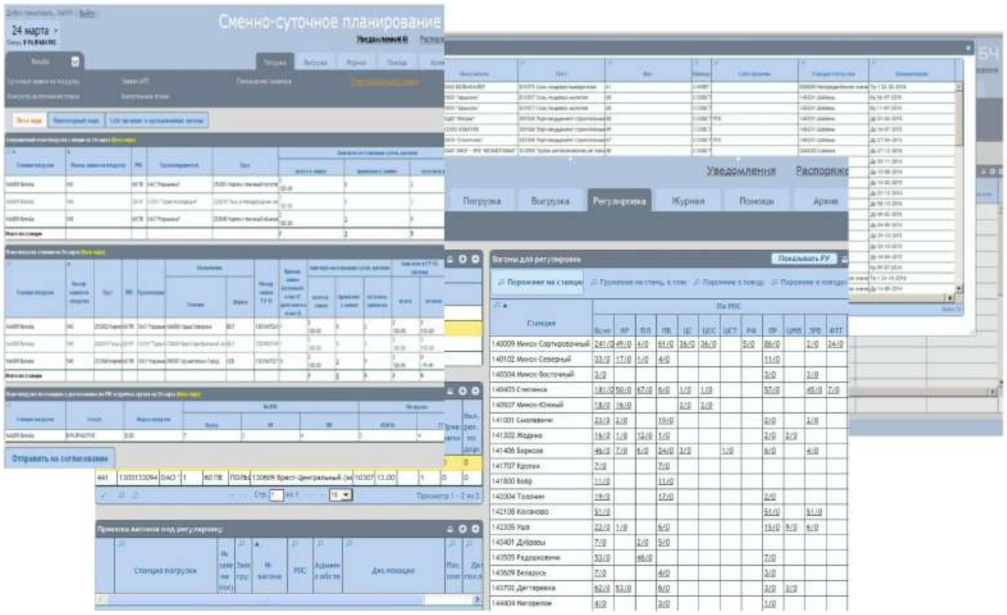

Figure 3. Modules for intelligent planning, linking applications to wagons and monitoring the implementation of plans in AS SDS.

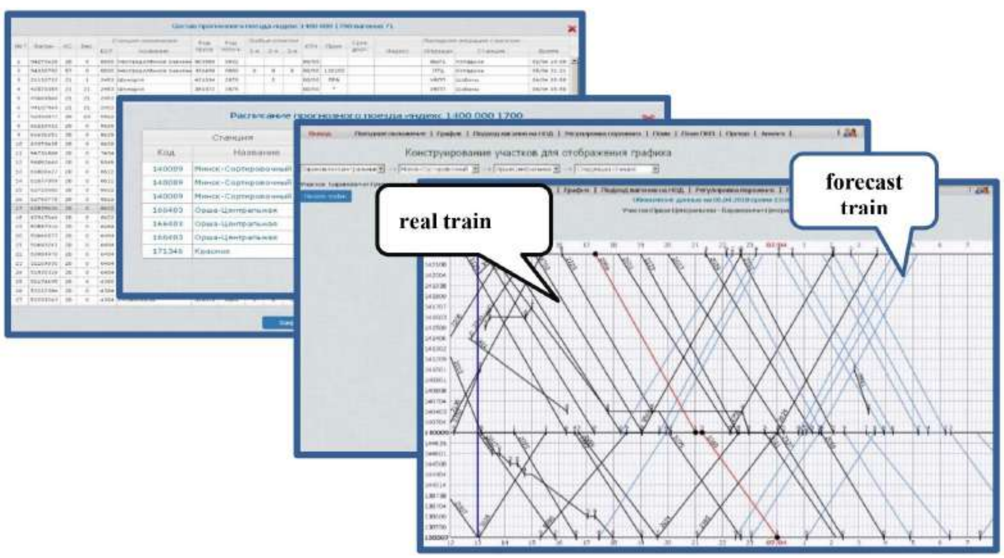

Figure 4. Modules of intelligent planning of composition formation and predictive DTS in LTFDTS.

Table I
DMTP FACILITIES

static objects (infrastructure objects)	dynamic objects (tracking objects)
Railway; – department; – railroad station; – interstate crossing point; – control area; – control room; – railway direction; – railway section; – haul; – block section; – depo.	– train; – railway carriage; – container; – sending; – locomotive; – brigade; – document.

Based on the digital transformation of the logical entities of infrastructure objects, an ontology of static objects is formed. Each logical entity consists of several connected objects, which in the database are divided into the following sub-schemes (groups of tables): railway, departments, railway stations, railway sections, depots and auxiliary tables. This subgroup of modeling objects also includes such logical entities of the TP as a train schedule, a train formation plan, a local cargo delivery scheme, etc.

The given subschemes consist of a number of separate interconnected tables with a description of elementary (topographic) objects. For example, the digital model of the "railway station" object includes the following elementary objects:

- paths;
- turnouts;
- traffic lights;
- passenger platforms;
- building;
- artificial constructions;
- subgrade, etc.

Based on the digital transformation of logical entities such as "train", "car", "container", "dispatch", "locomotive", "document", an ontology of dynamic TP objects is formed. Each logical entity consists of several logically connected objects. In accordance with this, the set of dynamic objects is logically divided into the following subschemes: trains, wagons, containers, shipments, locomotives, crews. When formalizing an ontology in the form of a database, the set of dynamic objects is supplemented by documents and auxiliary tables that describe the properties of each object.

Tables of descriptions of control objects are logically interconnected. Information about each tracking object is entered into the corresponding logical subcircuit, which consists of several levels. Each database table of the next level is a child of the table of the previous level.

Modeling of infrastructure objects and vehicles for solving operational problems of the ITCS is based on semantic and ontological links between these TP objects.

In the ontological scheme of TP, objects are interconnected within their group. The "station" object is an element (attribute) of higher-level objects – "department" and "railway section". In turn, the "railway section" is an element of the "department" object, and its attributes are determined based on the parameters of the station object. The topmost level in the group of static objects is the "railway".

The positioning parameters of dynamic objects (objects of tracking) are connected with each other and with elementary infrastructure objects. Depending on the stage of the SP, the parameters of the tracking objects are combined into one top-level tracking object, or vice versa, the top-level object is divided into lower-level objects. After the loading process, the "dispatch" object is included in the temporary group of the "wagon" object. The technological lifetime of this group ends after the unloading operation is completed. A similar procedure is performed when transforming the objects "car" and "locomotive" into the top-level object "train".

Traditionally, AS are focused on collecting, aggregating and presenting information to a person. A distinctive feature of the ISMS should be its focus on solving operational problems (problem orientation).

The object-oriented approach is based on the representation of each object of the software domain in the form of a classifier and its description by a set of properties – characteristics. To describe the relationship between objects, a special unit of data is used – a relation. Combinations of these elements form models of objects and situations. The classifier is a set of initial units of information (concepts of the selected subject area) systematized according to classification criteria and their groupings, representing generalized concepts. Creation of a model of objects of the required subject area of TP allows you to adapt the basic knowledge of the ITCS to solve the necessary ET.

The process-oriented approach is based on the formation of a model for the execution of technological operations of the software, aimed at achieving the ultimate goal of solving the operational and (or) completing the solution of the problem within the time limits established by the technology. A process is generally understood as "a set of interrelated and interacting activities that transforms inputs into outputs."

To describe the TPMS, a process-object ontology of TP is proposed as a symbiosis of ontological description, object-oriented and process-oriented approaches [1].

An effective tool for describing the process-object ontology of TP, in our opinion, is the OSTIS technology. This choice is due to the following important properties of the technology [8]–[10].

1) OSTIS technology is a technology of component (modular) and platform-independent design of semantically compatible intelligent systems that have knowledge bases of any complexity and implement parallel models of knowledge processing. This allows you to effectively integrate systems of various developers with each other and feel complex CD.
2) The knowledge base of an ostis-system, i.e., a system built using the OSTIS Technology, is a semantic network that generally has a complex hierarchical structure, in which there are elements denoting not only external entities and relationships between them, but also various classes elements of the semantic network, various fragments of this network, various connections between the indicated classes, between the indicated fragments. All this provides unlimited opportunities for the transition from knowledge to metaknowledge. This approach makes it possible to ensure the solution of new ET, including those based on the formation of CD under conditions of uncertainty in the initial data.
3) The basis of parallel models of knowledge processing in systems built using OSTIS Technology is the model of asynchronous knowledge management. The essence of this model is that all (!) knowledge processing processes performed by a certain set of agents are initiated by the corresponding situations or events that occur in the semantic memory during the processing of the knowledge base. At the same

time, any computer system, incl. and the one that does not solve intellectual problems can be built on the basis of the OSTIS Technology, i.e., in the form of an ostis-system. This property makes it possible to develop IS through the phased implementation of intelligent functions in automated systems.

However, the use of OSTIS Technology has significant limitations:

- a relatively small number of developers own this technology, and those companies that know this technology do not have the competence in building management systems in transport;
- the study of the OSTIS Technology is quite problematic, since a single description standard has not been approved.

The Republic of Belarus has the conditions to take the lead positions in the world in the development of intelligent control systems for railway transport:

- there is a team of scientists-experts who have been dealing with the issues of informatization of transport processes for decades. Most experts work at BelSUT or are its graduates;
- scientific schools in the field of artificial intelligence (BSUIR, BSU, etc.) are effectively functioning in a number of universities;
- there are many software development companies with a staff of highly qualified programmers, most of which are concentrated in the Hi-Tech Park.

In this regard, an important task is the formation of scientific and practical consortiums that have the necessary knowledge and competencies to build an ITCS using OSTIS technology.

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О создании интеллектуальной системы управления перевозками на железнодорожном транспорте

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Показана актуальность разработки интеллектуальной системы управления перевозочным процессом. Представлена структура теории построения систем. Описан опыт разработки автоматизированных систем на Белорусской железной дороге и оценена эффективность их внедрения. Установлено, что основным условием взаимодействия автоматизированных систем между собой является использование единой онтологии перевозочного процесса. Показано, что Технология OSTIS является эффективным инструментом описания процессно-объектной онтологии транспортного процесса. Установлены преимущества и ограничения использования Технологии OSTIS в ИТКС.

Received 13.03.2023