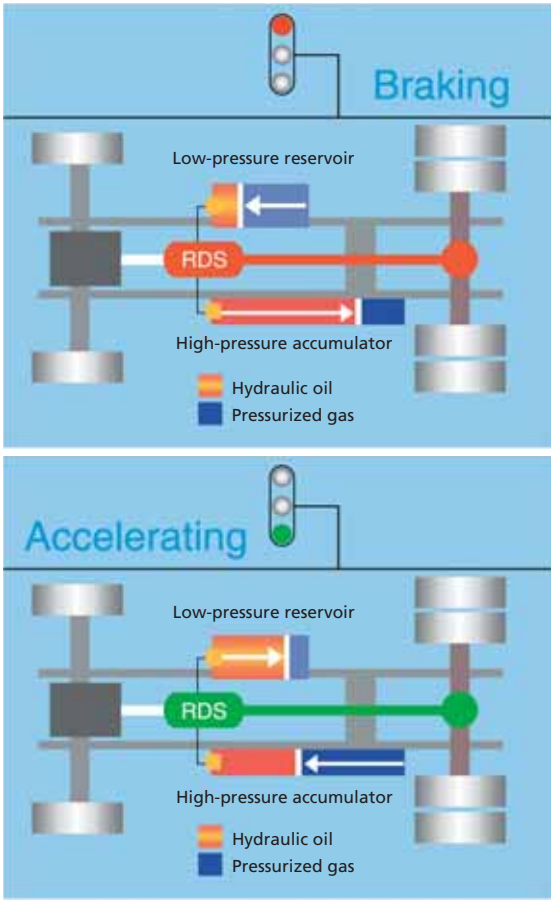
Smarter military vehicles

New technology could make cargo and other military-use vehicles get stronger fuel economy results, quicker acceleration, and longer brake life. If the next phase of the development project proves successful, the **U.S. Army**'s Family of Medium Tactical Vehicles (FMTVs) could gain that performance muscle via an Intelligent Hydraulic Drive system.

"Dana is doing the design and integration of the entire system," Edward Greif, Vice President and General Manager of **Dana**'s Intelligent Hydraulic Drive Products, said about customizing Australian-based **Permo-Drive Technologies**' Regenerative Drive System (RDS), a hybrid technology in which Dana claims exclusive licensing rights.

Dana's Intelligent Hydraulic Drive (IHD) portfolio, which includes Permo-Drive's Regenerative Drive System, is being customized for U.S. Army FMTV applications.

When the vehicle begins the braking process, the IHD system transfers hydraulic fluid via a driveshaft-driven pump/motor into a pressurized accumulator as shown in the 'Braking' diagram. Upon acceleration, the pressurized fluid from the IHD is used to power the pump/motor, assisting the engine by adding energy to the drivetrain as shown in the 'Accelerating' diagram.



RDS, a hydraulic regenerative braking- and propulsion-assist offering, is at the center-point of Dana's intelligent hydraulic drive technology portfolio. Dana's role for the military program is to make the overall system function without compromising vehicle attributes—namely, the driveline systems.

"Everything would use existing mounting points on the Army's FMTVs, so Dana's Intelligent Hydraulic Drive system, which includes Permo-Drive's RDS system, can be retro-fitted," said Greif.

Since the hydraulic drive system needs to fit between the frame rails, Dana engineers had to redesign a one-piece crossmember (a steel bent tube). "Whenever you change the geometry of a tube, you change the ability to handle torsional and compression loads, so we had to be sure we were matching the manufacturer's original requirements as well as accomplishing the packaging needs for a front-mount hydraulic drive unit," said William Spadafora, Chief Engineer of Dana's Intelligent Hydraulic Drive Products.

Placement of the hydraulic drive unit—consisting of a hydraulic pump/motor, gear case, and clutch—meant the "re-engineering of the entire driveline from the transfer case back," said Spadafora.

When the vehicle is operated in a fast acceleration (or dash) mode, the driveshaft will experience "almost a doubling of the torque," said Spadafora, who noted that the driveshaft used in the engineering qualification demonstration is of a larger diameter than the driveshaft it replaced.

"Because this is a battlefield vehicle, the driveshafts and drive axles have to absorb engine torsion and harsh ground inputs as well as the articulation of the system when the hydraulic drive unit is in place. In-house-developed software helped us better understand what the final outcome of a chosen design would be," said Spadafora.

As the project moves to the production design stage, component optimization takes the spotlight. "Right now, we have a large steel gear case, and we expect for production it will be either an engineered steel casting or an aluminum casting, which will mean a much lighter weight," said Spadafora. The pump also will be refined. "We expect that the next pump will have a 15% greater fluid volume displacement, but it will fit in the same package size," Spadafora noted.

Dana and Permo-Drive in 2003 signed an agreement to develop and commercialize RDS technology for the Army's FMTVs. "Our basic goal is to optimize the system—meaning the RDS, which includes the hydraulic drive unit—in such a way that it will provide the most efficiency in terms of fuel economy (up to 30%), weight, durability, brake life, acceleration (a 40% increase), and reduced emissions," said Spadafora.

Kami Buchholz

Building the future of mobile hydraulics

The concept of integrating electronics and hydraulics as the future path to more reliable, efficient, flexible, and easier-to-use mobile hydraulics is now accepted as commonplace. But how the industry will meet the various needs of the mobile industry is still a matter of lively debate. **Bosch Rexroth** uses a model for meeting customer needs based on seven building blocks that it believes describe how suppliers must evolve in the future to help their customers succeed.

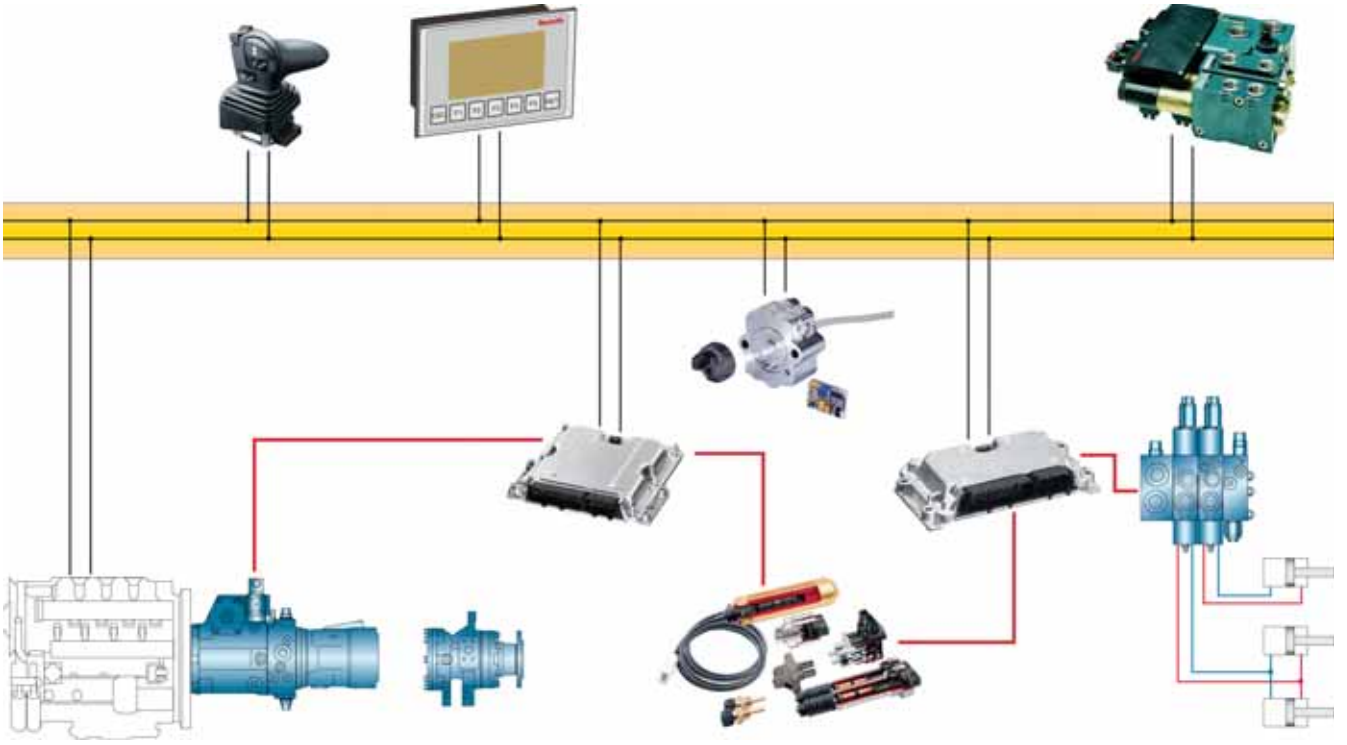
Services: Good suppliers like to tout the importance of getting involved early. Early involvement, beginning with an initial concept meeting, can pay big benefits for customers in increased functionality, lower costs, and fewer development headaches and delays. The supplier, by combining in-depth knowledge of a customer's needs as well as its products, can bring new insights into possible approaches.

Suppliers should also help with testing, commissioning, and fine-tuning. Equally important in evaluating suppliers are post-sale issues such as global supplies of spares over the expected life of the equipment, factory repairs and services, and all other life-cycle issues.

According to Mark Johns, Director of Sales and Marketing Services, Bosch Rexroth - Mobile Hydraulics, the company has a model for meeting customer needs based on seven building blocks.

Bosch Rexroth electrohydraulic control systems streamline hydraulics systems by eliminating the complexities and costs of hydraulic pilot lines and by lowering design and build costs with simplified wiring.

Open-protocol hardware: Proprietary systems are declining. Open connectivity based on CAN bus or other bus-based industry-standard protocols offer the benefits of interoperability among different manufacturers' products and significantly simplified wiring and system complexity. Bus-oriented architectures also promote distributing intelligence so that individual components or subsystems have more autonomy and the role of the central controller becomes more supervisory. CAN bus allows a higher level of modularity, which allows OEMs to view system design from a higher level.



The CAN bus is the backbone of a universal hardware structure. Intelligent components such as control units, joysticks, displays, and sensors communicate with each other via the CAN bus.

Development software: Comprehensive software development tools, such as Rexroth's BODAS, allow graphical representation to describe workflows, create sequential function charts and ladder diagrams, and write text-oriented structured programs. To speed development even more, templates are off-the-shelf application programs for controlling entire mobile hydraulic subsystems. No special software is programmed.

Instead, the program is fine-tuned for the particular application by changing the parameter settings. Or the template is used as a software template for adapting the programming. With the template, the programmer receives working software—the structuring and coding of which conform to the Rexroth programming guidelines. This ensures that the software is both functionally reliable and effective. It also forms a basis for quickly and easily exchanging programming experience and software.

Application expertise: More and more OEMs are moving toward a collaborative model for engineering, relying on suppliers for engineering support and integration of higher-level subassemblies—right up to the system solution in specific areas. The OEM wants to buy, for example, a complete engineered drive system tailored to its specific needs. The successful supplier will offer targeted application expertise rather than generic knowledge.

Having success in applying smart hydraulics in a forklift does not necessarily translate into expertise in logging equipment. Depth of expertise thus serves vertical markets while breadth of expertise allows the supplier to succeed in the widest range of off-highway markets.

Scalable solutions: This building block consists of the ability to meet varying needs of different applications in terms of volume, complexity, and levels of support. Quite simply, there are many more front-end loaders built than pavers. Can the supplier support both? Can the supplier offer low-volume custom solutions? Can the supplier help the high-volume manufacturer drive out costs while simultaneously increasing functionality?

Automotive electronics expertise: Automotive electronics represents the leading edge in capabilities, proven reliability, and R&D. Electrohydraulics suppliers for off-highway equipment look to the automotive industry for glimpses of the future. For Bosch Rexroth, being part of the **Bosch** Group means ready access to one of the best R&D think tanks for automotive electronics as well as high quality and throughput in manufacturing processes and techniques.

Synergies: Do claims like "comprehensive solutions" ring true? Or do they sound like marketing fluff? To a large degree, suppliers that can fulfill all of these building blocks will be positioned to go beyond their status as merely components vendors.

Fulfilling at these building blocks requires not only depth in vertical applications, but expertise across all off-highway markets and a product offering that spans pumps, motors, electronics, development, and diagnostic tools and controls, as well as the ability to integrate them into advanced application-specific solutions.

This article was written for SOHE by **Mark Johns**, Director of Sales and Marketing Services, Bosch Rexroth - Mobile Hydraulics

AxleTech loads axles with features

With a history that dates back to 1899 as part of **Timken** Roller Bearing Axle and later through incarnations as part of **Rockwell** and then **ArvinMeritor**, **AxleTech International** was "created to enable a singular focus on the needs of off-highway and specialty vehicle customers."

Part of that focus has been directed toward the 4000 series of planetary steer and rigid axles. In a project that began when AxleTech was the off-highway and European specialty vehicle business of ArvinMeritor, the 4000 series hub-reduction axle increases ground clearance and allows OEMs to design vehicles that are lower to the ground. Lower height adds greater stability for 4x4, 6x6, and 8x8 vehicles in high-speed, high-mobility applications. Load ratings range from 13,500 to 22,000 lb (6000 to 10,000 kg). Tandem, tridem, rigid, and steer versions are available to complete and complement the range.

Steer angles of up to 42° give OEMs the opportunity of meeting end-user demands for more versatile vehicles. Brake options include both air disc and cam or wedge drum. AxleTech says its outboard-mounted brake drums permit easier service. Wheel-mounted ABS is an available option, as well as optional central tire inflation for increased traction in rugged applications. Carrier differential options include air-actuated differential lock, limited slip, and a wide range of ratios and input flange sizes.

AxleTech also recently introduced the PRLC 124/144 series of planetary rigid axles for light- and medium-duty lift trucks, loader backhoes, compactors, and small loaders. The axles come standard with features such as wet disc brakes and integral parking brake, and offer improved life and high reliability vs. previous generations of axles, according to AxleTech.

The hydraulically actuated wet-disc brakes are insulated from external contaminants, which extends service life, lowers downtime, and reduces maintenance. The mechanical parking brake eliminates the need for a driveline brake by combining service, parking, and emergency braking into a single braking unit. Additional life-cycle and reduced-maintenance enhancements include unitized input pinion seals, face-type hub seals, and housing magnets to reduce wear contaminants. For severe brake-duty cycles, optional forced-cooling ports are available to allow for an auxiliary brake-cooling system.

AxleTech considers one of its core competencies its ability to quickly and cost-effectively provide customized solutions required by OEMs, as opposed to an off-the-shelf product.

Jean L. Broge

AxleTech says its 4000 series of planetary steer and rigid off-highway axles offers increased traction in rugged, high-speed, high-mobility applications.

Perkins expands NA genset line

The last couple of years have seen a renewed growth in the genset market. **Frost & Sullivan** has reported that the first quarter of 2004 had a double-digit increase in sales of gensets compared to the same period in 2003. With natural reactions to natural disasters such as the record 2005 hurricane season feeding the need for standby generation, that trend is not expected to go backward.

Perkins Engines believes it is in a good position to take advantage of the anticipated increased demand in gensets, widening its model offerings for a variety of applications in both the 400 and 1100 Series ElectropaK range. Perkins ElectropaKs are fully engineered, turnkey packages including an engine, radiator, charge cooler, air cleaner, and all necessary piping, hoses, and mounting feet.

"To date, our success has been based on a rather limited product line going into a few specialized areas," said Tim Cresswell, Marketing Manager, Electric Power, Perkins. "With this new, broader, more comprehensive offering we are targeting a broad range of applications from retail to farming, telecommunications, and municipal authorities."

Development of the ElectropaK Series has focused on achieving key customer benefits such as increased power density; lower installed costs; improved operational costs from two-year/3000-h warranty with optional three-year for standby applications than run less than 500 h per year and reduced fuel consumption; and overall lower noise signatures for smoother running. With a range of options from 12.5- to 219 kV•A, Perkins' ElectropaKs are designed for quick and easy direct integration with existing generating plants.

Perkins' ElectropaKs are turnkey packages that include an engine, radiator, charge cooler, air cleaner, and all necessary piping, hoses, and mounting feet. The new 1106D-E66TAG family includes three 6.6-L models with electronically controlled, turbocharged, and intercooled Perkins engines.

Perkins' 1104C-44TAG2 ElectropaK provides the convenience of a four-cylinder family of engines with the performance of a six-cylinder. It features common hook-up points to simplify installation.

A choice of three models is available in the 400 Series family, providing standby power in the 12.5- to 25-kV•A range. The four-cylinder 1104 Series includes four models, both naturally aspirated and turbocharged, which produce 56 to 125 kV•A in standby mode at 1800 rpm. For larger power requirements (175 and 219 kV•A), the all-new 1106D-E66TAG ElectropaK features three models with full electronic control and 6.6-L, electronically controlled, turbocharged, and intercooled Perkins engines.

The 1106D-E66TAG generator drive engine packages were developed to provide clean, cost-efficient, prime or standby power in a high-power-density package optimized for key market segments. Outputs range from 135 kV•A at 1500 rpm to

219 kV•A at 1800 rpm for both 50- and 60-Hz markets.

Built around the Tier 3/Stage IIIa compliant 1106D engine, the 1106D-E66TAG gensets use components of **Caterpillar**'s ACERT technology for low emissions, improved fuel economy, and low heat rejection. Worldwide acceptability has been improved due to increased fuel tolerance, which allows kerosene, jet aviation fuel, and 5% biofuel (RME) to power the units; further options are available, depending on local application needs.

Perkins also offers the four-cylinder 1104C-44TAG2 ElectropaK, a turbocharged, air-to-air charge cooled unit that addresses the 60-Hz standby market segment of 80 kV•A and the equally important 50-Hz prime power node of 100 kV•A. The unit features common hook-up points to simplify installation, 5 dB(A) noise reduction to lower noise attenuation costs, and 500-h service intervals for economic operation.

What Perkins describes as "aggressive development of the combustion system" has yielded and the addition of air-to-air charge cooling on the 100-kV•A model has enabled six-cylinder performance from a four-cylinder package, claims the company.

Jean L. Broge

Club Car increases IQ

Transferring the success its IQ System in golf car fleets, **Ingersoll Rand**'s **Club Car** has incorporated the technology into its lineup of utility vehicles that serve various commercial and industrial markets. Known as IQ Plus, Club Car says that the high-performance power source will enable electric utility vehicles to handle the same difficult jobs that normally require the strength of gasoline-powered vehicles.

The system's high-output charger and eight 6-V battery configuration—which replaces the six 8-V configuration—gives vehicles a range of 80 mi (129 km) on a single charge. Club Car says the high-output charger charges the battery pack faster than the previous Series system and faster than competitive models, leading to increased productivity, greater efficiency, and cost savings.

Utility vehicles with IQ Plus are suitable for various commercial and industrial markets including schools and universities, hotels and resorts, parks and recreation, and government.

"By better managing the power coming from and being restored to the batteries, our IQ Plus vehicles are just as capable as gas vehicles in this class," said Mike Packer, Vice President of Utility and International Sales for Club Car. "In fact, when you consider the efficiency and productivity advantages, IQ Plus makes electric a smart choice for many situations." Some of those situations include grounds maintenance for universities, hotels, and parks.

The IQ Plus System offers a 21-hp (16-kW) peak that automatically kicks in for situations that require extra power, such as going up a hill. That peak is more than a 100% increase over the 10-hp (7-kW) peak in the previous Series system. The speed of vehicles equipped with the IQ Plus System is programmable between 5 and 17 mph (8 and 27 km/h).

Environmental benefits such as quiet operation and zero emissions are inherent in the IQ Plus System. The fact that the IQ Plus is quieter than gas products makes it suitable for working in sensitive areas while not disturbing customers. It allows crews to start working earlier and stay out later while not disrupting students, residents, or the environment with engine noise.

Currently available in the Carryall 2, Carryall 6, Turf 2, Transporter 4, Transporter 6, Villager 6, and Villager 8 models, the IQ Plus System controller continually monitors vehicle performance and provides testing and diagnostic feedback through the IQ Display Module (IQDM). The programmer version of the IQDM (available to authorized Club Car dealers and distributors) can be used to adjust performance settings based on the needs of individual users.

Additional features and benefits of the system includes advanced motor braking with smooth transition for greater comfort, a performance selection key switch—Smart Key—that allows settings to be changed without additional tools, a best-in-class quick 10-h charging, and automatic alerts that let operators know when the battery needs to be charged.

Jean L. Broge

The eight 6-V battery configuration of the IQ Plus System gives vehicles an 80-mi (129-km) range on a single charge—the best in the market, claims Club Car.

Intelligent motor-controller technology in the IQ Plus delivers increased range and hill-climbing capabilities.

IQ Plus combines the reliability of Club Car's 48-V platform with the IQ Plus System's advanced drivetrain technology to provide for a utility vehicle that works long, hard, and fast.

Bus designer takes the local route

When does it make sense to bring outsourced manufacturing in house? A good case study is **Volgren**, one of Australia's leading specialty bus and coach manufacturers. Based in Victoria, Volgren is part of **Grenda**, and production volumes for its built-to-order vehicles fluctuate between 100 and 200 units per year at the main plant.

For years, the air-conditioning (A/C) ducting for Volgren's buses and coaches had come from a well-regarded European supplier. Volgren maintained a dedicated full-time operator who reworked the standard ducting modules for custom installation. Volume was usually low enough to justify the added cost and time associated with outsourcing and then customizing the imported components.

But when a big order promised to increase coach production by 50%, Volgren had to find ways to increase throughput—the ducting rework was a dangerous production bottleneck. Instead of setting up additional facilities for customizing the A/C ducting and then warehousing the stock, Volgren decided to redesign the ducting.

Production of Volgren buses and coaches starts with powertrain-chassis platforms from truck manufacturers such as **Volvo**, **Mercedes-Benz**, and **Scania**. Volgren constructs and installs the internal and external structure needed to make the vehicle. The A/C system spans both sides of the coach interior, with outlet vents positioned above the seats. The system interfaces with the overhead lighting, supports the loudspeakers and vents, and houses the wiring harness.

The imported A/C ducting was modular. Each subassembly consisted of a thermoplastic cover with two separate end-cap/seal assemblies, reinforcements, and numerous fasteners. The ABS plastic fascia was laminated with a special vinyl covering to provide a high-quality surface finish. Assembly involved installing about 16 separate modules into the coach with a number of fasteners. The modules, not all identical, butted together to form a continuously sealed unit.

Volgren's European supplier was willing to customize the ducting system to order, and had done so in the past. But years of experience had proven that communication missteps, long lead times for revisions, and long shipping times made it difficult to build the variety of models that were required. It was easier and more cost-effective for Volgren to import standard ducting modules from the supplier and rework the product in-house. Thousands of dollars' worth of ducting modules typically sat in inventory, ready for production when needed.

Redesigning the A/C ducting system required Volgren to assess the product geometry and materials and to analyze a large set of established work processes. To catch all the details, the company trained a cross-functional design team in the principles of Design for Manufacture and Assembly (DFMA) before starting the project. The DFMA approach mandates design input from the various manufacturing disciplines early in product development.

Volgren's DFMA team studied the options for manufacturing the A/C ducting and crunched the numbers so it could make decisions based on facts rather than opinions. It identified all the separate parts and manufacturing processes, and quantified assembly costs and times using actual times from its own production line. Step-by-step analysis exposed unnecessary parts, such as fasteners, and revealed processes it could eliminate, such as double handling. To guide the redesign process, the team used DFMA software from **Boothroyd Dewhurst**.

Volgren's redesigned A/C ducting system is now manufactured locally, saving time and money, improving performance, and eliminating shipping delays and communication problems.

By the end of its study, the team had a reliable benchmark to improve on. The imported A/C ducting system had 190 separate parts and processes and took 10.1 h to assemble into the vehicle. When the new design was complete, it had only 38 parts and processes and took only 3.15 h to install.

The new A/C ducting was so simple that it could be made locally using straightforward manufacturing processes. Sourcing the product locally would give Volgren more production flexibility and streamline design schedules. Shipping delays, communication lags, and other costly problems associated with importing the part would vanish, including all the custom rework.

The design team knew that tooling costs can be prohibitive in low-volume applications. Having little experience with thermoplastics, it was not sure what to look for in a quote or which process offered by local suppliers would be most cost-effective. A quick costing exercise using the DFMA software helped estimate tooling, piece costs, and manufacturing parameters for vacuum forming (thermoforming) and injection molding. Despite the lower piece costs for injection molding, the analysis showed that higher tooling costs made injection molding a more expensive process overall.

Volgren opted for vacuum forming and laser cutting. With its own cost analysis in hand, the purchasing department found a supplier in close proximity who could manufacture ducting at a competitive price with a six-week turnaround. The overall piece cost of the new A/C ducting was 71% less than the imported components.

Reducing the A/C ducting design down to one plastic cover panel with integrally formed air vents was a relatively easy concept to conceive. But DFMA workshop sessions had identified a host of other requirements, such as eliminating interior windshield glare and providing easier access to the wiring harness. Volgren broadened its analysis beyond the ducting to consider all the related component interfaces and wound up redesigning almost the entire internal roof area.

The savings were huge. Assembly time for the original roof structure was 85 h, including 20 h of offline subassembly work. Assembling the new roof design took only 45 h. Overall parts and processes for the roof were cut from 1235 to 300, and mass reduced from 230 to 175 kg (507 to 386 lb).

In addition to solving the throughput problem, many functional improvements came along with the new roof design. Airflow and A/C performance improved by more than 30%, the interior lighting caused much less windshield glare, and there was more headroom clearance.

Lou Travella, Principal Consultant at Design 4 Excellence, based in Victoria, Australia, wrote this article for *Off-Highway Engineering*.