Autonomous vehicle readiness ranking

Research

→ January, 2025

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Autonomous vehicle readiness ranking

This ranking has been prepared to assess the readiness of the countries for the introduction of autonomous vehicles. Three sets of criteria were used for the assessment, which allow countries to be compared on such parameters, as government policy in the area of transport digitalization, infrastructure readiness, production and technology development, and consumer readiness to change the way they interact with the vehicle. While the current development of autonomous transport technologies does not suggest that unmanned cars will be widely used on city streets and highways tomorrow, the compilation of the ranking allows us to, first of all, identify the barriers that will limit the penetration of autonomous vehicles when the technologies allow for their mass use. Thus, country's failure to produce cars or components for autonomous transport can be compensated by importing finished products. However, autonomous vehicles will require appropriate road and technology infrastructure, which will take more time and investment to create. In this context, China, which tops the rankings, shows a success story by prioritizing the development of advanced technologies in its national strategy. The high penetration of electric vehicle in China can be seen as a basis for the introduction of autonomous transport at a later stage. A similar path is being implemented by Russia, Brazil, Singapore, UAE and Saudi Arabia, where full-fledged testing of cars and trucks is underway. The lower rankings of Malaysia, Indonesia, Turkey and India, on the other hand, are mainly due to the lack of direct government funding and government strategy for AV development and production. The ranking of countries from 11 to 15 suggests that the development of autonomous transport is not a priority, although the conditions for future development are in place.

RANKING	COUNTRY	SCORE
1	China	62.4
2	Russia	57.5
3	Brazil	54.0
4	Singapore	54.0
5	UAE	52.3
6	Malaysia	51.6
7	Saudi Arabia	50.8
8	Indonesia	49.5
9	Turkey	48.8
10	India	47.6
11	Egypt	47.2
12	Serbia	46.5
13	South Africa	42.9
14	Kazakhstan	42.9
15	Azerbaijan	40.7

Levels of Driving Automation

LEVEL 0 No Driving Automation

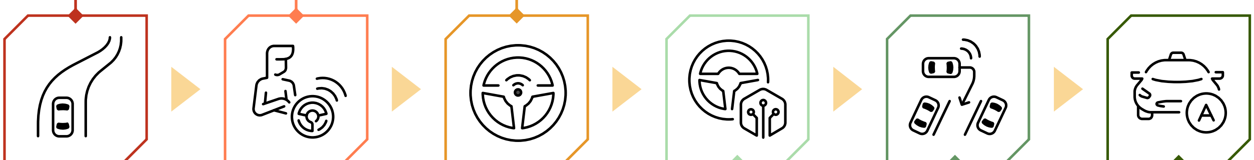
The driver is 100% responsible for driving. Automatic driver assistants only warn of danger or assist in emergency situations. This includes automatic emergency braking (AEB), blind spot monitoring and Lane Departure Warning System (LDWS).

LEVEL 1 Driver Assistance

The driver operates the vehicle independently. The driver assistance system is capable of controlling either the steering wheel or acceleration and braking. Examples of such systems are lane keeping system and adaptive cruise control.

LEVEL 2 Partial Driver Assistance

Advanced Driver Assistance System (ADAS) is a state-of-the-art driver assistance system. It allows “hands-free” ride under certain circumstances. The autopilot is capable of controlling turns, acceleration and braking. If necessary, the driver should be ready to take control at any time.



LEVEL 3 Conditional Driving Automation

The system can control the movement of the vehicle as long as it stays within the geographic area in which it was trained. The role of the driver is to provide backup. At the third level, the automation system can completely replace the driver in certain situations, such as in a traffic jam or on a high-speed highway. When such an area ends, the driver has to take control of the vehicle. This category includes, for example, traffic assistant in traffic jams, autonomous parking function and other similar functions.

LEVEL 4 High Driving Automation

The system works without a driver as long as the vehicle remains within the geographic area in which it was trained. The driver does not participate in driving, but must be ready to take control of the vehicle if need be. In case of emergency, the car will stop at the side of the road. Examples of Level 4 automation include Google (Waymo), Yandex, and GM (Cruise) test vehicles that can autonomously navigate the roads on which the system has been trained.

LEVEL 5 Full Driving Automation

No human intervention is necessary during the driving process. The car makes decision on its own, the steering wheel may be missing. The Level 5 automation system enables unmanned driving on all types of roads and in any conditions, as if the car were piloted by a driver.

Source: Society of Automotive Engineers, SAE

Autonomous vehicle (AV) development milestones

2021

Mercedes-Benz

Mercedes-Benz launched the sales of vehicles with the Drive Pilot solution in Germany, following approval for the introduction of the Level 3 autonomous driving system at the end of 2021

2022

Road Safety Regulation

In July 2022, the European Commission adopted a new Road Safety Regulation that, for the first time, establishes a legal framework for the use of unmanned vehicles on public roads

Audi

Audi is testing autonomous vehicles with Vehicle-to-Everything (V2X) feature in China, a system to exchange information between a vehicle and the environment

2023

The Swedish Transport Agency

The Swedish Transport Agency issues permit to test automated vehicles on public roads

Pony.ai

In April 2023, Chinese-American startup Pony.ai became the first in China to receive permission from the authorities of Guangzhou to test a fully autonomous robot taxi on an 803 sq. km area in Nansha district

WeRide

The UAE issued the first national license to operate unmanned vehicles on the country's roads to WeRide, a leading developer of Level 4 autonomous driving technology headquartered in China

Yandex SDG

In June 2023, Russian company Yandex SDG launched a robot taxi in Moscow. At the first stage, taxis appeared in Yasenevo, an administrative district of Moscow

Safety requirements

In December 2023, China approved national safety requirements for self-driving cars

Source: mass media data

Autonomous vehicle (AV) development milestones

2024

Baidu and Pony.ai

In February 2024, Baidu and Pony.ai received permits to provide driverless passenger transportation services in Beijing

Mercedes-Benz

Mercedes-Benz is the first car manufacturer in the world to start commercial sales of cars with advanced autopilot (that does not require constant control of the road). The sales were launched in the USA

Audi

Audi signed agreement with US-based company Applied Intuition to co-develop automated driving systems

Tesla

Tesla offered US customers a free trial of its more advanced autonomous driving function Full Self Driving

Waymo robot taxi

Phoenix, Los Angeles and San Francisco (the USA) launched Waymo robot taxi services without a standby driver

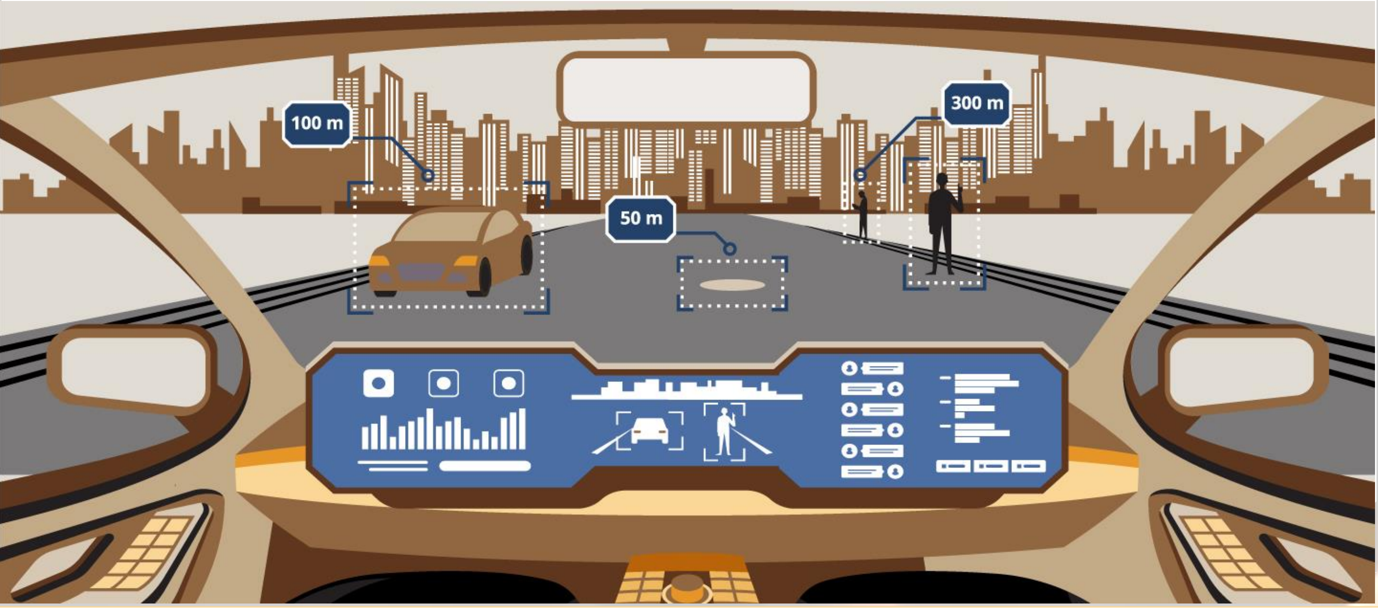
Baidu

Chinese manufacturer Baidu's unmanned taxis operate in Wuhan over an area of 3000 sq. km, covering more than a third of the city, including part of the city center

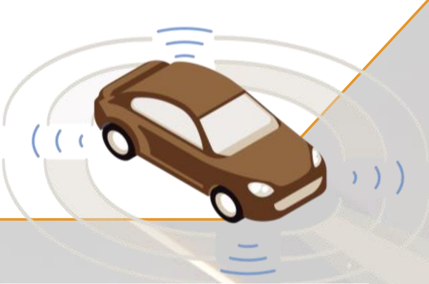
KAMAZ and Navio

16 self-driving trucks produced by KAMAZ and Navio (ex. Avtoteh) were launched on the Neva M-11 highway in Russia

Source: mass media data



Prerequisites for implementing autonomous vehicles



SAFETY

The adoption of autonomous vehicles is expected to potentially help reduce road traffic accidents. Statistics show that the human factor is responsible for 90–95% of traffic accidents worldwide. According to the Increasing the level of autonomy and improving AV control algorithms will reduce the impact of the human factor in driving. The algorithm will follow the safe driving mode by default and stop the car if safety conditions are not met.

COST REDUCTION

In turn, the growth of car sharing services will increase the utilization of the vehicle and ensure a more rational use of transport and energy. Currently in Russia the driver is paid 12–15% of the cost of cargo transportation. The introduction of self-driving cars will reduce personnel costs and, according to the Ministry of Transport of Russia, increase the commercial speed of delivery of goods by 25% and reduce transportation costs by more than 10% by 2030. It is expected that the development of AV technologies and more widespread use of unmanned vehicles will reduce the cost of one kilometer of robot taxi in Russia by more than 50% in the period from 2025 to 2030.

IMPROVED QUALITY OF THE URBAN ENVIRONMENT

The introduction of autonomous vehicles will not only turn the driver into a passenger, but may also further increase the share of vehicles used under the car sharing model. In 2021–2023, the car sharing and kick sharing in Russia grew from 6% to 9%, in total, and may potentially reach 20–25% by 2030, according to various estimates. Pursuant to research studies in Europe, one shared car can replace 12–15 of private cars on the road, which will have a significant impact on the urban landscape and infrastructure. Thus, AV development will not only lead to a renewal of private cars, but also to a partial replacement of private cars by public transport with autonomous driving function.

TIME SAVING

AV systems can make traveling more enjoyable and free up time on the road for communication, entertainment, or work. Currently, 43% of Moscow residents spend from 30 to 60 minutes commuting to work, and another 25% – less than 30 minutes. 27% need 1–2 hours to get to work. The average commuting time on a weekday is 47.9 minutes in Beijing, 33.2 minutes in New York, and 30 minutes in Paris. More than half of Moscow car owners (58.5%) use their cars up to 2 hours a day on average. In the US and Europe, this indicator reached 1 hour per day in 2019.

Source: mass media data

Barriers to autonomous transportation adoption

There are certain barriers that currently hinder the penetration of autonomous vehicles (level 3 and above):

01. Statistical confirmation

Need for statistical confirmation of the safety of using autonomous transportation on public roads. Before AV mass adoption begins, it is necessary to ensure that the AV is able to receive, analyze, and correctly interpret data about the external environment based on a statistically significant volume of research in different areas, on different roads, in different weather and climatic conditions.

02. Mass production of technical devices

Lack of mass production of technical devices necessary for the operation of autonomous vehicles. The technologies currently being tested are expensive and not intended for commercial production, so their use for the purposes of the tested AVs is limited. Such solutions should be launched for large-scale production and widespread adoption to achieve economic viability.

03. Economic feasibility

Need to confirm the economic feasibility of AV: the cost of owning an autonomous vehicle should be comparable to the cost of using a conventional car with a driver, and should be cost-competitive when choosing a mode of transportation or travel.

04. AV infrastructure

Low development level of AV infrastructure – roads and technologies. The development of AVs requires not only high-quality roads, but also an IT infrastructure that ensures the fast and reliable transfer of large amounts of information and strong data protection.

05. Legislation

No legislation regarding AVs on public roads. Only 7 of the 15 countries surveyed have legal regulations governing the use of AV at this stage of development. This is due to the lack of practical experience with the use of AVs on the road; and without proper regulation, the introduction of AVs will be subject to risks that are more likely to lead to the abandonment of AVs than to their successful implementation.

06. User mistrust

User mistrust, which may diminish as AVs become more popular, justified by statistically proven safety of unmanned vehicles and legal regulation of this market. AV users should be confident that AVs provide the required safety, reliability and accountability.

07. The readiness

The readiness of road traffic participants for changes in the vehicle usage model. While the introduction of AV in commercial and public transport is not related to changing user preferences, in the private car sector, AVs are most likely to develop according to an AV sharing model, which is unusual for users (as taxi or car sharing services), with a central operator responsible for vehicle behavior.

Source: mass media data

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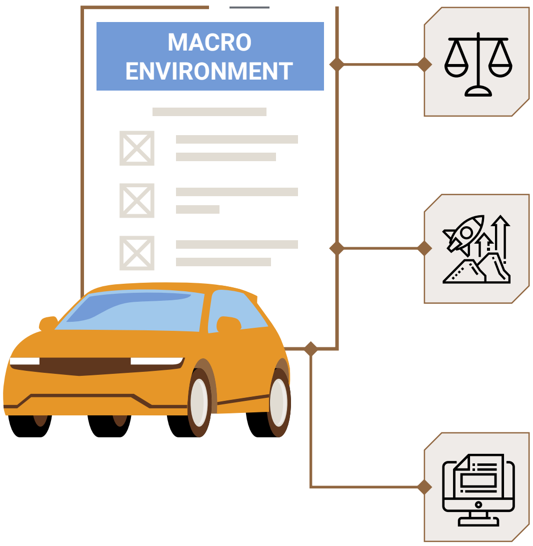
Macro environment readiness for autonomous vehicle adoption



Legal regulation

- Autonomous vehicle development strategies
- AV legal regulation

Infrastructure and technology development

- Assessment of the level of transport infrastructure development
- Assessment of the level of information and telecommunications technologies

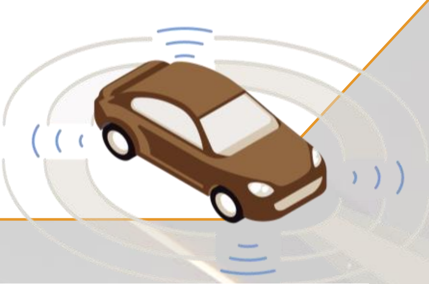
Household income

- Assessment of household income to afford autonomous vehicles

MACRO ENVIRONMENT READINESS RANKING

1	China
2	Russia
3	Brazil
4	Saudi Arabia
5	UAE, Indonesia, Malaysia, Singapore
6	South Africa
7	Kazakhstan
8	Serbia
9	Turkey, Azerbaijan
10	India, Egypt

Leaders in macro environment readiness



China

China is one of the leading countries in AV development. China has one of the highest levels of digital infrastructure readiness in the world, in addition to implementing an AV development program. The country has been testing autonomous vehicles, including public transport, for several years. Since 2022 China has also been testing AVs on public roads. Along with the rapid development of electric vehicles, the transition to AVs seems like a natural and expected next step in the evolution of the transportation system. The current focus of AV implementation in China is the adoption of laws regulating the operation of autonomous vehicles, taking into account the accumulated experience of the practical use of autonomous vehicles in certain cities.

Brazil

Brazil is among the leaders in this category scoring the maximum in all criteria except household income and road infrastructure readiness. In recent years, the Brazilian government has made efforts to develop innovative transport, including through the implementation of the ROTA 2030 and MoVer programs. These programs are designed to promote the development and use of electric vehicles and the modernization of transport infrastructure. As a result, the country has been successful in promoting electric vehicles and, together with Chinese car manufacturers, built production facilities for electric vehicles and batteries, which may further contribute to the introduction of autonomous vehicles.

Russia

Russia is one of the leaders in the AV readiness of the macro environment. The development of AV technologies is an element of the long-term development strategy of the transport industry in Russia. The regulatory environment aims to control AV testing in dedicated zones and the allocation of test lanes on public roads. In addition, the government is in the process of drafting legislation that will introduce AV regulations as unmanned vehicles are adopted. Russia's leading positions are supported by a high level of development of information and telecommunications technologies and road infrastructure, which allows the use of AV in the main transport corridors and in megacities. At the same time, the level of household income suggests that AVs will be in demand as a competitive offering emerges.

Saudi Arabia

Saudi Arabia's leading position is the result of the implementation of the Vision 2030 strategic program in the country. As part of the Strategy, the relevant authorities have developed and implement sectoral programs. In particular, the General Department of Traffic of Saudi Arabia has developed a program to prepare the Kingdom's transport network for the operation of unmanned vehicles. The Department also prepared amendments to traffic rules, updated environmental requirements, safety standards and police regulations. The new standards will apply to the design, construction and operation of all types of roads and streets and will be mandatory from 2025. The assessment of household income adequacy suggests that as technology advances and autonomous vehicles become more widely available, they will be in demand by the population.

Source: mass media data

Leaders in macro environment readiness

UAE

The UAE is emerging as a global leader in intelligent and autonomous vehicles and systems. The country has been consistently implementing the Net Zero 2050 strategic initiative, which, among other things, aims to spread electric vehicles and autonomous transport, both personal and public. As part of the overall strategy, some emirates are adopting their own programs based on the needs of the cities and setting targets for the introduction of autonomous transport.
The UAE is developing a road network that meets the requirements for unmanned vehicles, has a high level of digitalization, which, coupled with the high income level of the population, will enable the rapid penetration of autonomous vehicles on the roads as the products become mainstream.

Singapore

Singapore has historically been one of the world leaders in the development of autonomous vehicle technologies and readiness for its implementation. Singapore’s Land Transport Master Plan 2040 roadmap and legal regulations determine the development, testing and implementation of autonomous vehicles. Singapore has set a national AV standard called Technical Reference 68 (TR 68), which is a guideline for the safe introduction of autopilot vehicles on the country's roads. The document describes principles concerning vehicle management, implementation of safety and data protection measures, and prescribes data formats for connected vehicles. Singapore leads the surveyed countries in terms of readiness of digital infrastructure and society for autonomous transport with the Network Readiness Index (NRI) score of 77. When assessing road infrastructure readiness, it is necessary to take into account the peculiarities of Singapore's urban transport network, which is characterized by the limited total area of the country and the correspondingly shorter length of roads compared to the other countries analyzed.

Source: mass media data

Autonomous vehicle development strategies

AVAILABLE

The following countries have an autonomous transport development strategy, either as a separate document or as part of their transport development strategy:

Russia	Kazakhstan
Azerbaijan	Brazil
China	South Africa
UAE	Saudi Arabia
Singapore	Malaysia
Indonesia	

UNAVAILABLE

India	Turkey
Serbia	Egypt

The introduction of autonomous vehicles is impossible without the participation of the state:

- the transport industry is a backbone industry in any country. Changes in the transport industry affect the activities of other sectors and the population;
- the work and development of transport involves a significant number of participants, whose interests can be united and synchronized only at a higher level – the level of the state.

The strategic program for the development of unmanned vehicles defines key milestones in the main areas of transformation:

- road and technology infrastructure
- autonomous vehicle legal environment
- support for manufacturers and technology developers

In cooperation with industry experts, represented by car manufacturers, infrastructure operators and technology companies, the government works out the areas of development and sets the parameters to be met by vehicles, roads and technology infrastructure. Investors are able to track how projects perform against strategic parameters.

Autonomous vehicle development strategies

Russia | Russian Transport Strategy until 2030

Russia is actively developing AV technology initiatives as part of the digital transformation of the transport industry. The areas of development and implementation of digital technologies are defined in the Transport Strategy, which includes actions until 2030 with a forecast until 2035. The strategy includes the following areas for the development of autonomous vehicles:

- development of infrastructure for unmanned freight vehicles (digital equipment on the Neva M11 highway)
- digital transformation of all types of transport (implementation of integrated transport services, electronic platforms to order freight, logistics and e-commerce services)
- increased investment in the road industry in 2025–2030, with a focus on developing backbone network of roads, high-speed roads and highways
- increased investments in urban transport throughout the forecast period to 2035

China | Technology Roadmap for Intelligent & Connected Vehicles 2.0

Government targets:

- use autonomous vehicles in some Chinese cities (primarily Beijing, Shanghai, Shenzhen, Wuhan and Guangzhou) by 2030. By 2035 – in most regions

The program has been in effect since 2021 and aims to:

- upgrade China's industrial potential through the development of new energy vehicles, information technology (IT), robotics, and artificial intelligence
- develop regulatory measures for testing on public roads in accordance with the National Road Testing Manual

As part of the national program:

- support is provided for AV small and medium-sized enterprises through subsidies, low-interest loans and bonds from state-owned banks
- significant resources are invested in the upgrade of technologies from state funds: USD 3 billion from Advanced Manufacturing Fund and USD 21 billion from National Integrated Circuit Fund

Source: mass media, legal regulations of the respective countries

Autonomous vehicle development strategies

UAE | Dubai Autonomous Transportation Strategy and Abu Dhabi Surface Transport Master Plan

Autonomous vehicles and new mobility are being developed as part of strategic initiatives in Dubai and Abu Dhabi.

The Dubai Autonomous Transportation Strategy involves the introduction of AV in various types of transport in Dubai, including taxis and buses. Strategy goals:

- By 2030, 25% of public transport will be autonomous vehicles;
- Achieving time savings of up to 396 million hours per year;
- Reducing parking space requirements;
- Revenue increase to AED 22 million annually;
- Reducing government transportation costs by 44% to save up to AED 900 million per year.
- In addition, the Roads and Transport Authority in Dubai also plans to introduce 4,000 AVs for taxi services by 2030.

Abu Dhabi has Abu Dhabi Surface Transport Master Plan in place that aims to improve the transport system and mobility, including the introduction of autonomous vehicles. The Abu Dhabi Integrated Transport Center is developing an AV regulatory framework and a roadmap that includes the introduction of all types of unmanned vehicles into the Abu Dhabi transportation system.

The UAE invests in intelligent transport system and intelligent road infrastructure technologies, which contributes to the sustainable development of the region's transport network.

Saudi Arabia | Vision 2030

AV development in Saudi Arabia is an element of the implementation of the National Transport and Logistics Strategy as part of the Vision 2030 strategic program.

The development of autonomous vehicles involves the following steps:

- Building an AV regulatory framework;
- Establishing the rules and licensing requirements for the testing and commercial use of AVs;
- Improving transport and digital infrastructure;
- Attracting investments and increasing AV competitiveness;
- Increasing public awareness and confidence in the use of AV.

During the implementation of the pilot projects it is planned to:

- prepare the infrastructure for AV testing to collect data, improve technologies and assess AV performance in different conditions;
- develop AV infrastructure security and cybersecurity requirements.

The sovereign wealth fund of Saudi Arabia established a National Automotive and Mobility Investment Company to develop autonomous vehicles. The goal for 2030 is 15% autonomous public transport.

Autonomous vehicle development strategies

Brazil | MoVer and ROTA 2030

Brazil has launched MoVer and ROTA 2030 programs under the government's strategy to develop the automotive sector.

Government targets:

- improved technological efficiency of vehicles;
- encouraging R&D investments.

These programs include the ubiquitous deployment of 5G technology in Brazil by 2029, which will enable faster and more accurate data exchange to perform more complex functions.

South Africa | Green Transport Strategy for South Africa program

South Africa is implementing the Green Transport Strategy for South Africa program: (2018–2050), which involves intensive development of the transport industry through:

- road infrastructure development;
- digitalization – introduction of AI technologies, expansion of communication networks;
- increase in production capacity and launch of New Energy Vehicle (NEV) production;
- autonomous vehicle testing and adoption

India and Turkey

India and Turkey do not currently have any national AV development programs. However, countries are introducing artificial intelligence technologies as part of the Digital India strategic campaign and the Milli Teknoloji Hamlesi program in Turkey, which may serve as the basis for the introduction of autonomous transport in the future.

CIS

The development of national unmanned vehicle policies is still at an early stage in the CIS countries. Some countries are taking the first steps toward autonomous transport:

Kazakhstan: preparation of the infrastructure for the introduction of self-driving vehicles is underway as part of the Concept for Development of Transport and Logistics Potential of the Republic of Kazakhstan 2030. The Ministry of Transport continues to work on building a national intelligent transport system (ITS), linking existing information systems, hardware and software systems and future digital projects on big data processing, analysis and monitoring of the transport network. At the initial stage, the ITS will cover road freight transport and, at a later stage, other modes of transport as well.

- **Azerbaijan:** the state road safety program in Azerbaijan for 2019–2023 provides for the development of unmanned urban passenger vehicles, but currently there are no official reports on the introduction of such modes of transport into mass use.

Source: mass media, legal regulations of the respective countries

Legal regulation of autonomous vehicles

Autonomous vehicle legal regulations have been adopted

Russia	UAE
Brazil	Singapore
Indonesia	Malaysia
Serbia	

Developed in

China	South Africa
Saudi Arabia	

Not available

India	Turkey
Kazakhstan	Egypt
Azerbaijan	Singapore

In order to ensure the further implementation of self-driving vehicles in the urban environment, a legal environment should be created that determines the following aspects of the autonomous vehicle penetration:

AV technologies

The legislative regulation of the autonomous vehicle development should define the framework of the used technologies and establish requirements for manufacturers, with the primary aim of ensuring the safety of AVs.

Road and technological infrastructure

Artificial intelligence control system is at the core of the autonomous vehicle. Legislation should provide for liability in the event of failure or error, ensure compensation for victims and establish measures to improve the safety of technology. In terms of infrastructure development, the legislation establishes regulatory requirements for road infrastructure to enable the operation of AV on public roads and to ensure the interaction of the AV control system with the surrounding road environment

Relations between AV users

The key issue in relations between market participants is determining liability arising from accidents or emergencies.

Legal regulation of autonomous vehicles

Russia

Testing of technologies and solutions under experimental legal regimes is a peculiarity of unmanned vehicle development in Russia. This approach allows for the wide-scale operation of self-driving vehicles without waiting for the development and adoption of a large number of regulations, while at the same time working out different business models.

- Resolution of the Government of the Russian Federation No. 1415 dated 26 November 2018 "On Conducting an Experiment on the Pilot Operation of Highly Automated Vehicles on Public Roads" determines the procedure and terms and conditions for safe testing of AVs on public roads.
- The experimental legal regime for AV testing on the M11 Neva highway is aimed at stimulating the modernization of road infrastructure.

The draft of the federal law "On Highly Automated Vehicles" is being finalized. The law will establish federal regulations for AV operations and focus on improving traffic safety and comfort.

UAE

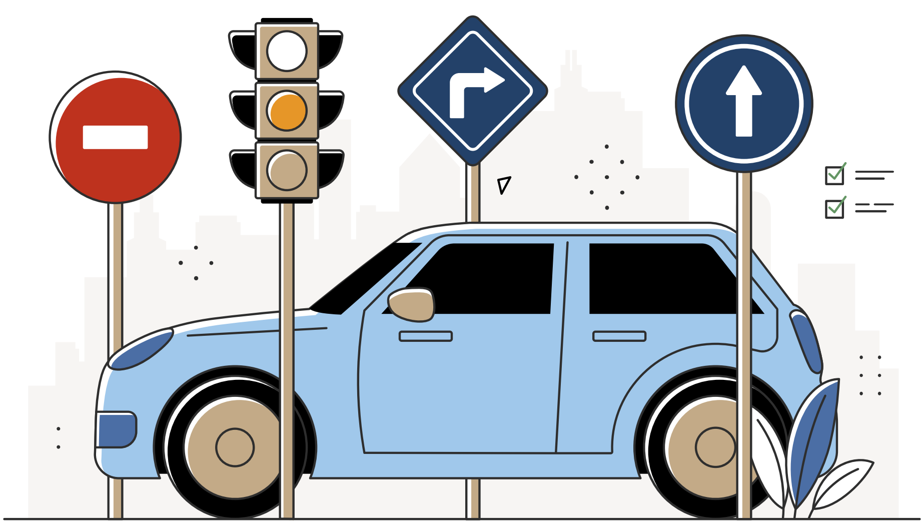
Dubai Law No. 9 of 2023:

- regulates the operation of autonomous vehicles
- defines the conditions for obtaining an autonomous vehicle license
- addresses regulatory issues arising from the use of artificial intelligence in transportation
- promotes safety for all road users

Saudi Arabia

The Saudi Road Code is in the test implementation stage and is expected to help optimize road quality, safety and security of autonomous vehicles in the Kingdom.

Testing will be completed by the end of 2024. From the beginning of 2025, the Code will be mandatory for all government institutions.



Sources: mass media, legal regulations of the respective countries

Legal regulation of autonomous vehicles

China

Currently, China does not have a single law that regulates the functioning of autonomous vehicles. There are separate legislative initiatives for the regulation of AV usage, primarily for safety reasons.

At the initiative of the Ministry of Industry and Information Technology, local authorities have been given the option of allowing autonomous vehicles to be tested on public roads. To this end, in 2021, the Draft Regulations of Shenzhen have been adopted to increase the number of road tests of autonomous vehicles and demonstrate their application on highways and urban expressways within the Shenzhen special administrative region. The document allows highly automated and fully autonomous vehicles to be tested in driverless mode, provided the vehicle has passed a safety assessment and received approval from the relevant authorities in the Shenzhen region.

The draft regulations primarily define safety and liability requirements in the event of an accident (liability is assigned to AV owner or operator), as well as cybersecurity requirements.

Testing on public roads is permitted for companies that have obtained a license and meet a number of requirements, including:

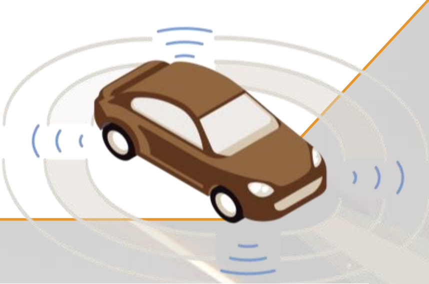
- availability of backup management systems
- continuous monitoring of the vehicle condition
- possibility of human intervention in case of unforeseen situations

In 2022, the Ministry of Transport published a draft directive regulating the autonomous driving industry in terms of public transport. The Ministry encourages the use of AV taxi in restricted traffic conditions. Baidu and Pony.ai unmanned taxis are being tested in restricted areas in Beijing, Shanghai and Shenzhen.

In December 2023, China approved national safety requirements for self-driving cars that apply to all types of unmanned vehicles, including buses, taxis, and trucks. Buses, trams and trucks should have a security operator on board. An operator is also required for taxis of level 3 and above (where the vehicle can move without driver control). Fully autonomous taxis (Level 4, where the car can move independently, take safety measures with notification if unable to make a decision) should be supervised by an observer (at least one remote operator for every three AVs). Freight AVs will only be allowed to make simple trips from the starting point to the place of destination on highways and roads where traffic control is available.

Sources: mass media, legal regulations of the respective countries

Readiness of road infrastructure



The road infrastructure requirements for autonomous vehicles are different from those for conventional cars.

Autonomous vehicles require:

- longitudinal and diagonal road surface marking, several lanes
- regulating road signs
- guide posts and other landmarks
- high quality asphalt pavement
- telecommunications networks (5G, DSRC, WIFI, LTE)
- high-precision maps

Developers and industry representatives claim that modern AVs are designed to operate on the existing road network without modification, and that there is no need to install special equipment on or near roads.

However, in the early stages, the introduction of autonomous vehicles may be more successful on higher quality roads with a separate lane dedicated for autonomous vehicles and with communication networks that can provide the necessary amount of data exchange at high speeds. Such requirements are met in most cases by the roads of national and international importance, which imply:

- four or more lanes
- physical median strip
- interchanges of different levels
- high quality of road surface
- 4th or 5th generation communications coverage
- electric charging stations

The ratio of the length of national and international roads to the total length of paved roads is used as a criterion to assess the readiness of road infrastructure for the introduction of autonomous vehicles. Countries with a higher proportion of national and international roads had higher scores.

The leaders by this criteria are China, Saudi Arabia, India and Brazil.

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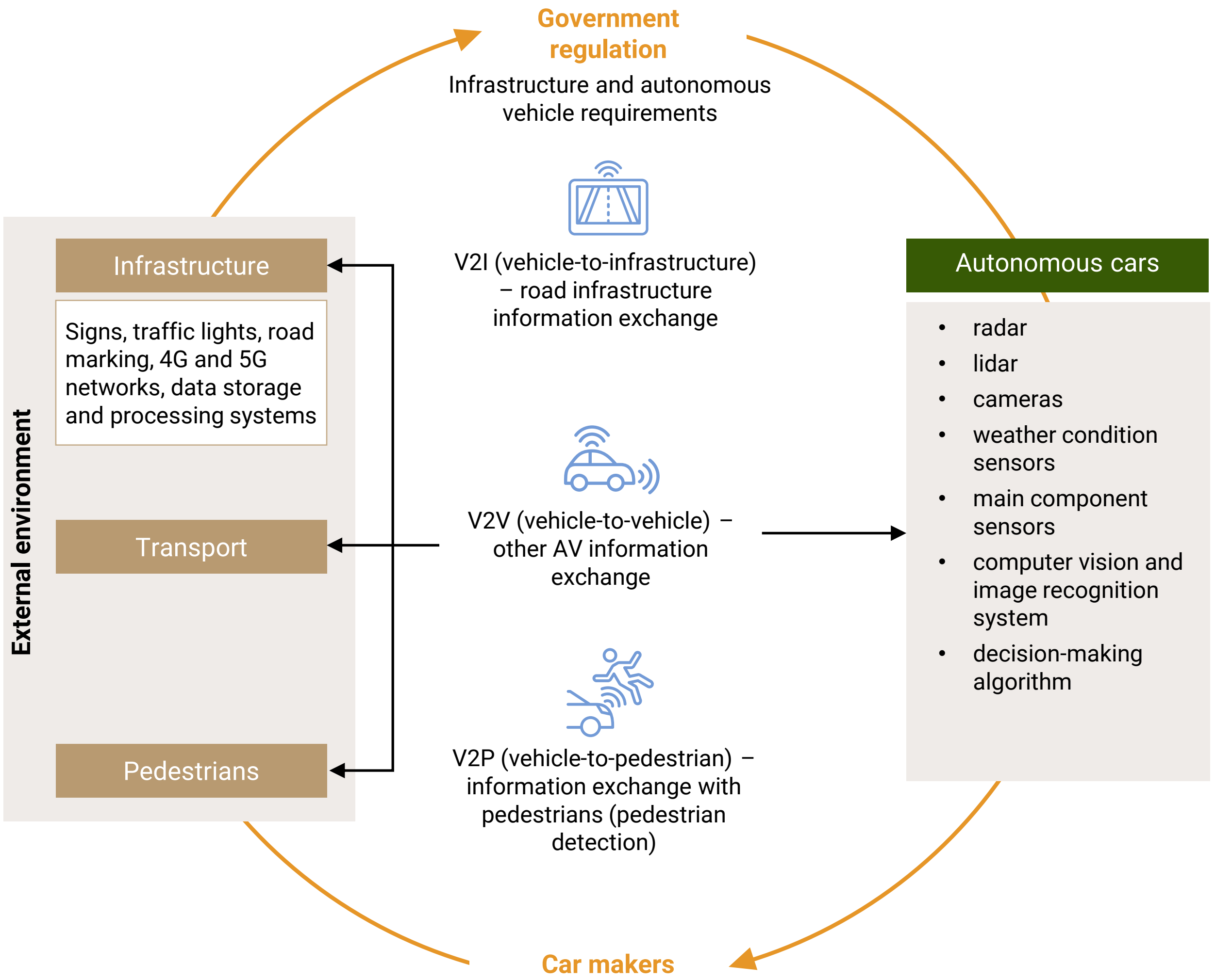
Assessment of technology and society readiness

The introduction of autonomous vehicles depends on the development of infrastructure, the availability of the necessary technologies, and legislation. However, the penetration of unmanned vehicles also depends to a large extent on the level of information and communication technology development in the country and the willingness of people and society to accept the proposed level of transport automation.

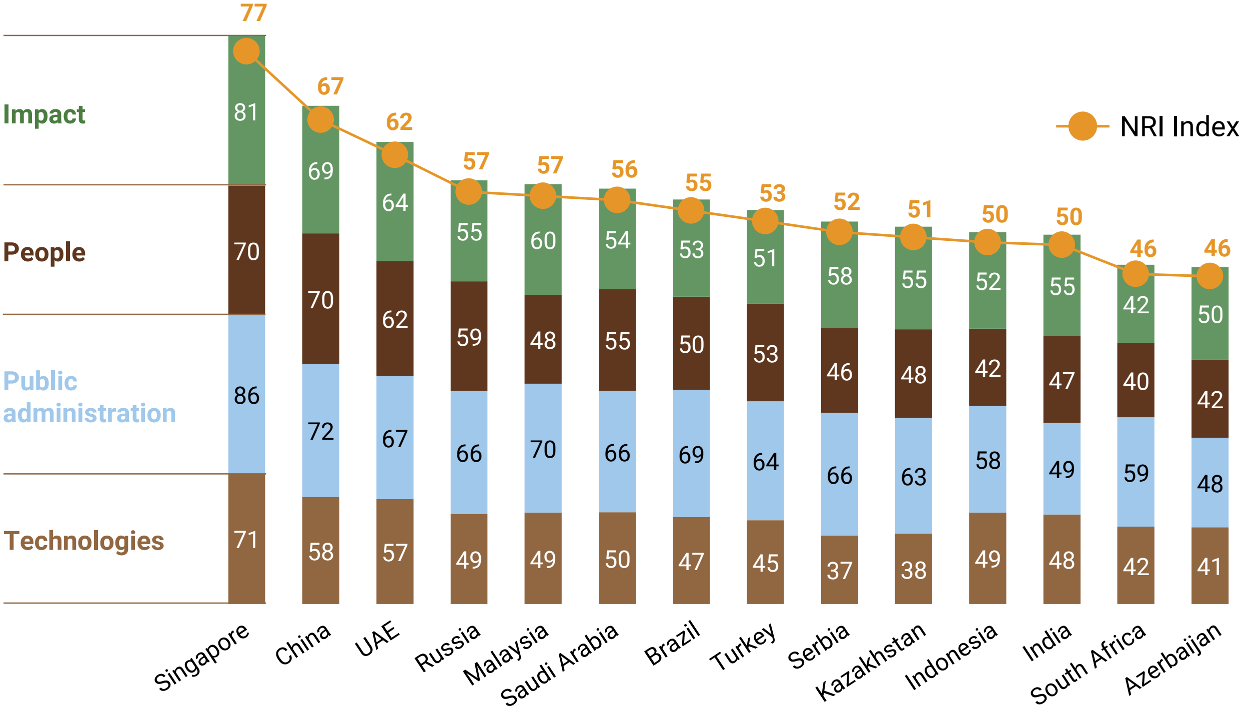
The penetration of self-driving vehicles will require the development of a system that includes vehicles, road infrastructure, 4G and 5G communications networks for data transmission, and big data processing and storage infrastructure.



Assessment of technology and society readiness

The Network Readiness Index (NRI) calculated by the independent research institute Portulans Institute together with the World Innovation, Technology and Services Alliance (WITSA) is used to assess the readiness of technologies and society to adopt unmanned vehicles. The NRI has been in use since 2001 and is an internationally recognized indicator for assessing the innovative and technological potential of countries and their development opportunities in the field of high technologies and the digital economy. The study is also used as an analytical tool to make comparative rankings that reflect the level of society information development in different countries.

Network Readiness Index (NRI data for 2023 were used)



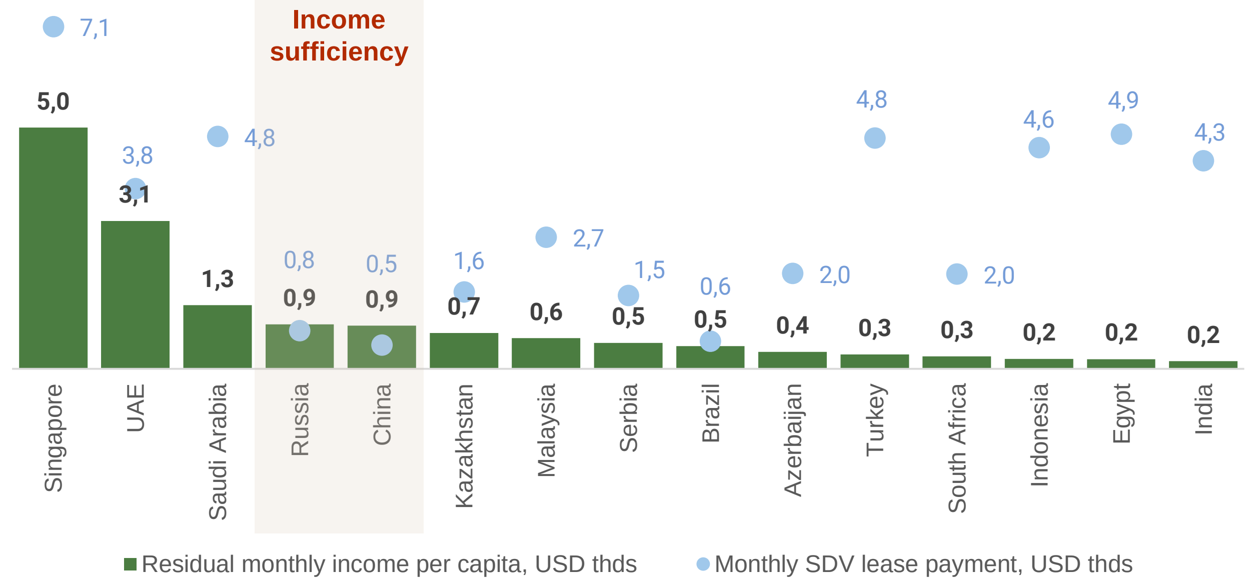
The index is calculated based on the assessment of 62 indicators, which are divided into 4 groups. Each group receives its own score, and the Index value is defined as the average of the group scores:

Technologies	Public administration	People	Impact
Assessment of the country's technological infrastructure	Assessment of the performance of government agencies in the network economy, including on security issues	Assessment of the use of technology by people, businesses and the government, reflecting their skills and engagement in the network economy	Assessment of the network economy impact on the quality of life of the population

Source: Portulans Institute.

Assessment of household income to afford autonomous vehicles

Gross National Income (GNI) per capita data published by the World Bank were used to estimate the adequacy of household income to purchase unmanned vehicles. Since AV, as a non-basic commodity, is only purchased with residual income, the amount of expenses on essential goods was deducted from the GNI (for the purposes of the study, expenses on essential goods are equal to the minimum wage according to legislation or statistics in each country). The resulting residual income in monthly terms was then compared to the monthly lease payment for AV purchase, calculated based on the value of the interest rate and the different lease term equated to the average vehicle age in each country.



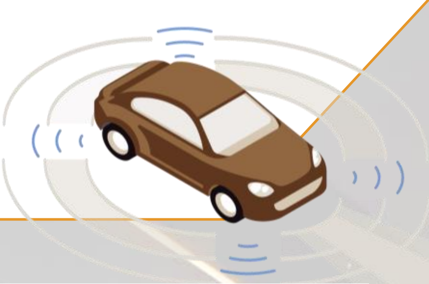
The results of comparing average per capita residual income with monthly AV lease payments show that autonomous vehicles are not yet affordable for the average buyer in the overwhelming majority of countries. This is mainly due to the high cost of the technology and its focus on a narrow premium consumer segment at this stage of development.

Nevertheless, the cost of AV begins to converge with the income of the population, as the level of development of AV production and technology in a country increases (China, Russia, Brazil, UAE). Singapore, also an AV producer, has a peculiar situation with the discrepancy between AV costs and the income of the population; this is due to the government's focus on introducing public unmanned vehicles to replace private cars. So buying a car in Singapore is associated with increased costs, including obtaining a permit to own a car.

Significant differences in the monthly AV lease payment are also due to its dependence on the current cost of AV production, as well as the lease term and the macroeconomic situation in the country, reflected in the value of the interest rate.

Source: the World Bank and open source data.

Development of the industry environment



Assessing the state of development of the industrial environment helps to understand if the existing manufacturing base is ready for mass production of AV. In turn, mass production can begin when the level of development of AV technologies makes self-driving cars competitive with conventional cars. The industry environment assessment also takes into account the investment attractiveness of the AV industry, based on an evaluation of the potential associated with market size, the ability to replace conventional vehicles with unmanned vehicles, government investment in the industry, and the number of specialized companies and M&A transactions. The evaluation criteria are divided into three sub-groups: conditions for manufacturers, market potential, nature of industry relations.

Assessment criteria of the industry environment development

Industry environment assessment

Conditions for manufacturers

- AV testing sites/ AV access to public roads
- Development of charging infrastructure (electric vehicles/electric charging station ratio)
- Production of AV components
- AV pilot/commercial production
- Availability/shortage of key production factors (for reference)

Market potential

- Car market size
- Average car age as an indicator of fleet replacement rate, potential replacement of old cars with more technologically advanced models

Industry relations

- AV development government funding
- Number of AV startups and enterprises
- Number of joint contracts and M&A deals between companies on AV development and AV adoption (for reference)

Ranking of countries by industry development criteria

RANKING	COUNTRY
1	China
2	Russia
3	Singapore
4	UAE
5	Brazil
6	Egypt
7	Saudi Arabia
8	India
9	Malaysia
10	Turkey
11	Serbia
12	Indonesia
13	Kazakhstan
14	Azerbaijan
15	South Africa

Leaders in the development of industry environment

China

The world's largest car industry with an active production of autonomous vehicles

Valued at USD 802.4 billion, the car market in China has seen steady sales growth of 5% per year. Car production in the country is outpacing sales due to overcapacity and strong competition, which may lead to a reorganization in a more technologically advanced industry and the elimination of uncompetitive players in the future.

The Chinese government is actively investing in the development of AVs as part of its USD 1.4 trillion New Infrastructure Initiative, and has also allowed unmanned vehicles on public roads in Wuhan. China has a well-developed related sensor technology industry, which is expected to grow from USD 4.9 billion to USD 10.5 billion in 2024–2030, according to international analysts. The associated infrastructure for electric vehicles is also well developed in the country with only eight electric cars per charging station.

With an average car age of five years, China's car fleet is also one of the fastest renewing in the world.

Of all the countries in the study, China currently has the highest number of AV development companies, M&A deals, and joint contracts. It also has the largest number of unmanned vehicle tests and has already introduced robot taxis. Companies such as Huawei, XPeng Motors, Li Auto, Baidu, Pony.ai and others are engaged in pilot and mass production of autonomous vehicles.

Russia

Supporting technological advances overrides structural constraints

The capacity of the primary and secondary passenger car market in Russia reached USD 101 billion in 2023. The government is actively subsidizing trials of highly automated vehicles up to 500,000 rubles per project, and has also initiated a project to introduce unmanned freight transportation services, “Unmanned Logistics Corridors”, which will cost about 5.2 billion rubles.

Eight companies in the country are engaged in pilot production of unmanned cars, trucks and buses, the most technologically advanced of which have already been granted access to certain public roads. The country's supporting industries supply electric wires for self-driving cars and develop their own lidars. Charging infrastructure is at a relatively high level: Russia has nine electric cars for every charging station.

At the same time, the industry's full development is hampered by a shortage of certain components and a lack of qualified specialists. A rather outdated vehicle fleet with an average age of 15 years for a passenger car also indicates a slow pace of fleet renewal, which hinders the introduction of new technologies into mass use.

Leaders in the development of industry environment

Singapore

One of the most developed economies to have a functioning autonomous public transport system.

Singapore has the smallest car market among the leading countries (USD 1.7 billion), which is commensurate with the country's total area. However, Singapore is a leader in all other development criteria. The focus on the development of public autonomous transport, supported by government funding policies, is a particular feature of this country.

The government has established a USD 20 million grant to fund five research teams exploring the use of AI technology, including in the AV sector, and has also authorized trials of unmanned vehicles on public roads.

The country currently has 13 companies and startups engaged in unmanned vehicle development. Sensor and lidar production is also well developed. Of all the countries surveyed, Singapore is the only country where the number of electric charging stations exceeds the number of electric vehicles. Car average age is six years.

UAE

Rapid progress on a small scale

Despite the small size of the car market (USD 6.4 billion) and the limited number of AV players, the UAE government has paid significant attention to funding this sector, which has allowed the country to advance in this area on par with other major leaders.

In 2017, the country developed the first AV prototype. In 2020, the Mubadala state fund invested USD 2.25 billion in a project to develop unmanned driving technology, and in late 2023, the country approved the first tests of a Level 4 self-driving car developed by WeRide on public roads.

The UAE also has developed supporting industries involved in software development, all production factors in the industry are available. With an average age of five years, the UAE fleet is one of the youngest among the countries surveyed. Charging infrastructure lags slightly behind the industry development, with 28 electric vehicles per every charging station.

Brasil

Progress in the development of supporting infrastructure has not yet enabled the widespread use of unmanned vehicles

Among the countries analyzed, Brazil is the fourth largest market (USD 56.7 billion) and is pursuing AV-related projects, including by investing in big data centers, 5G network deployment, and related device connectivity infrastructure. The country has nine AV test sites and produces sensors.

However, only a small number of companies are currently involved in the production of AV solutions, and the use of such vehicles is limited (buses, mining trucks, racing cars).

The rapid adoption of unmanned transport is hampered by an outdated fleet with an average vehicle age of 11 years, an overloaded charging infrastructure (24 electric vehicles per charging station), and a shortage of qualified personnel across the car industry combined with low labor productivity.

Countries with low level of industry environment development

	Egypt
	Saudi Arabia
	India
	Malaysia
	Turkey
	Serbia
	Indonesia
	Kazakhstan
	Azerbaijan
	South Africa

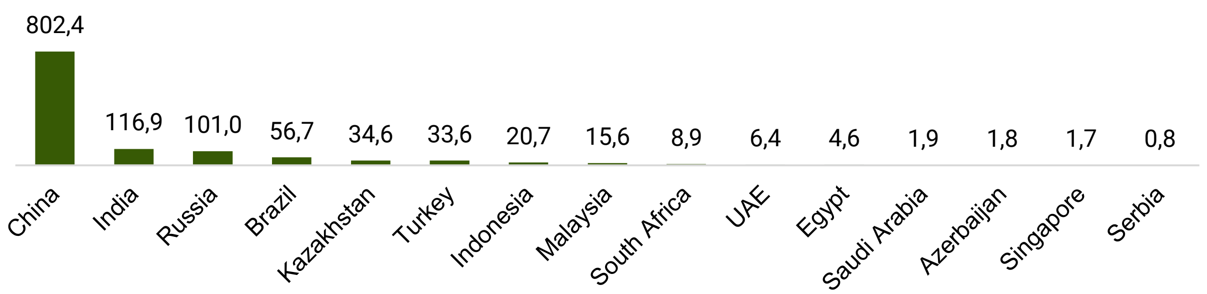
The largest car markets among the countries of this group are India (USD 116.9 billion), Kazakhstan (USD 34.6 billion), Turkey (USD 33.6 billion) and Indonesia (USD 20.7 billion). In other countries, the market does not exceed USD 16 billion. In addition, South Africa, Azerbaijan and Indonesia have low labor productivity and a lack of capital for process automation and infrastructure development, while Egypt suffers from a shortage of components.

Kazakhstan, Azerbaijan and South Africa currently lack AV developers and cases of pilot production of unmanned vehicles. All other countries listed have AV players and testing grounds. However, the AV development work in Indonesia and Serbia has not yet resulted in any prototypes.

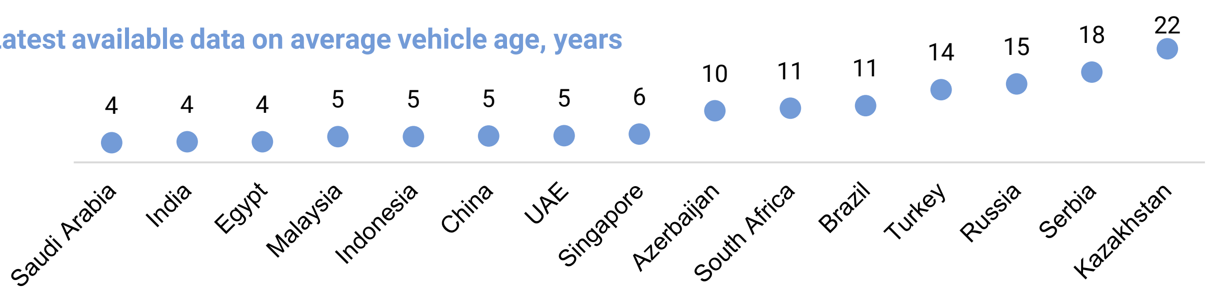
Another barriers to AV development in these countries are:

- lack of supporting industries (except Turkey, Indonesia and Malaysia)
- the general lack of public funding programs that directly target this area
- poor development of EV infrastructure (except Turkey and Malaysia)
- rather outdated fleet with an average age of 10 to 22 years in Serbia, Turkey, South Africa, Kazakhstan and Azerbaijan

Market size for light vehicles in 2023, USD bln



Latest available data on average vehicle age, years



Source: mass media data

Autonomous vehicle production development

When assessing the level of autonomous vehicle technology development, it is important to consider how far a country has come in turning theoretical developments into tangible products. Components such as sensors, processors, control systems, etc. are critical to ensuring the safety and efficiency of unmanned vehicles. Such manufacturing facilities operating in the country demonstrate the availability of the necessary infrastructure, skilled workforce, and government and private sector support for innovation.

Current state of autonomous vehicle manufacturing and number of autonomous transportation companies*.

China has the highest level of AV technology development among the countries surveyed, with mass production of highly automated vehicles and their trial commercial operation in real road network conditions.

* Based on publicly available data as at mid-2024. At the time of release, the data may differ.
** Including startups

Source: mass media data, industry databases

Autonomous vehicle production development

China

China boasts both a high level of AV technology development and a large number of AV companies. At the same time, technology companies are transforming into vehicle manufacturers, and automakers are building significant technology competencies. The transition to AV technologies is the next step in the development of electric vehicles, which are distinguished by a highly sophisticated electronics and control systems.

Leaders in autonomous transport are Baidu, Pony.ai, WeRide and Didi Autonomous Driving.

Unmanned transportation players such as Huawei, XPeng Motors, Li Auto, Baidu and Pony.ai increased their activities in 2023. In a highly competitive market each participant is forced to make additional efforts to improve their technologies, and to monitor the progress of their competitors. Last year, these companies announced plans to launch AVs with in-built Navigation on Autopilot (NOA) technology in Chinese cities. NOA is the Chinese equivalent of the Full Self-Driving (FSD) technology tested by Tesla, but it still requires a human behind the wheel. NOA can drive and change lanes in complex urban environments, recognize road signs, traffic lights, and detect pedestrians. However, NOA is only approved for use on highways outside city limits, despite its fairly broad functionality.

Currently, the Chinese market offers the following highly autonomous car models:

- Huawei Qiankun ADS 3.0
- XPeng: P7, Mona, G9, P5, G3
- Li Xiang L9
- Baidu: RT 6 (together with Jiangling Motors Group)
- Honqi Robotaxi
- Pony.ai
- SAIC Hongyan (testing self-driving trucks)

Electronic technologies gained from developing electric vehicles have become the basis for AV solutions. The country produces its own lidar systems, sensors, software and other components for unmanned vehicles. Baidu and Huawei are the largest manufacturers of automated system technologies. RoboSense is one of the world's leading manufacturers of lidar systems: the company's facilities are ready for mass production of solid state lasers for robot taxis.

Source: mass media data

Autonomous vehicle production development

Russia

Russia is one of the leading countries in the development of AV technologies. At least eight companies are engaged in AV development. The activities of the companies cover a wide range of tasks:

- software development
- development of software and hardware systems, including sensor systems and vehicle control systems
- testing of real vehicles on public roads in dedicated test areas.

Yandex SDG is an example of a software company that has successfully entered the new AV market. The company does not manufacture cars, but adapts autonomous driving technologies to other manufacturers' vehicles. The company's systems enable cars and other vehicles to drive completely autonomously, in compliance with traffic rules, avoiding obstacles, and planning a route depending on actions of other traffic participants. In addition to software, in 2021 the company developed lidars that can change their parameters in real time adapting to the traffic situation, as well as specialized camera models and computing equipment. The total traveled distance of Yandex SDG autonomous vehicles in Russia, Israel and the USA is tens of millions km.

Navio (ex. Avtoteh) company was founded in 2020 to develop a single system that integrates vehicles, an unmanned fleet management platform, and internal data services. In mid-2023, the company began testing self-driving cargo vehicles in public roads: in particular, together with GlobalTruck, one of the largest freight carriers in Russia, Navio launched commercial unmanned cargo shipments on the Neva M-11 highway. Autonomous vehicles equipped with Navio's solutions traveled a total of approximately 4 million km in a test mode.

In 2019, Sber and Cognitive Technologies (a group of companies engaged in the development and implementation of AI-based software) established Cognitive Pilot (C-Pilot) company to develop unmanned technologies. The company develops advanced driver assistance systems (ADAS) based on AI technologies and autonomous driving systems for vehicles and industrial equipment. C-Pilot solutions can be used for all types of autonomous vehicles.

Since 2015, KAMAZ has been working on the development and testing of unmanned trucks. 300 million of state funding from the Ministry of Education and Science was allocated to the project, in which Cognitive Technologies Group participated in the initial stages. In 2023, KAMAZ began testing unmanned trucks on the Neva M-11 highway.

In addition to the above-mentioned companies, other organizations engaged in the development of autonomous transportation include StarLine (StarLine autonomous vehicle can drive in low-traffic urban environments), Technical Vision Alliance (an association of companies and scientific laboratories from Tomsk with competencies in machine vision, development of sensors, robot hardware and various control systems) and the Moscow Automobile and Road Construction State Technical University (MADI). GAZ Group was engaged in AV developments together with Nizhny Novgorod Technical University. GLONASS UNION also participated in developing autonomous transport technologies.

Source: mass media data

Autonomous vehicle production development

Singapore

Singapore has made significant progress in developing and adopting autonomous vehicle technologies. In 2016, Singapore became the first country in the world to test a self-driving taxi service, and since then, the number of such vehicles has increased. The country has 13 companies engaged in unmanned technologies, including:

- Moovita
- Curium
- Nopilot
- Hertzwell
- Qandela

Autonomous vehicles are used in everyday life. For example, in 2023, Moovita launched a free electric autonomous bus, MooBus, to carry passengers from King Albert MRT station and around Ngee Ann Polytechnic (NP). Singapore has also introduced Auto-Dolly and Auto-DollyTug autonomous vehicles, which operate at Changi Airport to transport baggage to the aircraft and terminal and are equipped with security functions to detect people and obstacles on the road.

Willers, on-demand transport company, and the National Parks Board's deployment of an 11-passenger autonomous shuttle at a city garden is a successful example of how unmanned technology can help improve site accessibility and enhance the visitor experience.

UAE

The UAE is actively promoting its national strategy for the development of unmanned vehicles. The country has three key companies operating in this field.

Acacus Technologies develops advanced software and hardware solutions based on AI and machine learning for autonomous transport. Acacus was the first company in the UAE to develop and launch a prototype autonomous vehicle, which successfully completed road tests in 2017. The company is currently working with the local government to develop autonomous public transport as part of the Dubai Autonomous Transportation Strategy.

EvoCargo completed testing of the first autonomous trucks EvoCargo N1 on a designated route in a restricted area of a logistics district in the south of Dubai. The company plans to begin using unmanned trucks in 2025, after completing extensive testing.

The UAE is developing its own AV software, including in partnership with companies from other countries. Unique Group entered into a partnership agreement with Oxa, a UK-based AV software developer, to develop and deploy unmanned vehicle software in the UAE.

Brasil

Brazil is a leader in the development of autonomous vehicles among the countries of South America and has performed relevant projects in this area. In 2023, Brazil's Marcopolo and autonomous mobility startup Lua Robotics unveiled a prototype Volare Attack 8 autonomous minibus. The project was the first of its kind in South America and took two years to complete. The bus will be able to operate fully autonomously without the intervention of a driver or remote operator after the technologies used have been tested.

Source: mass media data

Autonomous vehicle testing

Improving road safety is one of the prerequisites for introducing unmanned vehicles. Autonomous driving is expected to eliminate human error, which is blamed for causing most accidents. However, this requires a high level of AV safety, which includes the ability of the AV to receive complete, accurate, and trustworthy information about the environment and make the right decision according to the traffic situation, as well as a sufficient level of vehicle reliability. Extensive testing is essential for the development of the necessary technologies and solutions, and to make sure that they are reliable. According to one of the studies*, the optimal test distance is 18 billion km. When this value is reached, the safety rating of autonomous vehicles will be statistically significant compared to the safety rating of conventional cars.

Testing is a critical stage in the development of unmanned vehicles and includes a number of criteria to evaluate, such as

- reliability
- safety
- technology performance

Russia

Russia is one of the leaders in testing autonomous vehicles, among the countries surveyed. The total mileage of Yandex SDG, KAMAZ and Navio vehicles is estimated at 40 million km. Russia is testing AV technology in light cars, trucks, and public transport.

In 2018, a special legal regime for the experimental operation of unmanned vehicles was established in Moscow and Tatarstan. In 2020, the list of the register of experimental legal regimes (ELR) was expanded to 13 regions. Currently, the experimental legal regimes for the operation of unmanned cars and trucks have been launched in 38 regions, including:

- at the Kalibr technology park in Moscow;
- Yandex SDG is testing robot taxis for daily trips in the residential areas of Moscow and in Innopolis (the Republic of Tatarstan)
- trucks are tested on intercity highways
- testing in different climate zones: Krasnodar Region, Crimea, Khanty-Mansi Autonomous Region and Yamalo-Nenets Autonomous Region

The results of testing AVs under experimental legal regimes will be used to develop further general regulations for the autonomous vehicle industry in Russia.

In September 2024, KAMAZ unmanned vehicles were launched on the Moscow – Sankt-Petersburg highway to transport commercial goods.

* Research study by Nidhi Kalra and Susan Paddock "Driving to safety:
How many miles of driving would it take to demonstrate autonomous vehicle reliability"

Source: mass media data

Autonomous vehicle testing

China

China is actively testing unmanned taxis. Currently, more than 16 cities are participating in the testing of robot taxi by 19 Chinese companies.

Beijing, Shanghai, Shenzhen and Wuhan are the main testing grounds for autonomous vehicle prototypes:

- In 2022, the authorities in Shenzhen allowed the testing of Level 4 taxis with a driver on board.
- Beijing has 116 autonomous test vehicles that have traveled nearly 2 million km as of July 2024.
- Chinese autonomous ride-hailing platform Apollo-Go Robotaxi is testing AVs on the streets of Wuhan. There are currently more than 500 autonomous cars in the fleet, and the number will increase to 1000 by the end of 2024.
- In February 2024, Baidu and Pony.ai received permits to provide driverless passenger transportation services in Beijing and Shanghai.

The number of AV development companies allowed to test vehicles on public roads is gradually increasing.

UAE

In 2021, Abu Dhabi's Department of Municipalities and Transport decided to start testing the region's first autonomous eco-friendly taxi service TXAI on Yas Island.

In July 2023, the UAE issued the first license to test AVs on public roads. The license was awarded to WeRide, a Chinese company that has been developing self-driving technologies since 2017.

The main testing site is Dubai, namely Jumeirah district and Southern Logistics district.

The following tests were held:

- the first driverless trucks (Dubai South logistics and aviation center and EvoCargo company)
- self-driving cars by Cruise company (USA)

Saudi Arabia

Saudi Arabia is testing autonomous vehicles, including through a joint project – REDD – between King Abdullah University of Science and Technology (KAUST), Intel, and Brightskies, an Egyptian high tech and digitalization company. The testing under the REDD project takes place on the university campus, which is a small town with standard road facilities such as road signs and traffic lights. This area allows developers to test the AVs in various driving scenarios.

The AVs are also being tested by Hyundai in Saudi Arabia as part of the joint development of the Kingdom's transportation industry.

Source: mass media data

Autonomous vehicle testing

Singapore

Since the AV test center opened in Singapore in 2017, more than 40 autonomous vehicles, including taxis, shuttles, buses, and road construction vehicles, have been tested and approved for road use. Another 10 self-driving vehicles certified by The Centre of Excellence for Testing & Research of Autonomous Vehicles (CETRAN) at Nanyang Technological University have been approved to operate on public roads for delivery services.

Egypt

Brightskies, Egypt's high tech and digitalization company, is developing technologies for autonomous vehicles. The company is completing the first stage of testing its own product – the Bright Drive autonomous driving system. Brightskies is in contact with the country's government to obtain a license and permit to conduct a second stage of testing.

Serbia

Recent amendments to the Road Safety Law and the new Regulation on Autonomous Driving Conditions allow testing of autonomous cars on Serbian roads with permits issued by the Ministry of the Interior. Following these changes, Self-Driving Group (SDG), an international subsidiary of Yandex SDG, started testing self-driving cars in Belgrade.

Malaysia

Autonomous vehicle testing has been underway since 2020, when the first routes for AV testing on public roads were identified in Cyberjaya. eMoovit Technology was the first company to receive the authorization for the route. Other test routes for light vehicles and public transport are set up in Putrajaya and Iskandar Puteri.

Turkey

Unmanned vehicles are tested at the Special Industrial Zone Innovation Center (TOSB) in the Kocaeli Province, Turkey. The center uses four training grounds to test autonomous vehicles.

India

India is testing autonomous technologies at the Global Automotive Research Center (GARC) and test centers under the National Automotive Testing and Research and Development Infrastructure Project.

Source: mass media data

Readiness of market participants to adopt autonomous vehicles

Analyzing factors specific to each market unit – producers and consumers – is as important to examining countries' readiness for AV adoption as the industry and macro environment indicators studied above.

The following criteria, which can be quantified in the countries analyzed, were added to calculate the ranking:

- AV economic feasibility for consumers in comparison with alternative types of transport
- Innovation potential, expressed in R&D performed by individual producers and other market participants

The economic feasibility of implementing autonomous transportation was calculated as the ratio of the average cost of AVs to the types of vehicles that could potentially be replaced by AVs. A standard private car with a driver and a taxi service with a driver were identified as such modes of transportation. In the first case, the calculation was made by comparing the cost of purchasing a conventional car and the cost of autonomous car, using personal funds at the time of purchase. In the second case, the average monthly cost of taxi services with the average bill for 2 daily trips was compared with the monthly AV lease payment, calculated based on the interest rate in a specific country and the lease term equal to the average car age in the same country. If AV is not produced in the country or its value is not disclosed, the average cost of AVs was used for the calculation available from open sources in the countries analyzed.

Under the potential for innovation criterion, an equal number of points were added to those countries that perform R&D in areas directly or indirectly related to the introduction of unmanned vehicles and related technologies for its further development.

RANKING	COUNTRY
1	China
2	Russia
3	Turkey
	Malaysia
	Singapore
4	Brazil
5	Indonesia
6	UAE
7	India
	South Africa
8	Serbia
	Saudi Arabia
	Egypt
	Kazakhstan
	Azerbaijan

Leading countries by market participant environment criteria

China

Low-cost AV leader

China stands out among the countries analyzed for having the most affordable domestically produced unmanned cars on the market at a cost of USD 28 thousand. Buying an AV in China is cheaper than the average conventional car (USD 34 thousand). However, compared with the taxi service, the AV leasing is 2 times more expensive, due to very cheap taxi services in China.

AV is entering the Chinese market also through the development of an unmanned taxi service that is proving to be economically competitive in urban environments with fares starting at USD 0.55 compared to USD 4.2 for a traditional taxi with a driver.

Baidu is one of China's largest AI and unmanned vehicle R&D companies. The company is known for its constantly improving Apollo platform for autonomous driving and cloud computing centers for urban traffic management.

China has set up research centers to develop the next generation 6G data transmission, which will speed up data exchange between autonomous driving devices, reduce interference and allow more devices to connect simultaneously.

Russia

Expensive AV is competitive compared to expensive alternative vehicles

Despite the relatively expensive cars with autonomous driving systems of own production (about USD 60 thousand), the ratios to the average cost of a conventional car with a driver and to the cost of a taxi ride in Russia compared to other analyzed countries is quite affordable for the consumer (the AV cost is 1.4 and 2 times higher, respectively). This price ratio is primarily due to the high average cost of a passenger car in the country (USD 42.4 thousand) and a fairly high average check for taxi rides (USD 6.3).

Several R&D projects are underway in Russia to develop unmanned vehicles:

- a traffic parameter forecast software module using digital twins of St.Petersburg Polytechnic University;
- road digital model and protection of data transmission lines of the Moscow Automobile and Road Construction State Technical University;
- Yandex SDG, a self-driving car manufacturer, has already developed proprietary control software, specialized lidars, cameras and computing equipment;
- Alliance Group presented a multi-sensor machine vision system for vehicles that can distinguish signals in poor weather conditions.

Source: mass media data

Leading countries by market participant environment criteria

Turkey

AV is not yet cost-competitive, but progress in R&D creates potential for development

The average cost of a car in Turkey is comparable to other leaders (USD 38,642), but the cost of AV is significantly higher (USD 179,900 and more). The country does not manufacture unmanned vehicles and imports only a limited number of vehicles that support autonomous driving, creating additional barriers to AV's price competitiveness.

Compared to low-cost taxi services (USD 4.1 per trip), the monthly AV lease payment is nearly 20 times higher, making AVs unprofitable for taxi riders.

Although the adoption of AVs faces cost challenges, Turkey is taking practical steps to promote R&D in this area. The major projects are:

- development of an unmanned bus by Otokar company together with Okan University, which was successfully tested in 2021. Currently, the research and development continues in several areas, including vehicle mechatronics, analysis of the sensor-to-computer information exchange process, and development of decision-making algorithms;
- the unmanned bus developed by Anadolu Isuzu in cooperation with the Gebze Technical University successfully passed the tests in 2023;
- joint activity of the Istanbul Technical University (ITU) with Turkcell and Ericsson to improve the interaction of unmanned vehicles in the 5G network. In 2024, an unmanned bus was tested at a specialized technological campus of the university.

Source: mass media data

Malaysia

AV remains uncompetitive in price, but R&D success makes the country a leader in Southeast Asia

The price competitiveness of AVs in Malaysia is similar to that in Turkey. AV purchase cost starts at USD 145,400 and remains unattractive to the average buyer.

The monthly taxi service cost (USD 5.1 per ride) is 9 times lower than the monthly AV lease payment, calculated based on a relatively short average lease term, which for the purposes of the study equals the average car age in the country. With a short lease term, the high AV cost is amortized over fewer years; the monthly lease payment is higher.

R&D in Malaysia is conducted under the national agency, Malaysian Research Accelerator for Technology and Innovation (Mranti). In 2023, this agency opened an AV multi-scenario experimental laboratory in its technology park. Since 2017, the University of Technology Malaysia (UTM) has also been developing autonomous vehicles in collaboration with Moovita Pte Ltd.

Leading countries by market participant environment criteria

Singapore

The world's most expensive road transport

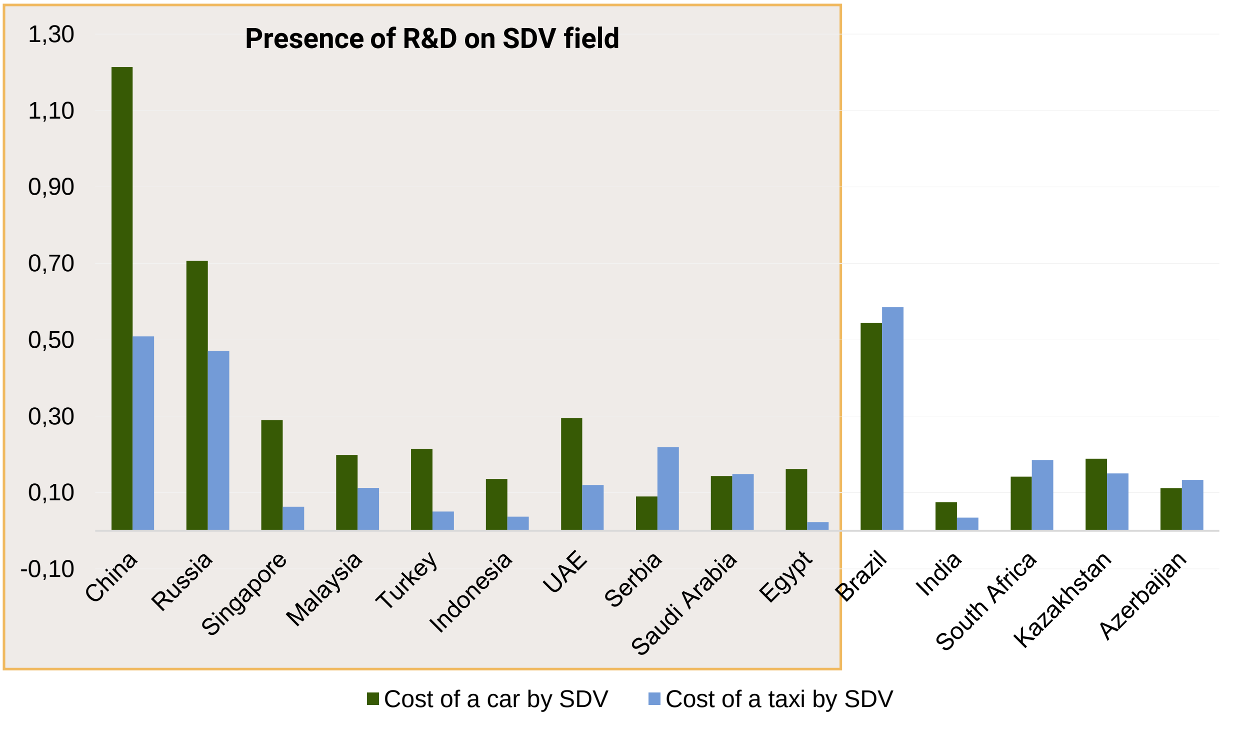
Due to the high density of buildings and the shortage of parking spaces, the Singapore government imposes high taxes and import duties to encourage people to give up their personal cars. A mandatory ownership permit of approximately USD 107,000 is added to the cost of the car, raising the average cost of the car to USD 125,000, AV – to USD 433,000.

In comparison with taxi services, the cost of AV leasing, calculated based on the above-mentioned high cost of the car, low interest rate and short term of use, also turns out to be the highest among the countries studied, exceeding 16 times the cost of taxi rides, despite one of the highest fares (USD 7) among the countries of the ranking.

The Center of Excellence of Nanyang Technological University (CETRAN) is conducting R&D to improve the safety of unmanned vehicles.

Criteria in figures

Countries that conduct R&D and have the lowest AV costs relative to alternative type of transport receive higher scores.



Source: mass media data, www.numbeo.com, Tenet calculations

Countries with a low level of development of the market participant environment

Brazil, Indonesia, UAE, India, South Africa, Serbia, Saudi Arabia, Egypt, Kazakhstan, Azerbaijan

The ratio of the average cost of an unmanned vehicle to the cost of a car with a driver in these countries ranges from 1.8 and 3.4 in Brazil and the UAE to 11.1 and 13.4 in Serbia and India, respectively. This is due to the varying average vehicle cost due to a number of factors. In particular, the UAE has a high cost of living and correspondingly high personal car prices. The Serbian car market is dominated by cheaper used cars, and the low cost of cars in India is due to cheap production factors. If these countries develop AV domestic production, the price gap could be narrowed.

Compared to the cost of taxi services, the use of autonomous vehicles is impractical in all countries of this group. The difference with AV leasing costs ranges from 2X in Brazil to 44X in Egypt. This significant discrepancy is not only due to low taxi fares in some countries (from USD 1.9 in Egypt), but also to AV high monthly lease payments calculated based on a shorter period of vehicle use (India, UAE, Saudi Arabia, Indonesia) or unusually high interest rates (Egypt).

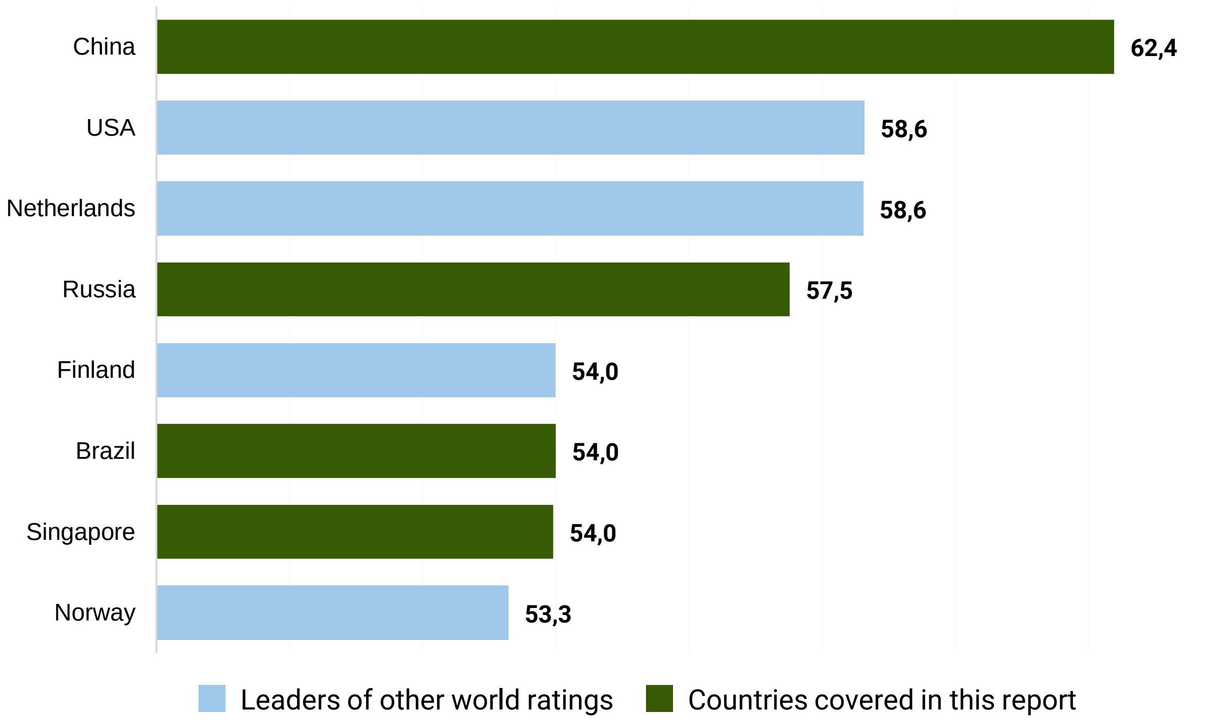
The low scores were also due to the lack of R&D in the field of unmanned vehicles in Brazil, India, South Africa, Kazakhstan and Azerbaijan.

Source: mass media data

Comparison with leaders in other world ratings

The development of unmanned vehicles and the readiness of various countries to adopt AVs has been analyzed in the ratings of different companies at different times. This section contains the results of assessing the readiness of leading countries to implement unmanned vehicles identified earlier in other world ratings, but with the calculation methodology used in this study. The calculation was made in order to compare the current positions of countries on the overall ranking scale used in this study, as well as to draw a more objective conclusion on the progress of certain countries in adopting autonomous vehicles.

COUNTRY **TOTAL SCORE**



Leaders in global AV adoption readiness ratings maintain their leadership positions in AV development. Further progress will be made through the widespread implementation of relevant legislation, strategies and R&D, as well as the development of supporting industries for unmanned vehicles and the expansion of test sites.

Nevertheless, recent achievements of some developing countries have brought them close to the level of the recognized leaders, and in some areas have helped outpace them. In particular, the new leaders are also focusing on government funding programs, road construction, and charging infrastructure, as well as taking advantage of scaling opportunities created by the size of the vehicle market and the speed at which it adopts more technologically advanced models at competitive prices.

Rating preparation methodology

Rating preparation stages

The development of the autonomous vehicle readiness ranking includes the following stages:

1. Identification of the purpose and object of the research. Countries selection
2. Formation of a list of assessment criteria
3. Determination of the assessment scale and calculation algorithm for each criterion
4. Data collection for each criterion and for each country
5. Calculation of points for each criterion for each country
6. Calculation of the final score for each country according to the assessment criteria
7. Ranking of countries based on the results of the assessment
8. The results analysis and summarizing

Rating preparation principles

Completeness of coverage

Criteria should address various aspects of autonomous vehicle implementation

Reliability and relevance

The data used to calculate the ranking should be reliable and provide relevant information at the time the ranking is prepared

Regularity

The selected criteria will allow monitoring the dynamics of these indicators in the future and analyzing the progress of different countries in AV adoption

Ranking geography

The ranking includes 15 countries

BRICS	Regional leaders	The CIS
Brazil, Russia, India, China, South Africa	Turkey, Saudi Arabia, UAE, Malaysia, Indonesia, Serbia, Singapore, Egypt	Kazakhstan, Azerbaijan

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Assessment criteria: Macro environment

Criterion	What we assess	How we assess
National AV development program (concept)	Country's interest and strategy in implementing advanced technologies and developing AV. Political actions to get autonomous vehicles on the road nationwide	**Maximum score** – active program in place **Medium score** – the program is under development and will be adopted in the next 1–3 years **Minimum score** – no program exists, its development is not under consideration in the next 1–3 years.
Availability of regulatory documents governing the AV development and use	Legal steps to implement AV. The availability of established requirements for the use of AV and the necessary infrastructure, as well as the rights and responsibilities of AV market participants	**Maximum score** – active legal regulations in place **Medium score** – legal regulations are under development and will be adopted in the next 1–3 years **Minimum score** – no legal regulations exist, their development is not under consideration in the next 1–3 years.
Ratio of category 1 roads (or comparable national and international highways) to the total length of hard roads	Road network readiness for AV	**Maximum score** – the ratio of the length of roads suitable for AV to the total length of the road network in the country should exceed 0.4 **Medium score** – the value of the indicator is from 0.2 to 0.4 **Minimum score** – the value is below 0.2
Network Readiness Index, NRI*	The level of development of IT and communication technologies and the network economy, the innovative and technological potential of the countries, their development opportunities in high-tech solutions and the digital economy. Readiness of society to adopt advanced technologies for everyday use	**Maximum score** – NRI exceeds 50 **Medium score** – NRI is from 40 to 50 **Minimum score** – NRI below 40
Sufficiency of household income to purchase AV	Economic feasibility of AV implementation. For the purposes of the study, the residual average per capita income per month was calculated (less the subsistence minimum) and compared to the monthly AV lease payment, calculated based on the average age of the car and the interest rate in each country.	**Maximum score** – residual average per capita income in the country exceeds the AV price **Minimum score** – the residual average per capita income in the country is less than the AV price

* The Network Readiness Index (NRI) is calculated by the independent research institute Portulans Institute together with the World Innovation, Technology and Services Alliance (WITSA).

Assessment criteria:
Industry environment

Criterion	What we assess	How we assess
Car market size	Maximum potential size of the car market, which might be updated and replaced by autonomous vehicles in the future	**Maximum score** – if the capacity of the passenger car market in the country exceeds USD 30 billion **Medium score** – the indicator is from USD 2 billion to USD 30 billion **Minimum score** – the indicator is below USD 2 billion
Average car age	Technological obsolescence and speed of fleet replacement, potential replacement of old cars with more technologically advanced models	**Maximum score** – the average age of passenger cars in the country is less than 5 years **Medium score** – the average age of passenger cars is 5 to 10 years **Minimum score** – the average age of passenger cars exceeds 10 years
AV development government funding	Availability of capital to fund AV development, as well as government interest in introducing advanced technologies and promoting innovations	**Maximum score** – access to government funding **Medium score** – no AV funding, but there are programs to develop supporting infrastructure and related industries **Minimum score** – no government funding
AV pilot or commercial production	Current stage of AV production development in the country	**Maximum score** – countries producing AVs, where Level 4 and 5 vehicles are being tested on the real road network **Medium score** – countries with working AV prototypes **Minimum score** – countries that have no AV production or prototypes
AV startups and enterprises	Current level of AV production, AV investment appeal	**Maximum score** – the number of AV startups and enterprises in the country exceeds 10 **Medium score** – the number of AV startups and enterprise ranges from 1 to 10 **Minimum score** – no AV startups and enterprises in the country

* The Network Readiness Index (NRI) is calculated by the independent research institute Portulans Institute together with the World Innovation, Technology and Services Alliance (WITSA).

Assessment criteria: Industry environment

Criterion	What we assess	How we assess
Availability of AV test sites and/or AV access to public roads	Level of infrastructure readiness for AV use	**Maximum score** – available **Minimum score** – unavailable
Production of AV components	Level of readiness of the industry for AV production	**Maximum score** – available **Minimum score** – unavailable
Number of electric vehicles per 1 electric charging station	Level of infrastructure readiness for AV use	**Maximum score** – less than 10 electric vehicles per 1 electric power station **Medium score** – 10 to 20 electric vehicles per 1 electric power station **Minimum score** – more than 20 electric vehicles per 1 electric power station

Market participant environment

Criterion	What we assess	How we assess
R&D in AV sector	Level of technology development and automakers' readiness for AV deployment	**Maximum score** – autonomous vehicle R&D is ongoing in the country **Minimum score** – no autonomous vehicle R&D in the country
AV to driver-operated vehicle cost ratio	AV economic feasibility for consumers	**Maximum score** – AV cost is lower than the average cost of a passenger car in the country **Medium score** – AV is at the most twice as expensive as an average cost of a passenger car **Minimum score** – AV costs more than twice the average cost of a passenger car
AV to taxi ride cost ratio	AV economic feasibility for consumers	**Maximum score** – AV monthly lease payment does not exceed 2X the cost of taxi service **Medium score** – AV monthly lease payment exceeds taxi service cost by 2–3 times **Minimum score** – AV monthly lease payment exceeds taxi service cost by more than 3 times

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