About Creation of the Intelligent Transportation Control System in Railway Transport

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***Abstract*—The relevance of the development of an intelligent system for managing the transportation process is determined. The structure of the system construction theory is given. The experience of developing automated systems on the Belarusian railway is described and the effectiveness of their implementation is evaluated. It has been established that the main condition for the interaction of automated systems with each other is the use of a single ontology of the transportation process. It is indicated that the OSTIS technology is an effective tool for describing the process-object ontology of the transportation process. The advantages and limitations of using OSTIS technology in ITCS are established.**

***Keywords*—Intelligent Transportation Control System, Ontology, process-object approach, transportation process, OSTIS technology**

Automation of individual tasks of managing the transportation process (TP) was one of the first areas of informatization of the railway transport activity. However, in modern conditions, the efficiency of previously developed automated systems (AS) has decreased due to significant fluctuations in the power and structure of traffic flows and changes in the technologies of the transportation process.Further development of existing AS has significant limitations: the exact mathematical model of the object may be too complex or unconstructible; changes in the external object environment lead to the action on the object of a number of perturbations, which are an additional source of uncertainty about the state of the object; performance requirements can be loosely formalized and inconsistent. It is proposed to overcome these shortcomings by moving from informationreference and settlement systems to intellectual ones.

BelSUT has developed a theory for building an Intelligent Transportation Control System (ITCS), the use of which in the development, implementation and operation will increase the adaptability of transportation process technologies to a changing operational environment, solve new operational problems, ensure coordination and continuity of control decisions, improve system manageability, which Together, it will ensure the efficient functioning of the railway in the face of changes in the volume and structure of traffic flows and optimize the operating costs for the organization of transportation activities [1],[2].

A graphical interpretation of the methodology for creating an ITCS is shown in “Fig. 1”.

The creation of the ITCS is aimed at:

- implementation of a coordinated integrated transportation process management system (TPMS) using by all participants in this activity a single digital model of the transportation process (DMTP), which describes the transport processes, covering the activities of all involved departments and all levels of management;
- improving the quality of information in the TPMS;
- formation of services for operational information and technological interaction of participants in the transportation process within the framework of a single long-term, medium-term, shift-daily and current planning, execution and control of agreed and approved plans;
- implementation of adaptive automatic control of technological processes for operational work and control over the execution of control decisions (CD);
- operational step-by-step and process assessment of CD.

The functioning of the ITCS is aimed at improving the efficiency of the TP by:

- increasing the speed of traffic flows;
- reducing the turnaround time of the wagon, including by reducing the time spent by the wagon in an empty state;
- reducing operating costs, including by increasings the productivity of locomotives in freight traffic, increasing the efficiency of using the car fleet;
- implementation of rational options for passing train flows in a changing operational environment;
- reducing the number of overtimes at technical stations during the turnover of a freight car and increasing the transit capacity of car traffic.

Currently, the following functional modules of the ITCS have been implemented or are being implemented at the Belarusian Railways. The AS ”Graphist” software package (“Fig. 2”) allows you to develop train schedules (DTS) [3], [4]. Currently, it is in commercial operation at the Transportation Control Center of the Belarusian Railways.

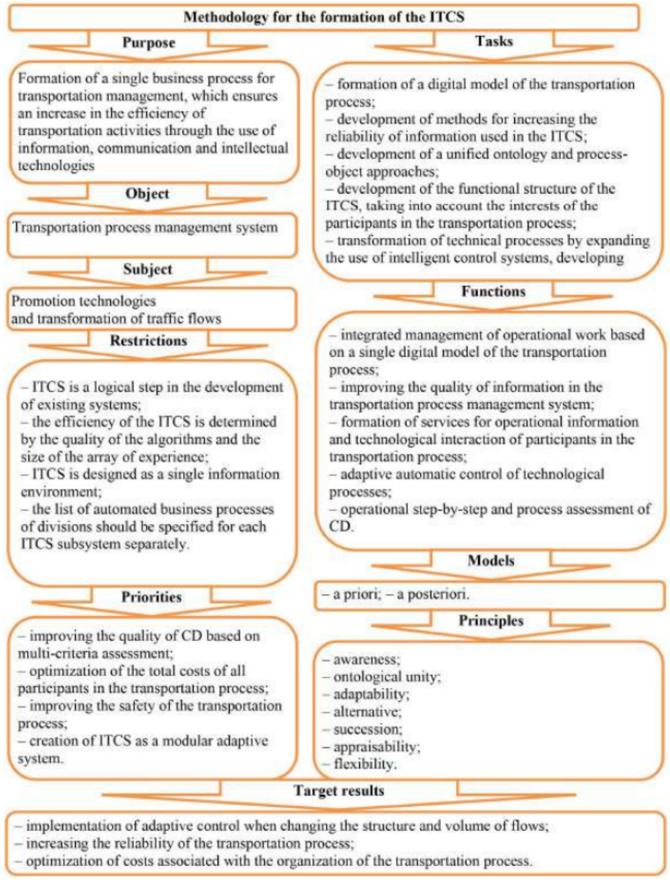

Figure 1. Graphical interpretation of the methodology for the formation of ITCS.

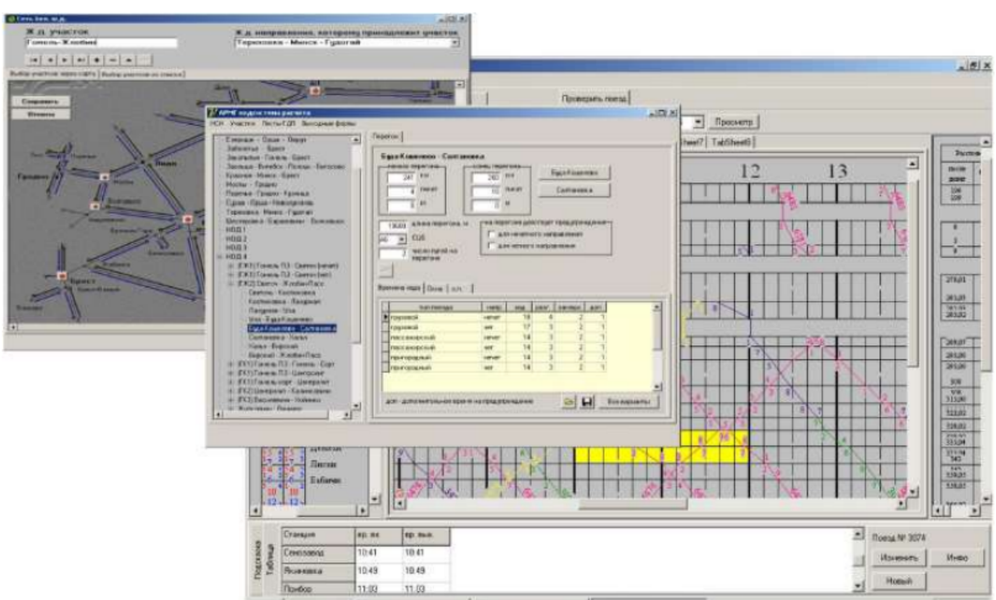

Figure 2. Modules for automatic construction of the DTS and its adjustment in AS "Graphist"

The intelligent algorithm for the development of the DTS is designed in such a way that, depending on the relative position of trains in the DTS and their categories, determine which of the station intervals should be used in each specific case. The calculation is made taking into account the mutual influence of the stations of the section. The solution of the problem is envisaged at the range of any length and configuration. Intellectualization of the functions of the development of the DTS allowed to reduce the workload of engineering personnel by 20- 30to increase the sectional speed by 7-11.5sections and reduce the specific energy costs for train traction by 3-6

An automated system for shift-daily scheduling of cargo work (AS SDS) has been developed and put into commercial operation, which for the first time in the world provides end-to-end scheduling of railway freight work for the entire polygon of the road, all levels of management (road, departmental, linear) and all planning periods [5].

The AS SDS ("Fig. 3") implements the functions of intelligently linking wagons to requests (taking into account their condition, location, expiration category, owner and other features), as well as other elements of intelligent technologies: forecasting the time of arrival of wagons at the station, adjusting planned indicators for the second shift depending on their implementation for the first; formation of plans taking into account the directive establishment of an increased task for loading, etc.

Based on the results of the operation of the AS SDS, it was found that by improving the accuracy of planning, the share of unscheduled loading decreased by 20-30For the first time, a system of number-wise planning of cargo work with high planning accuracy (91-94been implemented. The use of intelligent technologies in the planning system made it possible to increase the ratio of double operations by 8-12a local car at individual freight stations of the station by 6-9

An automated system for linking train formation with a train schedule (LTFDTS) has been developed and put into commercial operation ("Fig. 4") [6].

The main output decisions are: the schedule for the departure of freight trains from train stations for the forecast period; a plan for processing trains at train stations during the forecast period; dislocation of trains and wagons at train stations at the end of the forecast period. An intelligent solution of LTFDTS is also an abbreviated predictive DTS, in which, by means of multifactorial selection, all trains participating in train formation are linked to the threads of the predictive DTS.

Intellectualization of the train formation planning process at the Belarusian Railway range using LTFDTS made it possible to increase the efficiency of dispatching control by increasing the reliability and automating the development of a predictive train schedule with further use in the automated train traffic control system (autodispatcher). This made it possible to enlarge the ranges of train traffic control by 1.3-1.5 times and optimize costs; reduce the time spent by trains and locomotives at technical stations by reducing the waiting time of technological operations from 15 to 20 percent; to ensure the coordination of the predictive DTS with the train and locomotive model of the road, reducing non-production losses of locomotive crews up to 20 percent.

Various development companies participated in the creation of these and a number of other systems. One key condition for their creation was to ensure the exchange of CD between different systems of the ITCS. For these purposes, a unified ontology of the transportation process was formalized. The ontology of the transportation process presupposes the existence of unified ways of describing the system and the processes occurring in it. This task is inextricably linked with the formation of a digital model of the transportation process (DMTP). Actual mechanisms for the formation of the CMPP should allow for the realtime simulation of the state of the TP. This requires the unification of requirements for the content and form of presentation of information about the parameters of the functioning of objects [7]

DMTP may include:

1. models of objects (including resources) of the TPMS;
2. process models – a description of the processes occurring both in the TPMS and in the external object environment;
3. models of the external object environment, describing the external impact on the objects of the transportation process;
4. situation forecasting models – the study of options for the development of the transport situation in case of emergency changes in the state of the elements of the transport system, the external environment, with changes in the characteristics of information flows;
5. CD formation models that provide an analysis of the operational environment and the formation of effective CD;
6. assessment models that provide an assessment of the effectiveness of the implemented CD, the state of objects and the parameters of the software.

CMPP is focused on the implementation of dual control, i.e. adaptive control, in which not only the goals are achieved, but also the model is refined.

All DMTP objects are divided into the following subgroups:

- static objects (infrastructure objects);
- dynamic objects (tracking objects) ("Tab. I").