Engineers’ Guide to Transportation Systems

Transportation Designs Move Full Speed Ahead

Digital Signage Goes Mobile
Embedded Computers in Today’s Railway Systems
Use of Hall-Effect Rotary-Position Sensors in Transportation Applications
Embedded Firewalls: Seatbelts for the Internet of Things

Annual Industry Guide
Technology and applications for the embedded electronic design of transportation systems

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For most people, mobile devices mean small, powerful computers that can go anywhere – with brilliant, high-definition screens, innovative user interfaces, entertaining and informative applications, and connectivity that ranges from Bluetooth to Wi-Fi to 4G. For developers of embedded transportation computers, mobile devices mean – well, many of the same things.

Today’s embedded computer systems for commercial transportation applications such as buses, light and heavy rail, subways, trucking and shipping are more than just rugged computers on the go. Consumers and operators expect many of the same functions from those embedded computers as they do from the smartphones in their pockets.

In this issue, we bring you the product news and technology information you need to address these growing demands. Industry experts weigh in on everything from communications to user interfaces, form factors to power management, and sensors to security. Alongside in-depth technical articles, you’ll also find data sheets, whitepapers, event information and more.

We hope you enjoy this EE Catalog Resource Guide. As always, we’d love to hear your feedback, thoughts and comments. Send them to info@extensionmedia.com.

Cheryl Berglund Coupé
Editor, EECatalog.com

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Both wired and wireless communications within the transportation market are pushing the envelope on available bandwidth and data-rate speeds, according to Doug Patterson, vice president of the Military & Aerospace Business Sector for Aitech Defense Systems, Inc. Additional trends noted by our panelists include the use of modular, small form factor board designs, innovative user interfaces and power-management solutions designed to maximize available battery power and increase battery life. Patterson joins Douglas Tseng, product manager for Advantech-DLoG; Dave Middleton, sales manager for Elma Electronic UK; and Patrick Dietrich, hardware design engineer at Connect Tech to respond to these issues and more.

EECatalog: As transportation applications demand greater bandwidth and connectivity, what’s changing in communication requirements and protocols?

Douglas Tseng, Advantech-DLoG: Companies are starting to explore 4G LTE as an alternative solution to the current 3G connectivity standard, which is readily found across multiple facets of the intelligent transportation and fleet segments.

In addition to this, the functionality of mixed-use connectivity of different wireless communication protocols, such as Bluetooth and Wi-Fi, to help spread the bandwidth load for data transfer and interaction with peripherals like wireless IP cameras, printers, etc., is also being aggressive studied.

Doug Patterson, Aitech Defense Systems, Inc.: Communications – both wired and wireless – within the transportation market are continually pressing the envelope on available bandwidth and data-rate speeds. Newer applications using remote data monitoring to track transportation infrastructure require data concentrators, which offer some real relief as faster local processing and data storage allows measurable offloading and time-sliced/time-collated data comms.

Dave Middleton, Elma Electronic UK: We are still seeing customers using conventional cPCI and VME in transportation applications. We do, however, see a small number of customers considering VPX and PCIe, with VPX looking like the preferred option moving forward, as its inherently rugged design and bandwidth in a 3U form factor makes it the ideal architecture for many applications. Customers are also exploring the use of non-standard interfaces architectures based around Ethernet technology.

Patrick Dietrich, Connect Tech: We are finding that as a board-level solution provider, our transportation customers are requiring more multiple communication interfaces on the same design. This may be in the form of communicating back to their host platform for a fleet management through cellular, satellite of local wireless network link. Another related trend we are seeing with our transportation customers is the need for these high bandwidth links to be pared with more traditional slower/legacy protocols (J1708, J1939, CAN) that are already in use in many of existing transportation services vehicles such as bus and rail transport.

EECatalog: Outside of automotive, where are you seeing the innovative use of MEMS and sensors in transportation applications?

Tseng, Advantech-DLoG: MEMs are now starting to be utilized with vehicle air pressure detection systems as a means for monitoring a vehicle’s overall height.

Patterson, Aitech Defense Systems, Inc.: Micro-electromechanical systems, or MEMS, are seeing real applications in a wide number of public sector, surface and rail transportation sectors, many of which require low-power, reliable systems that function in remote locations.

These include wireless monitoring of bridge and railroad trestle loads, intelligent traffic monitoring and control, mass transit equipment monitoring and control, commercial capital asset tracking coupled with GPS data,
solar and conventional energy generation and smart grid distribution, waste management, defense and commercial advanced vehicle diagnostics and condition based maintenance, and more.

Because of their smaller geometries and lower costs, MEMS are being embedded into metal and concrete castings during manufacture and therefore major load-bearing beams and structures are data-interface ready.

**Middleton, Elma Electronic UK:** We see an increasing demand for small form factor (SFF) chassis in railway applications specifically for on-board and underground network applications where the environment is particularly harsh.

**EECatalog:** What kinds of user interface evolutions are you seeing for transportation applications such as passenger infotainment and safety, ticketing, etc.?

**Tseng, Advantech-DLoG:** Passenger infotainment/interface is becoming more customer-focused. Individual display units in taxis are starting to provide passengers with real-time mapping of the route being taken to their desired destination. Other features include integration of point-of-sale (POS) for payment of travel transactions, localized business advertisements, movie trailers, as well as niche entertainment applications like karaoke. Multi-channel video for peripheral views of surrounding activities outside of a vehicle are also becoming more commonplace.

**Patterson, Aitech Defense Systems, Inc.:** Greater worldwide adaptation and the adoption of data-interface standards will promote the expansion of these systems into new and exciting applications where remote, robotic electronics can proactively monitor stress and strains in a public transportation system’s infrastructure and predict when maintenance is needed, not just rely on some fixed – and potentially more expensive and reactive – rigid maintenance schedule.

**Dave Middleton, Elma Electronic UK:** Intelligent interfaces that provide passenger-specific information based on mobile phone technology and intelligent CCTV. Interfaces are all trending to touch screen and wireless applications.

**EECatalog:** With the proliferation of small board form factors and modules available, and the often-tight space requirements for transportation embedded computers, what makes some form factors more successful in this market than others?

**Tseng, Advantech-DLoG:** Small form factor boards permit for installation in places with restrictive application space while helping to minimize potential damage being caused to basic, low-performance units. While higher performance units may have a larger footprint, they are specifically designed with heat dissipation in mind. This permits for wide temperature operability as most vehicles are parked outdoors where environmental conditions and season temperatures may vary substantially.

**Patterson, Aitech Defense Systems, Inc.:** Form factors housed in self-contained, rugged enclosures that are inherently smaller and lighter, while consuming less power – preferably powered by low-voltage solar – will always capture the imaginations of design engineers with new applications and the lower costs will capture more of the program managers’ budgets.

**Dave Middleton, Elma Electronic UK:** Cost, thermal performance and aesthetics to a certain extent when visible.

**Dietrich, Connect Tech:** We see PC/104 and its variants (PC/104, PC/104-Plus, PCI-104, PCI/104-Express and PCIe/104) being used a lot by our customers in ITS because of its small size, ruggedness and wealth of available SBC and peripheral board hardware. Many times we are asked to develop custom hardware for ITS, but in most cases our customers can use our off-the-shelf hardware to create a complete solution for their end application. We are also seeing more and more use of computer-on-modules (COMs) and carriers by our transportation customers. This is primarily due to the fact that our transportation customers can quickly build up a system and future-proof their processor selection as well as freeing them to concentrate on their core ITS business (not the complex processor design).

**EECatalog:** How are designers of transportation applications addressing power management requirements, such as low power or energy harvesting implementations?

**Tseng, Advantech-DLoG:** Power management requirements are specifically designed with driver and vehicle ignition usage in mind. By designing solutions that start or only wake up when needed helps to conserve the vehicle battery life, especially when the vehicle is not running. And whenever a vehicle is not running, power management must be designed to instruct a unit to automatically shut down or go to sleep to further help conserve the longevity of the vehicle’s battery.

**Patterson, Aitech Defense Systems, Inc.:** Smaller, lighter and lower power microcontrollers – with intelligent power management – will maximize available battery power and increase battery life many-fold.

Other applications for small, lightweight remote interface units (RIUs) include PC-based data concentrators and machine interface applications in manned and unmanned,
For large commercial and military tracked and wheeled vehicles, low SWaP RIU and DCUs like the Aitech NightHawk RCU or RIO-NG with new, low-power and high-performance CMOS ARM and low-power Intel/AMD processors, combined with Power over Ethernet (PoE) can now be constructed and connected as flexible neural networks. This helps meet the system demands of tomorrow’s rugged industrial, commercial transportation and defense vehicles and platforms.

This weight reduction, combined with a slimmer profile and natural convection/radiation cooling in units that only dissipate from less than 1W to no more than 20W makes these rugged control units ideal for a variety of severe military, aerospace, and rugged industrial and commercial application environments.

**Dave Middleton, Elma Electronic UK**: System monitor requirements are becoming more advanced with active feedback and SNMP control requirements to optimize fan speeds and minimize energy consumption remotely.

**Dietrich, Connect Tech**: We are seeing our transportation customers’ power-management requirements moving from traditional direct power solutions to isolated uninterruptable power solutions. As DC/DC supply technology progresses, smaller isolated modules are becoming more readily available, and more affordable. At the same time battery technology has also progressed to the point now where a small, robust vehicle UPS is not only a great option for our customers, but they are now demanding this for most all of their power systems.

Cheryl Berglund Coupé is editor of EE-Catalog.com. Her articles have appeared in EE Times, Electronic Business, Microsoft Embedded Review and Windows Developer’s Journal and she has developed presentations for the Embedded Systems Conference and ICSPAT. She has held a variety of production, technical marketing and writing positions within technology companies and agencies in the Northwest.
Fleet Management Solutions

Fleet Management is a Complicated Business:
Operational costs are constantly on the increase. Fleet managers usually try to solve the need for vehicle tracking, followed by driver accountability, on-time delivery, monitoring vehicle usage, number of stops, etc. And high fuel costs, the largest business expense outside of the fleet managers’ control, can be offset by automated vehicle location tracking and by reporting and analyzing vehicle data. Vehicle tracking, scheduling software and asset management improves managers’ fleet monitoring abilities to streamline the mobile work activity and reduce company OPEX.

Advantech-DLoG In-vehicle Solution Design Capability
Advantech-DLoG industrial mobile computing solutions provide a wide range of products for a variety of vertical markets. Advantech-DLoG offers integrated solutions for all aspects of industrial mobile computing: systems that work under a wide range of temperatures; certified power systems; x86 and RISC-based architectures; a full suite of RF protocols; standardized vehicle diagnostic tools; rich I/O connectors; vibration and shock resistance; and a comprehensive software developer kit to facilitate application development, speeding up time-to-market for system integrators, and helping reduce costs.
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Best of breed for vehicle mounted terminals: From perfectly adoptable in-vehicle fleet management terminals to individually configurable VMTs for challenging off-road applications.

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**XMT 5/7**
- Fully rugged vehicle mount terminal, 360° IP protection
- 7” QVGA
- Marvell PXA processor
- Diversity WLAN
- GPS, GPRS/HSDPA
- DLoG specific resistive touch screen
- Sunlight readable solution
- Service USB
- Shock&Vibration 5M3

**XMT 5/10**
- Fully rugged vehicle mount terminal, 360° IP protection
- 10.4” SVGA
- Marvell PXA processor
- Diversity WLAN
- GPS, GPRS/HSDPA
- DLoG specific resistive touch screen
- Sunlight readable solution
- CAN 2.0B with J1939 ready
- Shock&Vibration 5M3

**XMT 5/10**
- Fully rugged vehicle mount terminal, 360° IP protection
- 10.4” SVGA
- Marvell PXA processor
- Diversity WLAN
- GPS, GPRS/HSDPA
- DLoG specific resistive touch screen
- Sunlight readable solution
- CAN 2.0B with J1939 ready
- Shock&Vibration 5M3

**TREK-550 & TREK-303H**
- Fully rugged vehicle mount terminal, 360° IP protection
- 7” QVGA
- Marvell PXA processor
- Diversity WLAN
- GPS, GPRS/HSDPA
- DLoG specific resistive touch screen
- Sunlight readable solution
- Service USB
- Shock&Vibration 5M3

**TREK-550 & TREK-303H**
- Intel® Atom™ based in-vehicle computing and communication solution
- Automotive grade operating temperature (-30 to 70°C / -22° to 158°F)
- DC power input for in-vehicle application
- 50 channel GPS with AGPS and dead reckoning
- Rich communication features WLAN/GPRS/HSDPA/CDMA
- CAN 2.0B with J1939 protocol & J1708 port
- Vehicle degree shock&vibration SAE J1455 & MIL-STD 810F
- Advance security & safety features: Analog AV-input ports (real-time rear view monitor application) & built-in G sensor (auto SOS)
- TREK-303H Display: 7” with 800 x 480 resolution
Embedded Computers in Today’s Railway Systems

Compact PCI-based systems for railway applications offer all current PC functions and up-to-date technology, as well as robustness, safety and long-term availability.

By Barbara Schmitz, MEN MikroElektronik GmbH

The growing number of electronic systems being incorporated into trains and subway systems are finding a home on the back end of the computing scheme, typically controlling specialized functions that reside out of passengers’ view.

So, in talking about the modern-day railway engineering market, it is not only the vehicles themselves that need to be considered, but the technology that is hidden away as well, ensuring passenger safety as well as railway efficiency.

Submarkets Within the Railway Market

Common studies, like that of the independent consultancy company SCI Verkehr, roughly divide the railway market into three segments:

- **Infrastructure**: the track system and electrification where no computers are typically needed
- **Vehicles**: the physical cars used to transport passengers (locomotives, high-speed trains, metro-trains, railcars etc.) and freight (locomotives)
- **System technology**: includes traffic management and train protection as well as "information technology" such as passenger information, passenger safety and fare management

It is these last two areas where computers are making the biggest impact.

The biggest initiative in updating vehicle technology is equipping cars with computers for train protection and control, while fulfilling many other passenger-related (or front-end) tasks. These can include the control of vital functions (e.g., drive, brake, power supply, tilting technology), safety management (doors, light, etc.) and convenience functions (heating, air conditioning, etc.) inside the vehicle.

System technology is the smallest, but fastest growing, segment of the railway market worldwide. Passenger information, which provides riders with conveniences, must also convey information on traffic management and train protection system-wide. With the ever-increasing speeds and denser traffic on the tracks themselves, safety and efficiency are primary concerns.

- **Fault-tolerant systems must continue proper operation when part of the system fails – an absolute must in a railway control center.**
Railway-Compliant Computer Systems

There are two striking differences between a computer inside a rail vehicle or in train protection and those computers in other embedded applications.

On one hand, the electronics for railway-compliant control have to meet more severe requirements with respect to robustness, reliability and availability. They demand corresponding precautions and thorough knowledge in design, production, qualification and product care.

The EN 50155 standard, for example, defines rules regarding different environmental impacts with a required operating temperature range of -40°C to +70°C, including up to 10 minutes of operation up to +85°C (Tx). Not only must the electronics be coated by a special varnish for protection against humidity and condensation, the housing itself should be protected against splashing water. These are only a sampling of the stringent demands within the railway market, but overall, EN 51055 dictates that electronic equipment must operate in trains for 20 years – without regular periodical maintenance.

The second main difference relates to safety-critical parameters of the system and the standards in place to ensure quality and reliability system-wide. Safety Integrity Levels (SIL), defined by IEC 61508, range from 1 to 4 and represent increasing layers of system reliability and redundancy as the level increases. A safe system is a system with a defined error behavior. In case of an error, fail-safe systems switch off into a safe state – a train, for example, would stop. Fault-tolerant systems must continue proper operation when part of the system fails – an absolute must in a railway control center. This is achieved through redundant computer architectures and permanent testing of all components.

CompactPCI and CompactPCI Serial are ideal platforms for safe computers in applications ranging from train control, train protection and control technology to driverless operation in ATO systems.

Long-term availability is extremely important in the railway market, because the vehicles have to pass complex acceptance tests before first operation and are then in use for several decades. The International Railway Industry Standard (IRIS) is a quality-management system built on ISO 9001. It requires very detailed documentation of key procedures and manufacturing processes to guarantee a high quality across the entire supply chain within the railway industry. IRIS processes include risk management, knowledge management or obsolescence management, among others.

The most significant IRIS procedures include Reliability – Availability – Maintainability – Safety (RAMS) and First Article Inspection (FAI). And finally all 12 knock-out criteria of IRIS, one of them being design validation, must be fulfilled during a certification audit, without exception.
Typical Railway Computer Architectures
While many functions of a railway computer are designed for the specific application, more of these computers can be partially built using standard components to save time and cost. Due to its modularity, maintainability and robustness, the CompactPCI bus system has proved itself in the area of 19” solutions. Based on the Eurocard format and recently updated to include serial interfaces, such as PCI Express, SATA, USB and Ethernet, via CompactPCI Serial, these systems remain an ideal choice in railway applications as content servers or multimedia access units and for recording and managing camera data as well as for ticketing. They can be combined with diagnosis, maintenance and service functions, a well.

One or several CPU cards in the same system can take over different control jobs and can exchange results. In terms of processor architecture, the most up-to-date Intel platforms are available – currently the i7 (first and second generation) or certain Atom processors, and also backwards-compatible CPU board models down to Pentium M. Thanks to individually designed heat sinks, power-saving versions operate without active ventilation in the system, where necessary.

Under even more severe conditions, the single assemblies are packaged into conduction-cooled assembly (CCA) frames and housed by conduction-cooled enclosures that are even protected against splashing water (IP67). In standard, less-protected 19” enclosures, designers can still opt to coat all of the electronics against humidity, condensation and dust, a consideration that should be analyzed in the development phase.

In environments prone to shock and vibration, all components – even the CPU and main memory – are ideally permanently soldered on the board and special consideration should be taken if connectors are needed on the board. The 2 mm CompactPCI system connectors that link to the bus backplane (including the new CompactPCI Serial connectors) are sufficiently robust. At the computer’s front, the usual RJ45 should be replaced with D-Sub, Lemo or M12 connectors instead. The latter are now also available for Gigabit Ethernet. For antennas on wireless I/O cards, SMA connectors can be effectively employed.

Redundant Systems for Safer Travel
CompactPCI and CompactPCI Serial are ideal platforms for safe computers in applications ranging from train control, train protection and control technology to driverless operation in ATO systems.

Sub-computers on separate backplanes, each with a PSU and identical CPU board and I/O configurations, are built into the same rack or distributed over several racks, connected as redundant, complete systems that monitor each other. They communicate via Ethernet, for example. This is a 1-out-of-2 (1oo2) architecture, and additional redundancy can be built in if safety as well as availability is demanded, resulting in a 2oo3 or 2oo4, etc. architecture. The main memory in systems like these is typically protected using ECC.

Another simple method is to use reflective memory assemblies in the system, or individual boards can be certified up to SIL 3 and SIL 4, which have a triple-redundant processor and main memory, and are equipped with onboard voters and other safety-relevant features like Built-In Test Equipment (BITE). Due to lockstep architecture, the (also safe) operating system only “sees” one CPU to reduce software overhead.

Depending on system requirements, different redundancy levels can be built into a safety-critical computing system.
Mixed Processors for Enhanced Function

Since many CompactPCI systems used in railway applications don’t necessarily need powerful graphics, and as Windows is not the most favorable operating system for safe computers, CPU boards with PowerPC processors are also used in many cases. With less than 1 W of power dissipation, some types of the PowerQUICC II and III families are very power saving, while the high-performance types of the QorIQ family offer up to eight processor cores.

Even combinations of Intel-based host CPUs with PowerPC-based slave CPUs inside the same system are common, such as for diagnosis and maintenance functions in different applications. A slave CPU connected via Ethernet could act as a diagnosis buffer. The PowerPC card running a VxWorks real-time operating system requires well under two seconds to boot and is ready for operation long before the Intel host is.

Reliability Lies in Design

No matter whether you deal with a CompactPCI, CompactPCI Serial or another type of embedded system – the top priorities are always compact and robust design, and standard conformity.

The train, as a modern transportation system, is getting computerized to a growing extent. Computer systems for railway applications have to be able to include all current PC functions and have to have all the up-to-date technology. But not only that: robustness, safety and long-term availability are also demanded on this market.

Since 1992, Barbara Schmitz has served as chief marketing officer of MEN MikroElektronik. Schmitz graduated from the University of Erlangen-Nürnberg. MEN MikroElektronik is an established manufacturer of failure-safe computer boards and systems for extreme environmental conditions in industrial, safety-critical and real-time embedded applications worldwide.
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Today, it’s all about using the best software language for the task at hand, be it C/C++, Java or Ada. Certainly anyone working on safety- or security-critical systems should become familiar with Ada, a formerly “niche” military programming language that’s not just for the DoD anymore. The benefits Ada brings are enormous in applications that cannot be allowed to fail and rely on robust software in medical, industrial, avionic, industrial, and transportation market segments.

In fact, all of these markets have similar safety (and increasingly “security”) requirements. In transportation alone, the tens of millions of daily passengers on railways, subways, roadways and in the air all expect to arrive at their destination safely and on time. They don’t think about source lines of code, priority inversions or software bugs, and they don’t expect hackers to compromise a city’s traffic signals like in the movie The Italian Job. Ada is an ideal language upon which to build secure, reliable software for safety-critical transportation systems.

We recently caught up with Greg Gicca, director of safety and security at AdaCore, and discussed how Ada fits into transportation applications. AdaCore is a recognized worldwide expert on the Ada language. Founded in 1994 with offices in New York and Paris, the company is stuffed with computer scientists and bona fide Ada language gurus. What follows are edited excerpts from that discussion, along with case studies available from AdaCore and their end users in industries related to transportation, air traffic control, and aviation.

But...What is Ada?
Ada was developed by a working group sponsored by the US Department of Defense (DoD) in an effort to consolidate the number of high-level software languages used in military projects. According to Wikipedia, Ada helped reduce the number of languages from 450 to 37 between 1983 and 1996. Ada is still a requirement on many new DoD programs and it continues forward migration (with backwards compatibility) as proven legacy code gets reused on recapitalized DoD systems. But the DoD might be considered an anomaly, having the ability to create technology from scratch and mandate its use. So Ada might be considered some sort of a “one-off,” used only by the military. That’s not true since Ada has many features that makes it ideal for safety- and security-critical systems.

Ada is a simple language that uses readable syntax such as “+” for addition and plain language conditions such as “if...end.” This makes it easier for humans to debug since the symbols used in other languages don’t come naturally and may be easily missed by developers. Ada doesn’t allow buffer overflows, a common mechanism used by hackers to corrupt a system and cause it to go unstable. Ada is also structured, object oriented, and strongly typed. This latter is one of Ada’s most redeeming features since it means there’s not a lot of ambiguity on how code is written. Wikipedia points out that Ada’s strong typed restrictions include:

- absence of unchecked run-time errors
- strong guarantees about run-time behaviors
- type safety that rejects function calls that disregard data types
- well-defined errors
- myriad other locked-down constructs that force the programmer to follow Ada’s rules which disallow room for interpretation.
Transportation systems, like Switzerland’s many high-speed railways, absolutely depend on software that has strongly typed features (Figure 1). It should be comforting then that railway control systems manufactured by Siemens Mobility use GNAT Pro, a version of the Ada language with a tool suite from AdaCore. “Safety has the highest priority in the railway business,” says Daniel Bigelow, Siemens software developer. “We invest a lot of time and energy in code-review and testing activities. [One of] our two most important requirements [was] an Ada compiler that could be configured to analyze code against a rigorous set of specific criteria.” Translation: Ada was chosen for Siemens’ safety-critical systems.

The Siemens railway control system is a modern net-worked application that covers every aspect of the railway control domain. It uses a distributed architecture to allow a computer to automatically take over control of a cell from another computer in the same cell due to a hardware failure or planned maintenance. This architecture guarantees high-availability of the system in accordance with European railway software standards. The current version of the system controls the train traffic throughout major parts of Switzerland and also parts of Austria, Hungary and Malaysia. Other Siemens railway computer systems are certainly candidates for Ada’s mission-critical assurance, such as the ZSI 127 Intermittent Automatic Train Control System shown in Figure 2. This transportation system monitors train movement using dynamic brake curve computation and applies the brakes in stages. According to Siemens, “data is transmitted on an intermittent basis via RF track-mounted Eurobalises, and also semi-continuously via Euroloop if necessary.” Railway signal controllers, track switchers, and even whole-system traffic monitoring are further examples of places where Ada could be deployed.

AdaCore’s Gicca says that his company’s GNAT Pro Ada compiler and other tools were used to discover problems at the source code level instead of in the lab. Tools developed for Ada by his company essentially automate the code-review process.

**What Makes Ada Unique?**

Although AdaCore didn’t invent Ada, they did invent GNAT, the GNU Compiler Collection (GCC) eventually made available by the Free Software Foundation for Ada. Since GNAT is obviously available free-of-charge, AdaCore makes its money selling GNAT Pro – the compiler along with some “60-odd tools that go along with Ada”– plus support services via subscription. Technically the company doesn’t sell products; rather, it’s the support for those products. And customers can switch to the fully functional and well-supported free tools at any time. This model allows AdaCore to get deeply involved with its paying customers, which is why, says Gicca, the company has so much domain knowledge on transportation applications such as the unique Siemens system.

Ada itself is also unique for many reasons, not the least of which is the number of platforms on which it can be hosted. A partial list of these platforms – native CPUs, operating systems, real-time operating systems, and cross platforms – is shown in Table 1. This is important in transportation due to the sheer number of different types of systems that make up “transportation”: from railways and subways, to buses, shipping, roadways and more. Each of these platforms uses different computers and infrastructure, and each has a combination of legacy hardware and software but must operate in different regulatory environments which vary by country. And don’t forget, all of these systems have some level of safety, security or both since lives are at stake when the system operates.
Table 1 shows that there are sources to the builds for Windows, Linux, Windows and anything else one could need. Ada was also designed for the types of embedded systems found in many transportation applications and it runs on all of the favorite embedded targets found there. Some of the most popular build platforms for embedded transportation targets include "various flavors of VxWorks, VxWorks-Cert, VxWorks-653, VxWorks for MILS [all available from Wind River], LynxOS [from LynuxWorks], PikeOS from Sysgo and a variety of different embedded platforms."

One example of a legacy platform that adopted Ada is the FAA’s User Request Evaluation Tool (URET), a conflict-resolution and detection tool for U.S. air traffic controllers. Created by federally funded research lab Mitre’s Center for Advanced Aviation Systems Development, URET helps enable the FAA’s Free Flight program by aiding controllers in meeting pilots’ requests for in-route flight changes due to weather, direct routing requests, or altitude changes for smoother flight or to capitalize on prevailing winds. Without the system, controllers in Air Route Traffic Control Centers (ARTCCs) were forced to rely on paper flight documents, hand calculations and mental notes to decide on granting a pilot’s request while assuring conflict-free route assignment. More automation reduces an element of human error.

URET was built by Lockheed-Martin, which used SPARC-based Sun workstations running POSIX thread libraries on Solaris to protect against software priority inversions. Ada was selected as the preferred language for this safety-critical system. Additionally, Lockheed-Martin had proven as reliable some legacy code on different platforms and AdaCore created a “type dictionary support tool” to port between platforms. More specifically, the company used an ASIS-for-GNAT tool based upon the ISO/IEC 15291:1995 international Ada Semantic Interface Specification. Ada was the ideal language to meet the priority inversion avoidance concern as certain POSIX thread priorities were maintained in the Ada program implementation. According to AdaCore, URET was installed at all 20 ARTCCs and is currently helping pilots map shorter routes, safely.

When Ada is Not Enough
For all the goodness of Ada, there are many applications that require more robustness, determinism and security. For those reasons, the SPARK language was created. According to Wikipedia: “SPARK is a formally-defined computer programming language based on the Ada programming language, intended to be secure and to support the development of high integrity software used in applications and systems where predictable and highly reliable operation is essential for reasons of safety.” Examples include avionics, such as those systems with DO-178B safety-critical certifications required; medical systems that mandate FDA certification; process control software in nuclear power plants with U.S. NRC certification; or even air traffic control.

Table 1: A partial list of the platforms that currently support Ada. (Courtesy: AdaCore).
In order to make it deterministic, changes were done such as removing the ability to perform exception propagation and handling. Also removed was general task rendezvous, while contracts were added that assured that certain certifiable requirements in the code were met. This allows programmers and certifying agencies to formally prove the correctness of code by setting, verifying and certifying to requirements. AdaCore notes that for safety and DO-178B, one still has to test the code – you can’t just prove correctness – but one can perhaps test less. (In the latest revision of DO-178C you do get certification credit using SPARK and can test in fact less.) SPARK is also ideal at implementing the Common Criteria certification assurance levels for secure software in EAL levels 1-7 (7 being the highest).

Says AdaCore’s Gicca, “SPARK now is an open source language that was developed by Altran-Praxis fifteen years ago. AdaCore enhanced the language and added a toolset,” similar to how the company rounded out GNAT Pro. SPARK is a subset of Ada with extensions, which is really unique since most compilers can’t handle a subset and extensions, but as a subset SPARK allows verifiable and deterministic coding like Ada. AdaCore’s partnership with Altran-Praxis was formalized three years ago, and it’s not surprising that Praxis selected GNAT Pro for yet another safety-critical application in air traffic control.

Besides creating SPARK, Altran-Praxis is a UK-based embedded and safety-critical systems integrator, and the company selected GNAT Pro for the UK’s next-generation Interim Future Area Control Tools Support (iFACTS) air traffic control system for its client NATS. According to AdaCore’s Gicca: “iFACTS will use a new program that is being designed and implemented from the start with the SPARK Ada language. The program used the GNAT Pro native toolset on IBM AIX workstations as the development environment.”

iFACTS helps Britain’s air traffic controllers based out of London Area Control Centre, Swanwick to meet increased air traffic and alerts them to flights that deviate from flight plans, something keenly learned in America post-9/11. Lead integrator NATS pioneered research, development and simulation of advanced air traffic control tools prior to contract award in 2007 (Figure 3). Using Ada derivative SPARK, NATS just reported that “figures for February to April 2012 show the average NATS air traffic control (ATC) delay was down to 1.4 seconds per flight compared to an average delay of 132.1 seconds 10 years ago; this is the lowest figure since records began in the mid-1990s.” Clearly the system works, and Ada with SPARK helps to make the software robust and safe.

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Digital Signage Goes Mobile with Heterogeneous Processing Platforms

APUs give mobile digital signage designers more compute resources and flexibility than ever before to extend ultra-immersive HD visual experiences to mobile, in-vehicle environments.

By Kelly Gillilan, AMD

The travel services industry has used digital signage as a means to provide timely, location-aware information that enables travelers to acclimate to unfamiliar environments, explore local attractions and get the most possible enjoyment from their travel. But where previously the travel services industry focused its attention on digital signage for fixed installations like hotel lobby and airport terminal kiosks, greater attention is now being devoted to mobile, in-vehicle digital signage that extends the hospitality experience to the local transportation network.

By introducing mobile digital signage into vehicles such as shuttle and tour busses, ferries, streetcars and metro railways, transportation service providers can provide travelers with helpful guidance that enables them to travel with greater confidence. Meanwhile, mobile digital signage can also be a significant revenue driver for transportation service providers. Local businesses recognizing the inherent value of “high proximity” advertising capabilities are increasingly vying for available in-vehicle digital advertising space, and this revenue can be enough to offset the capital and operating expenses tied to mobile digital signage installations.

Designing and implementing digital signage for mobile installations poses many unique challenges for system designers, however. Acute space, power and cooling constraints combined with exacting ruggedization requirements can be difficult to overcome with conventional embedded processing platforms, and high-performance video and graphics capabilities can be especially difficult to achieve without compromising space and power to accommodate graphics cards or ad hoc disparate chipsets.

The recent advent of heterogeneous processing platforms – exemplified by accelerated processing units (APUs), which combine a CPU and a discrete-level GPU on a single silicon die with a fully optimized data path – equip designers with the design flexibility and graphics performance needed to counter these challenges. Here we’ll assess some of the core design considerations associated with mobile digital signage, and the inherent advantages afforded via APU platforms.

Overcoming Size and Integration Constraints

Whereas hotel lobbies and airport terminals allow the space to accommodate floor-standing kiosks, vehicles like buses and metro trains are far less forgiving in terms of available space. In these space-constrained environments, ultra-thin flat-panel monitors typically need to be mounted flush to the interior surfaces of the vehicle cabin, where the signs will be less prone to damaging incidental contact and/or tampering.

Conventional desktop computer systems with integrated add-on graphics cards are generally ill-suited for these types of installations, as graphics cards are typically mounted to right-edge connectors within the system. In space-constrained designs, an edge connector takes up more space (card-edge boards are typically 3” to 5” taller) and exposes it to additional shock and vibration that can lead to system integrity issues.

The combination of a low-power CPU and a discrete-level GPU into a single embedded APU eliminates the need for bulky add-on graphics cards for mobile digital signage, and has enabled digital signage system vendors to develop ultra-compact “book sized” signage systems. The APU architecture reduces the footprint of a traditional three-chip platform to just two chips – the APU and the
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companion controller hub. This two-chip solution simplifies design complexity through a reduction in board layers and power needs, enabling mobile digital signage designers to achieve aggressive form factor goals while driving down overall system costs. Some newer-generation APU-based digital signage systems are small enough to be easily slipped into the tight spaces immediately behind wall mounted video displays.

The performance-per-watt gains enabled by APUs assure greater power efficiency and lower heat dissipation, which in turn can preclude the need for fan cooling within mobile digital signage systems and thus help to improve overall system reliability, limit system noise, preserve board space and lower bill-of-material costs. Supporting thermal design power (TDP) profiles starting at 5.5W, APUs can help mobile digital signage designers keep board-level total power dissipation to within the 25W threshold at which passive cooling is an acceptable (and typically favorable) option, enabling these designers to optimize their systems for harsh mobile environments and overcome challenging power and cooling constraints.

**High-Performance Graphics and Unified Video Decoding**

Even with continued evolutionary improvements in CPU and GPU performance and power efficiency, mobile digital signage designers remain challenged to achieve their most ambitious design goals centric to multimedia graphics performance and visual immersion. For travelers and transit passengers accustomed to wide-screen HD visual experiences in their homes, static SD multimedia displays won’t effectively capture or hold their attention, thereby negating the inherent value of digital signage.

New-generation mobile digital signs designed with advanced x86 APUs are suited to maximize overall graphics performance. The combination of general-purpose CPU and GPU onto a single die with a high-speed bus architecture and shared, low-latency memory model enables host systems to offload computation-intensive pixel data processing from the CPU to the GPU. Freed from this task, the CPU can serve I/O requests with much lower latency, dramatically improving real-time graphics processing performance. The integration of general-purpose, programmable scalar and vector processor cores for high-speed parallel processing establishes a new foundation for high-performance multimedia content delivery.

As with APU technology, unified video decoding (UVD) is another important mechanism for minimizing CPU load and maximizing overall processing efficiency, and is especially critical for mobile HD signage applications. Newer HD display systems require up to 6X more processing capability than earlier systems designed for standard definition (SD) content playback, so managing CPU load is especially important. By utilizing a dedicated UVD processing unit for the decoding of VC-1, H.264, MPEG4 and MPEG2 compressed video streams, the CPU is completely decoupled...
from the video decoding process, including the CPU-intensive entropy decoding stage. The net result of moving the entire decoding process off of the CPU to the GPU is that significant CPU cycles are freed up, enabling the solution to consume less power or perform other operations.

**Multi-Display Video Immersion**

The ability to support multiple displays simultaneously from a single mobile signage system is emerging as a key requirement for realizing immersive, eye-catching mobile displays and independent multimedia content feeds. Multi-display-capable mobile signage systems also help preserve valuable vehicle cabin space that would otherwise be lost to accommodate one-to-one system-to-display configurations. These types of systems are optimized to present multiple layers of dynamic video content cycling across in-vehicle displays in stunning 1080p HD resolution – overall picture resolution isn’t compromised.

APUs enable mobile digital signage designers to harness significantly higher levels of graphics processing performance while avoiding embedded design penalties centric to system form factor, power and cooling, and reliability. In this way, mobile signage designers are afforded more compute resources and flexibility than ever before to extend ultra-immersive HD visual experiences to mobile in-vehicle environments.

**References**


iiAMD does not provide a license/sublicense to any intellectual property rights relating to any to any standards, including but not limited to any audio and/or video codec technologies.

Kelly Gillilan has worked extensively in embedded applications for most of the past decade. He currently is the product marketing manager for the AMD Embedded Solution division, overseeing worldwide marketing strategy and activities. He holds a degree in computer engineering and is fluent in Mandarin Chinese.
**Editor’s note:** Although designed originally for applications looking for and identifying cellular signals, the QPADD tablet is a unique product. Not only does it meet harsh duty requirements – many tablets do that quite well – it has an inside expansion bay that accepts myriad I/O payload packages. Transportation applications are characterized by many different domestic and foreign standard interfaces and electrical specifications. QPADD might be one way for transportation field personnel to carry their custom test equipment but with the convenience of a tablet instead of an awkward laptop or rack-mount gear.

Chris A. Ciufo, editor

In the last few years, there has been a mini-revolution of sorts in the computer industry driven by the introduction of small man-portable computers such as netbooks and iPads. The main driver for adoption has been the performance available in a tablet form factor at prices often below that of conventional desktop and laptop systems. Consumers are in love with the Apple iPads, Asus Transformers and Samsung Galaxies for all the benefits they provide in portability, while allowing them to do whatever they need where they want to do it and when they want to do it.

In the transportation markets including railway, subway and intelligent surface roads, mobile computing takes on a different form where consumer tablets just won’t work. Professional mobile, field service and test/instrumentation applications have as key requirements high duty cycle (always on), ruggedness and sensor adaptability. For sensor packages, every application or market has its own unique interface or payload specs, necessitating a modular tablet that can accommodate myriad COTS and custom modules. This case study describes the development of QRC’s QPADD customizable, semi-rugged tablet computer with expansion bay. We’ll explore the tradeoff decisions made in creating this product which was originally intended for a market different than transportation.

**Baseline Requirements**

The consumer market drives all customers’ expectations. QRC’s main business as a system integrator is producing products for military and industrial clients in the niche of cellular RF survey. Simply stated, our products identify the existence of various cellular networks and provide technical data on nearby towers and network metrics. Initial products were lap-tops with sensors hanging off them, but they were very difficult to use in a mobile environment, prone to connection failure and in general just hard to use. Recognizing that, the company introduced the embedded ICS product line in 2006, and since then created embedded computers for use inside equipment that interfaced with measuring devices to serve as the system controller, user interface point and data collection engines.

When Apple’s iPad hit the market, we quickly realized that customers were going to begin demanding similar tablet form factors. This case study describes the development of QRC’s QPADD customizable, semi-rugged tablet computer with expansion bay. We’ll explore the tradeoff decisions made in creating this product which was originally intended for a market different than transportation.

**Case Study: Developing a Semi-Rugged, Field-Upgradeable Portable Tablet Computer**

The iPad created a demand for high-performance handheld mobile computing platforms, but its form-factor is not rugged. To meet these requirements, a ground-up tablet was designed to marry COTS, SWAP-C and modular sensor packages.

By Thomas F Callahan III and Rick Cellucci, QRC Technologies

When Apple’s iPad hit the market, we quickly realized that customers were going to begin demanding similar tablet form factors and LCD screen touch panel user interfaces that also support a robust set of conventional I/O’s such as Wi-Fi, USB or GPIO while still controlling and powering the cellular test and measurement sensor plus our software suite. We surveyed the market to see if a tablet computer existed with these general capabilities, but came up short of what was needed. Most tablet devices have very limited input/output capability (often restricted to Wi-Fi as far as data interfacing).
and are incapable of supplying the 10W our sensor required to operate with any type of reasonable battery life. The iPad, for instance, seems to have a USB port and SD card slot as an afterthought, and only then via a plug-in dongle. Clearly an iPad isn’t an option for our applications. The full set of requirements is shown in Table 1.

Unable to just buy what was needed necessitated building a platform capable of supporting the requirements in Table 1 with an iPad-like feel and reasonable battery life. This is the genesis of the QPADD, which has a tablet feel, modular equipment bay supplying 55W of power to run multiple peripherals, high speed data interfaces, and additional interface boards embedded inside the product itself.

Building the QPADD required many different aspects: selecting the right processor, determining the batteries and power system, selecting a touch-panel display, determining storage media, and building the interface circuitry, housing and heat management systems. The most important decisions were selecting the right processor and building the external and internal interfaces.

### Selecting the Processor
Because COTS modules are readily available, designing the single-board computer (SBC) at the heart of the QPADD was unnecessary. The market was surveyed and engineers shifted through hundreds of offerings from dozens of manufacturers. We knew we had to minimize the power draw of the system to allow for the longest possible battery life to meet a 4 hour target. We also knew we needed a system that could handle sufficient I/O (PCIe, Wi-Fi, Gigabit Ethernet, USB, SATA and VGA video were all needed), and could handle very high data rates to the sensor expansion bay (multiple large packet Gigabit Ethernet ports). Complicating things, finding as small an SBC as possible was also important, with our goal being no larger than a credit card.

<table>
<thead>
<tr>
<th>Requirement Type</th>
<th>Specification</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form-factor</td>
<td>Tablet, hand-held</td>
<td>iPad-like, and reasonably lightweight</td>
</tr>
<tr>
<td>Accommodate myriad modular and customizable I/O plus payload packages</td>
<td>Modular sensor/payload expansion bay</td>
<td>Example cellular sensor is Rohde and Schwarz’s TSMQ, PCTel SeeGull MX or Digital Receiver Technology’s DRT4301A</td>
</tr>
<tr>
<td></td>
<td>Multiple I/O types</td>
<td>Typical I/O: Ethernet, USB, GPIO, serial ports, programmable LEDs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>COTS add-on modules such as Express Cards plus custom modules would be ideal</td>
</tr>
<tr>
<td>Touch-screen display</td>
<td>At least 1024 x 768 at 10-inches (diagonal)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>External display desirable</td>
<td></td>
</tr>
<tr>
<td>Multiple network connectivity</td>
<td>Cellular, Wi-Fi, wired</td>
<td>Upgradable to the latest Wi-Fi and Ethernet specs would extend product longevity and minimize user re-training</td>
</tr>
<tr>
<td>Industry standard operating system</td>
<td>Windows or Android</td>
<td>iOS not available for non-Apple hardware</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drivers for Linux or Android might be challenging</td>
</tr>
<tr>
<td>Long battery run-time of ≥4 hours</td>
<td>Hot-swappable battery</td>
<td>Multiple on-board batteries</td>
</tr>
<tr>
<td>Rugged, passively cooled</td>
<td>Can take moderate abuse</td>
<td>Future potential for additional ruggedization, as required</td>
</tr>
<tr>
<td></td>
<td>No fan allowed</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Top-level Requirements for a portable, field modular tablet computer for cellular survey applications.
Form factors were found to range in size from the extremely small Mobile-ITX (60 x 60 mm) to the full-size WTX (356 x 425 mm), and everything imaginable in between. Some are standardized, such as PC/104 and COM Express, while others are proprietary. Some require extensive cooling solutions, while others can be passively cooled. Some are modular, allowing the designer to pick and choose which I/O interfaces are needed, while others are monolithic, with hard-soldered connectors.

A very small 67 x 100 mm computer-on-module (COM) containing a dual-core Atom processor was eventually selected with a retail cost of about $500 (Figure 1). The D510 Atom processor has sufficient computation power to satisfy QRC’s cellular survey needs while minimizing power consumption and board size. The key to ensuring adequate performance is the dual-core processor, so GUI updates and processing can occur simultaneously. While higher performance COMs are certainly available, the trade-off with power consumption and heat dissipation would have been unacceptable. The wide variety of interfaces on the SBC (particularly PCIe, USB, SATA and SD) gives a level of flexibility that satisfies all of our I/O requirements (Figure 2). Two USB connections are required – one for the expansion bay and one for external user I/O. In addition, an internal USB receptacle is used for a Wi-Fi dongle providing 802.11 a/b/g/n. SATA is used as the interface to the user-accessible CFast non-volatile storage for the operating system, while the SD interface provides user data storage. The COM board’s block diagram and all of its I/O is shown in Figure 2.

Building the Computer Around the Computer

Having found the SBC computer module, designers then had to build the “computer around the computer.” We had the raw interfaces but the glue and supporting logic needed to be provided and made appropriate for the tablet’s system design configuration. For example, although the SBC shown in Figures 1 and 2 contains a single Gigabit Ethernet interface, it lacks support for Jumbo packets and TCP offloading. The target application – looking for and characterizing cellular networks – requires a payload sensor system that relies on Ethernet to move data intra-system. Using the SBC’s host Atom processor for TCP offload would’ve swamped the CPU’s bandwidth. In addition, our goal was to provide up to four Gigabit Ethernet interfaces, so they were added via a separate “Main Board” (Figure 3).

The goal was to create a flexible, small form-factor computer architecture (including a computer module, a high-speed Main Board, and a Connector Board) that would be suitable for as many users as possible. Although a single carrier Main Board could have satisfied our requirements, the design was split into two boards (high-speed Main Board...
and Connector Board) as shown in Figure 3, which helped to maintain the small form factor and desired I/O flexibility. Additionally, the system was partitioned between these three boards such that as CPUs or I/O capabilities change, technology refresh should be straightforward.

Figure 4 is a more detailed diagram of the connector board. In the QPADD, all three boards are indeed stacked, making the Main Board a true carrier. However, back-side connectors and other header locations allow the boards to be separated and mounted individually for future QPADD variants and customer upgrades.

I/O Meets the Rest of the World
For an industrial computer that can interface with many devices we wanted to maximize connection capabilities. This is in stark contrast to other tablet computers, such as the iPad, which is limited to Wi-Fi and 3G cellular. Given the number of connections needed on the back of the unit, it was not possible to use standard full-size connectors without growing the QPADD’s outside dimensions (OD). For size and versatility, both being important design goals, we chose to use non-standard connectors to maximize I/O, rather than giving up capabilities just to use standard full-size connectors. This objective enabled using Micro-D style connectors. The QPAD-100 has micro connectors for VGA, GPIO and RS-232. However, in order to avoid needing special cables, engineers elected to use standard Gigabit Ethernet RJ-45 and USB type A ports (two of them).

Another useful feature in test equipment is a second, larger screen for indoor use. The SBC selected supports only LVDS and SVDO video, so an SVDO-to-VGA device had to be added on the Connector Board for external VGA. An ExpressCard/54 slot is located on the side of the tablet to address high-bandwidth applications and increase versatility. The ExpressCard is useful for A/D, D/A and even QAM Rx devices. This required both a PCIe lane and a USB interface, which the COM SBC has no difficulty providing. But note that these signals are brought out to the world via the Connector Board, not the SBC.

Wireless interfaces including an 802.11n Wi-Fi were designed in the system via the internal USB port. Cellular modems can also be added through several I/O ports: the internal USB (in lieu of Wi-Fi), external USB, ExpressCard or even via a custom sensor package mounted in the expansion bay.

And unlike any consumer tablet device, the QPADD has available nine general-purpose input/output (GPIO) lines that can read and/or write digital values. These, along with RS-232, are the mainstay of most test and measurement equipment and they’re extremely useful if, for example, someone wanted to interface via I2C to an external component.
Expanding the Options

Finally, it’s important to highlight one of the most unusual features in the QPADD: the expansion bay. As mentioned earlier, the expansion bay is an essential element of the QPADD as test equipment. The bay was designed to handle many types of user-provided peripherals, with a specific need for cellular radio equipment to satisfy QRC’s own needs. By putting a 6.6” length x 3.8” width x 1.68” depth “drawer” in the product, it’s possible to place sub-systems inside the tablet’s box and avoid the need for cables and devices hanging off the side where they can be pulled or cut. Expansion bay interfaces include a Gigabit Ethernet and USB 2.0 port, along with 55W at 12VDC.

Figure 5 shows the finished QPADD design, introduced in March 2012. As of March 1, QRC has spent more than 6,000 man hours and invested over $110,000 on the semi-rugged tablet’s design – including software APIs and creating Windows XP Embedded drivers. This package is modular and flexible enough to enable future product designs beyond the current device shown. Just as importantly, we believe it is something anyone building their own embedded systems can leverage off of to provide their own products less expensively and with much quicker time to market.

Mr. Cellucci is the systems engineering manager at QRC Technologies, responsible for electrical, mechanical, and hardware development efforts in the company. For 25 years he has designed hardware and software for commercial, rugged, and military systems, both small and large. Mr. Cellucci has an extensive background as a systems engineer, a real-time embedded hardware/software developer, a hardware/software integrator, a system software architect, and a signal processing expert. He has developed, implemented, and evaluated a variety of technologies from basic scientific principles through to prototypes and fielded systems.

Tom Callahan PMP is the general manager and CTO of QRC Technologies, where he has grown the organization to a top provider of Network Discovery Cellular Test and Measurement tools for Military and Government use. Prior to establishing QRC Technologies Mr. Callahan was the Vice President of Engineering for PCTEL’s RF Solutions group building cellular scanning receivers, and prior to that he worked as a DSP Engineer building signal intercept systems for Watkins-Johnson. He has a BSEE and MBA, is an expert in the air interfaces for cellular protocols, and has worked in numerous roles including as DSP Engineer, Software Engineer, Systems Engineer, and is a Certified Program Management Professional (PMP).
Use of Hall-Effect Rotary-Position Sensors in Transportation Applications

Designed to measure, monitor and provide feedback, Hall-effect rotary-position sensors are an integral component in many transportation and industrial applications.

By Chris Gottlieb, Honeywell Sensing and Control

There are a wide range of components, switches and sensors found inside most motorized vehicles that are used for personal transportation or for heavy industry. One interesting class of components is Hall-effect rotary-position sensors that may potentially be used in applications such as cars, trucks, buses and boats.

Hall-effect rotary-position sensors are designed to measure the angle position of a moving element by utilizing a magnetic field instead of mechanical brushes or dials. They use a magnetically biased, Hall-effect integrated circuit (IC) that senses rotary movement of the actuator shaft over a set operating range. Rotation of the actuator shaft changes a magnet’s position relative to the IC. The resulting flux density change is then converted to a linear output which can be used to provide feedback to either the operator or vehicle subsystem.

Solid-state Hall-effect technology provides non-contact operation. The internal section of the sensor uses a magnetic field, not a physical brush or wiper that is used in potentiometers. Wipers used in potentiometers can cause friction, which can reduce the product’s life. Using non-contact magnetic Hall-effect technology in a rotary-position sensor helps reduce worn-out mechanisms, lowers actuation torque and extends the product’s service life.

Hall-effect rotary-position sensors may be used in many harsh transportation and industrial applications at a competitive cost.

Potential Transportation Applications

Foot Pedal Position Sensing
In heavy-duty equipment and other vehicles, Hall-effect rotary-position sensors may be used to replace the mechanical cable connection between the foot pedal and the engine. A mechanical cable can stretch or rust, potentially requiring regular maintenance and recalibration. Eliminating the mechanical cable can improve the engine control system response, benefiting the vehicle’s emission, improving reliability and reducing excess weight. This type of drive-by-wire system can be both safer and less expensive than cable-connected systems.

For example, a rotary-position sensor may be mounted adjacent to the pedal to measure how far down the pedal is pressed. The harder the operator presses, the deeper the pedal is depressed, allowing more fuel and air to be delivered to the engine so the vehicle moves faster. When the operator removes their foot from the pedal, the Hall-effect rotary-position sensor senses...
the change in position and sends a signal to the engine to reduce the flow of fuel and air across the throttle plate. The vehicle responds to this signal by slowing down.

**Suspension/Kneeling Position Sensing in Buses and Trucks**

Hall-effect rotary-position sensors may also be used in buses and heavy-duty ride-height systems to sense travel of the suspension system. Buses utilize kneeling to lower their height so that passengers can board easily. The Hall-effect rotary-position sensor may be used on both ends of this application: one position sensor monitors the position of the control lever, and a second position sensor is deployed on a suspension arm or a linkage to monitor ride height.

Accurate position sensing validates that the vehicle is at the correct height for the application system’s requirement, improving vehicle ingress/egress. Large trailer trucks may also use Hall-effect rotary-position sensors to monitor trailer heights to improve warehouse docking efficiency.

**Tilt/Trim Position Sensing for Speed Boats**

Hall-effect rotary-position sensors may be used to monitor tilt/trim position for speed boats. The sensor accurately reports the angle position of the propeller, which can help the operator avoid damage and maintain optimum performance.

The Significant Seven: Specifications to Consider

1. **Is durability important?** Engineers should consider the type of environment in which the device will be used. For harsh environments, engineers should specify a package that meets IP67 qualifications for enhanced durability. This is especially important for vehicles and machines that are being designed to typically operate in harsh climates and environments.

2. **How long is the device specified to operate?** Check the product’s data sheet to determine the product’s documented cycle life. It may be better to have the sensor manufacturer perform this testing so that your engineering staff does not have to.

3. **Should you specify an integral connector?** Two important advantages of designing in a sensor with an integral connector are its smaller size and extended life. An integral connected sensor can be smaller than the overall package size of a sensor that relies upon a pigtail connection. This enables developers to design and build smaller overall system packages. Use of an integral connector increases durability because pigtails are notoriously fragile. Wires in a pigtail can become strained, frayed, eaten by rodents or crimped.

4. **Is EMI/EMC resistance important for your design?** Radio waves of different frequencies can interrupt electronics. Automotive-grade EMI/EMC protection provides reliability in sensor performance against radio frequencies in the environment.

5. **Can you utilize a standardized I/O?** Using industry-standard AMP termination, 32 mm mounting pitch and universal pin-out styles may help you save time and money. Standard I/Os can greatly simplify drop-in replacement because the mounting points, profile, and pin-outs are similar to those of the incumbent device.
6. How flexible do the sensors for your design need to be? Determine if you are working with one power setting or if the sensor should be able to work with a variety of input voltages. It could be beneficial to use position sensors that provide a wide span of operating voltages or ranges. A variety of operating ranges can provide design engineers the resolution needed in the span of travel in many common applications.

7. Is your sensor manufacturer reliable? It is important to consider whether your supplier can provide the engineering, testing, quality and customization expertise you need for your products. Additionally, it can be beneficial if the supplier knows and understands international standards, as well as manufacturing/shipping processes and policies.

Designed to measure, monitor and provide feedback, Hall-effect rotary-position sensors are an integral component in many transportation and industrial applications. Depending on your design application, choosing the right sensor and supplier can be essential to the success of your project.

Chris Gottlieb is Honeywell Sensing and Control’s senior global product manager for its position solutions product line. She holds a master’s degree in mechanical engineering from the University of Michigan, Dearborn, and a master’s degree in business administration from the Ross School of Business at the University of Michigan.

In addition to transportation applications, Hall-effect rotary-position sensors may be used in a wide range of industrial applications.

**Irrigation Pivot Control**
An interesting application for Hall-effect rotary-position sensors is irrigation sprinkler systems used by large farms. The sensor can monitor the angle range at which the sprinklers are irrigating. Is the irrigation system watering the section of the field intended, or is the system watering 360 degrees? This knowledge can help the farmer reduce water consumption and increase crop yield.

**HVAC Damper Control**
Heating, ventilation and air conditioning systems may use rotary position sensors for damper control. On a cold day, an open damper may feed cold air into a room, causing the HVAC system to engage heat. An open damper may feed air into a room that has open windows, reducing the system's efficiency and increasing heating and cooling costs. Effective use of Hall-effect rotary-position sensors, in conjunction with temperature sensors, allows the building manager to better control the HVAC system and reduce operating costs.

**Valve Position Sensing**
A common industrial application is the control of process valves. Oil fields, nuclear power plants, food processing plants and beverage manufacturers require that valves monitor position. Hall-effect rotary-position sensors are used to monitor position in large and small valves to help ensure that the valve is closed or if it's open, how open.
ADL Embedded Solutions Inc.

System Design and Integration for Transportation Applications

ADL Embedded Solutions Inc. provides a broad portfolio of standard COTS, stackable SBCs and peripherals supported by system design and integration services to enable customers to deliver a broad variety of transportation systems with quick time-to-market and low development cost and risk. The stackable nature of our embedded solutions means that even when standards and specifications are evolving, we can deliver solutions that meet product requirements today and throughout the life of the product. Our sophisticated Solidworks CAD design expertise, means that all design details are captured and maintained throughout the design and manufacturing process.

FEATURES & BENEFITS

◆ Broad portfolio of SBC options ranging from Intel® Atom™ (Z510/Z530, Pineview and Cedarview) to 2nd and 3rd generation Intel Core Sandy Bridge and Ivy Bridge processors depending on power and performance needs.
◆ Peripheral possibilities include: GSM, WLAN, WWAN, GPS, 3G cellular, storage drives and many more functions including custom board services for specialty applications.
◆ Power supply options exist for simple and high-powered systems with features including ATX, isolation, and EMI filtering for a broad range of requirements.
◆ Small stack footprints ranging from 95mmx96mm for Intel Atom SBCs to 96mmx115mm for Intel Core SBCs. Each peripheral card adds about .6” of height to the average stack.
◆ Custom enclosures can be designed for any stack configuration.
◆ Ruggedization and extended temperature options available.

TECHNICAL SPECS

◆ Systems can be designed for compatibility to a variety of customer specifications including:
  • Shock and Vibration Testing
  • IP67 Ingress Protection
  • Extended Temperatures -40C to +85C
  • Environmental Testing
  • EMI radiated and susceptibility, Mil-Std 461E and others.

APPLICATION AREAS

Application areas include train control, secure networking, radio, GPS, and GSM communication, entertainment systems, as well as station and wayside systems.

AVAILABILITY

Please call for design consultation.

CONTACT INFORMATION

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ARM-based In-Vehicle Computing Box

Compatible Operating Systems: Win CE 5.0 English core version as default
Supported Architectures: ST ARM based STA2062 333 MHz CPU

The TREK-510 is a dedicated box computer for industrial vehicle fleets, transport trucks, buses and taxis. TREK-510 combined with a variety of I/O connectors can be connected to devices like OBD-II or TPMS (Tire Pressure Monitoring System). Built-in wireless communications-WWAN enable TREK-510 to send important driver/vehicle/location/car information back to the control center. TREK-510 can also operate in extreme environments with features like a wide working temperature range (-30 to 70 degrees) and anti-shock/vibration design. TREK-510 also uses a special design to handle the critical issue of in-vehicle power. Special power protection (ISO7637-2/SAE J1455 Class A/ SAE J1113) and car power management software (Ignition on/off, delay on/off, low battery monitor) prevent electrical noise and surges from impacting the system, guarding against damage from transient car power.

FEATURES & BENEFITS

- Automotive grade working temperature range (-30 to 70°C)
- Rich I/O such as CAN, multi-COMs, isolation 4DI/4DO, line out, Mic in, USB, SD
- Built-in RF communication modules, such as GPRS/HSDPA/CDMA
- Ignition on/off delay; SW detectable/controllable for car power management

TECHNICAL SPECS

- ST ARM based STA2062 333 MHz CPU with Win CE
- 8-bit LVDS out,- 1 x RS-232,- 1 x audio line out,- 1 x USB Host,- 12 V @ 1 A output
- COM 1&2: 2 x Full Function RS-232, 5 V/12 V @ 0.5 A, ping9, by jumper selection;COM3: 1 x 4-wire RS-232/485 (controlled by software, 5 V/12 V @ 0.5 A, ping9, by jumper selection

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www.eecatalog.com/transport Hardware • 33
TREK-668 - In-Vehicle Surveillance and Fleet Management Box Computer

**Compatible Operating Systems:** Windows WES7/Win7  
**Supported Architectures:** Intel® Atom™ N2600 1.6Ghz. (Dual core) + Intel® NM10 Express Chipset

TREK-668 is an Industrial in-vehicle box computer designed to provide high-quality video surveillance and mobile resource management for a wide range of fleet vehicles.

TREK-668 delivers tracking and positioning and also supports dead-reckoning, which allows a truck to be traced even if the driver is in a tunnel. It supports the J1939 protocol for vehicle diagnostics and driver behavior management, and it supports high-quality, MPEG-4, MJPEG, H.264 recording, and transmission for up to 16 camera inputs. It has one PSE for an IP camera, and dual display/dual audio interfaces which support different resolutions. Each camera input provides motion detection capabilities; there are 16 audio inputs.

The TREK-668 provides a hybrid recording function allowing for images to be transmitted as either digital video signals using Advantech Power View software or as analog video signals. The TREK-668 provides reliable on-board recording and can transmit images or alarms for remote monitoring over a wireless, GPRS, 3G, or HSDPA network connection.

**FEATURES & BENEFITS**

- Automotive grade working temperature range (-30°C to 60°C)
- GPS with AGPS and dead reckoning technology (Gyro & speed line)
- 4/8/16 video input, one PSE for IP Camera supports 30 frames D1 resolution per channel per second.
- Built-in communication modules, including GPRS/HSDPA/CDMA, WLAN & Bluetooth
- Ignition on/off delay; SW controllable for car power management

**TECHNICAL SPECS**

- Rich I/O including CAN, RS-232, RS-485, J1708, isolation 4DI/4DO, Line out, Mic in, USB.
- Integrated 2D/3D Graphics Engine Supports Directx® 10.1 compliant Pixel Shader® v2.0 and OGL 3.0

**CONTACT INFORMATION**

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7” Touch screen Mobile Data Terminal - TREK-753

Compatible Operating Systems: Windows W.E.S. & WinCE 6.0 & Ubuntu Linux
Supported Architectures: Intel® ATOM™ Z510PT/US15 platform

TREK-753 is a new generation all-in-one 7” mobile data terminal with touch screen; compact design for commercial vehicles. With Intel® ATOM™ Z510PT/US15 platform; the system is high performing with wired connections like GB LAN & CAN2.0b with J1939 protocol support; users can also access radio transmissions easily with CDMA/ HSDPA/ GPRS/ GPS/ WiFi/ BT options. Focused on the automotive market, TREK-753 is designed with vehicle power which is compliant with ISO7637-2 & SAE J1113 so the system will be more stable when engine starts. Die casting & ruggedized chassis not only provide more capabilities in a wide range of temperatures (-30° C ~ 60°), they but are also suitable for harsh environments subject to shock (100G, 6ms) & vibration.

FEATURES & BENEFITS
◆ 7” WVGA LCD with 5 programmable adjustable brightness hot key
◆ Analog video input & CAN2.0b with J1939 protocol supported
◆ Supports CDMA/HSDPA/GPRS, GPS, WLAN, BT communications
◆ 48V option: 18~58V input range for specific applications
◆ Fanless and ruggedized chassis with aluminum able to work under -30° C ~ 60° C

TECHNICAL SPECS
◆ Intel® ATOM™ Z510PT/US15 platform
◆ 12V/24V option: 6~36V input range compliant to IOS7637-2 & SAE J1113

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ECGInfo@advantech.com
www.advantech.com
**Mobile Data Terminal - TREK-722**

**Compatible Operating Systems:** Windows® CE 6.0 R3 core version/
Linux Kernel 2.6.32

**Supported Architectures:** TI ARM Coretex-A8 AM3703

TREK-722 is a RISC platform MDT with 5” touch display. The radio frequency options and programmable function keys make TREK-723 suitable for local fleet management, especially small truck, local delivery, government fleet and taxi. It is designed with vehicle power compliant to ISO7637-2 and SAE J1113 ensuring the system is stable in dirty car power system. With Suspend/Wakeup feature, TREK-722 support 24/7 monitoring mechanism by periodical, digital input and WWAN wakeup.

**FEATURES & BENEFITS**

- 24/7 monitoring (anti-theft) mechanism
- 5”/7” touch screen display
- Video input port for rear view camera
- Fanless, ruggedized design & wide temperature operation -20 to +60°C
- CAN (J1939), GPS, Bluetooth, GPRS/HSPA+/CDMA

**TECHNICAL SPECS**

- RISC platform
- 300mW low power saving mode with periodical, DI, WWAN wakeup mechanism
- ISO7637-2 SAE J1113 and SAE J1455, MIL-STD-810G
Fanless, High Performance Processor Embedded Computer for Railway – tBOX320-852-FL

Axiomtek releases its new transportation solution, tBOX320-852-FL, a fanless embedded computing system incorporating the high performance Intel® Core™2 Duo SP9300 processor at 2.26 GHz with Intel® GM45 chipset, built for rugged working environments meeting demand for railway applications requiring EN50121/EN50155 certification. This innovative unit works effectively on mobility control units, passenger information systems, video surveillance and many other railway applications.

FEATURES & BENEFITS
◆ Intel® Core™2 Duo SP9300 2.26 GHz Intel® GM45 + ICH9M chipset
◆ Fanless Operation
◆ Operating Temp.: -25°C ~ +55°C
◆ 4 x Isolated RS-232/422/485 ports
◆ DDR3 max. up to 2 GB
◆ 1 x 2.5” swappable SATA drive bay

Fanless, Low Power Consumption Embedded Vehicle PC with CAN Bus – tBOX 311-820-FL

The tBOX311-821-FL is a cost effective embedded computer ideal for the transportation industry. It is rugged, and it incorporates a low power consumption Intel® Atom™ processor Z520PT 1.33 GHz with Intel® US15WPT chipset and is certified with eMark (e13) and ISO 7637 for vehicle applications. It supports 80W for any in-vehicle application use, and has one isolated COM port for other device connectivity. Built with numerous rich and robust features, this IP40-rated unit is ideal for mobile surveillance, fleet management, toll systems, intersection traffic controls and much more.

FEATURES & BENEFITS
◆ Intel® Atom™ processor Z520PT 1.33 GHz onboard
◆ Intel® US15WPT chipset
◆ Fanless Operation
◆ Operating Temp: -40°C ~ +65°C
◆ 1 x Isolated RS-232/422/485
◆ 1 x Isolated CAN bus (optional for RS-232/422/485)

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sales@axiomtek.com
us.axiomtek.com
Sandy Bridge Performance for Transportation Applications

The ADLQM67PC is a stackable PC/104-based form factor utilizing second generation Intel® Core™ Sandy Bridge processors. This small, highly-rugged form factor is ideal for applications where ruggedness and processor performance are critical. It brings unparalleled performance to applications such as radar and sonar processing, image signal processing, transportation and railway. The stackable nature of this SBC form factor coupled with a large ecosystem of stackable peripherals make this a perfect solution for a broad variety of transportation applications with evolving or variable specification requirements.

**PC/104 Stackable Benefits for Transportation Systems**
- Second generation Intel® Core™ Sandy Bridge processors in dual and quad core variants.
- Board is drop-in compatible with future third generation Intel Core Ivy Bridge processors.
- Extended temperature -40C to +85C available.
- Broad portfolio of alternate PC/104 SBCs including Intel Atom (Z510/Z530, Pineview D525 and Cedarview D2550), Pentium M, Core™ Duo, Core™ 2 Duo, GS45 and 2nd and 3rd generation Intel Core processors depending on power and performance needs.
- Peripheral possibilities include: GSM, WLAN, WWAN, GPS, 3G cellular, storage drives, power supplies and many more functions including custom board services for specialty applications.
- Small stack footprints ranging from 95mmx96mm for Intel Atom SBCs to 96mmx115mm for Intel Core SBCs. Each peripheral card adds about .6” of height to the average stack.
- Custom enclosures can be designed for any stack configuration for any environment including IP67 with extreme shock and vibration specifications.

**CONTACT INFORMATION**

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Floodgate™ Embedded Firewall

**Compatible Operating** Any embedded OS  
**Supported Architectures:** 8, 16, 32-bit MCU or CPU architectures

Floodgate is an embedded firewall that allows networked devices to control the packets they process. Floodgate protects against potentially malicious attacks by filtering packets before they are processed by an embedded device.

Floodgate uses a filtering engine that provides rules-based filtering, stateful packet inspection and threshold-based filtering. Rules-based filtering allows packets to be blocked based on static criteria such as port number, protocol, or source IP address. Stateful packet inspection maintains information on the state of each connection and uses that information to make filtering decisions. Threshold-based filtering protects against denial of service (DoS) attacks, broadcast storms, and other conditions that result in a flood of unwanted packets.

**Library for Embedded Devices**  
Floodgate is a source code library that provides packet filtering capabilities for embedded devices. Floodgate uses callback routines that are inserted into the device’s packet processing code. Layer-based callbacks allow filtering to be easily inserted at any layer in the network stack for maximum flexibility.

**Internet Threats for Embedded Devices**  
In enterprise environments, firewalls, intrusion prevention systems and other security devices protect against Internet threats. In the embedded environment devices are built using smaller processors and without the defenses found in more sophisticated environments. As a result, embedded devices are vulnerable to DoS attacks, packet floods and other Internet attacks.

**FEATURES & BENEFITS**
- Allows OEMs to easily add firewall security to existing products or new designs.  
- Portable source code for use with any embedded OS.  
- Configurable rules engine allows full control over filtering behavior.  
- Small footprint and optimized design for embedded systems.  
- Unique two-step filtering engine first blocks packets using filtering rules and stateful packet inspection and then using thresholds to protect from Internet threats, network traffic floods and DoS attacks.

**TECHNICAL SPECS**
- Static filtering blocks packets based on configurable filtering rules. Supports filtering by source IP address, MAC address/type, port, protocol or user defined criteria.  
- Built in Stateful Packet Inspection (SPI) filtering for TCP/UDP and ICMP packets.  
- Threshold-based filtering blocks packets in real time based on threshold crossings.  
- Supports both whitelist and blacklist filtering.  
- Layer-based callbacks allow filtering to be inserted at any layer in the network stack for maximum flexibility.

**APPLICATION AREAS**  

**AVAILABILITY**  
Now

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Seatbelts are now ubiquitous, providing a simple, elegant and effective solution to protecting people in car crashes. They are relatively inexpensive and universally recognized as an important component of the car’s safety system. They work in conjunction with anti-lock brakes, air-bags and the car’s other safety features to provide a high degree of protection. Embedded firewalls can play a similar role in protecting the devices comprising the Internet of things. A firewall provides a simple, effective and relatively inexpensive layer of security for embedded devices. When combined with security protocols such as SSH and SSL, it can be used to develop a highly secure device.

Recent reports of vulnerabilities found in embedded devices show that current security measures are not enough. In one reported incident, printers were reprogrammed with malicious firmware, causing them to send copies of printed documents to a remote location. Other devices that were successfully attacked include insulin pumps, pacemakers and automotive control and safety systems.

Embedded firewalls provide a critical layer of security for protecting embedded devices from attack. The role of a firewall is to control what packets are processed by the device. An embedded firewall is integrated into the TCP/IP stack of the embedded device and configured with a set of rules or policies specifying which packets are processed and which are blocked.

Rules can be set up to block or allow packets by IP address, port, protocol or other criteria. Some firewalls support advanced rules allowing additional fine-grained control over the filtering process. For example, the firewall in a printer may be configured to allow print commands from any IP address while blocking firmware upgrades unless from a known upgrade server.

In addition to rules-based filtering, embedded firewalls may also provide stateful packet inspection (SPI) and threshold-based filtering. SPI filtering maintains information on the state of the connection and uses that information to distinguish legitimate from malicious packets. Threshold-based filtering maintains statistics on the number of packets received to detect and block packet-flood DoS attacks.

An embedded firewall is integrated into the lowest layers of the TCP/IP stack, below SSH, SSL or other security protocols. By filtering packets before they are passed up the TCP/IP stack, many attacks are blocked before a higher layer connection is even established.

A firewall isn’t a silver bullet to thwart all attacks against embedded devices, but it does provide a critical layer of security for embedded devices. Combined with authentication and encryption protocols such as SSH and SSL, a firewall can be used to design a highly secure embedded device. Despite their relative simplicity and low cost, firewalls are virtually absent in embedded devices. With the growing attention to security for embedded devices and the Internet of things, it’s time to change that.

Alan Grau is president of Icon Labs. You can reach him at alan.grau@iconlabs.com

There is widespread recognition of the need for greater security for embedded devices. Security is garnering attention at conferences and in the media, and many companies are focusing more resources on building security into their devices. While security is getting a great deal more attention, people are still forgetting this one critical component; firewall technology is still nearly absent in embedded devices. Engineers just don’t see this as a critical part of the security framework, think that security protocols provide sufficient protection, or don’t feel that a firewall is important enough to justify the time and expense. Some engineers argue that embedded devices do not need a firewall because they are not running Windows.
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Internet
Traffic Management Center
Police Force
PoE IP Camera

ED3101
EX33000
rBOX104
ED3141

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