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Robots at the wheel: Outlook for the transition to self-driving vehicles in Russia

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Source: open sources,
Yakov and Partners analysis

4.6
trillion rubles p.a.

is the potential impact of the transition to self-driving vehicles on the Russian economy

Autonomous vehicles represent a significant and complex segment of unmanned technologies in terms of regulation, offering considerable economic potential. As various types of drones continue to be developed for use on land, water and in the air, road transport is expected to dominate the market. We estimate the overall positive impact of the transition to self-driving vehicles on the Russian economy at RUB 4.6 trln annually. However, unlocking this potential requires well-designed industry regulation, incentives for private investment in autonomous transport technologies, and the creation of smart infrastructure.

Source: open sources,
Yakov and Partners analysis

>80%

of the total vehicle fleet will be self-driving by 2042

Introduction

As different types of drones are developed, the popularity of autonomous transport around the world will grow. This scenario is supported by the ever-increasing rivalry between countries to lead the industry, which began at the end of the 20th century. Today, the biggest players in the segment are the US and China. In Russia, the development of autonomous transport began in 2010–2011. By 2035, more than a quarter of the vehicles on Russian roads will be self-driving, and by 2042, more than 80% of the total fleet will be driverless.

Our calculations indicate that realizing the full potential of using personalized self-driving vehicles on Russia's public roads could generate an annual economic impact amounting to RUB 4.6 trln. The transition to this stage will occur in waves: first, the technology will be introduced in predictable and isolated environments such as warehouses and logistics centers, then in long-haul logistics, and only then in urban logistics and mass transportation. To successfully navigate this transition, proactive and collaborative efforts are essential from both the government and the business sector. These efforts should include comprehensive regulatory measures, the development of smart infrastructure, and the promotion of private investment in autonomous transport technologies.

According to our estimates, the transition to fully autonomous solutions could reduce the operating costs of trucking companies by 30–40%, generating a positive impact on the logistics industry of RUB 2.1 trln per year. For motorists and city managers, the transfer of control to robotic systems will help alleviate the problem of traffic jams on the roads and reduce the number of accidents. Furthermore, a significant reduction in the accident rate will be achieved as drones replace approximately 25% of the traditional vehicle fleet in Russia.

The primary rationale behind the global transition to automated road transportation is the imperative for enhanced safety. It is estimated that approximately 88% of accidents are attributable to human error, underscoring the potential for automation to significantly reduce accidents and fatalities, with annual savings estimated at RUB 635 bn. In addition, self-driving vehicles greatly expand opportunities for those who, for one reason or another, do not have a driving license.

The transition to autonomous trucks will also provide a solution to a critical staffing issue. The shortage of drivers in Russia is estimated at more than 130,000[1] people, and the introduction of autonomous vehicles has the potential to not only reduce the shortage, but also stabilize the labor market. This will not only solve logistical problems, but also lay the groundwork for uninterrupted, cost-effective delivery of cargo along land routes.

Achieving full autonomy is a complex undertaking. In the current environment, there is a risk of creating a "menagerie" of technologies, with vehicles from different manufacturers and countries operating within the same ecosystem. To avoid chaos on the roads, it is essential to implement targeted measures that establish clear guidelines and a strategic plan for integrating self-driving vehicles into the transport infrastructure.

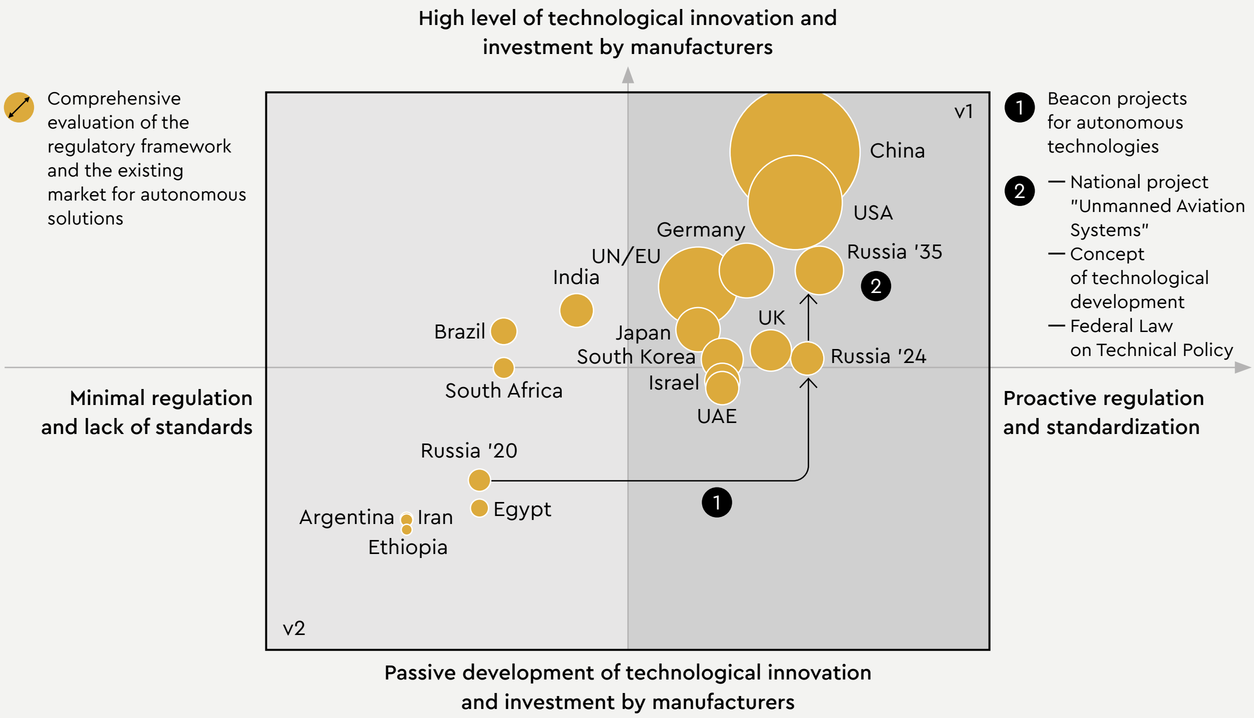
In the medium term, it is imperative for the industry to develop trusted and sovereign drone technologies. Without developing its own software, Russia risks becoming dependent and vulnerable to external interference. Self-driving technologies are not only a security issue, but also a powerful stimulus for the development of high-tech industries.

From global practice to the Russian experience

Drones are taking over the world

Many countries are contending for global leadership in this area, with the competition originating in the 1980s. China is proactively developing its national strategies and allocating resources to smart infrastructure. Major corporations in the US are implementing their solutions in over half of the states. Germany and the UK in Europe are also making significant efforts to adopt autonomous transportation. In Asia, Japan and South Korea are rapidly catching up. Russia has also rapidly adopted self-driving technologies and is poised to become one of the top three global leaders in the industry.

Russia has the potential to be among the top three leaders in the field of autonomous technology by 2035



Source: Estimate of Yakov and Partners team

Presently, the industry's leading companies are headquartered in the United States and China. Both nations are investing in a range of transportation options, including both private and public transit

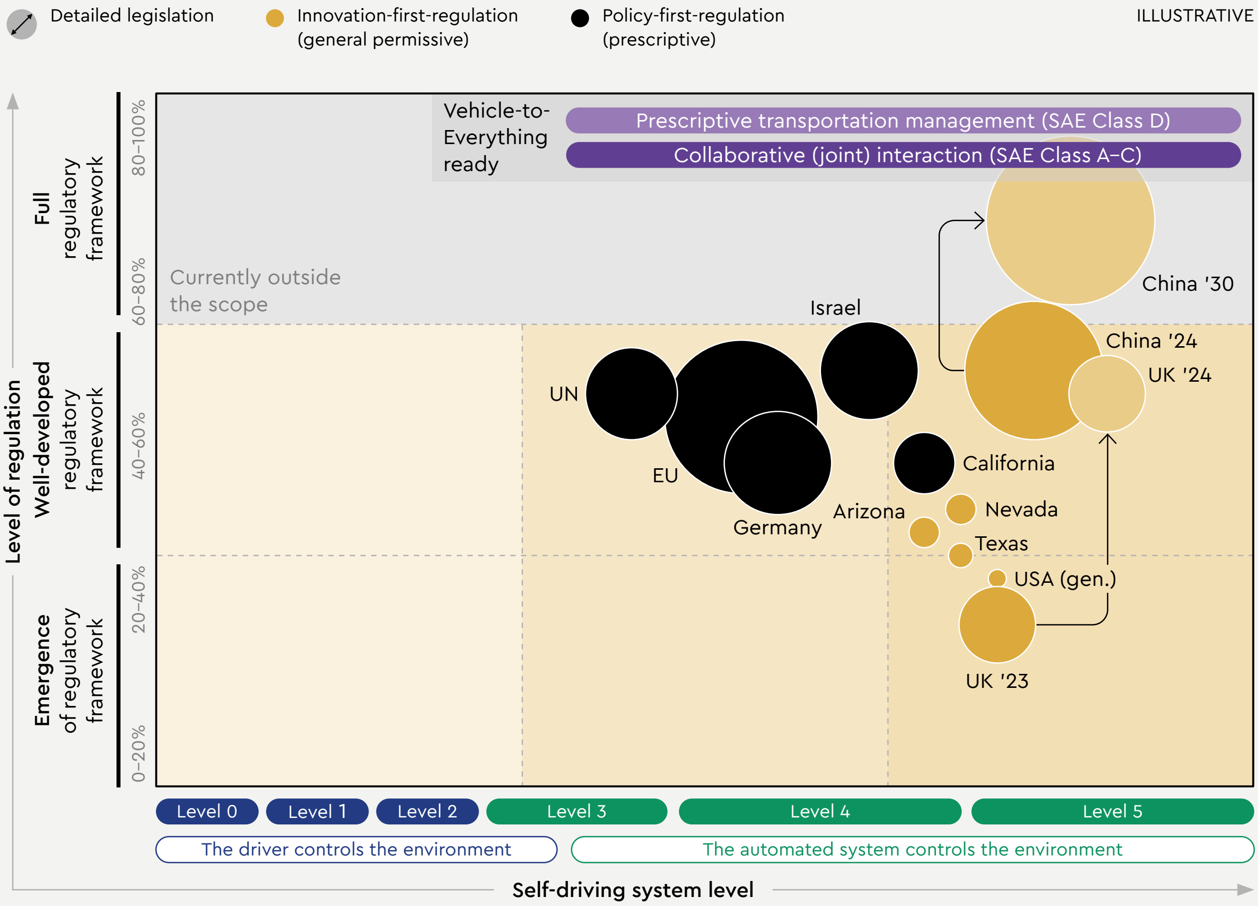
Presently, the industry's leading companies are headquartered in the United States and China. Both nations are investing in a range of transportation options, including both private and public transit. Robotaxis are becoming a common sight on city streets, with over 200 of these vehicles operating in major US cities like Phoenix, Los Angeles, Austin, and San Francisco[2] since June 2024. China has also embraced this technology, with over ten cities, including Beijing and Shanghai, granting approval for robotaxi operations on highways since 2023.[3] In the United States, Google, through its subsidiary Waymo, is actively developing drone operations, while Ford, Tesla, Aurora, and other companies are also pursuing this technology. In China, Baidu, Alibaba, XAG, and DJI are undertaking similar initiatives.

China is gradually taking the initiative in this area. Although Beijing started investing in autonomous driving technologies 5–6 years after the US, it has already equaled the US in terms of the scale of testing and deployment of self-driving vehicles. In the spring of 2024, for example, Beijing launched autonomous vans that seat nine passengers. These vehicles currently service three major cultural institutions: the National Center for Performing Arts, the Beijing Library, and the Grand Canal Museum.[4]

In addition, in June 2024, the PRC authorities granted nine national companies permission to test self-driving vehicles on public roads. In particular, drones will be tested by Changan Automobile (in Chongqing Central Subordination City in the southwest of the country), BYD (in Shenzhen, southern Guangdong Province), GAC (in Guangzhou, the administrative center of Guangdong Province), SAIC and NIO (in Shanghai), BAIC Magna and FAW (in Beijing).[5]

It is important to note that the Chinese government has prioritized the implementation of V2X (Vehicle-to-Everything) technology. This system facilitates the exchange of data with other vehicles and road infrastructure through a wireless network. In essence, self-driving vehicles not only "communicate" with other vehicles on the road but also receive data from smart roads systems. In contrast, the United States adopts a different approach. Self-driving vehicles primarily rely on information from their own sensors and autonomous control algorithms.

Outlook for regulating drone technology around the world



Source: McKinsey study "Autonomous Vehicles Moving Forward: Perspectives from Industry Leaders"

Levels of vehicle autonomy

Level 0	Only the driver	The driver maintains constant control of both longitudinal and lateral movement	No system
Level 1	Assistants	The driver maintains constant control of both longitudinal and lateral movement	Electronics assist the driver in the driving process
Level 2	Partial automation	The driver must continuously moni-tor the steering process. In certain conditions, the vehicle is capable of self-driving	The system is de-signed to execute both longitudinal and lateral movements, though this functionality is only available under the direction of the driver in some cases
Level 3	Conditional automation	It is not necessary for the driver to maintain control of the vehicle at all times	The system performs longitudinal and lateral movement in automatic mode under certain conditions
Level 4	High automation	Under certain conditions, a driver is not required	The system can take over control
Level 5	Full automation	A driver is not required	The system controls the driving process on all roads and in all conditions

Source: Estimate of Yakov and Partners team

As of November 2024, Tesla cars are technically at Level 2 autonomy, requiring constant driver supervision

At the same time, various models of passenger cars from leading automotive companies with a variety of electronic driver assistance systems are now widely available in the market. They can be classified as Level 1 and Level 2 autonomy, and some models (such as China's Changan UNI-T and some models of Germany's BMW, Mercedes-Benz)[6] as Level 3. Level 4 and Level 5 autonomous vehicles are not yet in mass production and are being tested by large corporations. It is worth noting that Tesla is actively working on developing its Full Self-Driving (FSD) system, which aims to achieve Level 5 autonomy, where the vehicle will be able to drive itself completely without driver input. However, as of November 2024, Tesla cars are formally at Level 2 autonomy, which requires constant driver supervision.

In part, the industry's development is hampered by serious safety risks. In addition, there is an acute problem of public acceptance of self-driving cars as a more reliable mode of transportation compared to human-driven vehicles. As a result, a single mistake can result in reputational costs for the company and, in some cases, bankruptcy, despite significant investment in the project. In 2023, the Cruise automated taxi prototype collided with a woman who had been struck by another vehicle in San Francisco.[7] Following the incident, California authorities revoked the company's license to provide commercial transportation using driverless vehicles. In December, it was announced that Cruise would lay off 900 of its 3,800 employees, or 24% of its workforce, and in April 2024, the company suspended driverless passenger transportation in the United States. At the same time, General Motors had already announced in the summer that it would invest USD 850 mln in Cruise to cover its losses.[8]

Three waves of drones: The road to mass adoption

The speed of autonomous vehicle deployment depends on the complexity of the environment and the level of potential risk. In closed areas, where self-driving systems can be isolated from external factors, deployment is faster. At the same time, urban infrastructure and long-haul transportation require complex solutions and significant resources, which slows their deployment. We can roughly distinguish three waves of deployment of autonomous solutions:

Green zone (1–3 years)

Minimal constraints and high payback potential.

— Agriculture;

— warehouse drones (AGV/AMR);

— port areas and airfields.

In this way, the green zone can become a launching pad for the use of autonomous vehicles.

Yellow zone (3–7 years)

There are still outstanding regulatory and efficiency issues that can be overcome in the next 5 years. This will kick-start widespread and systematic adoption in urban logistics, long-haul, and last-mile delivery.

— Mining equipment;

— urban robots (delivery);

— long-haul trucking;

— light commercial vehicles (LCVs).

Red zone (7–10 years)

There are clear barriers in this segment, both technological and social, that require new technologies, large-scale infrastructure, and overcoming a crisis of trust.

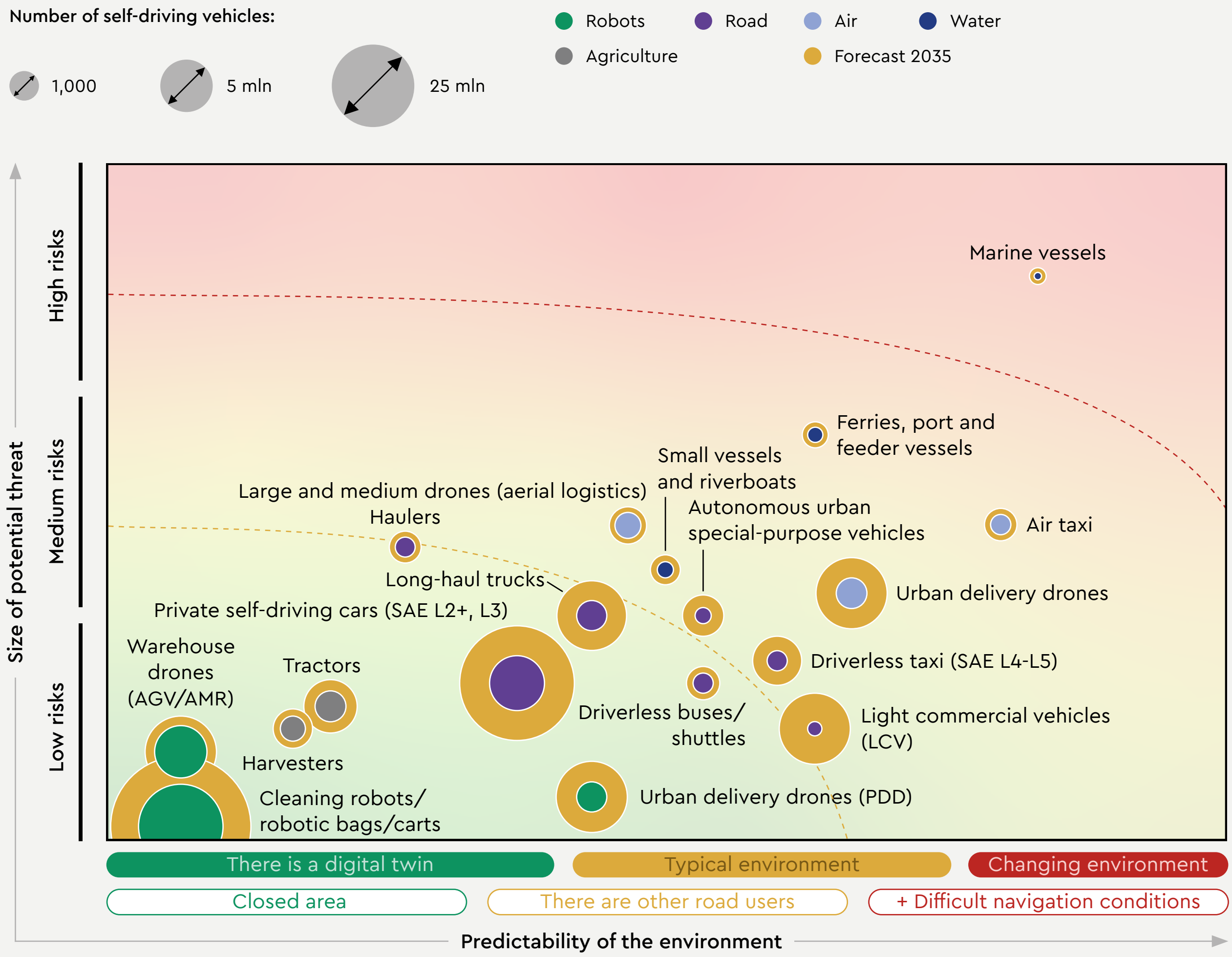
— Driverless shuttles and taxis (SAE L4-L5);

— urban robots (special-purpose vehicles, cleaning, housing, and utilities);

— self-driving city buses.

Mass adoption depends on the pace at which legal, technical, and social challenges are addressed.

Waves of autonomous transportation adoption



Source: Estimate of Yakov and Partners team

Milestones in the development of drones in Russia

The year 2019 marked a significant turning point in the development of self-driving vehicles in Russia. That year, the government showed clear support[11] for the industry, and the development of regulations for autonomous vehicles was initiated

The first mass-produced models of self-driving unmanned vehicles appeared in Russia as early as 2010–2011. Over the following five to six years, these projects evolved from isolated initiatives to permanent programs led by major corporations. For instance, in 2016, the Russian company Cognitive Technologies conducted a test of an autonomous tractor in Tatarstan, equipped with a computer vision system developed in-house.[9]

In the automotive industry, Navio (former SberAvtoTech) and Yandex[10] have been developing and testing their drones since the late 2010s. In addition, at different times, StarLine, BaseTracK, and several other companies have launched their own projects in this field.

The year 2019 marked a significant turning point in the development of self-driving vehicles in Russia. That year, the government showed clear support[11] for the industry, and the development of regulations for autonomous vehicles was initiated. In 2022, three regulatory sandboxes (experimental legal frameworks) were established in the country, allowing for the operation of highly automated vehicles with and without a test driver in the front passenger seat. To facilitate this, remote routing and dispatching of vehicles is required. These frameworks are currently in place in 38 regions of the country.[12] For instance, passenger cars with a test driver are permitted in Moscow, Innopolis (Tatarstan), and the federal territory Sirius in Sochi.

In the Russian business sector, autonomous solutions are being developed and tested by a diverse range of entities, including large corporations and smaller technology firms. Prominent players in this field include industry leaders such as Navio (former SberAutoTech), Yandex, KAMAZ, Gazprom Neft, Sitronics, and StarLine. The future of driverless transportation in Russia hinges on the creation of a comprehensive regulatory framework that will establish guidelines for testing drones on public roads and their subsequent mass introduction.

The economics of drones

Safety and benefits

The widespread adoption of drones has the potential to significantly reduce road accidents, saving lives and reducing the financial burden of accident recovery. Additionally, it can open new avenues for mobility among individuals with medical or other limitations that preclude them from driving, enhancing their quality of life.

Additionally, the development of sovereign trusted autonomous technologies has the potential to stimulate the growth of high-tech industries, such as sensorics, electronics, and software. This could strengthen Russia's competitive position in the global market and create new jobs in high-tech industries. Other potential benefits include a projected 8% reduction in CO_2 emissions, which could support global decarbonization targets.

The transition of passenger and freight transport to autonomous mode is estimated to generate a total economic impact of approximately RUB 4.6 trln per year for Russia.

The drone market is poised to become a catalyst for the advancement of numerous associated industries, as the demand for autonomous systems stimulates the growth in the production of computer electronics, sensors, actuators, and other components essential for the development and operation of these solutions. When considering the economic implications for related industries, the potential for a significantly higher positive economic contribution is evident. Achieving these benefits will require concerted efforts from both the government and high-tech Russian businesses.

Necessary measures:

At the government level:

- Invest in the development of smart road infrastructure and V2X technologies for areas where driverless transportation is likely to be introduced;
- Incorporate designated park-and-ride and automated parking zones within city development plans, leveraging these zones as pick-up and drop-off points for individual self-driving shuttles;
- Define a plan for implementing access restrictions for private vehicles in the central zones of cities;
- Define rules for allowing human-driven vehicles into the driverless transportation zone (additional equipment, communication beacons);
- Provide incentives and subsidies for companies developing self-driving vehicles.

According to our estimates, total investments in smart infrastructure by 2035 should amount to approximately RUB 1.5 trln. These investments will primarily be allocated to systems of precise navigation, communications, intelligent transportation, and smart cities, as well as V2X technologies within urban areas and on federal highways.

At the level of technology companies:

- Develop systems to ensure the safest possible integration of human-driven vehicles into autonomous driving zones;
- Develop an autonomous transportation control platform taking into account data from the Smart City and Smart Roads systems.

Road fatality reduction

Approximately 88% of accidents are attributed to human factors, such as driver errors, ranging from inattention to speeding and unwarranted driving behaviors

Russian President Vladimir Putin has set a target of reducing road traffic deaths by 1.5 times by 2030 and by 2 times by 2036 relative to 2023.[13] The introduction of autonomous solutions may positively impact this indicator.

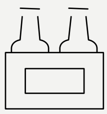
Approximately 88% of accidents are attributed to human factors, such as driver errors, ranging from inattention to speeding and unwarranted driving behaviors. In 2023, the State Traffic Police reported 132,466 road accidents resulting in injuries across the country. Of these accidents, 14,504 resulted in fatalities, representing a rate of one out of nine. Additionally, 166,500 individuals sustained injuries during these incidents.[14]

Autonomous vehicles are equipped with a range of advanced functions that can significantly reduce road accidents due to human error. Level 1 and Level 2 autonomous vehicles are programmed to ensure a safe braking distance, maintain a consistent distance when changing lanes, and navigate unsignalized intersections safely. Level 3 autonomous vehicles are designed to follow traffic rules and determine the distance and speed of other vehicles on the road. Level 4 and Level 5 autonomous vehicles are capable of predicting traffic situations and interacting with other vehicles on the road.

Main risk factors

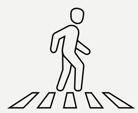
Driving under the influence of alcohol — 25.1%

Of all traffic fatalities, 25% involved drivers exhibiting signs of intoxication.



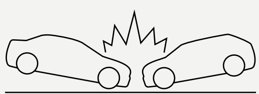
Pedestrian injuries — 25%

A quarter of all traffic fatalities were pedestrians.



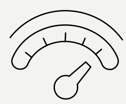
Driving into oncoming traffic lane — 24.8%

Of all traffic fatalities, 25% of victims were fatally injured in crashes involving driving into oncoming traffic lanes.



Errors in selecting driving speed — 26.8%

More than a quarter of all traffic fatalities occurred in crashes that were caused by driving at a speed that was not appropriate for the specific traffic conditions.



Source: Main Department of Road Traffic Safety of the Ministry of Internal Affairs of Russia, Scientific Center for Road Safety of the Ministry of Internal Affairs of Russia

The accident rate is expected to decrease significantly once 25% of the total vehicle fleet in Russia is comprised of autonomous vehicles

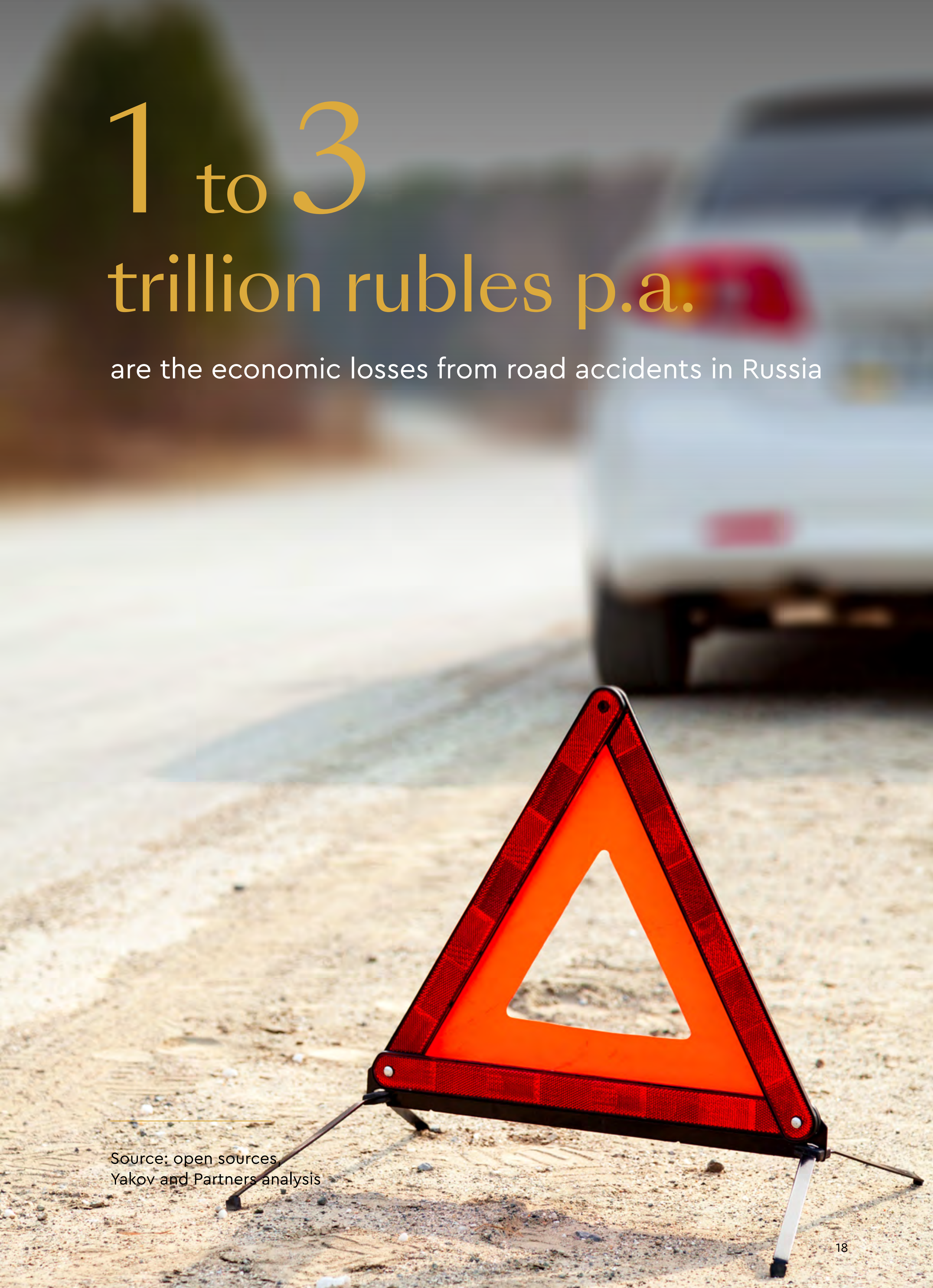
According to our estimates, the accident rate will drop sharply once the number of autonomous vehicles reaches 25% of the total vehicle fleet in Russia.

The introduction of basic AV systems will reduce the number of accidents by 11,631 per year, representing a 9% decrease from the 2023 figure, and the number of fatalities by 1,631, or 11%. Concurrently, budgets at all levels will experience savings amounting to approximately RUB 256 bn per year. The adoption of standard self-driving vehicles is projected to reduce accidents by 18%, fatalities by 20%, and generate savings of RUB 506 bn. For advanced AVs, the figures are estimated to be 22% and 27% per year, respectively, amounting to RUB 635 bn.

Estimates of when autonomous cars will become widespread vary depending on views on the pace of technological advancement, consumer acceptance of these technologies, the development of a favorable regulatory framework, and other factors. Analysts at Lux Research predict that by 2030, 92% of vehicles worldwide will be equipped with Level 2 technologies and 8% with Level 3.[15] Level 4 is widely believed to be most likely achieved only in the next decade, i.e., between 2030 and 2040.

In turn, reducing road accident rates will also reduce the associated economic losses. Currently, nine criteria are used around the world to assess economic losses from road traffic accidents. Key among them are the cost of lost production, as well as the costs of treatment, social security, rehabilitation, administrative costs, and material damage. In Russia, there is currently no official methodology for assessing damage (it was in effect from 2000 to December 2005). In 2018, the social damage according to this methodology was estimated at RUB 908.7 bn (not including environmental damage, damage to road infrastructure, and temporary losses of road users). Based on our estimates, the annual economic losses due to road accidents in Russia range between RUB 1 and 3 trln.

However, it should be noted that AVs will not be capable of preventing all traffic accidents and associated costs. For the foreseeable future, autonomous vehicles will share the roads with human-driven vehicles, which will continue to pose a risk of human error. It is important to recognize that no technology can yet prevent errors when operating in abnormal conditions that are not anticipated by AV software or in situations where all available responses could potentially lead to accidents. By transitioning to AV operations, the number of accidents related to drunk driving, speeding, and crossing into oncoming lanes could be effectively reduced to zero. This shift has the potential to reduce road accidents by at least 75%.



1 to 3 trillion rubles p.a.

are the economic losses from road accidents in Russia

Source: open sources,
Yakov and Partners analysis

Passenger cars

Russia faces significant economic losses due to traffic congestion, amounting to more than RUB 1 trln annually. When considering all driving time, including periods outside of heavy traffic, this figure increases by 2.5 times, reaching RUB 2.5 trln per year

There were 55 million passenger cars in Russia as of July 2024.[16] The global market for autonomous vehicles is projected to reach USD 400 bn[17] by 2035. This significant growth is driven by the increasing adoption of autonomous cars and trucks. If their widespread introduction starts in 2029, the share of autonomous vehicles is expected to reach 18–20% by 2035.

According to our estimates, the size of the AV market in Russia by 2035 could be between USD 25 bn and 32 bn annually. The total impact of the transition to AVs in the passenger car segment could be measured in several trillion rubles. We anticipate that the widespread introduction of highly autonomous robotaxis (Levels 4 and 5) will necessitate investments exceeding USD 5 bn in trusted technology stacks.

Russia faces significant economic losses due to traffic congestion, amounting to more than RUB 1 trln annually. When considering all driving time, including periods outside of heavy traffic, this figure increases by 2.5 times, reaching RUB 2.5 trln per year. Freeing up time spent behind the wheel is equivalent to an increase in the able-bodied population of the Russian Federation of 3.4%, or 2.8 million people. The mass deployment of AVs as private vehicles and taxis could alleviate traffic congestion.

Source: open sources,
Yakov and Partners analysis

30–40%

reduction in operating costs for trucking companies could be achieved by switching to fully driverless solutions, according to our estimates

Freight transport

Russia's light commercial vehicle (LCV) and truck fleet totals stood at approximately 4.22 million and 3.66 million, respectively, in July 2024.[18] At a certain stage, approximately 70% of all cargo in the country is transported by road. Given these circumstances, the introduction of AVs in the commercial segment is expected to generate a faster economic impact than in the mass (passenger car) segment. In particular, development companies are actively prioritizing solutions for freight transportation due to their understanding of the potential for the AV technology to generate tangible results and provide a return on investment.

Switching to fully autonomous solutions has the potential to reduce freight carriers' operating costs by 30–40%. This cost reduction is estimated to generate a positive impact of RUB 2.1 trln per year.

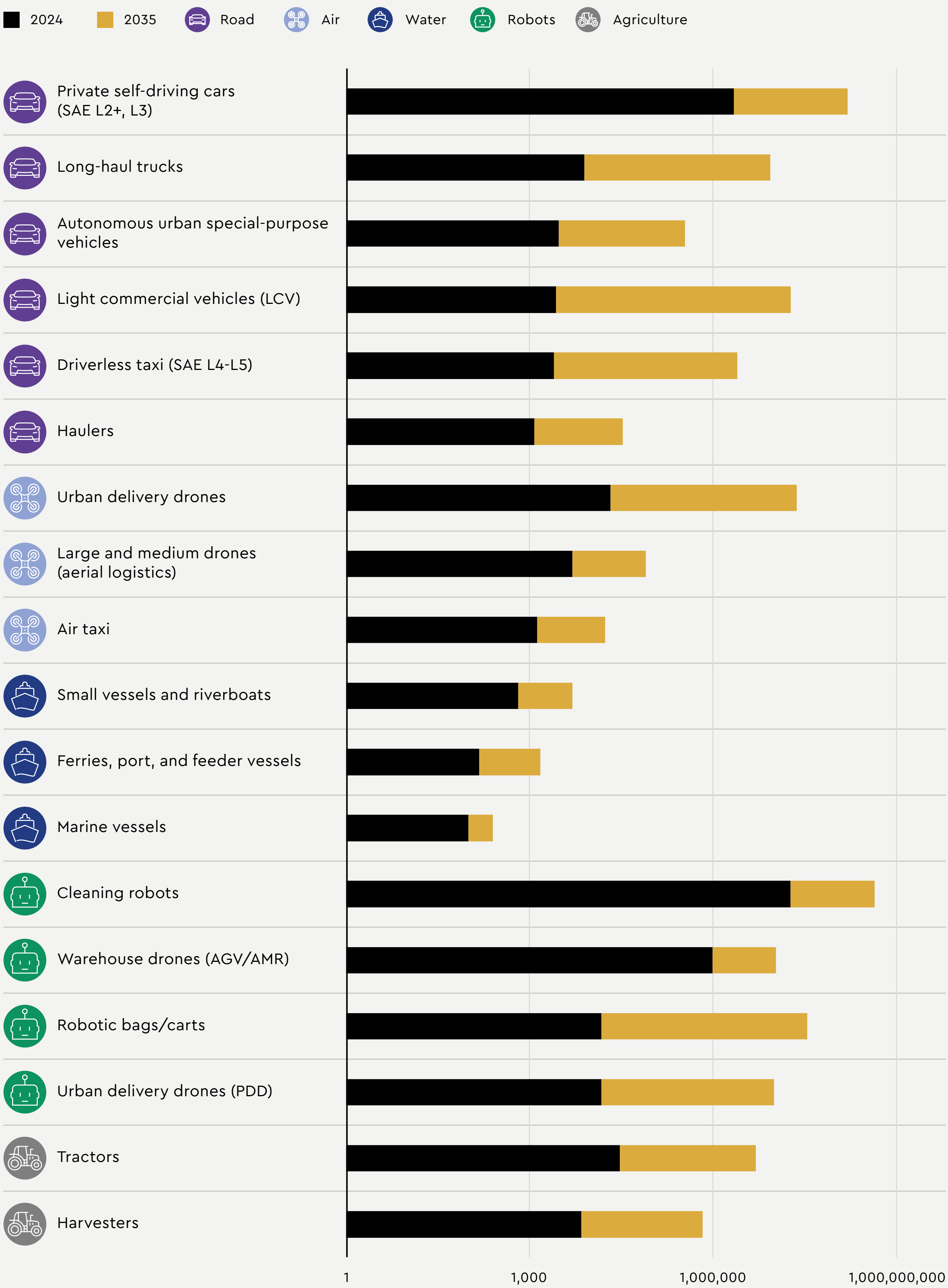
The first steps have been taken to implement this initiative. On the M-11 highway, work to deploy freight transportation commenced in 2022, with plans to introduce autonomous vehicles on the M-12 and M-4 highways to develop autonomous driving routes. In September 2024, the first self-driving trucks were launched on the M-11 Neva highway from St. Petersburg to Moscow.[19] In addition, a month later, Yandex's autonomous truck made the first delivery of Yandex Market cargo from Moscow to Tula on the M-4 Don highway.[20] Thus, by 2030 a backbone framework of internal and transit driverless logistics routes with a length of at least 19,500 km is planned to be established in Russia.[21]

Another promising area for driverless road transport is the delivery of goods and raw materials to hard-to-reach regions in the Far North. The number of fields under development and industrial facilities in the Arctic has increased in recent years.[22] Helicopter delivery is now the default option. This can be supplemented by autonomous vehicles to deliver raw materials to remote production facilities. In the Far North, both driverless long-haul vehicles, such as those used on the M-11 highway, and driverless cross-country trucks can be used.

Like Australia, Canada, and China (where 90% of the autonomous hauler fleets operate), Russia has developed and is testing high-potential models such as the Jupiter-30 and autonomous BELAZs.

Market estimates show that the launch of fully autonomous trucks (Levels 4 and 5) on Russian roads will require more than USD 4 bn, and investments in use cases involving Level 3 AVs on highways will exceed USD 2 bn.

Prospects for autonomous vehicle development, numbers



Source: Estimate of Yakov and Partners team

Addressing human resources challenges

Replacing 25% of the current fleet with autonomous trucks would fill all of today's truck driver vacancies

In 2023, the shortage of drivers in Russia was estimated at more than 70,000 taxi drivers and 60,000 truck drivers (long-haul).[23] In 2024, the negative trend continued: the demand for truck drivers for 8 months of 2024 increased by 58% year-on-year. At the same time, the average salary of this category of workers in the country had increased 1.5 times since the beginning of the year.[24]

A similar trend can be seen abroad. According to IRU, there is a shortage of up to 3 million drivers in the 36 countries in the Americas, Asia, and Europe surveyed for the report. This means that approximately 7% of driver vacancies are currently unfilled. In most countries, more than 50% of road hauliers reported serious difficulties in recruiting truck drivers.[25]

The global situation is expected to worsen in the future. In China, one in five vacancies will remain unfilled, resulting in a shortage of approximately 4.9 million drivers by 2026. In Europe, there will be a shortfall of 745,000, or 17%. Even Turkey, which has a more favorable demographic structure than Europe, is expected to have a shortage of 200,000 truck drivers in 2028 (28% of vacancies). Russia and China are projected to have 14% and 12% of unfilled vacancies, respectively.

Widespread adoption of autonomous trucks would help alleviate the industry's labor shortage. However, this will require a high level of autonomy, meaning the trucks will need to be able to operate without a test driver.

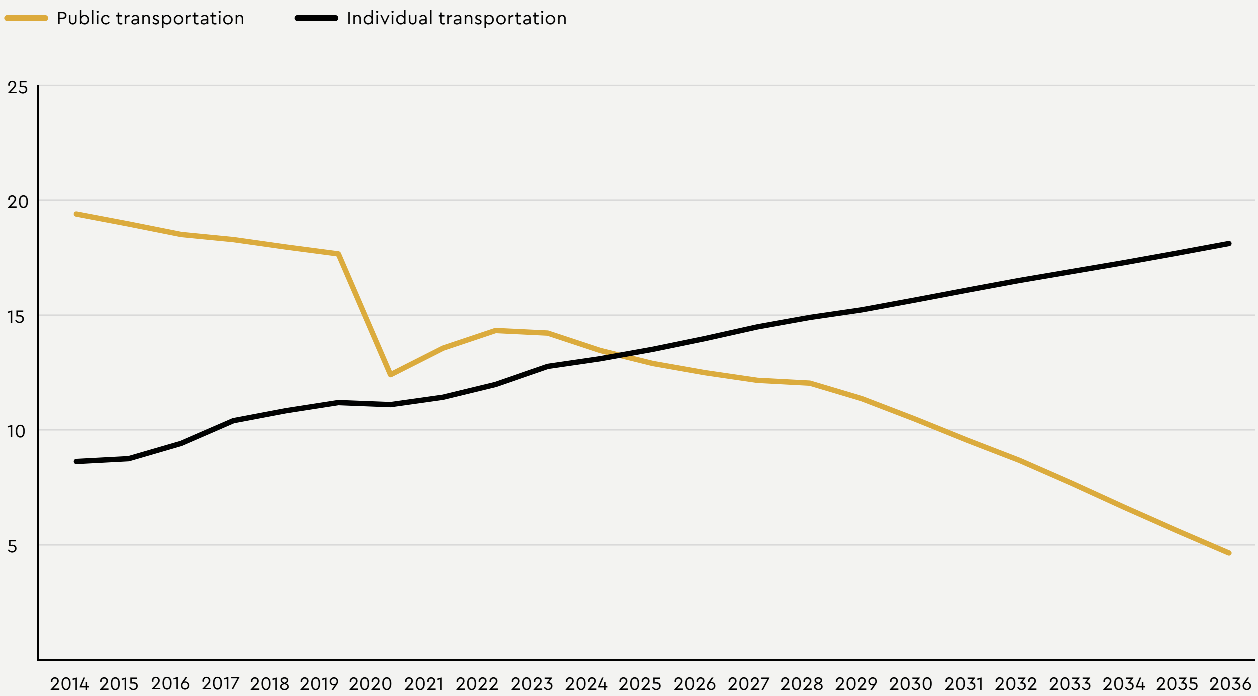
We estimate that all current truck driver vacancies could be filled by replacing 25% of the current fleet with autonomous trucks.

Self-driving technology architecture

A drone for everyone

Over the last quarter of a century, traffic by individualized road transport (private cars, taxis, ride-sharing) has been steadily growing, while traffic by public transport has been declining. In Russia in 2024, according to Rosstat data, they were equal. Our forecasts indicate that the trend towards individualization of transport will continue through 2050.

Ground transportation, public and private, million people



Source: Estimate of Yakov and Partners team

As a result, after 2050, driverless vehicles will be divided into private and shared

At the same time, the advancement of public transportation remains a primary objective for many nations worldwide. In pursuit of this goal, authorities introduce various restrictions, such as congestion charges in Stockholm and the proliferation of paid parking and dedicated lanes for public transportation in Moscow. In order to reverse the trend towards individualization of transport, governments are likely to continue to develop additional restrictions (by zone, time of day, etc.) on private vehicles to ensure the accessibility of urban roads. These measures, combined with the reduction of parking spaces, will not allow to provide private cars for the entire population, which will stimulate the development of public transit, including the development of a sharing model (shuttles, SAE L5 (fully autonomous cars), taxis, etc.).

As this market segment evolves, private driverless cars will be used more often outside urban areas, while ride-sharing services will be developed in urban centers (according to the Smart Roads and Smart City concept). At this stage, the authorities will have a new tool to promote public transportation: driverless shuttles and taxis. By 2050, the AV market will bifurcate into private and shared vehicles. To reduce congestion and traffic jams in urban centers and on the busiest highways, restrictions on private vehicles will be imposed, freeing up space for driverless individualized shuttles.

A "menagerie" of autonomous vehicles

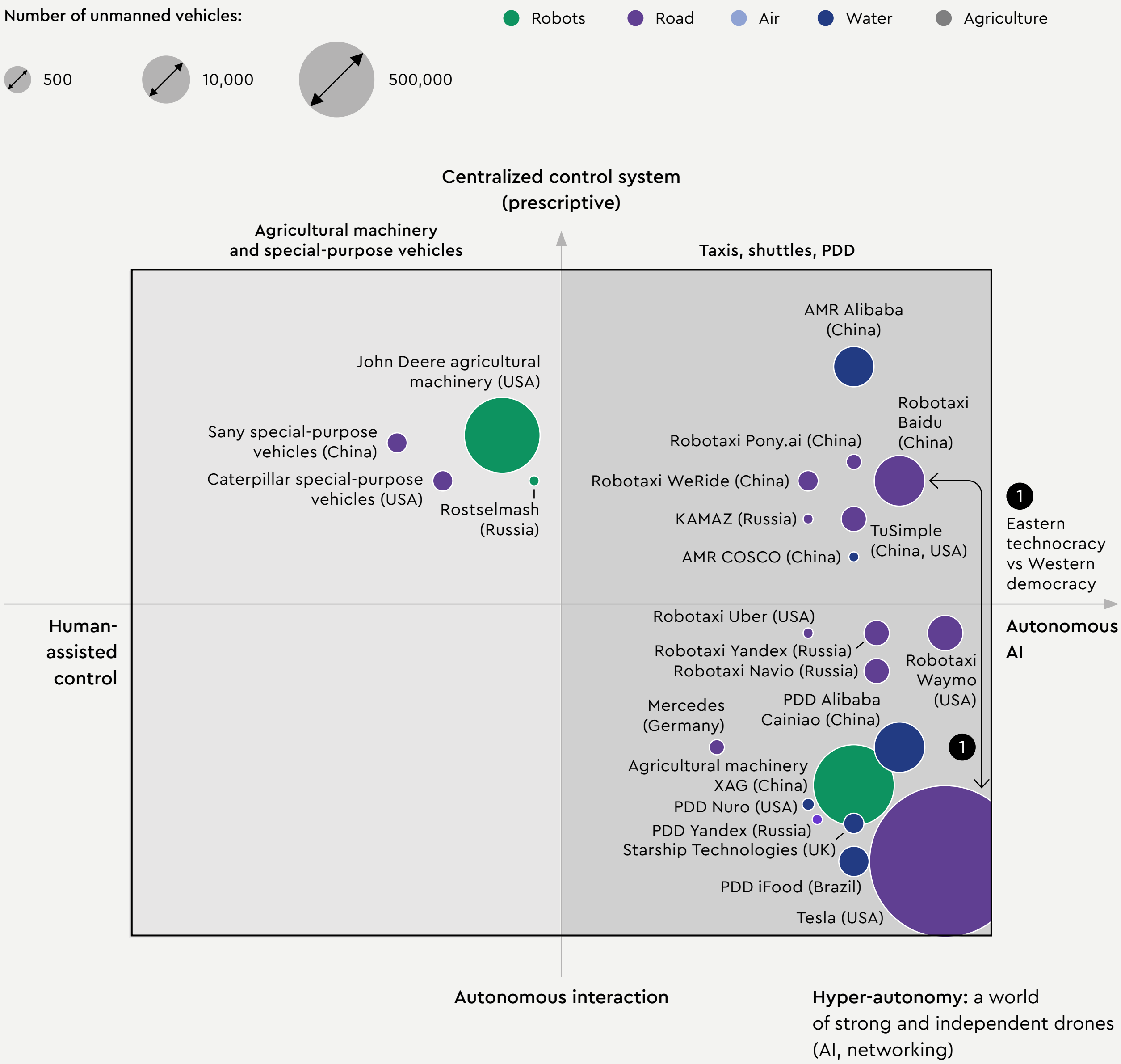
As they evolve, self-driving vehicles will be divided into two types – fully autonomous and connected, relying on interaction with infrastructure (via V2X). The former will be in demand for rural and inter-regional travel, the latter in cities with developed infrastructure equipped with V2X technologies.

The drone control system is designed to sense the environment, communicate with infrastructure and other drones, make decisions, and transmit control signals. In terms of sensor technology, capabilities that surpass human abilities have already been achieved. The basis for autonomous systems currently includes digital maps and GPS (navigation), cameras/radar (video orientation), and inertial systems ("cerebellum"). In the future, autonomous vehicles may also be equipped with microphones to analyze the sonic environment ("hearing"). In some respects, drones already demonstrate a level of sophistication that surpasses that of humans, and this gap is projected to widen further in the future.

By augmenting these fundamental competencies with the modeling of diverse objects' behavior (akin to intuition) and V2X communication with surrounding vehicles and infrastructure (akin to telepathy), drones will truly be imbued with "superpowers."

Despite the high accuracy of sensors, the primary challenges for the AV technology remain the issues of data integration and real-time data processing, as well as fast online decision-making. This is not always easy for robotic vehicles due to physical limitations, rapidly changing environments, and irrational behavior of other road users.

Drone archetypes



Source: Estimate of Yakov and Partners team

In this environment, technology companies must prioritize the integration of sensor and infrastructure data to develop real-time decision-making algorithms for various changing environments. This includes not only processing visual data, but also analyzing the audio environment and using V2X to share information with other vehicles and infrastructure. It also involves physically modeling and predicting the behavior of the environment.

A global standard for cooperative traffic management could be a viable solution.[26] As more countries adopt this standard, the easier it will be to integrate various autonomous vehicles. Russia has the potential to be a key contributor to the development of such a standard, and could at least define the standards for autonomous driving in our country.

To this end, the government of Russia must take the following measures:

— Develop, approve standards, and define the "rules of the game" for all importers of autonomous vehicles of varying degrees of autonomy;

— Determine the road conditions, technologies, and ethical and legal considerations under which foreign AVs should operate on domestic roads.

Technology companies must:

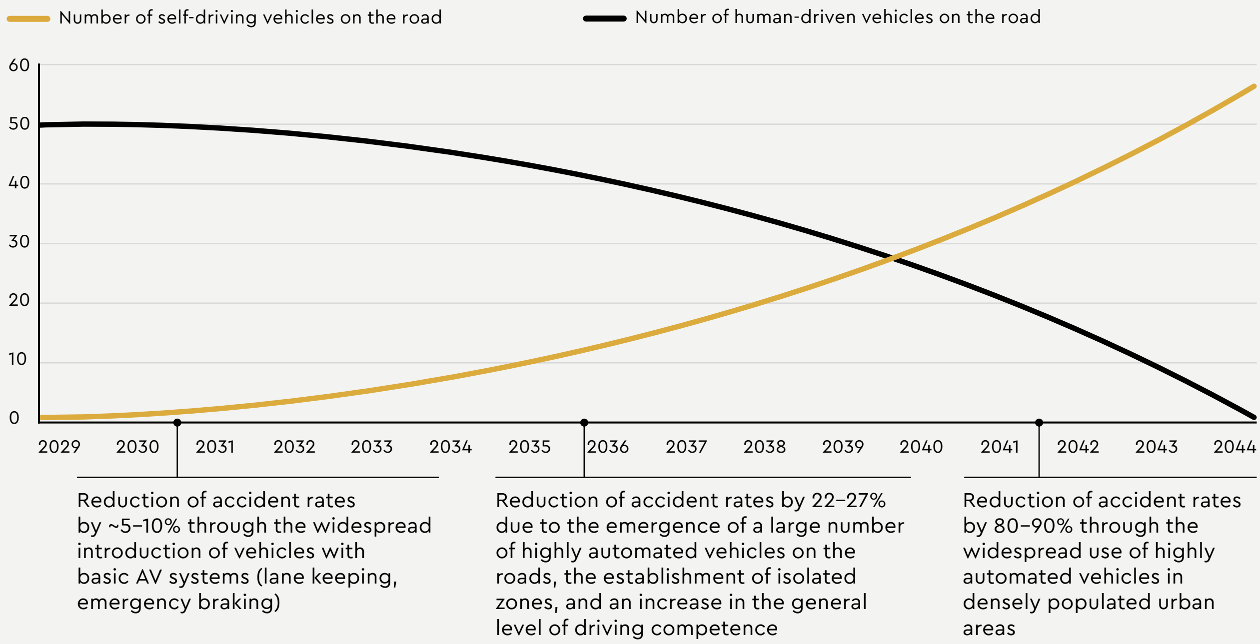
— Expand the range of perceived environmental information (sound, data from smart city/navigation systems, etc.);

— Optimize algorithms for integrating data from different sources;

— Enable the environment to acquire physical properties and characteristics, along with the prediction of possible behaviors.

If a uniform standard is not adopted, the absence of such a standard could result in a "menagerie" of autonomous vehicles on public roads, which may behave even less predictably than human-driven vehicles.

Transition period from human-driven to autonomous transportation in Russia



Source: Estimate of Yakov and Partners team

Drones with personality

Under such conditions, one system may decide that the other road user must yield, while the other one may think the very same thing – the result is inaction and congestion at best, and an accident at worst

Autonomous transportation is not just about technology; it is also about the rules, both formal and informal, that underpin transportation safety. Aviation, shipping, and road transportation have long had their own codes of conduct, from international standards to local unwritten laws. But autonomous vehicles that have been trained to follow strictly defined rules in places as different as China, the United States, India, or Russia may find it difficult to work together. Vehicles that "see" the world through their national algorithms risk not being able to "see eye-to-eye" on the road.

Under such conditions, one system may decide that the other road user must yield, while the other one may think the very same thing – the result is inaction and congestion at best, and an accident at worst.

And the main question remains: Are people ready to entrust their lives to algorithms that may break the rules depending on the circumstances? Should autonomous vehicles obey only formal rules, or should they adapt to real-world conditions and make decisions based on experience and common sense? In the future, people may have to choose between a world in which both humans and machines play strictly by the rules, or a world in which machines learn to live according to the laws of flexibility and adaptability, but sometimes make mistakes.

Behavioral models of autonomous vehicles

For the safe use of autonomous technologies, the industry needs to formulate proven use cases for autonomous vehicles on the road. The models already used in aviation can serve as an example. Airspace is divided into controlled areas, where traffic is managed by controllers, and uncontrolled areas, where pilots rely on visual flight rules (VFR). A similar approach can be applied to AVs: in some zones they can operate autonomously, while in others they can be controlled by external systems such as traffic control room or V2X.

Today, there are three basic scenarios for the safe use of AVs on the road:

— Isolated corridors. AVs operate autonomously in a fully controlled area where there are no other road users. In these conditions, AVs can move according to their own algorithms, minimizing the risk of collisions.

— Rules-based interaction. AVs are considered fully-fledged road users, but their capabilities are limited: they operate strictly according to formal rules and can shut down if the situation exceeds the prescribed capabilities. Other participants take these characteristics into account when interacting with AVs.

— External control. In this use case, an external system, be it a control room, V2X infrastructure, or smart city, is responsible for AV actions. This allows centralized control of AV movement and coordination of its actions with other participants.

Use cases for the safe deployment of autonomous vehicles

Use case	Descriptions	Features
Isolated corridors	AVs operate autonomously in a fully controlled environment where there are no other road users	Minimizing the risk of collisions by avoiding interaction with unpredictable road users
Rules-based interaction	Autonomous vehicles are considered fully-fledged road users, but their capabilities are limited: they operate strictly according to formal rules	AVs follow traffic rules; other road users take into account the specifics of interacting with AVs
External control	An external system, such as a control room, V2X infrastructure, or smart city, is responsible for controlling AV actions and managing AV movement	Centralized control, ability to coordinate with other road users

Source: Estimate of Yakov and Partners team

A centralized smart AV fleet management system has the potential to provide optimal safety and efficiency over time. During the transition period, a phased deployment strategy for drone technology will be essential. However, in the absence of uniform international standards, each AV will interpret rules differently, which could lead to conflicts on the road. Therefore, it is critical for authorities to develop a plan for the adoption of autonomous vehicles.

At the government level:

— define the differences between autonomous, driverless, and intelligent (connected) vehicles. The terms "autonomous",* "driverless",** and "intelligent (connected) vehicle"*** are often used as synonyms, but there are important differences between them;

— develop a deployment strategy for autonomous, driverless, and intelligent (connected) vehicles;

— conduct zoning to identify zones and/or combinations of zones and allowable operating models.

Examples of zoning:

— zones where the use of autonomous (driverless) vehicles only is allowed, e.g., dedicated lanes, routes, corridors;

— zones with an Intelligent Transportation System (ITS): In such areas, unmanned vehicles receive data from the Smart City and Smart Roads systems (for example, about traffic conditions and routes) and follow their instructions. ITS functions like an air traffic controller, coordinating movement and ensuring the safety of unmanned vehicles;

— "priority" zones, where special priority rules are introduced, such as prioritizing autonomous vehicles over other road users;

— V2X zones where guided and driverless vehicles interact with each other, infrastructure, and dispatch systems.

During the transition from manual control to ITS and V2X, an additional communication mechanism is required for guided vehicles to receive advisory information about the trajectory and parameters of AV movement for traffic optimization.

Additionally, visual labeling of AVs will be necessary for shared use zones between conventional vehicles and AVs.

* An autonomous vehicle is a car capable of moving independently without human involvement, using built-in environmental perception systems and decision-making capabilities.

** A driverless vehicle also does not require direct human control but can be under the supervision of a remote operator or operate according to pre-programmed instructions. Thus, drones are not always autonomous.

*** An intelligent (connected) vehicle is a car that exchanges data with other vehicles and infrastructure, enhancing safety and traffic efficiency. It can be manually driven, autonomous, or driverless.

350–390 billion rubles

is the estimated amount of investment required to establish a trusted technology stack of AV technologies

Source: open sources,
Yakov and Partners analysis

Risks in the absence of import substitution

Over 50% of the cost is allocated to software, algorithms, and safety systems, with 30% designated for chips, communications, navigation, and other electronic components

In the automotive driverless technology industry, the cost of software, algorithms, and safety systems accounts for over 50% of the total expenditure, while the procurement of chips, communication systems, navigation devices, and other electronic components constitutes another 30%. In light of these figures, ensuring the confidentiality of information during the development of the domestic industry becomes paramount. To this end, it is essential that all manufacturing processes be conducted within Russia.

AV control protocols and data are strategic assets, and their protection is critical to ensure national security. To develop and implement fully-fledged autonomous systems, Russia needs to develop sovereign software and trusted chips. Having sovereignty in this area ensures security, independence, and competitive advantages in the global market.

Investment in the development of a trusted AV technology stack for road vehicles is estimated at RUB 350–390 bn.

The absence of fully domestic software and microelectronics for autonomous vehicles leaves the industry susceptible to external interference and international restrictions. The opportunity lies in the development of domestic technology to establish a sustainable and independent AV ecosystem, ensuring data confidentiality and national security.

This is also evidenced by established global practices. In China, all smart vehicles must use domestic cloud services to transfer data so that sensitive information remains within the country. The National Data Administration (NDA) of the PRC has unveiled a three-year action plan for data utilization, including support for the development and training of artificial intelligence models.[27] China plans to develop more than 100 standards to ensure the security and cybersecurity of autonomous vehicles by 2025.

Conclusion. At the crossroads of a self-driving future

Today, we find ourselves at a critical juncture in the development of transportation in Russia. The decisions we make today will shape the future of transportation in our country. There are two potential scenarios: one characterized by disorder and risk, and the other by thoughtful planning and technological innovation.

Apocalyptic scenario

In this future, consumers continue to purchase vehicles according to their financial means, ranging from older, rusty clunkers to the latest in autonomous vehicle technology. All vehicle types coexist on Russian roads, but their interaction remains at the level of current standards. Different manufacturers train AVs in their own way, and without a centralized standard, each vehicle "speaks" its own language. Roads become a site for algorithm conflict: imagine a Chinese-trained drone, an American system, and an Indian autonomous car meeting on the same road. Confusion and mistrust lead to chaos, and safety remains at the same, low level. If left to fester, the result will be a mess on the roads where AVs and conventional vehicles just cannot coexist. This is a risky course of action, as it comes with a lack of reliability and clear rules.

Futuristic scenario

Imagine a different world – one that is orderly and efficient. In this future, AVs are an integral part of our daily lives, from shared media vehicles that safely transport children to their schools to mobile offices that allow us to work productively on the go. Personal cybercars are capable of transporting owners out of town on their own. To make this future a reality, we are developing traffic standards, certifying algorithms, and creating digital twins that allow vehicles to share data and warn each other of potential threats. In this world, Russian AVs are equipped with reliable and safe algorithms developed in accordance with national standards, and our roads are becoming an example of thoughtful automation and safety.

These two scenarios are not merely hypothetical; they are realistic future possibilities. The course of autonomous transportation in Russia is contingent on the decisions made today. The choice is ours, but we must act promptly to chart a course and seize the opportunity to create a safe and technologically advanced future on our roads. Which path will we choose?

Recommendations for the development of autonomous transportation

We have identified five priority areas that are essential for achieving the maximum growth of the AV market in Russia:

— Further refining the current legislative framework and associated legal initiatives to encourage the evolution and evaluation of AV technologies.

— Developing and defining the "rules of the game" for all AV importers of varying degrees of autonomy.

— Constructing new and modernizing existing infrastructure to promote widespread adoption of AVs on Russian roads.

— Developing a global standard to establish self-developing digital twin environments and their exchange between AVs and other vehicles, ensuring the standard's uniformity across all nations, with Russia potentially serving as a key initiator of the agreement.

— Creating domestic software for AV operation is crucial, as the use of foreign software may pose significant security risks, including the potential disruption of vehicle operations by external entities or a malicious attack that could turn a vehicle into a "controlled bomb." However, the use of foreign software is permissible under the condition that data transfer is prohibited.

The above conditions have the potential to position the country as a leader in this field. However, the key to success will be a flexible and highly adaptive approach to the interaction between the government and the industry. Achieving this will require a close collaboration between government agencies and major domestic companies. This partnership will be essential for developing a unified approach to development. Such an approach will ensure technological sovereignty and lay the foundation for promoting Russian autonomous systems in foreign markets. The experience gained from these efforts can be applied to other sectors in the future, including aviation, manufacturing, agriculture, construction, and other sectors of the economy.

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Robots at the wheel: Outlook for the transition to self-driving vehicles in Russia

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