 *By Maury Wright, Technical Editor*

AUTO ELECTRONICS

# PREP FOR A MULTIMEDIA FUTURE

**IT'S NOT JUST YOUR HOME AND OFFICE ELECTRONICS THAT MAY SOON HANDLE STREAMING VIDEO AND MULTI-CHANNEL AUDIO. DESIGNERS ARE FEVERISHLY PURSUING A MOBILE ENVIRONMENT—FROM POWER SYSTEMS TO IN-VEHICLE NETWORKS—IN WHICH THE INTERNET, WIRELESS LINKS, PERSONAL COMMUNICATION DEVICES, ENTERTAINMENT ELECTRONICS, AND TRADITIONAL CAR SYSTEMS CONVERGE.**

Like most other complex electro-mechanical devices, modern automobiles rely on a significantly increasing ratio of electronics components to mechanical and hydraulic components. Auto designers have used electronics to increase safety and reliability and to improve handling and driving. The automakers, however, have balked at relying on standards to accelerate the design cycle. Further, their inability to deliver state-of-the-art entertainment, communication, navigation, and other "telematics" (navigation, driver-warning, and communication systems) clearly highlights the manufacturers' reluctance at relying on these standards. The good news is that the automakers appear to have realized their errors and limitations and are participating in the development of new network standards for both mission-critical and convenience or entertainment systems. Some cars rely on several closed networks, but they will soon integrate one or more that are open to outside suppliers of everything from PClike systems to digital-versatile-disk (DVD) players. And an in-car network may soon carry digital video and audio streams, and a wireless link will maintain a persistent bridge to the Internet. Opportunities will abound for entrepreneurs and established vendors of everything from operating systems to consumer electronics. To prepare for this new open market, you need to understand the scope of auto networks and interfaces, as well as power, safety, and other systems that these open standards will affect.

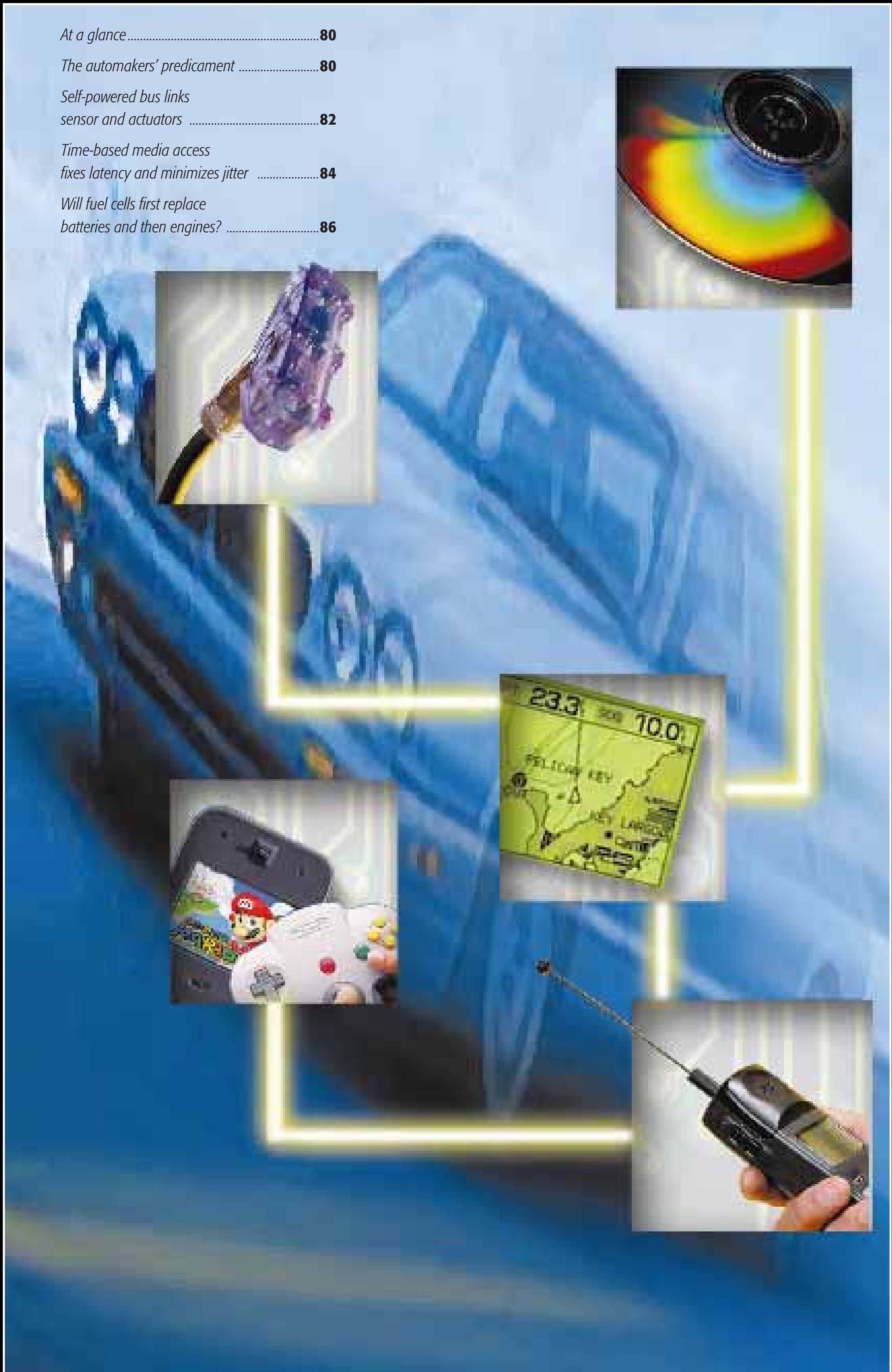



Illustration by Mike O'Leary

Before getting into network specifics, first consider some terminology and logistics that may be unfamiliar unless you have experience with automotive electronics. The automakers and the Society of Automotive Engineers (SAE) have classified networks for car systems as: Class A, slower than 10-kbps networks for convenience features, such as power seats and climate control; Class B, 10- to 125-kbps networks for body electronics and diagnostic systems; and Class C, 125-kbps to 1-Mbps networks for vehicle-dynamics systems, such as engine control and antilock braking (**Reference 1**). Participants in the industry collectively refer to the systems that connect to these networks as "OEM systems."

Today's cars typically lack an open network for telematics systems. Auto-industry participants also use the term "infotainment" to describe devices such as stereo systems, navigation systems, cell phones, and others. In any case, the auto industry is in dire need of a standard bus or network for telematics and infotainment systems that allows car manufacturers, dealers, and owners to easily add interoperable equipment (see **sidebar** "The automakers' predicament").

Automakers worldwide had significant motivation to move toward network or bus technology in the OEM vehicle-dynamics, body, and convenience systems.

**AT A GLANCE**

- The US automakers will move to the controller-area-network (CAN) standard by 2002 or 2003 models.
- The Automotive Multimedia Interface Collaboration is developing an open gateway to the vehicle networks.
- The Intelligent Transportation Systems Data Bus (IDB) network will open a diagnostic window into automotive systems.
- IDB will seamlessly connect telematics and infotainment devices.

As the demand for fuel-efficient cars escalated two decades ago, the weight of wiring became a significant roadblock to lighter and therefore more fuel-efficient cars. Moreover, the cost of spider-web-like wiring topologies became prohibitive. But, although the automakers realized the need for networks, they didn't necessarily buy into open standards in the area of electronics. Although you can attribute part of their reluctance to protectionist and not-invented-here philosophies, more valid reasons also exist. Cars had relatively few electronics 20 or even 10 years ago; therefore the economies of scale that electronics standards yield wouldn't have significantly benefited cars. Moreover, factors such as safety and reliability rightfully took precedence over cost. And the design cycles necessary to develop safe and mechanically and aerodynamically efficient cars were so long that electronics standards were unnecessary to meet time-to-market requirements.

Over time, distributed intelligence and the growing amount of electronics in cars made standards more attractive, and computer simulation and CAD have even shortened car-design cycles. European manufacturers soon recognized this fact and are far ahead of US manufacturers in adopting controller-area-network (CAN) standards. The domestic manufacturers and SAE took 10 years to develop the J1850 standard, and it's not a single standard. Ford (www.ford.com) uses a different J1850 physical layer from that of GM (www.gm.com) and Chrysler (www.chrysler.com). Moreover, GM and Chrysler use different data-frame formats above the physical layer, and all three companies have proprietary messages (**Reference 1**).

Domestic automakers may not have moved to any standard were it not for the Environmental Protection Agency (EPA) and the California Air Resources Board. Emission concerns led the agencies to demand a standard diagnostic interface for

## THE AUTOMAKERS' PREDICAMENT

With design cycles ranging as long as five years, automakers have been simply unable to deliver state-of-the-art electronics in automobiles. I realized the shortcomings of auto-design practices almost two years ago during a painful car-shopping experience. My wife wanted a new car and liked the Cadillac (www.cadillac.com) Catera, which was a relatively new model at that time. I can't say I've ever been a Cadillac fan, but the Catera was a new concept for Cadillac and had garnered relatively good reviews, and dealers were offering it with generous lease or loan terms.

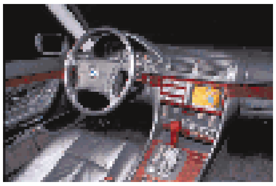
It also was one of the earliest vehicles to carry GM's (www.gm.com) OnStar (www.onstar.com) system. The OnStar system integrates a Global Positioning System (GPS) and cell phone in the car. Should you get lost or need to know the location of the nearest McDonald's restaurant or Chevron station, you simply use the cell phone to call the OnStar service center. An OnStar representative can then track your location via the GPS, which relays its data to an OnStar computer via the cell phone. The remote OnStar representative can then advise you in real time, guiding you to your destination. Should you lock your keys in the car, you simply call OnStar from another phone, and representatives will dial your integrated cell phone, unlock the car, and even switch on the lights.

At first glance, OnStar looks great, but the engineering side of my psyche began to find more faults than benefits with OnStar. Although the car has an onboard GPS receiver, the driver has no way to directly access the system. Moreover, it requires the owner to pay the monthly service for a fixed cell phone in an era when much of the population is already carrying pocket-sized phones. I decided against the Catera because of what I considered a poorly designed system.

The real culprit, however, was an extremely long design cycle for cars. Cadillac engineers probably designed the OnStar electronics three to five years before GM first shipped the car, yet designers of GPS receivers, cell phones, and LCDs went through five to 15 new designs—making vast improvements—in the same amount of time. The situation only gets worse when you consider that an owner might keep a car 10 years old. The electronics might be 15 years old by then.

The answer to the automakers' predicament is a generic bus or network for telematics, entertainment electronics, communication devices, and perhaps an in-car computer. Such a network will allow automakers, dealers, or owners to at any time add state-of-the-art electronics. Moreover, it will open the door to a plethora of new applications.

smog tests, yet, even with the agencies' mandates, no single standard exists. Since 1996, the EPA has mandated that all vehicles, including many 1995-model cars, include Revision 2 of the onboard diagnostics port (OBD-II, www.obd-ii.com) in the passenger compartment. But the OBD-II connector and standard support all the J1850 flavors and the ISO's 500-kbps 9141 network, which European and Asian—and even some Chrysler vehicles—use. The SAE and the EPA have also agreed to support Class B CAN signals in the OBD-II connector, although no current vehicles have implemented CAN for that application.



In the future, navigation systems such as this BMW unit will connect to other peripherals and perhaps a central in-car computer via a standard IDB network.

Unless you partner with an automaker to develop an OEM subsystem, the OBD-II connector is as close as you can get to the mission-critical networks. All automakers feel that, because of safety and reliability concerns, they must completely control the mission-critical networks. Several companies, including Dearborn Group (www.dgtech.com), make OBD-II-based diagnostic tools. Dearborn also offers seminars and is a leading authority on the dozens of SAE, ISO, and other standards that the auto and truck industries use.

As for mission-critical networks, the US automakers do all appear to be headed toward a standard Class C CAN implementation. Varying by make and model, by 2002 or 2003 models, most US vehicles will use a 500-kbps CAN bus, SAE J2284 (physical- and data-link-layer spec), which in turn uses the ISO 11898 physical layer. The US automakers appear headed in different directions for Class A and Class B networks. For example, in Class B networks, GM is adopting the J2411 single-wire version of CAN, whereas Ford is developing the proprietary UART Based Protocol (UBP).

CAN implementations are also inadequate for some mission-critical subsystems and may prove inadequate for a full "drive-by-wire" car design. For example, CAN buses cannot connect air-bag sensors and actuators because of potential latency problems and the need for a self-powered air-bag-firing bus (see **sidebar** "Self-powered bus links sensor and actuators"). Meanwhile, a full drive-by-wire design will be necessary for a car to finally meet Intelligent Transportation Systems (ITS) scenarios (**Reference 2**), in which computers actively control acceleration, braking, and all other aspects of driving. Moreover, proponents claim that a drive-by-wire design will further reduce weight and improve safety. State-of-the-art cars today use mostly electronic control systems, but antilock brakes remain an electronic-assisted electromechanical system. Some experts believe that latency and jitter on CAN channels will prevent their use in controlling brakes (see **sidebar** "Time-based media access fixes latency and minimizes jitter").

### THE GATEWAY

You can't expect convergence of mission-critical networks anytime soon. You may wonder why it matters what the automakers do on the OEM side of the car. Well, it's become obvious to the automakers and industry observers that customers could benefit if an onboard computer could at least monitor all of the mission-critical networks. For example, a computer with a wireless Internet connection that could also monitor the OEM

## SELF-POWERED BUS LINKS SENSOR AND ACTUATORS

Although the automotive industry has largely moved to networks or buses to connect subsystems from engine control to power seats, manufacturers typically still wire the air-bag sensors and actuators in a star fashion to a central control unit. Buses such as the controller-area-network (CAN) bus aren't useful in air-bag systems for two reasons. First, the crash sensors in an air-bag system send only short messages, so transfer rate is less important, but the message must get to the controller within milliseconds and CAN latency doesn't support such timing. Second, the air-bag actuators require a relatively high voltage, such as 25V, to charge the capacitor that fires the air bag.

The auto industry would, however, like to move to a bus architecture in the air-bag system, and the partnership of Motorola Semiconductor (www.mot-sps.com/automotive) and TRW (www.trw.com) has developed one such scheme, the Distributed Systems Interface (DSI). Moreover, embedded-systems designers might find the bus useful in other applications that require a combination of sensors and actuators on a self-powered bus.

You can download a system spec for DSI from either company's Web site. The two-wire bus carries a fixed dc voltage, such as 25V, except during signaling. During signaling, the constant voltage disappears, and a communication signal swings at 1.5 to 4V. The scheme supports 15 nodes and allows the polling of sensors, such as crash sensors, as often as every 3 to 5 msec. Each node includes a capacitor that charges and powers the node based on the constant voltage applied between signaling activity. Moreover, actuators such as air-bag-firing circuits use the high voltage to deploy the air bag. By using such a high voltage, the capacitor in the actuator can be relatively small, thereby fitting into tight spaces, such as steering-wheel hubs.

Several other automotive-electronics suppliers have air-bag buses on their drawing boards, including Philips (www.philips.com) and the partnership of Siemens (www.siemens.com) and Breed Electronics (www.breedtech.com). Only Motorola and TRW, however, have developed a scheme that can connect both the sensors and the actuators on a single bus. Overall, DSI allows the connection of eight buses to a controller, with each bus connecting 15 nodes. The partnership believes that DSI can serve seat-belt and other safety systems in addition to air bags. The companies have yet to announce customers but claim to have automakers working on designs. Embedded-system designers working with sensors and actuators outside the automotive arena should also note that the bus can operate at voltages as low as 8V if you don't need to fire something like an air-bag squib.

networks would allow remote diagnostics. It's not even beyond the realm of possibility that a remote facility could at least temporarily fix your car, allowing you to drive to a shop, now that a computer can prevent a car from starting. However, given the inability of the automakers to deliver even a state-of-the-art stereo, it's unlikely that they can add a wireless Internet connection to the engine controller. They are ready to offer a gateway with a LANlike firewall so that a telematics computer could handle communications. An open network may be as valuable to a next-generation maintenance-and-repair system as it is to a state-of-the-art Global Positioning System (GPS) receiver or stereo.

SAE has for some time been working on the ITS Data Bus (IDB), an open network. The IDB Forum (www.idbforum.org) is shepherding the standard, which initially includes the IDB-T implementation, a 115.2-kbps, RS-485-like, multidrop serial bus. A year ago, the forum proclaimed the standard as nearly complete, and cars with IDB were expected to debut this fall. A concept car from Chrysler with IDB onboard made an appearance at the Consumer Electronics Show (CES), which took place in January in Las Vegas. The Consumer Electronics Manufacturers Association (www.cemacity.org) has also endorsed IDB.

Despite the fact that representatives from the automakers had worked with SAE on the IDB spec, however, some among the persnickety group must have felt that the IDB-T flavor was not the answer. To help settle on a standard and to pursue a gateway standard, automakers DaimlerChrysler, Ford, GM, Renault (www.renault.com), and Toyota (www.toyota.com) in April formed the Automotive Multimedia Interface Collaboration (AMIC, www.ami-c.com). The popular press and, in some instances, the trade press, have depicted AMIC as planning to develop its own open network. However, all AMIC has done in the area of a network is to nudge the IDB Forum toward a common network to which the AMIC members are committed. Specifically, with input from AMIC, the IDB Forum has begun to rework the IDB spec to replace the RS-485 physical layer with a 250-kbps CAN physical layer. The new bus, IDB-C, will clearly be superior, although slightly more expensive, than IDB-T. And here, you have to think that a slight delay is better than a nonuniversal bus because a single standard is paramount to the success of IDB. The IDB Forum now claims that IDB-C will emerge in 2001 model cars.


**Prices for CellPort Labs' CP2100 Mobile Network Server start at $995, including interfaces to vehicle networks, such as CAN and J1850, and to wireless networks, such as cellular, paging, and personal communications systems.**

Meanwhile, AMIC is taking on other jobs that will ultimately allow IDB peripherals access to the OEM side of the car. AMIC will likely define both a hardware interface for the gateway and an application-programming interface (API) that allows IDB systems a standard

## TIME-BASED MEDIA ACCESS FIXES LATENCY AND MINIMIZES JITTER

Now that most automakers have adopted the controller-area-network (CAN) standard, it would in an ideal world serve as the only necessary mission-critical in-vehicle network for years to come. And perhaps CAN will fill most needs. But designers that have worked on highly reliable electronics systems, such as fly-by-wire controllers for jets, believe drive-by-wire designs—particularly for braking control—will require a different network. The naysayers claim that arbitration on CAN creates widely varying latencies. In some cases, the latency is too great for reliable operation in braking applications. And in all cases, the jitter—the difference between the worst- and the best-case latency—makes it difficult if not impossible to design a reliable braking system. Leading this chorus is start-up TTTech (www.tttech.com) of Austria; Motorola Semiconductor (www.mot.com) has recently allied with TTTech.

TTTech (Time Triggered Technology) is proposing the deterministic Time Triggered Protocol (TTP). Essentially, TTP handles media access using a time-division multiple-access (TDMA) scheme. The scheme divides the available bandwidth on a channel into a cluster cycle, and, during each cluster cycle, each computing node gets one or more time slots, during which it can transfer data. Buses or networks such as CAN rely on interrupt- or event-driven operation, whereas TTP relies on time- or state-driven operation.

Given a channel of equal maximum bandwidth, a CAN system might more quickly react to an external event than a TTP system does. On the other hand, CAN-bus arbitration could delay handling of an event, whereas TTP fixes latency and minimizes jitter. TTTech has also taken other steps to maximize reliability. The proposed network will continue to work even if one node fails; TTP includes mechanisms that monitor the health of each node. The company claims that a TTP-based braking system would work even if only three of four wheels could apply the brakes. The proposed scheme also employs dual redundant buses that connect with each node.

TTP also has some significant disadvantages. Designers must fully prescribe the TDMA media-access scheme, manually assigning time slots to nodes, thereby ensuring that each node gets the required channel access. Should you need to add a node to a TTP bus, you would have to adjust and reverify timing. With CAN, as with Ethernet, you can always add a node, although you always run the risk of overloading the channel. TTP networks will also cost significantly more than CANs, so near-term deployment will be much more likely to happen in luxury cars. See TTTech's Web site for several detailed but potentially biased comparisons of CAN and TTP.

means to access the car systems. IDB is continuing to flush out the IDB-C spec and is working on other aspects, such as plug and play. IDB intends to develop a spec that would ensure that any electronic device, ranging from a GPS or navigation system to a wireless phone to engine-diagnostic equipment, will connect and work seamlessly. The organization, however, isn't working on an API or defining any standard for a car computer. Instead, the IDB spec will define standard messages. Should a device such as a computer send a standard message requesting location, a GPS receiver will presumably respond with a standard message containing location coordinates.

The in-car network, however, may comprise more than devices directly connected to the IDB network and needs to link to external networks, such as the Internet. In a scenario that just might work or could end up like too many cooks spoiling the broth, yet another organization, the Telematics Suppliers Consortium (TSC), is trying to help. TSC includes members that offer telematics equipment, wireless equipment and services, consumer electronics, and others. TSC intends to support IDB-C and future specs and help layer other technologies and APIs above IDB. The consortium does not so much seek to develop specs as to identify symbiotic technologies and specifications and encourage the owners to meld them for in-car use.

### COMPLEMENTARY STANDARDS

For example, TSC has identified the Wireless Application Protocol (WAP) and Bluetooth (www.bluetooth.com) initiatives as potentially useful within a car. The WAP Forum (www.wapforum.org) is trying to define a de facto standard for delivering wireless Internet services to portable devices, such as cell phones, pagers, and personal digital assistants (PDAs). A modified version of WAP could be the means by which cars link to the Internet. Bluetooth, meanwhile, is working on a wireless scheme to connect PCs, cell phones, pagers, PDAs, and other devices for data sharing. Bluetooth in a car could be the easiest way for an occupant to link a handheld computer or an external network via a cell phone to the IDB through a wireless gateway.

Other standards that TSC may pursue could link cars to cars, cars to the freeway infrastructure, or cars to services at businesses, such as gas stations. TSC foresees a day when you can pull up to the gas pump and download a digital movie or e-mail over a short-range wireless link while you fill your tank. Possible options for such communications include the Dedicated Short Range Communication (DSRC) standard that ITS uses in scenarios such as automatic toll collection. A combination of the American Society for Testing Materials (www.astm.org) and the IEEE shepherds DSRC. TSC may also consider using the IEEE-802.11 wireless-LAN standard, which could find use in the gas-station application or in future ITS scenarios, such as enabling cars to communicate to reduce collisions and to travel in automatically controlled platoons. In all cases, TSC hopes to encourage the standards developers to customize the technology for a car applica-

## WILL FUEL CELLS FIRST REPLACE BATTERIES AND THEN ENGINES?

Although researchers have spent a lot of time on battery-powered vehicles that slash emissions, the best near-term alternative to internal combustion engines may be fuel cells. Fuel-cell theory is relatively well-known, although deployment of the technology is in its infancy. In a fuel cell, a chemical reaction at low temperature between hydrogen and oxygen yields water, electrical energy, and heat with no harmful emissions. Manufacturers are now deploying the technology in residential and commercial building applications to eliminate or minimize the need for commercial power from a utility. The technology will also find its way into cars, first to replace a battery and later possibly to drive an electric engine.

In the near term, BMW (www.bmwusa.com) has announced that it will release a series of test vehicles with fuel cells in place of a traditional battery by early next year. The fuel cells offer several advantages over batteries. For starters, fuel cells can generate more current, and that ability may be key as cars begin to host more electronic devices, including computers, that could easily drain a traditional battery. The fuel cell can also work independently of the engine, which means you wouldn't drain the battery with electronics, even when the alternator isn't operating. Moreover, BMW plans to use the fuel cells to run the air-conditioning and heating units, allowing those systems to also operate without the engine running.

The simplest fuel cells operate from refrigerated compressed hydrogen, but a water-vapor-reformation process can generate hydrogen from gasoline or methanol, allowing the fuel cell to run from the same fuel supply as that of the combustion

**DaimlerChrysler has surged to the forefront of fuel-cell research with a fourth-generation fuel-cell vehicle that evolved through Mercedes research efforts.**

engine. BMW could have a fuel-cell-based vehicle on the market within a couple of years yet claims to be set on the internal combustion engine as the main power plant. Several other automakers, however, believe that fuel cells can replace combustion engines. Both Chrysler (www.chrysler.com) and Ford (www.ford.com) have stated their intention to produce concept vehicles. Mercedes (www.mercedes.com/e/innovation/fmobil/necar.htm), meanwhile, has built several such demo vehicles, including a bus. The early experiments used much of the car's cockpit for the fuel cell and relied on hydrogen for fuel. Mercedes' latest designs, however, run on standard fuel and can carry passengers. Now that Chrysler and Mercedes are siblings under the DaimlerChrysler conglomerate, their separate fuel-cell efforts may merge, and DaimlerChrysler recently unveiled a fourth-generation vehicle that appears to be based on earlier Mercedes research (www.daimlerchrysler.com/news/top/t90611a_e.htm). Still, fuel-cell-based engines are much further from the open market than are cars that use the technology as battery replacements. For more information on fuel cells, visit the National Fuel Cell Research Center (www.nfcrc.uci.edu/).

tion rather than develop a standard in the TSC group.

One other industry group will also influence future directions. The Intelligent Transportation Society of America (ITSA, www.itsa.org) is working as a liaison between government and industry to develop ITS applications, such as lane tracking, adaptive cruise control, and totally automatic vehicles. By the time you read this, ITSA will have held Demo '99 in East Liberty, OH, in July, where manufacturers will demonstrate the latest ITS products (**Reference 2**). Products that connect to the IDB network will emerge directly from ITSA programs.

### WHO CONTROLS THE API?

With all of the industry groups and ego-laden companies involved, the question remains: Who controls the APIs that allow standard applications on an in-car computer to access IDB devices and those connected by wireless gateways? The IDB messaging scheme may work for baseline car systems, but Bluetooth or WAP devices could complicate compatibility. TSC believes a higher layer than IDB messaging will ultimately handle plug-and-play compatibility.

Microsoft (www.microsoft.com) has informed the world that its Auto PC is the heart of the car. Microsoft and its initial partner, Clarion (www.autopc.com), announced Auto PC with great fanfare at CES. According to most reports, however, consumers haven't rushed to buy the product, which is little more than a WinCE-based stereo and navigation system. Surprisingly, some third-party companies are shipping software for the unit. But the fact is that Microsoft has no clue about car interfaces and gateways and—to its credit—has joined the IDB and TSC groups rather than continuing to insist that its technology must immediately go into every car.

CellPort Labs (www.cellport.com) probably has a better handle on what's needed in an in-car computer than does Microsoft (see "Competition arrives for Auto PC," *EDN*, Aug 5, 1999, pg 22). The company has long developed custom systems for commercial and military vehicles and has now announced the CP2100 Mobile Network Server, prices for which start at $995. The system can support car interfaces, such as CAN and J1850, and most popular cellular and paging wireless links. Moreover, the company claims that it has a library of services that greatly simplifies the development of in-car applications. The CP2100 includes a PowerPC µP and QNX (www.qnx.com) real-time operating system. CellPort also claims that it may offer its library as a standard API for development and that you can use it with other operating systems.

Consumers are demanding in-car TV, gaming, and VCR systems, such as this Ford unit for minivans, but, in the future, they'll demand digital systems with a 100-Mbps in-car network for streaming video.

Ultimately, however, the IDB Forum and TSC believe owners should be able to choose the horsepower of their in-car computers, just as they do their engines. Some technophobes may want no more than a single-line alphanumeric interface to a GPS, whereas others will want the latest CPUs and operating systems with a true-color flat-panel display and DVD player. Some owners may want to buy fixed computers, whereas others may want to connect their notebook PCs or PalmPilots as user interfaces to their cars. The auto groups seem determined to allow owners the choice of hardware and software, so TSC may consider developing an API. AMIC has also endorsed Java for use in cars.

The IDB Forum also can't rest on its laurels because IDB-C is only a starting point. Car—and especially van and sports-utility-vehicle—owners are buying analog VCRs and TVs, and the arrival of digital video and audio is imminent. The group has labeled a next-generation effort "IDB-multimedia" (IDB-M). The goal is a 100-Mbps bus that could handle multiple video and audio channels, although backward compatibility with IDB-C is a likely requirement. The IDB group would clearly prefer to adapt some existing technology rather than start from scratch.

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Early in the process, the IDB Forum is considering IEEE-1394 Firewire and Oasis SiliconSystems' (www.oasis.com) Media Oriented System Transport (MOST) proprietary standard for high-end audio applications. IEEE-1394 has the speed necessary for the auto applications and can carry multimedia streams. IDB would have to adapt the technology for cars in ways as simple as adding more rugged connectors and ways as complex as adding IDB-C support. MOST, meanwhile, operates at 25 Mbps using a ring topology and fiber optics. The IDB Forum could adopt MOST as an interim technology, or Oasis could extend the data rate for video use. Mercedes (www.mercedes.com) is rumored to be using MOST in some 2001 model cars.

### WHERE'S THE POWER?

With all that's planned for cars, the power needs begin to look more like those of a mainframe computer than those of my relatively new pickup truck. The industry may move to a higher supply voltage, such as 42V, so that currents stay low and cars don't need even heavier duty wiring. But something must generate that current, and batteries may be unable to keep up (see **sidebar** "Will fuel cells first replace batteries and then engines?"). Myriad safety concerns also emerge once you add entertainment devices to an auto. And, if you are interested in designing for the car market, you may want to see "Embedded technology transforms the automobile," pg 91 in this issue and get a copy of *EDN*'s latest flat-panel-display supplement. □

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