Socio-Economic Aspects of the Introduction of Self-Driving Vehicles in an Urban Environment

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Abstract. The article gives the definition of an autopilot vehicle (AV). The classification of autopilot vehicles is given according to the degree of automation of various functions of the driver and vehicle. The data of official statistics describing the socio-economic situation in the transport in the country and the Omsk region are considered. The factors that have become the main prerequisites for the creation of autopilot vehicles are identified. On the example of a large sociological study, the attitude of the population in the world and the Russian Federation to the possibility of implementing AV is revealed. This study allowed us to identify the main factors that determine and constrain the possibility of mass use of autopilot vehicles in the urban environment. The authors have developed a model that gives a visual representation of the causes of the problems that determine the process of developing intelligent transport systems and suggests ways to solve them. The socio-economic effects of the introduction and use of autopilot vehicles are identified.

1. Introduction
Modern business conditions are indissolubly linked with information and smart technologies. Scientific and technological progress does not stand still and penetrate in all spheres of public life, including transport. GPS and GLONASS systems have already become familiar to many business entities that use forestry vehicles. Therefore, smart technologies are entering a fundamentally new level, namely, self-driving (smart) vehicles.

2. Main part
The topic of self-driving vehicles is becoming increasingly relevant, it receives a lot of attention both in the media and in technical periodicals. And the more the possibility of using self-driving vehicles is discussed, not only in closed areas, but also in cities, the more questions arise: from technical support issues to economic and social problems.

Summarizing the available research in this area, you can define an self-driving vehicle as a set of technical, software and infrastructure elements [1-6, 13-14, 22]. They provide automatic motion control without human intervention. Some of these technologies are available now. Onboard computers that are installed on private cars, a lot of sensors that allow you to monitor the condition of the car, and of course automatic parking systems. In addition, successful tests on the formation of an
automatic convoy of freight vehicles united by means of communication and equipped with radars and cameras were carried out, for example, in Holland [1].

Currently, self-driving vehicles are grouped according to the applicable automated functions. They also represent a six-level classification, which also reflects the chain of gradual introduction and development of autopilot vehicles (Table 1).

Table 1. Classification of autopilot vehicles [3].

| Level | Driver’s function | Availability of automated systems* | Automated systems's functions |
|-------|-------------------|-----------------------------------|------------------------------|
| 0     | Full car driving  | Sensors, notification system      | Informing about fuel level, tire pressure and other standard features |
| 1     | Switching to manual control in case of system failures | Cruise control, automated parking system | Support setpoint speed, position on the road |
| 2     | Driver's timely reaction required in the event of a system failure | Navigation system, control of acceleration, movement, braking, maneuvering | Setpoint speed support, control of distance, braking and acceleration process, automatic parking, maneuvering in the stream |
| 3     | Partial driver participation on roads with unpredictable traffic The level is similar to the previous one, the driver is required attention and partial control of the systems | | Full car control with the ability to switch to the driver in areas with predictable movement (autobahns) |
| 4     | Start the system, specify the destination. | | Complete driving in a geographically limited area |
| 5     | | | Full Self-driving |

Thus, the unmanned vehicle has already taken place as a technological system and, with some success, is being tested by various companies involved in smart and information technologies, as well as by major automobile manufacturing concerns. Vivid examples: GATEway (Great Britain), Jeneral Motors, Tesla Motors, Google, Uber (USA), Volkswagen, Audi, BMW (Germany), Volvo (Sweden), Nissan (Japan), Baidu, Chery (China), among domestic – Cognitive Technologies, KAMAZ, Yandex, Starline.

The prerequisites for the introduction of such advanced technologies is the increase in the mobility of the population, the intensity and density of traffic flow due to the high concentration of vehicles. According to the statistics of the world car park, it has overstepped the mark of 1 billion units, but this volume is distributed very unevenly. The highest rate in the state of San Marino - 1263 units/per., per 1000 people, for comparison: USA – 837 units/per., New Zealand – 839 units., Australia – 747 units., Italy – 695 units., Russia – 373 units./1000 people (according to 2013-2018). The lowest rates are in the countries of the African continent - from 2 to 5 units. But even such a concentration with a low level of development of transport infrastructure can increase the likelihood of road accidents and vice versa, a highly developed transport system cannot eliminate the effect of an excessive number of cars on the stability of the situation on roads, including not only safety but also traffic density [7].

Such conditions require significant physical and psychological effort as well as concentration from the driver. That also increases the risk of probability of road accidents. Let's consider the official statistics in the country and the Omsk region that describing the socio-economic situation in the transport area (Table 2).
It should be noted a significant increase in the number of cars in the Russian Federation - 20%, but in the Omsk region, there is a slight decrease, which may be due to a decrease in per capita cash income over the last 3 years. In the first quarter of 2018, cars were sold by 21.8% more compared to the same period of the previous year. At the same time, in 2018 a loan was issued for the purchase of cars by 28.3% more than in 2017, exactly half of the cars were sold on credit. This development was also promoted by the development and extension of state programs of preferential loans for the purchase of Russian-made cars [11].

Also, according to the Central Bank of the Russian Federation, payments under compulsory insurance agreements for the liability of vehicle owners in 2018 have noticeably decreased by 38.1%, the largest share in their total volume is payments for damage to property (96.8%), while the size of payments for causing harm to life and health for the year increased by 20.4 and 44.5%, respectively. There is a decrease in the number of reported insurance claims by 18.5% in the first quarter of 2018 compared to the same period last year, to 616.5 thousand insurance claims, which is associated with a decrease in the number of accidents [11].

In the country as a whole, the number of road accidents with injuries was reduced by 2.44%, which may be due to the government's attention to ensuring safety on the roads, increasing the number of devices on the roads, fixing violations, etc. [12]. In the Omsk region, this figure was higher by 3.32% this may be explained by the still not very developed infrastructure and the quality of the road surface. Interesting statistics of road accidents, depending on the day of the week and time of day: the number of accidents significantly increases on Mondays and Wednesdays, and from 7 am to 2 pm, that is, during the rush hour. More accidents occur precisely because of drivers: cars - by 2.6%, taxis - 15.7%, buses - by 3.7%, and the number of accidents caused by drivers who operated licensed public transport — by 40 %. Thus, we can conclude about the exceptional influence of the human factor on road safety and the associated socio-economic indicators. With high intensity and density of traffic flow, driving a car is becoming an increasingly difficult task, which requires a person to receive the maximum degree of attention and psychological and physiological potential, leading eventually to an emergency situation.

**Table 2.** Statistics selection describing the transport situation [8-10].

| Indicator | Region          | Period |          |          |          |          |          |          | Averag e growth rate, % |
|-----------|-----------------|--------|----------|----------|----------|----------|----------|----------|------------------------|
| Number of cars | Russia, thousand units. | 2011 | 1286     | 1,8      | 4538     | 4,1      | 4813     | 1,6      | 5050     | 0,2      | 5135     | 5,4      | 5233     | 7,5      | 4688     | 7,1      | 47425,4     | 20,49    |
|           | Omsk region     | 2012 | 5519     | 03       | 5870     | 74       | 6261     | 32       | 6572     | 16       | 6616     | 67       | 6338     | 41       | 5443     | 41       | 529989    | -0,58    |
| The number of road accidents with victims, units. | Russia | 2013 | 1998     | 68       | 2035     | 97       | 2040     | 68       | 1997     | 38       | 1840     | 16       | 1736     | 94       | 1694     | 32       | 168099    | -2,44    |
|           | Omsk region     | 2014 | 938      | 3        | 377      | 027      | 990      | 3        | 342      | 2        | 3094     | 2        | 962      | 2        | 2996      | 3,32     |
| Average per capita cash income, rubles. | Russia | 2015 | 2078     | 0        | 2322     | 8,3      | 2592     | 7        | 2776     | 7        | 3046     | 7        | 3074     | 2        | 3142     | -        | -         | 8,42     |
|           | Omsk region     | 2016 | 1651     | 6        | 1802     | 3,7      | 2136     | 0        | 2406     | 9        | 2583     | 1        | 2524     | 3        | 2522     | -        | -         | 7,29     |
Road congestion, inadequate road infrastructure, limited human capacities to influence emergency conditions create motivation for creating and using effective means of protecting the driver and passengers, namely electronic and intelligent human-support systems, inside or outside the vehicle. These factors have become the main prerequisites for the creation of unmanned vehicles in the future, which imply the complete elimination of human participation in the process of driving.

If at present, control, for example, by a plane using autopilot systems, is neither surprising nor doubt, then the use of such capabilities of artificial intelligence on land transport, namely, automobile, raises many questions.

Since the introduction of such developments concerns primarily the person and the replacement of his functions when driving a car, the first question arises. Is humanity ready to entrust its life to the electronic system?

In the United States, a few years ago, experts conducted a survey among 1,500 respondents in 10 countries around the world and found that half of the respondents were ready to entrust their lives and health to automatic control systems [13]. Later, a similar survey was conducted in Russia with the participation of about 8,400 people, 43% of whom have a negative attitude to the use of autopilots, justifying their answer by saying that automation can fail and in uncontrolled difficult situations their response will be lower than that of a professional driver. Indeed, according to statistics, there are about 20 incidents with self-driving vehicles, some of which have suffered people, and this is not a massive, but also experimental use of such vehicles. Thus, in 2015, the first accident of a vehicle with Google’s autopilot was recorded, in which its employees suffered, and in 2016 there were cases of the death of the driver of the drone, the reason in all cases was the errors of the onboard computers. In addition, the respondents did not ignore the social factor: 24% also gave a negative answer, justifying it by the fact that there would be a massive dismissal of drivers and rising unemployment [14]. 21% of respondents gave a positive response, considering the introduction of autopilots to reduce the influence of the human factor, leading to serious traffic accidents, 12% of respondents found it difficult to give an answer. Of course, a large part of the population is still skeptical of this kind of development, but scientific and technical progress makes itself felt, and society should move forward with it, so respondents hope that manned driving will become safer comfortable and less stressful. Surveys conducted abroad by Bosch show quite interesting results (Table 3) [15].

As can be seen from the survey results, the respondents most often (65%) mentioned the parking process and finding a place for it (60%), which is not surprising when the urban infrastructure is not yet ready to accept the number of cars growing every year.

Also, the respondent was asked about the use of time, released as a result of movement using the autopilot. The majority of respondents in these countries (63%) would prefer to look out the window, in second place - online correspondence (61%), and 56% would like to communicate with passengers, so that potential or existing drivers would like to engage that in fact distracts them from driving and subsequently leads to emergency situations. In addition, to the question “In what circumstances would you switch to autopilot?” The majority of survey participants (67%) unanimously responded - during long trips, which is quite understandable by the driver’s physiological needs in rest and sleep, 60% - on the freeway, then under conditions of sufficiently predictable traffic and uniform traffic flow, 53% would like to absolve themselves of responsibility for driving in bad weather conditions, and 52% while driving around the city, which is also understandable from the point of view of tension movements especially at rush hours.
Table 3. The results of a sociological study on the relationship of the population to the AV, %

| Functions that you can get away from thanks to AV | Survey place | Germany | France | Japan | Brazil | USA | China | Cumulative average indicator for all countries |
|-------------------------------------------------|--------------|---------|--------|-------|--------|-----|-------|---------------------------------------------|
| Percentage of respondents who chose the indicator, % |              |         |        |       |        |     |       |                                             |
| - parking spot                                   |              |         |        |       |        |     |       |                                             |
|                                                  |              | 66      | 64     | 56    | 77     | 50  | 76    | 65                                          |
| - parking spot search                            |              |         |        |       |        |     |       |                                             |
|                                                  |              | 59      | 60     | 51    | 70     | 45  | 77    | 60                                          |
| - driving in conditions of congestion            |              |         |        |       |        |     |       |                                             |
|                                                  |              | 60      | 54     | 63    | 67     | 44  | 66    | 59                                          |

It should be particularly noted that more than half of the survey participants conducted by Bosch consider the presence of autopilot functions to be an important point and incentive to buy a car, especially such a result is typical of the interviewed men, and the younger the respondent, the higher vehicle.

Undoubtedly, young people are the target audience of the latest developments in the field of transport, and a survey conducted among the population of Omsk proves this. In the test, conducted with the participation of students of higher educational institutions of the city of Omsk using electronic testing, 300 people, grouped into four, approximately equal in number, age groups, took part (see Fig. 1).

![Respondents's age](image)

**Figure 1.** Structural characteristic of the group of respondents surveyed.

Respondents assessed the possibilities of using autopilot vehicles, and the results of the survey revealed not only the direct attitude of the population to the latest developments in the field of intelligent vehicle control systems, but also to identify factors constraining or limiting the use of unmanned vehicles in an urban environment, in particular in peripheral cities with a population of one million, such as Omsk, for example. (Table 4).
Table 4. The results of a survey of residents of Omsk on the possibility of using auto-piloted vehicles.

| Possible answer                                                                 | Response percent, % |
|--------------------------------------------------------------------------------|---------------------|
| **How do You feel about the use of avtopilotiruemy vehicles in the short term?** |                     |
| 1. Positively, as the influence of the human factor leading to road accidents will decrease | 9,9                 |
| 2. Positive, as the capacity of urban roads will increase                        | 6,9                 |
| 3. Positively, as the possibility of movement of part of the population with disabilities (persons with disabilities, including vision) will increase | 22,8               |
| 4. Negative, as it will cause unemployment                                       | 11,9                |
| 5. Negative, because there is no trust in the electronic control systems of the car | 29,7                |
| 6. Negative, as climatic conditions can cause failures in the electronics        | 8,9                 |
| 7. Negative, as the quality and content of the road surface will not ensure the safety of electronic systems | 9,9                 |
| **If You were given the opportunity to use an autopilot vehicle, what would You do?** |                     |
| 1. Everything new is interesting, I sure would have tried                       | 20,8                |
| 2. More like Yes. The new is alarming, but the interest is stronger             | 25,7                |
| 3. Probably not. There is no certainty that the technology is finally adapted   | 23,8                |
| 4. Definitely not. Operation of autopilot vehicles in modern conditions is impossible | 18,8               |
| 5. Not sure                                                                    | 10,9                |

The survey revealed that 39.6% of respondents positively relate to the prospect of using self-driving vehicles in an urban environment, indicating the possibilities of both improving road safety and reducing road congestion. Almost half of the respondents would like to attempt to drive a car with an autopilot, but they are alarmed and stopped by the lack of confidence in artificial intelligence and the possibilities of system failure for various reasons. However, almost 60% of the respondents expressed a negative attitude towards the possibility of using unmanned vehicles, citing a variety of reasons, sometimes unexpected and different from the initial hypotheses of the developers.

Thus, we can single out the following main factors that determine and constrain the possibility of mass use of unmanned vehicles in the urban environment, which require special attention in their rationale and decision and are systematized in Fig. 2. It is necessary to note the close connection of causes, problems, ways to solve them, a certain “network” of social, technical, economic circumstances that determine the development process of intelligent transport systems and result in a synergistic effect that eliminates all negative prerequisites. Consider the whole system in more detail.
Among the factors limiting the widespread introduction of self-driving vehicles in the urban environment is to highlight, for example, natural and climatic. The territory of the Russian Federation has a significant length of territory and is located in four main climatic zones, each of which has its own temperature regime, humidity and other indicators, and in some regions, a snow shelter may be present for more than six months. Snow, ice can be a significant cause and a threat to the fact that the road markings, signs may not be recognized by electronic systems. The length of the rains, as well as the length of the daylight hours, may affect the performance of the sensors, since the projects are based on the detection of objects and objects using laser technology, as well as determining the distance between them. In the summer of 2018, Russian engineers were asked to develop an unmanned vehicle for operation at low temperatures and in conditions of abrupt changes in climatic zones; the initiator of the project, called the Winter City, is the Skolkovo Innovation Center. However, at present there are no results of testing the operation of autopilot vehicles at low temperatures and high humidity, therefore this issue requires a special solution, since adaptation to natural and climatic conditions carries a close connection both with the infrastructure of the urban network as a whole and with the provided safety and traffic conditions for all participants.

The development of scientific progress and technology depends largely on the political system, the structure of government in the country, its support, both legislative and financial. Currently, the government is actively promoting the development of unmanned systems, in particular, a roadmap has been developed to improve legislation and eliminate administrative barriers in order to ensure the implementation of the National Technology Initiative for Avtonet, which is aimed at developing and promoting technologies unmanned vehicles, service telematics platforms, navigation technologies, driver assistance systems, cybersecurity technologies, wireless systems One of the new generation of communication technology in the field of electric transport, other vehicles using alternative fuels, and related services [16].

Also, President of the Russian Federation Putin V.V. instructed the government to prepare measures for the creation of Russian service information and telecommunication platform that would unite the existing information systems ERA/GLONASS, Platon, the traffic police, the Emergencies Ministry, the Ministry of Transport and other services. In the future, this association can become the basis for creating rules, laws in the field of organizing unmanned vehicles, establishing their legal status.

Of course, the introduction of unmanned vehicles is primarily aimed at improving the quality of life of the population, eliminating such negative factors as traffic accidents, road congestion, and psychological overload associated with it. At the same time, unemployment is the most serious
indicator that worries all participants in the creation of unmanned vehicles today. Each unit of rolling stock, equipped with an unmanned system, provides for the reduction of one driver, which in the future may lead to a massive strike and conflicts. It is assumed that in the first place it will affect truck drivers. Transportation of goods across the country from manufacturers to retail networks, as well as the movement of military equipment is the most important industry, and it is in this direction that it is planned to use autopilot vehicles in the first place. It is also one of the directions for the gradual introduction of automated transportation along with their use in hazardous areas (for example, regional development and extraction of various resources), in closed experimental areas, such as Skolkovo or Innopolis, at night, when urban roads are relatively free [17]. The latter entails such advantages as transport provision of the population and the release of drivers from work in the dark.

Public rejection of the latest developments in the field of transport (recall that about 60% negatively relate to this kind of development) should be eliminated by the gradual introduction of automated functions of driving, their adaptation to the person himself and to the infrastructure of a particular city. Training is needed in handling unmanned vehicles, explaining all possible functions, benefits and consequences. The beginning of this process has already been made, many large automobile concerns are producing modern cars equipped with elementary sensors (level and fuel consumption, tire pressure) and more modern automatic parking systems. And even to them, a person needs time to adapt, and also in order for developers and manufacturers to make the cost of such intelligent vehicles affordable [4-5, 14].

Currently, about 1.3 million people get rights in the Russian Federation annually, and according to the forecast, in the next 20 years, about 4 million drivers will be left without jobs. Also, the full automation of the entire transport space will lead to a reduction of workers in the field of a motor vehicle and traffic management. For example, the work of traffic police stations, verification of accompanying documents and driver's licenses will be deprived of the need, and nowadays there is widespread use of street video surveillance systems, the use of which precludes human participation in traffic control. It is also necessary to note the restructuring of the insurance system, the reduction of employees of insurance companies since unmanned vehicles are positioned as a trouble-free type of transport and therefore do not require insurance coverage.

With the use of unmanned vehicles, inevitably there will be difficulties with protection against hacking of their information management systems. The question of car security will certainly arise since it is a vulnerable spot of modern information space [18].

All the problems, one way or another connected with the use of autopilot vehicles, require further solutions and considerable efforts by scientists in various fields, as well as the government and, of course, the population, as the main user.

From the positive socio-economic effects of the introduction and use of autopilot vehicles, the following can be identified:

- saving time. Of course, a driver who is free from driving can perform other functions at this time: rest, reducing his psychological or physical stress, or perform his work duties, conduct business correspondence, establish contacts and thus increase the productivity of labour. In addition, intelligent systems will provide the choice of the shortest path of movement, which will also help reduce the time of movement, the so-called "transport fatigue" of the population and improve the quality of transport services.;
- reduction of emissions of harmful toxic substances into the atmosphere through the use of alternative fuels and energy, as well as the utilization and optimization of old rolling stock;
- increasing the mobility of the population with disabilities, and as a result, the quality of their life, the possibility of trips carried out by persons without driving license or a minor.
- reducing the cost of transport services, primarily due to the reduction in the number of personnel and savings in the wage fund, as well as operating costs, which currently occupy the largest share in determining the cost of transportation. It is necessary to reiterate here the possibility of using alternative types of fuel and its savings due to its control by automated systems, given the rise in
gasoline prices and excise taxes on it, since the transport component in the final cost of production significantly affects the final prices of products as industrial, and of national importance [19-20]:

- an increase in the efficiency of the use of road capacity by almost four times, and as a result, a decrease in the number of road accidents, improvement of the ecological situation [21];
- economic development of a large number of companies and firms that in the future will be able to gain a "niche" in this field of activity, growth in the number of investment projects and financing, at the same time, providing jobs and improving the macroeconomic indicators of the country (gross domestic product, national income and others);
- development of a vehicle caching system that will allow companies to reduce operating costs.

3. Conclusion

Prospects for the development and implementation of autopilot vehicles in the daily lives of people are very attractive and, given certain prerequisites and problems, are urgently needed. Information technologies, autopilot vehicles are developing at significant rates and are actively supported in all developed countries of the world. Experts predict that access to the APTS market may take place by 2030, but the most important issue is the financing of such projects. For example, providing one city with a 5G network in order to make possible the creation and development of an intelligent transport system requires an investment of 3.3 billion dollars. The cost of the autopilot vehicle is about 35 thousand dollars [24]. Of course, with such numbers, there is a big question about payback, because technologies become massive, convenient and in demand when they are available and provided with all the necessary resources. Therefore, the joint work of state and private structures, scientific organizations, expansion and development of project financing mechanisms in order to ensure their effectiveness, the formation of common approaches, standards, model programs that will gradually create a modern, developed transport infrastructure is required.

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