On the road toward the autonomous truck

Opportunities for OEMs and suppliers

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Introduction

Four megatrends will shape and transform the truck industry in the period through 2025 to make it **EFFICIENT**, **GREEN**, **CONNECTED** and **SAFE**. The importance of **SAFE** is set to rise in the coming years. Efforts to increase truck safety were strongly focused on reducing the impact of truck-related accidents in the past. Advanced driver assistance systems (ADAS) now offer the opportunity to achieve accident-free transportation.

With fewer traffic-related deaths and lower transportation costs, the expected benefits of ADAS-enabled (limited) self-driving trucks are compelling. Today, over 90% of all motor vehicle accidents are caused by human error and were responsible for 26,000 deaths in 2013 in Europe alone. The potential of automated driving in avoiding or mitigating accidents is huge. The European Commission has therefore mandated that from 2015 onward all newly registered trucks must be equipped with lane departure warning systems (LDWS) and from 2018 onward with advanced emergency braking systems (AEBS).

Furthermore, advanced driver assistance systems (ADAS) will reduce the total costs of ownership (TCO) of trucks. Today, the two largest factors in truck total cost of ownership are fuel and driver costs. Functions that are available today, such as adaptive cruise control (ACC), already enable fuel savings. In the future, vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication will greatly increase savings potential. The second-largest cost factor, the driver, will still need to be in the cabin – at least for the next decade. However, in highly automated trucks, drivers will now have time to engage in productive work like planning the next delivery, or enjoy some leisure time.

"Limited self-driving trucks are not expected to reach series-production readiness before 2025. The technology is almost there, but legal hurdles have to be overcome", states Sebastian Gundermann, Partner in the Automotive Competence Center.

- From a technical perspective, the main need for innovation is on the software side. Systems must orchestrate highly complex driving behaviors and have a fail-operational architecture that protects against technical failure and covers system malfunction. In addition, the per-unit costs need to be further reduced.
- A new legal (end insurance) framework is required before any autonomous trucks can drive on public roads. Today, autonomous driving is prohibited by law. Key questions to be addressed by a revised legal framework are liability (OEMs, suppliers, drivers) and criteria to determine if the vehicle meets the required safety standards.

The trend toward autonomous driving requires action from both OEMs and suppliers. Roles and responsibilities will be strongly influenced by the stage of automation. For OEMs, the main task now is to prepare technologically for automated trucks by further developing ADAS understanding on the vehicle and system level in-house. For suppliers, the future focus must encompass both technology (sensor and software development) and effective business models (for providing both complete systems and ADAS components only).

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A. MARKET DRIVERS FOR ADAS IN THE TRUCK INDUSTRY

In Pilbara, Western Australia, Rio Tinto's 53 autonomous trucks are moving tons of material between the three mine sites at Yandicoogina, Nammuldi and Hope Downs 4. Together, the fleet has now driven over 4 million kilometers on non-public roads and moved more than 200 million tons of material. There is no driver behind the wheel. Instead, the trucks are supervised by remote operators and respond to GPS directions.

On-road, however, we still have a long journey ahead of us before we will see autonomous trucks. With fewer traffic-related deaths and lower transportation costs, the expected benefits of autonomous trucks are compelling. Today, over 90% of all motor vehicle accidents are caused by human error. In Europe alone, 26,000 people died in 2013 in road accidents, and for every death there are another estimated four victims who suffer permanently disabling injuries. In emerging markets, the situation is even worse: today's accident statistics are expected to double by 2030. The potential of automated driving in avoiding or mitigating accidents is huge. Systems like adaptive cruise control (ACC) have been estimated to be able to reduce truck-related rear-end collisions, currently still the most common type of truck-related accident, by over 70%. The European Commission has therefore mandated that from 2015 onward all newly registered trucks must be equipped with lane departure warning systems (LDWS) and from 2018 onward with advanced emergency braking systems (AEBS).

Furthermore, advanced driver assistance systems (ADAS) will reduce the total costs of ownership (TCO) of trucks. Today, the two largest cost items in trucks are fuel and driver costs.

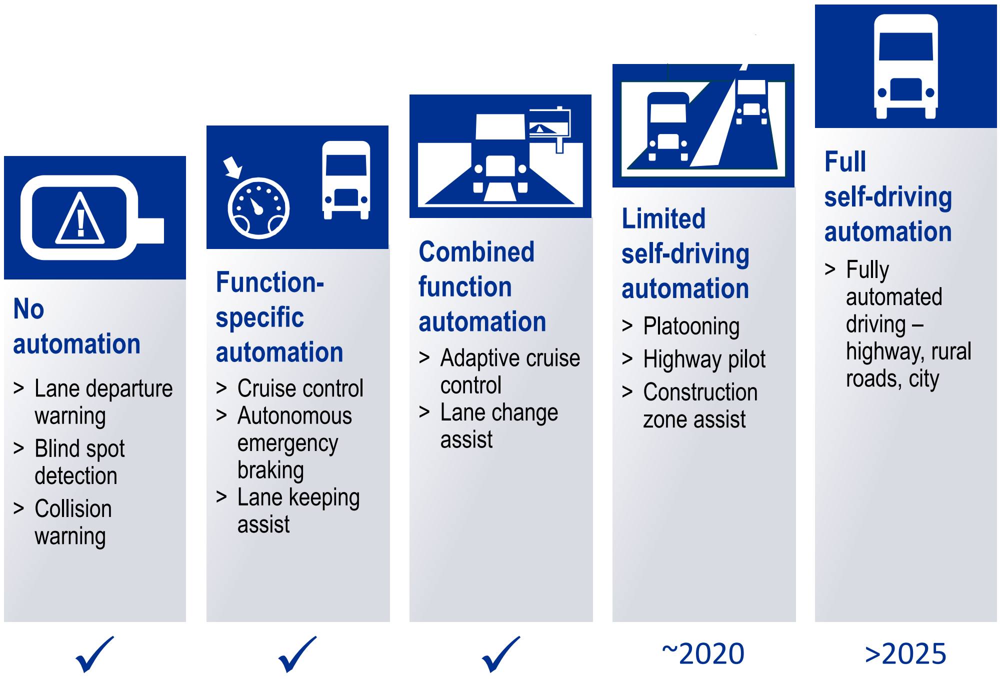
- Functions that are available today, such as ACC, already enable fuel savings. In the future, vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication will greatly increase savings potential. Vehicles will communicate with each other to synchronize traffic flow to avoid start-stop driving patterns and traffic congestion. Platooning, when a number of trucks drive together, has been shown to reduce the fuel consumption of the lead truck by 8% and that of the following trucks by 14% when traveling at 85 km/h.
- The second-largest cost factor, the driver, will still need to be in the cabin – at least for the next decade. However, in (limited) self-driving automated trucks, drivers will now have time to engage in productive work like planning the next delivery – or enjoy some leisure time.

B. SOFTWARE AND LEGAL CHALLENGES PRESENT THE GREATEST HURDLES

The path toward autonomous trucks will lead through five different stages. Stages 1 through 3 are already a reality:

> In the first stage, trucks are not automated and assistance systems provide truck drivers with warning information in clearly defined scenarios such as lane departure (lane departure warning system).
> In the next stage, vehicle systems actively assist the driver in clearly defined driving conditions such as in the event of lane departure (lane keeping assist system) for single functions (e.g. steering).
> In the combined function automation stage, vehicles take over driver tasks but not driver responsibility. The driver must still be attentive and able to retake control any second.
> Under limited self-driving automation, the driver can engage in other activities while the truck, for example, chauffeurs the driver along the highway or through traffic jams.
> The final stage is full self-driving automation where the driver is practically no longer required.

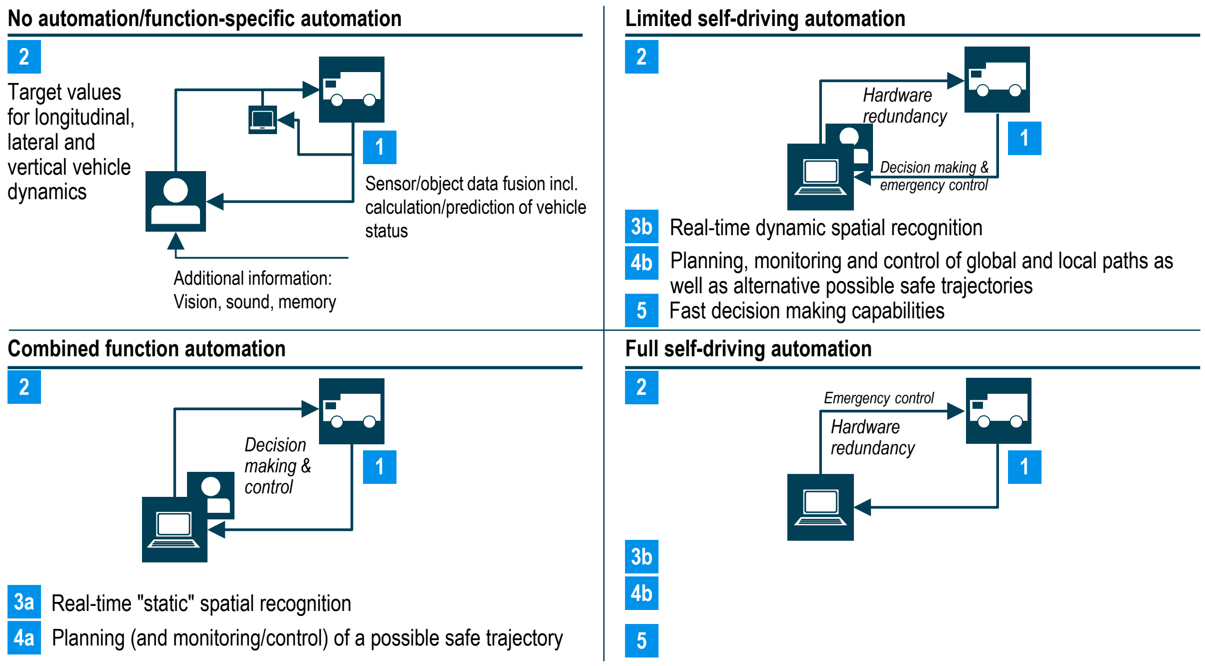
Figure 1: Functional demands in the 5 stages of automation



Source: Roland Berger

As can be witnessed on non-public land with Rio Tinto right now, the technology required for autonomous driving is surprisingly mature. On public land, the Daimler 'Future Truck 2025' has already traveled the first kilometers on a highway. Still, limited self-driving automated trucks are not expected to be series-production ready before 2025.

Figure 2: Functional demands for automation



Source: Roland Berger

To reach series-production readiness, advances in both sensor technology and the processing of sensor inputs are required. Advances in sensor technology are expected to be incremental rather than revolutionary. Next-generation camera sensor, for example, will offer higher image resolution and radar sensors longer ranges. From a technical perspective, the main need for innovation, however, is in the processing of sensor inputs, the software side. For early-stage ADAS functions, the two required software capabilities are the processing of sensor data (including combining input from more than one sensor) to estimate and predict the vehicle status [1] and overriding the driver control [2] by providing (new) target values for different vehicle systems (brakes, steering, dampers, etc.). For combined function automation, the system needs to further understand the immediate environment (e.g. the road with its markers, the curbs, obstacles, but also traffic laws and rules) and the exact location of the vehicle in that environment (the traffic), what is known as "static" spatial recognition. Based on this understanding, a possible safe path needs to be planned.

Limited self-driving automation has to deal with much greater complexity. It requires the prediction and anticipation of the behavior of others – vehicles, pedestrians, animals – basically everything that might create a potential danger in traffic, while simultaneous taking into account the movement of the vehicle itself, thus "dynamic" spatial recognition. Based on this information, the optimal route and trajectory has to be determined quickly. Full self-driving automation will ensure, in addition, that the assistance systems are capable of returning to the minimum-risk scenario under all conditions, so that there is no need for human backup anymore.

Overall sensor data fusion, spatial recognition, trajectory planning and control and decision making will almost certainly be realized through centralized system architecture. To process around 300 GB of data per hour, to integrate the truck with the cloud, and to implement stricter security mechanisms, the in-vehicle network will switch to IP-based communication. The key requirements of these architectures are safety and security. Systems must have a fail-operational architecture that can still function in the event of minor errors and has a safe mode in case of serious technical failure. Further, systems must be secure in order to prevent external access to the system.

Besides the technical aspects, a new legal (and insurance) framework is required before we will see (limited) self-driving automation on public roads. Today, autonomous driving is prohibited by law as the driver needs to be in full control at any given time. Key questions to be addressed by a revised legal framework are liability (OEMs, suppliers, drivers) and criteria that can be used to determine if the vehicle meets required safety standards.

C. IMPLICATIONS AND KEY TAKEAWAYS

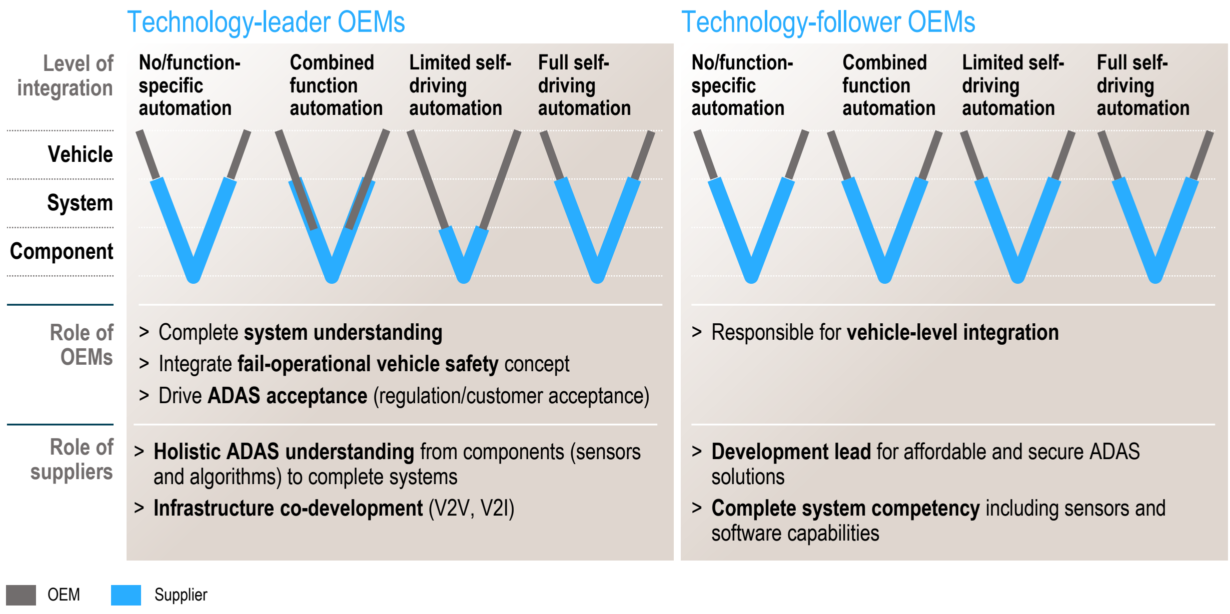
The trend toward autonomous driving requires action from both OEMs and suppliers. While roles and responsibilities will be strongly influenced by the stage of automation, the definition of the system architecture and system integration will remain the domain of OEMs across stages. Overall, we anticipate a stronger decomposition of the value chain, with specialists dominating specific 'functional clusters' that require specific competencies.

- For **function-specific automation**, complete functions can be sourced by OEMs from suppliers, including sensors and software (similar to pure warning functions in the no-automation stage)
- **Combined function automation** requires a more complex interaction between sensors, control software and actuators. These functions might be developed by the OEMs or by specialized engineering service providers or suppliers
- In a stage of **limited self-driving automation**, OEMs need to orchestrate component supplier activities as single ADAS functions converge to enable comprehensive trajectory planning and decision making functionality
- In **full self-driving automation**, the end-game scenario, this "brain" module might be rather standardized and configurable through parameters and models based on the physics of the underlying vehicle. In such a scenario, economies of scale are crucial, and it's possible that a large (software) player with a background in robotics may gain a significant share of the overall revenue and profit pool – offering complete systems to technology-follower OEMs at affordable prices

For OEMs, the main task now is to prepare technologically for limited/full self-driving automation**:**

- Further develop ADAS understanding on the vehicle and system level in-house to have relevant knowledge for designing limited/full self-driving trucks
- Partition ADAS based on clearly defined interfaces and responsibilities to facilitate interaction with the supplier base

Figure 3: Role sharing between OEMs and suppliers



Source: Roland Berger

For suppliers, the future focus must encompass both technology and business models**:**

- Develop advanced software capabilities and introduce next-generation sensor technologies to approach series-production readiness for the stages of limited/full self-driving automation
- Build effective business models for providing OEMs with both complete systems and ADAS components only

Roland Berger Strategy Consultants, founded in 1967, is one of the world's leading strategy consultancies. With around 2,400 employees working in 50 offices in 36 countries worldwide, we have successful operations in all major international markets. Within our Global Automotive Practice we have a dedicated team of Commercial Vehicle experts serving our clients all around the world.

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