Toyota Developing Its Own Operating System

Likely Replacement for Windows CE in G-Book Terminal

Tired of not being able to quickly fix bugs in the Windows CE operating system that runs its G-Book telematics terminal, Toyota has decided to create its own OS. Because Toyota can’t access the Windows CE code, it must go through Microsoft when problems arise—a disappointing experience, according to one supplier familiar with the carmaker’s deliberations. “Microsoft doesn’t understand car systems or criticality,” he said. “Toyota wants to be able to access the operating system’s code.” G-Book is installed on all Lexus vehicles sold in Japan.

A massive undertaking that will involve approximately 25 software developers for four to six years, the new operating system will support both multimedia and control applications on a single multicore microprocessor. Toyota intends to make the operating system available to other carmakers through JasPar, the Japanese software platform and architecture consortium.

According to Toyota, one benefit of the multicore processor is its ability to provide high processing performance without a dramatic increase in operating frequency, which means it generates less heat. The system will be able to support parallel execution of the information and control systems software. Toyota engineers say that will allow them to frequently update the information system software without having to modify the control system software.

Though it has no concrete plans to do so, Toyota says it wants to standardize the in-vehicle information platform so vendor-supplied data such as maps, points of interest, traffic information and trans-

AUTOSAR Standard Software Platform Only a Matter of Time

Despite some highly scrutinized growing pains, the AUTOSAR standard software platform initiative is very much alive and well around the world.

At last month’s automotive electronics conference, Fachkongress Elektronik, in Ludwigsburg, Germany, some suppliers voiced concerns about AUTOSAR’s progress, among them the worry that AUTOSAR has too many members—more than a hundred so far—and in trying to satisfy all possible use cases, the microcontroller/memory footprint might get too large. There was also concern about the business model: Who will pay for the software that, with AUTOSAR, can be unbundled from the hardware? Who will maintain the software? The automotive industry is used to paying for hardware, but not for basic or application software, particularly software that is sold separately.

Other attendees were concerned about the Japanese carmakers’ level of support for AUTOSAR. Very much focused initially on FlexRay, the JasPar collaboration of Japanese carmakers and mostly Japanese suppliers, hasn’t yet been able to provide much assistance to AUTOSAR developers, who are scheduled to complete version 2.0 of the specification by the end of 2006.

Carmaker Support

Another red flag is carmakers’ unwillingness to make public commitments to widely apply the standard to production vehicles. So far, only BMW and PSA are publicly committed to production programs, albeit modest ones initially.

The most influential champion of AUTOSAR thus far, BMW anticipated that the AUTOSAR spec would be ready in time for the new 7 Series, due in 2008. Of the roughly 47 software modules that comprise the 7 Series’ basic software platform, 20% to 30% will be AUTOSAR compliant. That basic software platform will support about 80% of the 7 Series’ powertrain, chassis and body control electronic control units.

BMW’s next opportunity to advance AUTOSAR will come with the 1 and 3 Series platform due in 2011. By then 100% of the modules that make up the basic software will be AUTOSAR compliant. That software platform will underpin 50% of the ECUs used on 1 and 3 Series vehicles. According to 3Soft, the AUTOSAR basic core software platform consists of 34 different software modules. BMW will produce between 800,000 and one million 1 and 3 Series vehicles per year.

PSA is also said to be keen on AUTOSAR and will implement parts of the basic software module coming in a mass produced ECU possibly as early as 2008. PSA has begun some projects to evaluate the AUTOSAR software and to test how their tier-one suppliers deal with the new methodology. AUTOSAR should figure heavily in PSA’s so-called 2010 platform.

According to engineers familiar with some of its projects, DaimlerChrysler will add some AUTOSAR basic software to the next Mercedes S Class, due in 2011, but they will probably not use the complete AUTOSAR basic software platform. Stung by quality problems in the past, Mercedes is now more risk averse and will not take the next big step into AUTOSAR until it is certain it will add and not detract from quality.

“Volkswagen, a fast follower, will probably wait until others use it and then jump on the train,” said one engineering manager active in the development of the AUTOSAR spec. NEC, Hella and 3Soft
Toyota OS...

port infrastructure data can be used by any carmaker or systems supplier. That will drive the prices for commercially supplied data services down.

Toyota will probably not start from scratch to build the new operating system, but rather will find an existing UNIX operating system, with POSIX interfaces, that can be adapted to meet Toyota’s requirements. UNIX, a very popular, multitasking computer operating system, is perhaps the most common operating systems for servers on the Internet. With UNIX, Toyota believes it can keep software quality high by improving the parts that should be changed and reusing the parts that don’t need changing.

The software will be developed jointly with the Center for Embedded Computing Systems of Nagoya University. The new operating system is expected to reach production between 2010 and 2012.

Despite developing its own operating system, Toyota is still actively working on AUTOSAR software. AUTOSAR is tightly linked to the OSEK operating system developed by the Germans, not for use in infotainment systems but rather in powertrain, chassis and body control systems.

Harman International Year-End Results, New Business

FY 2006 Automotive Sales: $2.236 billion, 68.8% of total Harman sales
Change from FY 2005: up 5.2%
FY 2006 Automotive Operating Income: $337.7 million, or 15.1% of sales

Harman International closed out its fiscal year June 30, 2006 with automotive sales up 5% over the prior year, but automotive operating income was down 3.0%. According to Harman, the results include $7.3 million in restructuring charges and substantial R&D spending (9.3% of sales) on behalf of new business awards that will not generate sales until fiscal 2007. The company expects automotive sales to increase by 7% in FY 2007, with automotive operating margins nearing 16%. Sixty-four percent of Harman sales were to automotive OEMs; Daimler-Chrysler accounted for 25% of total sales, BMW accounted for 10%.

Harman sees the growing trend among OEMs toward common electronics platforms as a potential boost to future sales and a way to penetrate non-luxury vehicle segments. Harman will supply Chrysler’s optional MyGIG hard drive infotainment system for the Sebring sedan, the Dodge Nitro and Jeep Wrangler models in 2007.

Harman has received significant contract awards, including a recent award for the refresh on the Mercedes 2009 S Class, and will begin producing new audio and infotainment systems for Chrysler, Hyundai, Peugeot/Citroën and BMW beginning in fiscal 2007.

Harman, along with Fujitsu-Ten and Panasonic, will supply Toyota with MOST components when Toyota replaces its AVC (audio video communications) LAN with MOST on all luxury vehicles, beginning with the 2008 LS 460. Toyota will use the MOST protocol on copper wiring to connect the head unit with the audio amp and to connect rear seat video monitors.

Helmut Schinagel, formerly BMW executive vice president, interior and driver environment, replaced Erich Geiger as CEO of Harman/Becker Automotive Systems on October 1, 2006. Dr. Geiger is now chief strategy and technology officer for all Harman businesses. The company’s CEO, Douglas Pertz, resigned in August just four months after his appointment.

J.D. Power and Associates Survey New Car Feature Interest

J.D. Power and Associates’ 2006 Automotive Emerging Technologies Studies for the United States, Europe and Japan reveal considerable differences between Western consumers’ interests and those of Japanese consumers, with the exception of side-impact airbags. Among the top ten features the surveyed Japanese consumers were “definitely or probably interested in buying” when the feature’s market price was revealed were hybrid powertrains (#3), HID headlights (#4), anti-whiplash seats (#5), two-way keyless entry (#6), and noise cancellation (#8).

**For Japan, this feature is listed as Rear Park Assist.

The ranking indicates consumer interest in a feature after exposure to its estimated market price. Rank is based on the number of consumers who said they were “definitely” or “probably” interested in purchasing the feature.

Source: J.D. Power and Associates

THE HANSEN REPORT ON AUTOMOTIVE ELECTRONICS

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Circulation Manager
Business Model Not Yet Defined

**Freescale Semiconductor,** very much an advocate for the standard, has sponsored AUTOSAR training sessions in the U.S., Europe, Japan and even China, which were very well attended. “I strongly believe that the industry will move in the direction of AUTOSAR,” stated Stephan Lehmann, in charge of automotive strategy for Freescale. However, he added, “I don’t think AUTOSAR is quite ready. The AUTOSAR spec we have today does not cover 100% of the use cases. But, we will continue to expand it and at some point I expect AUTOSAR to be widely used in the industry.”

Before that happens, however, the industry will have to figure out how to compensate software developers for their products, not only the AUTOSAR basic software, which can be decoupled from a specific microcontroller, but also the application software that, with the AUTOSAR platform, can be decoupled from the ECU and sold separately.

“It is our feeling at the moment that OEMs will not pay for basic software,” cautioned Karsten Hoffmeister, 3SOFT product manager responsible for embedded platform software products, including the complete AUTOSAR suite. “In the past BMW bought the basic software for some of its architectures and shared it for free with the tier ones. In the future this will change, because it will be too expensive for BMW to do that.”

Mr. Hoffmeister would prefer to see a wider acceptance of the business model emerging at Volkswagen. “Volkswagen suggested that the tier one can buy our operating system. We integrated our operating system in Volkswagen’s standard operating system. We integrated our operation software that, with the specific microcontroller, but also the application software that, with the AUTOSAR platform, can be decoupled from a microcontroller that must run the software, for example, the effects AUTOSAR software implementations will have on vehicle energy consumption. “To what degree should we transfer from hardware functionality to software functionality?” asks Freescale’s Mr. Lehmann. “You can run every algorithm in software if you want, but that will require more MIPS and more MIPS increase the demands for current. The problem is you can have 30, 80, or 100 microcontrollers in the car, but you still have the same battery.”

Mr. Lehmann wants to be sure that AUTOSAR leaves plenty of room for hardware innovation: “For example if you look at our S12X, 16-bit family, we have added a second core called XGATE that can generate a gateway with five CAN networks at extremely low current consumption. If AUTOSAR definitions are made so strict that XGATE wouldn’t be allowed, you take away the innovation.”

**Low Level Support from Japan**

With JasPar focused almost exclusively on FlexRay implementation, Toyota has been the only Japanese carmaker able to devote much engineering time to the development of AUTOSAR software. **Nissan,** for example, while a premium member of AUTOSAR, does not have enough software engineers fluent in English who could be sent to Europe to work on the specification. Along with Toyota, **Renesas** and **NEC** are actively participating in AUTOSAR software development, not at the overall concept level, but focused on such things as low-level I/O drivers.

For an excellent primer on AUTOSAR and its relationship to OSEK, HIS, CAN, LIN and FlexRay standards, see “No Detour Needed: Getting to AUTOSAR via OSEK,” by Jochen Schoof of 3SOFT and David Wybo of 3SOFT’s parent company, **Elektrobit,** SAE 06AE-70.

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**AUTOSAR Overview**

![AUTOSAR Overview Diagram](Source: SAE Paper # 2006-01-0168)
TRW Automotive

Background

TRW Automotive's roots go back to the Cleveland Cap Screw Company, founded in 1901. The company expanded into automotive and airplane engine valves in the early 20th Century and eventually became Thompson Products. The TRW name emerged in 1965 after Thompson Products' investments in electronics and missile technologies led to a merger with Ramo-Wooldridge Corp; TRW became a major player in the Cold War defense and aerospace industries. Its automotive product line grew with the 1996 acquisition of Magna International's steering wheel and airbag business and the 1999 acquisition of LucasVarity for $7 billion.

The acquisitions of the late 1990s left TRW with a substantial debt burden. Northrop Grumman launched a hostile bid for TRW in 2002 and eventually acquired the company later that year. The automotive business was sold for $4.9 billion in 2003 to an investment firm, Blackstone Group, which took TRW Automotive public through a stock offering in February 2004.

In early September 2006, the stock market valued TRW at $2,384 million, which is equal to just 0.2 times 2005 sales. Still, company insiders were net sellers of the stock with 40 sells totaling 312,362 shares over the three months ending October 9, 2006, according to Charles Schwab. TRW does not pay any cash dividends on its common stock.

TRW officials like to mention that 80% of the company's sales come from safety-related products, which according to one TRW spokesman, “continue to outpace the growth of production in the ma-
Debtor market regions of Europe and North America where TRW is strong.” While one could make the case that steering wheels, seat belts, stabilizer bars, suspension modules and many other products that TRW makes are related to safety, they are not necessarily high growth automotive parts. Even the airbag market is maturing. Nevertheless, TRW’s strong position in brakes, safety restraints and steering systems provides opportunities in fast-growing product segments such as electric parking brakes, electric power steering, electronic stability control and side impact airbags.

Highly Leveraged by Blackstone

Private equity firm Blackstone borrowed heavily at high interest rates to acquire a controlling interest in TRW. As a result, TRW is still saddled with a mountain of debt: $2,952 million long term, as of June 30, 2006. In 2005 alone TRW paid $228 million in interest payments, which is substantially more than it made in net earnings, which were $204 million for the year. Not only must TRW make onerous interest payments, but it must pay $5 million per year to Blackstone for monitoring, advisory and consulting services including advice about financing and corporate strategy. However, the company is also proactively restructuring its business and shifting its global footprint from high cost to low cost countries. In 2005 TRW spent more than $100 million in restructuring, or about $75 million more than in a typical year.

If TRW were less leveraged it could make greater investments in its future. In 2005 TRW spent just 1.6% of sales on R&D, 6.2% including engineering expenditures. TRW says that it adheres to “a strict definition of R&D that most companies do not employ ... and now employs more than 5,500 engineers and researchers worldwide when the number was less than 5,000 in 2002.” The company spent $503 million, or 4.0% of sales, on capital expenditures in 2005 and said it would put 4% of sales into capital expenditures in 2006. Through the first half, TRW had spent $202 million on capital projects, just 2.9% of first-half 2006 sales.

Standard & Poor’s has given TRW Automotive a corporate and bank debt rating of BB+, S&P’s highest “junk” rating, suggesting that the company faces major ongoing uncertainties to adverse business, financial and economic conditions. Its senior notes are rated lower, at BB-.

Still, according to one high-yield portfolio manager who follows TRW, the company is a good credit risk. “Analysts like TRW because it has good customers with geographic diversity; its business is spread geographically among the different OEMs. The company has been generating a decent amount of free cash flow, so they’ve been able to pay down quite a bit of debt. At year-end they had about $3.2 billion in debt, which will be down to about $3 billion by year-end 2006.” Even so, this analyst would like to see TRW get rid of some of its high-cost debt: dollar bonds as high as 11% and some euro bonds that are 10 1/8% and 11 3/4%.

High-Growth Active Safety Products and Applications

Active safety is particularly hot right now as carmakers look for products that assist drivers in avoiding accidents, or if they can’t be avoided, to make them less severe, so-called collision mitigation. Most of the first generation of active-safety systems will only warn the driver when unsafe conditions are sensed, but autonomous systems like electronic stability control (ESC) will increasingly act on behalf of the driver, often the weak link in any safety system. Autonomous systems automatically brake or steer the vehicle to avoid obstacles. According to Josef Pickenhahn, vice president for global brake engineering, the growing interest in autonomous safety will be spurred on by European, U.S. and Asian government initiatives to dramatically reduce the number of highway fatalities. “We have gotten almost all we can get from passive safety, from airbags and from optimized crash structures,” he noted. TRW’s current safety products business positions it well to be a player in advanced active safety systems.

◆ Electronic Stability Control

Probably TRW’s hottest product is electronic stability control, which recently received a big boost from the U.S. government. Last month the National Highway Traffic Safety Administration proposed regulations to require auto makers to install ESC in all light vehicles sold in the United States. The rule takes effect in 2009 and GM will do the same by 2010. Ford has already said it will make ESC standard on all 2009 model year and will be phased in over three years. Regardless, Ford has already said it will make ESC standard on all new vehicles by the end of 2009 and GM will do the same by 2010. Seventy percent of Chrysler models already come with standard ESC. The Insurance Institute for Highway Safety has estimated that ESC will save more than 10,000 lives annually when fully implemented.

continued on following page
Based on data from steering angle and yaw rate sensors, electronic stability control systems correct an over-steer or under-steer situation by reducing engine throttle and braking individual wheels. Unlike ABS, which is engaged when the driver slams on the brakes, ESC is automatically engaged without driver involvement.

ESC packaged with the antilock braking system effectively doubles the $100 price of TRW’s ABS. ABS and ESC accounted for 9.3% of TRW sales in 2005. TRW currently supplies ESC on more than 35 models in the 2006 model year and will supply more than 40 models with ESC for MY 2007.

◆ Electrically Assisted Steering

Demand is growing quickly worldwide for electric power steering systems, which reduce engine CO2 emissions by 3.5% compared with hydraulic power steering. Electric power steering does away with hydraulic fluid, reservoirs and hoses, and can be integrated with electronic stability control and lane guidance systems. TRW makes both electric power steering systems (EPS) and electrically powered hydraulic systems (EPHS) systems.

According to JTEKT Corp. the total demand for EPS units by all makers worldwide is growing annually at the rate of 20% per year to the point where by 2008 penetration of EPS into light vehicles will reach 30% from 21% in 2005. EPS penetration is just 6% of light vehicles globally, a percentage that will stay roughly the same through 2008.

This past June in Paris, TRW demonstrated some of the active safety features made possible by integrating its column-mounted EPS system with electronic stability control. To counteract, for example, split coefficient (µ) road surfaces or over- or under-steer situations, the EPS system generates steering wheel torque that helps coach the driver to turn the wheel in the direction of the required steering angle correction. The driver feels the opposing torque and can choose to bypass the intervention or accept the corrective measures.

◆ Brake Assist

TRW has been producing brake assist systems since it pioneered emergency braking on behalf of Mercedes with a production launch in 1996. Now widely available even in entry-level vehicles, brake assist measures brake-pedal acceleration and activates an electronic booster that initiates full emergency ABS braking in panic situations, even though the driver may not maintain full brake pressure. TRW still supplies Mercedes and the system is standard equipment on all Mercedes vehicles.

Brake actuators like brake assist will be used in autonomous systems that call for partial braking, collision mitigation or full-authority emergency braking without input from the driver.

◆ Radar Adaptive Cruise Control (ACC)

TRW introduced its first ACC product in 2002. The company ships radar ACC systems to Volkswagen, which makes it available on the Phaeton and Passat. The company also ships ACC systems to MAN for use in some trucks. A precursor to autonomous safety, ACC automatically maintains safe headway by varying the speed of the vehicle by adjusting the throttle.

TRW’s AC20 second-generation radar was first introduced in 2005 on the Passat. It uses just one long-range radar sensor, but is sufficiently robust to bring the vehicle to a stop with limited braking when the vehicle in front slows to a stop. To accelerate the vehicle after an automatic stop, the driver must depress the accelerator. TRW has booked an order from a European carmaker for a “follow-to-stop” ACC system that is to start shipping in mid-2007. The system can generate braking force up to 0.3g for ACC applications.

TRW has a contract to develop obstacle detection sensors that combine its existing 77 GHz long-range radar sensor with one or two 24 GHz short-range radar sensors for use in stop-and-go ACC systems. Stop-and-go ACC systems work in slow traffic without input from the driver. The 24 GHz sensor will be used to target the vehicle in the lane ahead that can be followed. While TRW manufactures its
As part of the TREAD Act, all vehicles sold in the United States with gross vehicle weight of less than 10,000 pounds must be equipped with a tire pressure monitoring system by September 1, 2008.

EnTire Solutions tire pressure monitors are installed on these vehicles: 2004-06 Acura MDX; 2005-06 Acura RL, TL; 2005-06 Honda Pilot, Ridgeline, Odyssey; 2006 Hyundai Tucson; 2006 Kia Sportage; optional on the 2006 Alfa Romeo 159.

In the coming years EnTire TPMs will be installed on Fiat, GM and Hyundai/Kia vehicles in North America and Europe.

Electric Park Brake

Although it was first brought to market in 2001, demand for TRW's electric parking brake is still growing quickly. While TRW will ship 700,000 units in 2006, it anticipates demand will grow to 2 million units per year by 2010, a 30% annual growth rate. The electric parking brake is more reliable, takes up less space and is cheaper to install than a conventional parking brake, which requires a mechanical hand- or foot-operated lever and stiff Boden cable that must be fished from the front of the vehicle to the rear axle. Instead of the lever cable, TRW's Electric Park Brake (EPB) uses an electric switch and wiring that connects to an electromechanical actuator built into each of two disc brake calipers, and a controller with redundant connections to the power supply. The system interfaces with the vehicle's CAN bus.

The electric park brake is almost always applied to vehicles with manual transmissions where its automatic hill-holding feature makes starting from a stop while heading up a steep incline a breeze compared with the non-electric parking brake, which must be disengaged manually while easing off the clutch and simultaneously stepping on the accelerator. Its biggest markets are in Europe and Asia.

Most of TRW's EPBs have shipped to Volkswagen for installation on the Passat, in addition to other VW and Audi models. TRW has just launched new applications of its EPB with Volvo and Ford of Europe. The mechanism sells to OEMs for between $50 and $75.

Acquisitions

According to TRW, it already has the full complement of major active and safety products represented in its portfolio, so any future acquisition will likely involve product lines it is already in. TRW's purchase in 2005 of a 68.4% stake in the Spanish steering wheel and airbag manufacturer Dalphimetal is an example of that strategy. TRW paid €113 million for the stake and also assumed debt totaling €84 million. In 2004 Dalphimetal produced sales of €317 million mainly to Peugeot, Renault, Volkswagen and Volvo.

TRW is most interested in making alliances with companies serving China, where it expects vehicle production to quickly grow, and in Japan, where it hopes to improve its prospects with customers that are growing successfully.

Asia and Eastern Europe Markets Emphasized

TRW's investments in Asia, particularly in China, are, by proportion, much larger than in other regions to take advantage of the region's high growth rates of vehicle production. TRW already operates 10 facilities in China through joint ventures or wholly owned facilities and all TRW product lines participate there. In addition, TRW has built and is staffing new technical centers in Shanghai and Yokohama as well as in Ansan, Korea. The intent is to help customers adapt TRW products to their specific platforms through applications engineering, and also to expand TRW's ability to develop new products globally through research and development. Investments in India and the ASEAN region are also underway.

Similarly, the Eastern European region is growing on both production and technical fronts, with significant TRW operations already established in the Czech Republic and Poland and now branching into other countries including Romania and Slovakia. New technical centers in Poland and the Czech Republic have been established and the number of engineers staffing these centers is increasing steadily. 

The Company Profile Continued

TRW's Principal Competitors by Product Segment

<table>
<thead>
<tr>
<th>Chassis Systems</th>
<th>Occupant Safety Systems</th>
<th>Automotive Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advics</td>
<td>Autoliv</td>
<td>Delphi</td>
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<tr>
<td>Akebono</td>
<td>Bosch</td>
<td>Eaton</td>
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<td>Bosch</td>
<td>Continental-Tesves</td>
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<tr>
<td>Delphi</td>
<td>Delphi</td>
<td>Kostal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nifco</td>
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</tbody>
</table>

As its 50-50 joint venture with Michelin, EnTire Solutions, with headquarters in Farmington Hills, Michigan, owns 77 GHz sensor, in Brest, France, it has not yet decided if it will make or buy the 24 GHz sensor. TRW's AC20 77 GHz radar can detect objects with an enhanced range up to 200 meters. Beyond this particular development contract, sensor fusion will also combine radar sensors with video sensors.

◆ Lane Departure Warning

TRW has won a development contract from a European supplier for a video camera-based system that will be integrated with electric steering to actively help the driver stay within lane markings. Production is to start in two years. Initially the system will warn the driver when the car strays unsafely outside of lane markings. If no action is taken, the system provides a light steering input.

Since inability to stay within lane markings can be indicative of drowsy or drunk driving, such systems could also be used to warn the driver to take a rest stop. Ultimately, lane detection will be used to automatically engage steering actuation to avoid accidents.

Tire Pressure Monitoring

TRW expects fast sales growth for tire pressure monitors developed and marketed by its 50-50 joint venture with Michelin, EnTire Solutions, with headquarters in Farmington Hills, Michigan.
There's still solid growth in DVD-based rear seat entertainment systems, but growth seems to have slowed when DVD players first started entering the vehicle five or six years ago. Automakers are staking their claims to a larger share of the market, focusing on high-end vehicle buyers who are willing to pay premium prices to gain the benefits of fully integrated systems and on people who frequently drive with children in the car.

According to Stephen Witt, marketing vice president for Alpine Electronics of America Inc., rear seat entertainment remains popular in one large market segment: "Rear seat entertainment is always in the top three purchase priorities for families with children."

Mr. Witt observed that aggressive moves by automakers have cut into aftermarket sales. "The aftermarket rear seat entertainment market is no longer growing; it's even showing some decline in the first half of 2006, primarily because the car companies offer broader product offerings." According to Steve Koenig, senior manager, industry analysis for the Consumer Electronics Association, carmaker pressure is most evident in the market for overhead console units, the configuration popular in SUVs and minivans.

On the OEM side, Mike Kane, director of advanced innovation strategy at DaimlerChrysler noted, "We're still seeing growth [in factory installed video systems] from 2006 to 2007 in vehicles in the over $30,000 range." But, he added, "At $25,000 and down, there's been deterioration or no growth."

At the low end of the market, automakers face another competitor beyond the usual aftermarket providers. J.D. Power and Associates' Automotive Emerging Technologies surveys (please see page 2) show that rear seat entertainment ranks near the bottom among the emerging features buyers want when they are told that it would cost them $1,500 to purchase a fully integrated system. Aftermarket-installed in-dash systems start at around $600. But handheld DVD players available at Best Buy, Target or other discount stores sell for $100 or less. While not the highest quality products, they are an adequate solution for occupying a restless child in the back seat whose audio quality standards may not be as demanding as his parents'.

"I'd be hard pressed to say that portable DVD players have had an impact in the overall rear seat entertainment market," said Mr. Witt, "though they've definitely had an impact at the entry level."

The unit volumes for in-dash DVD players have stayed pretty stable, according to Ralph Dominguez, senior product planning manager at Clarion. Though he derided portable players as "low-quality" and not a viable solution over the entirety of the vehicle's lifetime, Dominguez noted that "we've had to adapt to remain of value."

Looking beyond DVDs, Clarion is also developing entertainment systems that instead of playing DVDs, rely on video brought in via portable storage devices and flash-based video players.

Sales of built-in DVD players that can only be viewed in one family vehicle are sure to be further diluted with the rapidly expanding availability of video iPods, video-capable cell phones, notebook computers and mobile satellite video.

While these portable players undoubtedly impact OEM and aftermarket sales, system providers note that high-end consumers will continue to favor units that are integrated into the vehicle. "You can buy a bag at Wal-Mart and hang it on the back seat, but someone paying $30,000 to $40,000 for a car wants something that fits nicely," said Tarun Gupta, North American product strategy and innovation management manager at Siemens VDO.

### Aftermarket Mobile Video and Navigation Total U.S. Forecast

While 2005 revenues were nearly evenly split between navigation and video, navigation products account for almost 60% of total revenue in 2006. According to CEA, by August 2006 shipments of in-dash monitors were ahead of the forecast volumes, but overhead console sales were down significantly compared with 2005.

<table>
<thead>
<tr>
<th>Unit Sales to Dealers (000’s)</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2005-2010 CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Dash Monitors</td>
<td>226</td>
<td>313</td>
<td>365</td>
<td>404</td>
<td>448</td>
<td>482</td>
<td>16%</td>
</tr>
<tr>
<td>Stand Alone Monitors</td>
<td>221</td>
<td>320</td>
<td>330</td>
<td>326</td>
<td>296</td>
<td>260</td>
<td>3%</td>
</tr>
<tr>
<td>0” to 6.9”</td>
<td>95</td>
<td>126</td>
<td>130</td>
<td>130</td>
<td>118</td>
<td>107</td>
<td>2%</td>
</tr>
<tr>
<td>7” to 7.9”</td>
<td>120</td>
<td>186</td>
<td>193</td>
<td>190</td>
<td>172</td>
<td>148</td>
<td>4%</td>
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<tr>
<td>8” and larger</td>
<td>6</td>
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<td>298</td>
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<td>413</td>
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<td>138</td>
<td>150</td>
<td>161</td>
<td>172</td>
<td>183</td>
<td>16%</td>
</tr>
<tr>
<td>With Integrated Source (TV Tuner, VCP, DVD)</td>
<td>211</td>
<td>251</td>
<td>262</td>
<td>285</td>
<td>318</td>
<td>348</td>
<td>11%</td>
</tr>
<tr>
<td>Floor Console</td>
<td>66</td>
<td>66</td>
<td>67</td>
<td>72</td>
<td>73</td>
<td>74</td>
<td>2%</td>
</tr>
<tr>
<td>Systems in a bag</td>
<td>392</td>
<td>412</td>
<td>383</td>
<td>345</td>
<td>317</td>
<td>295</td>
<td>6%</td>
</tr>
<tr>
<td>Stand Alone VCPs</td>
<td>10</td>
<td>10</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>10%</td>
</tr>
<tr>
<td>Stand Alone TV Tuners</td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>22</td>
<td>20</td>
<td>18</td>
<td>1%</td>
</tr>
<tr>
<td>DVD Players</td>
<td>156</td>
<td>175</td>
<td>199</td>
<td>225</td>
<td>249</td>
<td>270</td>
<td>12%</td>
</tr>
<tr>
<td>Single play DVD head unit with AM/FM tuner</td>
<td>58</td>
<td>73</td>
<td>91</td>
<td>112</td>
<td>132</td>
<td>152</td>
<td>21%</td>
</tr>
<tr>
<td>Single play stand alone (no tuner, monitor) DIN size player</td>
<td>78</td>
<td>84</td>
<td>91</td>
<td>97</td>
<td>102</td>
<td>104</td>
<td>6%</td>
</tr>
<tr>
<td>Single play stand alone (no tuner, monitor) non-DIN size player</td>
<td>19</td>
<td>18</td>
<td>17</td>
<td>16</td>
<td>15</td>
<td>14</td>
<td>6%</td>
</tr>
<tr>
<td>DVD Changers</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>8%</td>
</tr>
<tr>
<td>Portable Navigation *</td>
<td>707</td>
<td>1,328</td>
<td>2,124</td>
<td>2,990</td>
<td>3,599</td>
<td>4,210</td>
<td>43%</td>
</tr>
<tr>
<td>Fixed Navigation **</td>
<td>101</td>
<td>153</td>
<td>203</td>
<td>237</td>
<td>260</td>
<td>255</td>
<td>20%</td>
</tr>
<tr>
<td>Total Mobile Video and Navigation</td>
<td>2,199</td>
<td>3,189</td>
<td>4,117</td>
<td>5,076</td>
<td>5,761</td>
<td>6,403</td>
<td>24%</td>
</tr>
</tbody>
</table>

*Handheld, transportable **CD, DVD-based

Data: Consumer Electronics Association