

Edited by **Darlene Fritz**

Supercharged Alpina roars with 500 hp

The **Alpina B7** is much more than a supercharged **BMW 750i** variant. However, its 500-hp (373-kW) edition of the 4.4-L V8 certainly is the centerpiece of a total performance vehicle, which is just Alpina's second entry in the U.S. market. The engine, rated at 500 hp (373 kW) at 5500 rpm and 518 lb-ft (702 N-m), compares with BMW's current naturally aspirated 4.8-L V8, rated at 360 hp (268 kW) at 6200 rpm and 360 lb-ft (488 N-m).

Supercharging offered the obvious advantage of fast response, but installing a conventional supercharger in the same

engine compartment as the naturally aspirated V8 was physically impractical. And conventional superchargers suffer high parasitic losses, which were deemed unacceptable.

A compact radial-type supercharger—similar in concept to a 1980s design patented by transmission manufacturer **ZF**—was developed by Alpina and **ASA**, a company founded by former ZF engineers. The radial supercharger bears some resemblance to the cold-air side (inlet) of a turbocharger but is belt-driven, as is normal with a supercharger. However, its design and operating features greatly reduce power draw.

The belt is driven through a centrifugal clutch, which produces a gradual lockup, typically between 1100 and 1300 rpm. The drive ratio is 17.6:1, a combination of the ratio between the pulleys with a 15:1 fixed-ratio planetary gearset that is contained within the engine oil circuit for lubrication. Supercharger speed increases proportionally at this ratio to a peak of 6000 engine rpm, 105,600 supercharger driveshaft rpm.

The airflow circuit has a pressure regulator before the supercharger to maintain the inlet airflow at atmospheric pressure, which results in the turbine wheel spinning at an rpm that is very close to that of the supercharger input shaft. A throttle plate after the supercharger maintains slightly subatmospheric pressure in the intake manifold. This combination keeps the supercharger ready to pump when asked, but until then the engine is controlled by the BMW Valvetronic system with Double Vanos (variable intake valve lift with variable intake and exhaust timing).

During Valvetronic operation, the supercharger is almost freewheeling, with no boost, no meaningful pumping losses, and good fuel economy. When intake valve lift is at maximum, Valvetronic action is finished. Then the pressure regulator operates as a throttle, responding to the accelerator and allowing the super-



Alpina's radial supercharger, which is belt-driven through a centrifugal clutch for gradual engagement, also features a 15:1 fixed-ratio planetary gearset.



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charger boost to build to a peak of 0.8 bar (11.6 psi) at 6000 rpm. Alpina holds patents on the combination of Valvetronic and radial supercharging.

Fuel pressure also is regulated according to the amount of boost.

The intercooler is large: 26 x 16 in (660 x 406 mm), and rated as 70% ef-

ficient at 220 km/h (137 mph). The B7 is speed-regulated to 186 mph (300 km/h).

Alpina Burkhard Bovensiepen is recognized as an independent car company, although its cars are based on BMW models. Many parts are made by BMW suppliers to Alpina specifications and there are many Alpina-specific compo-

nents. The only Alpina model previously sold in the U.S. was the Alpina roadster V8, which was based on the Z8, and imported in 2002.

Paul Weissler

Global engineers in high demand

One automotive supplier is on a worldwide recruitment binge for technical specialists.

"We're growing, in general, about 10% a year with our engineering work force," said William Kozyra, President and CEO of **Continental Automotive Systems** and Member of the Executive Board of Continental AG in Germany. During an *AEI* interview at the 2007 Chicago Auto Show, Kozyra said that Continental plans to hire 600 engineers this year in Japan, the U.S., Germany, Romania, India, Shanghai, and elsewhere. "We have a specific strategy to have a global balance with our engineering work force. It's not much different from our manufacturing footprint," he said.

In June 2007, Continental goes online with a technical center in Yokohama, Japan. Approximately 250 engineers already in the Tokyo area will relocate to the new center, and an additional 250 engineers will be hired. Fifty engineers will be hired in the Chicago area to join the existing staff at the Deer Park, IL, center, the former **Motorola** automotive electronics unit that Continental acquired in 2006. Germany, China, India, Romania, and Auburn Hills, MI, will account for the balance of the engineering hires.

"I have engineers all the time say to me, 'Hey, am I one day going to be out of a job in this country?' And my answer to them is, 'No.' But just know that as we add 10% per year to the engineering work force, don't assume it's all going to be in mature regions," Kozyra said.

Global-thinking engineers are in demand, which is why Continental AG facilitated the organization of a Global Engineering Initiative two years ago with eight international universities. Their findings and recommendations about engineering education could be the catalyst for establishing a Master of Global Engineering degree. "In the future, this



Continental is active in many emerging markets. In addition to a door, airbag, and central-control-unit production plant (shown) in Sibiu, Romania, the complex also includes an engineering center.

could be an elite title for top engineers with an excellent—and above all, internationally oriented—education," said Continental Human Resources Director Thomas Sattelberger.

The global engineer concept gets a boost in the fall of 2007 when Continental Automotive Systems launches a global automotive leaders program with the **University of Detroit Mercy** (UDM). Engineering students selected for the program will receive a two-term UDM study scholarship, followed by four months of paid cooperative education placement. Ideal candidates will be bilingual in English and either Mandarin Chinese, Japanese, Spanish, or Romanian. "Selection will be based on grade-point average, GRE (Graduate Record Examinations) and TOEFL (Test of English as a Foreign Language) scores, and extra-curricular/leadership activities," said Roxann Alonzo, Director of International Programs at UDM's College of Engineering and Science.

After completing the final term of graduation work, there will be one to two



Continental Automotive Systems President and CEO William Kozyra is an engineering alumnus of Michigan's UDM. The college is partnering with the supplier for an international engineering development program.

years of paid practical training in Michigan. The final step is a Continental work assignment in a developing market. "We're drawing students from [emerging-market] regions that pre-commit their okay of going back to their home country and functioning as an engineer after having been educated in a mature region and trained on the job in a mature region," said Kozyra, adding that the program "doesn't pose a threat to our engineers in mature regions because at the end of the day, it's part of creating a very sustainable company for the long haul that every engineer in every location should want."

Kami Buchholz

Transmission calibration challenges

The gap in fuel economy and performance between cars with manual transmissions and their automatic counterparts has driven the widespread introduction of a new generation of automatics with six, seven, and even eight forward gears.

These additional gears close the efficiency gap on manual transmissions and provide the opportunity for even more seamless gear changes as the result of smaller differences from one gear ratio to the next.

While these reduced splits between gears would seem to make transmission calibration simpler the increased number of available ratios for any given situation actually makes the task of choosing the right one more complex than ever.

"As the number of gears increases, there can be multiple operating regions in which three or more different gear ratios could be used to deliver the power required to move the vehicle at a given speed," observes Paul M. Williamsen, Product Education Manager for **Toyota Motor Sales USA**. "The challenge is in picking the one choice among several possible gears that best meets the driver's expectations for quiet, smooth, and pow-

erful operation." For Toyota's 8-speed AA80E transmission in the **Lexus LS460**, this was an even bigger task that necessitated double the amount of track-tuning lavished on any previous Lexus product, he added.

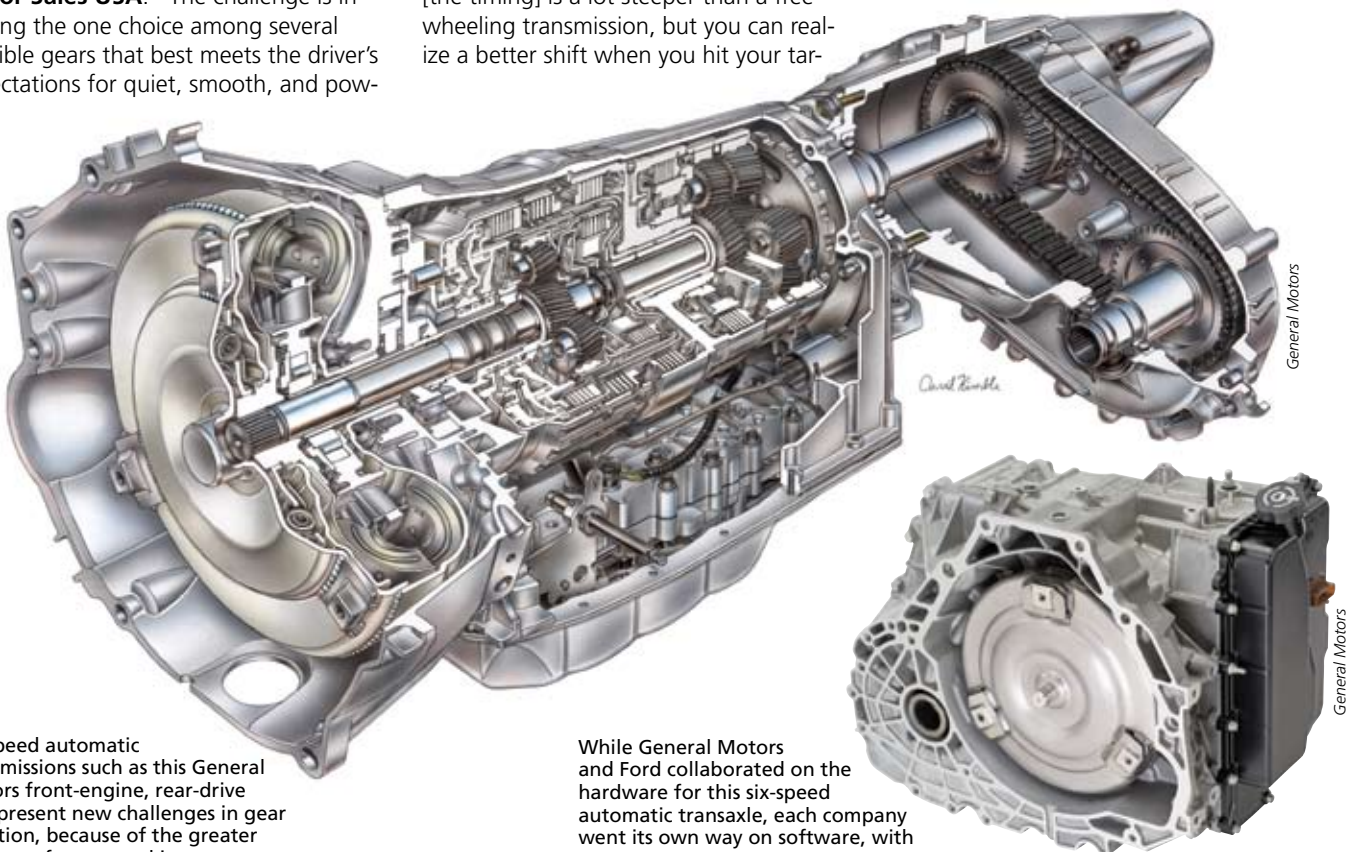
Another complication is the move from freewheeling transmissions to ones that shift from clutch-to-clutch, reports John Marano, Engineering Group Manager for Transmission Control Algorithms at **General Motors**. "It was a much greater challenge from a controls and calibration perspective than anything we have seen before in the freewheel world," he said. The switch in design was prompted by the desire to squeeze a six-speed into the space of a four-speed transmission, he said. "Clutch-to-clutch was a real enabler."

But that enabler came at the price of a tougher calibration headache. "It requires a very precise handoff from the outgoing clutch to the incoming clutch," said Marano. "The loss function of missing [the timing] is a lot steeper than a freewheeling transmission, but you can realize a better shift when you hit your tar-

gets." To do this, engineers examine peak-to-peak acceleration, jerk, rate of change of acceleration, and the shift times to provide the required gear ratio without exceeding the energy capability of the clutch friction material, he explained.

These challenges are sufficiently difficult that GM immediately recognized that it had missed its goals for the calibration of its version of the new front-wheel-drive six-speed automatic transmission developed in partnership with **Ford**. Upon introduction, the new transmission exhibited busyness and indecision when considering aborting planned shifts, as when a driver eases off the throttle just as the transmission is preparing to downshift two gears.

The company quickly improved its calibration and rushed the update into production only months after the launch of the new **Saturn Aura** and other models using the transmission, he said. The improvement comes in what GM calls

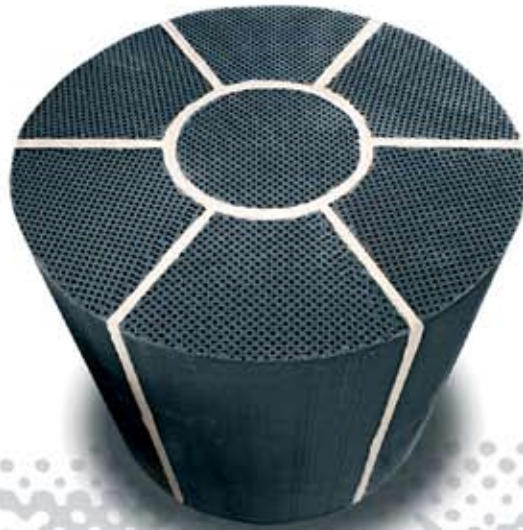


Six-speed automatic transmissions such as this General Motors front-engine, rear-drive unit present new challenges in gear selection, because of the greater number of gears, and in shift execution.

While General Motors and Ford collaborated on the hardware for this six-speed automatic transaxle, each company went its own way on software, with GM optimizing the response to change-your-mind shifts.

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Lexus reduced the mass of the clutch hub 50% in its 8-speed automatic transmission by making it from aluminum.

"change-your-mind" shifts, but which might be better termed "controller-guessed-wrong" shifts.

"Sometimes the driver doesn't get the feedback until the torque reaches the wheels," said Marano. Upon feeling a

surge in power to the road, the driver lifts off the gas because the transmission shifted down too many gears. "We opened up some of the abort windows on our shifts, so it is easier to process a change-of-mind and go to a different target gear," he explained.

Lexus has addressed this issue through close integration of the engine and transmission controllers, said Williamsen. Rather than separate controllers connected over a range of communication channels, the Lexus control module builds both controllers onto a single circuit board, letting them communicate and share more parameters.

"One example of the effect of this high level of integration is that the transmission decisions now can be based not only on instantaneous accelerator pedal angle, but also on the more advanced measure of rate of change of accelerator pedal motion," said Williamsen. "This means that shift decisions are based not just on current speed, but on predictive values of the future speed the driver is going to want."

Mercedes-Benz similarly found that integration of the gearbox and engine controllers was critical, said spokeswoman Nicole Patzer. "Modern gearboxes such as 7G-TRONIC place significantly higher demands on the gearbox applications, and in particular the coordination of the motor-gearbox-interface," she said, citing an official statement from the company's engineering department. "The close cooperation between the engine and gearbox applications plays a decisive role in the final result."

As with Lexus's use of rate of change data from the accelerator pedal, Mercedes also discovered a critical factor that could be exploited when the engine and transmission controllers were closely integrated, but the company would not say specifically what that factor was.

"In the development of the 7G-TRONIC we found that one particular adjustment could improve the drive and shift quality and thus integrated it," Patzer said.

Dan Carney

Battery safety switch

Although the **Delphi Connection Systems** stand at a recent show was visibly dedicated to vehicle electrical/electronic architectures—demonstrated in "EVE," a transparent 100% x-by-wire concept car that displayed some 50 core technologies—not every innovation shown at the stand was pure electronics. One of the highlights was Delphi's new-generation battery isolator switch, which is based on a pyrotechnic principle—a rare exception to today's tendency for vehicle innovations that directly translate into electronics.

The battery isolator switch serves to disconnect the main power cable between the battery and

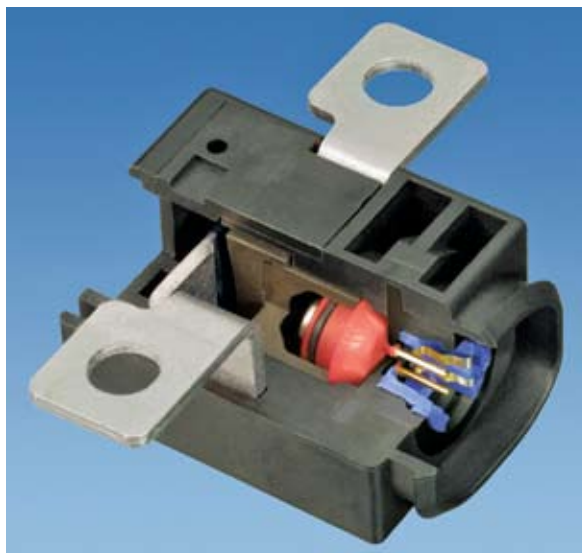
starter/generator during a crash. Long electrical wires are considered particularly vulnerable to deformations that could cause a short circuit between a live wire and ground. This type of emergency shut-down helps to prevent the potential direct ignition of combustible liquids that could be caused by the sparking, arcing, or smoldering fires associated with such

short circuits.

In May 2004, **Audi** became the first vehicle manufacturer to begin using the original Delphi pyrotechnical device to protect the long main power wire of a car with the battery in the back. According to Delphi, the OEM was not all happy with the previous relay-based solution. In addition to higher costs, relay technology is also associated with such problems as electrical resistance and potential contact corrosion or adhesion after a long service life. In addition, relay switching times cannot match the speed of pyrotechnical actuation, added Delphi.

When Audi approached the supplier, Delphi had just acquired the automotive business of **Dynamit Nobel**, which specialized in airbag actuators. This expertise was employed to help develop the pyrotechnical safety system (PSS), in which a pyrotechnical airbag actuator causes a plastic piston to open a specially designed copper power rail, resulting in a complete galvanic uncoupling.

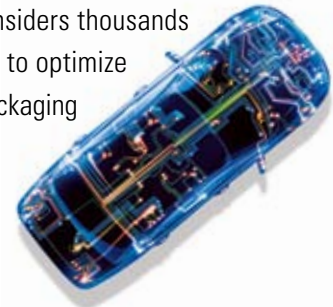
While this functional principle does not offer a simple reset option, it is fast: the piston cuts through the power in less than one microsecond said Delphi, which



In Delphi's completely encapsulated battery-disconnect switch, a pyrotechnical airbag actuator causes a plastic piston to cut through the power rail.

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compares to a relay switching speed of several microseconds. With the PSS cost advantage of about 25% compared to relay technology, not to mention expensive MOSFET technology that does not cause uncoupling, it is understandable why **DaimlerChrysler** is using the PSS in the engine compartment of the C-Class.

Control of the PSS function is provided by the airbag ECU and is basically triggered parallel to the airbag inflation. Breaking capacity of the PSS was confirmed up to 2500 A at 12 V dc, and the

continuous current-carrying capacity is 300 A at 85°C. The compact system is packaged in a fiber-reinforced housing that can be mounted close to the battery terminal or within a pre-fuse box. If integrated in a pre-fuse box, the PSS will only disconnect the major consumer while small consumers will remain on the vehicle electrical net.

While the PSS was originally developed for cars with long battery wires, it is now used in other configurations as well. According to Delphi, about 80% of

Audi vehicles are equipped with the PSS, and there is room for further growth.

Despite the importance of an emergency power cut-off device, the supplier claims that many vehicles of many makes are not equipped with a system to protect the largest electrical wire in the car. In hybrid vehicles or fuel-cell cars, the PSS could also be used as an additional safety element.

Jörg Christoffel

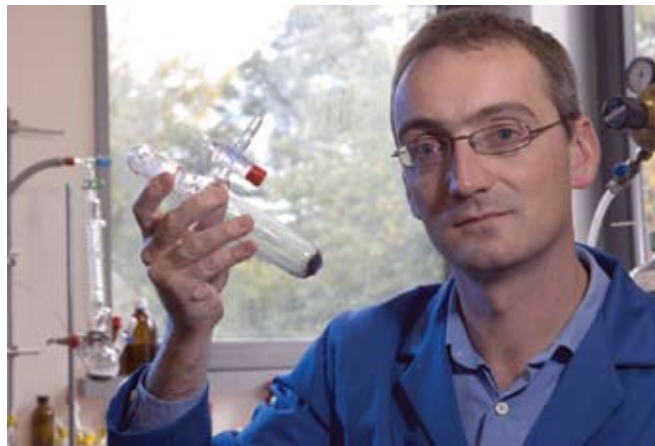
Hydrogen storage: the road to rhodium

Designing and manufacturing efficient, safe hydrogen storage systems is an essential part of the fuel application for mass automotive use. Now, scientists at the **University of Bath** in the UK have invented a system incorporating rhodium, which is claimed to readily store and release hydrogen at room temperature.

"The problem of how to store hydrogen has been a major bottleneck in its development for power technology," said Andrew Weller of the University's Department of Chemistry.

Hydrogen has a low density and only condenses into a liquid form at very high pressures and a low temperature of -252°C (-422°F). These extreme conditions make it difficult to use such conventional storage systems as high-pressure gas containers, which would need steel walls at least 3 in (76.2 mm) thick, making them too heavy and too large for cars, explained Weller. Further complicating the situation is the **U.S. Department of Energy's** position that it wants 6% of the total hydrogen storage system's weight to be hydrogen in order to give new hydrogen-powered cars the same kind of mileage per tank of fuel as gasoline-based systems.

Although metal hydrides and metal organic framework materials could achieve that order of ratio, Weller said, they would only work at temperature extremes that would be difficult to engineer into a regular vehicle, particularly the -198°C (-324°F) temperature necessary to maintain the required liquid nitrogen. Explained Weller: "Our new material works at room temperature and at atmospheric pressure at the flick of a switch. It is made from rhodium, a metallic element



"The problem of how to store hydrogen has been a major bottleneck in its development for power technology," said Andrew Weller, University of Bath.

used in catalytic converters, which is a heavy metal. The downside is that its weight-to-fuel ratio is currently very low—0.1%—but if this capacity could be increased to nearer 1%, it could certainly fill the time lag between a driver putting his or her foot on the accelerator and a metal hydride tank getting up to temperature."

The discovery was made during research work into the effect that hydrogen has on metals. Having constructed an organo-metallic compound containing six rhodium atoms and 12 hydrogen atoms, researchers studied its chemical properties, with teams in the UK and Canada focused on theoretical work and mass spectrometry. Researchers found that the material would absorb two molecules of hydrogen at room temperature and standard atmospheric pressure, and would release them when a small electric current was applied. From that it was deduced that at the atomic scale, the material would be suitable for hydrogen storage.


Now, research work is under way to

develop a process to print the material onto sheets that could be stacked together and encased to form a storage tank that could be positioned alongside a metal-hydride tank. As the car accelerator is pushed, the rhodium-based system would be activated initially, providing time for the main metal-hydride store to reach the 200°C necessary to recharge the material.

"The new material absorbs the hydrogen into its structure and literally bristles with molecules of gas," said Weller. "At the flick of a switch it rejects the hydrogen, allowing us to turn the supply of the gas on and off as we wish. The fact that we discovered the material by chance is a fantastic advertisement for the benefits of curiosity-driven research."

He added that other work at the University of Bath involving solar cell research and new battery and fuel-cell technologies could also help unlock the "hydrogen economy."

Stuart Birch



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Contests continue to attract students, corporate sponsors

The many auto-related contests for college students pose many levels of challenges, from the small tactical and technical issues up to the high-level strategic decisions. Teams must decide whether they're going to stretch the limits or take a more conservative tack.

When **Virginia Tech** entered the multi-year Challenge X contest sponsored by **General Motors** and the **U.S. Department of Energy**, it began with aggressive fuel-cell and hydrogen projects. But for the 2006 portion of the sustainability contest, Virginia Tech changed its approach. Using electric motors and ethanol instead of fuel cells earned the students a first-place prize, awarded for lowering fuel consumption and emissions while retaining or improving the performance and functionality of their vehicle.

"We wanted to go with something with a little lower risk," said Doug Nelson, Advisor for the Virginia Tech team, which won the 2006 portion of Challenge X. However, he noted that this did not lessen the educational value of the project. "Just figuring out the networks and control strategies is a big effort," he said.

Those educational benefits are a big

draw for the many college students who enter auto-related contests every year. Access to those students, and the novel ideas they often bring, are key reasons that corporations support the contests.

"Competitions really offer a design community where students and industry can come together," said Chris Cheung, Alias Product Manager at **Autodesk**. The design tool supplier recently sponsored the 2007 World Automotive Design Competition, a student event hosted by the **Canadian International AutoShow**.

The value of contests was highlighted when Challenge X was extended for a fourth year—a year beyond its original timetable. A key reason is that sponsors like the students who have gone through the process.

"The extra year gives companies a new round of students, provides more exposure for their tools, and gives us more face time with students," said Jeff Meisel, a Product Marketing Manager at



Virginia Tech won the Challenge X sustainability contest last year.

National Instruments who serves as the Challenge X liaison. GM has already hired many previous participants, he added.

That's largely because the students use the same tools used by automotive companies, so it's easy to compare the quality of the work done by students who know how to use those tools. "Some of the judges said the panels created by students are comparable to those prepared by professionals," Cheung said.

Often, the companies that sponsor contests participate in many of them, often working with students in many countries. The Canadian contest, for example, had teams from 18 schools in 11 countries.

Terry Costlow

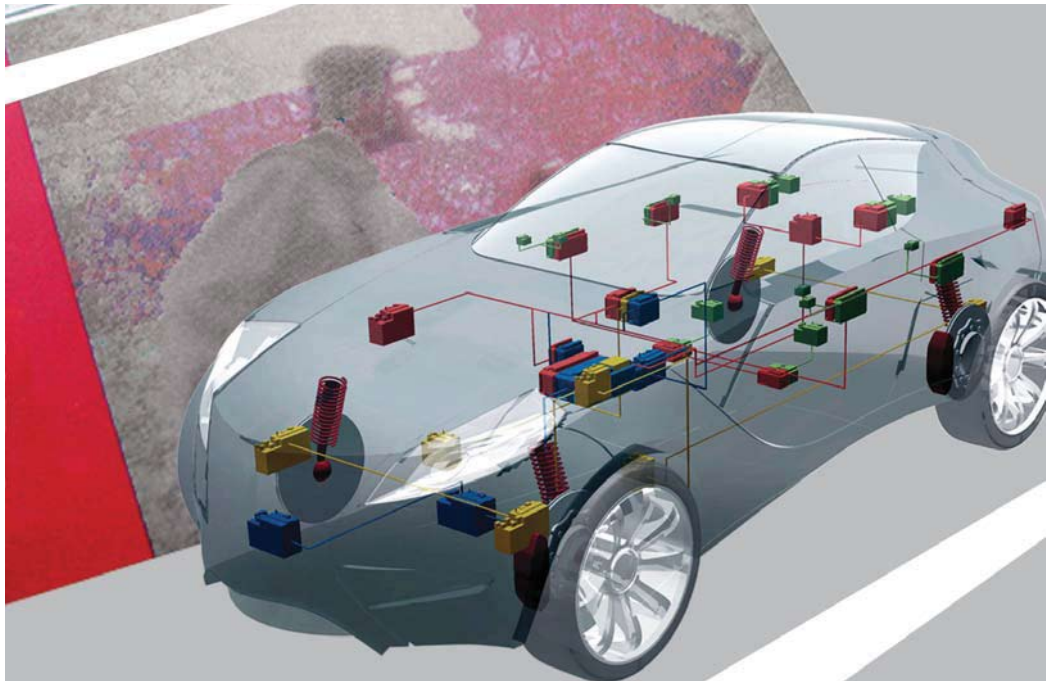
The V25i's interior adapts to active and automated driving modes. When in active mode, the driver can be positioned in either right- or left-hand-drive setups. When in auto mode, the steering wheel folds neatly away and the integrated electronic gauges return to the center position, allowing more space for occupants.

Fuel-cell technology allows for more efficient packaging of drivetrain components, providing the occupants with more accessible space for increased comfort and storage.

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Secondary Door System — Designed to accommodate people that have trouble getting in and out of their vehicle, the V25i uses patented sliding roof and floor sections that allow you to walk right into the car and sit. The floor section mechanically locks into the body structure to maintain structural rigidity.

Student-created panels "are comparable to those prepared by professionals," said Autodesk's Chris Cheung. A portion of one student's panel is shown here.



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