Main trends in digital transformation of passenger automobile transport

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Abstract. Digitalization has entered many areas of the economy and life. The transport industry has not become an exception and is actively moving into the era of digitalization. However, the use of modern technologies requires regulation and definition of common standards. Unmanned vehicles must comply with safety standards and be capable of functioning. The regulation must be synchronized with the appearance of drones. Digitalization is a complex of devices and software products that ensure the functioning of such vehicles. Software products (applications) entered the sphere of transportation by passenger taxis and buses, providing passengers with new mobility. Despite all the positive aspects of digitalization, it also brought some difficulties. Therefore, mutual deliberate and timely regulation of digital technologies in transport is required.

1. Introduction

The number of urban population in the world is currently increasing by about 75 million people annually. According to UN forecasts this growth will continue in the coming decades, although at an increasingly slow pace. The world urban population from 4 billion in 2015 will reach 6.5 billion in 2050 [1]. The symbolic threshold of 50% of the world population living in cities was passed in 2007 [2]. In all regions of the world, urbanization is expected to grow in the coming decades.

Almost 90% of the urban population growth occurs in Africa and Asia. In Asia, this is mainly due to rapid urbanization, especially in East and Southeast Asia. Between 2015 and 2050, China, India and Nigeria together are expected to account for about 37% of the world's urban population growth [1]. In the same period, the urban population of India will increase by 390 million, China by 270 million and Nigeria by 210 million [1]. Until recently, the largest urban areas were located in the more developed regions of Europe, Asia, and North America.

Today, the largest cities are concentrated in countries with transition and developing economies. Agglomerations with a population of 10 million are well known from various studies. The number is growing, today it is 28 against 10 in 1990. Megacities, however, account for only 12% of the world's urban population. About 50% of the world's urban population lives in small cities with population of less than 500,000 inhabitants. Although their proportion will gradually decrease, the role of these cities will remain significant. The fastest growing cities are those in Asia and Africa with population between 500,000 and 5 million people. Cities with less than 10 million inhabitants in countries with economies in transition or developing countries will account for almost 40% of the growth of the
global economy by 2025. This is more than the entire developed world and the markets of megacities together.

While urban sprawl has been observed in developed countries in the second half of the 20th century, there has been recent evidence that a reverse trend has begun (sometimes called «the great inversion»). For example, the density of the population in European megacities was increased by about 20% between 2001 and 2012.

In some cities, there is a concentration of population in the center. This phenomenon can be observed in Tokyo, where the population is growing faster within 10 km from the city center [3]. London has also seen steady growth in recent years. In North America, the real estate crisis has clearly accelerated the trend of moving back to city centers.

Sustainability and mobility limitations will be increasingly concentrated in cities, especially in lower-middle-income cities, where urbanization is the fastest. The International Transport Forum forecasts that from 2010 to 2050 the total world mileage of vehicles will increase from 117 to 233% [4].

Urban zones often extend beyond administrative and political boundaries, thus creating complex management challenges, especially in terms of mobility. In particular, the formation of polycentric configurations of megacities may lead to increased demand for space and equipment associated with the interaction of various sub-centers of agglomerations (Figure 1).

The world economy has moved into the phase of the fourth industrial revolution, which is based on digital revolution. Digitization has enormous potential for a revolutionary leap in various industries and activities. At the same time, it can become a destructive force for certain industries, and even for states in general. In the universal understanding of the trends of the further development of civilization, the mutual agreement and common understanding of the objectives of power, business and society, among different states, is crucial. A fundamental trend of digital development in business, government, and society is the policy of synchronization, integration of "all with all". Within this trend, the main and most significant challenge is the ever-increasing number, quality and diversity of interrelationships between the state, business, consumers and socio-economic systems.

Cybersecurity is already at the forefront of the agenda of global and inter-state relations. All of this is accompanied by a leapfrogging of data and transaction volumes.

Here are some predictions by well-known specialists of the patterns of global economic development as a result of its digitization [5]. By 2025, unmanned vehicles with a probability of 78.2% will account for 10% of the total number of US vehicles. With a probability of 67.2%, the number of commuting by vehicles will exceed the number of trips by private vehicles. With a probability of 63.7%, one can assume that the first city with a population of more than 50,000 without traffic lights will appear during this period.
As an example to justify explosive growth, table 1 lists the growth rates of companies before and during the digital revolution [5].

|                | Capitalization of the 3 largest companies | Revenue (Gains) | Staff         |
|----------------|------------------------------------------|-----------------|--------------|
| 1              | Detroit, 1990                            | Silicon Valley, 2014 |
| 2              | 36 billion $                             | 1.09 trillion $ |              |
| 3              | 3.250 billion $                          | 247 billion $   |              |
| 4              | 1.2 million people                       | 137,000 people  |              |

The automobile is increasingly becoming a computer, with the cost of electronics now almost 40% of its total value. Apple and Google are gradually targeting the automotive industry. In the future, when the share of electronics is larger than the rest, it may be more strategically profitable not to produce cars, but to develop and sell a license for software for cars.

Not all sectors of the economy currently experience the same destructive effects of digitization. But they will all be drawn into the process of continuous, hard natural selection due to digitization. Everyone will have to operate in a mode of constant development.

Digital technologies have led to new ways of combining goods and services that have disrupted the order and erased traditional boundaries between industries. Amazon has evolved from a traditional bookstore into a retail conglomerate with an annual return of $100 billion. This is the result of understanding customer preferences and timely execution of customer orders.

2. Vehicles

Automated vehicles moving in unmanned mode have been in place for quite some time. Technologies, element base, operating principles were different. With the development of electronics and new technologies, the very technological phenomenon of unmanned transport has reached a new level. The International Automotive Engineers Union SAE has developed a classification according to which drones are divided into five levels of autonomy [6].

Level 1 implies a level of automobile autonomy, where the driver needs to keep his hands on the steering wheel, but control makes electronic auxiliary systems easy [6].

Level 2 means that the vehicle can be maneuvered off-road without the involvement of the driver when the hands can be removed from the wheel. Many cars now "park independently".

All the companies of the large Euroscope are working on the development of Level 3 "Platooning" technologies, and MAN has already transferred such vehicles into regular test operation of one of the transport companies in Bavaria. You cannot reconfigure from stripe to stripe in automatic mode. The management should take over the driver. That is, the main condition of level 3 is that the driver should still be in the cab.

Driving without a driver by remote control, that is Level 4. It's targeting a kind of plunging technology that's connected to a truck leader with Wi-Fi. The vehicle is able to disperse, follow a straight or long-range curve and slow down to 12 km/h [6]. This has already been implemented in trucks.

In July 2018, logistics services operator DB Schenker, car manufacturer MAN Truck&Bus and the Fresenius University of Applied Sciences launched a joint project to transport goods on unmanned trucks [7]. The convoy is a system of vehicles on the road, at least two of which move along the highway in a caravan. They are equipped with driver support systems and automatic controls. All the trucks in the convoy are electronically "connected" by means of which they are connected. The leading truck sets the speed and direction, and the others follow.
A convoy of highway trains departed from the DB Schenker Neufarn near Munich for Nuremberg on the experimental section of the A9 motorway with a length of about 145 km. The first truck in this pair is driven by the driver, the second - by a computer. For safety in the cabin of the second truck there is still a person [7].

The use of self-propelled trucks in the transport of goods reduces fuel consumption and frees up space on motorways. The trucks are able to drive at a distance of 15 meters from each other instead of the 50 meters. This is the first case of the use of long-distance autotrains in a convoy in Germany, and it will set new standards in the logistics market [7].

There is no legal prohibition to use level 4 unmanned equipment in closed territories. In Norway, in the BronnoyKalk AS career, six Volvo FH freighters will transport the rock through a 5-kilometer route from the mine to the crushing complex [6].

The highest level of self-sufficiency Level 5 implies that the car has artificial intelligence. The unmanned truck should make its own decisions, analyze the situation. The first area of application of drones is military. It is the army's needs that have given impetus to the whole industry, the military sphere is in the vanguard of drone building. Volvo Construction has now launched its second generation of all-electric, unmanned Volvo VX1 dump trucks. But a fleet of a dozen of these trucks still needs to be monitored by a dispatcher. They are used in quarries with a high degree of gas and dust content. Another real application for unmanned trucks is warehousing and in-house logistics. Prototypes already exist, but in reality, it is not widely implemented [6].

Today's reality of unmanned trucks is a fourth level of autonomy and closed areas of industrial and mining industries, as well as the military sphere.

Currently, tractors under artificial intelligence control are being tested in California and Nevada (USA), and their serial production is planned for 2019 [8].

Mercedes-Benz company has developed a truck of the future Future Truck 2025. For unmanned control of trucks, Highway Pilot technology is used, which is responsible for automatic movement on the highway [8].

In 2016, Future Truck was tested: together with the European Caravan project, Mercedes delivered three unmanned trailer tractors to the road. The trucks driven by an autopilot drove more than 600 km from German Stuttgart to the Netherlands (Rotterdam) [8].

The column was 80 meters long. For comparison: in the case of conventional trucks with drivers, the length of the column is at least 150 meters. Fuel consumption during the experiment was reduced by 10% [8]. Trucks equipped with sensors and synchronized with each other via Wi-Fi, followed each other for a distance of 15-20 meters without any assistance of a driver.

Experts are confident that the technology of unmanned transport will be introduced more rapidly in the sphere of cargo transportation. Long and relatively straight routes are much easier in autonomous management, and light drones are much more difficult to operate in the urban cycle [8].

In February 2015, Cognitive Technologies and KAMAZ announced the start of joint work on the development of an unmanned truck. Cognitive Technologies started creating a brain for the car. In autumn 2015, the developers showed the first prototype of an unmanned truck [9]. In the Unmanned KAMAZ project, Cognitive Technologies used all the experience and achievements. The company's specialists taught the system of piloting to create a zone of interest - a narrow area of foveal vision that surrounds the observed object. In order to ensure safety from the point of view of reducing the number of accidents, the company involves external experts, creates a database of precedents, which allows learning from the mistakes of others. Many situations are processed by specialists at the virtual testing ground [10].

In PJSC KAMAZ in 2019, it is planned to launch an experimental route of intra-plant logistics transportation, in the framework of which the cabins from the press-frame to the automobile plant of the company will be transported on unmanned trucks [11].

This is just one of the unmanned projects that KAMAZ specialists are currently actively working on. It is assumed that serial production of unmanned KAMAZ trucks will begin by 2025 [12].

On May 21, 2019, the US Postal Service announced the use of unmanned trucks to deliver parcels and letters [13].

Volvo announced the commercial launch on 13 June 2019 of its first electric driverless trucks. The logistics giant DFDS started using them to transport goods between the distribution centre and the port in Sweden [14].
Electric truck from Einride has already started transportation on public roads. The T-Pod model can make short trips between the warehouse and the terminal in the industrial area in Jönköping, but at a speed of no more than 5 km/h (with a maximum of 85 km/h). The German Lidl supermarket chain, the Svenska Retursystem courier service and several Fortune500 retailers, in addition to the DBS Chenker logistics company, have already become interested in electric trucks. Even now, the t/Pod electric truck uses a platform from a third-party developer Nvidia to process information about the space surrounding the vehicle [15].

The research and development of unmanned vehicles continue to be actively worldwide. Large databases are being created that require government regulation. There is a need for unified hardware and software and for regulation to enable the movement of drones, including buses, on public roads.

A drone by itself will not create new mobility, but, together with technologies like "vehicle networks" and "smart road", this can be achieved. With smart networks, drones exchange different data among themselves, reporting and alerting each other about different road situations and fighting, allowing them to move at minimum intervals and at maximum speeds maintaining high levels of safety. Smart roads provide the vehicle's interaction with the road and the surrounding area. With this technology, it is possible to increase the throughput of roads by regrouping vehicles into a more efficient flow [16].

The transition to unmanned vehicles will lead to revolutionary changes and better transport management and environmental conservation. But there is a big transition problem. It is impossible to do so at the same time. New forms of mobility, such as drones, will overlap with traditional motorists on the roads. This could lead to controversial situations and the impossibility of applying all the technologies and possibilities built into the autonomous transport model. Resources and time will be required for the disposal refurbishment of the existing fleet of vehicles. It takes time for the production of unmanned vehicles to be mass-produced, and the government will need incentives from both automobile manufacturers and the public to switch to new modes of transport [17].

The substitution of the vehicle driver for automatic control systems (unmanned vehicles) radically-altering changes the transport economy toward important benefit for the service provider. Uber now estimates that between 60% and 80% of income covers driver’s costs. That is why many transport service providers are seeking to move to unmanned technologies. However, with the arrival of drones, a review of emerging risk standards and security assessment criteria will be considered [18].

Frost and Sullivan (California, Mountain View) and the RBK forecast that by 2025, unmanned vehicles will account for 40% of the global car market. The State should amend the legal framework, reducing the deterrent to the use of autonomous systems on public roads. Business structures, particularly taxi services, will facilitate the distribution of unmanned transport. PwS predicts complete drones will be available in the world's largest cities only by 2040, while the first drones will be available in 2021 [19].

According to the research unit of Swiss Investment Bank UBS: UBS Evidence Lab, by 2030, the global market for unmanned taxis and related industries could reach $2 trillion. The assessment is based on the modeling of autonomous transport development in New York. The authors of the report analyzed the road situation, population projections, demand for taxi services, development of public transport, and also used computer simulations of the movement of test unmanned taxis on different days of the week, segments of the day and in different areas [20].

UBS estimates that by 2030 the penetration rate of such vehicles in the global auto market will be about 5% of total sales of new cars [20]. Researchers estimate that by this time the UAV will reach 11 million cars, or 1% of the world's total fleet.

Experts believe that the development of unmanned taxis will radically optimize traffic and passenger traffic in major cities. The authors believe that the introduction of unmanned taxis will reduce by two-thirds the number of taxis now available in New York and significantly reduce the burden on the roads. According to computer simulation data, in a city like New York City, replacing the taxi fleet with unmanned vehicles will cover up to 15% of the demand for all public transport services [20]. Travel will be 80% cheaper by reducing the costs of paying drivers and managers, as well as reducing travel time by choosing the best route and mode of movement. For example, for Manhattan, it is estimated that a route that currently takes 40 minutes will take up to 15 minutes. UBS experts believe that the development of unmanned taxis stimulates the growth of related markets — most of the software, technologies, and components. According to Global Market Insights, the LiDAR
laser sensor market, which is actively used in autonomous transport, will grow to $10 billion by 2025 from its current volume of $1 billion.

The increase in the UAV fleet will lead to the development of the 3D-visualization market, microprocessors, new components from major automotive manufacturers, etc. The April Markets and Markets report notes that Europe's UAV market will be most advanced in Germany, France, Norway, and Holland. In these countries, the best way to develop infrastructure for drones is by now. In addition, they have great productive potential in the relevant industries. In total, there are about 180 automobile enterprises in the EU, with the EU automobile sector: One of the largest investors in research and development. Experts note that the development vector for unmanned taxis indicates that manufacturers will strive for more energy efficiency of cars [20]. By 2030, UBS estimates that unmanned taxis will account for up to 10% of global sales of electric vehicles.

“Markets and Markets” expect that by 2021, half of the robotics produced by Uber and Volvo will be electric. There is also a joint project between Daimler and Bosch to develop unmanned electric vehicles, which should reach public roads as early as the 2020s. A similar goal, but only in China, is a joint project between Volvo and Baidu [20].

In late April, at an event for investors, Ilon Mask reported that already in 2020, Tesla was launching a program to create unmanned electric taxis. Tesla's unmanned taxi service is expected to last for 11 years, with a total of 1.6 million kilometers [20].

The Zetta serial electric vehicle is prepared at the stage of the experimental-industrial production and certification procedure. The vehicle will be produced in several packages, totaling more than 10,000 units per year and distributed equally among the Russian and foreign markets [21].

In the Russian Federation, the first steps have already been taken to organize the work on the admission of passenger drones to the road network. According to the Russian Government Resolution, an experimental exploitation experiment is planned in Moscow and Tatarstan [22].

In late 2016, Yandex started work on unmanned vehicle management technology. The company tested the first prototypes of unmanned vehicles in spring 2017. There are already test zones in Skolkovo where you can take a taxi without a driver. In late 2018, Yandex received a license to test unmanned vehicles in Israel, and in January 2019 showed a drone at CES Nevada. In March, the company signed a Hyundai Mobis agreement to develop new prototypes of UAVs. Yandex plans to manufacture more than 100 drones in 2019 [23].

3. Taxomotor passenger transportation
American taxi aggregators Uber and Lyft have become leaders in the application of digital tools in passenger transport - they are vivid retailers.

Consumers needed a convenient, transparent, understandable and modern service that kept pace with the times. New Internet services responded and released the right product to customers. Are Uber and Lyft representatives of “new mobility”? Rather not, because their activities are very similar to those of classical taxis, but also to the use of digital technologies, both in interaction with the taxi application and in payment for it. This transparency with availability and has catalyzed the popularity of such applications [24].

People have been given an alternative to outdated, crowded, and late land transportation through new taxi services. However, this has resulted in an increase in the load on the already-filled road network and new traffic congestion [24].

It is clear from all this that online aggregators have created a dual product, on the one hand providing "new personal mobility", on the other hand having a serious impact on the road network and the city as a whole. All these aspects require attention from city authorities to ensure a compromise between convenience and consequences for cities [24].

There is another serious problem with the performance of aggregators: Often, Internet services violate drivers’ rights by lowering their salaries. These circumstances lead to the creation of protective structures for drivers defending their rights (in particular the hourly rate). The city adjusts the rent for the car that a park can charge drivers. Still, the distribution of income between drivers and landlords has not been fully resolved. For these reasons, trade unions and organizations are being established to protect and defend the interests of drivers [25]. The drivers of Uber and Lyft went on strike even before the IPO of these firms. Drivers demanded higher tariffs and lower internet service fees from 25% to 15%, as well as better working conditions (weekend pay and job security) [26]. The results of
such strikes and the work of the drivers' rights unions can already be seen, as on April 30, 2019, a New York Supreme Court judge, Andrea Masley, upheld the New York State Taxi Commission (TLC) rule on minimal payments to taxi drivers and rejected Lyft's protest against this rule [27].

Thanks to such events, drivers could count on a legal, decent hourly fee. In London, TFL in 2017 refused to renew Uber's license because it did not meet the security requirements required for private transport [28].

If operators are effectively and objectively controlled, a system can be established that: To solve transportation tasks in general and in certain areas, to plan transit between regions, to create zones required for the boarding and disembarkation of taxi passengers, to control compliance with the filling capacity of land transport [24].

4. Challenges and consequences of digitization of taxis

Providing regulatory and legal regulation of the new digital era of transport is a pressing issue at the current stage of industry development.

The problems of functioning in the modern taxi industry, based on the application of mobile applications, have become a laboratory for understanding what to expect in the future, when all passenger transport will affect digitization.

Should classic taxi rules be applied to "aggregators"? Should classic taxis and single-use vehicles be regulated to ensure fair conditions for all parties?

Unfortunately, up to now there is no clear understanding of the policy of regulating the activities of mobile application holders in transport.

Analysis of Bill No. 481004-7 of 28.03.2019 establishes the legal status of ordering services for light taxi aggregators. The task of these services is defined as "processing order information". The concept of "information processing", which does not contain anything concerning the formation of tariffs or the cost of carriage.

It is quite obvious that it is necessary to prohibit by the legislation of the Russian Federation "aggregators" of orders to make tariff regulations and to charge (offer) their tariffs on carriage of passengers. At present, taxi ordering aggregators are in fact implementing tariff regulation of transportation. The system of transport pricing shall be backwards: Taxpayers and individual entrepreneurs should send their tariffs on carriage to the aggregator(s) voluntarily. Aggregators are required to make available to potential charters the full "menu" on freight rates for all companies. The franchisor, i.e., the future passenger, when ordering the service for carriage, should have the right and possibility to choose from the general "menu" of the aggregator(s) an acceptable tariff. This will ensure real competition in the taxi industry, ultimately leading to improved transport safety and economic stability for freight operators.

The bill provides for notification procedures for the operation of the taxi service. In conditions where the "aggregator" is the main and the main "organizer" of transport. Obviously, it is necessary to introduce at the federal level the "Authorization" system of admission of services of order of passenger taxis (aggregators) to carrying out its activities. The authorities of the subjects of the Russian Federation should be empowered to establish requirements for taxi services and to organize their admission to carry out their activities.

New mobility systems should respond to the question of whether to encourage the carrier when the vehicle is full or not and when the limits are exceeded? The carpool system can help, but it requires incentives from regulators to allow passengers to travel on this system. Carpool transportation requires effective state control. To eliminate the operation of a dishonest carpool, you must introduce a limit on the cost of running. The driver shall not exceed the maximum permitted total cost of the journey, otherwise such carriage may include a taxi. There are questions concerning the safety and regulation of these transport operations, in the carpool system, as transportation is personal and is not currently regulated. Clearly, there is a need to create incentives and support for carsharing and carpool development, such as parking lots, allocated lanes, and incentives for the purchase of electric vehicles.

The introduction of new systems and tools, common travel services, and unmanned vehicles require the cooperation of many structures. It is necessary to create smart streets, infrastructure suitable for the movement of autopilots.

The digitization of the passenger transport system in any sector should be based on the unconditional observance of the following principles:
1. Unconditional compliance with the existing regulations on passenger transport at the federal and regional levels;
2. Inadmissibility of the introduction of digital technologies and mobile applications that conflict with established regulations and regulations on passenger transport;
3. Avoidance of the creation of technologies for the digitization of parallel state regulation of passenger transport systems, including with regard to tariff and cost regulation.
4. Correction, as necessary, of the existing legal regulation of passenger transport by the legislative authorities in order to quickly introduce digital opportunities, improve the quality and safety of transport services for the population of the country.

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