MEDEA+

Microelectronics driving a safer, more ecological transport market

EUREKA

Steady revenue growth

Findings from a recent market study suggest steady revenue growth for the automotive semiconductor market to 2015. The global market for automotive semiconductors is forecast to increase from €14.8 billion in 2007 to over €22 billion in 2015. With total 2007 semiconductor revenues of around €190 billion, this suggests the automotive sector accounts for between 7 and 8% of the total electronics market. Continued semiconductor demand is forecast in each of the main areas of the vehicle, as electronics increasingly pervade the main systems. Accordingly, average semiconductor content per new light vehicle is forecast to grow steadily from around €220 in 2007 to €280 in 2015.

Overall, highest growth is forecast for semiconductors used in entertainment systems, such as audio, infotainment, navigation and telematics. Here, demand is forecast to grow from €3 billion in 2007 to €5.6 billion in 2015, a compound annual growth rate (CAGR) of almost 9%. The evolution of the entertainment system from audio to infotainment to navigation is the key growth driver in this segment, while increased shipments of rear-seat entertainment systems such as video and games players, digital satellite radio and telematics will also drive growth.

Although most attention is often paid to trends in the entertainment segment, one key conclusion from the study is that highest semiconductor demand will continue in conventional under-the-bonnet systems. Analysis shows revenues for semiconductors in under-the-bonnet systems accounted for around 80% of the total in 2007 and this is forecast to decline only moderately over the period to 2015, to around 75%.

Microelectronics driving a safer, more ecological transport market

Microelectronics now form the backbone of safer, more efficient, economical and environmentally-friendly modes of transport. With the ever-increasing range of leading-edge technologies emerging in modern vehicles, driven by Europe and supported by MEDEA+ and the preceding MEDEA programme, global industry analysts estimate that 40% of the content of a mid-sized car could be accounted for by electronics in 2010 – with 90% of all innovations in cars related to electronics. Use of microelectronics in the automotive and aeronautics sectors has grown at a consistently higher rate than that of the semiconductor industry itself over the past two decades. A major trend has been a move from specifically designed electronic devices to systems based on standard off-the-shelf components, particularly in the lower volume aeronautics area, to reduce costs.

In the automotive sector, electronics is playing a key role in cutting fuel consumption and reducing emissions despite the move to more powerful engines. Use of electronics has been crucial in improving vehicle safety. And it is playing an important role in increasing vehicle comfort. Healthy growth rates and stable prices make this an interesting market, particularly in the form of application-specific integrated circuits (ASICs), despite its relatively small size. Technical demands include chips having to operate at ever higher temperatures – from the current 150° to 210°C in the future. MEDEA+ has made major contributions to platform development and *de-facto* standardisation.

Global production of light vehicles is set to grow from 67.4 million in 2007 to 80.3 million in 2015, with North America and West Europe likely to remain the two largest light vehicle production regions over this period. Revenues for under-the-bonnet automotive electronics are forecast to grow at a CAGR of almost 6% from 2007 to 2015, with the highest revenue growth for body systems. West Europe should remain the largest region for under-the-bonnet automotive electronics over this period, recording the highest revenue growth. However the fastest revenue growth is forecast for China, at a CAGR approaching 15%, with its proportion of the global under-the-bonnet automotive electronics market forecast to double over the period to 2015.

North American market research indicates commercial air travel is growing strongly worldwide, with air travel from the USA showing the most growth over the last couple of years. The USA in particular has gained market share in terms of regional demand for large commercial aircraft. The space aviation electronics market – which includes commercial aircraft and space – was worth some €270 billion for 2007.

Providing best solutions

Automotive semiconductor consumption, like the automotive electronics market in general, is driven by a variety of factors as suppliers compete to provide equipment and parts manufacturers with the best solutions. Key drivers for electronics in cars include higher emission standards, the need to reduce fuel consumption, increased demands for infotainment systems for both drivers and passengers, and higher safety standards with the introduction of so-called 'X-by-wire' applications such as in braking and steering.

The coming years will see the introduction of new products in the areas of advanced lighting and night vision, as well as technologies to help vehicle manufacturers comply with increasingly stringent fuel economy, environmental and safety standards. Moreover, carmakers continue to compete vigorously with each other in offering the latest electronic systems that make cars

Standardising software architecture

Upwards of 70 electronic control units are now found in cars to control major vehicle functions meeting ever-more demanding requirements on safety, environmental protection and comfort/convenience. Increasingly stringent legal requirements on exhaust emissions and safety have also fed the trend, as have the numerous infotainment and driver-assistance systems, whose functioning relies on the simultaneous interaction of a variety of different sensors, actuators and control units.

Until recently, carmakers and their Tier One suppliers have had to rely on individual basic software standards which have had to be maintained and integrated individually. Development of industry-wide standards was crucial to reduce maintenance and integration efforts in the whole automotive community.

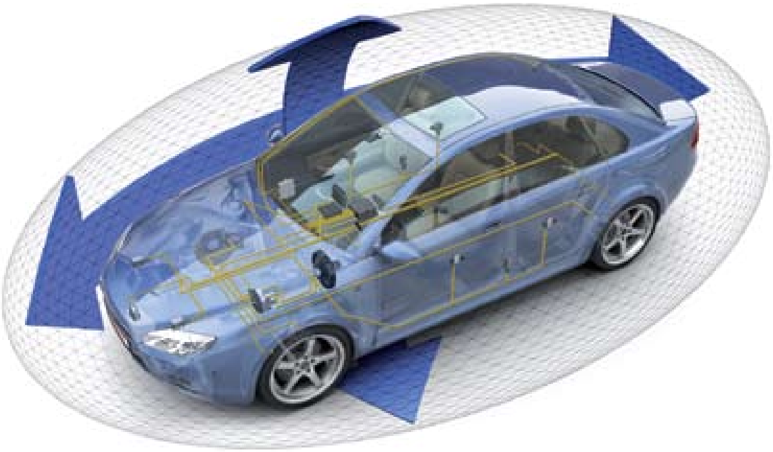
More than 20 partners from all parts of the European car industry worked together in the EAST-EEA project from MEDEA+ EUREKA partner Cluster ITEA to develop a common software interface for electronic devices in cars. It created a novel software architecture that allows easier integration of new electronics in cars through 'plug-and-play' technology, dramatically reducing development time and costs to market. The project was a massive undertaking and its results are being used as the basis for the car industry's automotive open-system architecture (AUTOSAR) initiative – a direct spin-off from EAST-EEA that is expected to produce its first results by 2010.

both better performers and more entertaining for drivers and passengers.

Although car production volumes in Europe are similar to those of the USA, the electronics content of European cars is around double at €8 billion a year. Constant innovation coupled with customer demand and expectations continues to drive the market forward, making vehicle electronics a highly lucrative business sector for solutions providers.

Growth opportunities in under-the-bonnet systems include:

- **Body and chassis:** Exterior solid-state lighting is a key growth application as carmakers change from conventional filament bulbs to LED lighting. Opportunities also exist in door electronics and air conditioning, while parking-assistance systems – both ultrasonic and camera based – are being adopted rapidly;
- **Power train:** Advancements in engine-control systems to reduce exhaust emissions and fuel consumption continue to be the key growth driver. With emissions regulations becoming ever tougher around the world, this trend will provide steady growth for semiconductor vendors in power-train applications for at least the next 20 years; and
- **Safety:** Driver-assistance systems such as lane-departure warning and blindspot detection offer high growth opportunities in the longer term, while electronic stability control (ESC), intelligent airbags and tyre-pressure warning systems are all seeing growth as a result of changes in legislation making adoption compulsory in regional markets around the world.



Integrating with the real world

Automotive and avionic electronics depend very much on so-called 'More than Moore' technologies where semiconductor devices are providing analogue rather than digital functions. These functions include power electronics, microsystems and sensors – ensuring an interface between electronics equipment and the 'real world'. They tend to be application-specific products rather than generic, resulting in lower volumes.

Integration of such 'derivatives' with advanced CMOS within the same system-on-chip (SoC) or system-in-package (SIP) design makes it possible to create complete systems tailored to the specific needs of the final customer. Such SoC and SIP devices make up half the semiconductor products used in the automotive and aerospace industry. This has required the development of new substrates, new electronic design methodologies and new cross-disciplinary collaborations that have been highlighted in a series of MEDEA+ projects relevant to the transport industry.

A major challenge in the automotive industry lies in the different development cycles of the areas involved. The life of a car can be from 10 to 15 years, while the design cycle for new vehicle models is 3 to 5 years. This contrasts markedly with the typical 12 to 18-month development cycle of the electronics industry. The multiapplication/multidisciplinary nature of the automotive sector, together with these different development cycles, requires agreed architectures to protect the investments of all players. So, systems development depends on close vertical cross-industry collaboration.

The MEDEA+ A404 SSAE project was such a cross-industry collaboration intended to speed development of safer, more reliable cars. It defined, designed and evaluated core silicon components and services relevant to a new electrical/electronic architecture.

Key objectives included the definition and design of low-cost components, equipment and associated services using widely-shared communications protocol and software standards – particularly that developed in the ITEA EAST-EEA project – see BOX. The intention was to generalise a series of new safety, comfort and communications functionalities at affordable prices based

Advanced communications system

FlexRay is a communications system that will support the needs of future in-car control applications. At its core is the FlexRay communications protocol, which provides flexibility and determinism by combining a scalable static and dynamic message transmission, incorporating the advantages of familiar synchronous and asynchronous protocols.

The core member companies of the FlexRay Consortium – BMW, Bosch, Daimler, Freescale, GM, NXP and Volkswagen – have been collaborating to develop the requirements for this advanced communications system for future automotive applications. These companies brought together their respective areas of expertise to define a communications system that is targeted to support the needs of future in-car control applications.

FlexRay focuses on the needs of present and future in-car control applications and the aim is to establish it as the *de-facto* standard in the automotive industry.

on multifunction chip modules that can easily be mass-produced for a number of car models.
Work was based on use of fault-tolerant buses to link and control a variety of generic central units and multifunction modules such as intelligent switching units (ISUs) for body and comfort functions, telematics (T-box) and multimedia (M-box) as well as other electronic control units (ECUs) and electro-mechanical (mechatronics) modules.
A broad study was carried involving various networking protocols available during the course of the project. A series of time-triggered communications protocols that provide inherent fault tolerance were demonstrated but the release of FlexRay Version 2 – now seen as the future global solution – was too late. However, a second MEDEA+ project – A409 SAPECS – continued this activity.

Ensuring safety first

More than 40,000 people die and 1.7 million are injured in car accidents every year in Europe according to the Community database on accidents on the roads in Europe (CARE). Carmakers and infrastructure authorities have therefore been working together to develop new electronics systems able to warn of the imminence of a crash or, ultimately, take control of a vehicle to avoid collision.

On-board metrology and the ability to transmit data relating to accident warnings, emergency localisation and crash-avoidance transmitted to in-car receivers opens the door to automatic or semi-automatic systems able to take appropriate countermeasures. However, this is only possible if the reliability of all control units is absolute. The MEDEA+ A409 SAPECS project focused on safe data processing in these modules and ensuring a fail-safe

intercommunication networks between the modules.
Prime objectives were to determine how silicon devices could meet the communications needs of such networks, and how safe data processing could be ensured within individual modules. Targets included: passive safety elements in cars; fault-tolerant/fail-safe error signalling; fault-tolerant architectures in control electronics; and non-ambiguous human-machine interfaces.
SAPECS also verified the ability of time-triggered technologies to satisfy the safety requirements of 'x-by-wire' applications. In time-triggered distributed systems, all significant events – such as tasks and messages – must adhere to a pre-determined schedule, rather than occurring at random. This ensures predictability in their real-time behaviour – making them particularly suitable for complex, safety-critical systems,
Such an approach is essential as vehicle makers replace hydraulic or mechanical actuators by electronics. Autonomous functions such as brake-by-wire and steer-by-wire could provide valuable assistance to drivers in hazardous situations, but pose major new safety and reliability questions.
European companies are very active in proposing protocols capable of high reliability and intrinsic fault tolerance – such as controller area network (CAN), time-triggered communication on CAN (TTCAN) and now FlexRay. Indeed, FlexRay, which offers the high data transmission rates and security required by advanced automotive control systems, has become the *de-facto* industry standard in Europe, supported by major automotive companies and chipmakers.

Overcoming electromagnetic compatibility issues

Building ever more compact and faster automotive electronics and avionics systems runs increasingly into physical limitations caused by electromagnetic compatibility (EMC) issues. The need is to improve design methodology and develop modelling techniques to simplify simulation of circuit performance and avoid electromagnetic incompatibilities at an early stage, reducing overall design time. The basic goal of the MEDEA+ A509 MESDIE project was to close the gap between IC-level design and application at system-integration level using electronic design automation (EDA).

Higher processing speeds, greater memory capacities, lower power consumption at lower logic voltages and much increased integration all mean EMI parasitic effects in chips will continue to grow. Use of high-frequency EMC modelling is critical with the increasing need for high-frequency analysis, simulation and modelling at chip, package and subsystem levels. Reasons includes multi GHz signal bandwidths at all levels of integration and packaging, mixed analogue, digital and radio-frequency signal functionality, and greater wiring densities in complex 3D environments.

A highlight of MESDIE was EMC validation at system level in a demonstrator using a new software package aimed at avionics as new planes require gigascale integrated microelectronic systems in high density packages. Signal paths were analysed in high density package and interconnect structures in an Airbus A380 control unit. Results were fed back to system designers prior to fabrication to achieve low parasitic emissions.

The MEDEA+ 2A701 PARACHUTE project took this work even further to ensure the electromagnetic reliability (EMR) of whole systems. It is developing an innovative integral design approach and the necessary models, algorithms and tools that take EMR into account all levels – chip, IC package, high density packaging, high density interconnect and printed circuit board. The overall objective is to improve the electromagnetic reliability of applications based on nanometre circuits, microelectronics, microsystems technology and power electronic systems, particularly in the automotive and aerospace sectors.

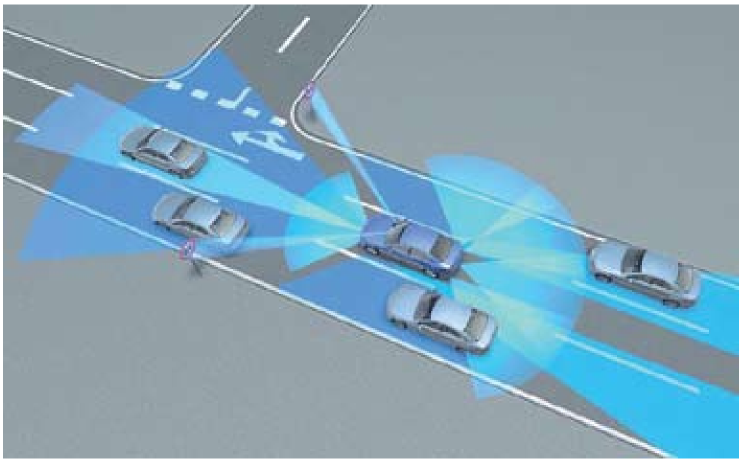
Robust device performance

Automotive electronics systems require complex power and mixed analogue/digital devices that are able to operate robustly in harsh environments. A particularly important demand is that such components are resistant to damage caused by electrostatic discharge (ESD).

The MEDEA+ T104 SIDRA project developed design-simulation methods for the protection of mixed-signal integrated circuits against ESD damage at chip level – particularly important with the trend to ever-smaller complete system-on-chip devices. It developed and verified simulation-guided design methodologies for protection at chip level to prevent weakness of ICs subject to fast transient pulses. Work centred on the use of the charge-device model (CDM) that allows very high currents, up to 10 A, with extremely fast pulses – durations less than 2 ns.

Mixed-signal ICs in automotive applications are subject to extremely tough specifications due to their safety-critical functions, the hostile environment and the high degree of heterogeneous complexity involving sensitive analogue, power and digital control elements. By simulating CDM stresses, it is possible to optimise ESD protection before initial chip fabrication – avoiding redesigns and so saving development time and costs. A large number of automotive applications – from engine control and active suspension to power steering and drive by wire – require high levels of power. Extensive work on high voltage capability and temperature robustness in the MEDEA+ T122 SC42VAA project resulted in a new generation of smart-power processes able to combine digital logic and high-power switching on a single substrate for applications up to 85 V in rugged environments.

The advantage of the technologies developed in SC42VAA is that it makes possible the combination of logic and power stages in the same device to provide high voltage and high power using standard silicon processes. Previously, it had been necessary to use separate ASICs and power transistors.



All-seeing cars

Cameras are increasingly common in cars. The MEDEA+ A406 PICS project made major advances in programmable CMOS imaging to improve motoring safety day and night. It developed high resolution CMOS-based cameras for innovative systems incorporating sophisticated image-capture and image-processing features to filter essential information – from warning of a pedestrian in the road at night to monitoring driver drowsiness.

Not burning up

It is increasingly necessary to place electronic control units directly on engines, in transmissions or near brake disks in mechatronic modules. Electronic controls incorporated into such modules must be capable of surviving long-term operation in high temperatures that substantially affect reliability.

While temperature limits for state-of-the-art engine and transmission controls are 125° and 140°C respectively, MEDEA+ T124 HOTCAR project targeted 150 to 200°C. The challenge was to achieve these goals with innovative yet inexpensive solutions, forcing a focus on extending existing silicon technology, rather than more exotic and expensive materials.

Development of specialised high-temperature products called for standardisation at all levels as this is only a comparatively small part of the global market. Carmakers needed to work alongside systems suppliers to define future environmental conditions precisely and build a common requirements platform to enable chipmakers to deliver reliable components working at the desired temperatures.

Most existing CMOS imaging applications depend on optimising all elements in the system for a specific purpose, limiting their range of use. In the PICS approach, the smart sensor system can be adapted for different applications by simply changing the embedded software.

This reconfigurability was demonstrated in two different applications.

- Automated car number plate recognition for car park entrance control – similar systems could be used for toll collection on motorways, congestion charging, border controls and identification of stolen vehicles; and
- Detection of the size and position of a driver or passenger for safer airbag deployment – a mandatory requirement in the USA for example to minimise the risk to children.

The MEDEA+ 2A401 Car Vision project involved innovative optical solutions for advanced driver-assistance applications with the intention of reducing traffic accidents significantly under difficult driving conditions such as in fog or rain. The consortium focused on new image-recognition and safety systems, and developed a state-of-the-art platform to enhance day and night vision. This exploits a CMOS-based sensing system resistant to the extremes of the car environment.

Although the market for automotive optical-recognition assistance and safety systems is very promising, there have been no significant European manufacturing activities in this sector. Field trials are in progress on a mix of costly radar and charge-coupled device (CCD) sensor technologies, with applications from parking assistance to use of rear-, front- and side-view cameras for collision avoidance. There are also tests for mirror/blindspot detection, seat monitoring and night vision.

A major innovation of Car Vision lay in the development of integrated vision technologies for the design of cost-effective recognition and assistance systems. Car Vision developed alternative solutions based on dedicated CMOS-based optical technology covering visible and both near- and far-infrared applications.

More than a sixth sense

Reports from the European Environment Agency estimate the indirect costs of transport at about 8% of GDP, a substantial part attributable to accidents. Each year over 40,000 people are killed and about 1.7 million injured on the roads in Europe. Research shows human error is the source of over 90% of all road accidents. Many could be prevented if drivers were made aware of their physical condition and encouraged to focus their attention or stop the vehicle.

The objective of the MEDEA+ 2A403 Caring Cars project is to increase car safety and enable wellness applications in an automotive environment – reducing accidents, while improving air quality and citizen's health. The project will create an open automotive infrastructure based on the extensive network of sensors already available in vehicles, plus new sensors to monitor human conditions. Existing electronics and sensors will be augmented with additional wearable and portable sensors as well as communications modules.

Applications visualised by the project include intelligent adaptive interior lighting, monitoring vital signs, voice dialogue, driver-attention monitoring and data exchange from car to emergency services and from an emergency vehicle to a hospital. To support these applications, Caring Cars will build sensor networks, application-specific processors and interface controllers. The intention is rely on existing technologies for the network infrastructure. Wherever possible, existing standards such as FlexRay will be used.

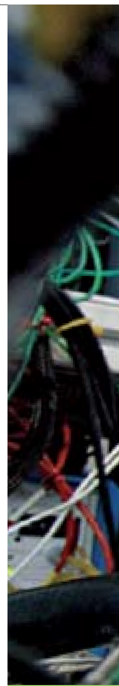
Facing up to the challenge

The new CATRENE nanoelectronics Cluster is more than ready to take up challenges of keeping the European automotive electronics industry at the leading edge worldwide as it succeeds MEDEA+. This is part of its objective to increase the interaction between applications and technology with a strong focus on markets with high-growth potential for innovation-rich goods and services.

Safe and energy-conscious transportation will be an important element in CATRENE as one of its lead markets. It will concentrate on:

- Safety;
- Energy-conscious transportation;
- Transport system control and security; and
- Mobility.

CATRENE
Cluster for Application and Technology Research in Europe on NanoElectronics



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MEDEA+ ∑!2365 (2001 to 2008) was the industry-driven pan-European programme for advanced co-operative R&D in microelectronics. Its aim was to make Europe the global leader in systems innovation on silicon. Some 90 projects were labelled, covering challenges in microelectronics applications and enabling technologies, and involving 2500 scientists and engineers annually from 23 European countries. The more than 600 partners included major microelectronics manufacturers, systems houses, SMEs, universities and institutes.