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PROBLEMS OF ANALYST COMPETENCY FORMATION FOR MODERN TRANSPORT SYSTEMS

Summary. Intelligent information and analytical basis of a modern transport system is a prerequisite for efficient functioning of the digital economy. Modern transport systems are based on new intelligent technologies and new organizational principles, which is why the functions and competences of specialists in transportation are changing very rapidly. This paper substantiates the need and reveals the content of new competencies of specialists for modern transport systems, which should be ready to take into account many different factors, process large amounts of information and solve multi-criteria tasks in transport companies for all management functions. Creation of digital analytical competency for transportation systems represents a new direction of the educational and training programs that must include courses in modern assessment and forecasting methods, big data operation, machine learning, neuron networks and other approaches in artificial intelligence area. This article describes a new approach to the teaching of transportation system analysts that is able to solve various types of tasks to implement Industry 4.0 elements in transportation as examples.

1. INTRODUCTION

Modern trends of economic development, dynamics and scale of ongoing technological changes are characterized as the Fourth Industrial Revolution by many experts [1]. As a result, now, a new technological paradigm is developing among all branches of economy, and the main goal of changing is crafting digital production [2]. Digitalization and digital transformation are objectively determined not only by the latest achievements in the field of science and technology but also by social changes: strengthening globalization, growing numbers and dramatic changes in the structure of population, urbanization and growing demands in terms of quality of life [3]. At the same time, development due to the exploitation of natural factors (hydrocarbon and mineral raw materials, soil fertility, ocean biological resources, etc.) has reached a critical limit. In response to these challenges, strategies oriented on developing Industry 4.0 technologies begin dominating around the world.

The core elements of Industry 4.0 are new information technologies: Virtual and Augmented Reality, Artificial Intelligent, Internet of Things, Cloud Technology, Big Data Analysis, Machine Learning, etc. As a result of their implementation, digital and physical objects and processes are integrated and cyber-physical systems are appearing in all industries and sectors of economy. For all management systems,

For all management systems, it is an absolutely new object, thus it is necessary to elaborate new approaches for operating and control – digital management systems based on Artificial Intelligent [4]. Mainly, there are many researches on changes as a result of digitalization and digital transformation of industrial production [5], but according to the authors' studies, the strongest influence of the new information technologies will be on the service sector: transportation, communication, utilities, retail, etc.

Service companies have to communicate very closely with their customers. In fact, a client is a part of the service process. The demands and needs of customers are very different and change very rapidly. To achieve customer satisfaction, service companies have to adapt quicker than their clients. As a rule, to maintain a high level of competitiveness, service companies are attempting to find and use new technological approaches that allow raising quality, reducing costs or adding new value of services for clients. In addition, they must be very flexible and adaptable. According to recent researches [6], the most successful service companies support their innovations by new information technologies that are very close to Industry 4.0: transport is aimed at developing unmanned vehicles, retail is moving toward internet sales, and communication is becoming smarter.

But it is necessary to notice that innovations in the service industry are different from those in real sectors of the economy. Service companies avoid developing new "hard" components of innovations by themselves – they implement new technics elaborated on and produced by others: machine-building, metallurgy, chemistry, etc. One of the best examples of this statement is transportation. Because of the long life-cycle of services, the main part of digital innovations aims to infrastructural equipment and constructions, so often transport innovation may be characterized as "infrastructural" ones.

Moreover, a new transport service as a product innovation means a new branch of transport. For example, now, many experts [7, 8, etc.] are discussing the prospect of UAM, Urban Air Mobility, as a new transport system (UAM). Adding the 3rd dimension to the movement of vehicles in cities might be an effective solution to improve heavy traffic [9]. Even if a traditional transport company starts developing the principles of UAM, it would involve more diversification into a new industry than an ordinary expansion of a product portfolio. This is why product innovations in service companies occur very rarely. Therefore, the focus of this paper is limited to process innovations in transport companies only, especially innovations based on intelligent information technologies or digital transformation of business.

According to the authors' research, most Russian transport companies base their digital transformation strategies on automatization of productive functions: unmanned operation, automatic control and self-regulating equipment, active monitoring of infrastructural objects and supporting processes, etc. For example, the Russian Railways built an automatic sorting station "Bely Rast," where all process of forming freight trains are succeeding without operators. Another example is car-sharing companies that are able to control the position and moving parameters of each their vehicle. But, as a rule, each innovation at transport companies is a separate project in a specific functional area without elaborating on a cross-functional corporate strategy. Sometimes, prospective solutions without support by other innovations at a transport company reduce the useful effects of their implementation. For example, a company plans to operate using high-speed vehicles, but without remodeling of road infrastructure, the efficiency of the company will decrease.

Often, when experts speak about digital technologies at transport and logistics companies, they mean unmanned vehicles, automatic warehouses and smart hubs, and other "hard" innovations. Although no doubt all of these solutions are very useful and effective, to achieve real positive results in one area, sometimes, it is necessary to develop a new solution touched other elements of production system. For example, to use double decker trains, a railway company has to rebuild tunnels and other engineering constructions. This is the reason why "hard" innovations are approved by transport companies not so often as at industrial plants.

On the other hand, "soft" solutions are interesting for transportation and logistics field if they are based on modern and effective equipment. Therefore, the development of a transport company must include innovations in both "soft" (planning, operation model, software, etc.) and "hard" (equipment, constructions, etc.) areas. To find a balance between "soft" and "hard" innovation, it is important to pay attention to many factors and their impact on each other. This is a sophisticated analytical task and, now,

there is a lack of specialists who can solve this. As a rule, engineers of transport companies ignore "soft" innovations or pay little attention to them.

The 4th Edition of Oslo Manual includes a special statement about "soft" innovations and their importance for modern companies [10]. The OECD experts added a description of the 5th type of innovations in a new edition of this document – "product and business process development", keeping in mind mainly a digital transformation process.

In the authors' opinion, the main focus of the management of a modern transport company should be on both "soft" and "infrastructure" innovations, which mainly relate to the management system of transport companies (organizing transportation and regulating infrastructure, making strategic and operational decisions, developing a smart communication system with clients, partners, interested parties and other external agents, etc.).

There is a new phenomenon at modern leading transport companies: competition at the transport service market (both among themselves and between different modes of transport) is being replaced by cooperation and partnership (for example, joint flights of different airlines, which are jointly and together responsible for the delivery of goods in a single supply chain, logistics companies, etc.). Also, multimodal and collective ownership and use of hubs are becoming more frequent in the field of transport and logistics. This is why the system of external management communications should become more open in transport companies. For crafting technological strategies, the external context and wider coverage of internal factors of the external industry environment become significant.

Thus, "product and business process development" as innovations of the 5th type [10] should take a central place in the technology development strategy of transport companies. This is a new type of innovation for transport companies, and to succeed in this area, it is necessary to have competent personnel with new analytical competencies.

2. NEW APPROACH TO CRAFTING A STRATEGY AT TRANSPORT COMPANIES

Because of the high cost of strategic mistakes in transport, it is very important to include a wide spectrum of internal and external factors in analytical tools and to combine them in the complex model. Classical analytical tools and models based on narrow methods of certain scientific areas use a limited number of parameters to justify a decision. For example, traditional economical and mathematical models (such as correlation, approximation, etc.) are useful for the analysis of general trends in stable conditions, but technological innovations or political decisions can generate mistakes in evaluations. For example, a railway company makes decisions on what kind of locomotives would be more effective: diesel or electric ones.

A decision could be made by the comparison of the direct costs of an operation:

$$C_i = (LH + E_i \times A\% + QH_i \times P_i) \times K_i \tag{1}$$

C_i – direct cost of an operation for the engine i; LH – hourly rate of the locomotive driver; E_i – full initial cost of the locomotive i; $A\%$ – amortization rate; QH_i – average energy consumption per 1 hour of operating the locomotive i; P_i – price of energy source for the engine i; and K_i – rate of performance and useful usage of the locomotive i.

It is clear that the result depend on prices of energy sources. However, a new – more effective – engine of a locomotive or some political disturbance could lead to changes in the prices. But now, there are only a few models including several heterogenic factors, but they consider only quantitative data. At the same time, qualitative models for forecasting have been developed recently. But often, they are used in specific functional areas and do not integrate in a common approach to decision-making.

In addition, because the modern economy might be characterized as a "knowledge economy' where new achievements in science and technology become one of the key factors of production, new knowledge as a significant quantitative factor must be included in the model of decision-making as a total factor of productivity (decreasing the direct cost of operation) and as an additional component of the full initial cost of the locomotive (increasing the direct cost of the operation). According to model (1), this factor acts linearly with relative constancy, but under conditions of changing technological

paradigm, the value of this factor is constantly and unpredictably changing and the probability of the mistake in decision-making is growing.

Because of high rates of technological changes, qualitative methods are optimal over a short prospective period. In particular, economic correlation models show quite high accuracy in retrospective calculations, but they are not always adequate at forecasting.

Because of high rates of technological changes, qualitative methods of decision-making are optimal over a short prospective period. Moreover, for service companies, quality of human capital might be characterized by differences. Such qualitative factors as the structure of human capital, competences, tacit and implicit knowledge, image and reputation and many others influence the business results stronger than small number of workers and hourly rates. Quantitative economic and mathematical models are useful for explaining causal relationships in the process of learning, but they do not work when making real business decisions. They are like physical models "absolutely elastic rigid body" or "ideal gas" that do not exist in nature.

Because existing economic and mathematical models work properly only in sustainable conditions, there is a strong demand for new specialists with advanced digital and analytic competencies in modern conditions of the 4th Industrial Revolution [11].

Because of the growing demand to detect or predict new market factors and trends of customer behavior, and to evaluate weak signals and implicit competitive forces in service sectors of the economy, it is necessary to elaborate new approaches to analysis and decision-making based on cross-functional methods and different (quantitative and qualitative, internal and external) factors. An example of this kind of decision is to build a new high-speed railway without forecasting the needs for transporting goods and passengers, analyzing the mobility and solvency of customers, and the prospects for alternative transportation and new technological opportunities. In addition, possible "strategic surprises" in the form of irrational political decisions, natural disasters and other unpredictable events should be considered. Additional complexity is added by the fact that the building or modernization of infrastructure facilities requires not only significant investments, but a long time to realize the project, that is, a decision must be made several years before the actual operation begins, when significant factors may either not manifest or act differently. Also, it is important to underline that the project of creation or modernization of transport infrastructure facilities attracts much resources. So, the price of mistake is raising.

Most traditional methods and models are decreasing their compliance with the requirements of unstable environment dynamics. According to the consulting experience of authors, transport companies feel the need to elaborate new approaches to make managerial decisions that would maximize the capabilities of artificial intelligence. There is a necessity to elaborate new approaches to decision-making that should provide a justification for the development strategies of transport systems and form the basis of operational models of business activity for the efficient and reliable transport of goods and passengers. This is a task that must be solved not only by a scientific methodology but also by education, which should transfer new knowledge and teach new specialists who would be able to apply modern analytical tools for transport companies.

3. TRENDS IN TRANSPORT AND CHANGES IN STAFF COMPETENCIES

One of the most significant changes because of the Industry 4.0 paradigm [12] is a new structure of human capital of transport companies: some competencies and work places are decreasing their business value or disappearing; in parallel, the demand for new competencies is forming and growing. As authors found during their researches, most new competencies were previously either unclaimed or implicit. For example, as a result of implementation of automatic control and diagnostic systems for monitoring railway tracks, on the one hand, a number of track workers are reducing, but on the other, it is increasing the need for specialists who would be able to provide an optimal support and repair plan path based on the prediction of its condition using data flow from the measuring equipment.

Other functional divisions of transport companies also face to changes of human resources. It is absolutely clear that the scope of work with the direct participation of workers and heavy manual

operations are reducing by automatization and use of robots, but at the same time new functions and operations are appearing and developing in the area of creation and configuration of technological solutions and operations. The more creative, intellectual and sophisticated the work activity, the faster the demand for such kind of competencies in the digital economy. This trend was predicted by P. Drucker, when he highlighted the fact that most management functions are routine and would be automated in future: "Because the purpose of business is to create a customer, the business enterprise has two – and only two – basic functions: marketing and innovation. Marketing and innovation produce results; all the rest are costs" [13].

This quote is applicable to almost all types of companies in all branches and sectors of the economy and this trend often also leads to changes in management activities. The Industry 4.0 is developing from trivial digitalization to sophisticated industrial systems where all managerial functions and production operations are combined with and integrated into each other as united complex [14]. Structural shifts occur not only as a result of redistributing tasks, responsibilities and productive operations between workers' and managers' workplaces but also as a consequence of changes in the functional composition in the company's management system. In addition, experts are increasingly talking about digital competencies as a cross-functional area, the value of which is constantly growing in companies [15].

Structural changes in competences occur so quickly that there is a gap between business requirements and the readiness of education and science to form and develop new knowledge and skills. For example, MSc programs in Russia have a duration of 2 years; as practice shows, during this period, significant changes occur not only in the field of IT decision-making tools but also in the organization of production and management. For service organizations, where customer contacts are one of the main industry attributes, the involvement of best business practices is becoming a key factor of competitiveness.

Industry 4.0 as a technological paradigm at transport companies means not only digitalization and digital transformation of traditional operations and function; these changes are associated with such new approaches to business as Multimodality, Uberization, Smart Transportation Operation Control and Management Systems based on Artificial Intelligence (AI).

Multimodality. According to the United Nations Convention on International Multimodal Transport of Goods [16], Multimodality "means the carriage of goods by at least two different modes of transport on the basis of a multimodal transport contract" from one place at which the goods are taken in charge by the multimodal transport operator to other place designated for delivery". Many experts underline many advantages for customers, but according to statistics, the interaction and partnership of various transport organizations in this area are not developing rapidly enough. This is why, for example, 2018 was named by European Commission as the Year of Multimodality [17]. Nevertheless, in the field of passenger transport, there are a number of successful examples of the development of multimodal transportation, primarily where different types of transport operate under control "from one center" (for example, urban transport systems operated by municipal governments and including buses, trolley buses, trams, subways and railways). Examples of multimodal freight traffic can be found in major transport and logistics holdings engaged in international transport with offices around the world. Multimodality requires the development of logistics up to 4PL and 5PL levels, as a rule provided by various types of transport belonging to the same holding structure. The idea of multimodality is not new, but its implementation becomes possible only with the development of the Industry 4.0 paradigm in various transport companies. Multimodal transportation requires not only a creation of docking stations (interchange systems for passengers or cargo hubs) but also a solution of complex analytical tasks on coordinating routes and schedules, optimizing flow topology, general monitoring and coordination of traffic. To support multimodality, not only is a smart operation system necessary but also special analytical tools for forecasting traffic volumes and for modeling transportation flows.

Uberization. Another actual trend of digitalization at transport business is the "uberization" phenomenon. This term was suggested as a common practice elaborated by urban taxi companies; the first time, it was UBER. Uberization means "providing on-demand services for as many needs as possible" [18]. Uberization might also be described as reducing and eliminating transit negotiators in supply chains: modern computer and mobile technologies based on AI allow simplification of contacts and communications between producers and customers. Uberization is a new approach of organization of transport systems based on a special multi-functional IT platform.

Being a new approach to organization of transportation, uberization is based on modern information and communication technologies, including mobile services, cloud storage, distributed computing, management and protection of high-loaded data processing systems, big data analysis, streaming data analysis, etc. To develop all of these technological components of uberization, it is necessary to elaborate and support virtual models describing the movement, goods or passengers flows and the operating parameters of vehicles in the relevant infrastructure and algorithms for an intelligent control system. These models, in turn, are being developed by specialists with new complex analytical competences in such fields as special chapters of Math, modern IT, Machine Learning and Logics (including Fuzzy Logics), applied to the tasks of transport logistics and the actual tasks of organizing the transport of passengers and goods.

Smart Transportation Operation Control. In general, Smart Transportation Operation Control is elaborated to realize operational functions for vehicles and infrastructure equipment; thus, there are two groups of solutions: technology for unmanned vehicles and smart traffic control technology for transport infrastructure. Both types of technologies belong to AI solutions, and they are developed on the basis of smart analytical models too. Such kinds of solutions might be named complex cyber-physical systems [19]. Internet of Things (IoT) technology takes the central place. This new technological solution integrates knowledge in such areas of Math as the topology of complex networks, and the identification and recognition of anomalies in the time number series (streams). To apply this approach, specialists at transport companies have to develop competence in information technologies: IoT, optimization, machine learning and predictive analytics, etc. Accordingly, transport companies have a growing need for new types of analysts who are able to formulate terms of reference and develop the concept of Smart Transportation Operation Control for transport systems.

Management Systems based on AI. A management system based on AI can become a key component of transport companies after digital transformation. The main function of this kind of a management system is to make strategic decisions that impact on the effectiveness of transport companies. The more the parameters included in a model for making strategic decisions, the more adequate and sharper the result will be. Therefore, the creation of management systems based on AI for transport companies must integrate all functional management tasks on a united platform. Unfortunately, now all of them are realized separately, with local and unrelated databases (ERP, HR-Analytics, etc.) at the most Russian transport companies. According to the consulting experience of the authors, in the process of making complex cross-functional decisions, specialists face to conflicting data and apply non-concordance criteria of performance; decisions made within one functional service contradict the decisions of another division, which inevitably leads to decreasing quality of the strategy and reduces the efficiency of the transport business.

Authors suggested dividing the tasks of transport management system based on AI into internal and external. Internal tasks aim at full or local automation of routine business processes (Financial Accounting, Human Resource Management, Planning, Procurement, etc.). Forming a united corporate platform helps to eliminate the contradictions of the local databases and reduce the decision-making time. The integration of local databases of a digital company generates possibilities for the development of new management models for automatization for making adequate managerial decisions. For example, at present, in Russia, to buy some infrastructure equipment at some transport companies, a business process is used that the following specialists are part of: engineers responsible for the track; procurement specialists; financial managers; and accountants. Because the number of specialists from the finance and commerce departments is much higher than from the technological departments in this business process, short-term economic interests prevail, and as a result, necessaire materials or services are acquired with a smaller quantity or bought ones with bad quality because of their low cost.

External tasks of the management system based on AI are to increase stability relations of and improve communications with stakeholders, including clients, investors and business partners. Common to service companies (including transport enterprises), the quality of performance of external management tasks becomes a key success factor because implementation of smart models of decision-making and automatization leads to the rapid responses to external requests, signals and growing adaptability and flexibility of business.

It is necessary to disseminate a unified decision-making methodology across all functional areas and integrate offline databases to create the possibility of sustaining successful management systems based on AI for transport companies. The simplest way to reach a common understanding of this task is to elaborate a common approach to teach transport analysts, who would be able to define the structure of tasks and describe new business processes on the base of new common solutions to the digital transformation of transport companies.

The new approaches (listed above) in the organization of cargo and passenger transportation and management of transport companies create a background for a new professional activity with special competencies. Therefore, it makes sense to describe both the composition of these competencies and approaches to their development.

4. TRANSPORT ANALYSISTS IN THE DIGITAL ECONOMY AND THEIR COMPETENCIES

The field of professional tasks of transport analysts has been described above. This description was based on studies of the practice of digital transformation of Russian and foreign companies and used as a basis for the development of the professional standard of transport analysis.

At present, in Russia, on the initiative of the Ministry of Labor and Social Protection, a system of professional standards is being created, which, in turn, is designed to determine the structure of human capital in the National Economy. The analysis of professional standards [20] shows that, as a rule, they capture the current practice of enterprises and ignore the structural changes that occur in the process of digital business transformation.

Therefore, the development of a new professional standard, which would describe business needs in the competencies of transport analysts, is incredibly important. The authors have prepared a draft of this professional standard and, in the near future, will begin the procedure toward its approval in the relevant government departments.

The emergence of the professional standard synchronized with a new demand for specialists is a new phenomenon in Russian companies. Despite the fact that a number of functional tasks and requirements for the competencies of new-type specialists in this standard were created mainly on the basis of the generalization of foreign experience and expert opinions of Russian specialists without a sufficient empirical base, it is a requiring approach in the conditions of high rates of scientific and technological development. This is the only way to overcome some technological lags in Russian transport (as one of the most important sectors of the National Economy) in the field of digital transformation.

According to professional experience of authors, to teach a qualified transport analyst it is required to develop four groups of competencies (fig. 1): ITC – Information Technologies and Communications, CSc – Computer Science, M – Math, and TT – Transport Technologies. On the one hand, Information Technologies is a core component of Industry 4.0. But, on the other, to elaborate any project, it is necessary to be ready to apply modern software and computer analytical tools and understand actual possibilities of modern IT including Cybersecurity and Cryptography. In process of digital transformation transport analysts at transport companies will face as real (physical) objects and process, as cyber models of them:

$$P \rightarrow D \rightarrow f(D) = D^o \rightarrow P^o , \qquad (2)$$

P – physical object or process before digitalization and digital transformation; D – digital model of physical object or process before digitalization and digital transformation; $f(D)=D^o$ – optimal digital model of physical object or process after digitalization and digital transformation (goal for physical object or process); and P^o – optimized physical object or process (a result of digitalization and digital transformation).

This is why the transport analyst should be able to understand transport technologies as an engineer and be ready for modeling and optimization using mathematical approaches and computer tools too.

The authors' suggestion is elaboration of new educational programs in universities training specialists for modern transport organizations operated by new organizational approaches. These might be MSc Programs that combine knowledge in such areas as Information Technologies, Computer

Science and Transport Technologies and prepare alumni for real practical activities in digital transport companies.
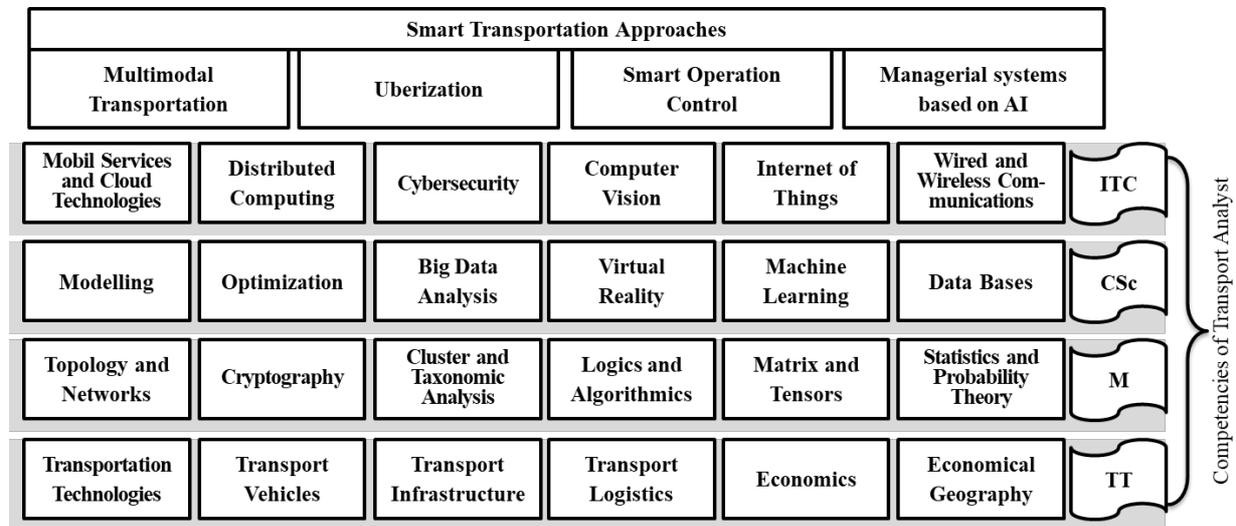
Smart Transportation Approaches			
Multimodal Transportation	Uberization	Smart Operation Control	Managerial systems based on AI

Mobil Services and Cloud Technologies	Distributed Computing	Cybersecurity	Computer Vision	Internet of Things	Wired and Wireless Com-munications	ITC
Modelling	Optimization	Big Data Analysis	Virtual Reality	Machine Learning	Data Bases	CSc
Topology and Networks	Cryptography	Cluster and Taxonomic Analysis	Logics and Algorithmics	Matrix and Tensors	Statistics and Probability Theory	M
Transportation Technologies	Transport Vehicles	Transport Infrastructure	Transport Logistics	Economics	Economical Geography	TT

Competencies of Transport Analyst

Fig. 1. Competencies of a transport analysist at a digital transport company (ITC – Information Technologies and Communications, CSc – Computer Science, M – Math, TT – Transport Technologies)

5. AUTHORS' EXPERIENCE IN CREATING TRANSPORT ANALYST COMPETENCIES FOR DIGITAL TRANSPORT SYSTEMS

It is well known that Information Technologies and Computer Science are significant updated currently approximately each two years. Many fundamental sciences are rapidly developing and changing, too. New technological achievements are made every day because of Industrial Revolution 4.0, which we can perceive. As a result, there is a dynamic generation change of transport machines and infrastructural equipment. Transport companies are increasing their demands for alumni of transport universities: because, in Russia, the duration of bachelor's degrees is no less than four years, and the duration of MSc programs is no less than two years, the knowledge gained by students becomes obsolete during both of these periods. In addition, it is very difficult to include rapid renovating knowledge in education programs, courses, and textbooks as new methods and models, new principles and approaches, and best practice and solutions. Thus, the traditional approach to university programs is not useful to satisfy the demand for new competencies for dramatically developing digital transformation of transport companies [21, 22].

In 2018, RUT (MIIT) received the status of a federal innovation educational platform of the Ministry of Education and Science of the Russian Federation for the project "Training System for the Operation of Integrated Ground-Based Transport Systems in the Conditions of Digital Transformation" initiated by the departments "Innovation Management in Transport" and "Electric Trains and Locomotives" at the Institute of Transport Engineering and Control Systems. As part of this project, methodological support is being developed for the work programs of the Transport Analytics profile within the framework of the Federal State Educational Standards on 27.04.05 – Innovatics, a master's degree.

As a federal innovation educational platform, the Russian University of Transport (previous MIIT) has created a new model of education. According to this model, during their studies, students take part in elaborating a new digital technology or solution for real transport companies. The Russian University of Transport has applied a modified model of "learning by doing" based on close and active collaboration with specialists and consulters of IT companies, academic and industrial scientific and research institutes, R&D centers, etc. (fig. 2). During all period of studying the work at one of the

university's Labs is due condition for all students who are training for digital transformation of transport companies.
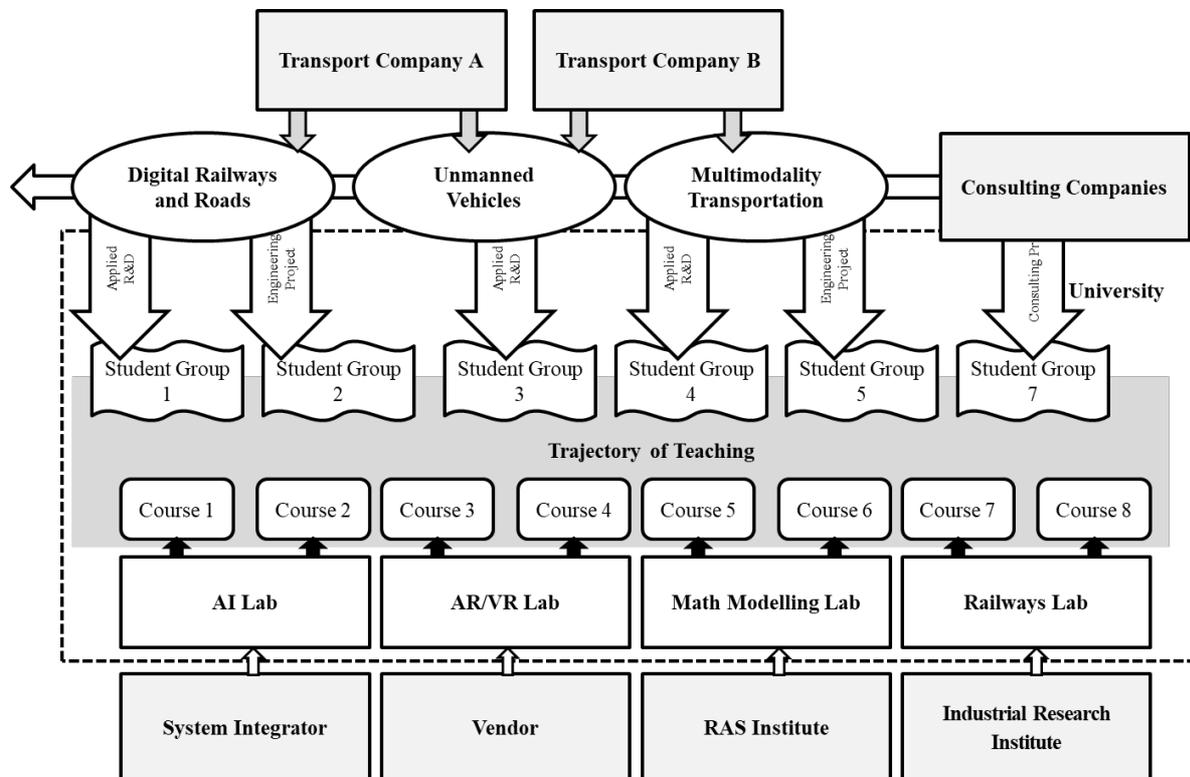

Fig. 2. New approach to creating competencies of a transport analyst (R&D – Research and Development AI – Artificial Intelligence, AR/VR – Augmented and Virtual Reality, RAS – Russian Academy of Science)

This new model of training specialists might be described as follows: a transport company with a general consultant initiates a project of its digital transformation, for example "Digital Railways" or "Digital Roads". The Russian University of Transport is a subcontractor of this project and an executer of some tasks. To find the best solution, the transport company invites different business companies, institutions and universities that compete with each other, and the company can choose the best solution for less money. It is very important for students and their teachers to compare their solutions with other executers and approve competencies in digital transformation. These real projects are realized in special laboratories at the Russian University of Transport, where students participate in both research and R&D projects of digital transformation. The described approach allows synchronizing processes of generation of new knowledge and forming actual competencies of future transport analysts.

As an initiative student project, the Russian University of Transport is elaborating a system for unmanned vehicles that would be able to reach a target without any external navigation system such as GPS or GLONASS – only by recognizing stationary ground objects and landscape. This is a sophisticated task that includes elements of Computer Vision, Math Modelling and Multi-criteria Optimization, Machine Learning. To find a solution, teachers and students from different departments unite in R&D groups, which are coordinated and synchronized by a group of transport analysists because of their cross-functional competencies and vision of the full process. The first results of this project were presented at some exhibitions and conferences where some potential investors and scientists participated. Now, this project has passed beyond the borders of the Russian University of Transport – it has become a multi-institutional project attracting several organizations from academic and industrial research institutes and centers, business organizations, consulters and universities.

In addition, the alumni of the Russian University of Transport as future transport analysts will provide information and analytical services for transport to increase the efficiency of the implementation

of the Transport Strategy of the Russian Federation for the period up to 2030, including a federal target program "Development of the Russian Transport System" (2010–2021). To develop a chapter about multimodality, it was necessary to create an economical and mathematical model of transport flows with elements of prediction. It is a typical task of Transport Analysis that involves mobilization of the different competencies described at the Fig. 1.

The Russian University of Transport initiated the MSc program focused on the formation of digital analytical competences in transportation, which is organically combined engineering knowledge and analytical methods, models and tools. The aim of the Program is to develop students' ability to identify technical, technological, organizational, economic and social problems in transport and logistics companies and solve them. Alumni of the Program are able to discover new opportunities for increasing their effectiveness of transport companies, and therefore the training is complex and cross-disciplinary. Based on the best traditions of high-quality engineering education, training of business analysts and economists, the program accumulates rich experience and empirical base (including a database of statistics of various types of transport).

The described Master's degree program was developed with the participation of the Association of Manufacturers of Railway Machinery, Russian Railways OJSC, Aeroflot PJSC and other employers, and is fundamentally new in the domestic system of higher education. This program provides for integration into the educational process of technological disciplines that are traditional for the training of engineers, as well as disciplines that form the basis of organizational and economic design and modeling. In addition, training includes an in-depth study of information technology and specialized tools that allow one to create and develop digital models of transport and logistics systems.

6. CONCLUSION

One of the main problems decreasing the dynamics of Industry 4.0 development is the lack of qualified specialists who would be able to elaborate and realize complex projects of digitalization and digital transformation. The analysis made by authors shows that it would be engineers with advanced digital competencies. There are four groups of competencies for such kinds of specialists described for transport companies (transport analysts' competencies): Information Technologies, Computer Science, Math and Transport Technologies.

High speed and scale of change in modern technologies impact traditional universities' educational programs. To prepare alumni with actual competencies, educational programs have to be flexible and adaptable. According to the authors' experience, there is the most fitted format for teaching on MSc program. The pilot MSc Program for Transport Analysts is a success at the Russian University of Transport. It would be useful to apply the new approach of teaching based on the "learning-by-doing" model: since their first days of learning students are involved in real R&D and consulting project realized for transport companies, and teachers from business took part in teaching process. This approach yields several advantages: for the university to gain actual knowledge about modern achievements, for alumni to have actual competencies and for transport companies to hire qualified transport analysts.

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