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ON THE COVER

The Hitch Detection system allows the ZF Innovation Tractor to automatically approach implements to within 1.5 cm (0.6 in) so they can be easily hitched. The SafeRange function allows the driver to leave the vehicle and remotely control the tractor/trailer combination from a safe distance. Automation is also one of several topics discussed with Daimler Trucks' Dr. Wilfried Achenbach. Read more on page 4 and page 26, respectively.

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EDITORIAL

Commercial vehicles in a digital world

"We don't want to have a Detroit and a Las Vegas," said Matthias Wissmann, President of the German Association of the Automotive Industry (**VDA**) at an international press workshop in advance of September's IAA Commercial Vehicles event in Hanover, Germany.

Wissmann was referring to the Consumer Electronics Show (CES) in Las Vegas being separate from—and now competing with—the North American International Auto Show in Detroit, both of which occur annually in early January. The goal with IAA is to effectively marry the "metal" side of the CV business with the now-indispensible "digital" side.

Many leaders of the CV sector emphasized their activities in this area at the workshop, including Dr. Wolfgang Bernhard, Member of the Board of Management, **Daimler Trucks & Buses**: "Our industry is experiencing a revolution, spearheaded by autonomous driving, connected driving and electric driving."

On the first two topics, Bernhard summarized Daimler's endeavors, including the "first-ever" autonomous truck in 2014 with its **Mercedes-Benz** Future Truck and, this past March, demonstration of "the digital connection of trucks" by platooning three WiFi-connected, autonomously driving Mercedes trucks on the A52 autobahn. This latest advanced system development is called Highway Pilot Connect.

"For high-performance logistics, real-time data are essential—and our trucks supply these data," he said. Each Daimler truck has about 400 sensors and is connected with 100 million lines of code, the company claims. And it plans to push this connectivity even further, by investing around half a billion euros by 2020 to connect its trucks with their environment and to develop new applications.

"We are connecting the truck with the internet, making it the mobile data center of the logistics network," Bernhard said.

Illustrating Volkswagen's growing emphasis on the CV market—not only because of the sector's success in recent years but also because of financial and image issues VW faces following its passenger-car diesel emissions scandal—the global OEM will exhibit at IAA for the first time this September. Andreas Renschler, Member of the Board of Management, Volkswagen AG, CEO of **Volkswagen Truck & Bus** GmbH, provided a future look of the CV sector.

"In the long term, we will move away from the role of an OEM with a traditional hardware focus. We will then be much more than just a 'manufacturer' when we offer our customers clean and intelligent transport solutions that help all of the players in the transport ecosystem to achieve real efficiency gains," he said.

By 2040, Renschler envisions fully connected, intermodal transportation systems "in which the flow of traffic is optimized through artificial intelligence." Digitization will drive out systemic inefficiencies; for example, helping to optimize loading capacities in order to minimize the transport of "hot air."

Major global OEMs are not the only companies playing in this space. Daimler's Bernhard acknowledged the emergence of Silicon Valley start-ups and their interest in self-driving trucks. One such company garnering a lot of press is San Francisco-based **Otto**, founded by former employees of **Google**'s autonomous car division and **Google Maps**. Otto has already outfitted three Class 8 tractors with its automated-driving technology, and testing is under way.

Even more recently, Elon Musk revealed in a July 20 blog post that autonomous trucks are on the docket at **Tesla Motors**. He writes, "In addition to consumer vehicles, there are two other types of electric vehicle needed: heavy-duty trucks and high passenger-density urban transport. Both are in the early stages of development at Tesla and should be ready for unveiling next year. We believe the Tesla Semi will deliver a substantial reduction in the cost of cargo transport, while increasing safety and making it really fun to operate."

What's certain, such lofty visions from industry luminaries is making it really fun to watch what's next in this increasingly digital world.

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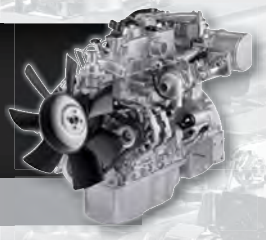

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ELECTRONICS | POWERTRAIN

Automation, electrification focus of ZF's Innovation Tractor prototype

Traction management on the ZF Innovation Tractor enables vehicles to start on uphill gradients of up to 30%, thanks to electrically powered wheel heads installed on the trailer that provide additional drive torque.

The passenger-car industry may be driving development of advanced driver-assistance systems (ADAS) and electrification, but the off-highway segment may be best-positioned to utilize them more widely—and sooner.

"The main movement for [driver-assistance systems] is in passenger cars, although it's much more difficult to get this on cars because of all the regulations," said Dr. Manuel Götz, responsible for Advanced Engineering, Industrial Technology at **ZF**. "So I believe in the future, we'll be seeing autonomous vehicles in off-highway more regularly and even earlier than on the highway. Due to the fact that we're in an enclosed environment and don't have the regulations of on-highway, this could make things easier to implement."

"A higher degree of automation also addresses the trend of operators being less trained in the future and not being able to find highly trained people to operate more and more complex machinery. So this [Innovation Tractor] is a step toward autonomous operation," he added.

ZF is making a concerted effort to transfer the intelligent systems it's developed initially for passenger cars into heavy trucks and buses, as well as off-highway equipment. To effectively illustrate this point, engineers in the company's Advanced Engineering department have spent the past year designing the Innovation Tractor, an advanced-technology demonstrator loaded with cameras and electronics to allow automated maneuvering and hitching, not to mention pedestrian detection. Electric single-wheel drive for trailers and implements helps to dramatically improve traction management, as demonstrated in Aachen, Germany, on a 30%-grade paved road that was thoroughly watered down.

"We have full control not only of the driveline and the engine on this vehicle but also the steering and the brakes," he said. "This is necessary to have full control over the vehicle and to do things like trajectory control and steering the vehicle."

Agricultural was selected as the first application for these automation technologies, but they are viable for construction and other off-highway segments, said Götz.

"The Innovation Tractor brings together in a test prototype all the new functions we believe are practical for agricultural and construction applications," said Dr. Harald Naunheimer, Head of R&D at ZF Friedrichshafen AG. "The focus was on demonstrating what is already possible and technically feasible today, but sets a benchmark on future innovation."

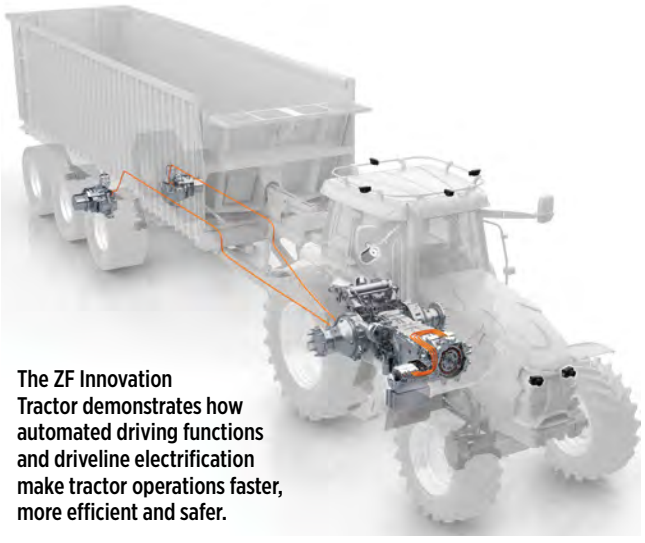
Automated operation and hitch detection

The Innovation Tractor is equipped with 10 environmental cameras to monitor its surroundings; the data from these cameras enables the vehicle to maneuver semi-autonomously or via mobile devices operated outside the driver's cab, making it easier to hitch implements, for example.

Six cameras are mounted on the driver's cab and the hood. A computer analyzes the images and generates a 360° surround-view image of the tractor's environment. The operator can view this image on a tablet from various perspectives, including a bird's-eye view.

These cameras could be linked to provide warnings for obstacle detection and to brake, if necessary, as is becoming more common in passenger cars, Götz said.

The Hitch Detection system allows the ZF Innovation Tractor to automatically approach implements to within 1.5 cm (0.6 in) so they can be easily hitched.



The ZF Innovation Tractor demonstrates how automated driving functions and driveline electrification make tractor operations faster, more efficient and safer.

Two cameras located at the rear of the tractor are used for the Hitch Detection function. Two additional rear cameras, monitoring a 180° swath, have pedestrian-detection capabilities. These four rear-mounted cameras have a separate data-processing unit.

In future iterations, the tractor ideally will utilize just four cameras, all mounted on the roof, to handle all of these functions, said Götz.

The Innovation Tractor's SafeRange function allows the driver to leave the vehicle and remotely control the tractor/trailer combination from a safe distance. The Innovation Tractor and trailer are outlined as a bird's-eye view on a tablet display from which all the relevant driving and steering commands are managed. Dragging the tractor or trailer image with a finger to the right or left on the screen causes the actual tractor/trailer combination to maneuver in the chosen direction. For reversing in complicated situations, the user can specify the desired direction for the trailer and the system calculates and executes all the necessary steering movements.

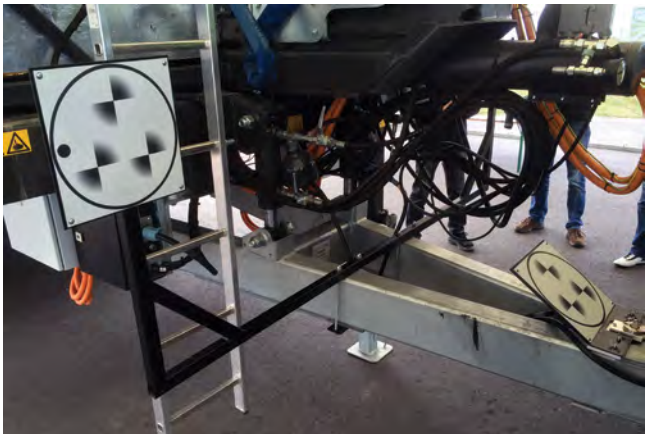
Pedestrian Detection ensures the ZF Innovation Tractor stops automatically whenever someone gets in the way.

Dr. Manuel Götz of ZF's Advanced Engineering for Industrial Technology believes autonomous vehicles will flourish in the off-highway realm earlier than on the highway due to the structured environments and fewer regulations. Behind him are the four cameras used for hitch and pedestrian detection. (Photo by Ryan Gehm)

Speed is set by swiping the screen from the center to the edge, across the tractor model or the trailer. The maximum forward speed is 4 km/h (2.5 mph), with the top reversing speed limited to 2 km/h (1.2 mph). When contact with the screen is removed, or if radio contact is lost between the tablet and the tractor, the vehicle stops automatically. SafeRange also works when maneuvering the tractor without a trailer.

For the automatic hitching, currently there are three target shields mounted on the trailer to help guide the system. These shields will eventually go away, said Götz, but additional technology is required for that to happen.

"You have the opportunity to train your algorithm better on different implements, but this is a very lengthy [process]. I believe that in the future we might have a system that combines an optical camera and a laser system. With laser you have additional possibilities of detecting much more accurately, not only distances but also how the environment is



For automatic hitching, currently there are three target shields mounted on the trailer to help guide the system. In the future, the system could use sensor fusion that combines an optical camera and a laser system to eliminate the need for shields. (Photo by Ryan Gehm)

changing. So I think we'll see this sensor fusion for autonomous operation," Götz explained.

The Hitch Detection system uses cameras to detect the exact position and angle of the trailer in relation to the tractor by using the targets. It works up to a distance of 7 m (23 ft). The position is continuously measured during the hitching process and the angle of the steered wheels corrected. The Innovation Tractor maneuvers automatically until it reaches the optimum position for hitching, which then is completed by hand. The system has a tolerance of 1.5 cm (0.6 in).

While using the tablet for maneuvering and hitching, cameras can detect pedestrians located between the vehicle and trailer up to 7 m away, with this information also displayed on the tablet. If the person controlling the tractor fails to respond, the system stops the vehicle. The interrupted hitching process can be restarted only once the pedestrian has moved out of the way.

"Many accidents happen on the farm with people getting run over, so this is a huge step," said Götz. "Right now we don't have the regulations demanding such a solution, but once the industry shows such technology I believe there will be regulations to have it implemented on the vehicles."

Driveline electrification

Drivetrain electrification for the Innovation Tractor comes via ZF's TERRAMATIC transmission with the TERRA+ generator module, an electric single-wheel drive for trailers and implements, coupled with specially developed traction management. An electric steering system, required for automatic-driving functions, has been built into the control network.

This system generation can provide 50 kW of continuous electrical power and serves as the power source for the electrical consumers in the trailer. Two liquid-cooled, 3-phase asynchronous motors are integrated into the electrical wheel heads, saving space on the trailer axle; for the Innovation

Tractor's trailer, the system was installed on the middle axle. The nominal voltage is 400 V, and the system also can be fitted with a wheel brake.

The motors provide 6000 N·m (4425 lb·ft) maximum torque to each wheel.

"We have not yet implemented [the braking] but it is possible; it will be our next step," said Götz. This function can help with deceleration when going downhill and making a turn, helping to prevent jackknifing and rollover. "We have to implement it in the control so we can use the electric axle to provide a braking torque. It is just a matter of applying the parameters."

Torque vectoring—which is employed in automotive differentials and provides the ability to vary the power to each wheel—is another technology currently not available on the tractor but would be possible to implement, he said.

"From a space perspective we can go up to 70, even 100 kW continuous power," said Götz. "In the vehicle at the moment we have installed a 50-kW generator system which is linked to our power electronics, from which we transfer the electric current to the wheels of the trailer. We're not only powering them, we're also controlling them; this way we are able to realize optimized traction control between the tractor and the trailer."

The all-wheel-drive function of the ZF tractor and the electrical-boost function from the single-wheel drive on the trailer combine to deliver optimum traction management. With electrical assistance from the trailer, the tractor can climb uphill gradients of up to 30%, terrain normally off-limits for a conventional tractor/trailer setup, Götz noted. It also helps in difficult conditions in the open field.

A combination of two inputs determine traction management: the coupling force to determine if the trailer is pushing or pulling, and detection of load in the trailer.

The additional power from the trailer also allows a higher payload to be transported with a downsized tractor, ideal for users who only occasionally tow a fully-laden trailer.

ZF admits that its current CVTs are about as efficient as the full electric drive and less costly, so that hinders the move toward electrification. Other factors, however, such as improved controllability and the possibility for optimized traction control can help spur electric-drive adoption. As, of course, could CO_2-emissions regulations, which "might not be that far off" for the off-highway sector, somewhere between five and 20 years down the road, Götz predicted.

Ryan Gehm

CHASSIS

Corrosion-resistant bearings extend equipment lifetimes in severe environments

High nitrogen corrosion resistant bearings can reduce failures in harsh environments like military landing craft.

In harsh environments, relatively small problems like corrosion in a bearing can stop multi-million dollar vehicles where they stand. **SKF** and **Textron** are betting that bearings made with high nitrogen corrosion resistant (HNCR) stainless steel technology can reduce downtime on a military landing craft.

Stainless steel bearings common in equipment made for harsh environments have long been regularly replaced to avoid seizing and freeze up. It's typically costly to replace bearings buried deep inside equipment, so a team within SKF's aerospace group that focuses on blank sheet engineering and cutting edge technology has used the material in a line dubbed MRC.

"This is one of the largest advances in bearings in a while," said Laurie Olson, Specialty Marketing Manager at SKF USA Inc. "This is the first completely non-corrosive stainless steel used in a bearing."

Textron is using the MRC line in a Ship-to-Shore Connector used by the **U.S. Navy** to move personnel and equipment. Textron received a $213 million detail design and construction contract in July 2012 to build a test and trial craft.

That contract has since been expanded to nine vehicles that use Textron's Landing Craft Air Cushion technology to hover above the water and move onto shore. They will employ a fair number of SKF's bearings.

"We're providing 13 sets of bearings for the new model, which has been in testing for two years," Olson said. "This meets all the load requirements and reduces corrosion so our bearings can meet the U.S. military's 25-year lifetime requirement."

SKF has made HNCR in very limited production for a few years, employing HNCR bearings in applications as diverse as cranes and ice cream production equipment. That's now changing as SKF's manufacturing teams improved production techniques and test results showed good results.

"This is now ready for prototypes and small lots; it's something we haven't been able to provide before," Olson said. "This will not become a commodity item; you're not going to open our catalog and see HNCR bearings."

The material has been used in a crane used to move materials from ship to shore for over five years, much akin to the Navy application. In an ice cream hardening tunnel, bearing lifetime went from around a year to more than five years, according to SKF.

Terry Costlow

POWERTRAIN

Two-stroke future for heavy-duty engine braking

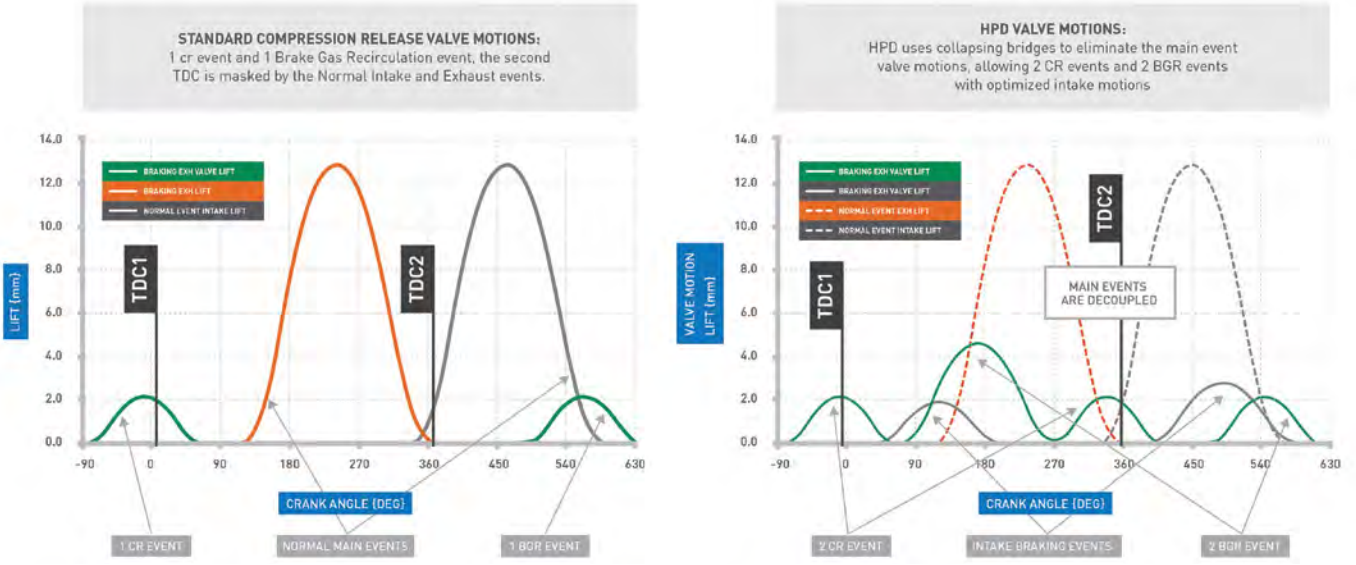
It is thankfully rare that the driver of a heavy truck or bus loses control of the vehicle because of brake failure caused by overheating the foundation brakes. This is partly because of the widespread use of auxiliary braking systems, which use equipment other than the foundation brakes to reduce speed, particularly on long downhill grades.

The compression release brake provides an alternative to traditional exhaust brakes and retarders, with a design pioneered by U.S.-based **Jacobs Vehicle Systems** in the 1960s. Conventionally, it takes the backpressure retardation principal a step further by controlling the exhaust valve opening on the exhaust stroke to create compression and therefore resistance to motion rather than the usual scavenging. Since the fuel supply is turned off when there is no demand for fuel in a modern diesel engine, there is no interference with the normal functioning of the engine. The exhaust valve remains closed until top dead center.

The effect is produced by installing a bridge under the cam follower. This contains a control solenoid valve that

Jacobs' HPD compression release engine brake adds intake valves and turbo boost control to hike efficiency.

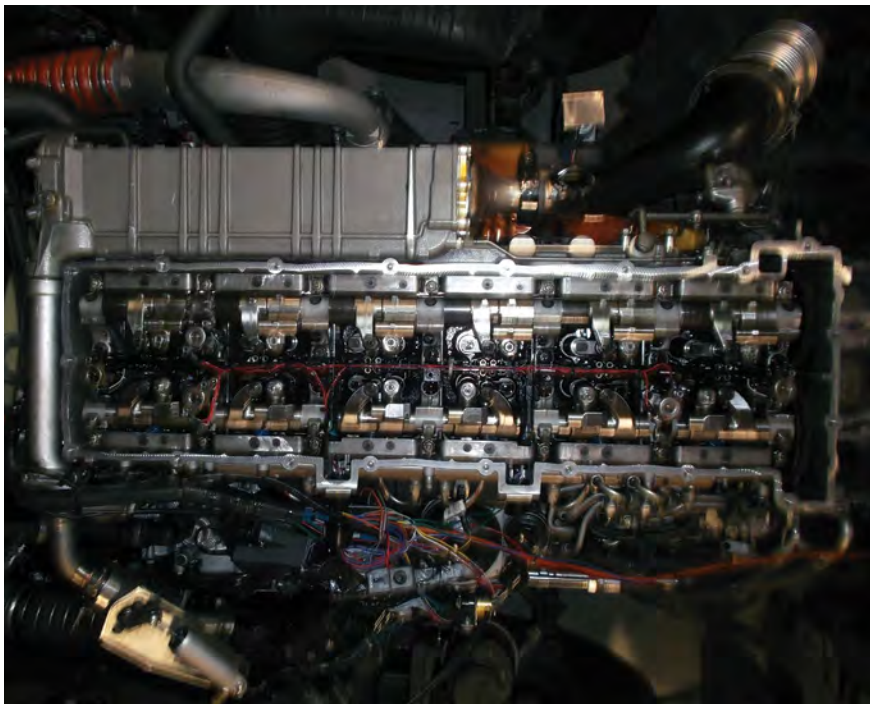
HOW HPD WORKS



Graphical comparison between regular compression release brake and HPD shows additional braking events.

controls the flow of oil to a hydraulic actuator, which acts on the cam instead of the regular cam follower. The oil supply is drawn through a drilling in the rocker shaft. Under power, the solenoid valve is closed and the actuator piston is locked to the bridge enabling the valve to follow the cam profile for four-stroke operation. When braking is required, the solenoid valve is opened, unlocking the actuator from the bridge and causing the valve to remain closed until top dead center is reached. Since the cam profile of the engine remains the same and the bridge cannot extend valve lift or timing, the brake does not pose a threat to the integrity of the engine.

It follows that larger-capacity engines offer the potential for more retardation, but the trend in recent years has been toward engine downsizing, which has had the effect of reducing engine braking potential. At the same time, rolling resistance has been reduced by the introduction of more aerodynamic vehicle designs, low rolling resistance tires, and reduced driveline friction. In other words, there is less built-in resistance to motion in a modern heavy vehicle. At the same time, gross vehicle weights for



Installed system on in-line six-cylinder engine shows components on exhaust and intake valve gear.

heavy trucks have increased since the 1990s in regions such as Europe, with maximum permissible weight reaching 44-tonnes for regular use in the European Union.

Jacobs' data suggests that continuous improvements in engine design and engine brake design have helped to raise compression release engine braking from around 8.0 kW/L at 1500 rpm from a 1960s heavy diesel with mechanical fuel injection to 20 kW/L at 1500 rpm by the late 1990s, when engines had adopted dual camshaft designs and the engine brake had been integrated into the valve train with a dedicated cam.

High Power Density engine brake

Despite the greater efficiencies of engine brake designs, increasing gross weights, lower rolling resistance, and engine downsizing have driven the need for more auxiliary braking power. Jacobs response is the High Power Density (HPD) engine brake.

With HPD, the same system of bridge, control valve, and hydraulic actuator is applied to the inlet cam as well. This enables the engine to switch from four-stroke operation under power to two-stroke operation under braking, thereby doubling the number of "braking" strokes. At the same time Jacobs is able to use boost from the turbocharger more effectively by controlling it to optimize boost charging for braking.

"You need to look at this as a system

Test track demonstration showed the performance differences between trucks equipped with Jacobs regular and HPD compression brake systems on a 26% gradient.

of how we control the valves on the intake, the exhaust, and the turbocharger," explained Tom Howell, Director of New Technology at Jacobs Vehicle Systems. "All these components need to be considered. By having two intake events, it enables us to get a larger amount of airflow through the engine and by having two compression release events, that's obviously utilizing the air that's provided by the two intake events."

The result has been to increase the available braking power to around 28 kW/L at 1500 rpm, with a maximum of around 37 kW/L at 2200 rpm. Jacobs claims one and a half times the braking performance of a traditional compression release brake over the engine's operating range with the same retardation at 1400 rpm as at 2100 rpm with the previous system. For a 13-L engine, Jacobs claims 2000 N·m (1475 lb·ft) of retarding torque at 1300 rpm and above with 611 kW (819 hp) of braking power at 2500 rpm.

As fitted to the **Mercedes-Benz** Actros demonstration vehicle, Jacobs claims braking power of around 370 kW (495 hp) at 1500 rpm. Jacobs says that the total system weight is around 12 kg (26 lb) compared with 150 kg (330 lb) for a hydraulic retarder. All additional heat is expelled through the exhaust system, helping to keep diesel particulate filters at working temperature.

Jacobs provided two identical Mercedes-Benz Actros models loaded to 40-tonnes gross combination weight for demonstration, fitted with 13-L inline six-cylinder engines. One was equipped with the conventional compression release brake and the other with the HPD system. Demonstration drives took place on the Hill Route at the **Millbrook Proving Ground** in the U.K., not normally open to laden trucks because of the 26% steep descent on one section.

While we were able to control descent on the 26% gradient in the vehicle equipped with the conventional system, additional check braking using the foundation brakes was needed. The HPD-equipped vehicle gave far greater control and with HPD engaged early enough, it enabled descent without using the foundation brakes, notable on such a steep descent.

The HPD-equipped vehicle was equipped with a potentiometer to control the turbocharger boost because it provided too much retardation on lesser grades. This could take the form of a four or five position column stalk on an OE-integrated installation.

John Kendall

POWERTRAIN

Unique piston design aids HD diesel waste heat recovery

Federal-Mogul will show its new Envirokool piston at the IAA Commercial Vehicles Show in Hanover in September. It's designed to withstand higher temperatures by incorporating a sealed-for-life cooling chamber within the piston crown. The chamber is filled with a specifically formulated cooling oil and an inert gas. The cooling gallery is integrated in the steel piston using friction welding and after charging with the oil and gas is permanently sealed with a welded plug. The inert gas ensures that the coolant will not oxidize.

As a result, the piston crown can withstand temperatures over 100°C (180°F) higher than possible today. By running at higher temperatures, it would ensure that carbon deposits that would normally form in the cooling gallery would be burnt off, which in turn would ensure that heat could be dissipated for the life of the piston.

Heat is transferred from the undercrown through the piston pin, skirt and ring pack and also by using a standard engine oil cooling jet. Since Federal-Mogul claims the Envirokool technology is so effective, the oil cooling flow to the spray jet can be reduced by 50%, which would reduce the workload on the engine oil pump, reducing parasitic losses as well as decoupling the engine oil from cooling, to an extent.

"The technology is mainly applicable to engines with waste heat recovery," explained Norbert Schneider, Director Global Application Engineering at Federal-Mogul. "Because just making a piston hotter doesn't save fuel. Right now, the piston is cooled tremendously with lubrication oil. All that heat energy is going into the radiator and is totally wasted. The idea is to increase the temperature of the exhaust gas by cooling the piston much less, but then the piston gets hotter, which is why we need this technology and then with the much hotter gases, a significant proportion of this waste heat can be recovered."

Up to 5% of energy can be recovered in current waste heat recovery systems and fed back into the drivetrain. "Future legislation will demand a significant reduction in fuel consumption for trucks, engines, and right now this is seen as having a very important potential," said Schneider.

Federal-Mogul's Envirokool piston incorporates a sealed-for-life cooling gallery under the piston crown.

Raising the temperature of exhaust gases will mean that emissions of oxides of nitrogen (NOx) will be increased. "The engine companies would have to optimize their whole combustion and they would have to investigate how much selective catalytic reduction (SCR) they use, or whether they would use exhaust gas recirculation (EGR). The emissions will still need to be compliant. This would change the combustion significantly.

"It will be several years before we could expect Envirokool to go into production. This is a relatively early stage. We have already been carrying out testing for two years with more than a thousand hours of successful results, and we are now in a pre-development stage with a small number of engine companies. We would expect mass production to begin from 2021."

The technology could be applied to both vehicle engines and stationary engines. Schneider told *Off-Highway Engineering* that the best results would be achieved from engines covering long distances or running for long hours.

John Kendall

ENERGY | INTERIORS

NREL cost-effectively eliminates diesel idling to condition Class 8 sleeper cabs

You see them at the side of roads, in parking lots and pull-off areas of highways—Class 8 over-the-road trucks with their diesel engines idling through the night to run the heating or air conditioning that assure comfort in the resting drivers' sleeper compartments. A lot of fuel might be saved—and CO_2 emissions reduced—with energy-efficient alternatives to extended idling.

The **National Renewable Energy Laboratory**, a federal facility based in Golden, CO, took on the challenge. The idle fuel-usage studies it found were from 2005; the outdated figures estimated idling is 7% of total diesel fuel consumption, so NREL focused on individual Class 8 trucks, proposing a package of technologies that can annually save 774 gallons on A/C cooling load alone compared with an idling truck; at $3 per gallon for diesel fuel, full payback of an investment in sleeper cabin climate-control equipment would come in about three years.

Only about half the states in the U.S. currently restrict idling for over-the-road trucks and laws often are observed in the breach, as some answers raise cost and reliability issues.

Driver comfort important

The trucking industry and regulators know there's a clear opportunity to save fuel and improve air quality. But resting drivers can't be confined to cocoon-like compartments with an occasional wisp of cool air in summer and/or wrapped in heavy blankets in winter.

Walls of the sleepers were fitted with various packages of upgraded insulation.

Today's sleeper compartments make driver comfort and convenience high priorities. Volvo VNL Class 8 series single-bed

Technologies evaluated in the NREL climate-controlled sleeper program. Advanced glazings were used for reference only.

Reflective "Thinsulate" was added as part of "plus" insulation package.

units are 118 ft^3/3.34 m^3 with a flat roof, and two-driver models with high roofs (77 in/1955 mm) have bunk beds in a 371 ft^3/10.5 m^3 living space—considerable area to be climate-controlled.

NREL's name points to its research in such areas as photovoltaics, wind and biosciences, but much of its work is on cost-effective solutions to real-world "lower-tech" problems. It has provided considerable study on climate-control related electric-vehicle range issues and at the 2016 **SAE** World Congress explained its extensive research into reducing Class 8 truck idling fuel consumption.

There are alternative approaches for climate control in sleeper cabs to avoid extensive idling, including battery-powered auxiliary A/C, fuel-fired or electric heaters and small diesel engines that serve as auxiliary power units (APUs). The popularity of diesel APUs peaked some eight years ago and the adoption rate today represents just 9%, explained Jason Lustbader, NREL senior research engineer.

NREL looked at many aspects of what it proposes as "complete cab solutions," with emphasis on low-cost additions or substitutions. "The project goal was to reduce cab thermal loads to enable smaller, lighter and more cost-effective idle-off climate-control equipment," explained Lustbader. The goal: a 30% reduction in big-rig sleeper climate-control loads with no-idle solutions that pay back within three years or less.

The NREL project evaluated four aspects in an integrated strategy: the solar envelope (as overall A/C energy use is in the equation), heat and cold conductive pathways into the sleeper, efficient equipment and the volume of the sleeper. In this effort, NREL works with industry partners, particularly **Volvo Group NA**, **PPG** and **Aearo Technologies**, which makes energy/sound absorbing materials.

35.7% reduction in A/C load

NREL testing showed its complete cab solution exceeded the goal, with its most advanced approach producing a 35.7% reduction in A/C load and 43% decline in heating load, with an even greater reduction of 53% with a more advanced approach to insulation. Translating those savings into dollars, NREL found that with the complete cab solution to reduce loads and adding a battery-powered A/C system for the sleeper, 774 gallons of fuel per year could be saved. Savings and cost analysis for heating the cabin is still underway, although some preliminary data was announced.

Prior testing by NREL indicated the best bang for the buck was in specific insulation, interior curtains, window shades and paints. Although all the actual testing was done at NREL headquarters, the data was plugged into NREL's own load estimating software, CoolCalc, to give the results a nationwide scope. The process provides fuel-use estimation by combining thermal loads with an A/C performance model to calculate an electrical demand. The load was combined with modeling to be able to

Test bucks and sleeper cabs were evaluated at NREL's Golden, CO facility. Electrical use was monitored from a 120-V AC source for testing convenience.

determine fuel use from recharging the battery pack. Because long-haul trucks operate across the country, the model used the 200 most representative weather stations nationwide to calculate total fuel saved.

Details that led to NREL's quantified results:

Thinsulate in "plus" package

Baseline insulation consists of foam attached to the door and body trim panels of the sleeper. The advanced package instead uses one- and two-inch insulation blankets with a thermal conductivity rating of 0.03-0.05 W/m-K. In addition to that advanced package is a "plus" addition of 0.25-in (6.35-mm) layer of **3M**'s Thinsulate, a synthetic fiber thermal insulation material which has a reflective radiant barrier. It is installed between the interior trim and the structure of the sleeper.

The three levels of insulation for the sleeper were combined with three different packages of privacy shades for the cab glass and sleeper curtains between the cab and sleeper: standard insulation with advanced shades and curtains, advanced insulation with standard shades and curtains and a package of fully advanced insulation, shades and curtains. The first two packages produced almost the same reduction in UA (heating load): 20.6% and 20.7%. The fully advanced setup resulted in a 43% reduction.

"Advanced plus" insulation also was evaluated against standard shades and curtains, advanced shades and open curtains and advanced shades and curtains. This "Complete Cab Plus" configuration yielded the greatest reduction in UA at 53%.

However, even with Plus insulation and advanced shades, leaving the sleeper curtains open to avoid a claustrophobic-feeling sleeper caused the heating load reduction to drop markedly to just 21.6%.

No-idle equipment

A **Dometic** no-idle 7000-BTU A/C system was installed. This truck sleeper system is battery-operated, has a three-speed blower and will run for more than 11 hours, the company claims. The system was powered by the laboratory's 120-V A/C for testing to obtain the most accurate data. However, the analysis assumed the use of 104 A-h AGM (absorbent glass mat) batteries that would recharge while the truck is in operation.

For heating, NREL chose a forced-air heater with the diffuser oriented to avoid air stratification. The heater was operated at 90°F (32°C) to provide a sufficient gap compared with ambient temperate for accurate measurement of the heat transfer coefficient (clearly much higher than would be used solely for sleeper comfort). A fuel-fired heater will be evaluated in future testing and it is expected to enhance the overall results.

Paint-color effect

Exterior paint color affects sleeper thermal loads only when the sun is out for a long time and intensity is high, typically in summer. However, because it does affect the total vehicle A/C load, the chosen white color was found to deliver a 20.8% load reduction compared with black. As an alternative, solar-reflective blue was compared with conventional blue and showed a 7.3% saving.

The white color combined with the NREL Complete Cab Plus package to deliver the lab's 35.7% cut in overall A/C energy consumption.

NREL's complete solution delivered results that equate to operating the trucks in year-round moderate temperatures. Modeling with CoolCalc showed major reductions in the number of both heating and cooling days in all parts of the country. This seems to provide an opportunity to save by downsizing the battery pack and other components in a fully optimized Class 8 climate-control system.

Paul Weissler

Clearing THE AIR

Sensors, diagnostics and controls advance to help trap emissions.

by Terry Costlow

Peering inside aftertreatment systems helps John Deere determine how sensors can help improve efficiency.

They're not as certain as death and taxes, but tighter emissions regulations have become a constant presence in off-highway vehicle development programs. Design teams continue to focus on meeting mandates or fine-tuning engine and aftertreatment systems to improve efficiency even when regulators give them a respite.

The European Union's Commission National Emission Ceilings and the California Air Resources Board's Mobile Source Strategy are both tightening requirements, though new regulations won't take effect for a few years. That's giving design teams a chance to refine their designs.

"We're in a regulatory lull, so companies are looking at making things cheaper or squeezing out better performance," said Dave Rodgers, Engines Business Unit Director at **Ricardo**. "They're not looking at components, most people are looking at the complete aftertreatment system, how it's architected and constructed."

Advanced emission controls systems that include the engine and aftertreatment systems are being revised to save space, cut cost and improve performance. Though mechanical elements are being updated, many of the changes come in sensors and electronic controls.

"Areas of most focus, and potential benefit, include combustion and aftertreatment, particularly in terms of characterizing the large set of kinetic reactions that govern pollutant production and subsequent reactions," said Alan Chewter, Senior Manager, Powertrain Systems, at **IAV** Automotive Engineering. "Additionally, since it is necessary to coordinate control of several actuators simultaneously to achieve stability and optimal performance, multi-input multi-output (MIMO) controller structures are common."

Sharper sensors

The digital side of electronic controls leverage the gains of microprocessors used in autos and consumer products, so advances in that segment of design are fairly predictable. But that's not the case in sensors.

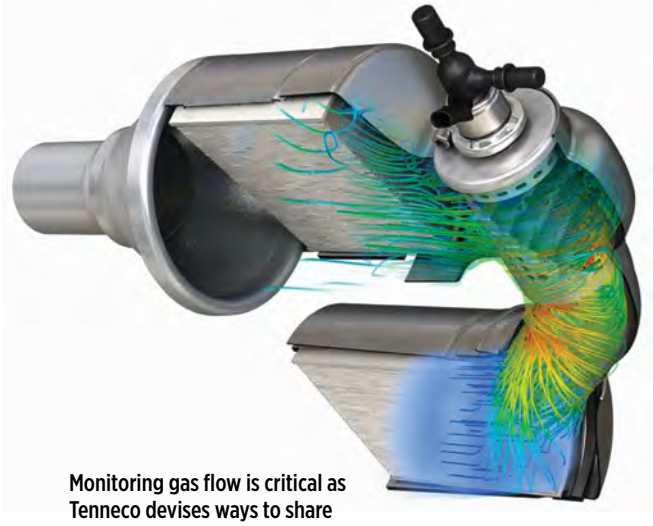
Finding high-performance sensors that can operate in harsh off-highway environments is not always simple. As requirements become more stringent, the need for sensor improvements will increase.

"Electronic controls will really come into play as we go to Tier 5," Rodgers said. "In Europe, that may be complicated because there's no set level for grams per liter, it's for particulate size. Sensor technology is not really there for that."

Design teams have made solid advances in recent years, for example using NOx sensors to tighten control of tailpipe NOx emissions. But many system developers are asking sensor suppliers for a range of advances so they can push state of the art further. Improvements could lengthen the time between chemical refills and regeneration cycles.

"New sensor technologies are being developed in the industry for detecting soot loading and ash loading in the diesel particulate filter (DPF), and for detecting ammonia storage levels in the selective catalytic reduction (SCR) system," said Jason Schneider, manager of product engineering at **John Deere Power Systems**

Perkins continuously strives to understand engine usage so engines can be made more efficient.



Monitoring gas flow is critical as Tenneco devises ways to share information and reduce emissions.

(JDPS). "These sensors could lengthen the time between active DPF regenerations, lengthen the time between ash cleaning service intervals and provide a better management of tailpipe NOx emission control."

Copious communication

Regardless of the type of sensors being used, technologists note that sharing data from sensors and related controllers can improve performance. This focus on sharing comes into play from the start of vehicle design. When all electronic modules communicate freely, engineers can locate computing power where it's most effective.

Engineers at Ricardo are testing engines and aftertreatment systems to see how size and performance can be improved.

"The sharing of sensor information, modeled parameters and data allows for the distribution of controls through the system," said Ben Patel, Vice President, Clean Air, Global Research & Development at **Tenneco**. "For example, in an SCR-coated DPF (SDPF) system, the engine may already be calculating the soot loading in the SDPF and measuring soot post-DPF. If that modeled and measured data is shared with the SCR model, it allows the model to be more accurate without the cost of developing a separate model for soot-loading."

Taking an overarching look at vehicle performance early in the design cycle helps at every level. When all factors are considered from the concept phase through completion, developers can reduce engine size. That helps trim emissions while reducing weight and cost.

"The real benefits of electronics are around the deep integration of the engine into the vehicle," said David Costura, New Technology Manager at **Perkins**. "By understanding what the vehicle is trying to accomplish and what its constraints are, the engine can be developed and customized to get every last bit of power, fuel economy and response within the emissions limits."

As planners have determined the size of the engine, they have to examine its interactions with the aftertreatment system. There are trade-offs between the two, where there's something of a battle between what engines emit and aftertreatment systems cleanse.

"Improved controls can result in reduced components in the engine; you can let the aftertreatment system clean it up and do the work that the engine used to have to do," Rodgers said. "But that's harder on a larger engine."

Close links and tight communications aren't limited to engines and aftertreatment systems. Engines and hydraulic systems make good

Clearing THE AIR

use of networks to share data so engines can deliver the necessary power while running the engine at the best rpm levels.

"The more specific and detailed information that can be shared between power-producing and -consuming functions on a vehicle system, the more opportunities there are for optimal control, and real time trade-off between competing objectives to be achieved," IAV's Chewter said.

The ability to share data can be used by companies to examine real-world usage. That should help as they develop next-generation equipment that can burn fuel more efficiently even as usage patterns change. Enhanced network communication may also be used to teach operators to utilize equipment more effectively, which can further trim emissions.

"As the controls architecture and hardware capability grows, we have more opportunity to use all the data available around the engine," Costura said. "We can look at the way the engine is operated by application, operator or even worksite to monitor performance, coach the operator to improve efficiency or even drive the development of custom ratings."

Prognostics and remote diagnostics

One benefit of having more electronic controls is that understanding faults becomes simpler. Diagnostic capabilities have become a central factor in electronic systems as developers marry the power of microprocessors with larger memory capacities, making it possible to look at events leading up to a fault.

Vehicle control systems are getting better at monitoring their own performance, constantly checking to

In aftertreatment, less is more

For design teams focused on aftertreatment, removing size has become almost as important as removing emissions. Combining catalysts, improving filters and integrating sensors are a few of the techniques being used to minimize package sizes.

Now that suppliers have figured out how to meet current regulatory requirements, they're striving to shrink packages while also gearing up for future cuts in emission levels. A range of strategies are being employed.

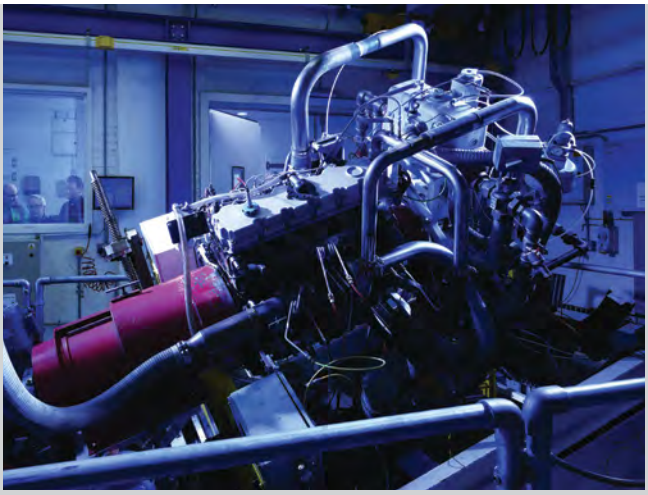
"We have optimized diesel oxidation catalyst (DOC) technology to improve emissions performance during active regeneration conditions while at the same time reducing the precious metal loading of the catalyst," said Jason Schneider, manager of product engineering at **John Deere Power Systems**. "We have also adapted new diesel particulate filter (DPF) substrate designs offering lower backpressure. These two advances allowed size reductions on the order of 25% more than our production launch of Final Tier 4 compliant systems with no negative performance impact to the engine.

There's also an effort to combine catalysts to shrink space requirements. While the benefits can be significant, developers note that it's often difficult to design systems that can save space and meet reliability requirements.

"Catalyst multi-functionality has the potential to reduce the number of substrates required in the system, thus shrinking the overall package space," said Ben Patel, Vice President, Clean Air, Global Research & Development at **Tenneco**. "However, complexity increases because now the DPF's soot loading mechanisms compete with those for NOx reduction, and both must be carefully managed to avoid catalyst and filter failures. Oxidation catalysts are becoming integrated with NOx adsorbers onto a single catalyst substrate upstream of other NOx reduction catalyst components. The NOx adsorber stores NOx under low exhaust temperature conditions, for example start up and idle, and releases it above the SCR catalyst activation temperature. That improves overall NOx conversion efficiencies."

However, some combination strategies simplify system production. Reducing component counts saves space while simplifying procurement and manufacturing functions.

"The combination of NOx sensor and O_2 sensor actually reduces the complexity of the system and provides cost reduction benefits," said Alan Chewter, Senior Manager, Powertrain Systems, at **IAV** Automotive Engineering. "Improvements are being made in particulate matter sensors to increase durability, repeatability and sensitivity. In combination with advanced signal processing techniques, it is becoming possible to effectively estimate the sooting rate as well as the total accumulated soot mass over time."



Simulations can help Perkins develop ways to combine particulate filters and SCR to shrink aftertreatment systems.

Much of the focus is on reducing size within aftertreatment systems. But it's possible to alter engine designs to help reduce the complexity of cleansing systems. When engines emit fewer pollutants, smaller systems can be used to meet environmental requirements.

"People are trying to reduce soot from the engine so the particulate filter acts more like a sponge," said Dave Rodgers, Engine Business Unit Director at Ricardo. "You don't want to be cleaning the particulate filter too often. There's also a push to put the particulate filter and SCR in the same box to reduce costs."

A range of techniques have been employed to reduce the size of mechanical components like pipes and valves. That can also help reduce noise, which is an important factor in many operating areas.

"Mixers have advanced and significantly reduced the mixing lengths needed for diesel exhaust fluid dosing, offering light-off improvements to the catalyst," Patel said. "The integration of exhaust valves has offered significant improvements in sound quality, engine power and reduced muffler volumes, becoming more important as space becomes even more premium."

Terry Costlow

Electronic controllers are providing more advanced diagnostics that can be used to reduce emissions. (Cummins)

see if each component is performing within expected parameters. Diagnostic systems are also getting better at fully analyzing any problem and presenting data that can shorten repair times.

"In some cases the more significant challenge is ensuring the system is operating properly and that the information the system receives from the sensors can be trusted, the on-board diagnostics," said Maurice Dantzler, Function and Component Architecture Director, **Cummins** Emission Solutions. "We also see a strong desire to have good fault isolation capability to reduce repair costs. From a downtime perspective, we are seeing a push for self-diagnosis of the system while in operation. So when the vehicle arrives at the shop, the diagnosis is done and isolated to a component for a quick fix."

As diagnostic technologies advance, developers are focusing on more ways to minimize unscheduled downtime. Some companies are working on prognostics as a way to predict pending breakdowns and plan repairs in a more strategic way. Others are utilizing telematics to give remote managers more capabilities to arrange maintenance and repair shutdowns.

"Greater emphasis is given to prognostics and remote diagnostics," said JDPS' Schneider. "These allow service repairs to be scheduled at a time convenient to the operator, resulting in increased efficiency and reducing costly work disabling failure modes."

John Deere is developing prognostics to help reduce downtime.

While diagnostic systems continue to improve, these advances are only made by overcoming significant challenges. The number of sensors and controllers on vehicles continues to grow, increasing the job of diagnostic functions that monitor them. The vehicle's control systems also perform more tasks, many of them are more precise than the jobs done in prior generations. All these factors make it more difficult to analyze what's going on.

"As systems become more complex and based on physical models of real systems, diagnostics opportunities improve," Chewter said. "However, in competition with this is the fact that systems operate at higher levels of efficiency: lower emission levels, higher catalyst conversion efficiencies, etc. These factors can act to reduce the final diagnostic system performance."

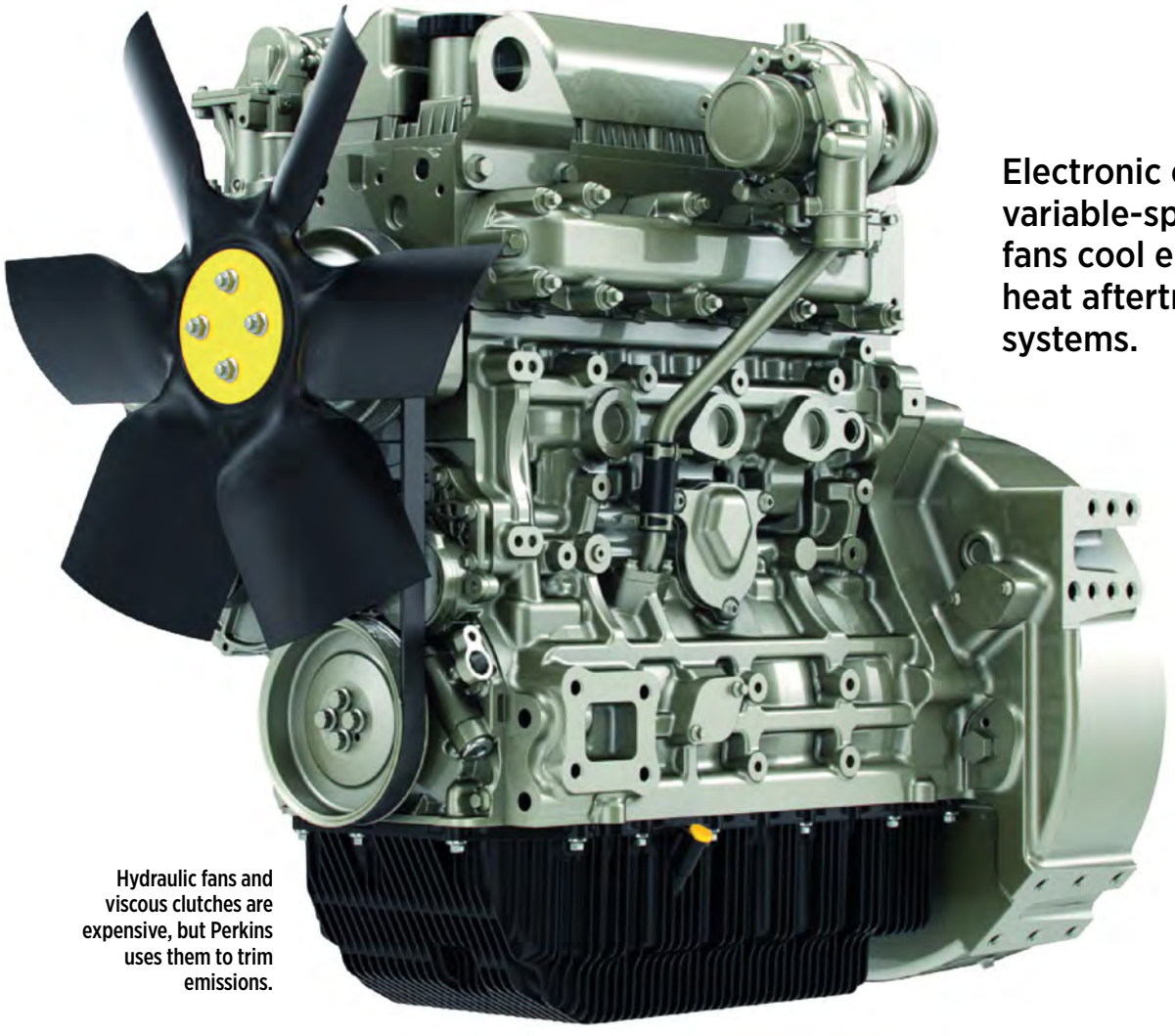
That doesn't mean that progress is slowing down. Engineers continue to work on techniques that let systems fix some of the problems they identify. This is another way to reduce unscheduled downtime.

"Improved diagnostics would be able to identify temporary fail modes and request corrective action to recover," Dantzler said. "For example, if a system has deposits, a special regeneration could be initiated to clear the deposits and get the system to a normal functioning state. This helps the system prevent the chances of going into an irrecoverable mode." ■

Advanced Emissions Strategies webinar in October

No one ever claimed, or dared believe, that Tier 4 Final was final. This Technical Webinar from the editors of *Off-Highway Engineering* will take us from where we were in terms of the major advances in emissions solutions over the past couple of years, to where panelist experts and futurists think we need to be, and what will get us there. During this free one-hour webinar, scheduled for late October, topics can range from advances in electronics, modeling and sealing technologies, to alternative power solutions. To register, visit www.sae.org/webcasts. Sponsors: **dSPACE, Interface, Tenneco**

Bringing the HEAT on COOLING technologies



Hydraulic fans and viscous clutches are expensive, but Perkins uses them to trim emissions.

Electronic controls, variable-speed fans cool engines, heat aftertreatment systems.

by Terry Costlow

Thermal management continues to become more complex as engineers strive to cool engines while generating enough heat to burn away unwanted emissions matter. Ever smarter electronic controls are helping design teams provide optimal performance and long engine life while meeting emissions requirements.

More demanding customers, expanding regulations and growing sophistication at all levels of system design are combining to make thermal management a multifaceted design challenge. Mechanical elements remain a mainstay in the battle to remove heat. But as in many aspects of vehicle design, electronic control units (ECUs) are gaining more of a role.

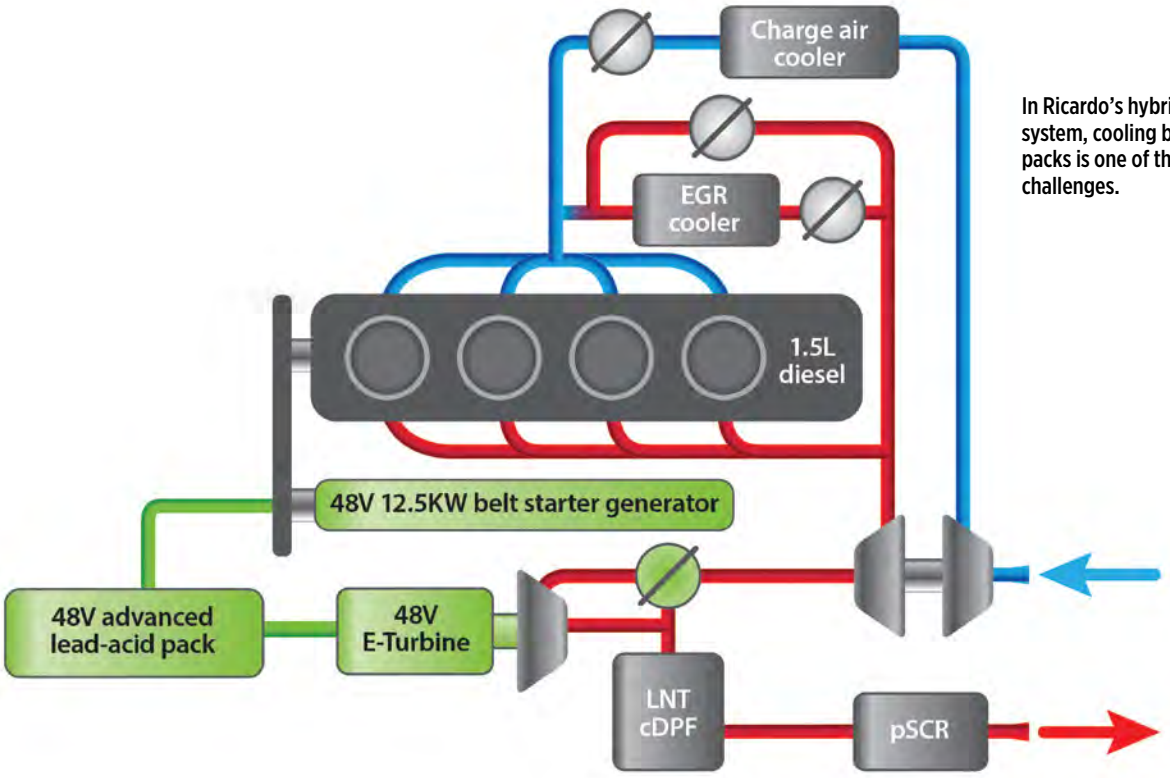
"Engine electronics can be tailored to the application in order to optimize cooling system operation to engine operation conditions," said Shelley Knust, Executive Director, Engine Business Unit Off-Highway Engineering at **Cummins**. "For example, faster engine warm-ups and maintaining optimal coolant operating temperature is desirable to reduce fuel consumption. Electronic controls can enable fine control of the fan speed based on the temperature requirements from engine coolant and charge air requirements."

Fans are a key weapon in the battle against heat. As variable-speed hydraulic fans displace traditional units, their controls are getting smarter. Pulse width modulation (PWM) is being used to maximize heat removal using minimal energy.

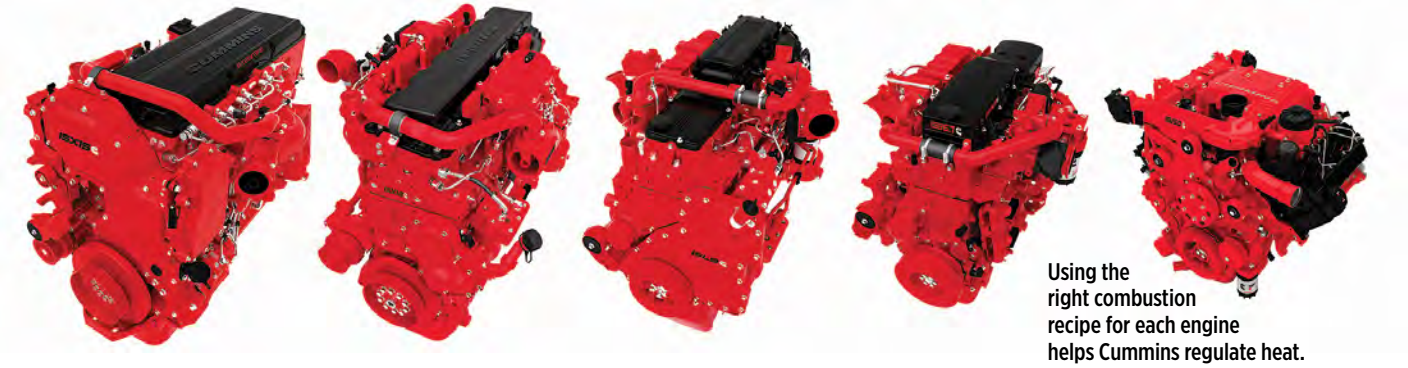
"PWM clutches on fans help keep the engine operating at the right temperature all the time," said Cedric Rouaud, Chief Engineer for Engines at **Ricardo** UK. "The speed of the fan and the flow of water can be adjusted or turned on and off with PWM controls."

When fans run at slower speeds, they're helping equipment makers meet ever-tightening regulations. Though fans' fuel consumption and sound levels are small compared to engines, they're still important. Both fall in correlation with fan speeds.

"Although hydraulic fans and viscous clutches are more expensive than traditional directly-driven fans,



In Ricardo's hybrid diesel system, cooling battery packs is one of the thermal challenges.



Using the right combustion recipe for each engine helps Cummins regulate heat.

they do help to reduce fuel consumption as the fan power can be modulated with the cooling requirement," said Oliver Lythgoe, Product Concept Marketing Manager at **Perkins**. "They are also a great tool for reduction of noise, which is regulated in many territories, especially Europe."

Cooling battery packs

Temperatures inside the engine are just as important as those outside. Microcontrollers also keep engines running at ideal temperatures to get the most from each drop of fuel.

"Electronic controls are also essential in controlling overall heat in the combustion event, and providing the optimal recipe of injection timing and fuel quantity, airflow and quantity, etc. to achieve the desired operating conditions," Knust said.

While most off-highway design teams focus on engines, others are considering batteries and electric motors, trading one thermal challenge for another. Hybrid technology is sometimes used to augment internal-combustion engines and reduce fuel consumption. That shifts the focus to cooling battery packs.

"With an electric hybrid, you can often downsize the engine," Rouaud said. "The thermal challenge then becomes keeping batteries at the right temperature. Some OEMs want to use ambient air cooling, but temperatures in the battery pack can go up to 45°C. It's better to use liquid cooling to keep batteries at 20-30°C."

Heating after the fact

After fuel is burned, the challenge shifts to preventing emissions from polluting the air. For engineering teams, the question becomes increasing heat rather than reducing it.

"The thermal management of aftertreatment is critical in the latest low emissions diesel engines," Lythgoe said. "Heat is necessary for

Bringing the HEAT on COOLING technologies

Chipping away at module temperatures

Semiconductors are tiny compared to the vehicles that carry them, but their thermal issues aren't small. Keeping the sub-micron elements of a chip cool is a major challenge for the developers of electronic controls.

In today's mobile world, chips are increasingly designed for lower power and cool operations. Nonetheless, harsh off-highway environments force design teams to take extra care to use semiconductors that add very localized heat to the ambient temperatures found in engine compartments and other hot, cramped areas. In these dirty environments, passive cooling is always preferable to fans. That means chips have to offer power and heat specifications that fit their surroundings. Placing controls as far away from hot spots is critical.

"This is achieved through careful selection of electronic components and consideration of thermal conditions in design of the enclosure for the electronics," said Shelley Knust, Executive Director, Engine Business Unit Off-Highway Engineering at **Cummins**. "This also requires knowledge of the ambient conditions of the intended mounting location of the controller."

Cooling the semiconductors in controllers comes with many trade-offs. In many modules, CMOS devices are the obvious choice. But in modules that work with high power levels, CMOS may not always provide the best thermal traits.

When modules manage electric motors and other more demanding equipment, alternative semiconductor technologies can often meet performance requirements while providing more flexibility to meet electrical or thermal demands.

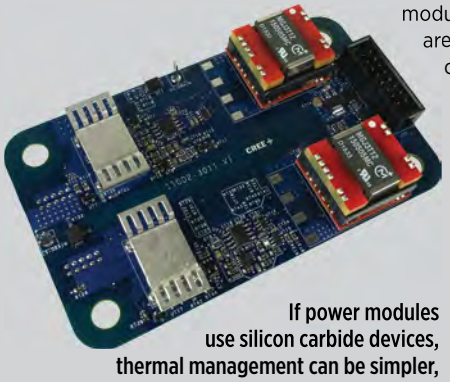
"Silicon carbide can cut switching losses in half," said Paul Kierstead, Director of Marketing for **Wolfspeed**'s Power Division, which is owned by **Cree** Inc. "You can use that to improve efficiency or you can move to higher frequency conversion electronics. Higher frequencies mean you can use smaller inductors and other components. This significantly reduces cooling requirements, so instead of using liquid cooling for silicon devices, you can use convection cooling for silicon carbide."

Regardless of the semiconductors being used, convection cooling is generally the desired methodology. Liquid or fan-based cooling systems add complexity and often bring reliability issues.

"Fans would require controllers for these applications to reside either on-engine or in the engine compartment," Knust said. "Environmental conditions and normal vehicle maintenance procedures, such as power washing of the engine compartment, would damage cooling fans. Fluid cooling (whether fuel or engine coolant) is not preferred due to the complexity of installation during both manufacturing and service."

While cooling is always a part of any electronic design, its impact doesn't usually extend beyond the module level. When engineers are creating architectures with centralized and distributed intelligence, thermal management isn't a consideration.

"The impact of cooling is not a primary factor in our electronic control system architectures including whether modules are consolidated or distributed," Knust said.



If power modules use silicon carbide devices, thermal management can be simpler, according to Wolfspeed's Kierstead.

Terry Costlow

Insulation on aftertreatment systems helps Perkins prevent fires and protect humans from burns.

the correct operation of the catalytic reaction in diesel oxidation catalysts, selective catalytic reduction systems and in particular to maximize passive regeneration in diesel particulate filters (DPFs)."

The heat used by DPFs comes from engines. Engines designed to run cool must heat DPFs to several hundred degrees centigrade during regenerations. As with most engineering challenges, there are many trade-offs.

"The engine system needs heat at the right place and right time to meet optimal performance and achieve emissions compliance, while reducing the impact to the machine cooling management," Knust said. "Closed cycle efficiency improvements in the combustion recipe and equalizing flow across the cylinders reduce the amount of heat rejected. Right technology and architecture is a key element of achieving this optimal performance, and our upcoming Stage V engines in the 100- to 515-hp range will utilize a non-exhaust gas recirculation solution, combined with our Single Module Aftertreatment system."

When aftertreatment system temperatures exceed 500°C (932°F), there's a danger of burning people or anything else that touches the equipment. Engineers have to devise strategies to increase the internal temperatures of aftertreatment components while protecting operators and the nearby environment.

"Whilst the internal components of aftertreatment best operate warm, it is important to limit the external temperatures, sometimes referred to as aftertreatment skin temperatures," Lythgoe said. "Perkins choose to insulate aftertreatment components where possible, which has the beneficial effects of maintaining high internal temperature, and also reduces safety risks to operators and service technicians. By keeping aftertreatment skin temperature down, the OEM can reduce the cost and complexity of additional shielding to protect temperature-sensitive components (especially plastics) that are fitted near to the aftertreatment." ■

3D PRINTING MACHINES can't be built fast enough

The Department of Energy's Manufacturing Demonstration Facility at ORNL is now home to the world's largest polymer 3D printer. The new BAAM (Big Area Additive Manufacturing) machine is another result of ORNL's yearlong collaboration with Cincinnati Inc.

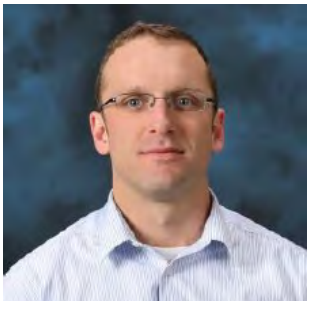
In the additive manufacturing world, the costs of components are dropping, the technology is becoming more reliable and parts are fabricated faster, allowing industries beyond aerospace to adopt additive technologies, says Oak Ridge Lab's Ryan Dehoff.

by Matthew Monaghan

As Deposition Science and Technology Group Leader at **Oak Ridge National Laboratory** (ORNL), Ryan Dehoff facilitates the development of additive manufacturing of components, utilizing various techniques including electron beam melting, laser metal deposition and ultrasonic additive manufacturing. He is developing processing techniques and exploring new materials via additive manufacturing to improve energy efficiency during component production, decrease material waste and improve material performance. We recently spoke with Dehoff to learn more about these innovations and industry trends.

What are some of the new applications where additive manufacturing could potentially be used?
A couple of examples I've seen in the automotive industry are things like utilization of metal powder bed systems to make injection mold tooling. That's a really big application for additive manufacturing because you don't necessarily have to certify and qualify an end-use part, but it can dramatically increase the cycle time of injection molded components and therefore lead to decreased cost of producing that component. People are also looking at utilizing additive technologies to build prototype engines that they might want to go into production in the future. So they're trying to make those engines more efficient and more cost-effective through design optimization, and additive gives them a valuable tool to be able to go through and look at those designs prior to going into the casting or production process.

Where is the 3D printing standards discussion at currently?
The standards that are being developed, I think, are a good first step in implementation of additive into different industrial applications. But I think the big challenge with additive is it may be difficult to actually qualify



"The big challenge with additive is it may be difficult to actually qualify and certify parts with a conventional mind-set," said Ryan Dehoff of Oak Ridge National Laboratory.

3D PRINTING MACHINES
can't be built fast enough

Big-time 3D printing: building an excavator, layer by layer

3D printing a car is impressive enough; building an excavator, layer by layer, is downright unimaginable. Researchers at **Oak Ridge National Laboratory** (ORNL) have not only imagined it, they plan to execute it next spring at ConExpo/Con-Agg in Las Vegas with a live demonstration.

Some off-highway companies took notice of what ORNL did with **Cincinnati** Inc. and **Local Motors** on the 3D-printed car (see http://articles.sae.org/13841/)—and wanted to go bigger, Lonnie Love, group leader for manufacturing systems research and corporate fellow at ORNL, explained to *Off-Highway Engineering*. "They wanted to do something similar in terms of demonstrating something grand that could get people excited about where additive manufacturing and construction is going. That was the catalyst for pursuing this vision of printing an excavator at ConExpo."

ORNL is teaming with several organizations to bring this vision to reality. Key partners on the 3D-printed excavator project include the **Association of Equipment Manufacturers**, the **National Fluid Power Association**, the **Center for Compact and Efficient Fluid Power** and the **National Science Foundation**. OEMs like **Case New Holland** and universities, including the **University of Minnesota**, are also contributing to the project, which is supported by the **U.S. Department of Energy**'s Office of Energy Efficiency and Renewable Energy – Advanced Manufacturing Office.

At the Manufacturing Demonstration Facility at ORNL, about 15 people, consisting of material scientists, engineers and

Components of the world's first 3D-printed excavator will be developed using the Wolf Robotics system installed at the Dept. of Energy's Manufacturing Demonstration Facility at ORNL. Actual printing has not yet begun. (Photo courtesy of ORNL, Dept. of Energy)

Additive Manufacturing webinar

Additive manufacturing is gaining steam in the automotive industry, and not just for prototyping parts. 3D printing processes increasingly are being evaluated for production components, with their promise of shorter development times, lower tooling costs, parts consolidation, more dramatic part shapes and sizes, among other benefits. During this free one-hour **SAE** Technical Webinar, scheduled for late September, experts will discuss these benefits as well as implementation challenges, detail current additive-manufacturing technologies and applications, and offer a vision for what the future could hold for 3D-printed parts in production vehicles. To register, visit www.sae.org/webcasts. Sponsor: **Stratasys**

and certify parts with a conventional mind-set. There are a lot of different groups; I know there are several different standards organizations and they all have efforts in additive manufacturing ongoing. Some of the government standards organizations also have some fairly large efforts going on in how to certify and qualify additive. It would be good to make sure as we go through and start trying to develop those standards that it's not only the aerospace community that's involved in standards development, but it's also automotive and other industrial sectors that are also involved with that development work.

How do you see the automotive industry embracing additive manufacturing?

There's a lot going on behind the scenes that a lot of people aren't necessarily talking about. Because it does have the potential to revolutionize people's business cases. Right now, most of the additive manufacturing are niche applications, especially in the automotive industry. We have a tendency for additive parts to focus on customization. An example of the potential for customization is something like Jay Rogers from **Local Motors**, and what he's trying to do is make a micro-factory where you may come in and design your car. At the same time, we see that going down into mass customization for the tool and die industry where you can start getting into very low-volume production as well, which is a little bit unique and a niche market. Eventually it may be adopted well beyond that also.

Is the aerospace industry much farther along in terms of adopting additive manufacturing?

The general trend that I've seen in the industry over the past decade is that aerospace seemed to be the main driver because it had huge payoffs associated with making components lighter and making components more efficient. What we're starting to see in the additive world is that the costs of components are dropping, the technology is becoming more reliable, you can get parts fabricated faster and that's allowing different industries to adopt additive technologies like the auto industry. There are some unique things that I know **Cummins** has done where they've been able to increase the efficiency of their engine through additive technologies. I don't know if it's being bulk adopted for 3D printing of car frames or bumpers; that's probably not where we're going to be any time soon, but on specific applications in turbochargers, water pumps and engine housings, those types of things may be a reality sooner than we think.

What are some of the materials being considered for additive?

Holistically, most of the materials that are being developed are materials that we currently use today in

mathematicians, are working on the project. "We have a core group that's looking at the next generation of large-scale 3D printers. A lot of work has gone on in terms of polymers and composites; now we're going toward large-scale metal," Love said.

There are three elements of the 3D-printed excavator, each created through different additive processes: a composite cab using Cincinnati's Big Area Additive Manufacturing (BAAM) system, a metal heat exchanger manufactured using the **Concept Laser** powder bed system, and a metal boom born of a large-scale metal printer that's still under development with **Wolf Robotics**.

"So in one demonstration, you really get a strong glimpse of where the technology's going," he said.

"We're going to try to print out a heat exchanger that will actually be functional and shows the limits of what you can do with additive in terms of increasing the [exchanger's] efficiency as well as making it lighter and smaller," said Love. The laser system enables very fine detail and high accuracy.

The biggest part and the most challenging, according to Love, will be the boom. The plan is to have the Wolf robotic system "growing" large metal parts at a fairly high rate within nine months. "I've been at Oak Ridge for about 20 years and this is by far, for me personally, the biggest challenge my team has tackled. It's a big leap, but I have full confidence in the team including all of the industrial partners," he said.

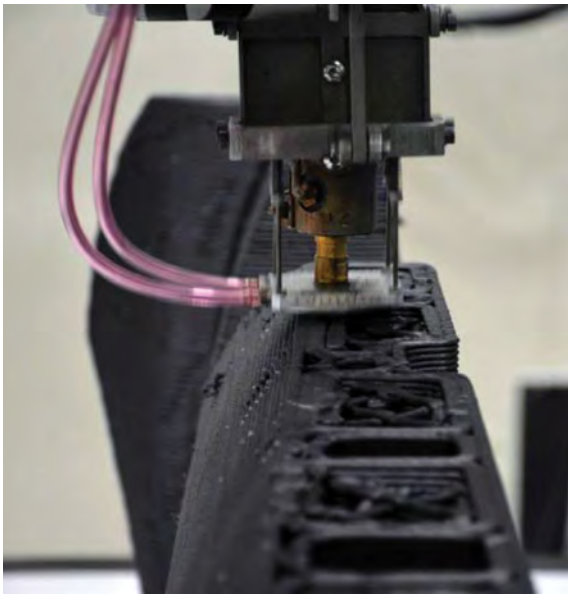
The printer will be smaller than the BAAM polymer system, which in terms of build volume is 8-ft wide, 6-ft tall and 20-ft long. The Wolf metal printer will be in the range of 4 x 4 x 10 ft, Love said.

ORNL is trying to overcome factors that have traditionally hindered the progress of metal printers—namely size, speed and cost of materials. "With metal printers, we're primarily making things that are about a cubic foot in volume at rates of about one cubic inch of material grown per hour," Love explained. "So to make something the size of a coffee cup will take you all day. And the materials are generally very expensive, hundreds of dollars a pound. That really is restrictive. So we're trying to use low-cost feedstock steel that's about a dollar per pound and trying to grow parts at relatively high rates—hundreds to thousands of cubic inches an hour. If you do that, then it starts to become compelling in terms of using additive for things like excavators."

Off-highway industries such as construction, with its relatively low volumes especially compared to passenger vehicles, is in the range where additive can be a powerful tool, if the technology progresses the way Love and others at ORNL envision.

"That's part of our focus at Oak Ridge," said Love, "how to enable these technologies to open up capabilities that are attractive for industries that, up until today, haven't been interested."

Ryan Gehm



BAAM system extruder.

Additive Manufacturing Symposium

Event: SAE 2017 Additive Manufacturing Symposium (AMS)
Duration: 2 days including ½ day tour
Location: Knoxville, TN
Dates: March 14-15, 2017

The SAE 2017 Additive Manufacturing Symposium presents:

- Projects and business cases in AM—solutions realized through the implementation of the technology
- Features and benefits and capabilities of 3D industrial-type printers
- Designing for 3D—how and why it is different and the implications
- Development and specifications in AM materials
- Status and activities in AM standards development
- How and why AM will affect your product development, testing, quality assurance and manufacturing

castings or machine forms. I think we're limiting ourselves a little bit when we do that. What we're starting to see a general trend in is the development of new materials specifically designed with the very harsh thermal environment during the processing condition. We get a lot of thermal transients during building. Those thermal transients can be very hard on conventional materials, but if we're developing materials specifically in mind of being processed with additive we can actually make better material than we can today with other processes. In the next 10 years you'll start to see customized materials specifically for additive manufacturing.

What are some of the challenges yet to be overcome?

One of the things that I see as a unique challenge in additive manufacturing is as these technologies show promise the additive manufacturing community is growing at a tremendous rate. If you look at some of the reports by Terry Wohlers [of consulting firm **Wohlers Associates**], there's a huge compound annual growth associated with additive manufacturing. In some cases, we can't actually build machines fast enough. There are a lot of companies out there that are machine vendors where if you order a machine today, you may have to wait a year until that machine arrives at your factory, there's that much demand on the industry. ■

Q&A

Higher levels of connectivity, automation drive commercial vehicle sector

Dr. Wilfried Achenbach, Senior Vice President, Engineering and Technology, Daimler Trucks North America.

Increased and enhanced connectivity is a megatrend impacting all ground vehicles, from passenger cars to commercial vehicles to off-highway equipment. So it's no surprise that connectivity is the theme for the **SAE** 2016 Commercial Vehicle Engineering Congress (http://www.sae.org/events/cve/), with several panels devoted to different aspects of the topic, such as how CVs will be affected by the Industrial Internet of Things. Helping to shape the event's program was Dr. Wilfried Achenbach, Senior Vice President, Engineering and Technology, **Daimler Trucks North America**, and other executives from DTNA, which is fulfilling the Executive Leadership role this year. Dr. Achenbach's responsibility covers the full development process including styling, design and testing for all Class 6-8 conventional trucks for the U.S., Canada, Mexico and other export countries. DTNA's Engineering and Technology department is part of Daimler Trucks' Global Engineering operation and is headquartered in Portland, OR. He recently shared his thoughts about a variety of pressing technical issues, to be discussed in greater detail at the ComVEC event from October 4-6 in Rosemont, IL.

What's new for this year's ComVEC?

As for ComVEC's value for the industry and mobility engineers, it is truly a special event where we come together to share our challenges and successes in the commercial vehicle industry. Daimler's executive leadership team is working with our industry colleagues to provide a relevant and valuable experience for participants visiting ComVEC in 2016. In collaboration with Tom Stover's ComVEC 2.0 committee we will pilot several activities that should benefit those attending this year's event. To point out some of this year's highlights to come:

We have a new symposia format including two interesting topics: "Autonomous Commercial Vehicles" and "Meeting the Challenges of Phase 2 Greenhouse Gas Emissions." The symposia will have a day dedicated towards keynote speeches and technical content focused on these two topics.

The leadership team has focused on bringing in a broader mixture of participants to ComVEC, emphasizing the importance of bringing together governmental agencies, academics and industry partners at ComVEC to discuss challenges for the future.

To benefit young professionals new to the commercial vehicle industry we have a team working on ideas which will help ComVEC participants to get in touch with younger generations. Ideas include bringing back mentoring sessions with a new format and exclusive networking events.

What are some of the mutual challenges facing both the on- and off-highway sectors?

Compared to the passenger car business, one major challenge is dealing with significantly lower volumes. In addition, the variability of applications for our equipment is crucial but also challenging for the industry/engineers. The customization drives the complexity in the product as well as the organization. We have to be smart managing and differentiating between value-add and unnecessary complexity to maintain a highly efficient organization and quality product.

Where do autonomous vehicles stand and what are the challenges to implementation?

Technology supporting autonomous driving has been and will further impact the commercial vehicle industry. When Daimler Trucks North America showcased the "Inspiration Truck" in May 2015 another milestone of AV [autonomous vehicle] technology integration was achieved contributing to discussions on creating a path towards partial autonomous driving. We did not expect that to take place for years to come. Over the last years the industry investments in autonomous driving technology has grown rapidly, leaving a wide range of opinions on how the future of autonomous driving will look like.

Despite DTNA's continued effort to develop technology for the next reasonable steps forward, it is important for us to be in sync with expectations and acceptance in our society and the legal framework supporting it. New standards are to be placed and the industry to be aligned and ready to support those very demands.

We are looking forward and will dedicate significant time [at ComVEC] to allow discussions for a broad mixture of industry experts, to learn about the current status, latest achievements, challenges and next steps.

What are the implications of Phase 2 GHG regulations? And what's Daimler's take on Phase 2?

DTNA has focused for decades on improving freight efficiency in order to lower customers' total operating costs. As the market leader in fuel efficiency, and the first to certify all of our products to Phase 1 GHG (greenhouse gas) standards, DTNA shares **EPA** and **NHTSA** goals to improve fuel economy and reduce greenhouse gases. We believe that the rule should reflect realistic vehicle production and operating conditions, and consider the cost-efficient, fuel-saving technologies in fleet

operations in order to successfully meet our shared goals.

The Phase 2 rule has not been finalized yet, so it's too early to know its implications, but I can tell you the proposed rule is very aggressive and will require the invention of new technology to meet the proposed standards. It takes time to do that, which is why DTNA has urged the EPA and NHTSA to not attempt to accelerate any of the stringency from the proposed rule.

One executive panel discussion centers on the Industrial Internet of Things? What does this entail? How does this intersect with commercial vehicles?

People are more familiar with the Internet of Things (IoT) where consumer products are increasingly becoming more connected with each other. Some examples include fitness applications working between watches and smart phones or a learning thermostat controlling a home air-conditioning unit. Applying this concept of connectivity towards industries has potential to provide similar benefits for convenience and efficiency.

As for the intersection with commercial vehicles, the optimization of asset utilization and maximizing vehicle uptime are some of the immediate benefits being realized today. The ComVEC panel discussion on IIoT will be an interesting one, especially for what the industry experts predict for the future.

The various SuperTruck vehicles will be on display at ComVEC. For the Freightliner SuperTruck, in particular, what are the next steps for Daimler?

DTNA is committed to developing the most fuel-efficient and cost-effective vehicles in the market. Systems developed within SuperTruck that demonstrate an attractive payback for the customer continue to be transferred to production vehicles. The Cascadia Evolution aerodynamics package and the Integrated **Detroit** Powertrain are examples for successful transfer of knowledge and systems from SuperTruck.

DTNA has submitted a proposal for the SuperTruck 2 program, with the goal of over 100% freight efficiency improvement while simultaneously removing cost barriers and making technologies more commercially viable.

How do you leverage the knowledge and technologies gained from this project?

The SuperTruck program enabled the aerodynamic team to further develop capabilities in terms of analytical methods for evaluating vehicle drag. The CFD tools and processes are being applied to development programs for production vehicles.

Technology integration within the Inspiration Truck creates a clear path toward partial autonomous driving.

DTNA has submitted a proposal for the SuperTruck 2 program, with the goal of over 100% freight efficiency improvement. Its first SuperTruck was revealed at the 2015 Mid-America Trucking Show. (Photo by Ryan Gehm)

SuperTruck also highlighted limits of certain technologies such as waste heat recovery. This technology is still in the early prototype stages and presents fundamental design questions around reliability, weight and system costs.

A parallel hybrid-electric powertrain was incorporated in SuperTruck, which manages kinetic energy while driving across hilly terrain. The system recharges the Li-ion batteries as the vehicle descends a grade. Another system onboard, called "Predictive Technologies," is designed to do essentially the same thing. In this case, GPS and 3D-digital maps are combined with clever software to anticipate upcoming terrain. The system adjusts the cruise speed, shifting and eCoast to optimize kinetic energy to save fuel.

(Read more on Daimler's SuperTruck program and its lessons learned in this previous Q&A with Principal Investigator, Derek Rotz: http://articles.sae.org/14446/.)

What are some of the most promising technologies stemming from SuperTruck?

Powertrain enhancements investigated in SuperTruck have shown commercial feasibility including downspeeding of the engine using direct drive AMT [automated manual transmission] and a 2.28:1 rear axle ratio as well as eCoast. Furthermore, DTNA continues to develop predictive powertrain controls by using GPS and 3D digital maps to more intelligently control the vehicle across hilly terrain.

Cybersecurity is a huge topic right now. What's Daimler doing in this area to be ready?

It is certainly a topic of increasing importance and something we take very serious. Cybersecurity and preventive countermeasures are part of our discussion around the Electrical/Electronics – Architecture for our vehicles. The whole topic will change the industry approach for open architectures, for sure.

We decided for our vehicles to implement a Hardware Firewall between the core EE-systems on a truck and the rapidly developing Telematics systems. We benefit from being part of a larger overall organization having access to standards developed for our passenger cars to ensure the highest security standards and experience.

Ryan Gehm

Western Star debuts Extreme Duty Offroad package, new 'transformer' chassis

The 6900XD Offroad MBT-40, dubbed the Multi-Body Transformer for its ability to quickly change from one fully functional in-cab-controlled body application to another, is the first XD Offroad series offering from Western Star and reportedly a new concept for off-road equipment markets.

The MBT-40 features multiple hydraulic air and electrical connections that allow it to connect and power a variety of body needs from flow-controlled hydraulic motors and pumps to heavy high-flow tip cylinders.

Western Star is known for its tough vocational trucks and now offers an off-road product that competes with the articulated and rigid frame markets. The truck maker recently announced its new Extreme Duty (XD) Offroad package and the launch of the MBT-40 Transformer chassis.

Available on both the 4900 and 6900 models, the Western Star XD Offroad package is engineered specifically for extremely rugged environments. The 6900XD Offroad MBT-40, dubbed the Multi-Body Transformer for its ability to quickly change from one fully functional in-cab-controlled body application to another, is the first XD Offroad series offering from Western Star and reportedly a new concept for off-road equipment markets.

Vehicles spec'd with the XD Offroad package provide customers with a low cost per ton product for offroad applications, the company claims. Western Star plans to expand the XD Offroad package to other models in the future.

"The MBT-40 package is a game changer in construction applications for its ability to be multiple pieces of equipment in one chassis," said John Tomlinson, XD and vocational sales manager, Western Star. "The development of this platform was all about finding better economic ways of filling needs for our customers. Off-road chassis equipment can be expensive to buy and maintain and new emissions levels are making the investment even more costly."

Using a **Palfinger** G68 hooklift, which has a lifting capacity of 68,000 lb (30,850 kg) and a new transformer package, the MBT-40 gives customers greater utilization of their chassis. It can take the place of multiple pieces of dedicated off-road equipment on a job site that sit for long periods of time when they're not needed. It is applicable for extremely complex and heavy capacity bodies.

The unit is equipped with a generic in-cab control system and a self-adapting hydraulic system that also allows the operators to quickly and easily swap the controls of multiple body applications. The MBT-40 features multiple hydraulic air and electrical connections that allow it to connect and power a variety of body needs from flow-controlled hydraulic motors and pumps to heavy high-flow tip cylinders.

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Carco Industries worked with Western Star to test the open platform concept on its equipment.

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Using a Palfinger G68 hooklift, which has a lifting capacity of 68,000 lb (30,850 kg) and a new transformer package, the MBT-40 gives customers greater utilization of their chassis.

Bodies can be swapped two or three times a day to maximize output efficiency.

"By maximizing the operation time, customers can have the equipment they need always for when it is required," Tomlinson added. Mining, quarry and off-road construction industries can benefit from this new product, he said.

Carco Industries worked with Western Star to test the open platform concept on its equipment, and the truck maker is working to expand the MBT's capabilities. The unit can be adapted to suit other body companies.

"Carco Industries is very experienced in mining and off-road fuel and service products along with carrying the Palfinger crane lines," said Charlie Schimmels, sales manager, Carco Industries. "This combination of experience and product along with the rugged design and carrying capacity of the XD40 Offroad chassis offered by Western Star makes the MBT-40 package a very unique product. With commodity prices down and budget cuts becoming common place, we need to think smarter about how we do business and the MBT-40 does that."

The 6900XD is available in both 6x4 and 6x6 configurations.

Ryan Gehm

PRODUCT BRIEFS

SPOTLIGHT: HYDRAULICS

CAN-enabled electrohydraulic mobile valve

Eaton's CMA Advanced Mobile Valve with Independent Metering offers manufacturers numerous possibilities to differentiate machine capabilities. The CAN-enabled electrohydraulic mobile valve features on-board electronics and sophisticated software algorithms. As part of Eaton's advanced class of Dynamic Machine Control solutions, the CMA valve empowers OEMs to impact and improve every phase of the machine life cycle. Through intelligent features, the valve provides a new level of efficiency, productivity and predictive maintenance solutions, such as: improved controllability, new capabilities, faster commissioning, real-time diagnostics, hose burst detection, and minimized downtime. The uniquely designed CMA valve, available with rated flow of 90 or 200 L/min, improves machine performance without the need to compromise. Independent metering on the valve allows each spool to control its own work port for consistent speed and better control on services, which transition between passive and over-running states. For more information, visit **www.eaton.com**.

Compact pressure sensors

For forklift trucks, telehandlers, and other logistical vehicles, the trend is moving toward more power in a smaller installation space, and **Rexroth** supports this development with its PR4 series 10 pressure sensors. In implement hydraulics and travel drives they cover measuring ranges of up to 600 bar (8700 psi) with a length of 55 mm (2.16 in). The new generation of robust and precise pressure sensors can be used universally in open and closed hydraulic circuits and deliver decisive information for energy-efficient power control. Approved for an ambient temperature range of -40 to 100°C (-40 to 212°F), the sensors can withstand pressure peaks of more than 130% of the nominal pressure; in the version for the highest pressure stage they can momentarily withstand up to 800 bar (11,600 psi). According to Rexroth, the sensors can be easily installed using a socket wrench with a tightening torque of up to 45 N·m (33 lb·ft). For more information, visit **www.boschrexroth.com**.

All-round view camera system

The 360° Local Situational Awareness System (LSAS) from **KTK Kommunikationstechnik** and **First Sensor** consists of four digital HDR-CMOS cameras in specially adapted rugged housings and a software-based video processing unit. The system approach enables easy integration into a wide range of military or civil vehicles. The robust, high-performance cameras from First Sensor feature a very wide dynamic range >100 dB for difficult lighting conditions and withstand the harshest environmental conditions such as cold, heat and permanent vibrations. Easily integrated in various operating and image processing systems, the platform-independent, flexible area view software can be adapted to customer requirements. The LSAS also can be customized to a wide range of applications such as military and commercial vehicles, special vehicles, as well as agricultural, construction and mining machines. Pictured is the camera itself that is used in the LSAS. For more information, visit **www.first-sensor.com**.

Atmosphere control system for annealing

Linde LLC's Hydroflex atmosphere control system (ACS) is a solution for clean and bright oxide-free annealing of steel, stainless steel, copper, bronze or brass with high reliability and repeatability and is suitable for applications including automotive, aerospace and military components, construction and industrial equipment and electrical systems. According to the company, the system can use one or more carrier gases—nitrogen (N2) or argon—to maintain the furnace pressure while a controlled ratio of hydrogen (H2) helps prevent oxidation. With this technology, many annealing tasks can be completed with non-flammable gas mixtures containing less than 5% H2, which contributes to fire safety while optimizing the use of H2 in the process. Features and benefits of Hydroflex ACS include precisely controlled atmosphere, improved heat transfer, uniform heat distribution, faster cooling rate, automatic safety purging with N2 and storage of process data history. For more information, visit **www.lindeus.com**.

PXI radio frequency multiplexers

Pickering Interfaces expands its range of PXI 50Ω 600MHz radio frequency (RF) multiplexers with 18 different configurations including a PXI two slot 32:1 configuration. This new range of PXI RF multiplexers (series 40-760) is available in the following configurations: dual, quad and octal SP4T; single, dual and quad SP8T; single and dual SP16T; and single SP32T. All of the multiplexers have versions with automatic terminations to manage voltage standing wave ratio effects (VSWR), which could degrade the performance of a test system. Additionally, all versions of this range of PXI RF multiplexers exhibit low insertion loss and VSWR through the use of modern RF relay technology. For more information, visit **www.pickeringtest.com**.

Probing software package

Renishaw offers an enhanced probing software package that automatically optimizes on-machine measurement cycles to minimize cycle time and maximize productivity. Inspection Plus with SupaTouch optimization uses intelligent in-cycle decision making to implement either a one- or two-touch probing strategy for each measurement routine and eliminates the need for manual optimization of on-machine positioning feedrates, measurement feedrates and strategies. It offers cycle time reduction of up to 60% on CNC machine tools compared with traditional software cycles, claims the company. The software detects any measurements taken during machine acceleration or deceleration phases and compensates for errors by taking corrective action and remeasuring. For more information, visit **www.renishaw.com/mtp**.

Automatic inflation system

Michelin Auto Inflate is a wheel-mounted tire management solution that allows fleets to automatically maintain optimal tire pressure. The system, powered by Halo in association with **Aperia Technologies**, can save fleets an estimated $2400 per tractor-tire annually by reducing tire-related downtime events, extending tire life, improving fuel economy and increasing safety. The device can be retrofit on existing vehicles or incorporated as an add-on to new equipment. It works with both duals and wide-base single tires. The self-powered pump can be mounted to the hub in 10 min using standard tools. With each wheel rotation, the device monitors and adjusts for low air pressure. For more information, visit **www.michelintruck.com/autoinflate**.

Custom, high-performance mufflers

Modular Exhaust, a division of **GLSV**, features custom sizing for three different shapes of mufflers—circular, elongated and rectangular—as well as custom-shaped non-modular mufflers, which are available upon request. The company offers customized design for both a desired flow and a desired noise level performance. Designing to a specific noise specification and backpressure is made possible through advanced exhaust modeling tools. Modular Exhaust works with a wide range of materials including carbon steel, stainless steel, titanium, and Inconel and also offers a range of heat treatments including reflective ceramic coating and integral wrap. Benefits and features include maximum engine performance and high efficiency, corrosion resistance and thermal protection, and streamlined design and manufacturing process. For more information, visit **www.modularexhaust.com/introducing-modular-exhaust/**.

Absolute encoder series

Baumer's absolute HeavyDuty encoder series HMG 10 and PMG 10 offer a resilient housing, optimally spaced fixed/floating bearings on both sides, and generously sized hybrid ball bearings. These features provide unrivalled long service life and reliability, according to Baumer. The robust magnetic precision sensing supplies a signal quality that is nearly identical to that of optical sensing principles, but withstanding dust, dirt and condensation. Even at high temperatures up to +100°C (212°F) and in adverse environments, the shock- and vibration-resistant sensing technology ensures high-precision signals for maximum processing accuracy and control quality in the application. The HeavyDuty encoders are particularly suitable for steel and rolling mills, cranes and lifting systems, and material handling and conveyer systems. For more information, visit **www.baumer.com/HMG10**.

NEW

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UPCOMING FROM THE EDITORS

August 2: Aerospace Engineering Technology eNewsletter

August 9: Off-Highway Engineering Technology eNewsletter

August 16: Automotive Engineering Technology eNewsletter

August 29: Automotive Engineering Technology eNewsletter

September: Automotive Engineering Print Magazine
- CAFE credits and the mid-term review
- Automated vehicles
- Hybrid & electric drives
- Intelligent manufacturing
- Electrical Components product spotlight

September 6: Aerospace Engineering Technology eNewsletter

September 13: Off-Highway Engineering Technology eNewsletter

September 15: Automotive Engineering Technology eNewsletter

September 22: Vehicle Engineering Technology eNewsletter (all markets)

September 27: Heavy-Duty Engineering Technology eNewsletter

October: Automotive Engineering Print Magazine
- New 2017 vehicle technology
- Super/Turbo charging boosting
- Interiors: Comfort and convenience
- NVH product spotlight

October: Off-Highway Engineering Print Magazine
- SAE Commercial Vehicle Engineering Congress (ComVEC) special coverage
- Electrification of driveline and subsystems
- Lightweighting heavy machines and trucks
- Operator comfort
- Test Equipment product spotlight

October 4: Aerospace Engineering Technology eNewsletter

October 12: Off-Highway Engineering Technology eNewsletter

October 18: Automotive Engineering Technology eNewsletter

October 25: Vehicle Engineering Technology eNewsletter (all markets)

October 31: Automotive Engineering Technology eNewsletter

November: Automotive Engineering Print Magazine
- The latest on fuel cells
- Aerodynamics and design
- Composites
- Vehicle testing
- Product Lifecycle Management product spotlight

November 1: Aerospace Engineering Technology eNewsletter

November 3: Electronics & Connectivity Technology eNewsletter

November 10: Off-Highway Engineering Technology eNewsletter

November 15: Automotive Engineering Technology eNewsletter

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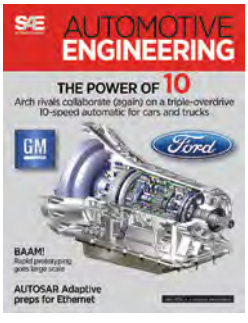

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COMPANIES MENTIONED

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WHAT'S ONLINE

VIDEO

SAE Eye on Engineering: TARDEC tests DSRC on I-69

In late June the **U.S. Army** and the state of Michigan began testing new technologies that will someday enable driverless operation of Army vehicles. In this episode of SAE Eye on Engineering, Editor-in-Chief Lindsay Brooke looks at **TARDEC**'s first public-roads testing of Dedicated Short Range Communications (DSRC). The video can be viewed at **video.sae.org/12189/**. SAE Eye on Engineering also airs Monday mornings on WJR 760 AM Detroit's Paul W. Smith Show. Access archived episodes at www.sae.org/magazines/podcasts.

FROM OTHER INDUSTRIES

Altair names 2016's lightweight standouts

For 2016, the fourth year of its annual Enlighten Awards that acknowledge innovation in vehicle weight reduction, **Altair** named **GM**'s 2016 **Cadillac** CT6 as the winner in the Full-Vehicle category and **ContiTech**'s polyamide rear-axle transmission crossbeam as the winner in the Module category.

Full-Vehicle category winner.

The Cadillac CT6 prevailed among seven Full-Vehicle finalists because of its outstanding strategic approach to weight reduction, Altair said. The all-new CT6 already is acclaimed for its svelte on-road dynamics and vault-quiet interior, achieved in part by the simulation-optimized multi-material construction of its variant of the global Omega II vehicle architecture that engineers said is 90 kg (198 lb) lighter than a predominantly steel counterpart (articles.sae.org/14020/).

The Omega structure is aluminum-intensive, but for the CT6 utilizes 13 different materials customized for each area of the car.

For Altair's Enlighten Awards-winner in the Module category, beating out 13 other finalists, ContiTech's polyamide rear-axle transmission crossbeam delivers on the long-discussed mass-reduction potential of composite materials for production-vehicle chassis components. The winning submission was for the crossbeam used in the 2016 **Mercedes-Benz** S-Class, but ContiTech said the fiberglass-reinforced polyamide (BASF Ultramid) component is used for many Mercedes models fitted with all-wheel drive.

ContiTech's polyamide crossbeam is roughly 25% lighter compared with its aluminum diecast counterpart.

Dave Mason, Altair's Regional Managing Director, Automotive, provided context for this year's Enlighten Awards program: "If you review all the vehicle designs in 2016, there are already great examples of almost every material/manufacturing option on the road today. This is the good news in terms of meeting the new CAFE standards."

ContiTech's polyamide rear-axle transmission crossbeam won the Module category.

Read the full article at **articles.sae.org/14924/**.

WHAT'S NEW

Modeling, simulation expand their role in powertrain development

Modeling and simulation continue to help suppliers and OEMs provide systems and vehicles that do more work while conserving fuel, reducing emissions and keeping costs in check. A broad range of tools come into play as engines and aftertreatment systems move through the design cycle.

Tighter regulations are forcing equipment makers to turn to smaller engines and system architectures that maximize efficiency by ensuring that all systems work together at optimal levels. New engines can increase lifetimes while lowering operating costs. In the past, these power plants ran at lighter loads to improve durability. Today's engines match or exceed the output of their predecessors in smaller form factors.

Deere uses a range of design tools to analyze gas volumes in engines.

"The latest modeling techniques enable us to predict with accuracy the hot spots in an engine design that might lead to failure, and then take corrective action," said Oliver Lythgoe, Product Concept Marketing Manager at **Perkins**. "This enables us to get more power and torque from smaller engines—and smaller engines help OEMs deliver machines that are lighter, have better turning circles and better operator sight lines."

OEMs and suppliers now work more closely together than in the past. Engine simulations are often shared with OEMs, who have broader insight into tight engine compartments that can make cooling difficult. CFD is a common tool for understanding cooling and noise movement.

Read the full article at **articles.sae.org/14920/**.

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