Escape Hybrid's stopping technology

The Ford Escape Hybrid uses a Continental Teves EHB system.

An electrohydraulic brake (EHB) system that monitors and controls every braking maneuver electronically on the world's first production-released full hybrid-electric sport utility vehicle is the culmination of a jointly developed product.

Continental Teves "wrote the system's algorithm and software code. **Ford** Motor Co. provided the system requirements and specifications" for the EHB system on the Escape Hybrid, according to Craig Belevender, Director of Brake Systems Engineering for Continental Teves North America. The software of the hybrid vehicle braking system controls the distribution between hydraulic brake force and electrical regenerative braking.

"Sensors measure the motion and driver's force on the brake pedal and transmit that data to the control unit. A computer calculates the optimum hydraulic pressure for each wheel and applies exactly the amount of braking force needed," Belevender said.

The system comprises a hydraulic electronic control unit (HECU) that contains an electronic control unit, hydraulics, and high-pressure accumulator as well as an actuation control unit (ACU) that contains a brake fluid reservoir, pedal feel emulator, and pedal travel sensor to measure the driver's brake request. Continental Teves supplies the complete EHB system, including HECU, ACU, brackets, and *g*-force sensor to measure horizontal deceleration during a vehicle stop.

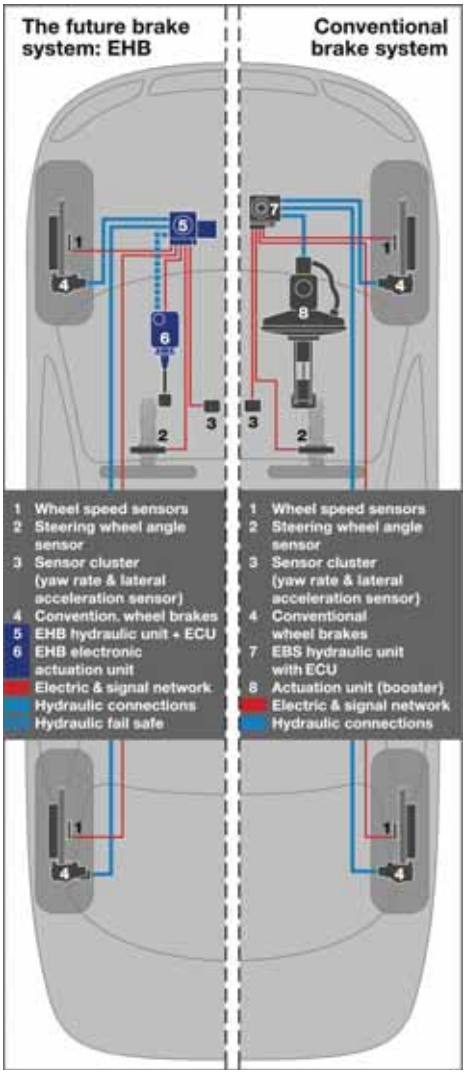
During a normal braking event, series regeneration occurs, meaning the hydraulic and electrical regenerative braking modes are working simultaneously. As the vehicle is being driven, the brake module receives a signal from the powertrain indicating how much regenerative torque or brake force is available from the powertrain.

"When the driver applies the brake, our system utilizes the regenerative torque that is available from the powertrain first. If the driver's request exceeds the amount of torque the powertrain can deliver, the brake system will then supplement it with friction brakes from the hydraulic system or EHB," said Belevender.

The EHB system is sometimes referred to as a 'wet' brake-by-wire system. "The 'wet' means that the EHB system uses a hydraulic brake fluid under pressure to supply the braking power," said Belevender, adding, "The 'by-wire' means that the driver does not directly build pressure in the system and that there is a pedal travel sensor that measures the driver's brake request."

Continental Teves is working on a next-generation braking system for hybrid vehicles. "It is under development currently, and we are unable to provide further detail at this time," said Belevender.

Kami Buchholz



Approximately 100 inventions relating to the electrohydraulic brake technology (system schematic shown) have patents issued or pending.

Briefs

The new CXT pickup truck from **International Truck** will ride on **Goodyear** commercial truck tires. The world's largest production pickup truck has 22.5-in wheels with Unisteel G159A rib radial tires in the front and G167A drive-wheel radials in the rear. Power from the International DT 466 diesel engine is delivered through an **Allison** 2000 Series automatic transmission.

ArvinMeritor has been awarded the design and engineering of the exhaust and manifold for the successor to the X5 from **BMW**. The new vehicle will be built in Spartanburg, SC, with production beginning in October 2006.

Aston Martin has selected the TPMS (tire pressure monitoring system) from **SmarTire Systems** for the DB9. The system was first selected for the V12 Vanquish. A SmarTire TPMS monitors all tires independently, ensuring they are properly inflated and running optimally. If an air pressure or temperature problem occurs, the driver is immediately alerted.

The new 612 Scaglietti from **Ferrari** features **Delphi**'s advanced climate control technology. The car's dual-zone system features automatic individually controlled front and rear controls to allow every occupant the same level of thermal comfort. A variable-displacement compressor at the heart of the air conditioning system automatically adjusts capacity to meet demand. Delphi also has full electrical systems responsibility for the vehicle.

MAGNA Drivetrain, an operating group of **Magna International**, is supplying the integrated transfer case (ITC) for the new **Land Rover** Discovery III. The ITC provides permanent all-wheel drive with constant torque distribution, and is a key component of Land Rover's Terrain Response system.

GKN Driveline has introduced a new range of all-wheel-drive technology for small and midsize vehicles that was introduced in the **Fiat** Panda 4x4. GKN will supply all the components in partnership with **Getrag** for the power transfer unit and **Dana** for the rear differential.

Quick change

Four transmission downshifts within 1 s and individual gearshifts in less than 40 ms are being achieved by a new all-electric gearshift system, according to the company that developed it, motorsports engineering specialist **Zytek Systems**. The technology is called EGS (electrically assisted gearshift system), and is said to be lighter and less complex than alternative hydraulic or pneumatic systems.

The precise movement of its electric actuators means that there is very little wear on the gear selector mechanism and dog rings, helping extend gearbox life while improving reliability and shift accuracy.

The EGS operates using fast-acting solenoids. A double-acting solenoid actuates the gearshift (twin single actuators can be used if required), with a single-acting solenoid providing a throttle "blip" function.

Zytek's electrically assisted Gearshift System can make four downshifts in less than one second.

Zytek's Chief Engineer, Aidan Gregory, states that electric power is the ideal solution to the challenge of achieving fast, reliable gearshifts in race conditions. "But the need for sophisticated energy management and delivery has proved a barrier to implementation in the past. Now we have been able to apply knowledge gained from our electric-vehicle programs to make a robust, flexible, and easily integrated solution."

Zytek—which has long-established expertise in control electronics and software, together with electromechanical design specialization in electric vehicles—claims the EGS, which has a mass of about 3 kg (6.6 lb), removes the need for a separate hydraulic or pneumatic system, thus reducing mass and complexity. It also states that

Driver control is via steering-wheel-mounted shift paddles, with separate push buttons to select reverse and neutral. Clutch operation is just needed for step-off, reverse, and neutral.

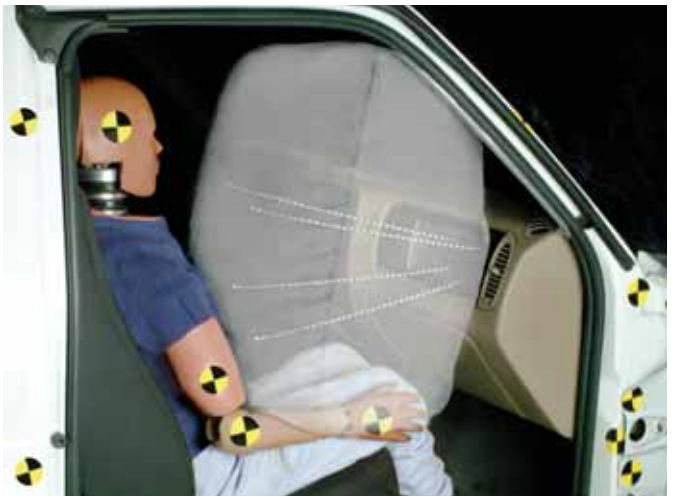
The control unit of the EGS includes built-in energy storage; it accumulates electrical energy from the vehicle's alternator between gearshifts and delivers high power extremely rapidly for a fast shifting action. Zytek developed all the components and the control and calibration software. The control system interfaces directly with both Zytek and third-party engine controllers using either hard wiring or a CAN interface. The unit also interfaces with steering wheel instrumentation.

Stuart Birch

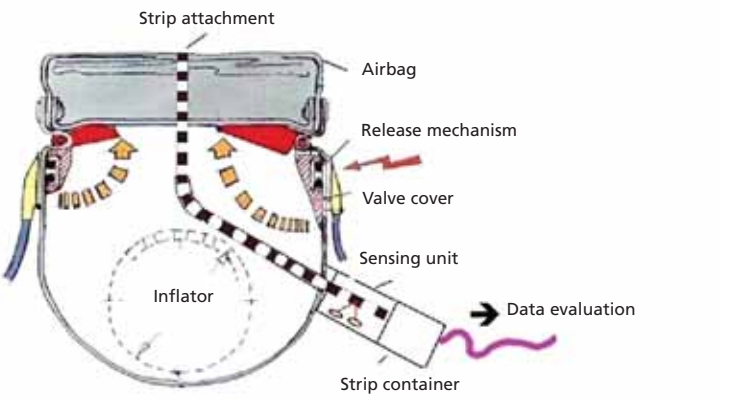
It's in the bag

Because of the potential interaction between inflating airbags and small or out-of-position passengers during vehicle crashes, **NHTSA** has proposed and implemented revisions to the crash protection regulations that call for automakers to install advanced airbag deployment technology. These revisions are to improve airbag restraint performance for a wider range of occupants and crash conditions.

The regulations allow for the suppression of airbag systems for small-stature occupants, as well as "low-risk" deployment in which the airbag is deployed but the interaction between the occupant and the airbag is reduced. This legislation was



In a crash, the tapes in Key Safety Systems' airbag are pulled through an optical sensing unit that reads the velocity and interprets critical data about the crash incident and the interaction of the airbag with the passenger.



TickerTape Airbag components can be configured into a package that conforms to current production modules, consolidating the electronic circuitry, airbag cushion, and hardware components.

enacted in June 2000 for implementation beginning with 2004 model year vehicles.

During this time, **Key Safety Systems**, a supplier of safety-critical components and systems including airbags, seatbelts, and steering wheels, began looking at new methods of low-risk airbag deployment. Low-risk deployment can provide for improved real-world occupant safety, since the small-in-stature or out-of-position occupant will still receive some level of restraint, whereas the airbag is not deployed at all with a suppression system.

The traditional approach for airbag suppression is to install an occupant classification system consisting of a pressure mat in the front passenger seat and sensors in the seat track and/or seatbelt mechanism to gather occupant data—whether the occupant is large or small, or out of position—for optimum cushion inflation. The data, in addition to the crash speed, is then used to adjust the response of the airbag, typically to one of three alternatives: no deployment, de-powered deployment, or full deployment.

The Key team developed instead a unique, active low-risk deployment technology called the TickerTape Airbag (TTAB), which gathers the required information during the inflation process and responds with an infinitely tailorable airbag deployment. Much of the time spent validating this concept was spent on timing and size—whether an array of sensors, electronic algorithms, software, and mechanical hardware could indeed prevent airbag injury in the time it takes for an airbag to begin inflating, and do so within the finite packaging limitations of a standard passenger airbag.

Several software algorithm modules were developed for detecting injury mode data during critical inflation stages, such as initial occupant interaction (when the bag first deploys) and membrane loading (when the bag meets the resistance of the seated occupant). The algorithm recognizes the velocity pattern for an out-of-position occupant, interpreting size, position, and speed of movement, then sends an actuating signal to a gas venting system.

An innovative sensing technology was conceived by Key's European engineering division and perfected by a multi-disciplinary team in the U.S. The sensing system consists of multiple strands of specially coded sensor tape—resembling stock-market ticker tape—sewn to strategic points on the inside of the front surface of the passenger airbag cushion.

In a crash, the tapes are pulled through an optical sensing unit that reads velocity and interprets critical data about the crash incident and the interaction of the airbag with the passenger. The module then dynamically assesses the correct amount of cushion for optimal passenger protection. This process occurs in less than 10 ms. A pyrotechnic venting device controls the amount of gas that flows into the cushion. Once enough gas has entered the cushion as determined by the software, an actuation signal opens a vent flap that directs the remainder of the inflation gas outside the airbag module.

Properly seated occupants receive a fully inflated cushion, while the inflation is proportionately reduced for smaller or out-of-position passengers by venting gas at a predetermined time depending upon seating position.

In recent crash tests, the TTAB system not only met but exceeded the NHTSA airbag safety requirements. Injury risk values recorded by dummies representing young children without seatbelts with the system in use amounted to less than half those recorded during baseline testing conducted with the TTAB system disengaged. Small infant dummies secured in child seats sustained less than 10% of the baseline injury values.

Since the TTAB system does not depend on seat occupant classification sensors or mats to determine the required airbag performance, carmakers can reduce or eliminate them altogether to save cost.

TTAB system components can be configured into a packaging size that conforms to current production modules, consolidating the electronic circuitry, airbag cushion, and hardware components without compromising performance.

In addition to the increased safety benefits, the elimination of seat mats allows interior designers a wider selection of seat materials and the ability to use heated seats, while eliminating the need for instrument panel warning lights that register seat mat sensor readings. The TTAB system is not susceptible to wear or abuse since all the components are contained within the passenger airbag module.

Barrett Kalellis

BorgWarner technology links the world

BorgWarner has begun production of the chain timing system for the "world engine," a family of four-cylinder gasoline engines produced by the **Global Engine Alliance**. The Alliance, a joint venture between **Hyundai**, **DaimlerChrysler**, and **Mitsubishi**, was announced in May 2002.

Total annual world-engine production is estimated at more than 1.6 million units, which would make it the highest-volume engine family in the world, according to BorgWarner.

"BorgWarner's globally integrated organization allows us to provide our customers with local service in each of the world-engine production regions," said BorgWarner Chairman and CEO Tim Manganello. "This capability is a consideration in many sourcing decisions today."

The world engine will be manufactured in production facilities located in the U.S., South Korea, and Japan. Because the development costs are shared between five operations in these three markets, the three OEMs anticipate significant economies of scale.

BorgWarner is supplying the engine chain timing system for a family of four-cylinder gasoline engines produced by the Global Engine Alliance.

BorgWarner will supply the chain timing system in all three markets. Vehicles equipped with these systems will benefit from reduced engine noise and emissions, and increased performance and durability, according to the supplier. Production is currently being launched for the Korean market. In North America and Japan, production is expected to begin in mid-2005.

In addition, BorgWarner will supply DaimlerChrysler with the electronic throttle control (ETC) for the North American version of the engine, which is produced in Dundee, MI. ETC provides unlimited calibration possibilities for improved drivability and fuel economy. Production is expected to begin in late 2005.

Ryan Gehm

Cool diesel

The R&D race between diesel and gasoline engine technology continues apace. A new research program into achieving significant improvements in fuel consumption and a reduction in emissions of diesel engines has begun in the UK at the **University of Bath**'s Department of Mechanical Engineering. **Ford** is giving the program financial support, together with the UK government via its Science Research Investment Fund.

The program emphasis will be on making the temperature control and cooling system more efficient, and increasing the number of components powered by electricity. A major aim of the work is to help reduce diesel engine pollutants by half over the next seven years; the program will help Ford's work with **PSA Peugeot Citroën** on advancing diesel engine technology.

Research work at the University of Bath into significantly reducing diesel engine fuel consumption and emissions is focused on making temperature control and the cooling system more efficient while increasing the number of components powered by electricity.

"This is not research that sits on a shelf gathering dust; our results will be in the cars people drive—cutting diesel bills and reducing waste products—within five to ten years," said Professor Gary Hawley, Head of the University of Bath's Powertrain and Vehicle Research Unit, which is carrying out the work.

The University is also looking farther ahead and considering other aspects of advancing vehicle technology. While 48-V systems are very much on hold due to cost and complexity issues and also to advances made by 12-V systems, Hawley believes that in the next five years, vehicle electrical systems will switch to 36-V. This would help facilitate stop-start technology and virtually eliminate pollution from standing traffic.

"Higher voltage would also allow water pumps and air conditioning to be completely driven by electricity rather than mechanically, and facilitate more elaborate entertainment and communications systems," added Hawley. "Catalytic converters would benefit from electrical heating."

Stuart Birch

Liberty endeavors live on

Engineers, technicians, designers, program managers, and others said goodbye to Liberty and Technical Affairs—an advanced technology division of the **Chrysler** Group—when Liberty dissolved a few months ago. But for former Liberty staff, their creative contributions continue to shape personal transportation options via **DaimlerChrysler** product teams.

Established in February 1989, the Liberty entourage worked to develop advanced vehicle concepts and prototypes, commonly building demonstration products to showcase potential production technologies.

"Liberty had so much diversity—people in design, people in body/chassis, people in powertrain as well as materials and manufacturing experts—and having those people meant Liberty could produce vehicles with advanced powertrains," said Jeff Cherry, a former Liberty team member now working as a project engineer for fuel-cell programs under the company's Advance Vehicle Engineering umbrella.

DaimlerChrysler is consumer-testing a fleet of fuel-cell passenger cars. The F-Cell is based on the Mercedes-Benz A-Class passenger car.

Future-generation vehicle designs, powertrains (including hybrid-electric and fuel-cell configurations), transmissions, body-chassis systems, lightweight materials, new manufacturing techniques, and telematics represented the bulk of Liberty's development scope. During the nearly 15-year lifespan of the group, various innovations moved beyond the research plateau.

The Large Injection Molded Body Technology (LIMBT) used to produce the hardtops on the 2002 **Jeep** Wrangler was one of many Liberty-developed innovations transferred to a production application. LIMBT initially was used to make the body of the **Dodge** EXS3, a family sedan hybrid concept. The Chrysler Natrium, a concept vehicle that runs on hydrogen extracted from sodium borohydride, was another project with Liberty origins.

"There were quite a few ideas that came from Liberty," said Doanh Tran, Manager of Fuel Cell Technology and Programs within the Advance Vehicle Engineering arena. DaimlerChrysler's F-Cell vehicle eventually was equipped with an onboard nickel metal hydride battery based on Liberty work for the 2000 Jeep Commander 2 fuel-cell concept sport utility vehicle and the 2001 Natrium minivan concept.

F-Cell vehicles recently entered fleet customer testing in the United States, Japan, Germany, and Singapore. "We're gaining valuable information from having F-Cell vehicles in fleet tests," said Cherry, whose focus encompasses Michigan customers such as the United Parcel Service (**UPS**).

"UPS drivers turn the vehicle ignition off and on at every delivery stop—maybe 100 or 200 times a day—and that starting and stopping represents an atypical driving cycle for a hydrogen fuel-cell vehicle. The ultimate software solution might be an adaptive driving cycle algorithm," said Cherry.

F-Cell vehicles represent just one ongoing project with a Liberty tie-in. While the Liberty group name is defunct, the group's staff continues in Advance Vehicle Engineering roles.

"The previous Liberty organization provided underlying technology for many past concept vehicles. The new organization structure helps align the goals, initiatives, and talents of all advance engineering activities into one cohesive focus," said Lou Rhodes, Director of Advance Vehicle Concepts and Innovation, an Advance Vehicle Engineering team that supports product creation of Chrysler Group vehicles.

Kami Buchholz

Combining powertrain forces

Rather than having powertrain engineers doing specific tasks from several buildings spread across southeast Michigan, **General Motors** innovation specialists will now share space in a dedicated facility. The consolidation of powertrain operations is being done to make the group's activities more united.

"It's about having the proximity of people—having everybody together—and it's about having a facility that can run all the tests," said Ed Koerner, GM Powertrain Vice President of Engineering. When the consolidation is completed in 2007, five sites will be removed from the powertrain engineering equation.

Wixom's operations for component testing, Ypsilanti's facility for transmission engineering and testing, Troy's hybrid propulsion systems engineering and testing locale, Warren's center for gasoline engine testing, and Romulus's spot for diesel engine engineering and testing will all vanish as job sites for powertrain engineers and technicians. The five sites will combine into a single site in Pontiac, MI. The Milford Proving Ground will continue as the site for powertrain vehicle integration and emissions testing.

Using multiple sites for powertrain engineering and laboratory work has presented a legacy that the automaker is ready to dissolve. "There is some level of flexibility (now), but not full flexibility," said Koerner.

"We need to change our focus to be working on an integrated powertrain," said Bill Whitley, GM Powertrain Executive Director of Engineering Consolidation Projects and Facilities. "And by being co-located, that will better enable people to work together."

With test equipment and engineers sharing the same work environment, the automaker can use the facility's people and resources to focus on whatever product requires attention at a particular time. "Right now, with the multiple facilities that we have, we can't do that. We're (also) doing a fair amount of outside testing now because we don't have the necessary capacity for a given type of powertrain need," said Koerner. Durability testing, for instance, is commonly done by outside vendors.

The $385 million Pontiac facility will have 90 dynamometers, a drastic drop

Wheel uniformity testing, done at GM's Milford Proving Ground within the Tire and Wheel Center, will not be affected by an upcoming consolidation of powertrain-related testing. But several other testing sites in southeast Michigan eventually will move into a central location in Pontiac, MI.

from the 154 dynamometers the automaker now has for powertrain testing. "We can run tests without operators there, and we will automate the type of data generation we need so we can literally run the facility around the clock," said Koerner, noting that being able to conduct 24-hour testing will enable the reduction in dynamometer equipment.

Much of the equipment in the various powertrain engineering and test sites will be discarded, in part because industry standards mandate different equipment, and because technology is evolving to a point where some test equipment has run its course. "Our current facilities have been in service for many, many years, and a lot of the equipment is outdated. To do the work that we're doing today, we have had to invest in new equipment in some areas. So, of course, the equipment that we can still use, we will transfer to the new facility," said Koerner.

Southeast Michigan has about 4000 powertrain engineers and technicians working for General Motors, and that job tally is not expected to change with the re-location to Pontiac. What will change is how engineers interact. "There's power in co-location. Even in this vast communication world with computers, there's still power in having everybody together. It also gives you the ability to grow and leverage skill sets across different parts of the organization, which is difficult for us when we have multiple sites," said Koerner.

The consolidated engineering and laboratory site will entail adding on to the powertrain engineering headquarters structure, one of three buildings on the Pontiac powertrain campus. When completed, the dedicated space will cover 420,000 ft^2 (39,000 m^2). "That's a 40% reduction in the footprint that is presently utilized by GM Powertrain," said Whitley, who added that having only one "fuel farm" for testing, instead of a fuel supply at every site, plays a role in needing less overall space.

One substantial gain from consolidating powertrain engineering and testing is "increased efficiency and throughput. We'll be able to do a quick change from one testing application to another testing application, which is very much modeled after GM's flexible approach to manufacturing," said Whitley.

Kami Buchholz