Application of Information Technologies for Automation of Railway and Cargo Owner Interaction

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Abstract. The results of formalization of the components in the process of calculation of the time of delay in the movement of wagons are presented. The formalization was carried out in accordance with the principles of system analysis with the purpose of next modeling and automation of the technological process of cargo transportation during the delay by the fault of a cargo owner. It was proposed to apply a methodology of the conceptual-logical mapping and project modeling by constructing models of the process of interaction between modes of transport.

1. Introduction
The problems of optimization of the interaction of railway with ports, industrial enterprises, border transit points include complex problems, which exist at the level of planning, coordination, realization of transportation and calculation of the performed work [1-6]. Solving such problems is associated with the development and implementation of information technologies in the management of transport processes on the basis of theory and methodology of a conceptual-logical mapping and project modeling [7] by construction of models of the process of interaction between modes of transport.

2. Aim of the work
The formalization of separate components according to the principles of system analysis is necessary for the next automation and modeling of the technological process of transportation. A detailed consideration of the components in the cargo transportation process with the analysis of costs, associated with a delay, remains urgent [8] and necessary to minimize the costs when changing the working schedule of enterprises and the effect on service conditions of the transport network. In such circumstances, the optimization of shipment planning can be made using the decision on the basis of a system for determination of a cargo traffic delay location.

The problems of the relevance in construction of a transport management system are discussed by scientists in numerous papers from different positions and considerations, but the development of a system coordinating the interaction and optimizing the management of the transportation process still requires significant theoretical grounds. In particular, the problem of coordinating the work at the junctions of railways and sea transport is problematic.

Interaction of the railway transport with the sea transport begins with the choice of the rhythm of shipment of cargoes destined to the port and the emergence of ships in the forecasted region. The work of ports, border stations of Ukraine is featured by handling powerful flows of transit wagons and cargoes arriving from the loading areas, located over a long distance, which complicates the forecasting and planning the operation of transport complexes. This results in considerable losses of time for using rolling stock and infrastructure of railways, causes arrhythmias in the operation of all transportation chains.
3. Investigation results

The degree of manageability in the railway subsystem of transportation management depends on numerous factors, such as largely stochastic provision of orders on transportation; volumes of transit flows forecasted on the basis of statistical and marketing studies; decision making by the dispatching unit regarding “leaving” of trains during delays in handling of cargoes in the traffic junctions, etc. The prerequisites for a quantitative evaluation of the railway subsystem conditions have been created, but the management of transportation based on the construction and use of optimization models as well as the integration of railway with industrial transport based on databases belongs to the future.

Multifactority in optimization of the management of sea transportation implies the dependence of ports functioning on the market situation, forecasting of arrival and servicing of ships at berths, navigational, climatic and weather conditions, rationality of internal organization, rhythm of railway trains approach, existence of differences in tariffs for handling and transfer of cargoes in different ports and other factors. Quantitative evaluation of the condition of the subsystem of sea transportation is problematic in connection with the lack of a single database, as in each port the own automated system operates, which is unique as to its construction and software. Specialists in the organization of sea transportation note that the activity of ports depends on other modes of transport and general logistics and marketing systems. Therefore, the development of the activities of sea ports, in their opinion, is related, in addition to the development of technical means, to the problems of integration, to the principles of logistics and system analysis, transport and automated information systems [9, 10].

Thus, the problems of interaction of railways with ports, industrial enterprises, border transit points exist at the level of planning, coordination, transportation and calculation of the performed work [8] or determining of a "culprit" of the unfulfilled work. Theoretically, the ways for solving these problems with the help of quantitative methods have been developed precisely in detail [11], but in practice it is difficult to use these methods.

Modern information systems allow performing an accurate quantitative evaluation of the state of objects and subjects of management due to the ability of a quick access to information about them [12] and then proceed to simulation of the technological process of transportation. In order to do that, according to the principles of a system analysis, formalization of separate components of the technological process of transportation is required. To understand the degree of detailing at the stage of understanding the process of interaction, let us consider the components participating in the automated (objective and transparent for both parties) determination of the time of delay in the movement of trains, wagons and cargoes caused by the stops of enterprises, including seaports. The processing of information flows in the automated system is carried out in the complex of workplaces available in the railway and enterprises, operating in a single information space, presented in the diagram of figure 1.

Delaying of a cargo, a wagon, a train at the approaches to the destination station is predetermined by the interaction of circumstances, namely:
- stop of the enterprise and transfer of data about that to the railway,
- quick response by the dispatching unit to stop the train movement or form wagons in a train at a sorting station, i.e., quick-response ordet to the stop station,
- existing situation (availability of free tracks) at the stations of a probable train stop.

For the development of information provision to determine the time of start and end of delay in the movement of cargo flows, it is necessary to formalize the components of the operational process events. The time of delay start (t_{as}) is calculated automatically, simultaneously the time of realization of three operational events is compared:
- order to delay a train or a group of wagons, to; such wagons include wagons which are handled at the stop station and have a destination to the station serving the user of services, who stopped receiving of wagons from the railway;
- arrival of a train to the stop station, t_{a} ;
- time of start of the enterprise stop, t_{s}.

In practice, all three events are carried out at different times. The 6 variants of staying on the time axis t_{s}, t_{a}, to are possible (figure 2). The time of a train delay at the approaches begins from a higher value on the time axis.
**Figure 1.** Automated interaction of information complexes: 1 - notification about the stop of the enterprise; 2 - message to the destination station for the consignee about delaying of the train; 3 - drawing up an act GU-23a; 4 - calculation of payment for using of the wagon; 5 - correction of the plan of departure; 6 - correction of the loading plan in the departure stations.

The time of end in delay (t_{ads}) is calculated automatically, simultaneously the time for the following operations is compared:
- order to resume the movement of trains or a group of wagons t_{k} ;
- departure of a train from the stop station, t_{d} ;
- end of the enterprise stop, t_{p} .

In practice, all three events are carried out at a different time. The 6 variants of staying on the time axis t_{k}, t_{d}, t_{p} are possible (figure 3). The time of delay of a train at the approaches is finished at the moment of the lowest value (the first one on the axis).
A cargo owner and the railway bear the minimum costs for idle time of wagons in detained trains and wagons in the case shown in figure 4.

In order to reduce circumstances of uncertainty in planning of the next transportation to the destination station by a recipient, a Message about the delay of wagons is automatically made, indicating the events with a wagon, a group of wagons, a train:

- about the order to delay a train or a group of wagons, \( t_o \);
- about arrival of a train to the stop station, \( t_s \);
- about the start of the enterprise stop, \( t_w \).

Data contained in the message about the delay of wagons:

- time of transferring the order and its number;
- time of arrival at the station of delay of a train, a group of wagons, a wagon;
- code and name of the enterprise;
- data on the cargo front (if available under the terms of the agreement);
- time of stop of the enterprise or the cargo front;
- time of start (determined in an automated way) of acting of the act about the delay at the approaches f. GU-23a;
- time of transfer of this certificate;
- numbers of a train and wagons with determined (as agreed with the user) cargo data.

The further detailing of the message depends on the set of constituent terms of the Agreement and takes into account the components of the Unified Technological Process of Work of the Station and Access Tracks. If necessary, the message for the user of services is detailed, indicating: an access track, an enterprise, a cargo front, a cargo area, a cargo, track, an individual customer.

Respectively, a message to the destination station about the end of a wagon delay at the address of the user of services is made, indicating the events with a wagon, a group of wagons, a train, namely:

- order for departure of a train or a group of wagons, \( t_o \),
- departure of a train from the stop station, \( t_d \);
- resuming of the enterprise work, \( t_w \).
Automated determination of the delay time is carried out in the information environment of the railway with the help of a complex of workplaces, available at the stations and enterprises.

The information provision of the technological process of transportation is a prerequisite for the development of optimization models of the systems of interaction of railway with ports, border stations and industrial enterprises. In this respect, it is relevant to develop a system of decision making by the dispatching unit in the railway concerning places of "leaving" trains during delays in handling of goods in the transport junctions. Stopping of work of the enterprises is connected with the change in the modes of movement of cargo flows, their delay and, as a consequence, the change in the plans of departure. To minimize the costs when changing the working schedule of enterprises and the effect on service conditions of the transport network and optimize the planning of shipment in such circumstances is possible by using the system for decision making on the basis of a system for determination of a cargo traffic delay location.

The development of a complex multifactorial task of operational planning is appropriate to be implemented using the methodology of a conceptual-logical mapping and project simulation [7] by constructing models of the process of interaction between modes of transport.

![Diagram of information flows during planning of cargo shipment](image)

**Figure 5.** Scheme of information flows during planning of cargo shipment: $S_1, S_2, ..., S_n$ – systems of intersection and interaction of cargo traffic; $V_1, V_2, ..., V_k$ – cargo consigners; $O_1, O_2, ..., O_j$ – cargo consignees.

To construct the system for determination of the delay location (limitation in movement) of cargo flows ($S_{pl}$) let us use the tools for system analysis.

The systems for determination of the delay location (limitation in movement) of cargo flows are the components of the system of transportation planning. In general, let us present the system of transportation planning as follows:

$$S_{pl} = \langle V, O, C, R \rangle$$

where $V$ - is the set of objects of cargoes shipment, $\{V_i\} \in V$; $O$ - is the set of objects of destination and handling of goods, $\{O_j\} \in O$; $R$ - is the relation between the objects, $\{R_i\} \in R$; $C$ - is the set of objects of a cargo traffic delay, $\{C_m\} \in C$, which is the result of functioning of the system $S_{pl}$.

The further development of the task of decision making on "leaving" trains, wagons and operational change in the planning of shipment is advisable in the terms of the theory of sets, theory of possibilities for the ultimate creation of simulation model of the process of interaction of transport modes in the general transport information environment.

The Ministry of Transport and Communications of Ukraine started works on the development and implementation of the Program for improvement of the level of integrated information provision for the participants of the transport process. The program envisages the creation and development of a transport information system for optimization of logistics.
services market in Ukraine, further improvement of coordination of the work and interaction of all modes of transport on the basis of introduction of modern information technologies [13-14].

4. Conclusions
The need in optimization of costs for all the participants of transportation requires a complete formalization of constituents of the transport process in order to understand the complex interaction system for creating the system for supporting the decision making of persons in the future, who organize and manage the traffic.

Aggregation of factors, their mutual influence at the level of contacts of related modes of transport, presence of contradictory criteria in the subsystems predetermines the problem of optimization of interaction and management of transport and handling complexes. From the scientific point of view, this problem remains unsolved.

Proceeding from the abovementioned, the management of transport interaction as a single transport line requires scientific developments to solve a complex task: coordination of functioning of the transport complex and represents a scientific problem which is rational to be considered in compliance with the system approach in the methodology of conceptual-logical mapping and project modeling.

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