DOI: 10.17747/2618-947X-2023-2-180-187
JEL: L91, L92, R41
UDC 332.1

Unmanned transport and the reformatting of human needs: Niche and evolutionary scenarios

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Abstract

There are quite a few phenomena in human civilisation that could be compared to transport in terms of the scale and irreversibility of their impact on the development of society. The domestication of the horse and the invention of the wheel are rightly regarded as some of mankind's greatest achievements. The current stage of transport development claims to be a Revolution 2.0: the advent of the Global Navigation Satellite System (GPS) has made it possible not only to locate but also to remotely control unmanned vehicles. In the near future, this could radically change both the transportation system and human life as a whole.

The purpose of the article is to consider niche and evolutionary scenarios for the development of unmanned vehicles. It is proved that unmanned transport involves large scale and very similar transportation of homogeneous products in order to cover higher investment costs through economies of scale. In addition, such transport requires extreme predictability in the entire chain: from the receipt of raw materials to the delivery of the finished product to the end user. The accident intolerance of unmanned vehicles can be solved by creating an isolated transportation system along closed circuits in which there is no room for a person.

The article notes that there is a non-zero probability that unmanned vehicles will not be able to outperform traditional transport in terms of their characteristics and will therefore only operate in certain market niches.

Keywords: unmanned transport, cargo transportation, region, dehumanised, unpopulated transport.

For citation:

Anokhov I.V. (2023). Unmanned transport and reformatting human needs: Niche and evolutionary scenarios. *Strategic Decisions and Risk Management,* 14(2): 180-187. DOI: 10.17747/2618-947X-2023-2-180-187. (In Russ.)

无人运输与人类需求的重新格式化：利基和进化设想

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摘要

在人类文明中，就其规模和对社会发展的不可逆转的影响而言能与交通相提并论的现象并不多。马的驯化和车轮的发明被认为是人类最伟大的成就之一。现阶段的交通发展可以说是 2.0 革命：全球定位系统（GPS）的出现不仅使确定位置成为可能，也使遥控无人 器械成为可能。这在不久的将来将极大地改变交通系统和人类的整体生活。

本文章介绍无人运输发展的利基和进化设想。作者已经证明，无人运输涉及同质产品的大规模统一运输，以便利用积极的规模经济来支付较高的投资成本。此外，这种运输要求整个运输链具有极高的可预测性：从接收原材料到将成品运送给最终消费者的整个过程。无人运输对偶然性的不容忍。因此，有必要建立一个与世隔绝的闭环不涉及人类的参与的运输系统。

本文章指出，无人运输在性能方面可能无法超越传统运输，因此只能在某些特定市场内运行。

关键词：无人运输、货运、地区、非人化。

供引用:

Anokhov I.V. （2023）。无人运输与人类需求的重新格式化：利基和进化设想。战略决策和风险管理。14(2)：180-187（俄文）DOI：10.17747/2618-947X-2023-2-180-187。（俄文）

Introduction

Currently, there is a huge amount of research being done on unmanned vehicles, and at the same time there is terminological uncertainty. Thus, in the English language a number of terms with similar meanings are used: driverless car, autonomous car, connected vehicles, robotic car, self-driving car, self-driving transport, autonomous vehicle, etc. Russian publications also use many terms: unmanned vehicle, autonomous vehicle, highly automated vehicle, robotic vehicle, self-driving vehicle, unmanned vehicle, etc. For example, in the draft federal law[1], a highly automated vehicle is defined as 'a wheeled vehicle equipped with an automated control system during its manufacture or as a result of changes in its design, which moves in an automated control mode'.

Such a variety of terms suggests that this technology is still in the active design phase and that its basic characteristics have not yet been defined.

In general, we can say that unmanned vehicles have at least two key components:

1) many sensors for orientation in space (radars, satellite navigation, range finders, lidars, etc.);
2) a programme that processes the information received and controls all the vehicle's systems.

The third element of unmanned transport should be an external information technology support system (ITS) that analyses traffic, regulates intersections, etc. ITS seems to be a necessary component to increase the level of vehicle autonomy: from level 0 (no autonomy: transport is completely controlled by a person) to level 5 (full autonomy: automation controls the system without any human intervention) according to the Society of Automotive Engineers (SAE) scale)[2].

This article argues that unmanned transport requires a fundamental transformation not only of the means of transport itself, but also of all participants in the transport system, including shippers, consignees and transport organisers. In this case, transport will not only be unmanned, but also completely deserted and dehumanised.

1. The evolution of transport

History shows that the emergence of transport links radically and forever changes the social landscape: warring tribes move to exchange, bandits begin to ensure the safety of transport, and populations no longer produce for themselves but for people they do not know. A clear example of this process is the Great Silk Road, which fundamentally changed not only the cultures and civilisations through which it passed, but also the entire continent ('world island'). In this sense, transport has a kind of social magic.

Moreover, the more different the societies linked by transport (in terms of natural resources, climate, list of products, etc.), the more profitable trade is for each of them and the greater the importance of freight transport. Conversely, the more similar societies are, the fewer reasons they have to trade and the more likely they are to engage in violent confrontation. For this reason, transport links between geographically distant areas have the most significant consequences.

When it is possible to establish sustainable transport links between previously isolated economies, these economies actually become a single economic whole. Transport opens up the flow of people and goods first, then technology and finance. The winner is the economy with a deeper division of labour.

It follows from the above that the historical importance of freight transport is incomparably greater than that of passenger transport. Therefore, we will continue to look at the transformation of the freight transport sector.

If we apply the apparatus of the Theory of Inventive Problem Solving (TRIZ) [Altshuller, 2011; Shpakovsky, Novitskaya, 2011] to the problem at hand, then in the most simplified version the transport system includes a number of subsystems:

– a subsystem of the transport movement relative to the earth's surface (let's call it 'Carrier'). This subsystem can be considered as a wheel, the hull of a ship or the wings of an aircraft;
– a subsystem in which cargo is stored during transport ('Storage'). Bags, crates, pallets, containers, etc. can be considered as this subsystem;
– a subsystem 'Engine' that powers the 'Carrier'. In different historical eras, this has been the physical strength of man, the strength of pack animals, a sail, an internal combustion engine, etc.;
– a subsystem designed to plan a route and manage loading, transport, unloading and storage ('Computer'). This function is assigned to drivers, machinists, dispatchers, etc.;
– an infrastructure subsystem (including roads, paths, canals, etc.).

Let's look at the simplest way to move loads - using the muscle power of one person (Fig. 1).

Fig. 1 shows that even in a scheme with one person, the above subsystems can be distinguished, each of which has developed along its own trajectory. At the same time, all these trajectories are united by a pattern: a person consistently rejects all new functions from himself and transfers them to technical systems.

Improvements in freight transport technology can occur under the influence of both random causes and conscious research. In both cases, however, their practical application takes place under the control of the 'computer'.

The history of mankind convincingly shows that the transport system has made a colossal leap forward. Today, however, many researchers argue that a fundamentally new stage of unmanned transport is coming, which will radically change the economy and society.

[1] The draft Federal Law 'On Highly Automated Vehicles and on Amendments to Certain Legislative Acts of the Russian Federation', prepared by the Ministry of Transport of the Russian Federation, project ID 02/04/06–21/00116763 (not included in the State Duma of the Federal Assembly of the Russian Federation). http://www.consultant.ru.

[2] Taxonomy and definitions for terms related to on-road motor vehicle automated driving systems (2018). Warrendale, PA, USA, SAE International.

2. Modernity

Transport is a much more complex system than individual production. This is particularly noticeable in times of crisis: any disruption to the transport system immediately affects the activities of producers and consumers. On the other hand, the dependency of transport on a specific customer is usually radically lower. This is because transport provides the basis for trade and not vice versa. Trade, in turn, leads to market-oriented production.

The key trend in the development of modern transport is unmanned vehicles. It is taken for granted (if not proven) that transport without human intervention is efficient. What is overlooked, however, is that the economic efficiency and feasibility of this technology can only be achieved if two conditions are met simultaneously:

1) significantly lower transport costs for unmanned transport than for traditional industrial transport;
2) guaranteed volume, frequency and uninterrupted transport.

These two conditions, in turn, can only be achieved if the transport becomes massive and, crucially, of the same type (along the same route, according to a single schedule, with the same type of cargo, etc.). This is where self-driving vehicles could theoretically offer the lowest variable costs not achievable by human-driven vehicles and recoup the higher capital investment of advanced transport.

In such favourable conditions, unmanned vehicles will be able to demonstrate all their advantages:

– The possibility of working around the clock and even all year round;
– Minimal variable costs;
– Easy and cheap scalability to all areas of the same type of transport.

The disadvantages should not be overlooked:

– Significant initial investment;
– Functional rigidity: technology, unlike people, is not able to adapt quickly to a qualitatively different type of activity;
– Absolute rhythm and predictability of transport: unmanned transport is intolerant of accidents;
– The inertia of transport technology: it can only be developed jointly with other entities (from software manufacturers to road builders and authorities).

It is the inflexibility and high cost of modern unmanned systems, as well as the unstable external environment, that do not allow them to displace humans from the field of transport today. The technology is almost there, but contrary to the dreams of science fiction writers, artificially intelligent systems today draw pictures, play chess, write songs, but the physical work, including the manual control of transport, is still done by or under the direct control of a human.

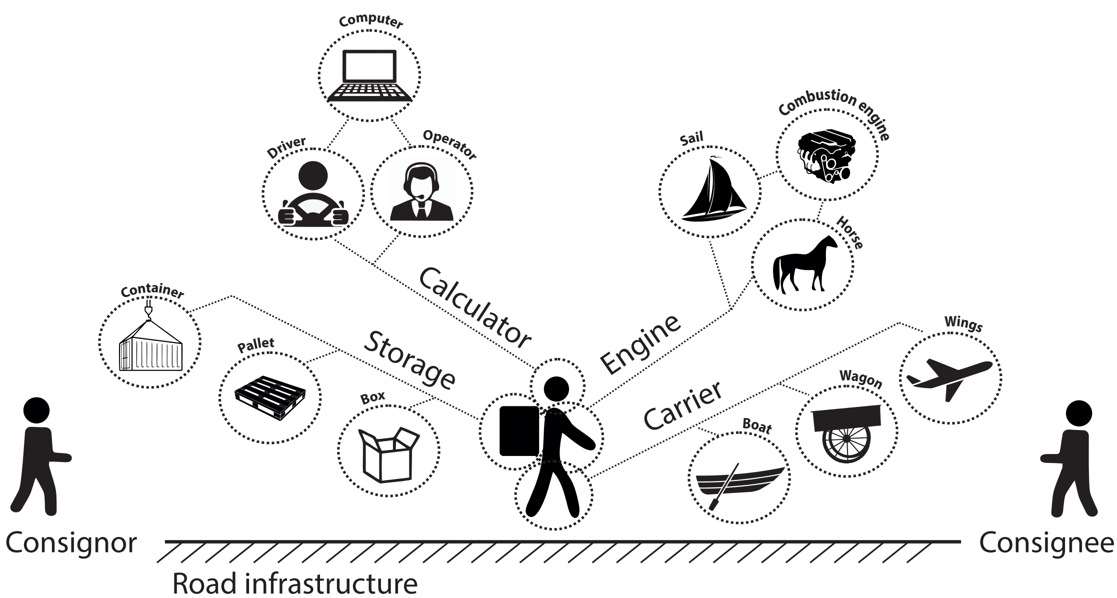
The current level of unmanned transport is such that its effectiveness in unpredictable traffic situations remains low. A clear example is autopilots in civil aviation: automation can control the aircraft, but in an emergency, control is immediately transferred to a human pilot.

In fact, drones claim to completely remove humans not only from direct manual control of transport vehicles, but also from dispatching and logistics (i.e. to become a completely dehumanised, unmanned mode of transport).

If we transform Fig. 1, we get a diagram of dehumanised, unattended transport (Fig. 2).

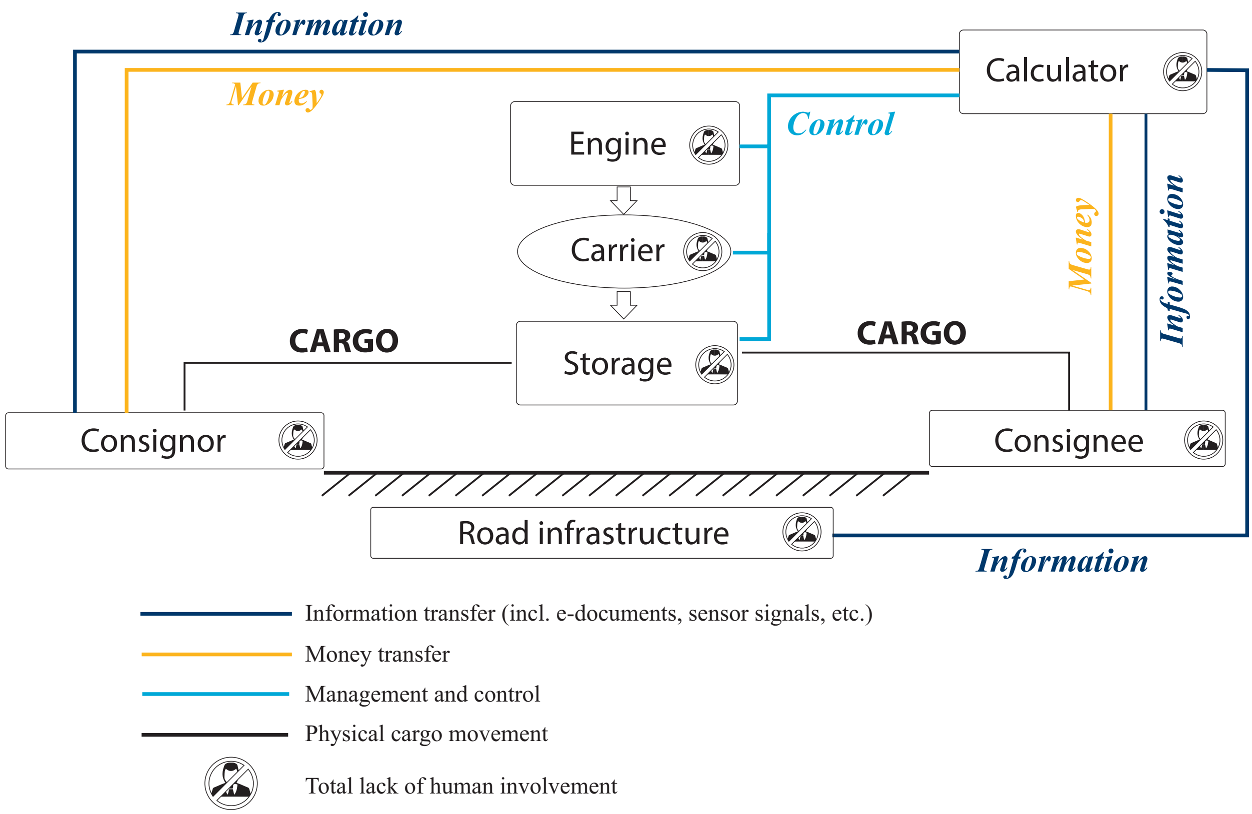
Humans create unpredictability, so their presence in any role (driver, consignor, consignee, etc.) is undesirable from the point of view of completely dehumanised transport. It is no coincidence that drones are most successfully introduced

Fig. 1. Structure of cargo handling system and development of its subsystems



Source: compiled by the author.

Fig. 2. Scheme of a completely deserted, dehumanised transport



Source: compiled by the author.

into the production process in places where human presence is minimal: mines, industrial sites, marshalling yards. The logic of the development of this technology suggests that the control functions should be transferred to the vehicle itself, and the coordination and forecasting functions to the road infrastructure, which should analyse road traffic, monitor weather conditions, control traffic lights, and so on.

3. Evolutionary scenario for the development of unmanned vehicles

Although unmanned vehicles are highly intelligent and rely on numerous sensors, computer vision systems and satellite navigation, they pose a danger to people and their property, as news reports have amply demonstrated. At the same time, there are no established legal models or operational regional unmanned systems in the legislation of different countries.

This presents a unique opportunity: the first country to introduce an effective system of regional unmanned transport will set the standard for unmanned transport around the world for decades to come. We see examples of this in past centuries: road gauge, power supply voltage, keyboard layout and much more. Today, there is no shortage of different models and prototypes of unmanned vehicles, but the regional door-to-door freight delivery system is not on show.

Many countries are working hard to take the lead in this race. Russia has adopted the Transport Strategy of the Russian Federation until 2030 with a forecast until 2035[3]. Projects are being developed under the National Technology Initiative: Marinet (maritime transport), Autonet (logistics for people and goods), Aeronet (unmanned aerial vehicles).

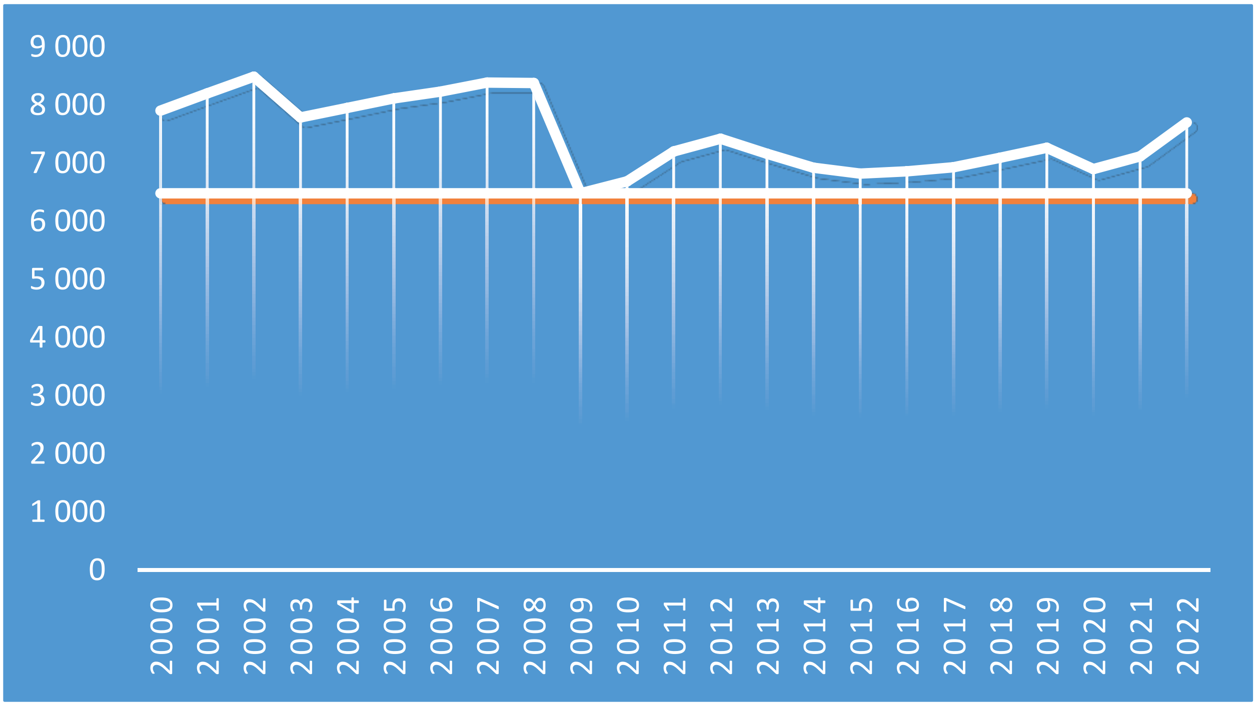
However, special requirements for transport infrastructure objects of unmanned vehicles are not regulated by law and apparently have not even been formulated yet.

The draft federal law 'On Highly Automated Vehicles and Amendments to Certain Legislative Acts of the Russian Federation' divides unmanned vehicles into two groups: vehicles in which a test driver is constantly present, and vehicles that are remotely controlled. In other words, we are not yet talking about the complete elimination of humans from the sphere of transport, but the level of technology described by the law will bring completely new risks [Begishev, 2021]:

– software unreliability, for which Tesla products, for example, are known today. In 2022, for example, a glitch caused a self-driving Tesla car to increase its speed to 198km/h instead of parking, resulting in the deaths of people[4];

[3] Decree of the Government of the Russian Federation dated 11/27/2021 No. 3363-r 'On approval of the Transport Strategy of the Russian Federation until 2030 with a forecast for the period up to 2035'. http://static.government.ru/media/files/7enYF2uL5kFZlOOpQhLl0nUT91RjCbeR.pdf.
[4] https://life.ru/p/1538680.

Fig. 3. Freight transport according to modes (excluding pipelines) (mln t)



Source: compiled by the author based on Rosstat data: https://rosstat.gov.ru/statistics/transport.

– information threats to intelligent transport. These include attempts to gain unauthorised access to the vehicle's systems, as well as sending false signals. In 2021, for example, it was discovered that car sensors may not recognise road signs correctly if they are slightly distorted[5].

Legal risks from the external environment are also increasing. For example, who will be responsible for the risks of emergency situations? What will be the consequences of legally significant actions performed between different unmanned and automated intelligent devices (e.g. entering a paid car park with automatic payment, receiving valuable cargo, etc.)?

The President of the Russian Federation, V.V. Putin, spoke on the subject. Putin said, 'From whom should we recover damages if, for example, an unmanned vehicle causes a traffic accident, and the authorities and management often reach a dead end... How to ensure liability for the actions and, in certain cases, for the inaction of robots and artificial intelligence algorithms?'[6]

Moreover, neither these legal questions nor fundamental ethical problems have yet been answered [Chen et al., 2023]. For example, the well-known 'trolley problem', formulated in 1967, has still not been solved: a speeding trolley can only move along two tracks on which people are chained (on one - five people, on the other - one). Which way should the driver choose in this situation? Today, the responsibility lies with the driver, but who will be held responsible for the actions of a completely inhuman vehicle? Many studies are devoted to this problem today, including those of theology, Protestant ethics [Németh, 2023], etc. However, some authors note that there is currently no alternative to the 'utilitarian principle of saving more lives' [Mayer et al., 2023].

As a result, traditional risk management strategies cannot be applied to autonomous vehicles because they require accurate and reliable estimates of the probability of choice outcomes and agreement on values [Resnik, Andrews, 2023].

Until all these issues are resolved, such transport cannot be used en masse [Jędrzejewska, 2023]. Real needs, of course, cannot expect a protracted solution to this theoretical problem and therefore rely on the usual algorithms for transferring responsibility to the manufacturer, owner, driver or operator..

Thus, in the state of California, where unmanned vehicles have the right to drive on public roads, the responsibility is assigned by law to the driver, who is obliged to take control of the vehicle at all times [Tsirit, Tatyanina, 2019]. German legislation establishes the mandatory presence of a driver at the wheel, who controls the movement of a highly automated vehicle, and each unmanned vehicle must have a black box installed to record the course of the journey and establish the

[5] https://www.securitylab.ru/news/487718.php.
[6] http://www.kremlin.ru/events/president/news/67099.

technical characteristics of a potential offence [Korobeev, Chuchaev, 2019]. In Russia, according to the federal bill 'On highly automated vehicles... '[7] responsibility will be assigned not only to the driver in the car, but also to the remote operator.

There seems to be only one radical solution to this problem - the separation and isolation of unmanned cargo transport in a separate system where there is no room for accidents. In the same way that oil and gas are transported today in closed loops along oil and gas pipelines, freight transport will most likely consist of isolated strings of identical transport units carrying a homogeneous cargo. Projects are already being developed that could serve as a basis for this: in the railway sector, there are plans to create separate tracks for passenger and freight transport [Ovchinnikov, Kulgin, 2021].

At the same time, it is necessary to realise that such an isolated transport system can serve only fully predictable cargo flows (in terms of volume, schedule, type, etc.). This in turn means that all human needs must be divided into stable (fully predictable) and unstable (unpredictable). The former will probably be served by unmanned vehicles, the latter will be served by traditional ones.

In our opinion, it is possible, as a first approximation, to estimate the ratio of stable and unpredictable needs based on the dynamics of freight transport by year (excluding pipeline transport) (Fig. 3).

Fig. 3 shows that, although the volume of goods transported by all modes of transport has changed continuously over the years, it has not fallen below the minimum volume of goods transported of 6485 million tonnes (which is approximately 87% of the volume of goods transported). It can be tentatively assumed that this ratio (13/87) over the period under consideration characterises the approximate relationship between the foreseeable and unforeseeable needs of final consumers, which in turn allows us to assess the prospects of traditional and unmanned modes of transport. It can be predicted that the transformation process will not be limited to the creation of an isolated system of unmanned freight transport. It will most likely lead to a fundamental change in consumer behaviour.

The demand for full predictability and rhythm of unmanned transport will be imposed on consignors and consignees. Freight with a constant volume will be transported according to schedule and at minimum prices. Freight with unpredictable volumes (e.g. due to fashion influences) is likely to be transported via traditional shipping lines and at higher rates. This means that the transport system will reward predictable human characteristics and indirectly 'punish' unpredictable ones (through higher transport tariffs).

As a result, there will inevitably be a reformatting of a person's needs and their whole personal life: they will become radically more 'predictable'. Spontaneity and chance will be slowly but surely driven by an iron roller into the immaterial sphere, where there is no material inertia and no resistance of the transport system.

Moreover, dehumanised transport will require sacrifices comparable to those of earlier technologies. Thus the advent of writing led to a weakening of memory (it is unlikely that any reader today will be able to recall and reproduce from memory 'the Rigveda', 'the Odyssey', or even an average story). The advent of the counting system has removed the need to count in the head. The keyboard weaned us from handwriting. Machine tools and tools weakened the strength of our hands, and optics contributed to visual dysfunction. Of course, some people retain and even develop these skills, but this is not widespread, and the skills themselves have been transformed from a survival tool into a hobby.

In this regard, we should expect a person to lose the ability to drive vehicles, the ability to navigate the terrain, and even the ability to anticipate their own needs.

If this scenario comes to pass, we will initially see a bifurcation of transport into unmanned and traditional transport, and after a certain period of time they will merge at a higher level of complexity. It is possible that in the near future there will be intelligent systems capable of predicting or directly programming even currently unpredictable needs.

4. Niche scenario for unmanned vehicle development

There is a non-zero probability that unmanned vehicles will not have a significant impact on the transport industry and will only serve some market niches. Let's consider the possible reasons for this scenario.

1. Unmanned transport as a regional or transcontinental system may not be economically competitive with traditional transport modes. This may be due to extremely high capital investment, higher transport costs, reduction of transport tariffs by traditional transport (dumping), etc.

2. To achieve dominance, unmanned vehicles must cover all stages: from the mine to the shop door. Otherwise, the stages that remain under human control will throw the entire transport chain into chaos. The result will be an alternation of emergency operations and downtime, with increased risks and costs. This means that unmanned transport should not even be national, but transcontinental. In other words, unmanned transport presupposes a globalised world economy.

However, world events in recent years may lead to a reversal of globalisation trends towards regionalisation. As a result, the world may be divided into economically isolated regions and the need for transcontinental transport will be minimal.

3. The global transport system is influenced by a myriad of factors: economic, demographic, political, natural and many others. This means that even the most isolated freight circuits are affected by an ever-changing external environment. This influence is virtually unpredictable (after all, man cannot control the entire universe) and can potentially paralyse unmanned traffic. In this case, even a series of small stops will be enough to change views on the means of delivery.

4. It is not yet clear how increasingly stringent environmental requirements will affect new forms of

[7] The draft Federal Law 'On Highly Automated Vehicles and on Amendments to Certain Legislative Acts of the Russian Federation', prepared by the Ministry of Transport of the Russian Federation, project ID 02/04/06-21/00116763 (not included in the State Duma of the Federal Assembly of the Russian Federation).

transport. In terms of carbon footprint, driverless vehicles are unlikely to differ significantly from traditional vehicles. At the same time, there is now a strong case to be made for moving away from modes of transport with high carbon footprints, such as rail over air. The ESG agenda is gradually becoming a mandatory practice, and many of the largest companies (e.g. Rusal, Novatek, Gazprom, Lukoil, etc.) have adopted ‘corporate climate strategies aimed at reducing CO2 emissions by increasing the share of carbon-free energy sources and investing in compensatory afforestation’ [Zhavoronkova, Agafonov, 2022]. It is possible that in the new round of the struggle to save the planet not only air transport, but also rail and road transport will be undesirable, and the most environmentally friendly will remain, for example, river transport. However, the instability of the external environment in water transport is much higher, which will cast doubt on the suitability of unmanned technologies there.

5. Such a development of additive technologies cannot be excluded when all consumer goods (including food) are produced close to the place of consumption from universal substrates. For example, bioprinting of meat and other prepared foods is no longer science fiction [Jeong et al., 2022; Tibrewal, 2023]. This could potentially lead to the transport of mainly basic substrates (proteins, fats, carbohydrates) from region to region, which can be easily handled by traditional means of transport.

In the scenarios mentioned above, unmanned transport will only serve a few relatively isolated niches: transport in mines, shunting locomotives in marshalling yards, delivery of parcels to consumers, etc. At the same time, where traditional and unmanned modes of transport meet, emergency situations will inevitably arise, as is already the case on public roads: unmanned vehicles have different speed characteristics, which leads to periodic congestion and traffic jams. Moreover, some authors consider it advisable to reduce the average speed of autonomous trucks, which will reduce costs and carbon dioxide emissions: according to some data, reducing the target speed from 90 to 70 km/h reduces fuel consumption and carbon dioxide emissions by 26% [Bray, Cebon, 2022].

5. Discussion and conclusion

In conditions of autonomy of the means of freight transport, the sensitivity of the transport system to disruptions will increase. The smallest disturbance can have unpredictable consequences for the regional or even continental economy. This requires the allocation of a separate, isolated freight transport subsystem. Furthermore, based on the unproven hypothesis that an increase in order in one place leads to a similar increase in chaos in another, an increase in order in the sphere of transport and people’s vital needs will lead to chaos in other areas of society.

Unmanned transport can lead to a complete reformatting not only of the transport system, but also of human needs.

In the niche option, unmanned vehicles will only take place in isolated transport circuits.

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研究领域：劳工、经济利益、公司理论、运输。

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The article was submitted on 10.08.2023; revised on 24.09.2023 and accepted for publication on 28.09.2023. The author read and approved the final version of the manuscript.

文章于 10.08.2023 提交给编辑。文章于 24.09.2023 已审稿．之后于 28.09.2023 接受发表。作者已经阅读并批准了手稿的最终版本。