Roundup of Japanese Automotive Electronics Suppliers

The fiscal year we refer to as FY 2000 is the period from April 1, 2000, through March 31, 2001.

Aisin Seiki
FY 2000 Consolidated Sales: ¥1,128.5 billion ($9.4 billion)
Change from FY 1999: up 12.8%
Net Profit (Loss): Net loss was ¥7.2 billion ($60 million), compared with a net profit of ¥18 billion ($150 million) in fiscal 1999.
FY 2001 Sales Estimate: Nearly flat, ¥1,130 billion ($9.4 billion)
FY 2001 Net Profit Estimate: ¥24 billion ($199 million), 2.1% of sales

Alpine Electronics
FY 2000 Consolidated Sales: ¥181.6 billion ($1.51 billion)
Change from FY 1999: up 6.1%
Net Profit: ¥3.3 billion ($27 million), or 1.8% of sales, the same margin as last year
FY 2001 Sales Estimate: up 2%, to ¥185 billion ($1.53 billion)
FY 2001 Net Profit Estimate: increase 6.5%, to ¥3.5 billion ($29 million), 1.9% of sales

Calsonic Kansei
FY 2000 Consolidated Sales: ¥430.2 billion ($3.6 billion)
Change from FY 1999: up 55%. Calsonic merged with Kansei in April 2000.
Net Profit: ¥1.8 billion ($15.1 million), 0.4% of sales
FY 2001 Sales Estimate: nearly flat, ¥440 billion ($3.65 billion)
FY 2001 Net Profit Estimate: ¥2.2 billion ($18.2 million), 0.5% of sales

Clarion
FY 2000 Consolidated Sales: ¥188.7 billion ($1.6 billion)
Change from FY 1999: down 1.6%


Model-Based Tools Update

Obstacles Make For Slow, Piecemeal Adoption
Software content has become the embodiment of most intellectual property aboard the vehicle, and its development will continue to be one of the fastest-growing segments in automotive electronics. A software has grown in size and complexity, software specs written as text documents have grown unwieldy, from a few pages to hundreds of pages. A result, complicated handwritten software specs can yield ambiguous results. The time it takes to develop proper software has expanded greatly and the cost has mushroomed.

Increasingly, as OEMs adopt a model-based tools environment, a computer model will replace the handwritten text specification given to OEM suppliers responsible for software implementation. The software model, a precise description of the vehicle subsystem, is a functional and visual representation of what the OEM desires. Model-based development tools will simplify and shorten the design and development process from concept through implementation, while creating software for onboard vehicle systems that is more reliable yet much less expensive to design.

OEMs first used software models in powertrain systems nearly a decade ago. Today software algorithms manage computer-aided design tools and methods automate the design, testing and implementation of software control algorithms. The model-based process begins with a computer-generated behavioral model that specifies the vehicle product planner’s requirements.

Benefits
- Compared with handwritten text specifications, software computer models are unambiguous, leading to reliable vehicle systems and customer satisfaction.
- Software development tools improve engineering productivity and speed, which results in dramatically lower software-development costs.
- With shorter development cycles, carmakers can bring appealing new features to market faster.
- With proper tools, carmakers will need fewer software developers, a scarce and expensive resource.
- Software models can be reused on vehicle models and vehicle platforms other than those for which the models were originally designed.
- Currently, software code is created for a particular computer platform and operating system, and rewriting code for different computer platforms is a monumental task. Model-based tool development will lead to the use of more advanced tools, particularly automatic generation of new code for different computer platforms and operating systems at the touch of a button.

- Before the actual code is written, model-based tools can find and correct errors in the system requirements and functional models. By doing so early in the development process, changes are far less costly than after code has been written.
- As software systems get more complex, and vehicle systems get more dependent on each, model-based development will be the only way to quickly develop code that reliably works with all the systems.

Obstacles
- Some major software/ECU suppliers are not able to make use of computer models.
- Design tools are complicated and difficult to operate; some take months to learn.
- Experienced electrical engineers are sometimes reluctant to embrace model-based design methodologies.
- Software writers that now code by hand may feel automatic code generation threatens their employment.
- To be fully effective, tools must be integrated into a revamped design process, yet many top OEM managers have not yet committed to making the changes necessary to accommodate that process. Strong management oversight, sufficient financial resources and radical reorganization of workflow.

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Roundup...

Continued from page 1

Alternative Power Concepts Promise Fuel Savings

Simulation results for reference vehicle, 3-cylinder turbocharged diesel engine, 1,000 kg, in MVEG Cycle (European reference cycle).

<table>
<thead>
<tr>
<th>Power Concept</th>
<th>Fuel Economy (mpg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>47.2</td>
</tr>
<tr>
<td>Parallel Hybrid</td>
<td>60.3</td>
</tr>
<tr>
<td>CVT with Start-Stop</td>
<td>73.5</td>
</tr>
<tr>
<td>AST with Start-Stop</td>
<td>73.5</td>
</tr>
<tr>
<td>CVT</td>
<td>60.3</td>
</tr>
<tr>
<td>AST</td>
<td>60.3</td>
</tr>
<tr>
<td>Conventional Drive</td>
<td>53.5</td>
</tr>
</tbody>
</table>

Parallel Hybrid: Two prime movers, an internal combustion engine plus an electric hybrid motor. CVT: Continuously Variable Transmission. AST: Automatic Shift Transmission, is a manual transmission equipped with electric or electrohydraulic actuators for shifting and clutch control.

Source: Bosch, The Hansen Report

THE HANSEN REPORT ON AUTOMOTIVE ELECTRONICS

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Automatically Generated Code

Models can and will increasingly be linked to software tools that automatically generate production-ready code from models. While targeted to a particular embedded computer platform aboard the vehicle, by going back to the model, new code for different computer platforms or operating systems can be generated. Unfortunately, compared with handwritten code, automatically generated code is not nearly as precise and conservative of memory and computing throughput.

Today automatically generated code is eight- to ten-times larger in size than handwritten code, but automatic code generation tools are getting better. "Vendors have been testing prototype code generation tools that develop code for specific applications that are almost one-to-one comparable with handwritten code," according to Rick Flores lead engineer, software development process at General Motors.

With model-based development tools, systems engineers can take advantage of so-called hardware-in-the-loop tools that simulate and test how the model works when connected to the rest of the system, or to other interacting systems. Hardware-in-the-loop tools can test the model in a working system either in the vehicle or on the bench. Once the model has been tested and verified, tools can automatically write production-ready code. I-Logix’s Statemate MAGNUM tool can automatically generate any combination of C, Ada, VHDL or Verilog code for vehicle systems.

Given that automatically generated code can itself be tested and verified by tools, Neeaj Chandra, senior vice president, sales and marketing at I-Logix, suggested that companies could easily retarget their applications from an operating system that requires royalty payments, such as the VxWorks, to one that doesn’t, like Linux.

Slow Adoption Despite Promise

While model-base software development tools promise a way to deal with the growing complexity of software used in vehicles, more than another decade will pass before carmakers fully adopt model-based tools. The degree to which the world’s leading carmakers are adopting such tools varies enormously, with several barely beginning to exploit their potential. Generally, carmakers have not committed sufficient resources to computer-aided model-based tools and to the training and reorganization required to make them effective. Seeing some pilot programs that prove tools work as advertised would help carmakers make the necessary investments.

Salim Momin, director of Motorola Semiconductor’s Virtual Garage in Northville, Michigan, had this advice on how carmakers could advance the adoption of model-based tools: “First, education. Then, you need to define the process, pick a pilot program, partner with suppliers and work through it. You will have to iterate a couple of times. ... Perhaps a pilot program could be funded through a USCAR initiative, in which carmakers fund the effort and establish incentives for tool vendors to provide solutions, based on the process they have developed.”

John Binder, automotive industry manager for The MathWorks, told us that in the next five to ten years, the automotive market for tools, like Simulink, will grow ten times over what it is today.

Body Electrical and Electronics Control

Today, the best application of model-based tools and processes is body systems development, suggested Momin’s Mr. Momin. “With so many new features and gadgets coming into the body, [body control systems] are the fastest growing part of the vehicle for software code development, yet not nearly as complicated as powertrain control systems.” For almost five years, Mr. Momin has advocated model-based tools and processes as the best means to shorten the time it takes to bring new components to production.

Increasingly, software will be the key ingredient in body control systems, including instrument cluster, seat controls, HVAC, remote keyless entry systems, interior lighting and door locking systems.

Chrysler’s Model-Based Software

Chrysler’s Jeep Liberty project may well be the most advanced application of body electronics in a production vehicle.
The Company Profile... Robert Bosch GmbH

Robert Bosch GmbH
Headquarters: Postfach 10 60 50, D-70049 Stuttgart, Germany; phone: 49 711 811-0; fax: 49 711 811-6630; www.bosch.com
2000 Sales: 61,717 million DM ($27,921 million)
R&D: 6.4% of sales in 2000
Investment in Tangible Fixed Assets: 4,128 million DM ($1,868 million)
Net Income: 4.4% in 2000; 1.7% in 1999
(Percents based on special effect of “pay-out-and-reinvest” accounting procedure.)
Employees: 198,700 (as of January 1, 2001), up 2.0% from the prior year
Ownership: The Robert Bosch Foundation owns 92%; the Bosch family owns 8%.

Robert Bosch Corporation: Wholly-owned subsidiary of Robert Bosch GmbH; responsible for North American operations
Automotive Group Headquarters: 38000 Hills Tech Drive, Farmington Hills, Michigan 48331-3417
2000 Automotive Sales: $4.4 billion, up 4.8% from the prior year

Background

Bosch was founded in 1886, when the 25-year-old Robert Bosch started the Workshop of Precision Mechanicals and Electrical Engineering in Stuttgart, Germany. Eight percent of the company is still owned by the Bosch family. In June 1964, the heirs of Robert Bosch transferred a majority of their holdings into a nonprofit foundation, the Robert Bosch Foundation, to pursue charitable goals. Today, the Robert Bosch Foundation owns 92% of the Bosch Group, and it is one of the largest nonprofit industrial foundations in Europe.

However, the Robert Bosch Foundation’s 92% ownership does not give it voting privileges. Robert Bosch Industrialtreuhand KG, known as the Robert Bosch Trustee, has 93% of the votes. The Board of Management, which handles the day-to-day operations of the company, reports to a 19-member Supervisory Council, whose members, currently all Europeans, come from the Bosch Group, trade unions, outside corporations, the Bosch family and the financial community.

The Bosch Group is not then a publicly-traded company, and that gives the company a big advantage when it comes to financing. Kurt Liedtke, chairman and CEO of Robert Bosch Corporation, as well as a member of the Robert Bosch GmbH Board of Management, noted that Bosch doesn’t rely on irrational or fickle stock market valuations for financing. While acquisitions have been funded recently by borrowing through company-issued bonds, earlier acquisitions were funded by Bosch’s own capital reserves. (A publicly-traded company with such large cash reserves would be susceptible to an unfriendly takeover.) Two recent acquisitions funded by company-issued bonds were fuel-injection-pump maker Zexel (Japan) in 1999, and the April 2001 acquisition of German hydraulics-maker Rexroth from Mannesman. (In April 2000, Siemens and Bosch agreed to each acquire various businesses that make up A tecs Mannesman. Today Rexroth is 100% owned and managed by Bosch, and the V DO division of Mannesman is 100% owned and managed by Siemens Automotive.)

Even before the acquisition of Zexel, now known as Bosch Automotive Systems Corporation, Japan was Bosch’s third most important foreign market. Currently, sales in Japan are about the same as those in France. The company has 34 consolidated subsidiaries, with 24 in Japan, three in the U.S., two each in Thailand, Belgium and Germany and one in South Korea, according to the Thomson Financial Network. Sales contributed by overseas companies more than doubled, from 16% to 34%, over the last decade.

Automotive Product Strategy

Since the mid-1970s, Bosch’s 3-S product strategy has guided most product and investment decisions. The 3-S principle stands for safety, emissions and economy (in German). “We have reviewed that basic product and investment strategy three times in the last decade, most recently last year, and concluded that the 3-S’s are still the right things to emphasize,” said Bob Oswald. Before his recent retirement, Mr. Oswald was chairman and CEO of Robert Bosch, and a member of the Robert Bosch GmbH Board of Management.
Safety has led to the current hot-selling product Electronic Stability Program (ESP). In the future, ESP will be integrated with other systems, like steering and suspension, to prevent accidents.

Emissions reduction applications have led to products and systems that cut down on CO₂, as well as toxic gas emissions, such as CO, NOx and sulfur dioxide.

Economy: By the year 2008, European automotive manufacturers are committed to reducing average CO₂ emissions in new vehicles by 25%, from 1995 levels. Since CO₂ is directly proportional to the amount of fuel consumed, deployment of new technologies that improve fuel economy in direct injection diesel and gasoline engines will lead to reductions in CO₂.

A few Bosch product lines do not seem to fit that strategy, for instance, multimedia. Blaupunkt makes a full line of audio and video entertainment products that seem to have little to do with safety, emissions or economy.

### Bosch Key Competitive Strengths:
Technology, as well as a unique corporate ownership structure that gives it greater financial strength compared with competitors

Employees: 140,000 (as of December 31, 2000); 12,600 of whom are in R&D

Bosch has recently reorganized the sector, including ZF Lenksysteme GmbH (50% owned), into three divisions: Gasoline Systems, Diesel Systems, Chassis Systems, Energy Systems, Body Electronics, Car Multimedia, Blaupunkt GmbH, 100% owned by Bosch), Automotive Electronics and Automotive Aftermarket.

#### Automotive Technology Focus
One manifestation of the success that R&D investments have brought to Bosch is that few automotive companies own more automotive patents than Bosch, according to the company. In 2000, Bosch filed 2,400 patent applications, 350 more than in 1999.

Compared with its major competitors, Bosch has invested heavily over the years in automotive R&D to maintain distinctive competences. The Automotive Equipment Sector contributed 71.2% of total Bosch Group sales in 2000, about 44.0 billion DM ($19.91 billion), of which 7.5% of sales went to R&D spending.

Bosch automotive sales per vehicle in 2000 ranged from zero to 7,000 DM ($3,167), averaging 650 DM ($294) per vehicle.

Over the last five years, these product lines benefited the most from Bosch investments in automotive technology:

- **Diesel Systems and Components:** $5 billion DM ($2.3 billion)
- **E-Brakes,** including ABS, stability control and electro-hydraulic brakes: 2.6 billion DM ($1.2 billion)

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**Diesel Engine Products**
Bosch says it is the world’s leading source of diesel engine components and systems. Among all Bosch Automotive Equipment products, diesel products have given the biggest boost to total sales, and diesel product R&D is more than twice that of electric brakes, the next biggest investor in R&D.

In Europe, greater use of diesel engines is a trend that Bosch has been riding. Bosch sold 9.6 billion DM ($4.3 billion) worth of diesel systems and components (fuel-injection products, mostly) in 2000 and expects to sell nearly 11 billion DM ($5.0 billion) worth in 2001. In 2000, 32.3% of all new cars sold in Western Europe had diesel engines, compared with 21.7% in 1997. Analysts predict that diesels will account for 40% of the total engines sold in Western Europe by 2005.

According to Bosch, 75% of diesel engines in Europe currently benefit from direct-injection technology. Direct-injection diesels consume less fuel, emit less exhaust gas, and operate more smoothly than engines without direct injection.

In the United States and Japan, the level of interest in diesels is not nearly that of Europe. By some accounts less than 3% of new American cars have diesel engines and likewise, only about 9% of Japanese consumers buy diesel-continued on following page
equipped vehicles. One reason Europeans buy diesel-powered instead of gasoline-powered vehicles is fuel economy. In Europe, the price of gasoline is more than twice what it is in the States. While gasoline prices in Japan are as high as they are in Europe, many Japanese consumers still believe, as Americans do, that diesels are smoky, underpowered, noisy and hard to start, despite new diesel technologies that have eliminated these negative characteristics.

According to a recent New York Times article, both environmentalists and governments in Europe agree that for diesel, as it is formulated in Europe, is more fuel-efficient and produces fewer greenhouse gases than gasoline. U.S. antipollution regulations restrict the sale of diesel engines, and Americans see no reason to change that. A new report, commissioned by the U.S. Congress from the National Academy of Sciences due out in July, suggests that the U.S. rethink its diesel policies. President Bush has said he is waiting for the report before deciding to change fuel-efficiency standards for vehicles. However, the president has decided to let stand President Clinton’s rule to clean up diesel fuel in the U.S., much dirtier than diesel fuel in Europe, by reducing the amount of sulfur, from 500 ppm today down to 15 ppm over a three-year period.

The American oil industry lobbied to prevent that rule from taking effect in June 2006. Too much sulfur in diesel fuel impairs the operation of the exhaust gas after-treatment system, both the particulate filter and the DeNOx catalyst.

**European Diesel Engines: Cleaner and Fun To Drive**

Direct-injection diesel technology has improved diesel engine performance to the point that diesel is now quite popular in Europe. BMW and Mercedes sell diesel engines in nearly half of their most expensive cars, according to the New York Times article. Kurt Liedtke suggested, “The great success of diesels in Europe doesn’t only come from the engine’s fuel economy. It comes very much from the fun of driving a car with a powerful diesel engine. If you drive a BMW 8-cylinder diesel, this car puts out 560 newtons [of force]. Next year the VW Passat D1 will have a 10-cylinder diesel engine that has 750-newton meters.”

Three new direct-injection components are primarily responsible for the recent surge in sales of Bosch diesel systems and components: a new common rail system (CRS), a new unit injector system (UIS) and a high-pressure distribution pump (VP44). These products have contributed to better fuel economy, and more powerful and cleaner engines by bringing fuel pressure higher for better atomization in the combustion chamber, and through better control of the volume of fuel delivered as a function of time. Bosch’s unit injector system operates at 2,050 bar.

Not only is the primary injection carefully metered, but so are pre- and post-injections of fuel. After a cold start, pre-injections can reduce white or blue smoke as well as engine noise. Post-injections reduce carbon emissions and help regenerate the particle filter. Piezo-controlled injectors, which switch quickly and precisely, will be part of the common-rail injector systems that become available for production in 2002.

Bosch is also developing exhaust-gas treatment systems that are essential to making diesel engines cleaner. So that midsize and larger vehicles can pass Euro-IV emission mandates that come into effect in 2005, Bosch is working on particulate filters. The company is also working on other emission control components and systems, like exhaust gas recirculation systems and turbo chargers, as well as developing improved fuel injectors and electronic control units.

**Gasoline Engine Management**

Despite a trend toward more diesel engines, Bosch believes that the spark-ignition engine will continue to be the world’s most important vehicle power source for a long time. Indeed, the company believes the spark-ignition engine has enormous potential for improvements in emissions reduction, acceleration and fuel efficiency.

While Mitsubishi Motors pioneered in the commercialization of the stratified-charge gasoline direct-injection engine, Bosch believes that its direct-injection technology will take the gasoline engine to the next level. In a press release, Bosch writes that it set the standard for gasoline direct injection technology with its first commercialized system, which goes into production in the new Audi A8. Bosch believes that its direct-injection technology will help improve fuel economy, reduce emissions and improve performance.

**Investments in the Japanese Auto Parts Industry**

More than other Western auto parts suppliers, Bosch owns controlling interests and minority positions in several large Japanese auto parts manufacturers. Currently, the company has 24 consolidated subsidiaries in Japan. Bosch had interests in the following companies in Japan, as of March 2000.

<table>
<thead>
<tr>
<th>Company</th>
<th>FY 1999 Sales</th>
<th>Employees</th>
<th>Bosch Ownership</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akebono Brake Industry</td>
<td>¥95,443 million ($796 million)</td>
<td>2,850</td>
<td>Robert Bosch Corporation, 13.39%</td>
<td>Brake systems, components, friction materials, pads</td>
</tr>
<tr>
<td>Bosch Automotive Systems</td>
<td>¥196,065 million ($1,635 million)</td>
<td>4,769</td>
<td>Robert Bosch GmbH, 51.2%</td>
<td>Diesel and gasoline fuel-injection equipment</td>
</tr>
<tr>
<td>Bosch Braking Systems</td>
<td>¥77,137 million ($643 million)</td>
<td>3,331</td>
<td>Robert Bosch Group, 10.17%; Bosch Automotive Systems, 50.3%</td>
<td>Braking systems</td>
</tr>
<tr>
<td>Bosch Electronics Corp.</td>
<td>¥9,555 ($80 million)</td>
<td>259</td>
<td>Robert Bosch GmbH, 50%; Bosch Automotive Systems Corp., 50%</td>
<td>Electronic components and ECUs</td>
</tr>
<tr>
<td>Denso Corporation</td>
<td>¥1,387 billion ($11,568 million)</td>
<td>38,200</td>
<td>Robert Bosch GmbH, 5.18%</td>
<td>Electric and electronics parts, other auto parts and systems including climate-control</td>
</tr>
<tr>
<td>Nippon Injector</td>
<td>¥10,559 million ($88 million)</td>
<td>296</td>
<td>Robert Bosch GmbH, 35%</td>
<td>Fuel injectors</td>
</tr>
<tr>
<td>Unisia/JECS Corp.</td>
<td>¥185,640 million ($1,548 million)</td>
<td>6,021</td>
<td>Robert Bosch GmbH, 10.1%</td>
<td>Auto parts, machine tools and electronics parts</td>
</tr>
</tbody>
</table>

The Company Profile Continued

the introduction in 2000 of Bosch’s new D1 Motronic system on the Volkswagen Lupo FSI. “Thanks to direct-injection stratified-charge technology and other technical measures, fuel consumption in this car was reduced 15% compared to conventional manifold injection.”

Bosch is working on the second generation D1 Motronic, which will use a high-pressure fuel pump. Improvements to D1 Motronic components will bring fuel consumption down another 5%, for a total fuel savings of 20%, compared with manifold injection engines. Improvements include development of a new gasoline fuel injector that has a spray-guided pattern like diesel injectors, as well as a faster, more precise electrically-actuated exhaust return valve and improved ignition systems. Bob Oswald elaborated: “We have put a strong emphasis on delivering consistent direct-injection test results. Our second objective is to reduce the cost of the system, so it is more commercially accessible. The cost challenge comes from the fact that we are dealing with high-precision components and a complicated control system.”

E-Brakes

ESP: Bosch antilock braking systems (ABS) were first introduced in 1978 and today the ABS market is mature. The next major advance in E-brake (electronically controlled brake) systems happened in 1995 when Bosch brought out its Electronic Stability Program (ESP). Today ESP is very hot, with penetration likely to grow significantly worldwide over the next 10 years. In 2002, Germany will lead the way with ESP applied to 56% of the vehicles produced there. Bosch shipped 1.4 million ESP systems in 2000. Unit sales of ESP has grown at the annual rate of 44% since 1997.

ESP uses a hydraulic modulator to control brake pulsing at each wheel, an electronic control unit and sensors that measure yaw, sideways acceleration and the position of the steering wheel. ESP, which is automatically activated without driver intervention, can be connected to the traction control system to modulate the powertrain torque. Modulating the brakes independently at each wheel and controlling the drivetrain minimizes skidding.

A cording to the Institute for Vehicle Safety in association with the German Insurance Business Association, in 30% to 40% of all fatal accidents in Germany the vehicle began to skid due to excessive speed, exaggerated steering reaction or driver error. Based on this data, the institute issued a recommendation for safety systems such as Bosch’s ESP.

A cording to Bosch, these are the benefits of ESP:
- Improved steering
- Reduced danger of slipping or skidding
- Greater vehicle stability within physical limits
- Optimized stopping distances

<table>
<thead>
<tr>
<th>Electronic Stability Program Penetration in Percent</th>
</tr>
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<tbody>
<tr>
<td>2000</td>
</tr>
<tr>
<td>Germany</td>
</tr>
<tr>
<td>Europe</td>
</tr>
<tr>
<td>World</td>
</tr>
<tr>
<td>Japan</td>
</tr>
<tr>
<td>NAFTA</td>
</tr>
</tbody>
</table>

EH B: After ESP, the next E-Brake product to be implemented will be the electro-hydraulic brake system (EH B). In vehicles without EH B, the driver must apply enough brake pressure to bring the vehicle to a stop by pressing forcefully on the brake pedal; foot pressure exerted on the master cylinder in turn produces hydraulic brake pressure on the wheels. In contrast, EH B delivers full-authority brake pressure automatically, from a high-pressure brake reservoir. An electric-motor-driven piston pump pressurizes the hydraulic fluid. When the driver activates the brakes or when ESP intervenes to stabilize the vehicle, the EH B control unit calculates the brake pressure required at each wheel. EH B is able to bring the vehicle to a full stop and will complement adaptive cruise control systems designed to operate in stop-and-go traffic.

Additional advantages of EH B:
- Soft, smooth stopping
- When the roads are wet, EH B will automatically and instantly pulse the brakes to dry the brake discs so the brakes can operate normally.
- When idling on an incline, the car will stay put even without a foot on the brake, once the brake pedal is firmly pressed. The brakes are then automatically cancelled when the driver puts his foot on the accelerator.

Bosch has been developing EH B with DaimlerChrysler for some time, and according to a source at DaimlerChrysler, EH B will first appear in production on the new Mercedes SL in the fall of 2001.

Aviation

Over the last five years, Bosch has invested 500 million DM ($200 million) to bring navigation systems to market. That continued on following page

Bosch Automotive Products

<table>
<thead>
<tr>
<th>Powertrain</th>
<th>Alternator starters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injectors</td>
<td>Air moving equipment</td>
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<td>Electric fuel pumps</td>
<td>Engine cooling modules</td>
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<td>Fuel pump kits</td>
<td>Relays and switches</td>
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<td>Fuel rail assemblies</td>
<td>Small motors</td>
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<td>Fuel injector coils</td>
<td>Airbag sensors</td>
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<td>Pressure regulators</td>
<td>Electronic control units</td>
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<td>Oxygen sensors</td>
<td>Windshield wiper systems</td>
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<td>Integrated air/fuel modules</td>
<td>Rear park-assist systems</td>
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<td>Common rails</td>
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<td>Inline injection pumps</td>
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<td>Injection pumps</td>
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<td>Electronic diesel controls</td>
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<td>Unit injection systems</td>
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<td>Transmission controls</td>
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| Electronic/Electrical
| Vehicle entertainment systems | Master cylinders |
| Video sensors | Front- and rear-disc brake calipers |
| Navigation systems | Drum brakes |
| Programmable instrument clusters | Disc, wheel-hub and bearing assemblies |
| Bosch Automotive Products: Bosch Product Line NEW ! | \_ Adaptive cruise control systems |
The Company Profile Continued

Investment seems to be paying off—Bosch sold 775,000 navigation units in 2000 and plans to sell 1.2 million units in 2001. Bosch sold only about 250,000 navigation systems in 1998. In 2000, two-thirds of Bosch’s navigation units were shipped to OEM customers; one-third were sold in the aftermarket.

Bosch owns navigation mapping technology that it licensed to Denso, the company with the leading share of the Japanese OEM market for navigation equipment. Bosch owns 5.18% of Denso. Bosch has invested in dynamic route guidance systems that take account of current traffic conditions. With a dynamic route guidance product on the market since 1999, Bosch says it is the world’s number-one player in the product category.

**Semiconductor Product Strategy**

Bosch chooses to make in-house the application-specific semiconductors that are unavailable from other sources. Ten years ago, Bosch was not interested in marketing to the outside world the semiconductors it made in-house. That has changed, and today, 40% of its semiconductors are sold to outside customers. Kurt Liedtke cited this example, “The high-temperature diodes that we are using in our generators, we are also selling to Valeo and to Delphi.” In addition, Bosch sells sensors, including acceleration sensors, to outside customers.

### Tools...

The program for the Liberty SUV, Jeep’s replacement for the Cherokee, was so successful that the Chrysler group will probably adopt the model-based approach for other platforms. The 2002 Liberty went on sale in May with a suggested list price of $17,000; production could reach 200,000 units per year.

Bob George, who is in charge of electrical/electronics engineering for Jeep, and also has responsibility for Chrysler’s electrical engineering tools and methods group, told us, “On the Liberty, we decided to do away with written specifications altogether, and using Statemate from I-Logix, we gave our supplier [Huntsville Electronics] models from which [the supplier] wrote the software.” Chrysler also used a software tool to test the written code versus the model, but did not use automatic code-generation tools or hardware-in-the-loop testing.

The project was difficult, according to Mr. George, who felt he successfully managed the project because he was in control—of databases, tools and the body electrical engineers who all report to him—so he was able to issue the decree, “You shall do it.” “It’s not just a matter of buying some tools and using them,” he added. “It’s more a matter of human behavior. A tool we expected, there was a lot of pain as we tried to change the engineering process.”

The return on investment, however, was “fantastic,” explained Mr. George. “We were able to shorten development time and the launch itself was glitch free as far as body electronics were concerned.” Further, he expects that as the launch continues, there will be no major electrical quality problems. While Chrysler Liberty engineers plunged into model-based tools, DaimlerChrysler Stuttgart is holding back. Dr. Thomas Raith, responsible for electrical/electronics systems integration, explained: “In contrast with our colleagues at Chrysler, we have the problem that some of our key engineers, who work on these systems, are not convinced. Our culture is different here in Germany. We can’t just tell our engineers what to do, we have to convince them that it’s right.”

**General Motors**

Electrical engineers at GM are just beginning to apply modeling tools to body systems. Ben Baker, director of GM’s Electrical Product and Process Engineering Center, told us, “A system of systems have gotten more complex, we are at the point where we need tools to help us with the integration.” GM’s Mr. Flores added, “A system gets more complex, we would like to add more rigor to the process, and tools would do that.”

GM is currently struggling with the same obstacles that have bedeviled other carmakers, most notably, how to motivate engineers to use the system. Mr. Flores noted: “The background of our functional experts is electrical engineering, not necessarily software code development.” Mr. Baker compared introduction of software modeling tools to introducing word processors when they were first available. While initially there is resistance, once users get comfortable with them, there is no turning back.

A concomitant of one industry insider, GM has made progress, and its work to build the infrastructure necessary to deliver models to suppliers could begin to pay off by MY 2003 or 2004 in body electronics in the Cadillac Seville.

**Ford**

For years, Ford has been applying The MathWorks’ Simulink modeling tools for continuous control systems, but has been the slowest among the Big Three to take up body electronics modeling software. We asked Paul Duffy, manager of Ford’s electrical and electronics computer-aided engineering department, to share his thoughts on why that might be. Mr. Duffy told us that one reason Ford has been slower to implement tools is that the carmaker has a different tool philosophy from other carmakers: “Tools are so complicated to use that they should probably be operated only by specialists.” Therefore, the carmaker does not buy a license from the tool vendor for every designer.

Like others in engineering management, Mr. Duffy believes that only incremental changes have occurred so far, and that the design and development process must change dramatically. The reason the process is so slow is that the necessary changes will be orders of magnitude more difficult than the changes that have occurred so far. A application of model-based tools at Ford has been piecemeal, according to Mr. Duffy, and Ford is maybe one tenth of the way to where it will be in five to eight years. He predicted that in eight to ten years, there would be a quantum leap in the application of model-based design.