STUDY

Automated Vehicles Index

Q4 2017

Roland Berger GmbH – Automotive Competence Center &
fka Forschungsgesellschaft Kraftfahrwesen mbH, Aachen
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Dear Reader,

Never has the subject of automated driving attracted so much publicity as in recent months as OEMs, suppliers and tech companies race to be the first to bring highly automated vehicles onto our roads.

Developing and testing powerful algorithms in real conditions on the public highway will be the key to success here. OEMs and their R&D partners are deploying fleets of technologically advanced test cars in a bid to achieve this. But such vehicles are subject to different laws and approval procedures in different countries. Simulation is another of the methods being used to test automated vehicles. Waymo, for example, is simulating some 25,000 vehicles simultaneously in virtual versions of actual Austin, Mountain View, and Phoenix streets and on a number of different test routes. Together the vehicles are driving more than 6 million kilometers a day in the virtual world. In 2016 the number of virtual kilometers driven exceeded 2.5 billion – as against some 5 million "real" kilometers driven by physical test cars over the past eight years.

Against this backdrop, this edition of the Automated Vehicles Index zooms in on the status of the global test fleets being operated by OEMs and other market players, along with the specific legal framework within each of the key automotive nations. We also shine a light on the technological expertise present in selected economic areas and examine the launch of relevant technologies in the volume segment.

As always, the AV Index also provides a comparative update on the competitive positions of individual national automotive industries. The countries' competitive positions have been updated based on the following indicators:

1. Industry: The state of technological development for vehicles designed and produced by the countries' OEMs, plus the scope and focus of corresponding research activities.

2. Market: Market size, represented by demand for advanced driver assistance systems as an indicator of user acceptance, alongside an assessment of the legal framework governing the operation of automated vehicles in each country.

Roland Berger GmbH and fka Forschungsgesellschaft Kraftfahrwesen mbH Aachen (fka) combine these indicators to produce the quarterly Automated Vehicles Index, which facilitates useful comparison of the competitive positions of the relevant automotive countries (the US, Germany, China, Sweden, the UK, South Korea, France, Italy and Japan), as well as using harmonized global benchmarks to measure these automotive markets against each other.

1. Key insights from the Automated Vehicles Index Q4/2017

OEMs: Almost all OEMs offer mass-produced vehicles with automated driving functions

Partially automated driving functions are now available to a significantly greater extent than last year, particularly in vehicles manufactured by American, Japanese and South Korean OEMs. At the same time, German OEMs have been able to defend their lead here: Whereas most of the automakers focus their efforts on certain specific functions or a select number of vehicle categories, German OEMs are now offering relevant driver assistance systems (up to and including SAE level 2) across almost all vehicle categories – with the exception of city cars. And the momentum is set to continue as we see more and more partially automated driving functions becoming available. In the future, new functions won't even need to wait for a facelift before being brought in – we will see OEMs implementing additional functions between model upgrades or even enabling them during a vehicle's life cycle.

Expertise: Testing remains a focal area for research; test facilities being built up worldwide

Research into automated driving has been stepped up dramatically in almost all of the countries in the index. This goes some way to explaining the improvements in the countries' positions in the expertise indicator. Testing and validating automated vehicles remains a focus of research activities. Numerous new test beds and testing facilities for automated vehicles have been established in various parts of the world in the last 12 months. Besides closed test sites, there are now ever-increasing numbers of test environments equipped with measurement instruments being established on public highways. This just goes to show how important automated driving functions have become for a country's economic attractiveness going forward.

Legal framework: Clarity has been achieved in the legal situation in the US, Sweden and Germany

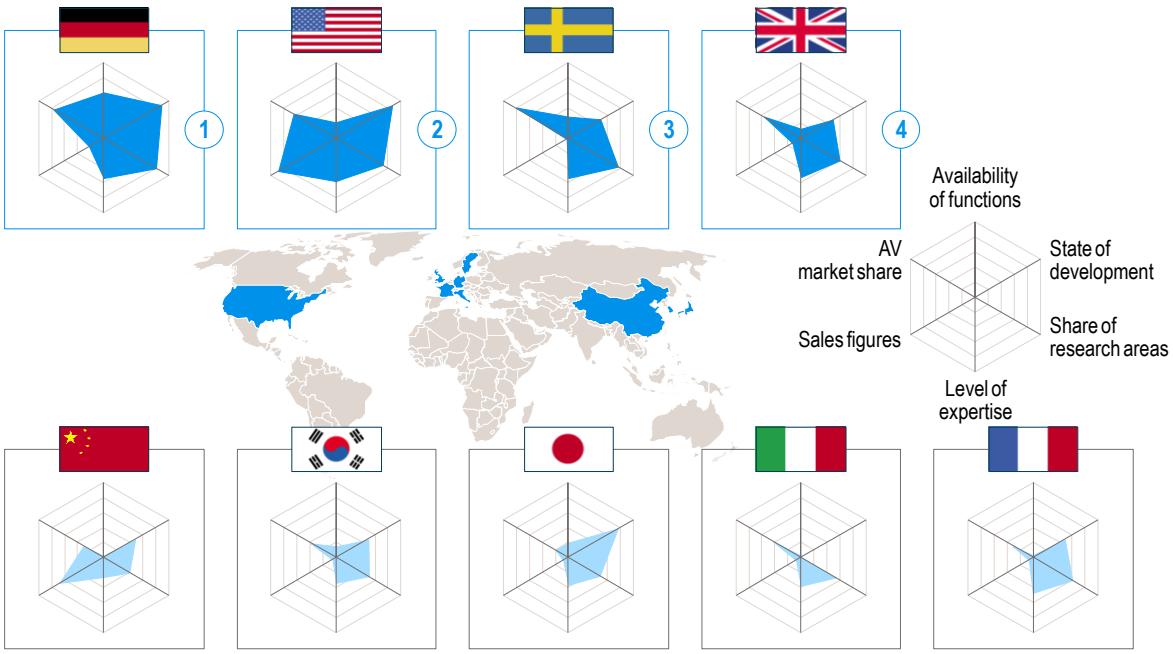
A great deal of lawmaking has taken place in the automotive nations in the last 12 months, alongside numerous amendments to existing laws. Looking at the US, Sweden and Germany in particular, we can see that the legal framework for automated vehicles has been clarified. The US continues to lead the field here: not only can automated vehicles be tested on public highways, some states have even passed laws permitting their operation. Sweden enacted an extensive package of legislation covering the testing of AVs in 2016 and 2017; laws governing their operation are currently in preparation. Germany's amendment to the road traffic act also regulated important aspects of AV testing and operation. However, it is still impossible to obtain type approval for AVs, partly as a consequence of ECE Regulation 79.

Market volume: Driver assistance functions in mass-produced models benefit the US, South Korea and China

Since the last issue of the AV Index there has been some movement in the top three slots when it comes to the sale of mass-produced cars with automated driving functions. China is fast closing the gap to market leaders the US and Germany thanks to the expansion of its sales market in general and the launch of relevant level 2 functions in volume models. China and Germany thus share second spot in the Q4 rankings, while Sweden was able to defend its third place.

South Korea has been able to continue on its upward trajectory and is still gaining ground on China and the West. As a result, Korea is now on a par with Italy and has even overtaken France in the sale of mass-produced vehicles with SAE level 2 functions.

Figure 1: Comparison of the competitive positions of the world's leading automotive nations in the field of automated driving

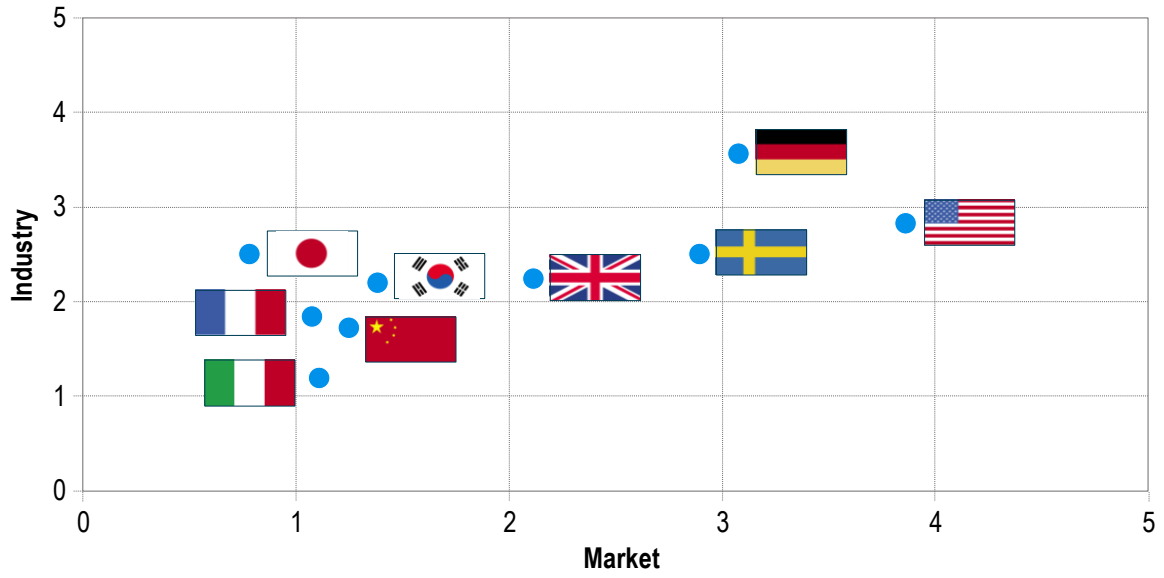


Source: fka, Roland Berger

2. Comparison of the competitive positions of the world's leading automotive nations

Combined analysis of both dimensions – the industry and the market – enables us to produce a visual summary of the competitive positions of the world's leading automotive nations (Fig. 2).

Figure 2: Germany and the US defend their lead in the AV Index, with Sweden third and the UK leading the rest of the pack (AV Index – Q4 2017)



Source: fka, Roland Berger

Within the **industry indicator**, Germany was again able to defend its leadership over the US and Japan in the past year. **This success is mainly attributable to the good availability of automated driving functions in mass-produced cars made in Germany**. That said, their availability has also increased markedly in the portfolios of American, Japanese and South Korean OEMs, though these countries tend to concentrate on certain vehicle categories or selected functions. **Most nations have also significantly ramped up their research activities in this area**, with a focus on testing and demonstrating automated vehicles. The UK in particular is currently subsidizing numerous projects in a bid to position itself as an R&D and testing hub and has benefited from a marked improvement in its position. All in all, this movement in the industry indicator results from changes in OEM activities and expertise, as described in more detail below.

OEM activities are assessed according to the availability of automated driving functions in mass-produced vehicles and the state of technological development on the basis of the mass-produced and prototype vehicles that have been demonstrated. On this count, Germany was able to maintain its lead in the past year, but American, Japanese and South Korean OEMs did close the gap considerably.

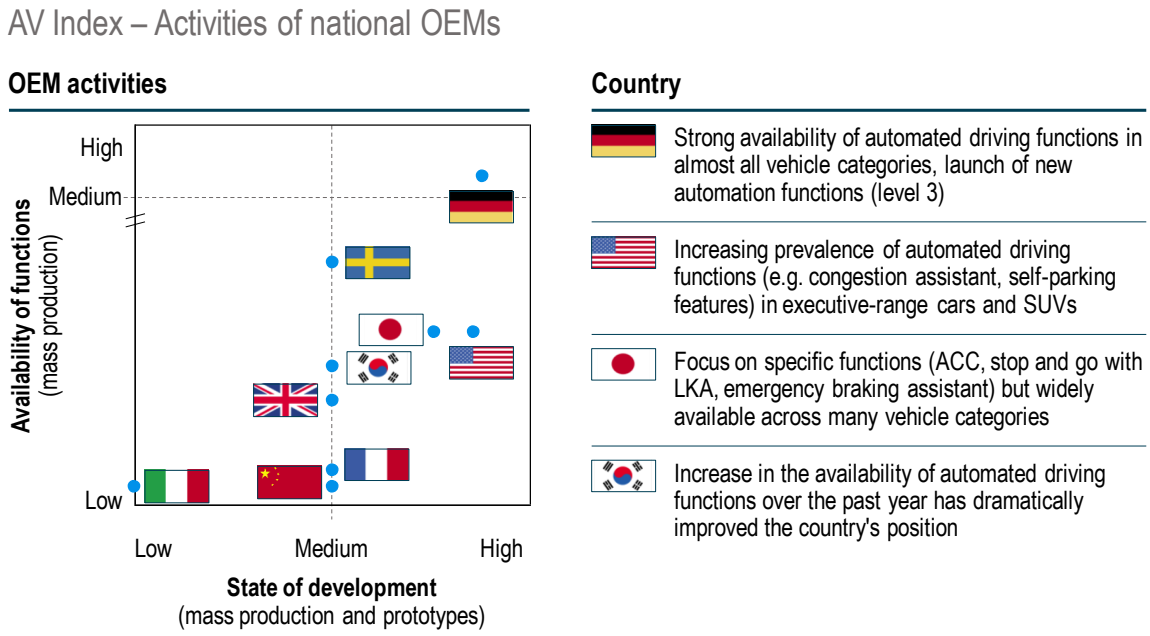
The number of vehicle models equipped with automated driving functions rose dramatically across all countries in the last 12 months. Nevertheless, this barely affected Germany's position in the rankings because German OEMs already offer automated functions in almost all vehicle categories (with the exception of city cars). Germany will only be able to improve its position through the launch and diffusion of new functions at SAE level 3 (e.g. the Traffic Jam Pilot in the Audi A8).

Japanese and South Korean automakers performed so well principally as a result of the now widespread availability of automation functions with a focus on safety and convenience (such as emergency braking assistants with pedestrian detection and ACC in combination with a steering assistant). OEMs have already announced the imminent launch of additional automation functions in other vehicle models (such as a congestion assistance system in the Nissan Leaf), which will give a further boost to the position of Japan and South Korea.

Chinese OEMs have launched their first vehicles with partially automated driving functions (e.g. the Wey VV7). They were brought to market in the SUV segment, with the focus being mainly on convenience-based features. This concentration on just one vehicle segment is the reason why China's position registered only a minor improvement. That said, there are two sources feeding into this development: not only are local automakers working intensively on R&D but Chinese OEMs are already taking advantage of existing functions developed by European companies (as in the case of Geely with Volvo's technologies).

Taken as a whole, there is an incredible amount of dynamism surrounding activities to increase the availability of automated driving functions right now. In the future, new automated functions won't even need to wait for a facelift before being brought in – additional functions will be implemented between model upgrades or may even be enabled during a vehicle's life cycle (as in the Tesla and the Audi A8).

Figure 3: Better availability of AV functions and intense R&D activity influence the competitive positions of the countries in the index



Source: fka, Roland Berger

As in the last AV Index, Germany and the US continue to lead the field in automated vehicle **expertise** (Figure 4). In fact, almost all nations saw their position in this dimension improve over the past 12 months owing to the intensification of research activities worldwide. A key indicator of this development is the fact that substantial amounts of money are now being poured into a large

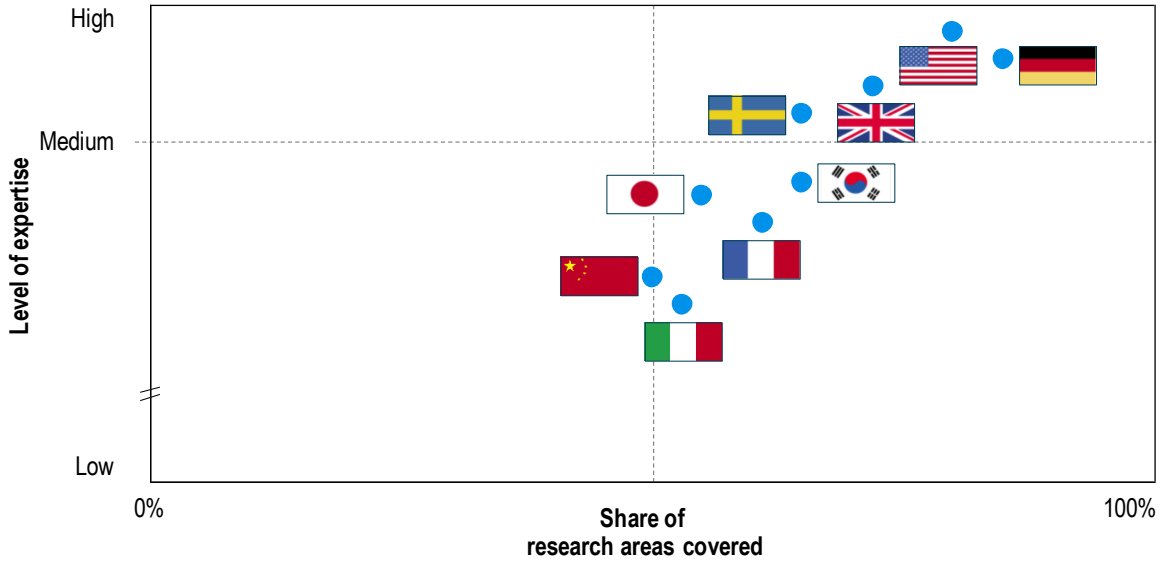
number of international research projects. As one noteworthy example, the British government's budget for automated vehicle development and testing currently exceeds £ 200 m (some € 220 m). The UK is keen to position itself as one of the world's leading hubs for the development and testing of connected and automated vehicles. On a European level, a number of research projects were launched in 2016 and 2017 with a focus on cross-border cooperation and coordination. One example is the "L3Pilot" research project involving eleven European countries conducting joint fleet tests and demonstrations of level 3 automation functions (total budget € 68 m, 100 vehicles).

The overall focus of research activities in all of the countries in the AV Index lies on testing automated driving functions. Various different test sites were established around the world and opened in 2016 and 2017 – on both public roads and private land. In the United States, for example, ten facilities were selected by the U.S. Department of Transportation and designated as automated vehicle proving grounds, chief among them the American Center for Mobility (ACM) in Michigan boasting a project volume of more than $ 55 m (approx. € 47 m). South Korea is pursuing a similar approach with its K-City test bed for self-driving cars, constructed near Seoul and endowed with $ 10 m (some € 9 m) in government subsidies. The entire testing facility is scheduled to open in mid-2018, the specially built highway model having already been in operation since November 2016.

China, too, inaugurated a closed testing facility for automated vehicles in 2016 and named it Shanghai International Automobile City. In Japan, testing takes place in both closed test sites (e.g. in the grounds of the Japan Automotive Research Institute) and on public roads (expressways and city streets). The German government has been financially supporting the trialing of automated vehicles on the country's Autobahns in a project known as Digital Motorway Test Bed since as far back as 2015. In 2016 they resolved to expand the test beds to cover urban areas (e.g. "Digital Test Bed Düsseldorf" with a total budget of € 15 m) and cross-border projects ("Digital Test Bed Germany – France"). In total, Germany has set aside some € 100 m in government subsidies to fund AV testing on public highways.

Publicly funded research into automated vehicles is not the only activity ongoing in this sphere: private companies are increasingly funding research themselves these days. Chinese web services company Baidu is one example, having invested RMB 10 bn (approx. € 1.3 bn) in the development of an Open Source platform in a project dubbed Apollo. More than 70 partners are currently cooperating in the project, including China's top five universities.

Figure 4: Increased global research activity is influencing the rankings – Germany and the US continue to lead the pack (AV Index – Automated vehicle expertise)



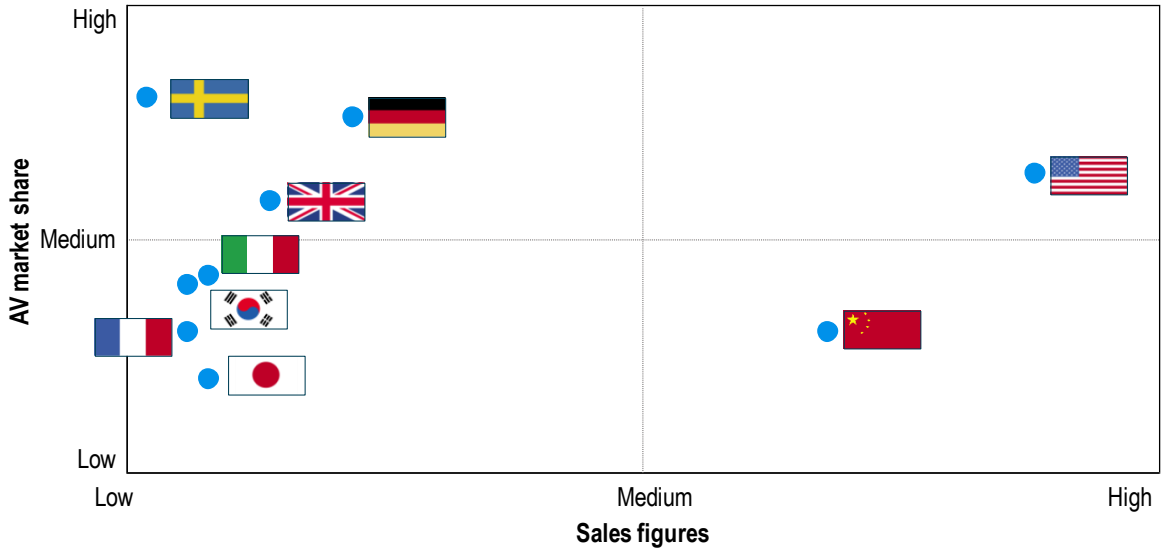
Source: fka, Roland Berger

Reflecting the availability of vehicles with level 2 functions (e.g. congestion assistance, automated parking, evasive maneuver assistance) in the respective national markets, the **market indicator** has seen a lot of movement at the top since the last edition of the AV Index as nations like China and South Korea have gained ground continually. The position of China registered the biggest change – in fact, China now ranks equal second with Germany, trailing only the US. This pushed Sweden back into third place (Figure 5). South Korea continued to advance and is now on the same level as Italy, while France even managed to overtake South Korea in terms of its offering of level 2 functions for the mass market.

Nevertheless, the Unites States was able to pull even further ahead in this indicator by launching relevant assistance functions in mass-market models. For example, the models with particularly strong US sales figures produced by Toyota (esp. the Camry) and Honda (incl. the Civic and the Odyssey) are now available with advanced driver assistance functions. The Chinese market, too, has benefited from the launch of relevant assistance functions in Land Rover, Toyota (incl. the Camry) and Honda models (incl. the Civic), resulting in a significant expansion of the volume segment.

It should be noted that the US and China have an advantage in the market indicator owing to the absolute size of their national markets and the associated opportunities for the sale of mass-market vehicles with level 2 functionality.

Figure 5: South Korea and China have benefited from the launch of partially automated functions in the volume segment (AV Index – Market potential for vehicles with advanced driver assistance systems[1)], Q1 through Q4 2017)



1) Theoretical market ceiling for vehicles with ADAS fitted as standard or as optional extras

Source: IHS, fka, Roland Berger

The **legal framework indicator** examines the legislation in the specific countries in order to consider how compatible it is with testing and operating automated and driverless vehicles in public (Figure 6). A great deal of lawmaking has taken place in the automotive nations in the last 12 months, alongside numerous amendments to existing laws. The legal framework for automated vehicles has been clarified in the US, Sweden and Germany in particular.

The US continues to lead the field in this indicator. Michigan, for example, not only permits the testing of automated vehicles on public highways but even allows vehicles with no previous testing history to be operated in the public domain. Waymo is already operating its first driverless vehicles on public highways in Arizona, where the legislation does not restrict the operation of AVs. With American states exerting considerable influence over lawmaking, there is in fact intense competition between the states given that the testing of automated vehicles is more than just a matter of public interest – it is of huge economic significance. That said, the debate over standardized nationwide legislation continues to raise its head periodically in the United States, one example being the Self Drive Act demonstrated in September 2017, which permits the U.S. DOT to issue test licenses for automated vehicles.

Both Sweden and Germany have gone a long way toward staking out the necessary legal framework for automated driving in the last 12 months. Sweden enacted an extensive package of legislation in May 2017 regulating such aspects as liability and the conditions for operating AVs in test scenarios. Corresponding laws governing the operation of mass-produced automated vehicles are currently in preparation. Germany's amendment to the road traffic act dated May 12, 2017 also regulated important aspects of AV testing and operation (e.g. liability and data logging). However, as in all UNECE member states, ECE Regulation 79 still makes it impossible to obtain type approval for vehicles with higher levels of automation.

There is intense debate over the legal regulations concerning automated vehicles in other countries, too. The UK is at one end of the spectrum, in that driverless vehicles can be tested even in the

absence of any explicit legislation, and China marks the other extreme, where the testing of AVs on public roads is totally prohibited at the present time. Both countries plan to enact new legislation: to replace the non-legally-binding code of practice in the UK, and to define the legal framework and conditions under which testing on public highways can take place in China.

Figure 6: Recent lawmaking to clarify the legal framework for AV testing and operation
(AV Index – Legal framework)

	AV testing	AV operation (level 3)	AV operation (L4/L5)	Notes
US				First regulations passed permitting the operation of AVs with no testing history
Germany				Road traffic act amendment dated May 12, 2017 defines certain key aspects
UK				Code of practice on testing AVs is not legally binding
France				Draft legislation on AV testing in preparation
Italy				Testing and operating AVs in Italy is currently incompatible with highway code
Sweden				Extensive legislation on AV testing enacted in May 2017
China				Testing AVs on public highways is currently prohibited
Japan				Testing AVs on selected public highways is possible
Korea				Increased possibilities for testing AVs on all public highways

Source: Press clippings, fka, Roland Berger

3. Focus on test fleets

European OEMs are exercising caution, US companies picking up speed

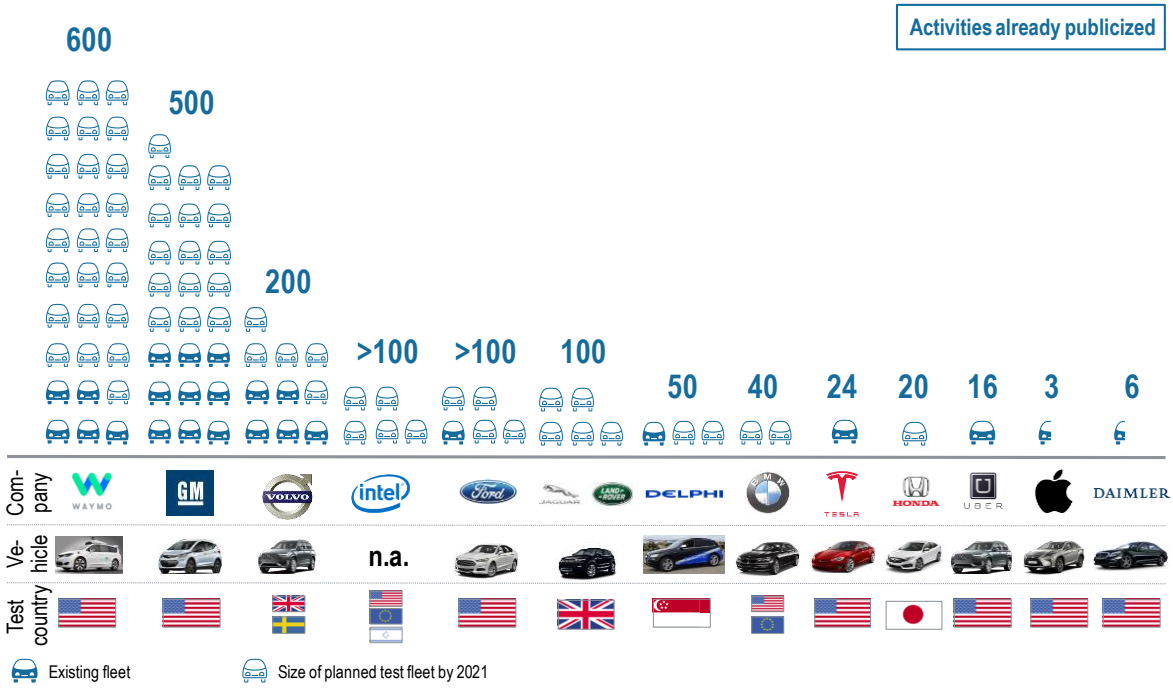
The presence of highly automated vehicles on our city streets will not become a reality without their control algorithms being thoroughly tested and 'trained' in real-life traffic conditions, or at least in environments that are as close to reality as possible. Even though more than 95% of the training can be done in the virtual world, real fleets of physical test cars are going to be indispensable for the foreseeable future. Whereas most incumbent OEMs have opted for an evolutionary approach and are developing automated driving functions step by step, American tech companies – and Chinese firms, too – are pursuing much more aggressive tactics. They are pushing to get their self-driving fleets into commercial operation as soon as possible in order to be in a position to develop and refine their systems based on the real-life driving data collected by the vehicles. This will make their fleets universally deployable much sooner – and thereby give them faster access to training data. Dubbed the network effect, this is the foundation on which most of the successful internet-based business models are built. And now it looks set to help mainly the American OEMs to dominate the market.

Waymo and GM, in particular, are massively expanding their test fleets, which by 2021 will number more than 600 and 500 vehicles, respectively. Waymo is currently launching its first tests in winter conditions in the US state of Michigan. This will be the first time there is no back-up driver onboard – all there will be, in the event of any problems, is an emergency stop that can be activated by a company employee riding along in the back seat.

Over and above the numbers depicted in Figure 7, Volvo is going to be supplying Uber with several thousand vehicles fitted with the appropriate hardware, which Uber will then equip with its own software to facilitate highly automated driving. And judging by public announcements concerning US companies' plans to put fleets of test cars on the roads, the US (where Intel, Delphi and Ford are also active, besides Waymo and Google) would seem to be taking a much more aggressive approach to highly automated driving on public highways than Europe and many of its incumbent OEMs.

The Americans' ambitions are supported by a legal framework which, unlike Europe's, already permits the commercial operation of AVs. Other automotive nations should therefore be under no illusions that leading the field in traditional ADAS and partially automated systems will necessarily earn them a place on the winners' podium in the autonomous driving race.

Figure 7: Fleets of highly and fully automated vehicles operating on public highways for testing and R&D purposes now and in the future (according to market players' activities already announced as per Q4/2017)



Source: Press clippings, fka, Roland Berger

4. Interview with Amitai Bin-Nun (PhD), Vice President, Autonomous Vehicles and Mobility Innovation, SAFE (Securing America's Future Energy)

Roland Berger Senior Partner Wolfgang Bernhart spoke with Amitai Bin-Nun, Vice President, Autonomous Vehicles and Mobility Innovation at "Securing America's Future Energy" (SAFE). SAFE (http://secureenergy.org/) is a non-partisan organization committed to combating the economic and national security threats posed by America's dependence on oil. It unites prominent four-star retired military officers, Fortune 500 CEOs, and its expert staff to produce high-quality, fact-based analysis and policy recommendations for lawmakers, regulatory agencies, and the public. To do so, SAFE is working closely with key decision makers in the US government administration and key agencies. A key area of its work is around innovation in transportation, especially around alternative propulsion and autonomous driving.

RB: Considering the US Administration's actions and regulatory activities, what benefits do you think the government expects from autonomous technologies?

The US government expects several benefits from autonomous technologies, with a particular focus on most likely short-term gains. The first and most important one would be significant improvement in driving safety.

Then, the federal government has a significant focus on benefits for those with limited access to mobility solutions: autonomous vehicles could help people who are too young or too old to drive, and/or living in areas with limited modal options (rural or at least remote from big city centers), or with disabilities. Improving mobility solutions and increasing the number of beneficiaries is definitively in the interest of the political parties, and consequently takes up a large space in legal discussions.

RB: From your perspective, which states in the US currently offer the most attractive framework conditions for a market introduction of AVs?

Currently, we are still at an early stage of development at which access to talents and the number of actors incubating new technologies is the most important factor – California is leading here.

But we also see a lot of activities in Arizona, where it is technically and legally easier than in other states to introduce L4 vehicles: think about the weather, for example.

New York and Las Vegas are chosen for publicity – and might be interesting places to commercialize respective developments, especially around driverless cabs first.

RB: Where do you see the US right now in terms of legislation towards level 4-5 vehicles compared to Europe and Asia (particularly Singapore and China)?

As distinct from Europe, where a type approval is needed, the US works on the principle of self-certification. Vehicles need to comply with the Federal Motor Vehicle Safety Standards (FMVSS). Since there is no regulation that prohibits autonomous functionalities for light vehicles, they need to comply with the standards outlined: they need to have a steering wheel and other features, but other than that, as long as the feature is not forbidden, it is considered legal.

The situation for trucks is different: for trucks above 10,000 pounds [4.5 tonnes], regulation assumes that there is always a driver behind the steering wheel. Getting autonomous trucks on the road is therefore not as simple.

RB: What would be the main differences in legislation between the federal US government plans and states'' regulation?

The federal government puts a high priority on autonomous vehicle safety, both for passengers and for economic benefits, and is consequently deeply engaged in related design and performance regulations. Under existing law, states cannot require a different number of airbags than the federal government requires; they cannot define or add their own design or performance standards. The federal government is interested in maintaining this division of labor for autonomous vehicles as well.

States' scope of concern is about what comes after, once the safety, design, and performance regulations are settled, and include much of what regulates AV usage, i.e. getting suitable license, registration, and insurance.

In early September, the House of Representatives had already passed a self-driving legislation bill. In early October, Senators in the Commerce, Science, and Transportation Committee unanimously approved the AV START Act. There are some common themes between the legislation.

First, the legislation declared that autonomous vehicle design, performance, and safety regulation is a matter for the federal government only and began a process creating regulations. Second, it requires that autonomous vehicle developers submit a letter to regulators describing the safety of its vehicles before deployment. Finally, car makers wishing to pursue alternative design for autonomous vehicles are allowed to pursue safety exemptions up to a certain level of production volume. The legislation would allow states to retain control over rules for registration, licensing, and insurance. Both bills do not include self-driving trucks in their frameworks because of pressure from labor unions regarding job security and safety for truckers.

There continues to be no federal requirement for a fallback to human control for light-duty vehicles. Instead, companies can produce highly or fully automated cars as long as they comply with existing vehicle design regulations. They also have the ability to manufacture a certain number of units in a given year that use innovative designs and are not currently allowed. In the finished version of the Senate bill, companies are capped at 15,000 vehicles in the first year, 80,000 in three years, and no cap in the fourth. These stated restrictions on production are only applied to vehicles that do not meet the current safety specifications for vehicles (e.g. no steering wheel). If the AV is designed conventionally, there are no restrictions to be considered.

However, the bills still need to be voted on in the Senate. This might happen in the next three months. If it does not happen by mid-2018, it might take considerably longer, since there would be an election in November 2018 and a new congress would "start from scratch".

RB: A final question: what role do city regulations play? How do they interfere with the rest?

Mobility services are traditionally regulated by cities. However, as large companies play a bigger role in this space, companies such as Uber and Lyft have pushed very hard to obtain state decisions regarding their activities. State regulation regarding autonomous technologies can supersede municipality regulations. For example, if a state legislature licenses the operation of an autonomous ride-hailing service, you will likely not need another license to operate in the city.

At the same time, respective decisions create tensions between these two administrative layers and are likely to generate more in the future as actors and services expand.

RB: Amitai, thank you very much for your valuable insights!

The road to level 4/5 automation

The developments outlined in this edition of the AV Index, both in respect of the legal framework and the operation of automated test cars in the key automotive nations, leave us in no doubt that the R&D activities concerning testing and technology undertaken by most OEMs and suppliers are currently concentrated in the Unites States.

This is attributable partly to the Silicon Valley start-up mentality and partly to the fact that test preparations and indeed the testing itself on the public highway is likely to be comparatively unbureaucratic in the US. Under the current status of legislation, the majority of the existing or planned test fleets will therefore do their driving there – giving a further boost to America's leading position in automated driving and in the numbers of related tech companies that choose to set up business there. The strength of this trend is unlikely to diminish given that, unlike in Europe, no type approval is necessary in the United States – self-certification is fully sufficient, and all that this requires is the presence of certain vehicle attributes like a steering wheel. Even for level 4/5 certification only certain criteria need to be fulfilled, making the licensing process relatively uncomplicated by comparison.

Germany is sure to remain a leading player in automated vehicle technology and expertise – assuming that legislators are not slow to create the necessary basis by implementing regulations that reflect reality. Then, and only then, will it be possible for Germany to be America's equal. Future legislation passed in Germany needs to aim at making the country an attractive place for leading companies to do business and making the nation fit for the future. The amendment of key aspects of the road traffic act in May 2017 was without question an important act, but it was certainly only one of the many overdue steps toward level 4/5 automation on public highways.

Other markets, such as China – which has, up to now, been very conservative in its provisions for the public testing and operation of automated vehicles – could quite conceivably cause a sudden and significant shift in the balance of power in the market for autonomous vehicles by enacting corresponding legislation. The US, too, could quickly give itself a crucial edge in the race to achieve level 4/5 automation. Right now, though, we cannot say for sure what will happen given the current status of technological development. But one thing is for sure, and the latest AV Index proves it: developments may be moving fast, but the automated vehicles industry is still in a fledgling state.

5. Methodology

The relative competitive position of the different automotive nations is measured on the basis of two key indicators: the industry and the market.

Industry

> OEM activities: The current state of the country's automotive industry in terms of the availability of (partially) automated driving functions in mass-produced vehicles and their realization in prototype vehicles

> Research and expertise: The country's position on knowledge and expertise in research areas of relevance to automated vehicles, as represented by the research activities of the top universities and relevant research programs

Market

> Legal framework: Comparison of the legal frameworks for operating and driving automated vehicles

> Market volume: Comparison of total sales figures with the share of vehicles sold that have relevant driver assistance functions

The individual indicators are weighted by Roland Berger and fka and compiled in the Automated Vehicles (AV) Index. Each indicator is ranked on a scale from 0 to 5. The index facilitates useful comparison of the competitive positions of the relevant automotive nations (the US, Germany, China, Sweden, the UK, South Korea, France, Italy and Japan). National automotive markets can also be compared on the basis of harmonized global benchmarks. The index thus reveals the extent to which each of the countries surveyed is able to participate in the growing market for automated vehicles. The indicators we apply are assessed based on the following parameters:

OEM activities

> The availability and performance of the (partially) automated driver assistance systems that are available in current vehicles, differentiated by vehicle segment

> The state of technological development, measured by the number and complexity of automated driving functions that the country's automotive industry currently makes available in mass-produced vehicles or has demonstrated in prototypes

Research and expertise in the field of automated vehicles

> The expertise in driver assistance systems and advanced levels of automation possessed by those of the country's universities and research institutes that are strongest on research

> The scope and breadth of research topics covered in the fields of sensors, vehicle intelligence and validation/testing, as well as adjacent fields such as connectivity and digital infrastructure in light of the depth of expertise

Legal framework

> Legal conditions governing vehicle licensing and operation, subject to due account for civil law, public law and existing norms and standards

> Legal constraints with regard to liability issues and driver behavior law

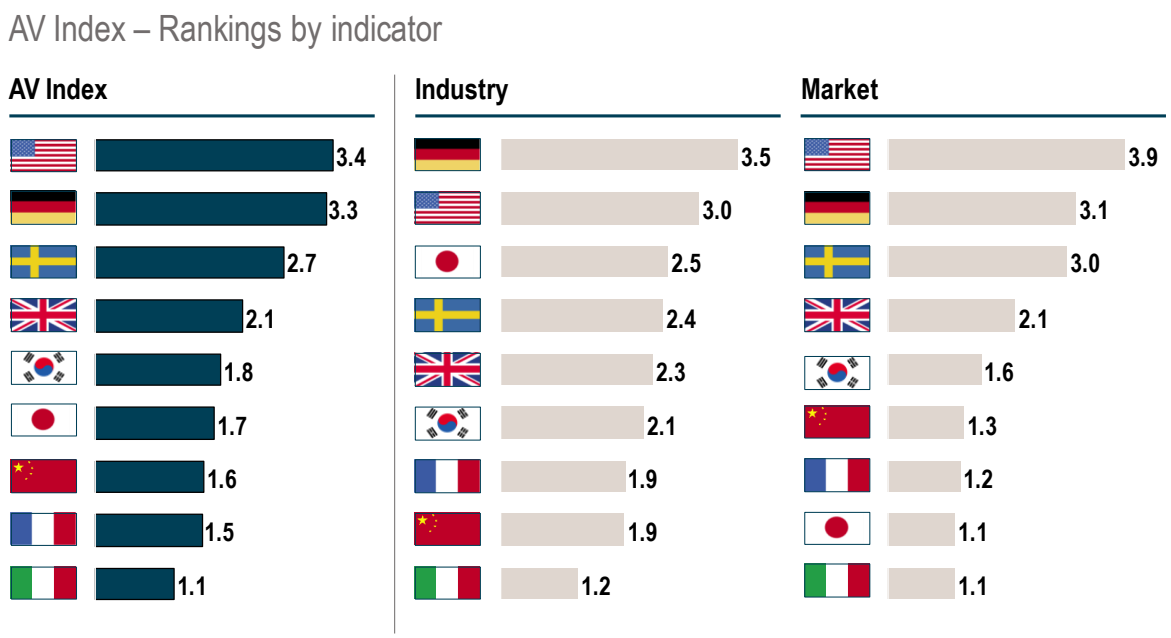
Market volume

> Sales figures for all vehicles in each country, plus the share of vehicles fitted with driver assistance systems on SAE levels 2 and higher (e.g. congestion assistance systems)

> Compared to the previous edition of the AV Index, the scores for market volume have all moved down in absolute terms owing to a change in the way this criterion is weighted. However, their relative comparability to the previous scores remains and was further verified by comparing them against the previous figures recalculated with the new weighting.

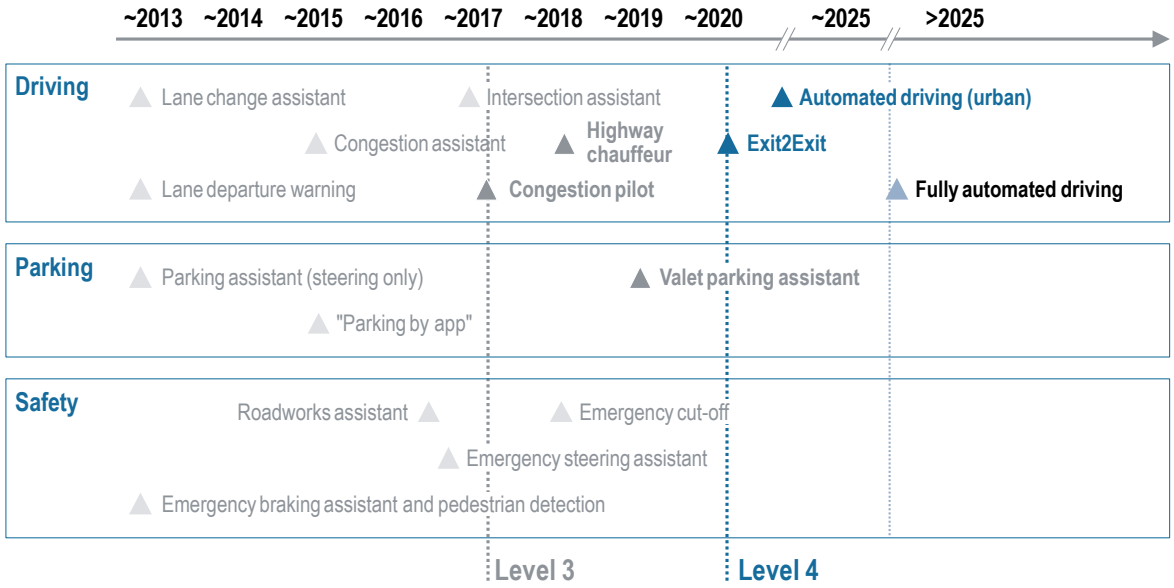
6. Appendix

Figure 8: Germany and the US lead the AV Index – Sweden follows in third place. The US has significantly extended its lead in the market indicator owing to favorable legislation



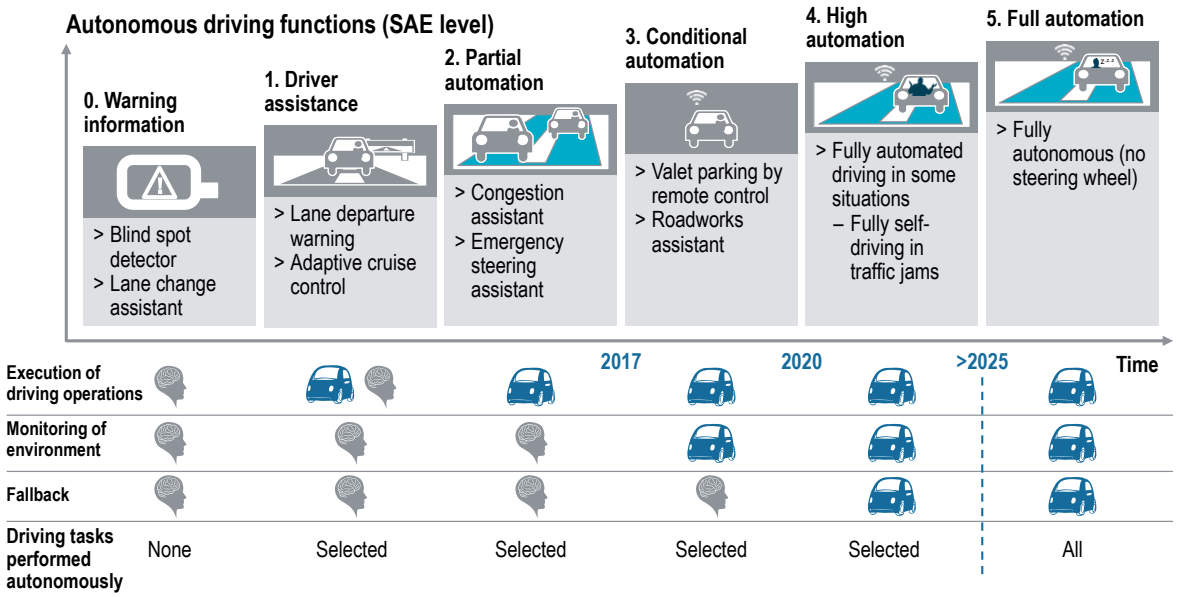
Source: fka, Roland Berger

Figure 9: OEM activities are benchmarked on the basis of driver assistance functions, including fully automated driving (AV Index – Launch horizon for automated driving functions)



Source: Roland Berger

Figure 10: Driver assistance functions of relevance to the index are those on SAE level 2 and higher (AV Index – SAE level definition)



Source: SAE Int., J3016, fka, Roland Berger

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