TRANSPORT AND LOGISTICS ENTERPRISE ARCHITECTURE MODEL

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ABSTRACT

The article argues that the fundamental transformations of business processes, characteristic of the era of digital economy, have so far affected Russian motor transport industry to a small extent. Digital transformation assumes a cardinal revision of the role of information technologies in management of the transportation process, based on a deep and comprehensive analysis of data, a fundamental change in approaches to organization of road transport production.

To this end, it is proposed to consider the concept of enterprise architecture, covering various aspects of shaping different aspects of a transport and logistics company, as well as methods for modeling system solutions. The article analyzes transportation management system solutions, compares different approaches to the architecture of an enterprise, tools of its development like ER-charts, basic notations, life cycle, business motivation model. The suggested model semantically links real objects, IT- and business processes, social aspects, and structure organisation of an enterprise.

Keywords: motor transport, enterprise architecture, freight transportation, business motivation model, TMS solutions.

Background. *The practices show that in modern Russian conditions domestic transport and logistics companies underestimate information technology as an asset, which is a source of increased profits and profitability. Often, even software and hardware (computers, servers), as well as related IT infrastructure and technical support are largely perceived by business leaders as just one of the items of forced costs. Obviously, for such directors and owners of companies, the means of production is a tractor with a semi-trailer, a truck, and the information system (IS) and computer hardware are considered auxiliary and not the most necessary attributes of an organization. Moreover, managerial traditions of enterprises of the road transport industry are such that it is manual or semi-automated work using Excel that seems much more rational from the point of view of production needs.*

Meanwhile, development of logistics principles and methods of organizing road transportation is more and more confidently demonstrating the positive impact of the innovation factor of business informatics to improve competitiveness and efficiency of transport structures.

Objective. *The objective of the authors is to suggest a model of a transport and logistics enterprise architecture.*

Methods. *The authors use general scientific and engineering methods, comparative analysis, graph construction, modeling, specific IT-methods, TMS tools, Zachman's architecture framework.*

Results.

Information carriers of TMS solutions

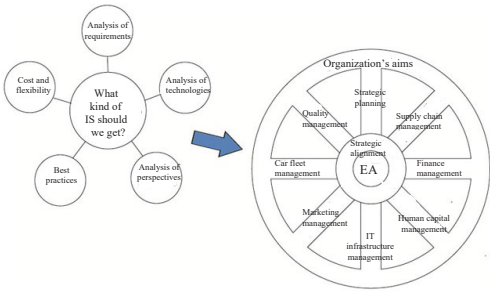
Trends that develop in the market competition, in one way or another (though more indirectly), but change the angle of view on transport and logistics problems, long-term goals and current objectives of relevant enterprises. At the same time, particular attention is paid to formation of an effective development strategy, marketing of transport services, more productive organization of human resources, improving the structure of car parks and optimizing planning, improving quality of the transportation process. Of course, such important components help to achieve a stable position of the logistics company in the market, as well as contribute to the growth of productivity and labour efficiency.

At the same time, it is known that for logistics, management of information flows is not less important than management of material and financial flows. Indeed, any movement of goods and cargo, their storage and processing are always accompanied by a certain document flow, which is part of the logistics business processes and is inseparable from them. All operational activity is recorded in relevant contracts, invoices, payment orders and other forms. Directly during operation of road transport within supply chains, a separate component of the general information flow is formed by waybills, route sheets, statements on fueling and installation of spare parts and other operational data. That is a long time ago that it became obvious that any business activity of a logistics company is accompanied by the processes of generation, transport, storage, and dissemination of information, which are an integral part of business process.

As a rule, and to a large extent this document circulation is perceived as a kind of routine office work, most of which is prescribed by Russian legislation in order to control the accounting and management records of organizations. On this basis, it is time to consider the information system from the standpoint of office automation based on achievements of the computer industry. For example, if earlier invoices, waybills or statements were generated in Excel or manually, then the task of IS is to prepare the same and other similar documents with greater speed and less laboriousness, while network capabilities will provide multi-user access to this information.

Information technologies to a certain extent will have a beneficial effect on effectiveness of the organization as a whole. For example, the time of acceptance and receipt of cargo, releasing cars on a route, and generating various reports will be reduced. Moreover, operational work can be performed by less qualified personnel and, which is quite likely, in a smaller number. This in turn is a prerequisite for reducing labour costs. In addition, the cumulative staff efficiency is growing due to emergence of a single information environment that provides for improved interaction between employees, eliminating duplication of information, increasing its availability and reliability. For managers, a single database makes it possible at any moment to receive a variety of analytics, selected and filtered according to their requirements.

Of course, all these factors are attractive in terms of improving technological business processes.



Pic. 1. Enterprise architecture as a means of integrating the transport and logistics business and information technology [2].

However, very often a person, who is to make a decision to invest funds in an information system, should answer a set of questions: «What will be the return on such investments? Do they contribute to achievement of business goals and what is their practical value? Will they give a competitive advantage? How does the implemented software innovation meet the needs of the enterprise?».

Certainly, such a strategic vision, the desire to link the company's development trajectory with the business impulse that modern information technologies are expected to impart, is absolutely natural for the executive. It should be noted that the very task of assessing and selecting the optimal TMS (Transportation Management System) solution is rather complicated and requires a comprehensive analysis of the enterprise's activities. Therefore, it seems expedient to use the architectural approach, which is designed with participation of information media to combine the operational, tactical and strategic aspects of management and the personalized nature of various business roles (logistic managers, car maintenance specialists, IT specialists, owners and managers of the company).

Wheel and wheel spokes

From the analysis of scientific sources it is known that development of the architecture of enterprises and organizations is of great importance due to complexity of modern IT infrastructure and the lack of flexibility in perception of its necessity on behalf of the business. Despite the fact that IT-industry experts have been engaged in research in that field for almost 15 years, the process of implementing architectural solutions in an industry or company is far from optimal. Moreover, the very concept of «enterprise architecture» (EA) still has several definitions and interpretations. For example, in IEEE Standard 1471–2000, the Enterprise Architecture is defined as «fundamental organization of a system, embodied in its components, their relationships to each other, and to the environment, and the principles guiding its design and evolution». There is also a concise definition of EA: «a complete set of description of the enterprise, valid for a long time» [1, p. 30].

For practitioners, the concept of enterprise architecture is causing considerable skepticism. A comprehensive and multifaceted study of the company's activities from different points of view, a description of the organizational structure, including numerous connections and interactions, remains a challenge and requires special approaches [1, pp. 22–34].

In general, the most simplified model of organization can be represented in the form of a wheel, the center of which or the hub represents the enterprise architecture, and the external rim is associated with the company's objectives. The eight spokes of this wheel – IT infrastructure management, strategic planning, financial management, production management, supply chain management, sales management, marketing management, human resources management [2] – ensure the interconnection of goals, business processes and enterprise resources, as well as ideas and approaches to how to optimize the company's activities. That is, it turns out that from a single center, symbolizing the organization's strategy, equal rays diverge, which characterize the equal value for the company of all of these areas, which implies a uniform forward movement of the company (Pic. 1).

From the point of view of completeness of the functionality, one of the most famous and popular models is the architecture framework of J. Zachman (Pic. 2), which is a matrix reflecting different views on the designed information system, as well as its layers and levels. This matrix has five (six) rows and six (five) columns, they are successively filled in during the analysis of the relevant data. The model reflects the opinion of specialists at various levels in the hierarchical structure of the enterprise, which can be divided into several categories: «planner», «process owner», «designer», «builder», «programmer», «user» [3].

Thus, the first row demonstrates the strategic vision of top management of the company's transport and logistics business. The second row reflects the way of viewing by business managers and process owners of the information system as of a complete solution. The third is the designer's view on the synthesis of the enterprise's business processes, their information model and technical as well as physical capabilities for automation. The fourth and fifth rows are the points of

	DATA What?	FUNCTIONAL How?	NETWORK Where?	PEOPLE Who?	TIME When?	MOTIVATION Why?
Planner	Business objects	Business processes	Location	Personnel	Production cycle	Business aims
Owner of processes						Business plan
Designer						
Builder						
Programmer		select id_car from car where id_car=134	IP 172.16.0.0 IP 172.16.1.0 IP 172.16.2.0			
User						

Pic. 2. The model of the enterprise architecture by J. Zachman, suggested in authors' interpretation [4, p. 386].

view of the system builder and programmer directly on the technical implementation of IS. The sixth row depicts the perspective of the already detailed solution from the position of the end user [4].

The content of the «data» column answers the question «what?», i.e. What information sets will the system include? Thus, the cell of the intersection with the first row may include information about the main business objects of the logistics company (vehicles, drivers, customers, facilities or routes). Then, at the second level, a conceptual model is designed, and at lower positions, further detailing of the elements of the information system takes into account existing data.

It is necessary to consider how business objects are reflected in the documents accompanying the activities of the enterprise, and how these business objects are interconnected. Most often, such a model is represented in the form of an ER-diagram (ER – Entity-Relationship). For example, the entity «car» with the attributes of «model», «car plate» is entered (the relationship «is entered») in the trip ticket (the entity is «trip ticket» with the attributes «departure date», «return date»).

In particular, at the second level, specification of vehicles (brand, model, capacity, body type, etc.), documents (trip tickets, route sheets, fueling lists, waybills), and of other inputs, are described, i.e. their semantic relationship is established. At the third level, in fact, basing on the business objects and documents that make up the information flow, a list of database tables and the relationship between them is formed. At the fourth level, the tables are normalized, keys are established, and at the fifth level, the fields are defined, the physical data model is drawn up. The sixth level forms the data directly (Pic. 3).

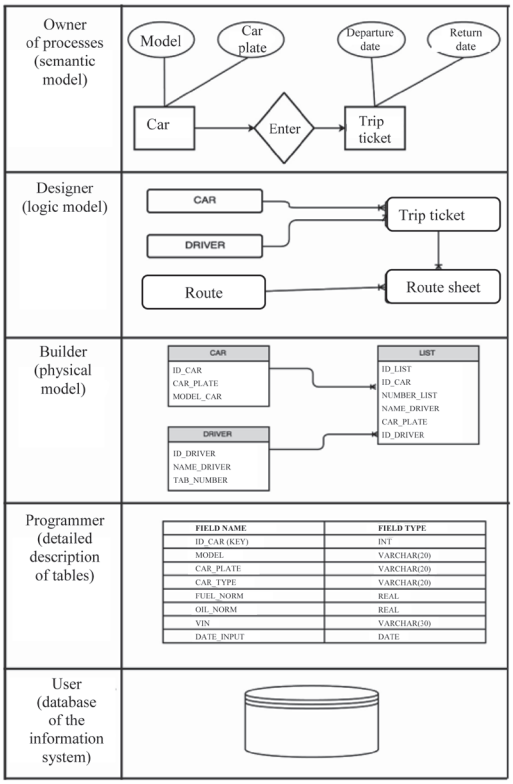
The content of the «function» column answers the question «how?», i.e. through what operations the company's strategic goals will be achieved. At each level, the degree of granularity corresponds to the point of view of a specialist in the management hierarchy. So, the first cell of this column contains a list of the main business processes that are in the field of view of the owner of the company («planner») and determine the strategic direction of the company. For example, transportation of dairy products by commercial vehicles of small capacity to retail outlets of nearby cities and towns.

At the second level of the column there is the company's business process model, the implementation of which can be performed in one or another notation, for example, UML or IDEF0. Moreover, the model in this cell reflects the point of view of «process owners», for example, the head of the planning and dispatching department, the chief mechanic, and may assume the following processes:

- *development of applications for transportation (under contracts, on schedule, upon request);*
- *preparing of trip tickets (on the basis of applications, on the basis of shift schedules, according to the schedule, manually);*
- *organization of procurement of spare parts;*
- *organization of repairs, maintenance, etc.*

The third-level cell of the column «how?» represents the detailing of business processes from the perspective of a «designer» and describes how actions are performed directly with the data in accordance with customer requirements.

Let's take the following example, when the sales department carries out preparation of invoices and waybills for supply of goods. As a result of operation, an electronic document is created (must be indicated



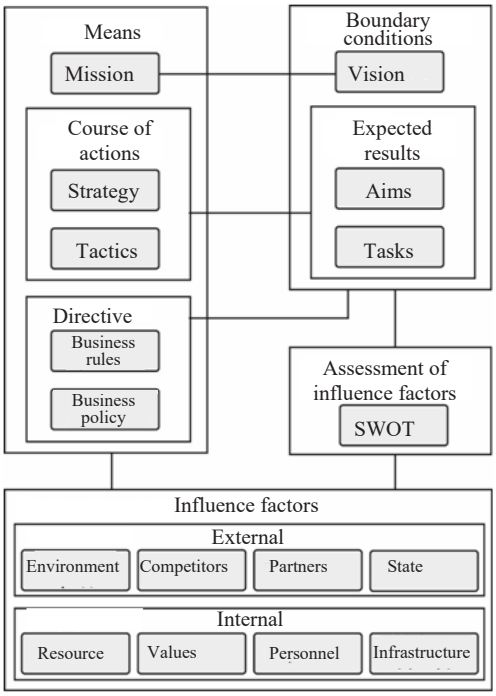
Pic. 3. The content of the «data» column answers the question «what?».

in the column «data»), in which the customer's name, his address, and the list of goods being shipped are present. On the basis of these documents applications for transportation are created, which can be combined into groups according to the zonal principle. For each group of aplications the dispatcher allocates a car and driver according to the schedule of work shifts, and also indicates the delivery time for each customer.

Further, detailed business processes are implemented in the form of program code, which belongs to the fourth level cell. At the fifth level, ready-made modules of the information system are located [5].

It is known that a real transport and logistics organization may have a distributed structure and have various channels of interaction with its divisions, subsidiaries and partners. In large industrial enterprises, often the transport department provides not only delivery of a final product to a consumer, but also moves various materials within the factory territory to support various technological processes. Accordingly, information flows that accompany movement of material resources circulate through the local network of the enterprise, as well as on the Internet, broadcasting electronic documents to a user. Thus, we can say that the scheme of this information network, in which data originates and moves, should be described in the column «where?». This issue becomes especially relevant when integrating several IS or services into a single information space.

At the topmost level of this column in the first cell location of various units or employees who perform certain functions should be described. For example, often the repair area may be located away from the main office or production site. Or the company has



Pic. 4. Model of business motivation.

branches in different cities, where distribution of vehicles on routes, accounting and maintenance of route documentation are carried out. Thus, in our TMS architecture model, location of centers of the origin or processing of information flows is recorded.

Then, at the second level, locations of production processes are clarified and territorially linked to information flows. In fact, we get a picture reflecting location of workplaces, indicating which business processes are running on them and what data should be processed. Basing on this information, the task is to equip workplaces with computers of appropriate computing power and connect them via wired or wireless channels into a single network. The topology of the computer network, including location of servers, routers, and others, is described in the third column level. The fourth cell, in turn, contains a detailed list of necessary configurations of computers and servers. At the fifth level, hardware is bound to IP addresses. As a result, the sixth cell receives a complete description of the single information space of the transport and logistics company.

Next, it is necessary to think over and describe the quantitative and qualitative personnel composition of both drivers, mechanics, and engineering and technical staff, as well as high-ranking managers. Accordingly, in the Zachman framework, the first cell in the column «who?» is used to fix the list of employees. It is clear that employees must be organized by departments and divisions. At the same time it is necessary for each employee to determine their business roles, labour duties, list of tasks and assignments that this person will have to solve and perform. Consequently, the organizational structure of the company, description of the sequence of actions of employees (Workflow), scenarios of their possible interaction within departments and between departments are displayed in the second cell of the column.

In the third cell, it is necessary to fix the level of powers and the degree of responsibility of assigned employees in performance of certain actions, and then develop a model of access and control rights with regard to certain tasks of the future information system. This is especially important when building a distributed architecture. For example, if there are branches or remote subdivisions, dispatchers in branches must «see» in TMS only the cars of their particular branches, while the central office dispatchers will see the cars of all branches. Moreover, dispatchers in the branches should not be able to introduce new cars into TMS or delete records and edit them. These rights may belong only to dispatchers in the central office.

Thus, in the framework of Zachman in the fourth cell, it is possible to describe the rights and privileges policy for each user. It is also necessary to provide monitoring of user actions in order to control possible errors or deliberate malicious manipulations with data. The policy of monitoring user actions is recorded in the fifth cell of the column «who?». As a result, the final sixth column contains the contours of a ready access control system that can monitor user activity.

Building a motivation model

Obviously, any entrepreneur starting a commercial activity, including in the field of cargo transportation, can develop on paper an excellent concept for his business. However, in real life in a competitive environment and constantly changing environmental conditions, the logistics services market is experiencing periods of ups and downs in demand for transportation. Over time, the demands and requirements of customers in various market segments are subject to inevitable changes. It is known that many private transport companies first started from the moment when a driver decided to buy his own truck (lorry or truck) and start working «for himself». And further, under favorable circumstances, one of these private workers, «finds his feet», acquires not one, but several cars, and develops his business in a new format. That is, any firm is very much like a living organism, which is going through various stages of its development – birth, adolescence, rapid growth, stability phase and, possibly, decline.

In turn, each vehicle also passes certain periods of its operation. So, at the initial stage, the car does not require repair, and the costs are only expenses for fuel. Then, depending on mileage and working conditions, periodic maintenance is carried out, the costs of current repairs begin to grow gradually. Accordingly, at the peak of demand for transport services, cars must be in good condition, and we must reckon with the fact that most cargo transportation follows certain schedules, and all this requires looking for a reasonable balance between commissioning and decommissioning of vehicles, frequency of their maintenance and repairs, dynamics of demand in the logistics market.

It is no coincidence that considering a logistics company as a complex system that passes through certain stages of development and depends on dynamically changing external conditions, the technical condition of rolling stock, within the Zachman model, the answer is to the question «when?» And the stages of the enterprise life cycle are determined [6, p. 60]. In general, the main stages of the life cycle are as follows:

• development of transport services, including shaping of the idea to start freight transportation business, analysis of strengths, weaknesses, threats and opportunities in the market;

• *entry into the cargo transportation market, the start of transport activities;*

• *growth, development of the company;*

• *company maturity;*

• *decline of a company or a change of type of activity (against the wishes of any business owner who, for obvious reasons, would not like to bring his brainchild to decline and closure).*

The stages of the life cycle consist of a sequence of various operations (marketing the transport services market, signing of contracts with customers, performing dispatching, logistics, repair and safety operations, etc.) with a specific time duration. In order to ensure the rational use of financial, material and human resources, managers seek to optimally distribute various work and logistics operations over time. For this, in the second cell of the column «when?» Zachman model includes the company's work plan in the form of, for example, a network diagram or Gantt charts. This is especially important if transportation planning should be synchronized with the production cycle of an industrial enterprise. At the same time, it is known that the transportation process is highly dependent on the optimal route planning, which will have to be dynamically adjusted during trips. In other words, the information system should have a routing and monitoring module for vehicles.

Obviously, the order of messaging between all participants in the logistics process is also needed, as well as fixing what events should occur after each message. Diagrams of UML sequences that are indicated on the fourth level of the model column are suitable for visualizing the pattern of such interaction. From the point of view of the TMS programmer, whose vision is fixed at the fifth level, one should have rules for performance of certain actions by users in the information system depending on the logistical operations scenarios presented at the previous stage. As a result, any operator receives a sequence of actions coordinated in time with all business processes in TMS, which also depends on the actions of other users of the information system and other participants or events of logistics activities.

The main task of a commercial enterprise is to make a profit, for which purpose, the management of the enterprise makes purposeful efforts. The justification of these efforts, their motivation is described in the sixth column of the Zachman model, which answers the question of why certain actions are taken [7, 8]. In general, the content of the response can be formed on the basis of the Business Motivation Model (Pic. 4), which defines the boundary conditions (goals and objectives to be achieved), the means (to ensure the boundary conditions), and the influence factors (both internal and external factors, affecting the enterprise). For example, if the management of a transport company aims to achieve leading positions in a particular region or city, then a local task could be to reduce delivery times by 20 % [9, p. 58; 10, p. 395]. To assess the external and internal factors of influence, as well as the company's position in the market, it is supposed to use a SWOT analysis.

Conclusion. *As can be seen, in the suggested model, real-world entities (vehicles, buildings, geographic location), information technologies, business processes, social factors related to the quality of management decisions and the entire work of the staff as a whole, and organizational structure of the enterprise are semanticallly linked. Considering the design of the transport organization, in the context of the concept of the enterprise architecture, the head of the company gets a clear picture of how his organization units interact, what information flows should circulate between them, how they can be interpreted and how to achieve success and promote sustainable corporate development.*

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