electric & hybrid

vehicle technology international

annual review
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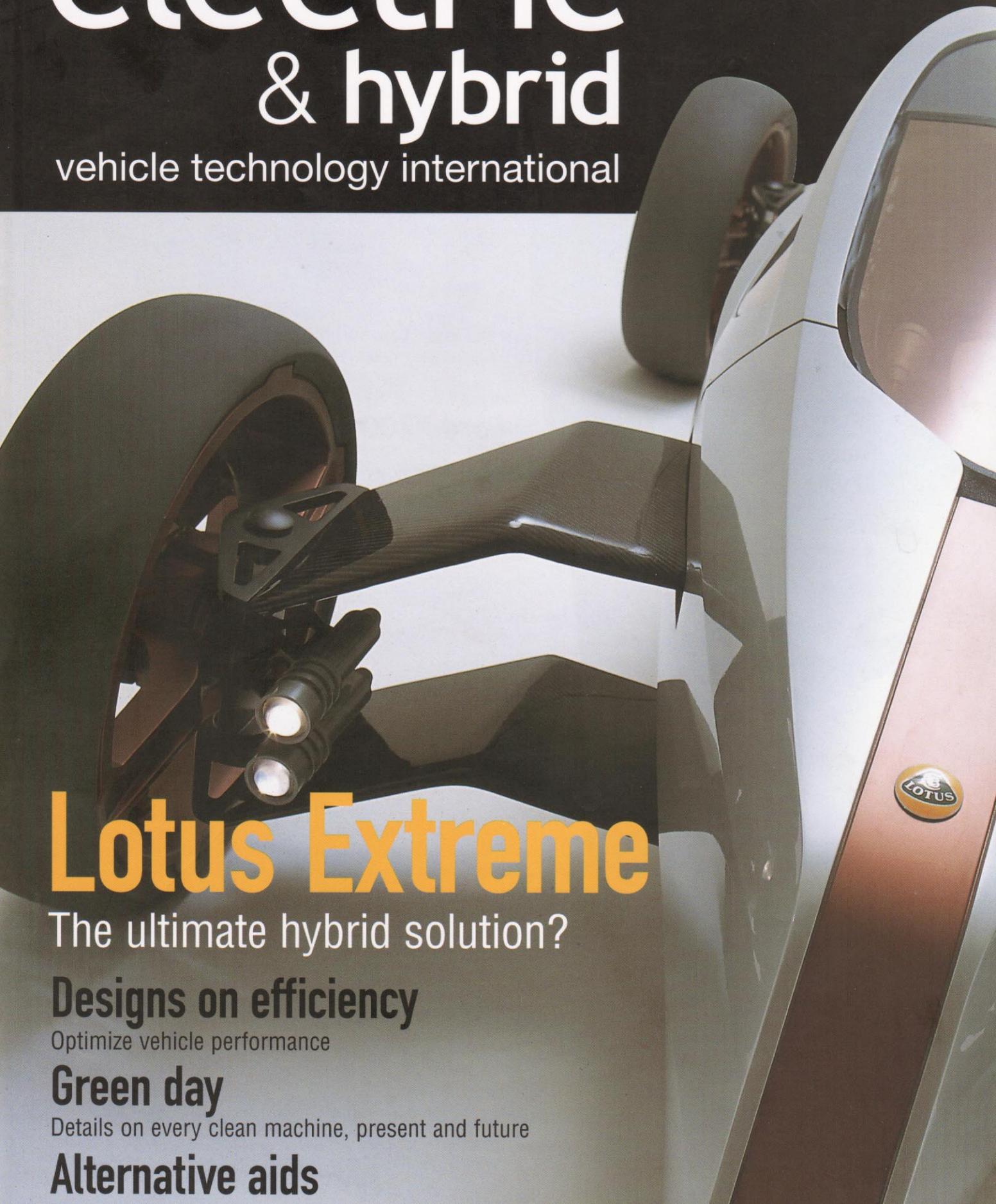

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Think big

Integrating electric traction into regular vehicles is nothing new, but putting affordable technology into a 33-ton expanded mobility tactical truck is something else

by **Chris Yakes & Marcia Smith, Oshkosh Truck**

What mode of transport is having the biggest negative environmental impact? The answer is almost certainly the passenger car. What can be done to clean up these dirty boxes on wheels? Actually, quite a lot. The environmental eye may move away from the passenger car in the future. And the attention could well fall on industrial vehicles; tons of big, inefficient, polluting haulers. It is therefore time to integrate electric traction motors into 33-ton expanded mobility tactical trucks. Or at least that is what Oshkosh Truck Corporation (OTC), a US-based industrial truck builder, believes.

OTC is forging ahead with ETV technology developments for its big haulers. Since 1917, the company has put more than 55,000 military and commercial trucks on the road around the world – a total that includes 24,000 military vehicles for all branches of the armed forces.

Oshkosh Truck's vice president of technology, Don Verhoff, says that although some electric-heavy equipment vehicles already exist, large scale development is not really viable due to excessive costs; "Some competitors are attempting to get to this level, but they are trying to do it by putting the technology into existing trucks. We're truck builders," he said, "and we can put trucks together from the ground up. From a technological standpoint, we'll be on the cutting-edge, and the cost savings will be substantial for our customers – when they speak, we tend to listen."

The demands center on the need for 21st century emission control standards and fuel efficiency. The company intends to meet and exceed all current and future requirements of existing mechanical systems in both military and commercial markets. "We're not going to build vehicles for the 'wow' factor," says Verhoff. "The trucks will be built for a specific purpose and form will follow."

One of the keys to developing an effective ETV system will be Oshkosh Truck's modular Independent Suspension (IDS) system. The IDS system allows modular design and assembly, resulting in easy configuration and 'plug-in' component capability. According to Verhoff, the system is currently being sold both commercially and to the military on some Oshkosh Truck platforms, and is the only cost-effective system of its kind on the production market today.

Combining the modularity of IDS with electric drives will provide the chassis commonality so sought after in tactical and combat fleets. Verhoff notes that; "This commonality is something that has never been prevalent before, but may now be achievable."

Oshkosh Truck intends to begin ETV production within two years with Air Rescue and Fire Fighting (ARFF) vehicles, and other units that can fully utilize the performance increases and the increased onboard power generation capabilities. When completed, OTC anticipates that the configuration will be the military's heavy/medium tactical truck of the future. The company then plans to phase the ETV technology into many of its commercial-vehicle platforms including fire trucks, snow-removal vehicles, refuse trucks and tactical vehicles.

For its power architecture, Oshkosh Truck has chosen the Series Hybrid (SH) arrangement. Verhoff says that the direct-torque-to-wheel capability will create the 'ultimate all-wheel-drive vehicle'.

The SH system will give Oshkosh Truck the simplest power transmission possible and allow for removal of the torque converter, the automatic transmission, the transfer case, all driveshafts, and all differentials. Ultimately, each wheel will be driven by an independent motor, and each motor will, in turn, be controlled by its own power converter. With this arrangement, torque will be controlled at each wheel in a real-time basis. Verhoff said the system will prove excellent for unpredictable environments and terrain situations.

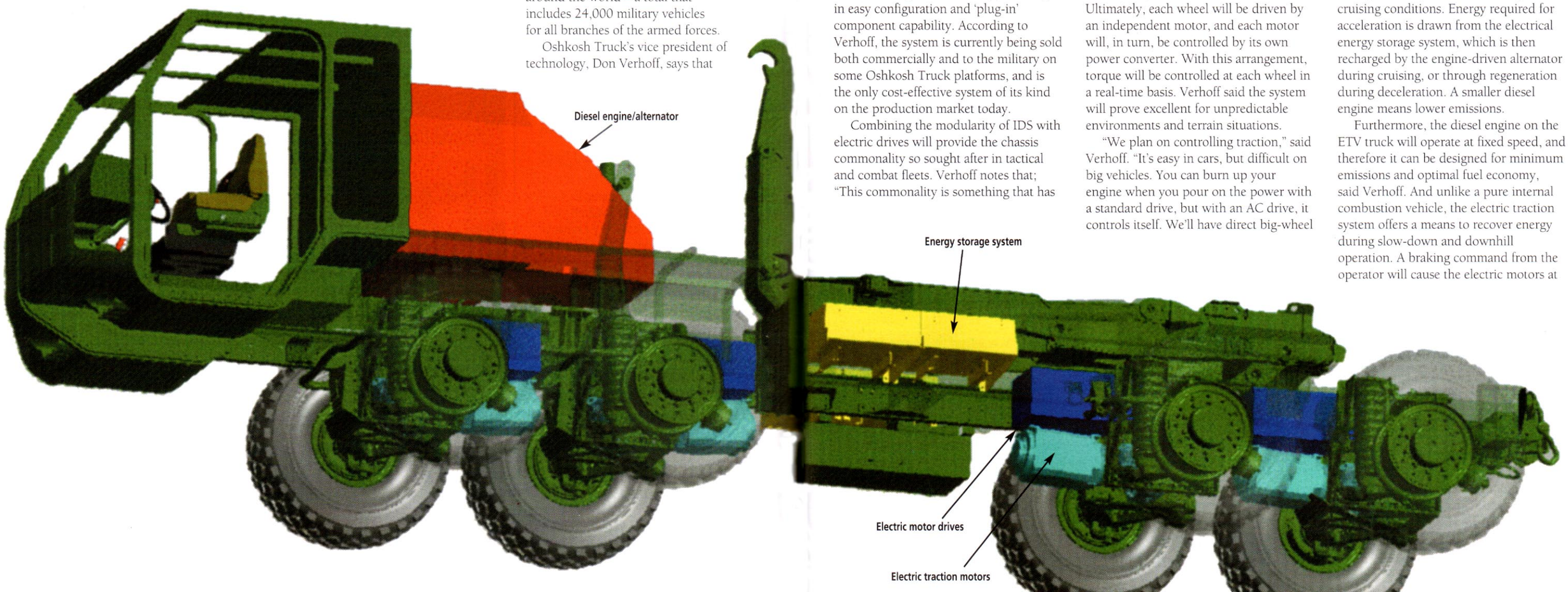
"We plan on controlling traction," said Verhoff. "It's easy in cars, but difficult on big vehicles. You can burn up your engine when you pour on the power with a standard drive, but with an AC drive, it controls itself. We'll have direct big-wheel torque control and exact control per wheel down to 0.01 per cent of full-rated torque, great news if you have one wheel of a big hauler in an ice skid."

A huge technical advantage of the SH system is its power-generating ability. "Rather than being a truck trailing a generator, we will be the generator," said Verhoff. He explained that when the truck's traction drives are disconnected, the alternator becomes the source of site power. "You can power rocket launchers, or light up a fire scene,' said Verhoff, noting that a big diesel engine can produce around 500kw of power – enough to supply peak power to around 25 American homes.

Meeting and exceeding emission regulations is, according to Verhoff, an 'Oshkosh Truck priority'. The smaller IC engine of an ETV is expected to achieve superior results for guidelines laid down by the EPA, the FAA, and the National Fire and Protection Agency.

In a series-hybrid truck, the horsepower rating of the diesel engine can be reduced to bring it closer to the horsepower required under steady-state cruising conditions. Energy required for acceleration is drawn from the electrical energy storage system, which is then recharged by the engine-driven alternator during cruising, or through regeneration during deceleration. A smaller diesel engine means lower emissions.

Furthermore, the diesel engine on the ETV truck will operate at fixed speed, and therefore it can be designed for minimum emissions and optimal fuel economy, said Verhoff. And unlike a pure internal combustion vehicle, the electric traction system offers a means to recover energy during slow-down and downhill operation. A braking command from the operator will cause the electric motors at



the wheels to act as generators, and their generated power is returned to the energy storage system. Only under very heavy braking, or when the energy storage system is at capacity, will the friction brakes be employed.

The emission reduction benefits tie-in increased vehicle range and fuel savings that could reach 40 per cent for the big haulers. "Together," said Verhoff, "they are the tools through which the vehicle designer maximizes system efficiency."

OTC also expects overall ETV savings to come from the reduced parts count resulting from the IDS modular design, and through life-cycle costs. The life-cycle cost savings include a control system that provides not only diagnostic information after an event has taken place, but also prognostic data for the operator regarding the general health and status of the system prior to any unscheduled events. "Changes can be made quick and early, preventing costly errors," said Verhoff.

Oshkosh Truck will be teaming with the industry's leading companies to bring the electric-hybrid truck into reality. Rockwell Automation is one such partner, and will be the primary source for vehicle control, power conversion, traction motors, traction control, networking and communications.

"Oshkosh has asked us to install the very things that we've been doing for decades in industry onboard its ETV," said Jerry Pollack, manager, market planning, Rockwell Drives Group. "The company has given us the opportunity to apply electric motors, motor drives, automation and communications to vehicle platforms, and we've jumped at the chance. In this application, we're able to apply all the tools and experience we've gained in the industrial automation market and bring them to the team."

Rockwell Automation will combine technology from its development centers in California, Wisconsin, and Ohio, drawing experience from other heavy-vehicle traction developments and the design of an automotive traction system currently underway through the US Department of Energy and the PNGV.

Rockwell Automation and others are working with Oshkosh Truck to provide a worldwide system of support and maintenance. End-users will not be left adrift according to Verhoff, who says that the team members that Oshkosh is putting together are all global leaders in their respective fields.

Oshkosh is confident that its heavy vehicle experience, integrated with state-of-the-art technology and the government's move towards non-developmental and commercially available products, will be perfect for developing the ETV vehicle. The company expects to produce the world's most advanced, rugged and commercially producible ETV system for commercial and heavy/medium-duty tactical vehicles.

"We've seen the future," said OTC vice president Verhoff. "And it's ETV. But we're not going to sit back and let technology be our driving force. We intend to be the driving force in our market during the 21st century."

Oshkosh Trucks has targeted the year 2002 for completion of its first prototype vehicle, although a full-size axle model was displayed in the Oshkosh Truck Booth at the Association of the United States Army (AUSA) Trade Show. ***E&H***

Why design ETV technology?

Improved fuel economy, increased range and reduced emissions are primary benefits for both military and commercial heavy hybrid vehicles.

In a conventional internal combustion-powered vehicle, the engine provides both average and peak tractive force, but there is no means for energy recovery in downhill or braking situations.

In the general model for electric traction, it is possible to separate vehicle propulsion into two systems – one optimized to provide average tractive force for constant-speed operation, and a second specifically designed for peaking and energy recovery. A connection of some sort is required for recharge from the land-based energy infrastructure.

In a series-hybrid electric vehicle, the ICE runs at fixed speed and is sized only for average power plus battery recharge. The onboard battery system provides energy for peaking and a means to recover energy while braking or operating downhill.

Along with the development and introduction of hybrid-electric heavy vehicle traction systems, there are three evolving technologies working together in the gasoline-electric hybridization process for autos and light trucks. They are:

- Revolutionary advances in vehicle automation;
- Planned replacement of all belt-driven and hydraulic vehicle accessories with individual powered electric accessories;
- Replacement of steel with alternative materials in the vehicle body and frame systems.

The sequence below clearly shows the interaction:

1) Vehicle automation will add smart sensors, replace relays and contactors with solid-state switching, and make the transition to by-wire operation of steering, brakes, throttle and suspension. Electronically operated valves, without cams or cam drives, will be introduced into specific vehicles by 2005.
2) The vehicle electrical system will undergo an increase in supply voltage for capacity. So called 42/14V systems will begin to appear by 2003 – first with two batteries, and then with a single battery and DC-to-DC step-down converters. Concurrently, chassis networks and multiplexing will simplify vehicle wiring, replacing large wire bundles with network wiring.
3) With suitable higher voltage power on board, accessories are now driven by the engine serpentine belt (called the FEAD – the front-end accessory drive) will become individually electrically driven. For the automobile designer and stylist, the advantages are huge. Accessories can now be flexibly located, and not all clustered at the front end of the ICE. Furthermore, the ICE can now be stopped without losing A/C, power steering, etc. A hybrid-electric traction system can be added, and the ICE programmed to shut down at spotlights, when creeping forward (on the electric motor) in slow traffic, or for sustained electric-only operation at low-speed or light-load.
4) The introduction of light alternative materials will decrease the vehicle weight, bringing a wider range of speed and load into the operation envelope of the electric traction system.
5) This process enables the introduction of hybrid-electric traction systems as we now see them under development.

Imagine an affordable ETV hauling 70-ton loads.

Imagine Oshkosh.

It's big. It's bold. It's revolutionary. It's the next generation vehicle — the severe-duty ETV system now in development at Oshkosh Truck. Oshkosh engineers are hard at work advancing simplified, cost competitive hybrid systems for big platforms used in military and commercial applications. Expect improved performance levels at every turn:

- Emission reductions that meet and exceed government standards
- 10 to 40 percent increase in fuel economy
- Increased on-board power
- Life cycle cost savings

Advanced technology in ETV systems. It's what the world expects from Oshkosh Truck Corporation.

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