity, cut, etc.), as well as truck and driver data are entered in the system. The truck driver's PIC serves to identify the request and the driver at the control points through which the truck has passed through. Through the PIC, a check is made on the execution of the order (type, quantity and cut of the load or product, place of execution of the order, loading/unloading machine, etc.) as well as a record of the activities carried out. The identification of the PIC and the registration of the activities performed is done by means of a reader. The system automatically analyses data about the availability of materials and the capacity of the loading and unloading machines and determines a location for the current request. The analysis is achieved through data exchange between the system and a database in which information about available quantities on products/cargoes, warehouses, spare capacity, pending execution orders, etc. is stored. The database may be external or internal to the system. The system generates a route for the truck in the enterprise (Fig. 3). The route of the truck and a sequence of required control points to pass through are visualized on the PND.

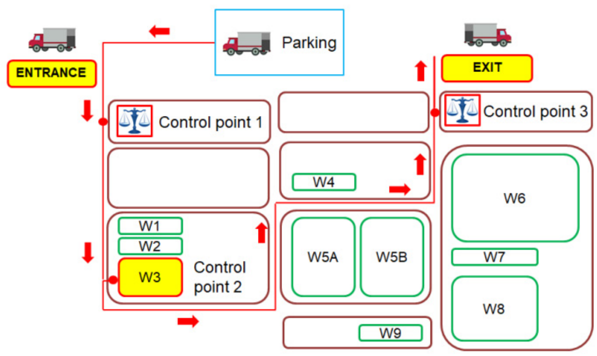

Fig. 3. Route of the truck.

The principal sequence of activities, the place of execution, the means used and the result from handling a request with a road vehicle are described in Table 1. The stages in their sequence (Table 1) are:

- *Truck entry, weighing:* After passing through the enterprise's entrance, the truck is directed to the vehicle scale (Control point 1 – Truck weighbridge) for weighing (tare or gross) and logging the data in the system. The identification of the truck and the registration in the system is performed by means of the truck driver's PIC and a reader located at control point 1;
- *Loading or unloading:* the truck is directed to the loading or unloading point (Control point 2 – Warehouse). At control point 2, the truck is identified by the truck driver's PIC, the LUM is identified by LUM's IC and the LUM operator is identified by his PIC. Identification in the system controls the execution of the request at the correct location of the respective LUM and registers that the LUM and the LUM operator are busy;

Table 1. The principal sequence of the activities (for trucks).

Location	Action	Mean	Result	
Process: Truck weighing				
Control point 1 (Truck weighbridge)	Registration of truck	PIC "Truck driver"	Registration	Entry of request
			Control	Insert of data in the system
Process: Loading/Unloading activities				
Location	**Action**	**Mean**	**Result**	
Control point 2 (Warehouse)	Registration of truck	PIC "Truck driver"	Control	Execution of request
				Place of execution
	Registration of LUM	IC "LUM"	Control	Execution of request
				Place of execution
			Registration	LUM is busy
	Registration of operator of LUM	PIC "Operator of LUM"	Registration	Operator of LUM is busy
Process: Registering a completed request				
Location	**Action**	**Mean**	**Result**	
Control point 2 (Warehouse)	Registration of truck	PIC "Truck driver"	Registration	Completed request
				Place of execution
	Registration of LUM	IC "LUM"	Registration	Completed request
				Place of execution
				LUM is released
	Registration of operator of LUM	PIC "Operator of LUM"	Registration	Operator of LUM is released
Process: Truck weighing				
Location	**Action**	**Mean**	**Result**	
Control point 3 (Truck weighbridge)	Registration of truck	PIC "Truck driver"	Registration	Completed request
			Control	Insert of data in the system or redirects the truck for reloading/unloading

• *Registering a completed request:* the registration is carried out at loading/unloading location (Control point 2 – Warehouse) by the PIC "Truck driver", the IC "LUM" and the PIC "Operator of LUM". The system registers that the current request is executed at the appropriate location and the LUM and the LUM operator are released from the current request;

• *Truck weighing:* the truck moves to a vehicle scale (Control point 3 – Truck weighbridge) where it is identified by the PIC "Truck driver". Control mass measurement of the truck (tare or gross) is carried out, the measurement data is compared to the collected data from the request so far. When a match is registered (loaded or unloaded quantity matches the requested value), the system finalizes the execution of the request, inputs real-time data into the system, and directs the truck to the enterprise's exit. The route to the exit is visualized on the driver's PND. Upon difference between measurement data and control data, the system determines a location and a LUM and redirects the truck for reloading or unloading. The corresponding route is visualized on the driver's PND. The system reports that the execution of the request is not completed and that the truck cannot leave the enterprise. After reloading or unloading to adjust the difference, the truck is redirected to a vehicle scale (Control point 3 – Truck weighbridge) for weighing. When the measurement data matches the control data, the system finalizes the execution of the request and directs the truck to the exit of the enterprise.

The above described sequence is similar when the process is carried out with freight cars. The difference consists in the fact that upon entry freight cars are not identified by a driver's PIC. The identification and registration of the freight car is carried out by a dispatcher. The sequence of activities for processing freight cars is shown in Table 2.

Table 2. The principal sequence of the activities (for freight cars).

Location	Action	Mean	Result	
Process: Freight car weighing				
Control point 1 (Freight car weighbridge)	Registration of freight car	By dispatcher	Registration	Entry of request
			Control	Insert of data in the system
Process: Loading/Unloading activities				
Location	**Action**	**Mean**	**Result**	
Control point 2 (Loading/ Unloading freight car ramp)	Registration of freight car	By dispatcher	Control	Execution of request
				Place of execution
	Registration of LUM	IC "LUM"	Control	Execution of request
				Place of execution
			Registration	LUM is busy
	Registration of operator of LUM	PIC "Operator of LUM"	Registration	Operator of LUM is busy
Process: Registering a completed request				
Location	**Action**	**Mean**	**Result**	
Control point 2 (Loading/ Unloading freight car ramp)	Registration of freight car	By dispatcher	Registration	Completed request
				Place of execution
	Registration of LUM	IC "LUM"	Registration	Completed request
				Place of execution
				LUM is released
	Registration of operator of LUM	PIC "Operator of LUM"	Registration	Operator of LUM is released
Process: Freight car weighing				
Location	**Action**	**Mean**	**Result**	
Control point 3 (Freight car weighbridge)	Registration of freight car	By dispatcher	Registration	Completed request
			Control	Insert of data in the system or redirects the freight car for reloading/unloading

3 Structure of the system and functional capabilities

Transportation and logistics systems are a multitude of interrelated elements and the relations between them, subject to a guiding principle defining the purpose of the system [2]. The structure of the system is an essential component that characterizes it. The structure of the system is defined as the set of elements and the relationships between them that are necessary and sufficient to achieve its objective [3]. The system analysis allows complex systems to be decomposed into subsystems viewed as elements of the higher-end system [4, 5]. Applying the principles of the system approach [5], we will look at the three main logistics systems: "Logistics – Road Transportation", "Logistics – Loading/ Unloading Services and Warehousing" and "Personal Navigation Devices", as functionally linked subsystems of the automated logistics management system in an enterprise through control points (Fig. 4). Besides the functional connectivity between the three subsystems, the system also allows connectivity with other systems used in the enterprise, such as: warehouse software; software for control of truck scales (or railroad scales); data base; systems for the control and/or management of production processes; security systems, safety and video surveillance, etc.

Each of the subsystems consists of different modes, ensuring its functional capabilities and the capabilities of the system as a whole. The main functionalities provided by the subsystems are listed in Table 3. The system is flexible and allows for re-tuning, with the specified basic functionalities being exemplary and subject to change and/or addition, according to the specific conditions and processes in the enterprise.

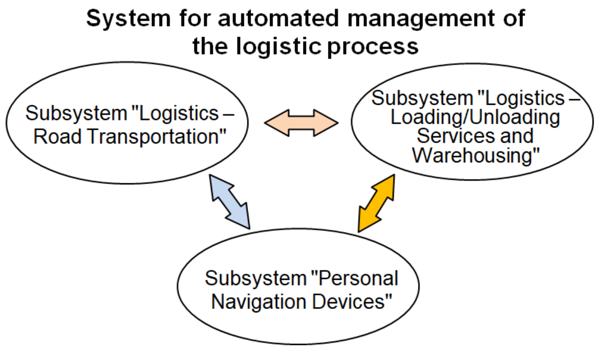

Fig. 4. Structure of the System.

Table 3. Main functionalities of the subsystems.

Subsystem	Functionality	Mode of transport
Logistics – Road Transportation	Route planning	Road
	Rerouting	
	Order of entry of the trucks into the enterprise	
	Data correction	
	Mass measurement of the truck	
	Truck drivers	
	Control	
	Administrative tools	
	References	
Logistics – Loading/ Unloading Services and Warehousing	Identifying the LUMs	Road and/or rail
	Operator identification of a LUM	
	Warehousing	
Personal Navigation Devices (PND)	Process of providing of the PND and subsequently returning of the mobile devices	Road

The operation of the automated logistics management system is provided by a basic software package and software modules for the three basic subsystems, as well as hardware elements and devices providing: real-time data transmission; memory for data storage; visualization and management of logistics processes in the enterprise; route visualization as well as vehicle and driver data; registering the location of a road vehicle in the enterprise; visualization of information for LUM operators; identification of truck and LUM operators; identification and registration of LUM at control points, etc.

3.1 Subsystem "Logistics – Road Transportation"

The subsystem "Logistics – Road Transportation" automates the following processes: route preparation of the trucks delivering and transporting raw materials and/or finished products to and from the enterprise; organizing and managing the order of entry of the trucks into the enterprise; tracking and controlling the vehicles when moving in the yard of the enterprise; rerouting.

"Route Planning" functionality allows manual (by dispatcher) or automated route planning for trucks in the enterprise. The system of roads, loading and unloading sites and warehouses where the loading and unloading activities are carried out is stored in a digital map of the enterprise. The digital map contains information about: the areas in the enterprise; the enumeration of entry and exit points, roads and junctions in the enterprise; separate traffic routes in line with existing or new restrictions; the enumeration of the warehouses; the location of the entrances to the warehouses and storage spaces, etc.

The subsystem "Logistics – Road Transportation" allows for uninterrupted real-time truck monitoring when in the enterprise. This is achieved through comparing the assigned route to the actual location of the vehicle. The truck's route is visualized on the PND in the driver's cab. The PND is based on the use of the satellite positioning and navigation system – GPS (Global Positioning System) [6, 7]. The system "Logistics – Road Transportation" checks for deviations from the intended route of the vehicle and/or stopping in unauthorized locations in the yard of the enterprise. If there is a deviation from the set route or a need for rerouting, the system indicates and defines a new route, according to the road network limitations in the company. In the event of unforeseen situations, the system can restrict the movement of trucks on selected routes in the enterprise. The truck's route is organized and visualized on the PND at stages from the entrances of the enterprise to the exit, indicating the sequence of pass-through the control points. With the developed algorithm and mathematical model, the system automatically evaluates the expected time of start of servicing requests and the order of entry of the trucks into the enterprise [8, 9]. With a notification via the PND, the driver is informed of the time of entry into the enterprise, the type and quantity of the request, the request's loading/unloading area, etc.

3.2 Subsystem "Logistics – Loading/Unloading Services and Warehousing"

The subsystem "Logistics – Loading/Unloading Services and Warehousing" automates the processes related to the work of LUMs which service requests. The subsystem is primarily intended for use in enterprises with mobile loading/unloading machines with cyclic action for handling single loads or unit loads of bulk cargo [10]. Modification allows the system to be used in factories with rail and non-rail cranes to handle single or compound bulk cargoes as well as bulk loaders with a load weight measurement system.

The subsystem is capable of: identifying the LUMs and their operators; displaying current request information on the screen in the LUM; validating the accuracy of the current request; registering loaded or unloaded quantities, thus measuring progress of request completion; verifying completion of a request at the checkpoint.

By means of the "Loading and unloading identification" functionality, the LUMs are recognized and checked when approaching and passing through control points. The functionality ensures timely control and automatic registration of a processed request at a control point.

Through the "Operator Identification of a Loading Machine" functionality, the LUM operator is recognized and is provided access to the request information, the means of transportation, the type and quantity of the cargo.

The "Warehousing" functionality provides access to up-to-date information about warehouses, availabilities per product or cargo, free space, loading/unloading areas status information, and more. The functionality allows for: creating, removing or changing virtual warehouses in the system; to enter and change the number of loading/unloading sites; to allocate LUMs to workplaces and warehouses.

According to the specificities of the loading and unloading activities and the servicing of railway transportation requests, the functioning of the system is ensured by the subsystem "Logistics – Loading/ Unloading Services and Warehousing".

3.3 Subsystem "Personal Navigation Devices"

The "Personal Navigation Devices" subsystem covers the process of providing drivers with and subsequently returning mobile devices which are to inform the drivers while executing a queries. PNDs are allocated to the drivers upon entry for execution of a query in the enterprise. After the correct execution of the request the PND is returned at the exit. The assignment and return of PNDs is verified in the system via an electronic protocol. The "Personal Navigation Devices" subsystem allows for organizing and managing the process of: registering the PNDs with a unique identification (ID) number in the automated logistics management system; assignment and activation of the PND upon entry in the enterprise; monitoring for repair necessity; cancelling a PND – when a PND's operating life has expired, it will be removed from the system; return of PND by the driver after execution of the request; reporting on the status and condition of a PND.

4 Conclusion

The proposed system allows for continuous automated control of the logistics process in the yard of enterprises serviced by road and/or rail transport, which need to weigh vehicles at the entrance and exit of the logistic chain.

The principles of design and operation of the automated logistics management system through a network of control points allow for: integration with paperless (e-Freight) logistics systems and development of Electronic Data Interchange (EDI) systems in transport; dynamic real-time traffic management of road vehicles in the yard of the enterprise; use of satellite navigation to direct the road vehicles in the yard of the enterprise; real-time control of logistics processes in the yard of the enterprise and limiting the possibilities for errors and abuses; enhancing safety and security in the yard of the enterprise.

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