Special Edition 2021

automotive engineering iav

Commercial **Vehicles**

Dear reader,

Commercial vehicle drives are already the benchmark in terms of efficiency and emissions. Powered by extremely challenging CO_2 legislation worldwide, fleet consumption values must be further significantly reduced. So we are now at the beginning of the next era. Whether electric drive, highly efficient internal combustion engine, alternative fuel or fuel cell – the development of new solutions ready for series production and at the same time high market attractiveness (Total Cost of Ownership) poses great challenges for us all. IAV considers itself well positioned to make a contribution to the long-term "Vision Zero CO_2" in commercial applications.

Future commercial vehicles will be fully connected. Intelligent route planning, prediction and condition-based maintenance, highly automated and autonomous driving functions as well as Car2X communication will make the transport task more efficient overall, increase availability and make the driver's workplace more attractive.

With more than 35 years of engineering excellence for commercial vehicles, a global setup and our strong international network, IAV is the ideal partner for bringing new technologies reliably and safely to market – while adhering to all processes and safety aspects.

We support you from the business idea, through initial demos, to the series product. Our development processes already rely on innovative methods such as the use of artificial intelligence to develop your product efficiently and robustly.

Enjoy reading!

Matthias Kratzsch
President, CTO

Carsten Rinka
Executive Vice President
Global Sales

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Senior Vice President
Commercial Vehicles

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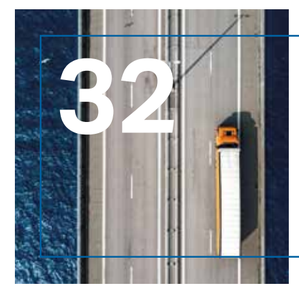

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Looking ahead: cost break-even for new technologies

Our Mission

We need to re-think the trucking industry! Global CO_2 & emission regulations, total cost of ownership pressure – all this will bring up new powertrains, but also connected and automated vehicles.

IAV is your sustainable partner to make your way even more successful.

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"Trucks are leading technology"

Developments for commercial vehicles have been a key pillar for IAV for many years. In an interview, Dr Jörn Seebode (Senior Vice President Commercial Vehicles) and Tom George (Director Business Development Commercial Vehicles) explain why projects in this field are particularly exciting and what unique selling points distinguish IAV.

What challenges is the commercial vehicle sector currently facing?

Seebode: The European Union's ambitious CO_2 targets are certainly the biggest challenge. By 2025, carbon dioxide emissions must be cut by 15 percent compared to 2019, and then by a further 15 percent by 2030. And we see comparable pictures nearly worldwide. That's why manufacturers must now make great efforts to avoid the threat of fines that would otherwise be imposed. An important element here is the drive combination – but this alone will not be enough. In order to reduce carbon dioxide emissions as required, possible solution scenarios must be considered as a whole, taking into account the specific fleet combination.

George: This is why a holistic approach is particularly important for commercial vehicles. The manufacturers evaluate their portfolios and determine which vehicles with which technology package can contribute what proportion towards reducing fleet emissions. Application scenarios and load profiles are particularly important here. Only vehicles that have been sold are evaluated in the balance sheet. Therefore, in addition to the CO_2 contribution, customer benefit is extremely important in the choice of technology. This is the only way to put together a successful package consisting of drivetrain, auxiliaries, aerodynamics, axles or, for example, a predictive navigation system. In other words: The products must be optimized as a whole, taking into account the fleet, legislation and the usage profile of the end user.

Why is this market so interesting for IAV?

George: Because the impending technological upheaval offers an engineering partner like IAV many opportunities. We are dealing with highly interesting challenges in many different areas. In the field of drive systems, for instance, we will see a variety based on use cases and existing platforms – in addition to highly efficient diesel engines, CNG drives, hydrogen combustion engines, fuel cells, and battery electric solutions will play a role in future commercial vehicles. In addition, optimized aerodynamics will make an important contribution towards lower CO_2 emissions.

Seebode: And there will be other developments with high technological demands, such as highly automated driving, digitalization or the connectivity that is so important for fleet management. These projects will also be particularly challenging due to the large number of variants in the commercial vehicle sector, which makes virtual model-based development particularly important. This makes future projects extremely exciting for engineers.

Why should a customer come to IAV with his project?

Seebode: Because we have been operating in this field for many years and have demonstrated in numerous projects that we can make a significant contribution for our clients! Our experts have proven time and again that they have outstanding expertise in commercial vehicles and mobile machinery. And we have a truly unique selling proposition: We have all the trades under one roof and can offer our customers a one-stop service. Developments for commercial vehicles are now a firm pillar at IAV and a significant business for us.

In the commercial vehicle sector, IAV pursues a three-pillar strategy. What does that mean?

George: The first pillar is our aforementioned expertise that covers the entire vehicle. The second pillar has to do with the international market in which we operate: Our customers are global corporations. They need solutions that are tailored to the different needs of their customers and local conditions, for example in terms of fuel qualities, user behavior, goods traffic or TCO. Because buyers know exactly what they need and whether a commercial vehicle meets their requirements. Different technology packages must therefore be put together depending on the market. IAV is represented worldwide and knows the respective markets very well thanks to our local commercial vehicle experts. We are where our customers are and work with them to find optimum solutions.

Seebode: The third pillar concerns project design. We assume greater responsibility and can take on development packages on our own responsibility – this is very interesting not only for established OEMs but also for many start-ups that are now entering the commercial vehicle market. Many of them have exciting ideas but do not know how to turn them into a product. This is where our service starts with the definition of requirements and then extends through development to the transition to series production. Thanks to our professional project management and process reliability, we can trustfully lead such complete packages to success – for established OEMs as well as for new players.

How have you positioned yourself internally for this?

Seebode: We have established a cross-functional organization and Centers of Excellence for commercial vehicle-specific topics, for example "TCO & CO_2 Efficiency" and "E-Mobility." Our colleagues here deal exclusively with special solutions for our commercial vehicle. They know the markets and requirements and are therefore able to combine the best technologies with the requirements of our customers. As a global key account manager for the commercial vehicle sector, I am responsible for the sales interface with our customers. This gives them a central contact person who takes care of their concerns.

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Markus Petzl, CEO at disruptive

"In these disruptive times, what we need above all are pioneers"

Markus Petzl is a strategy consultant specialized in disruption. In an interview, he describes the disruptive forces that are important for the commercial vehicle industry and how OEMs can adapt to the new world.

Mr Petzl, which disruptive forces are relevant for the commercial vehicle industry?

There are three fields that offer starting points for disruptive developments: technology, legislation and mindset. Technologically, the new drives are worth mentioning, but so too are topics such as autonomous driving, artificial intelligence, connectivity, and Big Data for fleet management. Legislators are promoting disruption primarily through strict CO_2 limits, but in the future perhaps also through new regulations for noise in cities. The mindset brings together several developments: For example, there are new business models based on sharing rather than ownership – keyword: Transport as a Service. But we also see a change in drivers, because there are fewer and fewer people who want to do this job. And because of autonomous driving, the last human driver has already been born anyway.

What do these disruptive forces do?

Disruption means that there is a sudden rather than a smooth transition – for example, when new technologies emerge that allow things to be done more efficiently or more safely. This releases an enormous potential for change. In the case of commercial vehicles, for example, existing pain points could be converted into good points. This calls for innovative providers who see new business opportunities. For example, they could establish a completely new service at the very top of the value chain, and thus, capture the largest share of the margin. Today's commercial vehicle OEMs and logistics providers could thus become mere suppliers. A good example of this is Uber Freight: The company arranges unused space on trucks, and thus, optimizes their capacity utilization. Customers don't care which logistics provider or truck is used to transport the goods. Truck brands and designs are therefore becoming less and less important. And the service provider has the bulk of the margin.

How can established OEMs still hold their own in this world?

They may have to move up one step in the value chain themselves and offer their customers more than just vehicles. And many companies are trying to do just that: They are giving a lot of thought, especially in their "labs", to how to respond to the disruptive forces. However, they have one disadvantage: Many initiatives fail because they jeopardize existing business and are therefore not supported by sales, for example. The OEMs are in a prison of sorts. Start-ups, on the other hand, have no such persistent forces and also have much more time: They are financed by venture capital and do not have to make a profit at first. In an established company, on the other hand, the change agents always have controlling and the banks breathing down their necks. New ideas are often buried there far too quickly. And because they have supposedly been burned at the hot stove, innovations are better left alone altogether.

It sounds as though the established manufacturers have no chance against their new competitors...

But this is not the case! Because the good news is: Right at the front, at the forefront of development, it is like being in an unknown country. No one really knows their way around there. That's why in these disruptive times we need pioneers above all else – and that's exactly what the established companies used to be themselves, otherwise, they would never have become so successful in the first place. They have to revive this pioneering spirit, which is also being attempted through start-up purchases and the various innovation labs and accelerators. Unfortunately, these initiatives often involved relatively unimportant areas, which meant that the whole thing could be dismissed out of hand and quickly ended. But it does not have to be this way: Even large and successful companies can be pioneers; not just start-ups.

> "Disruption means that there is a sudden rather than a smooth transition – for example, when new technologies emerge that allow things to be done more efficiently or more safely."

How can this be achieved?

Through bipolar management that drives existing and new business models in parallel. Instead of delegating new initiatives to fringe areas, they must be returned to the company core and become a matter for management. This is only possible with a cultural change that must be supported by the board of directors. This can take years, but it also promises potentially big profits. After all, there will always be a need for freight transport – the question is who can secure the bulk of the profits. IAV itself is a perfect example of this: The company has been successfully putting innovations on the road for decades, reinventing itself time and again in the process. This makes IAV the perfect partner in these disruptive times.

Contact: disruptive.wtf

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Technology paths towards a CO_2-compliant fleet in 2030

A further reduction in carbon dioxide emissions cannot come from the powertrain alone. Rather, a combined approach consisting of a CO_2-optimized combustion engine, complete vehicle measures and an adapted fleet and zero-emission strategy is required. This is why IAV has developed a roadmap with which the savings potential of individual technologies can be assessed.

The legal requirements of the European Union envisage a gradual reduction in CO_2 emissions, and thus, fuel consumption in the transport sector by 2030. Whereas fuel consumption was previously primarily relevant for end customers (Total Cost of Ownership, TCO), this is now changing: The vehicle manufacturer is moving into focus through penalty payments. In addition, the perspective is broadening – away from the combustion engine and away from individual vehicles, towards a fleet-based view of the entire vehicle.

Commercial vehicle fleets are generally characterized by a high degree of heterogeneity. There are different configurations, weight classes and superstructures (Figure 1). This requires a holistic view. That's why there is no generally valid answer to the question of the CO_2-optimized vehicle fleet. Specific framework conditions of the vehicle manufacturers as well as particularities in the usage profiles, performance requirements and infrastructure must be reconciled.

Fleet and TCO calculator for scenario comparison

This is why IAV has developed a CO_2 technology roadmap. It enables technology paths to be defined for vehicle and powertrain technologies using a fleet and a TCO calculator. The fleet calculator allows synthetic fleet compositions to be generated, with the savings potential of vehicle and powertrain technologies being calculated on the basis of the CO_2 emissions simulation VECTO (Vehicle Energy Consumption Calculation Tool). The TCO calculator provides a holistic cost consideration, including fuel and energy cost scenarios.

For the following consideration, Figure 2 provides an overview of possible technology packages. Figure 3 shows possible CO_2 benefits for a synthetic fleet composition. As Figure 3 illustrates, a high proportion of Zero Emission Vehicles (ZEV) is required to achieve the targets. In addition, two percent ZEV must be available in the fleet annually from 2025. Otherwise, the specific CO_2 fleet value will increase.

In the area of ZEV, a relevant market penetration with Battery Electric Vehicles (BEV) in urban areas or in hub-to-hub traffic is possible in the short term. Up to a daily mileage of a few hundred kilometers, a BEV has advantages in terms of local emissions and driving noise. It also meets with high public and political acceptance. Class 4 and 5 vehicles are particularly interesting for electrification because of their high market shares. BEVs with today's technology are unsuitable for heavy transport tasks over long distances – because of their short range, disadvantages in payload due to heavy batteries and the currently insufficient charging infrastructure. This is why IAV is assuming a 50 percent share of BEVs in Class 4 and 10 to 20 percent in Class 5 by 2030.

From IAV's point of view, it must be of great interest to the established vehicle manufacturers to enter the market for alternative drive systems quickly and decisively. On the one hand, CO_2 legislation is expected to become stricter after 2030 ("EU Green Deal") – this means that a technological lead will still pay off after 2030, and that it will become more difficult for manufacturers with a technological gap to achieve their targets. On the other hand, it can also secure a market segment that would otherwise be occupied by new competitors.

CO_2 savings through optimized aerodynamics

A lot of new vehicle technologies can be brought into series production largely independently of the powertrain and at comparatively low cost (Figure 2). Particularly in long-distance traffic, the optimization of aerodynamics opens up high CO_2 saving potentials. If tractors and trailers are aerodynamically matched to each other, fuel savings in the double-digit percentage range are possible. However, legislation currently only takes the tractor unit into account. Changes to this could be brought about by the review of the CO_2 target values scheduled for 2022.

In the VECTO methodology, the determination of aerodynamic parameters is mandatory. Active systems such as radiator blinds are only permitted to a limited extent when carrying out measurements (constant speed tests). However, the exact knowledge of the aerodynamic potential that becomes visible with the specified test procedure is decisive for optimization. This is why IAV has conducted intensive test series: In addition to the aerodynamic potential, additional potential can be seen in the tires as well as in the regulation of the speed trajectory. If all the potentials that can be credited to VECTO are taken together, IAV believes there is a possible benefit of eight to ten percent less CO_2.

	Axle type	Chassis configuration	Gross vehicle weight (tonnes)	Vehicle group
	4 x 2	Rigid (or tractor)	7.5 – 10	1
		Rigid (or tractor)	> 10 – 12	2
		Rigid (or tractor)	> 12 – 16	3
4		Rigid	> 16	4
5		Tractor	> 16	5
9	6 x 2	Rigid	all weights	9
10		Tractor	all weights	10
	6 x 4	Rigid	all weights	11
		Tractor	all weights	12
	8 x 4	Rigid	all weights	16

VECTO-relevant vehicle configurations

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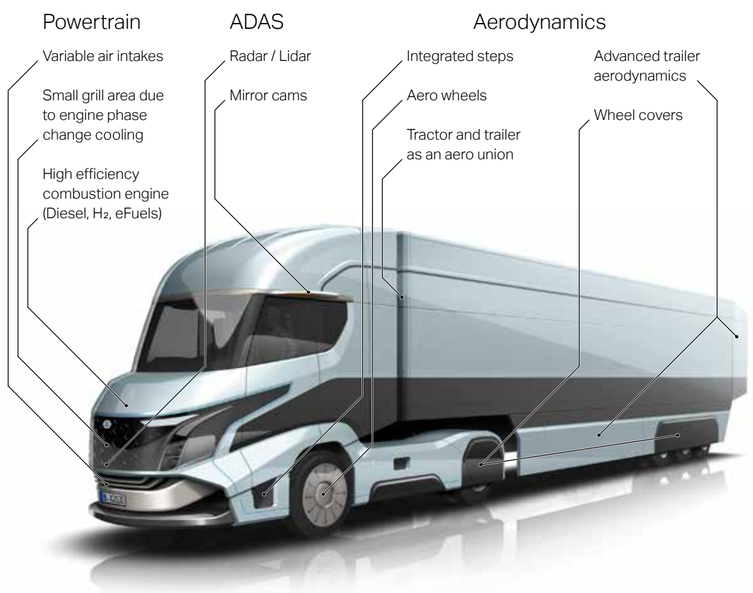
Increases in efficiency are also possible with today's Euro VI engines, but they involve comparatively high costs. From IAV's point of view, one scenario could therefore be the development of a high-efficiency diesel engine (HED). The HED is designed by way of example as an In-line 6 engine in the 12 l class. A reduction in internal engine friction ensures low CO_2 values for the base engine. The consistent design of the combustion process for low fuel consumption further reduces carbon dioxide emissions. The drive system also features waste heat recovery from the exhaust gas, supplemented by phase change cooling. From IAV's point of view, the HED engine concept has a possible CO_2 potential of seven to ten percent.

It could also be used as a development basis for a H_2 combustion concept that could then achieve ZEV status. This requires the implementation of a direct injection system with adjustments of the air and exhaust gas path.



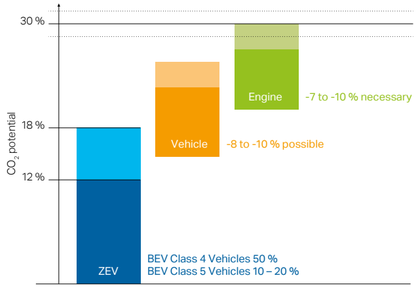
Efficiency measures and technology packages

Specific scenarios for a synthetic vehicle class composition

Vehicle fleets, and thus, the basis for achieving the CO_2 targets are manufacturer-specific. For the following scenarios (Figures 4 and 5), a synthetic fleet composition of a typical European OEM is used as a basis. A high proportion of BEV vehicles is important, as they contribute most towards CO_2 reduction. These are considered with 50 percent in Class 4 and 10 percent in Class 5 in both scenarios. Based on this, the decision is made as to which vehicle and powertrain technologies must be brought into the fleets. Due to the improved cost-benefit ratio, the vehicle technologies must be prioritized. These are included in both scenarios with an eight percent reduction in CO_2 emissions.

From IAV's point of view, the fuel cell is an important component of mobility in the long term. For robust operation, however, it currently requires high-purity hydrogen (H_2). A H_2 engine, on the other hand, also operates with a less pure and less expensive quality, and thus, plays off further advantages when considering the TCO. It can be developed relatively quickly to standard eries production readiness and can act as a pioneer of the fuel cell in the development of the infrastructure.

In the long term, it is expected that fuel cell systems will become more powerful, cheaper and more robust. They will therefore become the preferred solution for innovative drive concepts. Fuel cells can already be optimal for niche applications today. However, they are currently not



CO_2 saving potentials on the basis of a synthetic vehicle fleet

relevant for VECTO, and thus, for fleet considerations and must first be considered by the legislator. In scenario 1, the development of H_2-ZEV technologies therefore plays the central role in achieving the goals. This includes the risk of missing these targets in case of low market penetration (especially in 2025).

Through the parallel development of the H_2 engine and the high-efficiency diesel, scenario 2 additionally uses the margin of the HED with a 10 percent CO_2 advantage. As a result, the 2025 targets appear to be safely attainable.

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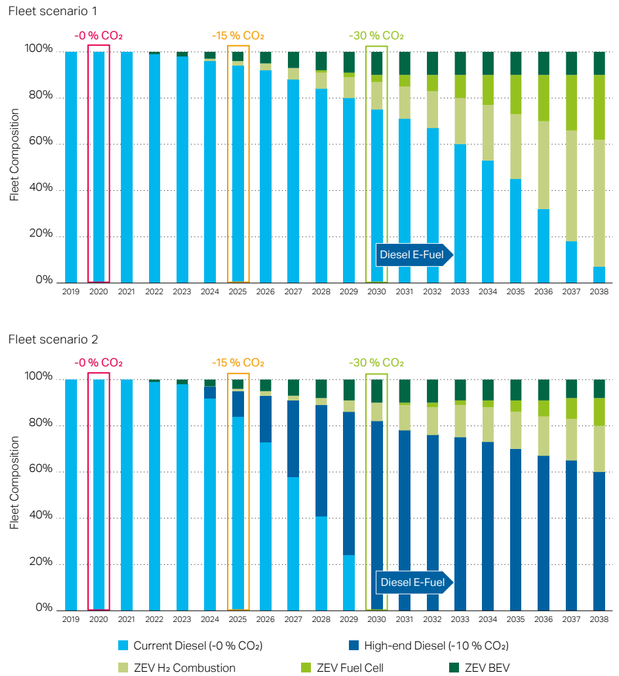
Scenario 1: ZEV

- Development of H_2 combustion engines and fuel cell systems
- Retention of the current diesel engine generation (no CO_2 benefit)
- Achievement of the 2030 goals primarily through ZEV

Scenario 2: HED and H_2 engine

- Development of the HED (10 percent CO_2 benefit) and long market use
- Slow replacement of the diesel engine by the H_2 engine and fuel cell systems
- Achievement of the 2030 goals by HED and ZEV



The scenario is thus less dependent on a rapid and high market penetration with alternative drives. At the same time, the HED can be used in the long term and is available as a basic engine for markets with less stringent CO_2 regulations. The costs associated with the system complexity of the HED should be mentioned as a risk.

Continuing the development of combustion engines has a decisive advantage: In the long term, the introduction of CO_2 targets based on well-to-wheel or life cycle considerations can be expected. This would enable the use of e-fuels, which can form a closed CO_2 cycle in the powerful and efficient HED engine.

Adapted fleet strategy required

In order to achieve the CO_2 reduction targets for commercial vehicles in the EU, an adapted fleet strategy is required, which depends on the technology portfolio of the manufacturers. More than ever before, holistic system approaches will be required to limit the costs of an increasing number of technology variants. The achievement of the 2030 targets will depend to a large extent on the combined use of vehicle measures (aerodynamics), powertrain technologies (development of HED) and the targeted development of ZEVs. However, the real use of all available potentials requires consideration by the legislator. Hydrogen and e-fuels as drop-in fuels are of great importance. In addition, it is essential that the solutions implemented are accepted by customers – because only vehicles that are actually sold contribute to the balance sheet. One thing is clear: A "diesel-only" strategy will not lead to success!

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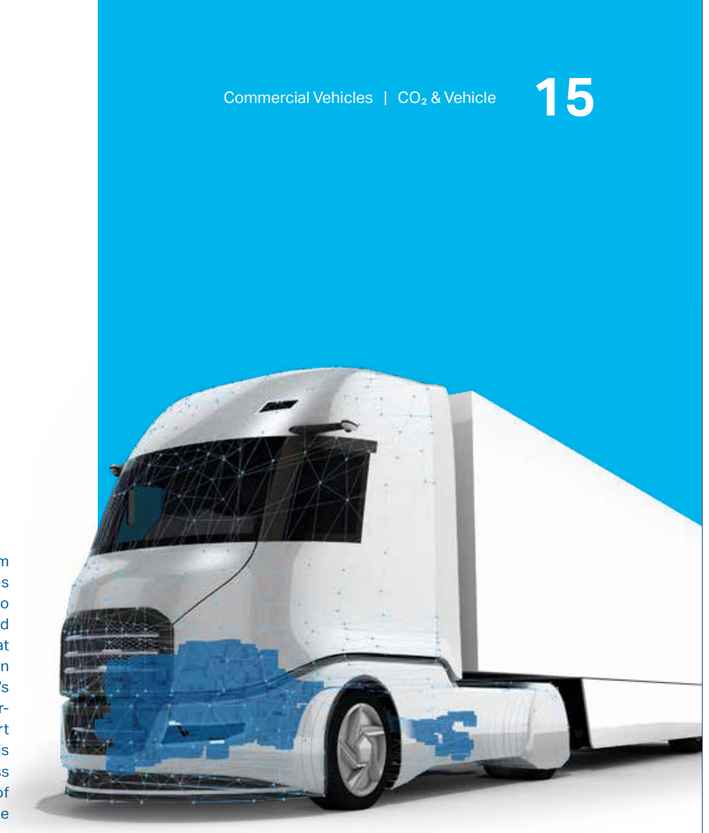
For more information watch our video on YouTube! >

Virtual trucking with IAV



Fast and high-quality overall system simulations of commercial vehicles and mobile work machines – also in combination with cosimulations and commercially available tools: This is what our model-based development toolchain offers. By using Matlab/Simulink and IAV's own libraries, as well as GT-Suite, customer-specific models can be created in a short time and with high precision. IAV ZEYA is used throughout the development process and is based on more than 15 years of experience in the field of complete vehicle simulation.

There are many typical questions at the beginning of a development project in the commercial vehicle sector: What does a powertrain that fulfills both customer requirements and legal specifications look like? How can the operating strategy be optimized? What specifications, for example, must the electrical components have? The large number of application scenarios and the multitude of future drive options make it even more difficult to find reliable answers to these questions early in the development process. IAV ZEYA supplies this information and is used at IAV from the concept to the start of production. "The tool specializes in the overall energy simulation of commercial vehicles", explains Dr Dennis Jünemann, simulation engineer and expert for overall vehicle simulation at IAV. "We use our own libraries with commercial-vehicle-specific subsystems such as vehicle longitudinal dynamics with trailer or a twelve-speed switching logic." From the submodels for the individual commercial-vehicle subsystems, IAV has created basic models for entire commercial vehicles using state-of-the-art technology, for example for trucks or agricultural tractors. They can be adapted to the specific requirements of a customer project without major modifications, meaning the preparatory work carried out by IAV results in significant time savings.

Simple combination with domain-specific simulation tools

The tool has been intensively enhanced over the past months: On the one hand, its optimized bus structure allows the sub-models to be connected even better with each other. On the other hand, the simulation experts have improved the signal management to ensure low-error modeling. "This is essential for the complex models in the commercial vehicle sector and an important prerequisite for cooperation between different teams", explains Jünemann. "Especially with the new powertrains, we must combine different tools, which presupposes error-free signal transmission." Typically, IAV ZEYA is connected with models for fuel cells, for hydrogen combustion (co-simulation with GT-Power) or battery electric drives.

"Fast and high-quality simulations are indispensable today in light of the complex powertrains", summarizes Jünemann. "We developed IAV ZEYA because there are no commercial tools on the market for this purpose. Thanks to the integrated interfaces, we can work with it across domains and answer all new questions very well with simulations. By collaborating with our colleagues from the synthesis & testing department, we are also able to make use of synergies and to validate our models optimally."

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Trucks of the future

Stricter CO_2 limits and changed legal requirements for vehicle registration: These are the main drivers of current truck development. IAV is looking to the future with its own truck design and has developed two variants for the US and European markets.

For European truck drivers, the new nose at the front is probably the most striking innovation. Thanks to changes in legal regulations, it can now be 80 to 90 centimeters long, which means that future trucks on European roads will be more reminiscent of their US counterparts. Nevertheless, differences remain: "As before, the front axle of the European model is at the height of the driver further back," says Olaf Jacob, project engineer for commercial vehicles at IAV. "In addition, the wheelbase of the EU version is shorter than that of the US truck. What's more, the latter is only available with two rear axles in a 6x4 configuration as is customary in the USA."

IAV's experts and designer Nils Poschwatta were guided by the big drivers in truck development: the desire for lower CO_2 emissions and the new specifications for vehicle dimensions. "Many manufacturers are currently on the lookout for solutions that will reduce fuel consumption," says Jacob. "This is where the Future Truck comes up with numerous innovations."

Measures for better aerodynamics

For example, the nose and the stem of the EU version provides significantly better aerodynamics compared to the previously common front designs. In both versions, the windshields have also been tilted and curved to optimize the airflow around the vehicle. Here, however, it was important to avoid undesirable side effects: The new design should neither lead to a lens effect when looking outwards nor to excessive heating of the driver's cab – and the associated additional load on the air conditioning system. Movable flaps on the radiator grille open when required and also contribute towards improved aerodynamics. Finally, the elimination of the classic exterior mirrors also leads to lower driving resistance – their function is now taken over by cameras that protrude from both sides of the truck and hardly obstruct the air flow. Additionaly, camera-based systems offer increased safety due to a wider field of view.

The windscreens, which are pulled down further, and the lower parapet line, lead to better visibility. In addition, the Future Truck is to be fitted with sensors for pedestrian detection to increase traffic safety. Other assistance systems such as a distance radar and an emergency braking system are integrated. Optimum night vision is another element in preventing accidents – this is what the LED matrix headlights in the Future Truck promise. And even the tractor's light band has more than just an aesthetic function: It surrounds the entire driver's cab and also serves as daytime running light, turn signal and position indicator.

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Open for different powertrains

The Future Truck can be operated with different powertrains, which makes it future-proof. "This could be a highly efficient diesel engine that is likely to dominate long-haul transport for years to come," says Jacob. "But, of course, the layout is also prepared for alternatives such as fuel cells, hydrogen engines or battery electric drives." To further increase efficiency, the trucks are ready to fit a waste heat recovery system and phase change cooling, which allows to reduce the number of air intakes in the front.

For IAV, the Future Truck provides a basis for talking to potential customers. "On the one hand, the design is highly innovative and, on the other hand, suitable for everyday use and already designed for standard production. We had the great advantage of being able to work free from the constraints of existing designs," summarizes Jacob. "We are currently using the Future Truck as a basis for discussion with OEMs and suppliers. It shows that IAV is capable of developing complete commercial vehicles – while also taking into account the various usage scenarios in the logistics process."

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"Don't be afraid of unusual solutions!"

Together with IAV experts, Nils Poschwatta has designed the IAV Future Truck. In an interview, he explains what was particularly important in terms of design and what trucks will be making the difference in the future.

You usually design cars and motorcycles. What was it like for you to develop the design for a truck?

Commercial vehicles are not a new topic for me, although up to now I have developed light trucks as a whole and only designed interior concepts for heavy trucks. So the IAV trucks were my first project where I was able to design the exterior of a heavy truck. This gave me the opportunity to design the appearance of a future European truck rather than "just" formally editing existing packages. As many innovations as possible were to be embedded in the new form and new functional concepts integrated. I had to comply with current legislation as well as the requirements of aerodynamics. And there were to be two variants for the EU and the USA. During the project, I worked together with many colleagues from IAV's specialist departments. And although IAV is a large company, we always had very short lines of communication and were able to implement everything quickly. It was very precise work!

How does the new design differ from existing trucks?

In the EU variant, the nose on the front end is certainly the most striking new feature. It ensures better crash behavior, its radial base also optimizes aerodynamics and gives the vehicle a new look. Up to now, trucks in the EU have tended to be "rolling shelves". The US version is also more aerodynamic. For this reason, we have tilted the windshields of both models more and added a stronger base to make the greenhouses and stem more closely resemble one unit. A visual as well as functional highlight is the light band that extends over the front and around the grille, continues along the sides and closes again around the rear. It serves as a daytime running light in the front area and forms the characteristic face of the truck, which is normally defined by the main headlights. In addition, it takes over various functions pertaining to the truck and can be used to communicate with the surroundings through the freely programmable RGB LEDs. Another innovative concept is the entry level. We use a sliding door, which is not yet available in trucks in this form. In this way, we improve the staircase or entrance clearance, but also the accessibility between parked trucks.

Nils Poschwatta

After studying industrial design at the Muthesius University of Applied Sciences in Kiel, Nils Poschwatta worked for Volkswagen Design in Wolfsburg for eight years. During this time, he created the interiors of several concept and production vehicles, including the "IROC," "Scirocco" and "the Beetle." Since 2009, he has been Managing Director of Modus GmbH and in charge of the Poschwatta Automotive division.

Could such a truck also be built and marketed?

Yes, certainly. Everything is designed in such a way that it can also be registered. I deliberately did not want to build design locks and I wanted to follow the criteria for approval. And the result shows: You can comply with the legal requirements and still break new ground. This is also my wish for all truck manufacturers: Try to meet conventions with innovations and don't be afraid of unusual solutions!

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Robert Dolan, Director of Commercial Vehicles and Government Programs at IAV

"OEMs need to achieve optimal end-user value when selecting technologies"

In the USA, future regulatory requirements are putting commercial vehicle manufacturers under pressure. In an interview, Bob Dolan (Director of Commercial Vehicles and Government Programs) reports on what makes the market there so special and how IAV Inc. and IAV in Germany support their customers in making technology decisions and developing products.

What does the US market for commercial vehicles (CVs) currently look like?

It can be divided into four principle areas: Heavy-duty and medium-duty on-highway products are the most recognized and subject to the most demanding regulatory requirements. Off-highway products range from adapted on-highway products, to real industrial engines with more than 19 liters displacement, and are applied into incredibly diverse, specialized applications, e.g., stationary, wheeled, tracked and marine. The US Government is a CV market sub-sector, including the Department of Energy, the National Labs and Department of Defense. And the start-up companies (aka, Innovation Companies) constitute an increasingly relevant CV sub-sector, with CO_2-efficent and zero emissions solutions being fast-tracked to demonstration phases. This sector is characterized by rapid capital infusion from the investment community, into high clock-speed teams that lack the internal resources needed to fulfil their objectives. IAV Inc. is active in all four of these CV market sub-sectors here in the US.

What role does proposed legislation play for your customers?

A major role. And a lot is happening here at the moment because many individual measures are positioned to have a compounding impact on our customers' development programs. For example, the EPA is poised to enact demanding particulate matter (PM) reductions, from 0.01 grams per brake horsepower hour (g/bhp-hr) to 0.005 in 2024. At the same time, it is also considering significantly extending the "Useful Engine Life" from 10 years or 435,000 miles, to 18 years or 850,000 miles, and emissions-relevant warranty periods from 5 years or 350,000 miles to 14 years or 800,000 miles. Keep in mind, Green House Gas Phase 2 is still in implementation phase to realize CO_2 reductions. And in the background, the current voluntary CARB Ultra Low NO_x program is under consideration by the EPA as a 50-state mandate. Individually, each of these initiatives drives significant development activities for our customers, and combined, they underscore the need for companies like IAV to provide guidance on technology selection and application, as well as expert engineering support to enable customers to meet their objectives.

> "We have many building blocks that will make future commercial vehicles more environmentally friendly."

Are customers in the USA prepared to pay more money for environmentally friendly solutions?

Outstanding and relevant question! Short answer: rarely. Unlike the passenger car sector, CV customers simply do not make impulse or emotional purchase decisions. Total Cost of Ownership (TCO) is the main driver for fleet managers when specifying their equipment. To illustrate the market challenge, consider the 24-month leasing model that is prevalent for US Class 8 long haul trucks; TCO considerations dictate that add-on costs for CO_2 reduction equipment pay for themselves within 24 months or 200,000 miles. Very challenging where $2.50/gallon Ultra Low Sulphur Diesel is concerned. As a result, major changes in technology adoption are typically only driven by new regulatory requirements. Considering the competitive landscape, this underscores the need for vehicle manufacturers to achieve optimal end-user value when selecting technologies for meeting future regulatory requirements. Innovation companies like Nikola, pursue novel approaches to the New Tech – TCO challenge, by combining vehicle lease, H_2 fuel and all maintenance costs into a single lease payment equal to the national average of clean-diesel truck operating costs of $0.95/mile.

How do you support your customers in the transition to new technologies?

We have many building blocks that will make future commercial vehicles more environmentally friendly. Take, for example, our footprint in fuel cell development: IAV operates a state-of-the-art test facility for stack development. Now couple that block with the many that comprise IAV's electrified powertrain capabilities and you see how we are positioned at the component, sub-system and full system development levels to meet customer needs. Another example is fleet simulation, where individual and combined technologies can be studied on application-specific drive cycles to identify the mix of technologies needed to achieve a sales weighted fleet solution to regulatory requirements. Aside from the direct engineering support, the IAV Inc. Northville, MI facility is equipped with four medium duty and heavy duty sophisticated transient emission test cells, where our highly talented staff supports US customer product development activities with engine and aftertreatment system calibration activities, OBD development and compliance testing.

What is the cooperation between IAV Inc. in the USA and IAV GmbH in Germany?

In terms of CV activities, the level of cooperation is outstanding. Many CV customers are in fact global players and we are able to present one IAV Team to them, independent of geographic location. The IAV Global CV team is driven by a robust and well aligned customer strategy plan, we are in frequent and regular communication, we effectively leverage same working methods, acquisition materials, deep technology exchange, marketing, and social media, and we operate inside same project management tools. There are over 8,000 globally placed employees at IAV, across all portfolios, and we are fortunate to have more than 300 CV experts interspersed among them. As a result, we have options in terms of meeting customer requirements globally. Support is provided bilaterally and the working relationships are very good.

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Innovative truck infotainment

Future commercial vehicle infotainment systems must reconcile the requirements of OEMs, commercial vehicle owners and drivers. While many cockpits are still improvised today, the future belongs to sensibly integrated solutions. IAV advises vehicle manufacturers on architecture issues as well as on testing and integration and user interfaces.

Radio, navigation system, computer for logistics software: Many truck cockpits contain a variety of different devices, some of which originate from passenger cars. "But that's not an ideal situation, because commercial vehicles require their own solutions – for order management on the road, for instance," says Torsten Herrmann, Senior System Architect at IAV. "It would be better not to improvise and instead to integrate everything in a sensible way."

However, the different requirements of OEMs, logistics companies and drivers must be reconciled. OEMs, for example, want a recognizable design and a wide range of variants – from a simple radio to an infotainment system for coaches. In addition, a flexible architecture is required to enable the integration of modules from external suppliers. This is important, for example, in order to log compliance with the cold chain in refrigerated trucks or to be able to control structures from the cockpit.

This does not always meet the requirements of customers such as freight forwarders. "They often have several brands in their fleets, for which the manufacturers each offer their own fleet solutions," says Herrmann. "But this does not help users who would rather use a uniform system on all vehicles in their fleet. It would therefore be better to have a connectivity interface from the OEM, to which any third-party solutions can be docked as an open platform."

"IAV offers support along the entire development chain – from initial studies, prototypes, tests with the target group, HMI specification through to HMI series development and testing."

E-test bench to go

Flexible, effective and economical: With IAV Auros, we offer mobile test bench automation for electric drives and auxiliary units.

Electric mobility is picking up speed. Nearly all manufacturers will launch new models on the market in the next few years. And the trend is rising. For developers, this means a growing need for suitable test benches to put high-voltage components and electric drives through their paces. Conventional test benches are suitable for this purpose, but the test bench times are rare and relatively expensive. In order to resolve this area of conflict, we have developed IAV Auros, a mobile test system for electric drives that is easy to transport and yet contains all the features required for high-voltage testing. With our system, all rooms with a voltage supply of 63 amps become potential high-voltage test benches.

Despite its compact size, the mobile test bench does not compromise on performance. It can control and monitor a single motor or two electric motors in so-called back-to-back operation. Drive motors with up to 150 kW mechanical power – such as traction drives for hybrid or electric vehicles – can thus be tested without any problems. An expensive test bench, for example for endurance tests, is not required. IAV Auros can be booked as a customized service package for specific projects or purchased as a fully functional test bench solution.

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Product by IAV

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For the drivers, on the other hand, the truck is their living space on wheels. Driving time is life time, and therefore, the infotainment system must fulfill two roles at the same time: On the one hand, it is an aid to work, but at the same time it is also responsible for entertainment on the road. In individual cases, the equipment depends on how much time the driver actually spends in the commercial vehicle – a lot in the truck on long-distance journeys, less in the vehicle for delivery services.

Flexible "multi-box" architecture

The future therefore belongs to modular E/E architectures that separate logical domains for the workplace such as Advanced Driver Assistance Systems (ADAS), the instrument panel and the display for the driver, as well as the domain for integrating third-party software modules (e.g., logistics, body manufacturers) from the domain for entertainment. This is the best way to meet the different requirements for safety and robustness. The corresponding hardware should consist of several boxes that can be combined according to the specific requirements. This "multi-box" design is more flexible than an "all-in-one" design, given the typically low volumes in the commercial vehicle sector. "We advise our customers on such architectural issues, but we also undertake the testing and integration of infotainment systems for commercial vehicles," says Herrmann.

In the human-machine interface (HMI), the trend is moving towards large, freely programmable displays – as has also been observed in the passenger car sector in recent years – which allow greater flexibility and must be operated intuitively. The masses of switches in the cockpit that still exist in many places are thus noticeably reduced. In addition, the future belongs to HMIs that can be adapted to the respective needs of the customer. "In this area, IAV offers support along the entire development chain – from initial studies, prototypes, tests with the target group, HMI specification through to HMI series development and testing," says Dr Marcus Heinath, head of the UX, HMI & Instrument Cluster department at IAV. "We are able to cover many topics from a single source, thus noticeably relieving our customers of a great deal of work."

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Test management à la carte

Commercial vehicles are characterized by a wide variety of variants. In light of the small quantities involved, customized test management is therefore indispensable. IAV uses impact analyses throughout the entire development process to keep the effort involved in safety tests and vehicle validation as low as possible.

Different numbers of axles in the towing vehicle, a whole range of possible superstructures or the same powertrain in different chassis: In the commercial vehicle sector, the diversity is much more pronounced than in the passenger car sector. "We are dealing here with many more mechanical variants," says Rene Zschoppe, head of the Functional Safety & Concepts department at IAV. "This means that the same basic vehicle can have completely different bodies such as a tipper or a crane." At the same time, however, the development costs must be spread over far fewer vehicles. What is therefore needed is a method that avoids unnecessary effort and reuses existing results as far as possible.

Only carry out tests that are really necessary

This applies throughout the entire development process – even shortly before the start of series production, when safety tests and investigations for validation are on the agenda. "We use impact analyses to determine the influence of changes, for example on the safety concept," explains Zschoppe. "On the basis of the results, it is possible, among other things, to identify the really necessary tests in the case of vehicle derivatives and to concentrate primarily on these in the test execution. In the case of modified superstructures, for example, it may be that the powertrain is adopted unchanged, but we must test the changes in braking, Electronic Stability Control (ESC) and Anti-lock Braking System (ABS) in detail."

In the impact analyses, IAV's experts look at every change and decide whether it will result in new tests in line with current standards – and how they can be carried out most effectively: Depending on the verification and validation objectives derived from the impact analysis, virtual methods are often the obvious choice. Although they cannot replace every real test, only a few test objectives completely exclude the use of virtual methods.

"The comparatively inexpensive and fast virtual methods are of great benefit, particularly in the early phase of a development project," says Thorsten Scheibe, head of the Autonomous Driving Validation & Automation department at IAV. What's more, they can be easily extended to intelligently examine the parameter space under investigation beyond its actual limits. "This means that the results cover a wider range of applications, and thus, allow us to reduce the testing effort required for subsequent changes in the area already investigated," says Scheibe.

"For each customer, we develop an efficient and effective test management system tailored to the identified verification and validation objectives," adds Zschoppe. Naturally, IAV also takes account of current standards, for instance in the field of functional safety. Following the amendment of the ISO 26262 standard, the vehicle assembler has a greater responsibility in this area: They must themselves carry out a hazard and risk assessment and provide their suppliers with specifications for their development work. "In the end, the assembler must then check whether the specified targets have been met. As a result, functional safety is now better integrated into the development process," says Zschoppe. "With our tailor-made test management, we support vehicle manufacturers, assemplers and suppliers in complying with all specifications with as little effort as possible," adds Scheibe.

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Putting a stop to hackers

With increasing interconnectivity, vehicles also offer criminals more scope for attack. Security is therefore becoming an even higher priority for manufacturers and their suppliers. In addition, UN regulations impose new requirements – a challenge that IAV is tackling.

No motorist wants to experience something like this: From the sofa, two hackers from the "Wired" magazine demonstrated a remote attack on a Jeep Cherokee in 2015. From a distance, the two took control of the vehicle, switched off the engine, deactivated the brakes and intervened in the steering. How could this happen? The vehicle's control unit architecture was insufficiently protected by Wi-Fi and mobile communications, and the other entrance gate to the attack was inadequately secured software updates. A series of security problems enabled the two hackers to take control of the vehicle via radio.

Today, many vehicle manufacturers and their suppliers must struggle with security problems: The number of known cybersecurity attacks has increased sevenfold between 2010 and 2019, according to the Upstream Security Global Cybersecurity Report 2020. This is because with increasing interconnectivity, the targets and possibilities for attacks on vehicles are multiplying – whether via vehicle keys, Wi-Fi, Bluetooth or logistics systems networked with mobile communication, to name just a few examples. And in the future, too, the problem is likely to grow rather than shrink: Already today, more and more functions are being combined on domain computers. In the future, these will be at least partially outsourced to the cloud – and thus, create new targets for attacks.

Combine security and safety

How can this be prevented? An important step is to combine security and safety, i.e. cybersecurity and vehicle safety. An attacker only needs to find one way to attack a vehicle, while the developers need to know and protect all of them. This means that the safety systems in the car can be infiltrated in a targeted manner by a remote attack, as in the example above. Safety and security are thus closely related – even if in the past they were usually considered separately.

IAV offers special expertise and experience in…

- the establishment of a cybersecurity management system
- the analysis of threats and risks
- the creation of cybersecurity concepts on process, product and information level
- the design of vehicle architecture with domain separation
- the observation of hacker progress, CVEs and CWEs (especially for FOSS software)
- penetration tests

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UN-ECE WP.29: New rules for cybersecurity (CS)

Cybersecurity requires the vehicle to have:

- Architecture with domain separation
- Security protection for critical vehicle systems such as systems with an influence on:
  - external interfaces
  - safety (including longitudinal and lateral acceleration)
  - availability (including theft protection)
  - type approvals
  - emissions
  - personal data
- Manipulation detection (intrusion detection)
- Passed penetration tests

Cybersecurity requires companies to:

- establish a Cybersecurity Management System (CSMS)
- introduce processes and responsible persons (roles)
- manage security for suppliers and service providers
- identify, assess and respond to risks
- monitor attacks, threats and vulnerabilities (e.g., hacking successes, quantum computers)
- continuously evaluate the effectiveness of previous measures
- always be ready to respond to (detected and threatened) attacks
- quickly deploy security patches even after EOP

The United Nations has also intervened to further improve the cybersecurity of vehicles: The UN/ECE Economic Commission has adopted comprehensive regulations on cybersecurity and software updates that must be applied to the work of manufacturers and suppliers today, as they will be relevant for type approvals from 2022 and all new registrations from 2024.

Shared responsibility

A central point of the new regulations is that in the future manufacturers, subcontractors, suppliers and potential third parties will be jointly responsible for improving the security of systems in vehicles. In doing so, all must prove that they meet the official requirements in terms of the principles of security. In the future, vehicle architectures must be designed in such a way that by overcoming one component it is not possible to access the next. In addition, it will be the task of companies in the future to digitally monitor cybersecurity throughout the entire life cycle of a vehicle and to react to incidents accordingly.

A mammoth task for vehicle development

This is a mammoth task for all those involved – including IAV. For example, all ECUs with security relevance must be checked, and functions such as a dedicated security module for communication (e.g., Autosar SecOC – Secure Onboard Communication) must be added. The new standards also fundamentally change the customer process: This means that a risk analysis will be central to every system and every function in the future.

IAV is already working flat out to master this complexity and implement the new standards. For instance, the company is currently redefining processes and roles – also together with customers. We are also expanding the methodological expertise of employees through security training and risk analysis are already part of our everyday development work. Although there is still some work ahead of us in implementing the directive – the goal is clear: We do not want to give hackers a chance.

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Ready for all powertrains & energy types

IAV's test bench portfolio leaves nothing to be desired. Whether internal combustion engine, fuel cell drive or battery electric solution: Our experts can put all propulsion systems to the test as they are perfectly positioned for the future – for example, with a test cell for electric axles and a battery test bench at our E-Mobility Excellence Center in Stollberg. In Gifhorn, we have two facilities to test hydrogen drives while in Berlin, we can conduct tests with synthetic fuels.

"Seamless testing is the key"

Andreas Geistert, Senior Vice President Test Center & Powertrain Systems Development at IAV, talks about IAV's test benches and the upcoming diversity of commercial vehicle powertrains.

What makes IAV's test benches stand out? First of all, we have test benches at our four locations in Berlin, Gifhorn, Stollberg and Northville, MI for various components and in many performance classes. This enables us to cover all our customers' requirements. We also combine test benches with simulative approaches by running real-life driving profiles under real conditions with regard to coolant or oil conditioning – always using state-of-the-art measuring technology.

What services do you offer?

We are at our customers' side from start to finish. Upon request, we can even accompany them all the way to certification. This enables us to offer our customers a continuous service without any gaps. We always work closely with our colleagues from the specialist departments to find optimal solutions – a close interaction of engineering and experience. This also applies internationally: With our own test benches in the USA and cooperation with partners in other countries, we are always close to our customers.

How are you positioned with the new drives?

We can test all drives – powered by diesel, LPG, CNG, synthetic fuels or hydrogen. And of course, we also have test benches for battery electric drives, which we can examine with real batteries if desired. So we are ideally positioned for the coming variety of commercial vehicle drives.

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Digitized from scratch to delivery

The digitalization megatrend is also a major topic in the commercial vehicle industry – from the development of new vehicles to the driver's workplace and autonomous driving. IAV uses state-of-the-art digital tools and offers its customers a modular technology kit from which tailor-made solutions can be derived.

Small quantities with a high degree of variance and particularly high demands on reliability and durability: Commercial vehicles are a challenge for developers – especially when it comes to issues such as application and protection. "We cannot test all vehicle variants in real-life trials with prototypes," explains Matthias Schultalbers, Executive Vice President Powertrain Mechatronics and CDO at IAV. "Virtual development methods as well as digital twins have therefore been playing a central role for us for years." IAV customers benefit from lower development costs in the medium term and consistently high quality across all variants, even if these cannot be built as test vehicles. "This is a huge issue for us right now," says Schultalbers.

IAV engineers use digital twins, for example, to verify and validate ECUs (Electronic Control Unit) or the entire ECU network. But more and more activities in function development and calibration are also being shifted into virtual space. "With the electrification of commercial vehicle powertrains, this approach is becoming even more important," says Florian Brandau, Director Business Development Commercial Vehicle E-Mobility at IAV. "After all, we are dealing here with a high degree of technological novelty that we can better master with the digital tools."

Virtual tools for alternative drives in commercial vehicles

This also applies to the installation of electric drive trains in existing vehicle platforms that were originally designed for diesel engines. Commercial vehicle platforms generally have a service life of between 20 and 25 years – so switching to a "zero emission" drive is still attractive even in the middle of the planned platform service life. "Here, too, we use digital tools, for example to integrate the new powertrain, to examine the effects on the entire vehicle and to validate the individual variants in virtual endurance runs," reports Schultalbers.

In the meantime, more and more fleet data from the field is flowing into the development processes, where it supports validation and safeguarding. But it also makes it possible to provide commercial vehicle customers with information on predictive maintenance. "Among other things, this makes it possible to determine the severity, priority and the point of origin of a fault and, if necessary, to predict restrictions in the availability of the vehicle," says Schultalbers. "A dashboard can provide the fleet operator with an overview of the condition of all vehicles, and thus, prevent breakdowns. This enables us to plan workshop stops and increase vehicle availability." Finally, future vehicles can be optimally tailored to the respective application scenario and important questions can be answered: Which drive is optimal for the customer? Which battery size fits best? How will the vehicles be used in practice? Those who can answer these questions can optimize their customers' TCO.

Making the profession of "long-distance driver" more attractive

However, drivers are also affected by the digitalization of commercial vehicles. Their workplace is changing and is increasingly becoming a rolling office. "In future, they will be shown messages on their windscreen, for example to optimize route planning," says Schultalbers. "This is part of the generally stronger networking of driver, vehicle and logistics planning: In order to avoid empty runs as far as possible, orders and fleets will be synchronized in real time – also with the support of artificial intelligence." This will not only improve the profitability of fleets, but also increase the attractiveness of the profession of "long-distance driver": The long-distance driver is increasingly transforming from a driver to a logistics manager, and the technology provides them with tools that enable them to position themselves and their company in the best possible way within the logistics chains – an important signal in light of the lack of new talent in this field.

Autonomous driving will have a major impact on the entire logistics industry. Highly automated driving functions on levels 4 and 5 will probably first go into standard production in commercial vehicles because there are clear financial benefits here. In the "HEAT" (Hamburg Electric Autonomous Transportation) funding project, IAV has shown how an autonomous shuttle can be integrated into the traffic of a major city. This experience can also be transferred to other commercial vehicles and application scenarios.

> "The trend is clear: Digital methods and processes are headed towards commercial vehicles. IAV has a broadly diversified technology kit that can be used in a variety of domains."

"We are currently receiving many enquiries about digitalization topics and can offer solutions along the entire development chain, right up to support for operational fleet management," says Schultalbers. "The trend is clear: Digital methods and processes are headed towards commercial vehicles. IAV has a broadly diversified technology kit that can be used in a variety of domains. And the response of our customers shows that we are very successful with it."

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New momentum for hydrogen mobility

The e-drive is a key instrument for reducing CO_2 emissions. However, batteries are not yet the first choice for many commercial applications due to their low energy density. Therefore, the future belongs to a mix of different commercial vehicle drive systems. Hydrogen will play a key role as an energy carrier. However, it is important to take a cross-sectoral view and make a rapid development decision.

In addition to diesel, battery electric drives and hydrogen will also play a key role in future commercial vehicles – the latter either as a fuel for combustion engines or as an energy supplier for fuel cells. "The future is not black and white, but gray," says Dr Jörn Seebode, Senior Vice President Commercial Vehicles at IAV. "In the case of commercial vehicles, we are dealing with so many different applications and usage profiles that there cannot be one optimum drive system for all constellations. Which drive is optimal in each individual case is determined by the specific load collectives based on the application scenarios. This is why it is so important to approach the topic openly with regard to technology."

The CO_2 specifications of the European Union increase the pressure on manufacturers and also give hydrogen mobility a new boost. It can be usefully applied where battery electric drives have system-related disadvantages – for example, in long-distance heavy goods traffic. Technically speaking, the hydrogen internal combustion engine and fuel cell are ready for standard production in commercial vehicles, and in a few years' time parity with diesel should also be achieved in terms of Total Cost of Ownership (TCO). Their impact on the environment varies: In terms of emissions, the fuel cell performs better because it does not emit nitrogen oxides, particles and hydrocarbons, and therefore does not need an exhaust aftertreatment system. However, in certain applications, the internal combustion engine can also show its advantages. This also makes it a very interesting candidate for CO_2-neutral commercial vehicle applications in the short term.

Building on existing technology

Moreover, it is hardly different from a diesel engine, and therefore does not represent a fundamentally new technology. "The hydrogen combustion engine could be brought into series production a little faster than the fuel cell, because it can make use of existing technology and production capacities. It would also allow us to maintain value creation with OEMs and suppliers," says Seebode.

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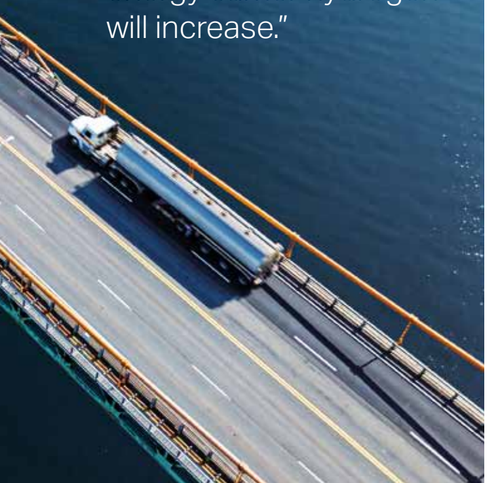
"The situation is somewhat different with the fuel cell, even if components could also be adopted here – for cooling or air supply, for example."

The alternative drives for commercial vehicles would thus be available in principle – but there is still a lack of an adequate filling station infrastructure: Around 1,500 filling stations would be needed throughout Germany to make the new energy source attractive. The supply of hydrogen from "green" sources has also been growing for years – its production is ideally suited to convert excess wind or solar power into the energy-rich gas by electrolysis. However, there is also competition for the energy carrier. "Hydrogen is not only an energy carrier that is absolutely essential outside of mobility, but also an important raw material for processes in the chemical industry," explains Marc Sens, Senior Vice President Advanced Development Powertrain at IAV. "We must therefore create sufficient production capacities so that the mobility sector can also be reliably supplied in the future." Sens adds: "In this respect, IAV is also considering solutions for decentralized hydrogen production, e.g. from synthesis gases, which in turn can be produced easily from organic waste."

"Hydrogen mobility is an important component of future commercial vehicles. But there is no time to lose here, as competition for the environmentally friendly energy carrier hydrogen will increase."



Cross-sector thinking required

It is therefore all the more important to think across all sectors in terms of overall systems and processes: For example, the efficiency of future electrolyzers must be further improved so that the maximum possible amount of hydrogen can be obtained from green electricity. IAV can support its customers in this and other areas: "On the one hand, we have expertise in the field of mobility and know the needs of fleet operators very well," says Ralf Wascheck, Head of Department Fuel Cell and Hydrogen Mobility. "But we also offer engineering in the areas of wind power and hydrogen production and can therefore consider the entire value chain. This approach across all sectors enables us to develop the ideal mobility concept for every user." Sens adds: "Such a consideration across all sectors will become even more important in the future when legislators demand a life cycle analysis (LCA) that takes into account all influences on the ecological footprint."

However, OEMs are also called upon to help hydrogen mobility achieve a breakthrough. "They must offer their customers new concepts and sell them mobility, not just a vehicle," says Wascheck. "Pioneers like Nikola or Hyundai do just that – and such all-inclusive packages are the key to success. The examples show that the changes in the coming years will not be linear, but rather disruptive." IAV offers OEMs holistic consulting services to help them successfully manage the tough upheaval.

No time to lose

"Hydrogen mobility is an important component of future commercial vehicles," summarizes Seebode. "But there is no time to lose here, as competition for the environmentally friendly energy carrier hydrogen will increase." Wascheck, Seebode and Sens agree that decisive action is needed to exploit market potential. "If we do not bring any vehicles onto the market in the next four to five years, it could be too late," says Seebode. "Together with our customers, we therefore want to press ahead intensively with this topic now and bring solutions into production as soon as possible."

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"Similar mindset in Gifhorn and in Karlsruhe"

Prof. Dr. Thomas Koch, Head of the Institute for Piston Engines at KIT

IAV and Institut für Kolbenmaschinen (IFKM) of the Karlsruher Institut für Technologie (KIT), University of Karlsruhe, cooperate in the development of hydrogen combustion processes. Prof. Thomas Koch (Head of the Institute for Piston Engines at KIT) and Dr Reza Rezaei (Manager for Advanced Combustion Development Commercial Vehicles at IAV) report on their collaboration in an interview.

What exactly are IAV and KIT working on?

Rezaei: We generally work very closely with universities to learn the latest methods and build up know-how that we can later use in customer projects. IAV and KIT have been collaborating for about two years in the field of hydrogen combustion process development for heavy-duty applications. To this end, we have carried out experimental investigations on a heavy-duty single-cylinder engine.

Why is now exactly the right time to conduct such research?

Koch: The political and legislative trends in heavy-duty vehicles are moving towards a further tightening of global NO_x and CO_2 emission limits. One way to reduce CO_2 is to use hydrogen as an alternative fuel. However, this presents many challenges, such as combustion anomalies or the development of exhaust aftertreatment systems that are significantly simplified compared to diesel engines in order to comply with Real Driving Emissions (RDE). What is needed here is a deep understanding of the internal hydrogen combustion processes in engines and a great deal of research to optimize the processes.

What are the most important new results?

Rezaei: As part of our collaboration, we have studied the hydrogen combustion process for a two liter heavy-duty single cylinder engine. After defining and implementing the optimization measures to avoid knocking and preignition, we were able to raise the indicated mean pressure (as a measure of torque and power) above 19 bar. In addition, a number of measures were successfully developed and implemented, such as emaciation and exhaust gas recirculation to minimize nitrogen oxides.

Koch: We are currently working on the development of hydrogen direct injection to further minimize combustion anomalies, increase engine performance and reduce nitrogen oxides. In a first step, we have developed a concept with an injection pressure of up to 50 bar. In the next step, we will jointly research hydrogen high pressure injection with more than 200 bar and diffusive combustion.

How does the collaboration with IAV work?

Koch: From the university's point of view, a trusting exchange, in-depth discussion and critical analysis are very important. The engineers can only draw the right conclusions from a critical view of the analysis results. This applies to both research and development. A similar mindset in Gifhorn and in Karlsruhe helps us a lot in the constructive collaboration.

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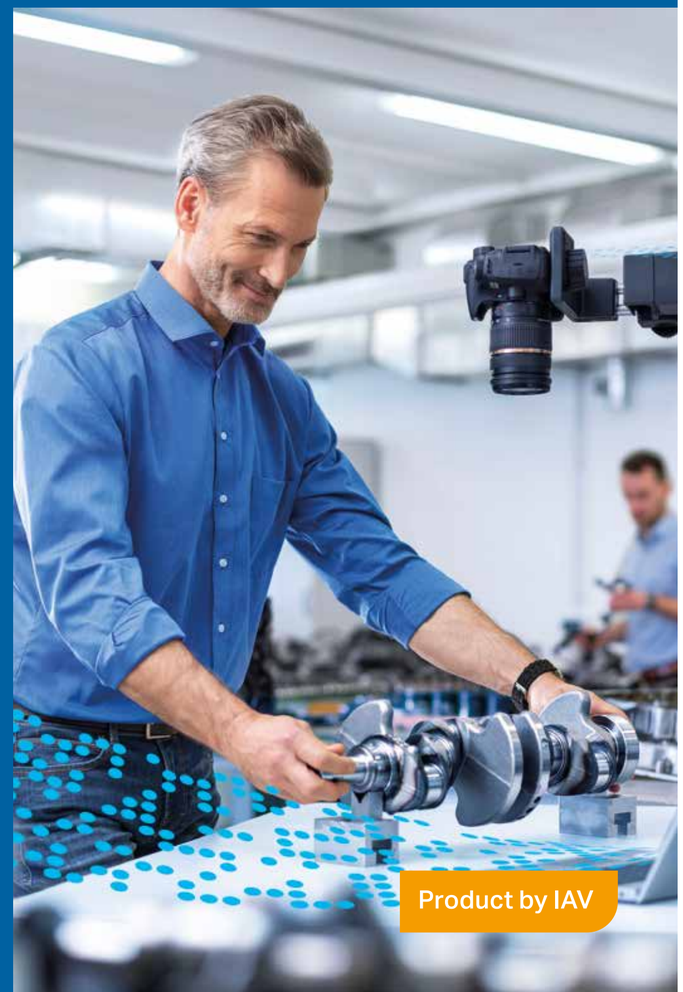
IAV Teslin: Maximum efficiency for testing and appraisal

Today, various tools such as Excel, Word or PowerPoint are used to record data from functional or endurance testing, before the data are stored on drives or in several databases. This process is not only very slow and error-prone, it also makes it very difficult to compare different endurance runs at great manual effort.

IAV Teslin remedies the situation. The intelligent tool manages the data in a central server database and makes them available intuitively on a client (Windows or Linux PC) for subsequent analysis, comparison and reporting. Component owners and diagnostic experts working for OEMs, suppliers and service providers benefit from far greater efficiency as well as improved evaluation possibilities during and after test runs. Besides standardized data recording, the tool also offers flexible add-ons, depending on customer or project demands. Furthermore, IAV Teslin produces semi-automatic reports in various formats and makes it easy to compare test specimens in different test programs, among others. Interfaces integrate the tool smoothly in existing system landscapes.

Customers in the non-automotive sector will also benefit from these advantages when diagnosing or assessing their products aftertests or endurance runs. IAV Teslin has been in productive use at IAV since 2014. It undergoes continuous optimization and has already proven its worth in numerous customer projects.

Interested? To make swift arrangements for an online demonstration without any obligations, simply contact **teslin@iav.de**.



Looking ahead: cost break-even for new technologies

OEMs want to offer customers environmentally friendly vehicles and at the same time reduce their Total Cost of Ownership (TCO). Zero emission vehicles are the solution, but new technologies are inherently more expensive than existing ones at first. With the TCO calculator, IAV can calculate which drive will be the cheapest option for the specific use case, and thus, present potential market scenarios.

Many drive options will be competing for the favor of buyers in future. So the big question is: What should vehicle manufacturers and their customers (e.g. fleet operators) choose in the coming years in order to be able to offer or make use of the best TCO package? The answer to this question is far from simple – because no one knows exactly how, for example, the prices of individual energy sources and state subsidies will develop.

What is needed, is a tool with which different scenarios can be calculated in order to provide an objective comparison. The TCO calculator from IAV does just that: As input, it requires data such as the acquisition and distance-dependent toll costs of a truck. It can then be used to examine various conceivable developments and make a product development or purchase decision based on the best currently available knowledge.

Scenarios for the CO_2 price

A central constraint is the future CO_2 price. "It depends above all on the legislator, so this is where political influence is greatest," says Florian Brandau, Director of Business Development for Commercial Vehicle E-Mobility at IAV. "What is certain is that diesel will become much more expensive – but nobody knows the exact course of events because future political currents and the global oil price can have a major influence here." Forecasts by experts place the CO_2 price per ton between EUR 60 to EUR 170 by 2030; the median scenario is EUR 120 per ton. For diesel, that means: In ten years, it will cost between 19 and 54 cents more per liter. In the median scenario, the increase is 38 cents per liter. Depending on the electricity mix, battery electric vehicles are also affected by CO_2 costs.

The corresponding price scenarios predict electricity costs of 24 to 28 cents per kilowatt-hour for external sources (e.g. on the freeway) by 2030; the median forecast here is 26 cents per kilowatt-hour. Costs for hydrogen, on the other hand, are expected to fall significantly by 2030: Today, it costs 9.50 euros per kilogram; in 2030, the price is expected to be between 4 and 6 euros per kilogram, with the median forecast being just over 5 euros per kilogram. For comparison: In terms of energy content, one kilogram of hydrogen equates to around 3 liters of diesel, but the better efficiency of fuel cells results in a rough utility factor of 4.5 liters of diesel to one kilogram of hydrogen. "That's why a price of less than five euros per kilogram of hydrogen is the magic hurdle compared to diesel," Brandau explains. IAV bases its forecasts on its own research from public sources.

However, other factors are also included in the TCO calculation. There is no difference in personnel costs for the driver for the different types of drive, while repairs

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and maintenance are lower for battery electric or fuel cell vehicles. The reverse is true for the acquisition costs: Battery-electric and fuel cell commercial vehicles are currently about three times as expensive as their diesel counterparts. "The state should therefore subsidize these new technologies for a transitional period to cushion the additional costs," says Brandau. "This can be done, for example, by exempting them from tolls." However, this can only be an interim solution – in the long term, the new engines must pay for themselves even without state aid.

Diesel already beaten in many applications in 2024 when it comes to TCO

Based on the premises mentioned and the possible subsidy strategies of the legislators regarding acquisition and toll costs, the following possible scenario results from the current state of knowledge: Battery electric vehicles will undercut diesel in many applications in 2024, with fuel cell vehicles doing the same four years later. The race between the two alternative drive systems will also have a clear winner within this decade: The fuel cell is likely to be cheaper than the battery electric variant on long-distance routes from 2029. One reason for this is energy storage: Batteries for commercial vehicles are heavy and expensive, and in addition a high variance must be converted to small quantities. "The fuel cell is particularly well suited for heavy trucks in long-distance operation when refueling en route," says Brandau. "However, the situation is different if you generate your own electricity or can buy electricity very cheaply: In this case, the battery electric variant is cheaper." But the important thing is that as soon as individual parameters change, the TCO curves for alternative drives can be completely different. This is why we must constantly check all the premises and readjust them if necessary.

The figures of the TCO calculator in the current scenario show that the traffic turnaround can be achieved in the next ten years. "With cars, things will happen very quickly because of new models like the ID.3 from Volkswagen," Brandau is convinced. "There, according to the ADAC study from September 2020, the TCO is already lower than that of a diesel or gasoline engine." It is now important to reduce the cost of drive systems in the commercial vehicle sector as well. "At the moment, they are simply still too high because we have a revolutionary development here and everything is very new," says Brandau. "In the case of the diesel, on the other hand, proven basic designs are being developed further in an evolutionary way, which means less effort is required."

> "By working with IAV, our customers don't have to start from scratch. We have basic modules that can serve as blueprints for getting started in e-mobility."

Basic modules as blueprints for development

It will be crucial for OEMs to bring the new technologies to market quickly – otherwise they risk losing their competitiveness and facing competition from new players. "But by working with IAV, our customers don't have to start from scratch," says Brandau. "We have basic modules that can serve as blueprints for getting started in e-mobility. So customers don't have to do all this legwork themselves and together we can quickly arrive at solutions that are fully ready for production."

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Holistic approach for active thermal management

Thermal management is particularly important in electrically powered vehicles, because the requirements for convenience, range, charging system, operating strategy and temperature control of the components must be harmonized. A typical example: In winter, the driver wants a warm cab when starting the vehicle, but at the same time the battery should also reach the optimum temperature range of 20 to 35 degrees as quickly as possible. An electric auxiliary heater can speed up the speed at which the energy storage unit warms up, but this is at the expense of the range.

IAV approaches active thermal management in electrically powered commercial vehicles with a holistic simulation approach and a large team of experienced employees – from hardware and system development to application safeguards. Using commercial and proprietary tools, our experts bring new technological approaches such as phase change cooling, phase change materials or newly designed thermal management systems to series production. "The focus is always on system optimization, for example, by using air conditioning for component temperature control," explains Ronny Mehnert, Manager Energy & Thermal Management Powertrain at IAV.

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Mature battery system for special tasks

Working machines are often only produced in small quantities; other commercial vehicles are to be retrofitted with an electric drive during their service life. In both cases, a modular battery and Battery Management System is required which can be flexibly adapted to the respective requirements and integrated without much effort. IAV has a technically mature solution that allows, among other things, a wide range of voltage and power levels.

"In the case of relatively large volumes such as trucks, OEMs cover the demand for batteries and battery management systems themselves," explains Dr Thomas Henke, Head of Battery System Development at IAV. "However, such products are not available for working and special machines. We have therefore developed a solution that allows a battery system to be integrated into a commercial vehicle without much effort – either in new vehicles or as a retrofit solution."

The battery cell modules come from established manufacturers and are available in various voltage and power classes. They can be used to cover a wide range of performance requirements – for example, in terms of energy content, maximum output or rapid charging capability – and by using several packs, the given installation space is always optimally utilized. The Battery Management System (BMS) developed by IAV is designed to enable different battery topologies: Up to four batteries can be optionally connected in parallel or serially in the vehicle. In addition, each battery can in turn be subdivided internally into four partial batteries with up to 112 battery cells each, thus enabling a system output of up to four megawatts to be realized.

> "We have therefore developed a solution that allows a battery system to be integrated into a commercial vehicle without much effort."

Fourth generation Battery Management System available

In addition to a flexible battery topology, IAV's battery management system also allows the use of interchangeable batteries: If the energy storage units are empty, they can be quickly and easily replaced with charged batteries at a depot, for example. The BMS is also technically mature: "We have been working on electrified drive trains for around 15 years, so our Battery Management System is now in its fourth generation," reports Henke. "In the future, we want to expand it to include additional functions, for example, the determination of battery aging using artificial intelligence. The aim is also to minimize the ecological footprint of the IAV solution. Together with cell manufacturers and recycling companies, the aim is to optimize battery production in such a way that the recycling rate increases significantly.

"Our solution is already in use in the prototype of a light commercial vehicle, and we are in talks with other customers," Henke summarizes. "We can make it ready for series production in a short time, and thus, close the existing gap in battery systems for working and special machines."

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Minimizing sooting of exhaust gas recirculation

Exhaust gas recirculation (EGR) is an effective and proven way of reducing nitrogen oxide emissions from diesel engines. However, it can lead to sooting of the EGR cooler and the EGR bypass valve. IAV examines and simulates this process in detail – enabling the experts to support their customers in making optimum use of EGR.

Diesel engines must comply with strict nitrogen oxide limits in all operating conditions. Exhaust gas recirculation is a suitable alternative or supplement to SCR systems because it reduces the temperature in the combustion chamber. In addition to slightly higher fuel consumption, however, it has another undesirable side effect: It leads to sooting of the EGR cooler and the EGR bypass valve as well as to disturbances of the thermodynamic processes in the engine.

"The biggest problem is the long-chain hydrocarbons, which, especially at low load, encrust and stick to the EGR cooler," explains Ronny Mehnert, Manager Energy & Thermal Management Powertrain at IAV. "This leads to a reduction in the cross section and interferes with the control system. In the end, the component can fail completely." Soot in the exhaust gas also leads to stress for the EGR components: It deposits on the walls and also reduces the cross sections, impairing the function of the components and reducing their service life.

Combination of test and simulation

IAV wants to defuse the problem and is therefore examining in detail the processes involved. Measurements of hydrocarbons and soot in the EGR tract serve as input for precise simulations of sooting. By combining tests and simulations, experts can predict which areas are particularly at risk and how the sooting can be contained or removed. The results show, for example, that an increase in the EGR rate from 25 to 30 percent at cold temperatures, such as in low-load operation, can lead to a doubling of deposits. Endurance tests can be used to determine how long the EGR components will function properly under different conditions.

"Sooting cannot be completely avoided," says Mehnert. "But something can be done about it: For example, we can tell our customers in which engine map areas there are enough free resources for regeneration of the EGR components. In this way, we can remove ten percent of the sooting. Of course, it is also possible to get to the root of the problem and avoid particularly critical map areas by using a smart calibration."

Entire OEM fleets at a glance

IAV is already using its findings in customer projects, for example, for the optimum geometric and thermal design of EGR components and systems. "We also look at entire OEM fleets and point out to them vehicles with particularly critical drive concepts where there is still potential to be leveraged through the application," says Mehnert. "In this way, they can make optimum use of exhaust gas recirculation to make their diesel engines even more environmentally friendly."

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Ulrich Weiß, Managing Director at Liebherr Machines Bulle

"E-fuels would be ideal for us"

Ulrich Weiß, Managing Director at Liebherr Machines Bulle, reports in an interview about the special features of the off-highway sector, possible alternative fuels and the importance of digitalization for his company.

What are the special challenges for off-highway vehicles?

Of course, the off-highway sector is extremely different from the on-highway sector, mainly due to its great diversity. There are completely different machines with completely different load profiles – which the engine must cater for. The number of variants is almost endless, which is very difficult to control and secure. Robustness is another issue: We have to deal with strong braking and acceleration processes, and the use of the machines in undeveloped areas also generates heavy loads. Added to this are the demands on service life: Our machines are in use for ten years or more, and we must guarantee service for more than 20 years. Downtimes are also particularly critical, as breakdowns can result in high costs for our customers and possibly also for us.

Why is a Liebherr powertrain particularly suitable for these requirements?

Because we have many years of experience with off-highway machines and develop everything from the outset to meet the requirements in this area – for example, our engines, where we always keep an eye on the subsequent applications, e.g., with things like special power take-offs. Of course, there are many competitors in the on-highway sector who convert their engines for off-highway applications – but this is only possible by making compromises. We design our engines for off-highway applications right from the outset.

Cities in particular are driving "green" solutions. Are battery-powered off-highway vehicles an option?

There are niches where it makes sense. For example, with relatively small excavators or wheel loaders. On cordoned-off company premises, machines can be operated electrically via cables, for example in recycling yards. At Liebherr, we have implemented two projects, among others: a drilling rig weighing 55 tonnes and a hybrid concrete mixer in which the truck is driven by a diesel engine and the drum is electrically driven. This allows the engine to be switched off at the unloading point and work can continue without exhaust fumes. E-mobility naturally plays an important role in the off-highway sector, although it will probably not be the central solution.

Hydrogen is considered a promising alternative fuel. Is it suitable for off-highway vehicles?

Hydrogen is one of the possible energy carriers of the future for us. Liebherr is working on hydrogen combustion engines in its pre-development phase, which we are already testing on the test bench. Among other things, this involves determining the best combustion processes and achievable power densities. This is important because we must integrate the new engines into our machines. We are also investigating fuel cells – but here we see certain limits, for example, with power outputs of more than 150 kilowatts, where the peripherals become very complex. At the moment, there are also question marks over robustness. But it is also important within this context to create the necessary infrastructure for the supply of hydrogen.

What other alternative fuels are interesting in your view?

From the point of view of a machine and drive train manufacturer, e-fuels would be ideal, because we would only have to make minimal adjustments to our engines. The space requirements of the tanks would also be comparable – in contrast to hydrogen or even batteries. CNG and LNG are not interesting for us because they hardly reduce CO_2.

What does Liebherr Machines Bulle think about the digitalization of its vehicles?

Our colleagues from other divisions are already working on it! We as engine manufacturers contribute to this by translating our core competences and knowledge into useful KPIs for our customers. For us, the most important question is always: How can we increase the benefit of the machine for the end customer? For example, by conveniently planning the unavoidable downtime for service. We can also provide spare parts faster if we know the condition of an engine earlier. And, of course, we are constantly optimizing diagnostics. These are the issues we are pushing forward with the help of digitalization at Liebherr.

> "We have developed methods that allow us to draw conclusions about the entire field and cater for many applications with just a few variants using artificial intelligence."

Digitalization is also interesting for development – especially because of the many product variants. How much are you already exploiting this opportunity?

Because of the high variance, we are in a very special situation and have to go our own way. There are some machines of which we only sell a few dozen – if we were to develop and validate them in-house, we would first have to build and test these machines ourselves. Of course, that is not possible. This is why we have developed methods that allow us to draw conclusions about the entire field and cater for many applications with just a few variants using artificial intelligence. Simulations are also very important for us.

The business with off-highway vehicles is becoming increasingly global. How is Liebherr adjusting to this?

Liebherr is already globally positioned. We have 48,049 employees in over 140 companies on every continent. We usually enter into partnerships or joint ventures to strengthen our presence in certain industries.

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A deeper look inside your vehicle

Many of the newly emerging, smaller commercial vehicle fleets with battery electric or fuel cell drive systems do not offer remote access to vehicle data. IAV's DiSA Remote Service Monitor bridges this gap: The system can be easily retrofitted and supplies important data from the field – for optimized operation of existing fleets and the development of the next generation of environmentally friendly drives.

Fleet managers in logistics as well as bus operators today use the interconnectivity of their vehicles to obtain information on the position and route or the "state of health" of their vehicles. "Fleets of battery-powered vehicles or vehicles with fuel cell drives, on the other hand, are usually not yet interconnected," reports Florian Brandau, Director of Business Development for Commercial Vehicle E-Mobility at IAV. "But it is precisely with these new drivetrains that information from the field is particularly important, for example, to learn more about their practical use, to increase vehicle availability or to be able to better specify the next generation of vehicles."

With IAV's DiSA Remote Service Monitor, this gap can be bridged quickly and cost-effectively. The solution consists of a small, interconnected control unit that is installed in the vehicle and can access the vehicle data as an IoT unit (Internet of Things). The data is then transferred to the cloud via mobile communications (3G, LTE or 5G) where it is processed. The user can view all information on a PC, a tablet or smartphone.

Direct access to internal vehicle communication

What's special about the IAV solution: It can "look deep inside" the vehicle. "For example, you can immediately see whether the electric drivetrain or the brakes are working perfectly," explains Dr Thorsten Schröder, Head of the Diagnostic Software & IT Solutions department at IAV. "Remote Service Monitoring provides detailed information on this: How often were they used? Are they being operated at an unfavorable operating point? Is there a leak in the compressed air system?" Normal products for fleet management do not have such a precise view of the vehicle's ins and outs. In addition, they are usually not available at all for commercial vehicles with electric drives in niche applications: OEMs cannot integrate their standard solutions here, so fleet operators are dependent on third-party suppliers.

"The DiSA Remote Service Monitor provides most of the data when the powertrain and diagnostics come from IAV," explains Dr Alexander Roy, Senior Technical Consultant for Advanced Diagnostics & Digital Product Life Cycle at IAV. This is because in this case, the messages on the vehicle's internal communication buses are known down to the smallest detail, and all available information can be used for detailed analysis. In the event of a technical problem, a service ticket is automatically generated in the cloud and listed in the DiSA Remote Service Center. Depending on the application scenario, other information can be recorded in addition to vehicle data – for example, images from a video camera to prevent vandalism.

The data can be evaluated on any cloud. There applications from IAV are responsible for receiving and securely storing the data, for data analytics and predictive diagnostics as well as for the graphical visualization of conditions and results. Even if the vehicle is temporarily not online, the latest data can be viewed and evaluated in the cloud: It requires no up-front investment in IT technology by the fleet operator and can be used immediately worldwide.

Frontend makes information easily accessible

Access to the information is provided by the front end, which flexibly displays all results via a browser and can be adapted to customers' design specifications. For example, the user can immediately see where a vehicle is currently located, whether it has a defect and how long until the next inspection. Based on selected aggregated measurement data, predictive diagnostics can also be performed – either on a single vehicle or on an entire fleet of vehicles. This means that any service or maintenance requirements that arise can usually be diagnosed easily in advance.

With the help of the DiSA Remote Service Monitor, drivers can also compare energy-conscious driving styles or determine the battery electric consumption depending on the outside temperature. "Our solution also provides information on whether the battery is correctly dimensioned – an important indication for later optimization," says Brandau. "All these evaluations enable fleet operators to reduce their TCO and avoid breakdowns. High fleet availability is in turn important for the good image of innovative systems and for the operator's profit."

IAV uses data collection and assessment for advanced tasks:

Find out more about the use of Artificial Intelligence for prediction and condition-based maintenance in this video. >

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Seamless engineering right up to standard production support

The DiSA Remote Service Monitor is already in use in a bus fleet in Berlin that has been electrified by the "Modular E-Powertrain for Commercial Vehicles," a retrofittable battery-electric drivetrain developed by IAV. Other potential customers are also showing interest. "Our service is designed for regular operation and is not a development tool," Schröder emphasizes. "It shows that IAV offers seamless engineering over the entire product life cycle – from the design right up to support for real world operation and down to the very last detail." The Remote Service Monitor can also be used to monitor warranty claims and check the quality of suppliers. Especially with innovative powertrains and the steep learning curve of new technologies, such information is crucial for further progress.

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IAV products: the easy way into new commercial vehicle mobility

In addition to engineering services, IAV also offers product solutions that enable OEMs and end customers to electrify and automate commercial vehicles in a clean-cut and tailored way. The "Modular E-Powertrain for Commercial Vehicles" and the autonomous shuttle HEAT are examples of e-mobility and autonomous driving at the highest level – and are also interesting for small production runs.

From consulting and engineering to the production-ready product: IAV's portfolio covers all development steps in the commercial vehicle sector. "This enables us to offer our customers precisely the service they need," says Utz-Jens Beister, Head of Product Solutions at IAV. "OEMs and end customers as well as bus or logistics companies can thus electrify their vehicles or implement autonomous driving functions without any major development effort. In addition, future engineering projects will also benefit from our product expertise."

The Modular E-Powertrain for Commercial Vehicles: retrofittable e-drive for different scenarios

For suppliers and municipal companies as well as bus and fleet operators, IAV's Modular E-Powertrain for Commercial Vehicles is the easy way to enter the electric age. As a customizable solution, the powertrain offered as a kit of parts covers many different application scenarios and adapts to the specific needs of each user. The kit of components suitable for series production can be easily tailored to suit different installation spaces and performance requirements. This makes it an economical solution even for small quantities – also for retrofitting existing vehicles.

"At the start of every project, we clarify with our customers which requirements the drive system must meet in practice," reports Jens Granel, Head of Business Development Vehicle Dynamics at IAV. "We then configure the system in such a way that the user benefits from it to the maximum – we take into account, among other things, the available installation space as well as the required drive power and range. In this way, we ensure that the vehicle can be used to optimum effect in terms of payload or number of passengers, for example."

When it comes to the electrification of commercial vehicles using the modular electric kit, IAV assumes the role of system integrator and parts supplier. This includes the specification, approval and procurement of all drive components (including electric machine, battery, power electronics, and control units) by the respective experts at IAV. In doing so, IAV relies on cooperation with proven industrial partners to ensure both state-of-the-art technology and optimum conditions for the components.

In addition, IAV handles the entire engineering, for example, for communication and functional safety of the overall system. Here, IAV customers benefit from the interdisciplinary cooperation between the various trades and the consideration of all requirements throughout the entire product life cycle. However, the experts' task does not end with the delivery of the parts kits for the electric powertrain: IAV also offers its customers professional support in customer operations. This also ensures that the Total Cost of Ownership (TCO) and service costs of vehicles equipped with IAV's electric drive unit are very favorable.

IAV's modular electric kit for commercial vehicles has recently been put into practical use in sightseeing buses. Further applications in municipal and delivery vehicles – both as original equipment and as a retrofit solution – are planned.

HEAT: universal platform for autonomous vehicles

As part of the HEAT (Hamburg Electric Autonomous Transportation) research and development project, IAV is breaking completely new ground with partners such as the German Aerospace Center, Hamburger Hochbahn AG, the Hamburg Ministry of Economics, Transport and Innovation, Siemens and IKEM (Institute for Climate Protection, Energy and Mobility): The aim is to integrate an autonomous shuttle bus into the regular road traffic of a metropolis like Hamburg. The HEAT vehicle will be tested under real conditions in public spaces and will initially be able to drive autonomously at speeds of up to 25 km/h.

"We ensure that the vehicle can be used to optimum effect in terms of payload or number of passengers, for example."

The test track in Hamburg's HafenCity is 1.8 kilometers long. During its journey, the minibus will stop at five stops, three of which are regular HVV stops and two of which are new stops set up for HEAT. "In order to be able to drive safely on the test track, the shuttle uses its onboard sensors and communicates continuously with the additional sensors installed along the track, the light signal systems and with the central control center HOCHBAHN," reports Veit Lemke, Executive Project Manager Project Management Office. "From the fourth quarter of 2020, HEAT will be able to carry passengers."

By integrating the shuttle into the overall system, it is possible to increase the performance of the shuttle in a complex and highly dynamic traffic environment and to implement functions such as an automated intersection crossing. "HEAT has several technological unique selling propositions in the area of autonomous travel, especially in combination with object data from the infrastructure," says Lemke.

In the HEAT project, IAV is responsible for developing the entire vehicle. This includes the areas of body, electrics/electronics, chassis, drive, and autonomous driving – from the definition of the shuttle properties and the system and functional requirements through the development of mechanics, hardware, software and application to validation at system and overall vehicle level. Within the consortium, IAV also makes a decisive contribution to the specification, integration, commissioning and validation of the overall system, consisting of shuttle, infrastructure, control center, and high-resolution map.

Although HEAT is designed for autonomous passenger transport, it can also be adapted to other deployment scenarios. For example, the technology is also suitable for driverless delivery or logistics vehicles. "HEAT offers a platform to bring autonomous driving into the commercial vehicle sector, where there are numerous useful application examples with a clear business case," summarizes Lemke. The HEAT project also provides important insights into the mobile value chain. IAV is thus acquiring the competence not only to develop autonomous shuttles but also to operate them if necessary.

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For more information watch our video on YouTube! >

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One more thing…

Fuel cells fail due to a lack of infrastructure!

George: I don't think so. It is true that there are only about 85 hydrogen filling stations in Germany today. However, both the German government and the EU want to invest in the transport and storage of hydrogen in the future. So, over the medium term, there will be more filling stations for the energy carrier. Intelligent sector coupling is likely to play an important role here: Local hydrogen production from surplus green electricity is ideal for supplying filling stations.

Brandau: And there is a lot happening on the demand side too: Fuel cell drives and hydrogen-powered combustion engines could go into series production in the next few years and help the energy carrier make a breakthrough – initially through large fleets and hubs, which will entail the construction of filling stations. In terms of price, hydrogen remains unbeatable anyway: Due to the great demand in industry and the associated production capacities, it will continue to decline and make the alternative fuel even more attractive. That is why I expect a sufficient network in five years, initially in cities and along the freeways.

The new CO_2 legislation is much too strict. This endangers the German and European commercial vehicle industry!

Töpfer: You're not thinking outside the box. Of course, the upcoming CO_2 limits are a big challenge – after all, emissions are supposed to fall by 15 percent by 2025 compared to 2019 and by another 15 percent by 2030. However, this offers innovative companies a historic opportunity: They can realign themselves and occupy new market segments. In the foreseeable market shakeout, the winners will be those who decide early on a clear sustainability course and implement it consistently.

George: And 30 percent by 2030 is only the beginning. In the long term, I expect a shift to a well-to-wheel approach and lifecycle assessments. Don't forget: Our goal remains to achieve CO_2 neutrality by 2050. Innovative products and complete solutions will then be even more important. Many jobs will be created here in future-proof fields. In short: The CO_2 legislation is an important impulse to demonstrate the innovative ability of the German and European commercial vehicle industry at a very high level.

The technological change will be expensive for transport companies, public transport and for consumers!

Brandau: That is not true. Of course, the purchase price of battery electric and fuel cell vehicles is currently still significantly higher than for diesel commercial vehicles. That is why the governmant must help with incentives to accelerate technological change. But battery electric vehicles will break even in terms of Total Cost of Ownership (TCO) by 2024. In the case of fuel cell vehicles, I expect this to be achieved by the end of the decade. The lower operating costs, such as fuel and maintenance, will also contribute to this.

George: In addition, the first business models from, e.g., Hyundai Trucks are already in place today that enable cost-effective operation. Hyundai is exempt from tolls in Switzerland, and other new players offer Transportation-as-a-Service, which pays off for both users and providers. So the technological change is already in full swing, and I don't expect it to be more expensive for consumers than it is today.

Nobody wants to become a truck driver anymore…

George: This doesn't have to be the case. At the moment, the job is certainly very strenuous and comparatively low paid, but this may change in the future. Autonomous driving reduces stress because the vehicles can drive themselves even for large parts of the journey – but at the same time it will not completely replace human drivers because there are still situations that cannot be automated.

Töpfer: Drivers will also take on new tasks. They will take care of distribution, dispatching and fleet management in an exciting interactive environment, which should make the job much more interesting. I think that in the future, drivers will become transport managers. Coronavirus has also shown that "working remotely" is possible in many areas. So why not also in an autonomous truck?

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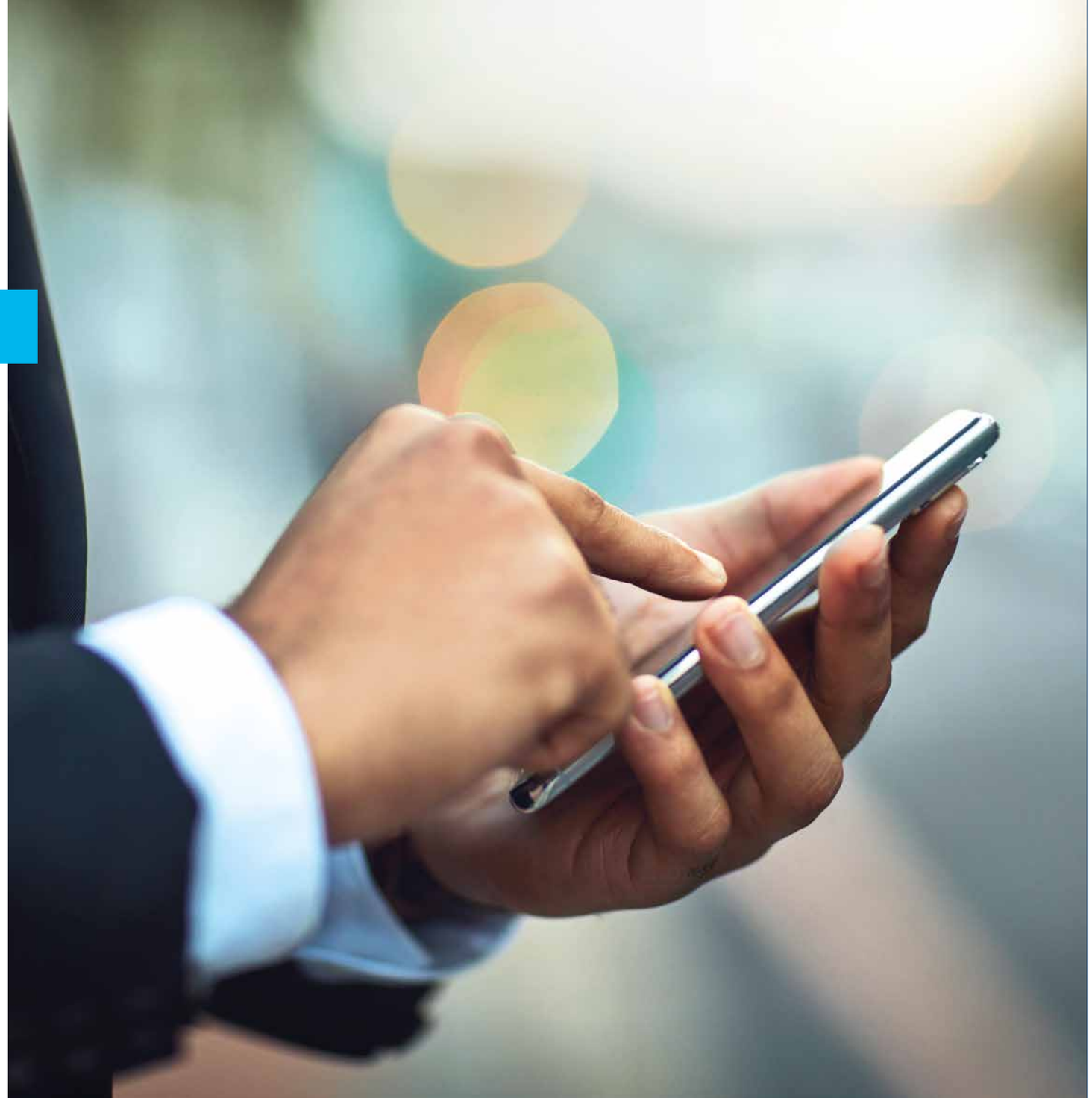

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