Detroit Startup ElectroJet Could Soon Take Off

A mid the gloom in Detroit and in spite of the global automotive industry crisis, a promising vehicle electronics startup founded by a young electrical engineer is well-positioned for a prosperous 2009. ElectroJet, based in Brighton, Michigan, is on the verge of booking big orders for its electronic fuel injection system. Several Chinese motorcycle makers need and want the product in order to pass new Euro III-like emission laws scheduled to take effect in China starting in 2010.

Founded in 2003, the company’s technology and manufacturing processes are mostly in place. The only major hurdle that remains is winning independent certification in China for each of the motorcycle models that have been equipped with the ElectroJet prototype.

With little sales revenue thus far, ElectroJet plans to ship 500,000 EFI systems in 2009, which will produce revenues of $18 million to $20 million in 2009. By 2014, ElectroJet expects sales in the billions.

Turn to ElectroJet, page 3

DSRC and Vehicle Infrastructure Integration in Trouble

No Funding in Sight

At the ITS World Congress in New York City this past November, carmakers and a research institute ran very impressive live demonstrations of what could be the next breakthrough in vehicle safety technology: car-to-car and car-to-infrastructure communications. The technology, known these days by its only slightly simpler name—vehicle infrastructure integration or VII—lets vehicles see potential hazards that might be around the bend, over the hill or at intersections. Experts agree that with advanced warning, more accidents could be avoided, saving lives, reducing injuries and property damage, and improving traffic flow. But the build-out cost of the infrastructure required to deploy these enhanced safety technologies makes them a luxury few nations can presently afford.

I rode in a fully autonomous vehicle, developed by Southwest Research Institute (San Antonio, Texas), which automatically stopped at a green light when a pedestrian suddenly emerged from behind a vehicle parked at the curb. A very graphic demonstration of the safety potential of car-to-car communications, the pedestrian had been spotted by a separate LiDAR-equipped vehicle near the intersection, which automatically relayed the pedestrian’s position, speed and direction of travel to the SwRI vehicle.

A Mercedes S-Class sedan I rode in automatically slammed on the brakes when the driver tried to speed through a red light. The demo showcased the vehicle’s ability to act on real-time information broadcast by a roadside traffic signal controller equipped with DSRC (dedicated short range communications). The traffic signal information was enhanced by onboard navigation equipment and sensors, including a front-view camera. Volkswagen, Nissan, Honda and Toyota also presented vehicles that demonstrated VII applications.

“The important message of the demos is that the research is done,” explained Russ Shields, chairman of Ygomi, LLC, a U.S.-based holding and operating company, and the gray eminence behind ITS World and the promotion of VII technology. “The car-to-infrastructure stuff is done. The DSRC radios are done. The communications are done. We’ve proven the research. Now we need to figure out how we get the infrastructure built out.”

Current conceptual plans for VII technology call for deployment via a network of short-range DSRC beacons. The beacons, one per major intersection and along main highways, will enable two-way data communication with DSRC-equipped vehicles.

According to estimates, installing a nationwide network of beacons throughout the United States would cost between $11 billion and $15 billion, plus hundreds of millions of dollars each year for maintenance. In addition, carmakers would need to install DSRC transceivers, costing several hundred dollars, in every new vehicle. The investment necessary to build the VII infrastructure is by any measure enormous. So the major unanswered question and obstacle becomes “How do you fund VII?”

It’s a problem that the global recession and very troubled auto industry have made all the more complex.

Industry officials and those advocating for VII agree that the technology will greatly improve safety and reduce congestion. “Forty-one thousand people are killed each year in road accidents,” said Scott Belcher, president and CEO of ITS America. “And if you take the money spent or lost in the U.S. as a result of traffic accidents, and the money wasted on traffic accidents, and the money wasted on...
DOT’s Brubaker: “Don’t Limit VII to DSRC”

In the United States, DSRC advocates were thrown a curve earlier this year when Paul Brubaker, a top Department of Transportation official responsible for research, began to seriously question the single-minded focus on DSRC as the de facto communications standard.

“We don’t think it is prudent or necessary at this point for the government to make this giant commitment to DSRC and go off and spend—there are estimates between $11 billion and $15 billion, and it would probably be north of that—to deploy a DSRC infrastructure, when you’ve got Wi-Fi hot spots and mobile ad hoc peer-to-peer networks that will be enabled by IPv6 (Internet Protocol Version 6). … I think we fell into a trap a while back, when we started putting all the eggs in one basket [DSRC] as opposed to taking a dispassionate step back and looking at the horizon,” said Mr. Brubaker, who is himself a top DOT official.

Mr. Brubaker’s replacement will soon be named by the Obama administration.

“But understand,” he cautioned, “we are not suggesting that we are going to turn our back on DSRC. DSRC should be part of a comprehensive solution involving an interoperable platform. … We want to concentrate on coming up with a high level open architecture approach, so if you go out and buy a DSRC-enabled device and somebody comes along with a WIMA X device, or a 3G device or an LPE device, all of these devices should be interoperable and IP-based.”

Mr. Brubaker believes that an open architecture will help the DOT meet some of its safety and mobility objectives by taking advantage of communications infrastructure that will be built and funded by the private sector. “The private firms are investing heavily in this infrastructure. We want to ride that wave.”

Infrastructure Is Necessary

Not much can happen without a communications infrastructure, says Ralf Herrtwich, director of information and telematics group research and advanced engineering at Daimler AG:

“One of the most compelling VII applications is probably hazard warning, which lets drivers know exactly what’s coming in the next two kilometers—black ice, fogbanks or traffic jams, for instance. To me hazard warning is not possible with a mere vehicle-to-vehicle system. With V-to-V you have the inherent problem of providing a value proposition to early buyers because you need to rely on many, many other vehicles equipped to communicate with your vehicle. The likelihood that another vehicle driving nearby will have the same [communications] unit is, unfortunately, pretty small. This is why we say that we need to start with vehicle-to-infrastructure communications, so we can provide instant value on day one.”

In Europe, the Car 2 Car Communication Consortium, a group of carmakers and suppliers working to standardize interfaces and protocols for communications between vehicles and the infrastructure, estimates that at least 10% of the vehicles on the road need to be equipped with a communications device in order for inter-vehicle danger warning applications to work. Even under ideal conditions, where 100% of new cars are equipped with communications, reaching that 10% penetration would take at least a year and a half. Reaching 50% penetration would take more than six years.

A N Alternative Approach to Funding

With the U.S. economy ailing, it’s hard to imagine the federal or state governments coming up with the necessary funding anytime soon. There has been nothing definitive to suggest that DSRC funding would be part of President-elect Obama’s soon-to-be-released economic stimulus package aimed at clean energy and improving highways and bridges. A tentative approach is attracting the private sector.

According to Mr. Shields, some groundwork has been laid with the current U.S. Department of Transportation for a private consortium to make an investment, similar to what has been done with private toll roads. “A company would be selected and given the right to build and operate the infrastructure, maybe on a 40-year term. The safety and environmental communications would be free; other government-related communications services could be purchased by the government and paid for on a monthly basis. A ny left-over capacity could be used for commercial purposes. … The spectrum that has been allocated [for DSRC] would probably be valued at $10 billion to $15 billion. It’s a huge asset.” Mr. Shields believes the next step would be for the FCC and the new U.S. DOT leadership to get together,continued on page 3
ElectroJet... Continued from page 1

Excess of $500 Million. While it has not yet booked a major order, the company says it has letters of intent from several major customers.

ElectroJet’s product advantages are compelling. The electronic fuel injection system, including fuel pump, injector, throttle body, sensor and electronic control unit, is completely self-contained and a direct replacement for the carburetor; no engine modifications are required. Providing complete engine control, both spark and fuel, it meets the new emissions requirements and provides a 12% to 15% improvement in fuel economy, better starting, more power, improved acceleration, and it costs only $15 more than the carburetor and catalytic converter system it replaces.

In China, ElectroJet is competing against systems that meet Euro III with a carburetor and catalytic converter. Electronic fuel injection has obvious advantages over carburetors. EFIs are calibrated digitally. Carburetors are tuned with screws, so settings can be altered in the field or changed as the engine ages, making it difficult for the manufacturer to guarantee emissions compliance. Compared with carburetion, fuel injection results in a 10% to 25% improvement in fuel economy and a reduction of emissions between 35% and 85%.

What’s special about ElectroJet’s electronic fuel injection system is its extremely low cost. “Most of the motorcycles developed for developing countries sell brand new for $550 or $600,” noted Kyle Schwulst, the 29-year-old founder of ElectroJet. “You can’t take an automotive fuel injection system that costs between $130 and $150, or more, and put it in a $600 motorcycle. The benefits are great, but the price is way too high.”

The key to ElectroJet’s tremendous cost advantage over automotive electronic fuel injection systems is its reliance on a single pressure sensor in the air-intake track, from which it gets five streams of data. Conventional fuel injection systems use individual sensors for pressure, temperature, engine position, engine speed and oxygen.

The bulk of ElectroJet’s intellectual property is concerned with reducing the sensor set. That means fewer parts, fewer connectors, a smaller wiring harness and fewer failure modes. ElectroJet measures pressure and temperature with the same sensor element.

A 2002 graduate in electrical engineering from Kettering University (formerly General Motors Institute) with a background in engine controls, Mr. Schwulst conceptualized the technology in 2002, when he was working for Arctic Cat. While attending Kettering, Mr. Schwulst interned for Ford and Visteon. He went back to work for Visteon until 2005, and then devoted himself full time to launching ElectroJet. “I love cars. I was excited to work for Ford, but I got put in a cubicle, did a bunch of supply chain management stuff and never got to see a car. At Visteon, I was a technical expert handling a family of Freescale 32-bit microprocessors,” he said.

A half of ElectroJet’s prototypes have been made using Freescale processors, most recently a 16-bit S12XE MCU featuring an integrated X GATE coprocessor. Mr. Schwulst has started working on an EFI prototype that uses a small 32-bit V850 processor from NEC.

“We love the performance of the Freescale device and the tools,” said Mr. Schwulst. “But our product is really driven by cost; and there may be a cost advantage to an NEC part.” The circuit boards will be assembled in Michigan by a contract manufacturer.

Funding

About $2 million has been invested in ElectroJet. The initial funding, worth $400,000, came by way of a Small Business Innovation grant from the U.S. government. Much of the rest came in the form of convertible debt from the state of Michigan: nearly $1 million from the state’s 21st Century Jobs Fund and $100,000 from Automation A Iley’s Seed Fund.

Mr. Schwulst is talking with some venture capital firms about an additional $2.5 million investment in ElectroJet, which would help to accelerate sales growth even beyond what has been planned. “We have customers all over the world asking us to do development projects, customers who are aiming to meet emission regulations that begin phase-in in 2010. We would like to be able to add to our staffing right away so we can handle more projects concurrently,” he said.

DSRC... Continued from page 2

work out the rules and submit them to Congress for authorizing legislation.

The Europeans are struggling with the funding as well. Mr. Shields noted. “Not only will the investment there be larger than in the U.S., but something like this has never been done before, throughout all of Europe. The Europeans are working on the funding but may need us [the United States] to take the lead. In Japan, it is much easier. The Japanese government is spending all the money; they are already out there building stuff.”

Japanese Dominance

If it can be demonstrated that VII built on a DSRC foundation is indeed the next breakthrough in safety technology, the Japanese are in a position to dominate, as they are doing with hybrid-vehicle technology. German companies are likely to be in the game as well.

Back at the ITS World Conference in New York, where the industry was spending millions of dollars promoting VII, I didn’t see very many U.S. companies as I walked through the exhibit hall. The economic crisis kept most of them away. GM was supposed to show its VII demo vehicle, but pulled out of the conference at the last minute. Most of the biggest booths and the biggest signs bore names of Japanese companies. Denso supplied the DSRC communications units for the Mercedes, Honda and Toyota demonstration vehicles.
The Hansen Report on Automotive Electronics, Portsmouth, NH USA  www.hansenreport.com

Page 4, December 2008/January 2009

The Company Profile...  Denso

Denso

Headquarters: 1-1 Showa-cho, Kariya, Aichi 448-8661, Japan; telephone: 81-566-25-5511; www.globaldenso.com
FY 2007 Sales: ¥4,025 billion ($42.4 billion)
FY 2007 Automotive Sales: ¥3,911 billion ($41.2 billion), 97.2% of total
FY 2008 Sales Estimate: ¥3,300 billion ($34.8 billion), an 18% decline

Fiscal Year 2007
R&D: 7.7% of sales
Capital Expenditures: 8.5% of sales
Net Cash Flow Provided by Operating Activities: ¥572,663 million ($6,033.1 million)
Net Margin: 6.1%
Working Capital: ¥663.3 billion ($7 billion) as of September 30, 2008
Long Term Debt: ¥149.5 billion ($1.6 billion) as of September 30, 2008
Shareholders’ Equity: ¥1,994.8 billion ($21 billion) as of September 30, 2008
Market Capitalization: ¥1,367 billion ($14.4 billion) as of November 13, 2008
Ownership: Toyota Motor Corporation, 24.5%; Toyota Industries, 8.54%; Robert Bosch Industries AG, 5.84%
Employees: 118,853 as of March 31, 2008
Sales per Employee: ¥33.9 million ($356,785)

Background
Denso was founded (as Nippondenso) in 1949, when Toyota set up its radiator and electrical operations as a stand-alone company. The automotive market accounts for 97% of Denso’s sales. The majority of sales, 55%, comes from thermal system and powertrain control system products. Most of Denso’s business comes from its OEM customers, which together accounted for 88.9% of sales in the fiscal year ending March 31, 2008. The Toyota Group is by far the company’s largest customer, responsible for 49.2% of sales. Toyota is also Denso’s largest shareholder, with 24.5% ownership of the company.

Comfortably the world’s largest automotive parts supplier, Denso’s sales significantly outpaced those of Bosch, its closest rival. Bosch’s 2007 automotive sales totaled $35.6 billion at today’s exchange rate, compared with Denso’s $42.2 billion for its automotive business in fiscal 2007. Net sales, operating income and net income have risen for nine consecutive years. The vast majority of Denso’s sales growth over the last decade has been organic, not a result of acquisitions.

Denso, which is growing considerably faster than the market, expanded by 12.3% per year in the four-year period ending March 31, 2008. Due primarily to slowing auto production in North America, the company is anticipating a decline in profit as well as an 18% drop in sales revenue for the 2008 fiscal year, from ¥4,025 billion in FY 2007 to ¥3,300 billion. Denso produced ¥1,892 billion in sales in the first half of FY 2008, which ended on September 30, 2008, down 2.9% from the first half of FY 2007.

Compared with its peers, Denso’s sales per employee, at nearly $356,000, is impressive. In the last fiscal year, Continental’s sales per employee came to $239,000; Valeo’s was $194,000; Bosch’s was $168,000.

Denso has penetrated U.S. carmakers to a greater extent than it has penetrated European carmakers. In FY 2008, 20.7%

Denso’s 2007 fiscal year ended on March 31, 2008.

FY 2007 Total: ¥4,025 billion

Automotive, 97.2%

Other Automotive, 1.1%
Small Motors, 6.7%
Electrical Systems, 8.7%
Electric Systems, 9.1%
Information and Safety Systems, 16.2%
Thermal Systems, 32%
Powertrain Control Systems, 23.4%

Industrial Systems and Consumer Products, 1.5%
Others, 1.3%

FY 2007 Total: ¥4,025 billion

Denso Automotive Sales by Fiscal Year
FY 2003 to FY 2007 CAGR: 12.3%

In ¥ billions

2003 2004 2005 2006 2007
2,456 2,691 3,067 3,489 3,911

FY 2007 Sales Estimate: ¥3,300 billion ($34.8 billion), an 18% decline

FY 2007 Total: ¥4,025 billion

Thermal Systems, 32%
Powertrain Control Systems, 23.4%
Information and Safety Systems, 16.2%

Industrial Systems and Consumer Products, 1.5%
Others, 1.3%

FY 2003 to FY 2008 CAGR of Denso’s Business Segments

<table>
<thead>
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<tbody>
<tr>
<td>Thermal Systems</td>
<td>32%</td>
<td>32%</td>
<td>32%</td>
<td>32%</td>
<td>32%</td>
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<tr>
<td>Powertrain Control Systems</td>
<td>23.4%</td>
<td>23.4%</td>
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<tr>
<td>Information and Safety Systems</td>
<td>16.2%</td>
<td>16.2%</td>
<td>16.2%</td>
<td>16.2%</td>
<td>16.2%</td>
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<tr>
<td>Electric Systems</td>
<td>9.1%</td>
<td>9.1%</td>
<td>9.1%</td>
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<tr>
<td>Electronic Systems</td>
<td>8.7%</td>
<td>8.7%</td>
<td>8.7%</td>
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<td>8.7%</td>
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<tr>
<td>Small Motors</td>
<td>6.7%</td>
<td>6.7%</td>
<td>6.7%</td>
<td>6.7%</td>
<td>6.7%</td>
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<tr>
<td>Other Automotive</td>
<td>1.1%</td>
<td>1.1%</td>
<td>1.1%</td>
<td>1.1%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Industrial Systems and Consumer Products</td>
<td>1.5%</td>
<td>1.5%</td>
<td>1.5%</td>
<td>1.5%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Others</td>
<td>1.3%</td>
<td>1.3%</td>
<td>1.3%</td>
<td>1.3%</td>
<td>1.3%</td>
</tr>
</tbody>
</table>

FY 2003 to FY 2008 CAGR: 12.3%

The Americas, 20.7%
Europe, 15.0%
Asia & Oceania, 14.9%
Japan, 49.1%

Denso Employees by Region

As of March 31, 2008:
118,853
Asia & Oceania, 21.8%
Europe, 13.3%
Japan, 49.9%

The Americas, 14.9%

Denso Sales by Region*

FY 2007 Total: ¥4,025 billion

Asia & Oceania, 14.9%
Europe, 15.0%
Japan, 49.1%
Others, 0.3%

*Customer location

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of Denso's sales went to companies located in the States, compared with 15.0% to companies located in Europe. In the last few years, however, Denso's sales to European customers have grown faster than sales to North American companies.

**Why Denso**

According to Denso, the company's most important competitive strengths are its advanced development capabilities, its ability to create high quality products, its wide ranging technical expertise and its global manufacturing footprint. To these we would point out that Denso also has a strong balance sheet, which will help the company weather the current slump in car sales. Denso's financial position is sound. Its Standard & Poor's long term bond rating is AAA+, meaning the company has a very strong capacity to meet its financial commitments.

Denso is a very strong competitor to a large degree because of its close relationship with the Toyota Motor Corporation. Toyota is the world's most successful carmaker, ranking number one in sales and number one in profits. Not only does it nurture its suppliers, but it also demands great quality and great technology. Certainly, if you can serve Toyota you can serve the world, and Denso serves every major carmaker worldwide.

The company has a number of joint ventures and alliances. For example Denso is partnered with Toyota Industries in the A/C compressor business; with Toyota Boshoku in the filter business; and with Robert Bosch in the fuel pump, diesel particulate filter, and navigation and multimedia-related component businesses.

Denso's technical cooperation with Bosch dates back to the 1950s, when Bosch granted the company a license for automotive electrical parts.

**Focus Is on Environment and Safety-Related Products**

Denso has been focusing its R&D and capital investments in two key areas: reducing the impact of motor vehicles on the environment and improving vehicle safety. Denso believes that reducing fuel consumption and CO2 emissions is the auto industry's most pressing issue.

With 65% of sales coming from thermal systems (heating, ventilation, air conditioning and engine cooling), powertrain systems and electric systems (starters, alternators, inverters and DC-DC converters) Denso is well-positioned to focus on innovative technology that will help carmakers improve the environmental performance of their products.

**Stop-Start**

Denso believes that fuel savings can be maximized when various systems are coordinated. By working with carmakers at an early development stage, it can propose technologies that combine systems and components. For example, if the stop-start function is to be implemented, the engine control and electric power control must be coordinated. It is also important to consider the air-conditioning system, which must work even when the engine is stopped and the compressor can’t be used. Denso is currently developing a unit that stores cooled refrigerant for use when the engine isn’t operating.

Denso believes carmakers will adopt micro-hybrid technology rapidly starting in 2015, first in Europe and then in Japan. By 2020, according to the company’s annual report, 30 million vehicles will be produced globally with stop-start capability, up from about 7 million units in 2015. That's 33.8% annual growth in unit sales.

In anticipation of market demand for stop-start systems, Denso began developing its Permanently Engaged Starter. The machine's flywheel has a built-in one-way clutch. It is also important to consider the air-conditioning system, which must work even when the engine is stopped and the compressor can’t be used. Denso is currently developing a unit that stores cooled refrigerant for use when the engine isn’t operating.

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Denso operates 218 consolidated subsidiary and affiliated group companies worldwide.

### Japanese Operations

<table>
<thead>
<tr>
<th>Operations</th>
<th>Main Automotive Products/Research Fields</th>
<th>Employees March 31, 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anjo Plant</td>
<td>Starters, alternators, hybrid vehicle components</td>
<td>2,494</td>
</tr>
<tr>
<td>Nishio Plant</td>
<td>Air conditioners, radiators, fuel injection systems for diesel, electronic fuel injection components</td>
<td>7,012</td>
</tr>
<tr>
<td>Takatana Plant</td>
<td>Instrument clusters, displays, sensors, navigation systems</td>
<td>2,736</td>
</tr>
<tr>
<td>Dalian Plant</td>
<td>Ignition devices, driving control/safety products, oxygen sensors, other actuators and sensors</td>
<td>4,237</td>
</tr>
<tr>
<td>Kota Plant</td>
<td>Integrated circuits, electronic control components</td>
<td>3,531</td>
</tr>
<tr>
<td>Denso Research Laboratories</td>
<td>Research in semiconductors, information and communications systems, HMI technologies</td>
<td>396</td>
</tr>
</tbody>
</table>

### Group Companies (Denso Ownership)

<table>
<thead>
<tr>
<th>Company</th>
<th>Main Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asmo Co. (73.4%)</td>
<td>Small motor systems (power window regulators, blower and fan motors)</td>
</tr>
<tr>
<td>Anden Co. (100%)</td>
<td>Relays, electronic products</td>
</tr>
<tr>
<td>Hamanakodosensei Co. (76.5%)</td>
<td>Vacuum switch valves, magnet switches, horns</td>
</tr>
<tr>
<td>Denso Tecnco Co. (100%)</td>
<td>Software for information processing and control</td>
</tr>
<tr>
<td>Denso Manufacturing Michigan (100%)</td>
<td>Air conditioners, radiators</td>
</tr>
<tr>
<td>Denso Manufacturing Tennessee (100%)</td>
<td>Electrical components, instrument clusters, auto electronics</td>
</tr>
<tr>
<td>Denso Manufacturing Athens, TN (100%)</td>
<td>Injectors, oxygen sensors, stick coils</td>
</tr>
<tr>
<td>Denso Mexico (95.0%)</td>
<td>Instrument clusters, valves, variable cam timing</td>
</tr>
<tr>
<td>Denso do Brasil (90.6%)</td>
<td>Air conditioners, compressors, bus A/C, radiators</td>
</tr>
<tr>
<td>Denso Manufacturing UK (100%)</td>
<td>Air conditioners, heaters</td>
</tr>
<tr>
<td>Denso Thermal Systems S.p.A (100%)</td>
<td>Air conditioners, heaters, radiators</td>
</tr>
<tr>
<td>Denso Manufacturing Italia (100%)</td>
<td>Starters, alternators, small motors</td>
</tr>
<tr>
<td>Denso Manufacturing Hungary (100%)</td>
<td>Common rail systems, diesel injection pumps, variable cam timing</td>
</tr>
<tr>
<td>Denso Thermal Systems Polska (100%)</td>
<td>Heaters, cockpit modules</td>
</tr>
<tr>
<td>Denso Manufacturing Czech (100%)</td>
<td>HVAC units, evaporators, condensers, radiators</td>
</tr>
<tr>
<td>Denso Thailand Co. (52.3%)</td>
<td>Electrical components, air conditioners, magnets, spark plugs</td>
</tr>
<tr>
<td>Siam Denso Manufacturing (90.0%)</td>
<td>Fuel pumps, injectors</td>
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<tr>
<td>PT. Denso Indonesia (58.3%)</td>
<td>Air conditioners, radiators, spark plugs, filters</td>
</tr>
<tr>
<td>Denso PS Corporation (72.9%)</td>
<td>Small motors, fuel pumps, electrical components</td>
</tr>
<tr>
<td>Denso Malaysia SDN. BHD. (72.7%)</td>
<td>Electrical components, air conditioners, engine ECUs, programmable logic controllers</td>
</tr>
<tr>
<td>Tianjin Denso Electronics Co. (93.0%)</td>
<td>Electronic control components</td>
</tr>
</tbody>
</table>

### Denso's Distinctions

- World’s largest automotive parts supplier*
- Denso fuel injectors have the world’s best fuel atomization technology: Particle diameter just over 10 microns makes for good combustion.
- World’s first diesel common rail system for trucks, launched in 1995
- At the 2007 Tokyo Motor Show, Denso exhibited the world’s first electric variable valve timing control system.
- Denso’s new starter for stop-start systems is the world’s first starter that is always engaged with the engine.
- In 2003, Denso, Toyota and the Tiger Corporation developed and launched the world’s first production heat storage system, which helps to quickly warm up the engine to make it more fuel efficient.

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**Hansen Report assessment**

> Small Air Conditioner for Compact Car

In October 2008, Denso announced the development of a new air-conditioning unit that is 20% smaller, 12% lighter and consumes 14% less power than the unit it replaces. Much of the size reduction is achieved with new resin molding technology applied in manufacturing the blower fan. The new blower fan is roughly half the size of the older unit, which allows carmakers to mount the new A/C unit in the center of the instrument panel, providing more legroom for the front seat passenger. The small air conditioner will be installed on Toyota’s new iQ minicar, which was launched in Japan in November and will be launched in Europe in early 2009.

### Converting Heat to Electricity

Denso is developing a system to convert waste heat from the exhaust system of Prius, Denso’s system stores hot water from the engine’s radiator in a three liter thermos tank. A loop part of the system are an electric water pump, water-flow valve and temperature sensor. Warm water (at least 65 degrees C) is sent to the engine from the tank. The system reduces unburned hydrocarbons in the exhaust by 14%.

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*Hansen Report assessment
into electrical energy. Exhaust gas losses account for 25% of the fuel energy consumed by a vehicle. Denso's system will be able to reduce fuel consumption by about 3%, according to the company. Beyond saying that managing the high exhaust temperature is one of the issues that needs to be resolved, Denso would say no more about its new technology except that “the system under development does not use a thermoelectric exhaust system.”

Hybrids

Denso was one of the first companies in the world to produce components for hybrid vehicles. In 1997 it was making battery control units, DC-DC converters and high-voltage relays for the Toyota Prius, the world’s first commercially successful hybrid. Since then, Denso has been aggressively developing hybrid products and today has a complete product line including hybrid vehicle ECUs, DC-DC converters, battery monitoring units, high-voltage relays, battery current sensors, battery cooling systems, electric motor driven A/C compressors and high-output power control units.

Very optimistic about the future of mild- and full-hybrid vehicles, Denso expects the market will grow dramatically, especially after next year, from 1.4 million units in 2010 to anywhere from 12 million to 22 million units by 2020. In 2005, the market for hybrids was about 300,000 vehicles, according to the company. By 2020 the market for hybrid-related parts and systems—one of Denso’s fastest growing product segments—will reach between ¥1.8 trillion and ¥3 trillion ($19.0 billion to $31.6 billion).

Denso power control units (PCUs) are installed on the Lexus LS 600h and Lexus LS 600h hybrid vehicles introduced last year. The PCU raises the main battery voltage from 288V to 650V, and feeds that voltage to two inverters that convert the direct current to alternating current to drive the main traction motors. The PCU employs a unique cooling structure that allows each side of the power semiconductor devices (an insulated gate bipolar transistor and a diode) to be connected to a heat sink and cooling tube. As a result, the PCU can produce 60% more output power per unit volume than the PCU it replaces.

Future power control units are likely to include power semiconductors made not from silicon but from silicon carbide (SiC), which Denso has been developing. Last May at the Automotive Engineering Exposition in Yokohama, Japan, Denso demonstrated a SiC power module comprised of power MOSFETs and Schottky barrier diodes. SiC components can operate at higher temperatures than silicon, up to 300 degrees C vs. 200 degrees C.

Safety

According to a written statement from Denso to The Hansen Report, most traffic accidents occur as a result of rear-end collisions, road departures, and at intersections. With that in mind, Denso is most hopeful about the accident prevention potential of pre-crash safety systems, lane departure warning systems and vehicle-to-infrastructure cooperative systems. In support of those, Denso is promoting and developing sensing technologies that detect the vehicle’s surroundings, for example millimeter-wave radar, vision sensors (cameras and pattern recognition) and vehicle-to-vehicle and vehicle-to-roadside communications technologies such as DSRC (dedicated short range communications).

Denso has demonstrated technology that monitors the driver’s attentiveness and alertness to the driving task. This technology measures heart rate or uses a camera to study the driver’s face and keep track of the driver’s eye blinking patterns and direction of gaze.

Denso is also working to reduce the cost of established safety systems such as airbag ECUs and sensors, A BS and electronic stability control.
In two demonstrations in November, Mercedes Research gave us a look at the role the Internet is likely to play in cars in the not-too-distant future. At the ITS World Congress in New York City and again at the Los Angeles Auto Show, Mercedes demonstrated working prototypes of an Internet-based infotainment system called myCOMAND.

With the infotainment system connected to the Internet, new and updated infotainment features could automatically be downloaded to the vehicle, just as software updates are automatically made to our personal computers. “The main reason we wanted to build this is to gain a higher level of flexibility with our in-vehicle systems,” explained Ralf Herrtwich, director of infotainment and telematics group research and advanced engineering for Daimler AG. “I can determine the software content of the vehicle head unit on a daily basis. What I put on my server determines what appears in the vehicle.” Today, any changes to infotainment system features require a trip to the dealer. Mercedes isn’t looking at the Internet as an opportunity to sell aftermarket features to its customers. “When you buy an iPod and Apple releases a new version of the software it’s your assumption that because you’ve already made the investment in the iPod you’ll get the update,” noted Dr. Herrtwich. “We don’t want to nickel and dime our customers.”

The Internet will also be used to download content directly to the vehicle, which will be especially useful in navigation applications. “The Internet already has things like Google Maps. You just need to make that accessible to the vehicle,” said Dr. Herrtwich.

With myCOMAND’s World Radio feature, drivers could listen to any of the tens of thousands of radio stations available on the Internet while traveling in their cars. And streaming radio from the Internet at anywhere from 128 kbps to 196 kbps could provide even better performance than HD Radio, which operates at 96 kbps.

The myCOMAND prototype was designed to work on 3G and 4G cellular phone networks of the future, networks with ubiquitous coverage. With Internet connectivity, coverage is more crucial than bandwidth. “That is the next task: to come up with a version of myCOMAND that can work better in a scenario where you have lower bandwidth and lower coverage,” Dr. Herrtwich noted.

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Japanese Automotive Electronics Conference, July 2009

A ny company that is serious about competing in the global automotive electronics industry should consider being part of Automotive Technology International 2009, the three-day automotive electronics conference, which this year will be held in Yokohama in July. AT International planners had Convergence in mind as a model for their conference. Convergence, held in Detroit every other year, is the granddaddy of all automotive electronics meetings.

Building on the theme “Global Mobility Innovation,” the conference will be organized around three main topics: the Electrically Powered Automobile; Making Automobiles More Intelligent; and Auto-mobile and Information Technology. Noteworthy is the organizers’ decision to focus on Germany, China and India and, according to the literature, “deepen our discussions as to how the issues of the auto industry in each area will affect the global market in the future.”

The AT International Forum, one of the events held each day of the conference, presents three different keynote speeches and nine themed technical sessions.

The tentative schedule for the 2009 Forum lists the following session topics:

- Making Cars More Intelligent (2 sessions)
- A utomotive Software (2 sessions)
- Vehicle Electrification (2 sessions)
- Networks in the Vehicle
- Automotive SPICE
- Electronic Platform for the Vehicle
- Much of the conference is Japanese language only. The keynote speeches in Japanese will have simultaneous translation to English; keynotes in any other language will have simultaneous translation to Japanese. The session presentations delivered in Japanese will not be translated; the sessions given in other languages will include simultaneous translation to Japanese.

Registration for the conference begins May 20, 2009. For more information, visit http://expo.nikkeibp.co.jp/ati.

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CO2 Reduction from Electrical System Improvements

<table>
<thead>
<tr>
<th>Electrical System Improvement</th>
<th>CO2 Reduction g CO2/km</th>
<th>Fuel Efficiency Increase in mpg</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWM (pulse width modulation) for bulbs</td>
<td>0.8</td>
<td>0.18</td>
</tr>
<tr>
<td>Replacing bulbs with LEDs</td>
<td>1.2</td>
<td>0.26</td>
</tr>
<tr>
<td>Reduce operating current of infotainment ECUs</td>
<td>1.2</td>
<td>0.26</td>
</tr>
<tr>
<td>PWM to variably control fuel pump</td>
<td>1.9</td>
<td>0.42</td>
</tr>
<tr>
<td>PWM to control HVAC fan</td>
<td>1.9</td>
<td>0.42</td>
</tr>
<tr>
<td>Replace alternator diodes with switching MOSFETs</td>
<td>2.4</td>
<td>0.53</td>
</tr>
<tr>
<td>Electric power steering</td>
<td>5.9</td>
<td>1.30</td>
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<tr>
<td>Electrically driven water pump</td>
<td>7.1</td>
<td>1.56</td>
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