Porsche's Uwe Michael on Automotive Electronics

If there is one person's job that I would instantly trade for, it is Uwe Michael's. Not because I am the slightest bit qualified to be Porsche's top electrical engineer, but because I would love to do what he does: drive a Porsche to work, many different Porsches, in fact. I sat down with Dr. Michael in July, after his presentation at the Ludwigsburg, Germany, meeting of automotive electronics VIPs. “Every evening the engineers ask me to test their functionality. Plus, my wife drives a Cayenne,” he said.

Dr. Michael is responsible for everything in Porsche vehicles that’s electrical or electronic or software—all functional domains including powertrain. Most carmakers don’t give the top electrical engineer responsibility for powertrain electronics and software, but in Dr. Michael’s experience, “A’s complexity rises, it is easier to manage electronics from one central point of view.” A approximately 300 engineers work in his organization.

Quality

Dr. Michael is laser-focused on Porsche quality. “It is the core of everything we do,” he declared. It must be, given the challenges faced by Porsche—the challenge of innovation, rising unit sales, rising complexity and costs, shortened time to market and a plethora of government mandates around the world.

Electronics complexity does not usually correlate with great quality, but in the case of Porsche it seems to. In 2007 Porsche topped the overall nameplate rankings in J.D. Power and Associates’ initial quality rankings for the second consecutive year, beating out Lexus, which was number two in 2007.

T hectric D evices Promise Energy Savings

Spurred on by high fuel costs, the desire for energy independence, and strict limits on CO₂ emissions, automotive engineers are looking to thermoelectric devices to help increase the energy efficiency of vehicles. In ten years or so, if developers get their way, some passenger vehicles could come equipped with as many as nine thermoelectric devices—two to four for each front seat passenger, and one to generate electricity from the engine’s exhaust. Thermoelectric devices use solid state materials to convert temperature differences into electrical energy (the Seebeck effect) or conversely, convert electrical energy for heating or cooling (the Peltier effect). Thermoelectric generators have been used reliably in space for decades.

Thermoelectric technology has been applied in autos at least since 1999, when A merigon, a company devoted exclusively to thermoelectric technology, began shipping its thermoelectric devices (TEDs) for use by Ford in A merigon-branded Climate Control Seats (CCSs). CCSs are made to A merigon’s specifications by the carmaker’s seat supplier. Since 1999, more than three million thermoelectrically cooled and heated seats have been shipped to Ford, G M, Toyota, N issan and H yundai using components from A merigon.

The seats use one or more TEDs to heat or cool, depending on the polarity of the current applied to the device. A TED is the heart of a compact heat pump built by A merigon for the seats. A ir is forced through the heat pump by a fan and circulates through ducts in the seat cushion and seat back. Occupants feel the heating or cooling from the seats before the vehicle’s central HVAC system can modify the temperature of the passenger cabin.

The demand for thermoelectrically heated and cooled seats could well multiply as carmakers press for ways to improve the energy efficiency of their vehicles. For example, hybrid vehicles (especially plug-in hybrids) are often running while the engine is off, so there is no engine heat to warm passengers in the winter. Hybrid vehicle manufacturers get around this by using supplemental electric heaters, which make the hybrid vehicles less energy efficient. “If you use resistive heating then the efficiency is limited by the conversion efficiency of electricity into heat,” said Lon Bell, founder of A merigon.

Some Hansen Report readers will recall that Dr. Bell also founded electromechanical airbag crash sensor pioneer Technar, acquired in 1986 by T RW. A merigon had revenues of $51 million in 2006. Automotive veterans Francois Castaing and O.B. “Bud” M axx serve on A merigon’s board.

“A complaint you hear about hybrids is you don’t get the mileage claimed on the sticker,” noted Dr. Bell. “A nd one of the primary reasons is because in the federal government testing, they didn’t have the heater or air conditioner on. ... [Using thermoelectric heat pumps] we can increase the mileage of a plug-in hybrid, and we can do it using one-third to one-fourth of the electric power used by a conventional electric heater.”

Thermoelectric heat pumps are still too inefficient and the solid state material too expensive to provide adequate cold-climate heating at an affordable price. Nor is thermoelectric technology sufficiently advanced to cool the whole vehicle. According to Barry Nickerson, CEO of Marlow Industries, it will take years before thermoelectric climate control systems will begin to replace the vehicle’s...
Porsche...

I asked Dr. Michael how Porsche maintains its high quality. "One key is the Porsche Research and Development center in Weissach, Germany [about 15 kilometers northwest of Stuttgart], where we are working," he said. "All of my colleagues sit not more than 100 meters from me. I personally attend the 'change control board,' so nothing happens that I don't know about specifically. We are small and I am able to manage it. If there is a problem with a motor, or a security problem, or a chassis problem, the colleagues are asked to come together, and we decide how to solve the problem while minimizing the risk."

Another key to quality is Dr. Michael's caution in bringing new technologies to market. Rather than rushing to integrate unproven technology the first year a new model is introduced, he prefers to save it for a later year when the model is refreshed. "When we come close to the start of production, and somebody says they have a great idea to optimize the climate control or something, we say, 'don't do it yet: we want to ensure we have the best quality.'" This strategy helps maintain sales of the model through a typical seven-year product life.

Porsche appoints one person to take sole responsibility for the development of a particular vehicle function, for example, traction control. "When a function, such as traction management, is distributed across several domains, it is particularly helpful to have one manager responsible for the electronics, the motor applications, the chassis application—all these things," noted Dr. Michael.

Sport Chrono Package

Another such function whose development was overseen by a single individual is the Sport Chrono Package Plus, a $960 option available on the 911, Cayman and Boxster. Sport Chrono reprograms the engine management system and electronic driver aids. "Press a button on the dash and the whole car goes into sport mode. Except for the analog/digital stop watch mounted on the instrument panel, the feature is implemented entirely with software; 24 different ECUs are changed," said Dr. Michael.

In sport mode the gas pedal becomes more responsive, and the dash pot on the throttle butterfly allows the throttle to close faster when the driver takes his foot off the gas. Modifying the control thresholds in the stability management system allows greater swerve action at the rear. Sport mode also limits ABS intervention and modifies the active suspension control, which improves wheel contact with the road. A nd for vehicles fitted with the Tiptronic S option, the transmission changes to a more sporting control map. Tiptronic S combines an automatic transmission with the option of manual gearshifts.

How Suppliers Can Help

◆ Porsche is feeling a lot of pressure around the world to make its vehicles significantly more fuel efficient. "The big things, like hybrids, we are already working on. Now we have to optimize power consumption on a lot of smaller things in the non-hybrid cars. With every 100-watt savings, fuel consumption is reduced by around 0.1 liters per 100 kilometers. The generator's power consumption can be cut, for example, through need-driven control of the electric motors, and by reducing the current draw of the numerous electronic components," said Dr. Michael, adding, "Every company within its own core competence needs to contribute to this. It's a big problem."

◆ A nother area where help from suppliers would be appreciated is in lowering the cost to comply with the many automotive regulations in force in the countries where Porches are sold. According to Dr. Michael, there are more than 450 different requirements and regulations worldwide for automotive electronics alone. He thinks that technology necessary to meet the occupant protection standards in the U.S. safety mandate FMVSS 208, for example, is too expensive. That mandate led to the need for sensors in the front seat to detect for the presence of passengers too small for safe deployment of the airbag. A ruling on side impact protection, likely to require all carmakers to install side airbags, is due from NHTSA soon.

◆ Dr. Michael would like suppliers to invest more to optimize their processes.

"For the most part I am happy with the level of technological innovation I see. However, big and small companies alike have a lot of work to do to adopt the processes that are needed. Suppliers have a lot to deal with. We have a very complex integration process and if something doesn't work, even one element, the whole system stops."

He elaborated: "During the OEM integration process, the functions agreed upon in release planning are incorporated into the vehicle. This incorporation is carried out approximately 12 times during the vehicle's development, with increasing functionality and maturity at each stage. Many functions span numerous components from different suppliers—the immobilizer system, for example, comprises 15 components—which pose challenges to incorporation. The suppliers must have a handle on their development processes and deliver absolutely on time."

New Architecture

For the last three years, in cooperation with Audi, Dr. Michael's organization has been developing a new architectural platform that will debut in 2009 on Porsche's newest model, the Panamera, a four-door, four-wheel drive.
High Copper Prices Give Rise to Aluminum Wiring

Only the Biggest Cables, for Now

The price of raw copper has been going through the roof, rising from about $.71 per pound in January 2002 to $3.72 per pound by August 2007, a five-fold increase. With over a mile and a half of copper wiring in a typical luxury car, according to industry estimates, carmakers are looking for alternatives.

BMW and Volkswagen/Audi began installing aluminum battery cables in some of their vehicles in 2001, and have been working to qualify aluminum for other parts of their vehicles. BMW intends to replace all of its largest copper cables with aluminum. It has already made the decision to replace all copper wires with cross sections of 35 mm² or larger, and it will likely decide to replace everything from 16 mm² and above. “We use aluminum for the so-called B-plus connections and all the connections which bear high current, even in the engine compartment,” noted Günther Rechait, BMW’s director of central vehicle systems and services.

It should be pointed out that a large proportion of the wiring circuits in a vehicle have cross sections smaller than 16 mm², and these will stay copper. “If you go to the very small cross sections, there are clear advantages for copper, which can not be replaced by aluminum wire,” said Dr. Rechait.

Battery cables were the first to go aluminum, because they are the largest in the vehicle and have the most copper. “When you have a one-meter battery cable, which is a typical length, you can save around 15% to 20% of the cost,” noted Franz H. Ocker, who manages battery cable development for the auto industry for Gebauer & Griller Kabelwerke, an Austrian firm. “In the next five or six years, every one of our German customers will change to aluminum battery cables.” The Yazaki battery-inverter cable on the Toyota Prius is also aluminum.

In switching to aluminum not all of the wiring costs go down. A aluminum has greater resistance to current flow than copper, so a greater cross section is needed, and that requires more material for insulation. A aluminum cables must be 1.6 times larger in cross section than copper to maintain the same resistance. And since aluminum is more reactive than copper, simple crimp connections between wire and terminal or to splice wires together will not suffice.

“The aluminum strands tend to oxidize very quickly, so you don’t get the conductivity between strands that you get with copper,” explained Rick Burns, an engineering manager at Yazaki. Plus, aluminum has a greater potential for creeping and thermal cycling. The aluminum expands and contracts, which can make the connection unreliable. As a result, aluminum cables require more expensive terminations.

continued on page 8

Thermoelectric...

 According to Dr. Jihui Yang, GM Research and Development Center, a merigons C C Ss work pretty well. “One degree delta is often enough to make you feel the difference. But if you are talking about replacing the air conditioning unit, I think a lot of work needs to be done.”

A merigons Dr. Bell believes that by 2012, or sooner, thermoelectric technology will have been developed to the point where it will begin to substitute for conventional heating and cooling systems. He outlined how the process could unfold: “First we need to agree with automotive companies on what a new architecture that replaces existing HVAC systems looks like. … There might be a couple of thermoelectric devices in each seat, and then to heat the face and torso there would be others surrounding the occupant, maybe in the headliner, or in the instrument cluster, and in the steering wheel, all catering to the requirements of individual occupants. [A II except for the steering wheel would heat convectively.] Then we need to build demonstration units and get a lot of experience with durability, ruggedness and longevity.” A merigons has already delivered bench-top prototypes of such systems.

Regardless of its potential to substitute for conventional HVAC systems, thermoelectric technology is expected to have a big impact on the vehicle. The Japanese component maker Kyocera Corporation, which has been developing Peltier mod-ules for seats, expects unit demand for temperature-controlled seats to grow six times larger by 2010 compared with 2006. A nother Japanese player in thermoelec-tric modules for car seats is Ferrotec.

Exhaust Heat Recovery

According to a presentation made by Bosch senior vice president Walter Grote, 70% to 75% of the fuel consumed by gasoline engines is wasted in thermal losses. Most of that energy is lost to the engine’s cooling system, and the rest is exhausted out the tailpipe. (See figure, above.) So Bosch, as well as many other players around the world, has been looking at the feasibility of using thermoelectric generators to convert that heat into electrical energy, which could be used as an auxiliary source of power. Anywhere from 700 watts to 1 kilowatt could be made.

continued on page 8
Background

Yazaki was founded in 1929 by Sadami Yazaki and is still run by members of the Yazaki family. The company incorporated in 1940 and established a North American presence in the mid-1960s. Throughout the next three decades, starting with its first overseas factory in Thailand in 1962, the company expanded into Southeast Asia, Australia, Mexico, Europe, China, India, South America and Eastern Europe. Yazaki moved North American operations into the facilities it now occupies in Canton, Michigan, in 1986.

Yazaki operates in 40 countries, on six continents. The company maintains 40 R&D centers all over the world, but especially in the regions where its customers are located. There are 19 R&D centers in Japan, 16 in Europe, four elsewhere in Asia and Oceania, and one in North America.

Yazaki claimed a 32% share of the total market for automotive electrical distribution systems in the fiscal year ending June 2007, up from an estimated 29% share in 2002. The total global market for electrical distribution systems is about $28 billion.

More than three-quarters of Yazaki’s sales revenue comes from automotive wire harnesses, the bundled electrical wires and data circuits, including terminals, connectors, tapes, clips, grommets, protective coverings and routing aids that, as Yazaki says, function as the car’s central nervous system.

For years people have expected the number of cut leads (point-to-point wire circuits) used in the average vehicle to decline, but that hasn’t happened as more and more features enabled by electronics are applied to vehicles. The vehicle harness in a typical mid-sized sedan can have between 800 to 1,200 circuits of different wire sizes and temperature characteristics, depending on the vehicle’s features, options and architecture. In a high-end luxury vehicle, the number of circuits can reach as high as 2,500. Circuits might vary in length from eight centimeters to 15 meters. Anywhere from 400 to 800 molded connectors might be required, some of them standard, but some unique to specific electrical/electronic devices in the vehicle.

Some automakers prefer a one-piece harness, while others prefer the electrical distribution system to be partitioned into a number of smaller harness assemblies.
Regional Balance

As a Japanese supplier, Yazaki has the greatest penetration with domestic Japanese carmakers, but sales are also strong in North America, where Yazaki took over Chrysler’s in-house wiring harness business in 1994, and where the Japanese transplants are strong.

Chrysler is Yazaki’s second-largest customer, followed by Ford, with GM coming on strong at number six. Yazaki reports that its business with traditional European carmakers will triple in the next few years, which will bring sales in Europe into balance with the other regions.

“Shortly before 2001, when we formed our joint venture with Siemens, we were relatively small in Europe,” said Mr. Perry. “Although Yazaki had a small amount of business with traditional European automakers such as Opel, Fiat and Volvo, the majority of our European business came from Ford, Jaguar and Japanese OEMs. As the Japanese OEMs’ share has grown, so has ours. In addition, since Siemens sold us their entire EDS business, with the exception of Volkswagen, we now serve Renault-Nissan, BMW W, Ford of Europe and M ercedes out of the S-Y joint venture. Yazaki has a major share of BMW W’s business.” Europe's largest vehicle producer, Volkswagen, is served by A FL, Sumitomo and its traditional German suppliers. The only other major carmaker not served by Yazaki is Hyundai.

Yazaki is also growing quickly in Southeast Asia. The company has major R&D centers in the Philippines and in Thailand. Yazaki operates six manufacturing facilities in China, three in the Philippines and three in Thailand.

New Product: 0.13 mm² Wire

Developed with Toyota and introduced in late 2006 in the Lexus LS460 sedan and later in the LS600h hybrid, Yazaki’s newest wiring product is one-third the cross section and one-half the weight of conventional low-current wiring. One of its most appealing properties is its high tensile strength, which allows it to be pushed and pulled during installation without folding, despite its small diameter. As a result, it will initially be most appealing to makers of luxury vehicles like the Lexus, which are so loaded with electronics that wiring bundles have become unwieldy. A further benefit is weight savings; harnesses made with 0.13 mm² wire yield a 53% weight savings compared with conventional wiring.

Typically, low current wiring is spec’d at a larger gauge than is needed for the small amount of current it must carry, in order to make the harnesses sufficiently robust for assembly. New wiring can be chosen that closer fits the current-carrying requirements. The wire is made using copper-tin alloy. A long with the thinner wire, Yazaki developed smaller and lighter connectors with narrower pitch between terminals.

According to Rick Burns, chief engineer, research and development at Yazaki North America, 30% of the wiring circuits in a vehicle could benefit from 0.13 mm² wire. But since many of those circuits are exposed to the vehicle’s exterior, like those in the engine compartment, sealed connectors will have to be developed. Without sealed connectors, about 15% to 20% of cut leads could be converted to 0.13 mm² wire, a very significant segment of the market.

Initially, the cost of harnesses made from 0.13 mm² wire will be roughly equal to those made with larger gauge conventional wire, but that may change as volumes increase. While the raw material cost is lower, additional processes are required in manufacturing and assembling harnesses with the smaller wire. Mr. Burns believes the real payback will be the packaging and weight advantages that come with a smaller bundle size.

Yazaki is working with Toyota to improve performance of the wiring and eventually expand its use to more mainstream models. Beyond Toyota, Yazaki says there are “a number of early development programs aiming toward implementation globally in the 2009 and 2010 model years,” but no programs are yet underway in North America.

continued on page 6
Why Yazaki?

When we asked George Perry, president and CEO of Yazaki North America and a member of Yazaki’s board of directors, why carmakers buy from Yazaki rather than from the competition, he was ready with at least seven convincing reasons.

- “EDS is our core business; everyone knows we are here to stay.
- We bring a breadth of experience due to our large, diverse customer base. We know what everyone is doing in terms of electrical and electronics architecture and where the strengths and weaknesses are.
- We have a great track record for delivery. That instills confidence with automakers, who are stretching to be global and to be in every market.
- We stick to our commitments [even in the face of rising copper prices]. We satisfy our customers first and then deal with the commercial issues.
- We are flexible, willing to work cooperatively in development, or we can propose a whole new architecture ourselves. We are a full service supplier.
- We have a global footprint, so we can do local application engineering, development and manufacturing almost anywhere in the world.
- Customers know we are always working on continuous improvement in the product and manufacturing process to drive costs down.”

Yazaki’s instrumentation strategy received a boost in 2001, when Delphi decided it would exit that business. “Here was a market with only a few major global players (Denso, Siemens VDO, Delphi and Visteon) and one of them was exiting,” said Mr. Perry. “That gave us some openings at GM, where we have won a lot of business, state-side. We did the design and development for the GMT 900 [GM’s full-size truck platform], all the instrumentation.” However, in 2006 Delphi reversed itself and decided to keep its instrument cluster business, making it part of Delphi’s controls and security products.

The Company Profile Continued

Global Instrumentation Market
Anticipated Product Mix, 2015

<table>
<thead>
<tr>
<th>Analog displays have pointers and are driven by stepper motors. LCDs (liquid crystal displays) are fitted within the instrument cluster or installed separately, typically in the center stack.</th>
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<tr>
<td>Analog instrument clusters</td>
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<td>Digital displays (LCDs mostly)</td>
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<td>Head-up displays</td>
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Data: Yazaki

Yazaki Products

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<th>Wire (meets JASO, SAE and ISO specifications)</th>
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<tr>
<td>Compressed core</td>
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<td>High voltage</td>
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<td>Battery cable</td>
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<td>Shielded</td>
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<td>Halogen-free</td>
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Provisional Components

| Troughs |
| Grommets |
| Clips |
| Coverings |
| Brackets |
| Eyelet, battery and specialty terminals |

Connectors

| USCAR-compliant terminals and connectors |
| Matte sealed and cable sealed systems |
| Gold, tin and silver plated terminals |
| Safety and squib connectors |
| High vibration resistant connectors |
| IDC |
| FPC/FFC |
| Mechanical-assist and low insertion force |
| High voltage connectors (motor, inverter, DC to DC converter, service plug) |
| Headers |
| Axial adjustable self aligning connectors |

High-Speed Connection Systems

| USB (headers, in-lines, connectors & assemblies) |
| LDVS/GVIF (headers, connectors & assemblies) |
| IEEE 1394 (headers, connectors & assemblies) |
| FAKRA (headers, connectors & assemblies) |
| Optical (headers, in-lines, connectors & assemblies) |

Digital Power Modules (DPMs) - power distribution center (PDC); Junction box (JB)

Component Two

In another change in product strategy, Yazaki is now interested in pursuing opportunities to also sell the components that make up its wiring harnesses, including connectors and terminals. M. R. Perry noted, “We were doing in-line connectors almost exclusively before, but now we’ve even expanded into header connectors—part of the ECU — as well.”

Porsche...

Premium-class sports car with sufficient room for four adults plus luggage. Similar but not identical to the Audi A 8’s architecture, Porsche’s will have one main gateway connected to five domains: powertrain, chassis, comfort, M MI and driver assistance. “A far tier, all our cars Panamera, 911, Cayman, Cayenne and Boxer, will have the same electronics,” noted Dr. M ichael. A udi is responsible for the high-end architecture for the Volkswagen Group. Porsche presently owns more than 30% of the Volkswagen Group, which includes A udi.

Wary of Private Equity Sponsored Suppliers

Dr. M ichael thinks that, in principle, if a supplier faces a takeover it is best if the supplier can be bought out by another company within the automotive industry, rather than private equity investors. “We need good, competent suppliers that are financially sound. The technologies for the future are not something you can work on for three months and bring to market. It requires long research and pre-development. Private equity investors don’t support this long view.”

Continued from page 2
Copper...

For small-gauge wire, which accounts for most of a car's wiring, the cost benefit of switching to aluminum is not great enough to cover the extra cost of the connections and the insulation. According to the German cable-maker Auto-Kabel, 86% of the total weight of a vehicle wiring harness comes from wiring that is 6 mm² in cross section or smaller. Such wiring weighs 14.7 kg (32.3 pounds) compared with 17.1 kg (37.6 pounds) for the whole vehicle harness.

Still, aluminum wiring is making headway. A auto-Kabel manager of aluminum cable development, Martin Schloms, told us he’s qualifying aluminum engine cables with cross sections between 25 mm² and 60 mm² for Mercedes, Volkswagen, Ford and Audi. “Our work over the last two years has made aluminum fit for the engine compartment and the high requirements of temperature, vibration and chemicals.” A auto-Kabel, which has been friction welding aluminum cables since 2001, has been qualifying new ultrasonic and orbital welding processes, which should lower costs while maintaining reliability.

To solve the problem of electrochemical corrosion that occurs when aluminum is connected to copper terminals, Gebauer & G rillier, for about eight years, has been using an epoxy resin filled with nickel powder, but it is very expensive. “In the future we will instead use solder. We crimp the terminal to the aluminum cable, and then we solder this using special aluminum solder developed by our company,” said M r. Hocker.

A merigon’s Lon Bell thinks thermoelectric generators powered by exhaust heat could be ready for production between 2012 and 2014. “The timing [for waste heat recovery] is longer than for thermoelectric heating and cooling because of the need to integrate advanced thermoelectric material into the designs. If I have a brand new material then I have to learn how to manufacture it, use it, metatize it and solder it.”

“The most prominent challenge is to efficiently extract electrical power over the broad operating range of the vehicle. Very little heat is generated when the engine is at idle, but a lot is produced when going up a hill at full acceleration,” said M r. Bell. A nother challenge is enduring high exhaust temperatures, which can range upwards of 600 degrees Celsius, or more. “Most thermoelectrics today are low-temperature materials. Power generation requires high-temperature materials, a whole different set,” said M arlow’s Barry Nickerson.

Carmakers and suppliers worldwide are working on thermoelectric generators. BMW North America is participating in a $6.3 million U.S. Department of Energy-sponsored program to create a cost-effective and commercially viable system. Ap working prototype of the system is to be installed on a BMW 5 Series by 2011 or soon thereafter. The project, which also involves M arlow Industries, Visteon and others, is being led by A merigon’s development arm, BSST (Bell Solid State Thermoelectrics). General Motors has a similar DOE-sponsored program that plans an on-vehicle demonstration by 2011. The Japanese also have government-supported thermoelectric power generation research in the works.