Car Audio/Video Update from CES

Every January a flurry of new product announcements surrounds the International Consumer Electronics show in Las Vegas, held this year from January 5-8. The world's mobile electronics suppliers channel creativity and technical expertise into a variety of multimedia entertainment, infotainment, communications, telematics—you name it—devices that might make one believe again that spending countless hours in a car could be, if not actually fun, then at least not monotonous.

The idea that the car should be an extension of the office and "wasted" commuting hours could be productive work time might be giving way to the notion of the car as an extension of the family room. For someone willing to hang up and drive, a wide selection of entertainment options can make a long commute or a family road trip more enjoyable.

Satellite Radio

Since its launch of service in September 2001, **XM Satellite Radio** had enrolled more than 6 million subscribers as of year-end 2005 and continues to forecast a subscriber base of 20 million by 2010.

Sirius Satellite Radio, which began broadcasting nine months after XM, reported 3.3 million subscribers at the end of the year, 2.2 million of them added in 2005. Satellite radio service at $12.95 per month ranked thirteenth in consumer interest in J.D. Power and Associates' 2005 U.S. Automotive Emerging Technologies study.

Beginning in 2006 **Hyundai** will start implementing its plan to make satellite radio standard in all models. **Delphi Corp**. will supply receivers for the Santa Fe, Azera and Elantra models.

Bosch-Denso JV Delivers T-Engine Infotainment Platform

T-Kernel Operating System Based on ITRON Is Royalty-Free

The infotainment market is about to get a whole lot more competitive. *The Hansen Report* recently learned that the **Bosch Blaupunkt-Denso** joint venture chartered in July 2003 to develop a new multimedia computing platform for its parents is delivering a platform based on T-Engine, an all-encompassing development environment created by the Japanese electronics industry. Blaupunkt and Denso will almost certainly make the specially developed T-Engine platform the basis for almost every new navigation and multimedia product planned for the future.

With a standard platform in place and much of the engineering work already on the shelf, Bosch and Denso will be able to quickly respond to OEM market opportunities with full-featured, highly competitive product offerings. The first new Blaupunkt and Denso products based on T-Engine could ship as soon as the end of 2006 or early in 2007.

Before selecting T-Engine, the 50-50 joint venture by Denso and Bosch known as **ADIT** (Advanced Driver Information Technology) had considered a number of operating systems. Denso engineers favored Linux, WinCE and T-Engine, while Bosch engineers supported VxWorks, QNX and T-Engine.

Unlike other candidate operating systems WinCE from **Microsoft**, VxWorks from **Wind River** and QNX from **Harman International**, the T-Engine operating system—called T-Kernel—is royalty-free. And no less important, since T-Kernel is a follow-on to the vastly popular micro-ITRON operating system, the platform will have wide industry support from tool vendors and other providers. Programmers with experience in ITRON will easily be able to adapt to T-Kernel. According to the T-Engine Forum Web site, "ITRON is the world's number-one adopted standard in the field of embedded systems." Based on proven technology, T-Kernel is robust and, like micro-ITRON, it has a small footprint, which minimizes memory and computer overhead.

According to the T-Engine Forum, while ITRON standardized the API (application programming interface) for basic functions of the operating system, it lacked standards or guidelines for hardware, device drivers and a development environment. T-Engine widened the scope of standardization so that T-Kernel enables the distribution of middleware on top of the existing basic ITRON RTOS (real-time operating system) functions. The biggest goal of T-Engine was to enable distribution of software resources independent of CPU architecture.

Some legal questions surrounding the Linux general public license influenced ADIT's choice of an OS. T-Kernel licensees are under no obligation to make altered T-Kernel code open to the public, which means they can safeguard their product know-how. Versions of the T-Kernel standard are maintained by the T-Engine Forum.

The ADIT platform's two main microcontrollers were developed jointly by ADIT and NEC; NEC will be the sole supplier of the two ASICs (application specific integrated circuits) designed specifically and exclusively for Bosch and Denso's use. In order to provide scalability from mid- to the very high-end price/performance, the platform's architecture can accommodate a one- or two-microcontroller chip solution; one chip delivers 800 million instructions per second and

T-Engine...

the other 1.3 billion instructions per second. First functional silicon samples of the chips have been completed.

Unlike the QNX operating system and development environment from Harman, which is used not only by Harman but is also actively promoted commercially to other infotainment suppliers, the ADIT platform was developed for the exclusive use of Blaupunkt and Denso.

Aimed broadly at infotainment markets served by both Denso and Blaupunkt, ADIT developed middleware to support RDS TMC data communications applications in Europe and DARC VICS communications applications in Japan. Resource management software was also developed by ADIT as well as certain application software, for example a browser and DVD player.

Managed by the T-Engine Forum, T-Engine encompasses a 32-bit microcontroller hardware reference platform, a standard real-time operating system and a wide selection of middleware that can run on the T-Kernel RTOS. T-Engine was conceived by Professor Ken Sakamura of Tokyo University. In the 1980s, Dr. Sakamura launched the TRON project, from which came ITRON, the hugely popular real-time operating system.

The T-Engine Forum is a huge and potentially powerful organization. Forum board members active in the automotive industry include Denso, Hitachi, Matsushita Electric Industrial, Microsoft, Sun, Mitsubishi Electric, NEC, Renesas and Toshiba. The vast majority of forum members are Japanese.

With headquarters in Kariya City, Aichi prefecture, Japan, and an office in Hildesheim, Germany, the home of Blaupunkt, ADIT employs about 55 people. ADIT serves just two companies, Bosch and Denso, but those two companies are respectively the number-one and number-four global automotive OEM suppliers. Denso is among the world's top three manufacturers of navigation equipment. ◆

T-Engine Development Environment

T-Kernel: An open source, real-time (sub-microsecond) operating system that's royalty free. Modifications of T-Kernel will be strictly controlled to maintain compatibility with the middleware it is to run and the microcontroller that will run it. T-Kernel is a close relative of ITRON, the world's most popular embedded operating system.

Middleware: A growing library of middleware includes device drivers, network protocol stacks, filing systems, Japanese language processing, eTRON security software, graphical user interfaces, voice processing and a Java runtime environment.

32-Bit standard hardware platform: Includes target system processor boards based on SH, MR, ARM and MIPS series processors.

T-Engine Forum: Established in June 2002, the T-Engine Forum conducts R&D and promotes the popularization of the T-Engine architecture. The Forum lists 491 member companies and universities.

Main benefits of T-Engine architecture: Enables the speedy development of inexpensive embedded computing systems.

Web site: www.t-engine.org

Microsoft Targets Infotainment

Since **Harman International** acquired operating system maker **QNX**, Harman's competitors in automotive audio and infotainment such as **Visteon**, **Delphi** and **Johnson Controls**, who have developed products based on QNX's software, are re-examining their OS options, according to Peter Wengert, global director for the **Microsoft** Automotive Business Unit. Windows Automotive is definitely an available option, and Mr. Wengert admitted, "Microsoft is getting a lot more phone calls," from suppliers seeking an alternative platform.

Microsoft's Automotive Business Unit has been developing software for the automotive industry for more than a decade. Its first venture, the Windows CE-based AutoPC, developed with **Clarion** as an aftermarket product, never gained wide acceptance with consumers. In 1998, Microsoft decided to market just the underlying software from the AutoPC, which it called Windows CE for Automotive, to tier one and aftermarket navigation and telematics developers. By the fourth release of the software, Microsoft shortened the name to simply Windows Automotive. Version 5 of Windows Automotive followed in July 2005. According to Microsoft, Windows Automotive-based navigation and entertainment systems are shipping today in "61 preinstalled, dealer option and aftermarket devices from 18 world-class automakers and suppliers," including **Alpine**, **Panasonic**, **Mitsubishi Electric**, **Pioneer**, **Kenwood** and **Clarion**. The company estimates between 300,000 and 500,000 navigation systems in the U.S. today are running on Windows Automotive.

Alpine Electronics selected the Windows Automotive platform for all its mid-term AVNC (audio, video, navigation, communications) products under development for both OEM and aftermarket applications. At the 2006 Consumer Electronics Show, Alpine demonstrated its new Blackbird portable navigation device based on Windows Automotive and Windows Automotive-based navigation systems on the new Honda Odyssey, Ridgeline and Civic models.

Turn to Microsoft, page 8

CES...

At CES, XM demonstrated in-car satellite video using **On2 Technologies'** video compression technology. The demo car was also equipped with Voice Command, co-developed with **VoiceBox Technologies**, which allows you to control XM Radio features by speaking the channel selection or music genre. XM's NavTraffic feature, already standard on the Acura RL since MY 2005 and an option on the Cadillac CTS, could in the future be enhanced with ParkingLink, a feature designed to locate available parking places in designated facilities.

Satellite Radio Competition

Offering a viable challenge to satellite radio and to iTunes is **Motorola**, with its announcement at CES that **iRadio** service is now available to U.S. wireless carriers. Consumers should be able to subscribe to the service later this year for a monthly fee comparable to or less than the $12.95 charged by XM and Sirius for their basic plans. Motorola plans to launch the service internationally later in 2006.

According to Motorola, iRadio will launch with 435 commercial-free Internet radio channels covering all types of music, talk radio and news. Subscribers need a special iRadio wireless phone—due later this year—with a memory storage card and a high-speed Internet connection on a USB-equipped PC running Windows XP.

Users can download from their PC to their phone up to six channels of content from the iRadio catalog: for example five radio stations and one playlist, or 6 playlists. Users have the option of listening via Bluetooth adapters through their home or car audio speakers. With the radio content cached on the phone, there is no interruption when the phone is moved from car to home or connected to earphones, and the music pauses when a call comes in. With Internet radio programming, iRadio is free of the bandwidth limitations faced by XM and Sirius. The satellite radio providers are each allocated 12.5 MHz of the S band by the Federal Communications Commission (FCC).

iBiquity Digital, the sole technology provider in digital AM and FM broadcasting, enthusiastically reported that the number of on-air HD Radio stations had reached 634 at the end of 2005. The rollout was aided by a commitment from the leading broadcast groups to eventually convert 2,000 stations. More companies are supplying HD Radio receivers to the aftermarket including **Alpine**, **Fujitsu Ten** and **Panasonic**. According to iBiquity, more than 10 new products were announced in 2005. At CES iBiquity also announced a new reference design for a "tuner box" that allows any satellite-ready head unit to receive digital radio signals—AM, FM and FM Multicast.

After purchasing an HD Radio receiver, there are no further costs to consumers. In the 2005 J.D. Power and Associates Emerging Technology survey, consumers ranked HD Radio with a price of $150 for the receiver at number 3 in the list of features they would like in their next vehicle. **BMW** offers factory-installed HD Radio receivers on the 2006 model year 6- and 7-series.

Beyond Radio

There are plenty of options for bringing your personal music and entertainment selections wherever you go. While many carmakers provide MP-3 compatible car stereos, aftermarket suppliers are way ahead of OEMs with a flood of iPod (audio and video) docking devices, multimedia drives, TVs and video game players.

Antenna-maker **RaySat** recently introduced TeleRay, which it says is the world's smallest satellite TV antenna for vehicles. Measuring just one inch thick and 16 inches in diameter, TeleRay is compatible with all the mobile TV receivers currently on the market in Japan. Sales will begin later in 2006.

KVH, another antenna supplier, partnered with **Microsoft** to create a mobile Internet receiver with MSN TV service for mobile Internet access in cars.

Visteon's market research revealed that video gaming ranks among the most desirable in-car entertainment options. Visteon's Aftermarket division added Nintendo Game Boy capability to its Dockable Family Entertainment system.

NHTSA (the National Highway Traffic Safety Administration) estimates driver distraction contributes to 25% of all police-reported traffic crashes. ◆

eMOST in the Works

For now **Mercedes** has decided to stick with plastic optical fiber for its MOST multimedia communications bus but will eventually switch to copper. A year ago Mercedes was considering a move to glass fiber. "We had two problems," explained Stephan Wolfsried, Mercedes' top electrical engineer. "One was insufficient robustness against mechanical damages, and the other was insufficient temperature range." The stability problem has been fixed and the temperature range of the plastic has been improved to as high as 95 degrees F, with expectations that getting beyond 100 degrees F is possible.

Since the physical advantages of glass are not much greater than plastic, Mercedes has decided not to make the expensive engineering switch. "We will stay with the improved plastic until the electrical solution is available," said Mr. Wolfsried.

Having pioneered in the development of the fiber-optic MOST physical layer, Mr. Wolfsried is now content to let **Toyota** take the lead in developing a protocol that can be transmitted over copper wires without excessive electromagnetic noise. Two protocols are under consideration, one from **Panasonic** and the other from **Harman-Becker**.

According to Toyota's top manager of electronics, Takashi Shigematsu, the MOST E5 working group has not yet decided between the two protocols, though he did say that the Harman approach has better noise performance. A decision from the E5 working group is expected soon, after which Toyota will consider the possibility of replacing its proprietary AVC (audio video communications) protocol with MOST. According to one well-placed source, that could happen as soon as the 2008 model year. ◆

The Company Profile...   Harman International

Thumbnail Sketch

Harman International Industries
Address: 1101 Pennsylvania Ave. NW, Suite 1010, Washington D.C. 20004
Tel.: 202-393-1101; www.harman.com
FY 2005 Sales: $3,031 million
FY 2005 Operating Margin: 11.6%
FY 2005 Net Margin: 7.7%
R&D: 7.3% of sales
Net Cash Provided by Operations: $419.7 million
Shareholder's Equity: $1,038 million as of September 30, 2005
Market Capitalization: $6,600 million as of October 31, 2005
Ownership: FMR Corp., 15.2%; Barclays Global Investors NA, 9.2%; Sidney Harman, 6.8%; Goldman Sachs Asset Management, 5.9%
Employees: 10,845 as of June 30, 2005
FY 2005 Sales per Employee: $279,000

Automotive Segment
FY 2005 Group Sales: $2,126 million
FY 2005 Operating Margin: 16.4%
R&D: 10.8% of sales, or about $230 million, 17% of which is spent on basic research
Products: Infotainment and audio systems
Top Customers: #1 DaimlerChrysler; #2 BMW
Note: Harman's fiscal year ends on June 30.

Harman International Sales and Net Margins

2000 to 2005 CAGR: 12.6%

in $ millions

FY 2000	2001	2002	2003	2004	2005
1,678	1,717	1,826	2,229	2,711	3,031

Net Margin

FY 2000 4.3%	FY 2003 4.7%
FY 2001 1.9%	FY 2004 5.8%
FY 2002 3.1%	FY 2005 7.7%

Distinctions Claimed by Harman
- 10 million vehicles equipped with Harman systems, cumulatively
- Harman produces 1 million infotainment systems per year.
- Harman produces 1.5 million sound systems per year.

Harman International Sales by Reporting Segment

FY 2005 Total Sales: $3,031 million

Professional, 16%
Consumer, 14%
Automotive, 70%

Employees by Region

Total June 30, 2005: 10,845

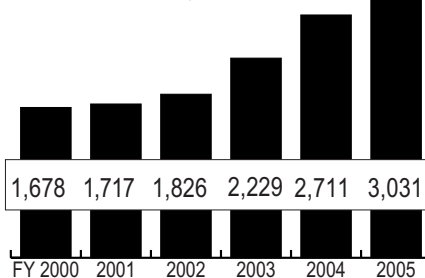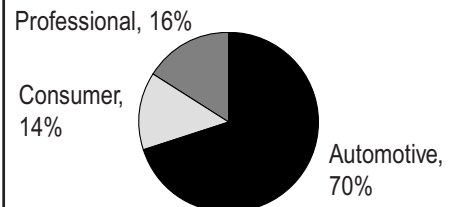Outside North America, 55.1%
North America, 44.9%

Background

Harman International's roots go back to 1953, when founder Sidney Harman partnered with Bernard Kardon to form Harman Kardon. Harman Kardon's first product was an FM tuner, followed in 1954 by the world's first hi-fi receiver, a monaural unit that incorporated a tuner, control unit and power amplifier in the same chassis. A stereo receiver debuted in 1958. The company expanded through the next two decades, acquiring the speaker-maker JBL in 1969. Dr. Harman sold the company to the conglomerate Beatrice Foods in 1976 while he served as U.S. Undersecretary of the Department of Commerce under President Jimmy Carter.

Dr. Harman reassembled the company as Harman International Industries, a holding company, in 1980 and began acquiring companies and technologies that enabled its expansion into the automotive sector. In the 1990s, Harman acquired AKG (microphones), Lexicon (digital audio signal processing), Becker GmbH (automotive head units), Madrigal Audio Labs (Mark Levinson audio systems), Oxford (automotive speaker supplier to Chrysler) and Audio Electronics Systems (speaker supplier to European carmakers). Dr. Harman served as CEO until 1998 and as chairman of the board until 2000, when he became executive chairman. Harman International stock has been traded on the New York Stock Exchange since 1986 under the symbol HAR.

In FY 2005 the automotive group accounted for 70% of Harman's sales, while the consumer and professional groups roughly split the remaining 30%. According to Dr. Harman, that breakdown will stay nearly the same for the foreseeable future. Each segment of Harman's business feeds the other segments. For example, some of the Harman brands now popular in the automotive industry were first made popular in the high-fidelity audio consumer market.

Harman's high stock market valuation, with price to earnings ratio currently at 26.7, is a direct result of respectable margins. For the most recent quarter, ending September 30, 2005, Harman yielded an operating margin of 10.2%, and it has won more infotainment systems bookings outside of Asia than any of its competitors. Harman says it will be the exclusive or nearly exclusive infotainment system supplier to Porsche, Audi, PSA and Chrysler and the principal supplier to Mercedes and BMW. Harman expects its infotainment sales to grow 18% per year from FY 2005 through FY 2008.

Harman's well-respected high-fidelity audio brands including JBL, Infinity, Harman/Kardon and Mark Levinson also distinguish the company from its competitors, as does Harman's technology, says Erich Geiger, chief technical officer and executive vice president of Harman: "We have the largest portfolio of [infotainment] technologies under one umbrella." Since 2002 Harman has acquired several relatively small companies, each with important pieces of infotainment technology. These include: Xsys, CAA, Temic Speech Engines, Margi Systems, Wavemaker, QNX and PhatNoise. Dr.

Harman Automotive Segment Sales and Operating Margins

FY 2003 to 2005 CAGR: 24%

FY 2003	2004	2005
1,383	1,873	2,126
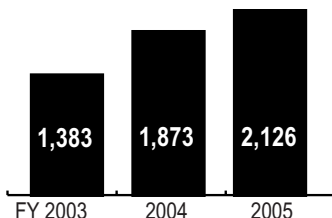
Operating Margin

FY 2003	15.4%
FY 2004	16.5%
FY 2005	16.4%

Harman's Top Automotive Customers by FY 2005 Sales

#1 Mercedes	$773 million
#2 BMW	$330 million
#3 Lexus/Toyota	$300 million
#3 Audi*	$300 million
All others	$397 million

*In the next few years Audi will move up to #2.

Harman Automotive Segment Sales by Product Type

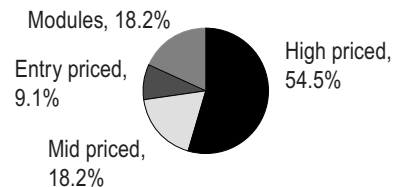FY 2005 Automotive Sales: $2.1 billion

Aftermarket and other, $0.2 billion

Audio systems, $0.8 billion

Infotainment, $1.1 billion

Harman Infotainment Sales by System Type*

FY 2005 Infotainment Sales: $1.1 billion

Modules, 18.2%

Entry priced, 9.1%

High priced, 54.5%

Mid priced, 18.2%

*Entry: $300–$500; Mid: $500–$800; High: $800+

Total Automotive Group Estimated Sales by Product Type in $ Billions*

	FY 2005	2006	2007	2008	CAGR
Infotainment	1.1	1.2	1.4	1.8	18%
Audio systems	0.8	0.8	0.9	1.0	8%
Aftermarket and other	0.2	0.3	0.3	0.3	8%
Total	2.1	2.3	2.6	3.1	13%

*Based on 1 € = $1.25

Geiger was with Becker Automotive Systems before it was acquired by Harman. In 1996 he was named managing director of Harman/Becker GmbH.

Harman's liquidity is good. In September 2005, Standard & Poor's gave Harman a BBB/watch positive credit rating. Companies rated BBB have adequate capacity to meet financial obligations but are more subject to adverse economic conditions than A-rated companies. Watch positive companies have near term potential for a positive change in their credit rating, though change "will likely be limited to one notch, to BBB+," says S&P. On September 30, 2005, Harman's ratio of current assets to current liabilities was 1.7 with $505 million of working capital.

Sidney Harman not only built one of the world's leading audio companies, but he was also a pioneer in progressive business management strategies that recognize the value of employees. He is an educator, a prolific writer, a public servant and a patron of the arts. I asked Sidney Harman how at age 87 he still manages to run Harman, a multibillion American company that is thriving in two of the world's toughest industries: automotive parts and consumer electronics. "I am in superb physical condition," said Dr. Harman. "I have exercised every single day for 60-odd years. And I'm not very interested in food. I drink almost no alcohol. I have a vivid appetite for lots of stuff including, but not limited to business. I have young kids ... a very active life."

Automotive Segment

In November Harman told investors that automotive sales will grow 14% annually from $2.1 billion in FY 2005 to $3.1 billion in FY 2008, based on orders that have already been booked. Automotive group sales grew 13.5% in fiscal 2005.

Harman's objective for the automotive segment is to maintain its leadership position in the infotainment business. Infotainment products combine information systems with audio and/or video entertainment systems. In its simplest form, a radio-navigation head unit with a video display would qualify has an infotainment product. Other producers of infotainment devices who compete very aggressively for a larger share of the market include Alpine, Aisin AW, Bosch/Blaupunkt, Denso, Hitachi Automotive, Mitsubishi Electric Company, Panasonic and Siemens VDO.

Integration Through Software

According to Dr. Harman, the company's margins are higher than what you would expect from automotive electronics companies due to its ability to reduce the amount of hardware in infotainment systems through integration, while leaning heavily on software to implement infotainment features: "We are in the forefront of morphing hardware into software."

Harman's integration expertise is best exemplified by Mercedes' new S-Class, which was introduced in the fall of 2005. "The S-Class represents the most integrated and homogeneous way to combine all the functions, whatever you need, from video to audio processing to navigation, all under one [human-machine] interface," explained Dr. Geiger. "We integrated all of the electronics, the DVD player, the encoding, the data flow and the display, all of which is under our infotainment HMI (human-machine interface). When you set the seat position or seat heating, or if you go to your car menus, it is the same machine doing this, there is no extra computer." The HMI also provides access for diagnoses of various body electronics functions.

Harman reports that through integration it reduced from 18 to three the number of devices and modules in its head unit from the first generation to the second. For example, before integration of
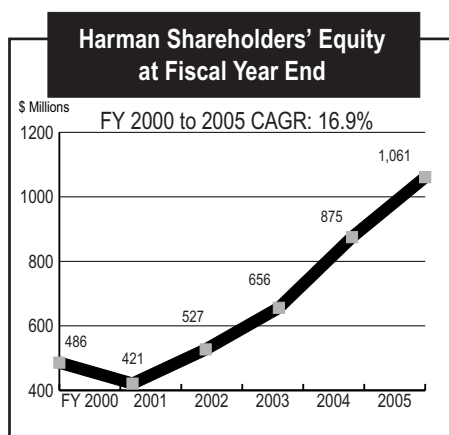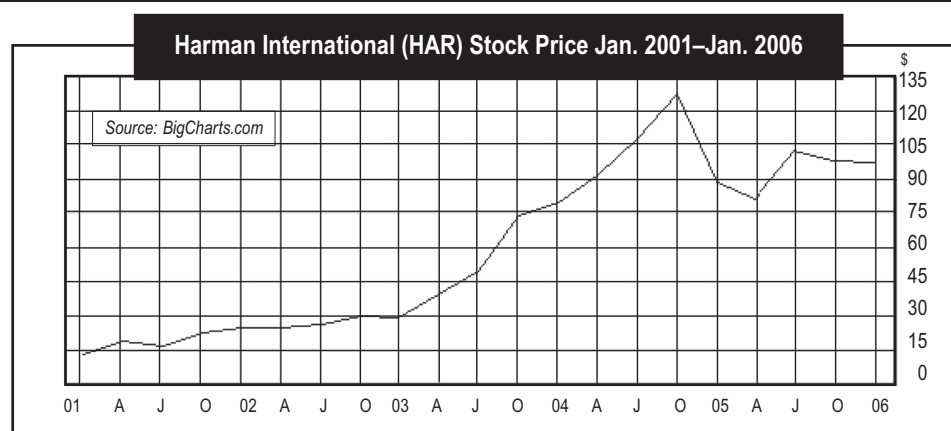
Harman International

the S-Class infotainment system, Harman sold a voice control feature to carmakers for hands-free operation of the telephone and navigation system as a separate add-on function for about $150. It included an extra processor, memory, software and connectors. In place of that, Harman now provides Mercedes with a $20 voice control software module, which along with the audio signals, runs entirely on the infotainment system's host computer located in the head unit. Likewise, a navigation software module or a noise-cancellation software module can also run on the host processor.

With responsibility for the entire infotainment system including audio and rear-seat entertainment, Harman's S-Class content amounts to more than $2,000 per vehicle. More than 60,000 S-Class vehicles are sold each year.

Can Harman Further Penetrate the Infotainment Market While Maintaining High Margins?

While Harman's S-Class infotainment system is impressive, it's not clear at this point how quickly and how deeply infotainment systems will penetrate into the lower-priced vehicle segments and whether Harman will be able to compete with the world's major infotainment players as it tries to expand its business beyond Europe, beyond German-owned DaimlerChrysler and beyond the luxury car segment. Harman's top three custom-

Harman International (HAR) Stock Price Jan. 2001–Jan. 2006

Source: BigCharts.com

Harman Shareholders' Equity at Fiscal Year End

$ Millions

FY 2000 to 2005 CAGR: 16.9%

486, 421, 527, 656, 875, 1,061

FY 2000 2001 2002 2003 2004 2005

Harman Stock Earnings Per Share

FY 2001	$0.48
FY 2002	$0.85
FY 2003	$1.55
FY 2004	$2.27
FY 2005	$3.31
FY 2006*	$3.85
*Company guidance	

ers for all its products are Mercedes, BMW and Lexus (audio only) with Audi coming on strong.

Harman has little prospect of penetrating Ford or GM in North America or Europe, or of winning domestic Japanese business with Toyota, Honda and Nissan, while Japanese suppliers are slowly gaining market share in Europe at Harman's expense. Executives close to Mercedes' sourcing decisions tell us that Harman will not win high-end navigation for the 2007 C-Class or the 2009 E-Class. And Alpine will continue to supply navigation for the M-Class in the U.S. Alpine also supplies navigation for the E-, S- and C-Class in the United States.

Still, Harman has landed most of the infotainment business available in the West. The company says it owns 80% of Mercedes' infotainment system bookings worldwide and 100% of audio bookings. According to Harman, "Mercedes has committed itself across the board to all Harman/Kardon branded audio systems." Harman has also booked all of PSA's and Audi's future infotainment business, from

luxury vehicles down to entry level.

In 2004, Harman was awarded Chrysler's NTG 4 system business, Chrysler's first infotainment system, slated for model year 2007. In May 2005 Harman picked up Chrysler's new entry-level entertainment system beginning with model year 2008. That system will integrate AM-FM, DVD, rear-seat video, backup camera and hard disc drive with "jukebox music management functions." "We have all of Chrysler's infotainment business," declared Dr. Harman.

According to Dr. Harman, Siemens VDO has been awarded infotainment system business at Volkswagen and Renault. In 2004 Fiat and Microsoft announced a long-term alliance to develop telematics systems that use Bluetooth to wirelessly connect to portable phone or music player devices. Magneti Marelli will supply that hardware.

Entry-Level Integrated Embedded Infotainment Will Be Limited

Harman forecasts that 17% of its infotainment sales in fiscal 2008 will be entry-level systems. Dr. Harman said he expects that "ultimately some expression

Price-to-Earnings Ratios of Harman Compared with Other U.S. Auto Electronics Stocks

as of December 7, 2005

	P/E
NAVTEQ	26.85
Harman	26.70
Gentex	26.17
JCI	16.15
Autoliv	13.01
TRW	11.35
Lear	N/A, loss quarter ending 10/1/05
Visteon	N/A, net loss last four quarters
Delphi	N/A, under Chapter 11 protection

Source: MarketWatch.com

of integrated infotainment systems is going to be found in just about all of the vehicles built worldwide." That just isn't going to happen, at least within the next decade or two. Infotainment systems usually combine navigation with radio and CD player, the most expensive piece of which is navigation. But increasingly, portable navigation devices like those made by Garmin and TomTom, as well as smart mobile phones with navigation capability will greatly bite into demand for embedded navigation systems. Portable navigation devices cost as little as $199 and can be used in any vehicle or while navigating on foot.

Harman's so-called entry-level product includes a radio, display, CD player, some sound processing and an RF-only GPS receiver. For this carmakers will spend anywhere from $280 to $420, depending on the size of the display and whether it is color or monochrome. Not inexpensive, the basic device would retail for between $560 and $840, at least. Navigation can be added to the system at the dealer by plugging in an SD-card or some other Flash memory device that contains navigation software and the map data. A similar plug-in module provides Internet and phone connectivity; another module provides hands-free phone capability.

Telematics devices like those made by Motorola ACES for OnStar also preclude demand for the sort of navigation-integrated infotainment products made thus far by Harman. OnStar platforms are installed in almost every vehicle General Motors produces for the North American market. OnStar currently serves nearly four million subscribers.

In November 2005, Harman's consumer products sector began selling a Becker portable navigation device called Traffic Assist. Offered in the aftermarket in Europe for about $550, the unit includes a 3.5-inch touch-screen LCD with 1-GB SD map, GPS receiver, MP3 player and digital picture viewer.

Parallel Processing

Among the basic research projects underway at Harman, Dr. Geiger is especially keen on research to connect infotainment computing platforms in real time and thereby avoid bus systems like MOST or CAN, which are expensive. "Our goal is to have two [infotainment] boxes in the car, one in the front and one in the rear," he explained. "In between we will have a QNet link (from QNX) which is able to connect several core processors in parallel.

You could have a head unit in the front of the car and an extension box somewhere in the trunk or in the body, with all of the [audio] power electronics, antennas and things." Each box's MCU would have full access to the resources at each box, for example, a telephone circuit or DVD changer. The two MCUs would work as a single processor with one operating system. First prototypes of this concept have been demonstrated. Actual production of such a system wouldn't begin for at least five years, says Harman. QNX is a division of Harman.

New Products

Harman says its automotive segment will stay focused on infotainment systems to the exclusion of vehicle control and body electronics for many years to come. However, the company will use its infotainment expertise to pursue opportunities in driver assistance systems, diagnostics and connectivity to outside of the vehicle.

"We already have the display, we already have the [MOST] bus structures with bit rates of 150 Mbps to 500 Mbps. We already handle digital video and audio, we handle all of the gateway functions to the body, it is very natural that we get this extra functionality on our platforms," asserted Dr. Geiger.

Dr. Harman believes Harman International's greatest and continuing challenge is "to continue to understand the technology and interpret it creatively. Not to let engineers do whatever they can with it, but to exercise the kind of discipline that makes the product of their efforts altogether useful." ◆

Recent Acquisitions

A significant part of Harman's technological competence has come from relatively small acquisitions.

Company	Acquired	Technology
Xsys (Villingen, Germany)	1998	Video signal processing
CAA (Filderstadt, Germany)	June 2002	Automotive PC systems
Temic Speech Engine (Ulm, Germany)	April 2002	Speech recognition
Wavemaker (Vancouver, Canada)	2003	Noise cancellation
Margi Systems (Fremont, California)	September 2003	Multimedia software*
QNX (Ottawa, Ontario, Canada)	October 2004	Embedded operating systems
PhatNoise (Los Angeles, California)	August 2005	Multimedia hardware and software

* For handheld devices

Principal New Infotainment Awards*

Mercedes
FY 2006
S-Class sedan, $175 million
M-Class Europe, $50 million
B-Class, $25 million
R-Class, $40 million
FY 2007
S-Class coupe, $20 million
C-Class sedan mid, $65 million
FY 2008
C-Class wagon mid, $15 million
BMW
FY 2006
3 Series wagon, $17 million

FY 2007
3 Series coupe, $25 million
3 Series convertible, $18 million
Audi
FY 2006: Q7 Europe, $15 million
FY 2007: Q7 U.S., $15 million
FY 2008: All, $350
Porsche
FY 2008:
Carerra, $35 million
Cayenne, $45 million
Chrysler
FY 2007
Mid/High, $350 million

FY 2008
Entry, $200 million
Hyundai
FY 2007: Dynasty, $70 million
Peugeot Citroën
2008
All Platforms, $250 million

*Sales value when programs are fully launched.

Harman's OEM Price Categories for Infotainment Systems:

Entry	$300–$500
Mid	$500–$800
High	$800+

QNX Advances in Automotive

Founded in 1980 by partners Dan Dodge and Gordon Bell, QNX, originally named Quantum Software Systems, released the first commercial PC operating system to use microkernel architecture, in 1981.

After a decade of building a business around real-time operating systems for PC/x86 platforms, QNX saw opportunity in adapting its OS architecture to run on other platforms. The list of supported platforms now also includes PowerPC, MIPS, SH-4, ARM and StrongARM.

Since its acquisition by **Harman International**, QNX no longer reports sales numbers. However, Linux operating system supplier Green Hills Software has reported that QNX sales were about $24 million in 2004. We estimate QNX's 2005 sales at $50 million, roughly. Harman International purchased QNX in October 2004 for $138 million.

QNX first targeted the automotive industry about four years ago and since then has grown automotive sales from zero to 30% of total revenue, according to Andrew Poliak, automotive business manager. The basis for QNX's penetration in the auto industry is its QNX Neutrino real-time operating system, which is used in a variety of infotainment applications around the world, most notably those produced by Harman International. Presently however, QNX receives its greatest automotive revenues from **Visteon**, which makes Bluetooth hands-free kits installed in some 2006 **Nissan** vehicles.

The QNX operating system also powers Bluetooth hands-free car kits installed on **Acura** TL, **Audi** A8L and **Chrysler** Pacifica models. **NAVIS** chose QNX for a navigation system it makes for **Daewoo**. QNX can also be found in a navigation system produced by **Hyundai Mobis** and in an infotainment system used in the **Saab** 9-3 in Europe and the United States. **LG Electronics** opted for a QNX operating system to run a small-footprint telematics platform it supplies for a limited number of **OnStar** applications.

In Japan, the QNX operating system has found its way into ten 2006 Toyota models, where it runs an infotainment feature supplied by Denso. The company is picking up additional automotive business in Japan. Indeed, QNX recently signed a memorandum of understanding with Hitachi subsidiary, Akita Electronics Systems, a systems integrator active in automotive electronics. Akita already has five engineers working on QNX projects.

QNX is confident its longstanding relationship with Renesas will benefit its growing business in Japan. Renesas is the world's number-one supplier of MCUs for car navigation and ranks Honda, Nissan and Toyota its top three end-use customers. According to QNX, tier one suppliers in Japan consider Renesas the leader in Japan for infotainment, navigation and telematics products. QNX is well-positioned as Renesas' lead RTOS vendor,

QNX Sales by Product

Estimated 2005 Sales: $50 million

Customer support and engineering, 33%

Runtime royalties, 33%

Tools, 33%
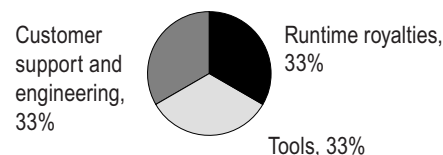
and the two companies worked together to define a technology roadmap for future products. Mr. Poliak noted, "They are making a strategic investment in us as an architecture, to work with us for the Japanese market."

In OEM applications in particular, QNX's main competition in Japan comes from the ITRON operating system but according to Mr. Poliak, ITRON may be reaching its limit. "You can make voice recognition, TCPIP, Bluetooth, things like that run on ITRON but as more functionality is added, complexity gets to the point where it is difficult to debug. The automakers are now saying, 'What is the next operating system.'"

Over the next several years QNX will be in a shootout with other operating systems for infotainment applications worldwide. At least five operating systems will be contenders: QNX, WinCE, VxWorks, ITRON (T-Kernel) and Linux.

One of the best things about QNX is that it is based on standards. "We are POSIX compliant," said Mr. Poliak, which is similar to Linux. So if you are familiar with Linux you can quickly program for QNX. QNX's tool suite conforms to Eclipse, an industry standard tool integration platform. Another benefit particularly important to automotive customers is the operating system's reliability. "We are pretty much the definition of hard real time," declared Mr. Poliak. ◆

Microsoft...

Microsoft offers Windows Mobile for Automotive as a solution for connecting consumer electronics devices such as Bluetooth mobile phones, digital music players and portable navigation in the car. Mr. Wengert refers to Windows Mobile for Automotive as "a category in which we include the software and hardware reference designs to actually make a consumer electronic gateway box in the car—more of a turnkey solution." With such a gateway box, any Bluetooth phone can connect with the car audio system and steering wheel controls. With an added USB port, any digital music player can be connected to the audio system, including an iPod if the carmaker has licensed the proprietary Apple protocols.

Windows Mobile for Automotive is the product of Microsoft's collaboration with the **Fiat Group** to develop a low-cost telematics software platform and hardware reference design. Fiat will introduce the first implementation at the Geneva Auto Show in March 2006, eventually rolling out to all 23 Fiat, Lancia and Alfa Romeo models. ◆