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TRENDS & FORECASTS IN SMART SYSTEMS TECHNOLOGIES

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(Chemnitz) and its Examples of Best Practice" ♦♦♦

nation of factors: development of enabling technologies for the modular components; integration of key components into systems using novel, low-cost manufacturing techniques; interfacing of systems to the external environment and, most importantly, understanding the requirements of the user community and target market trends. To achieve this successfully (both technically and commercially) is a significant challenge and requires the combination of multi skills and disciplines, often residing in multiple partners and diverse stakeholder groups.

In addressing these issues, the SmartHEALTH project produced an initial development roadmap (Fig. 2) at the outset of the project (December 2005) to help schedule, plan and implement the underlying technological developments.

However, as the project is now in its 3rd year of operation, a re-assessment

of technologies used, market trends and routes toward the optimal exploitation of results will be necessary. To achieve this, the following actions are planned in upcoming months:

- Interviews with potential stakeholders
- Launch of cancer diagnostics user group
- Two user group workshops to discuss:
 - o expected project results versus user needs
 - o markets and market strategies
 - o commercialisation routes
 - o ideal partners for commercialisation
 - o further development needs

The aim of the SmartHEALTH roadmap is, firstly, to ensure alignment of the needs and restrictions of the principal stakeholders to the program's objectives. Secondly, it is to ensure alignment of the project part-

ners' individual inputs. From this it is already clear that, in order to ensure the roadmap reflects the real issues, discussions between with stakeholders and project partners are needed. Those discussions are not only beneficial for the project partners; the stakeholders will also be sure that the developments fit neatly into their needs. For this purpose, the SmartHEALTH project is now setting up a user/expert group.

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The Consumer Electronics Roadmap: From Single Components to Smart Systems

J r mie Bouchaud and Dr. Richard Dixon

The combined market for Microsystems-based sensors and actuators is set to grow from \$6.13 billion in 2006 to \$8.75 billion in 2012, a CAGR of 6.1%. Applications in consumer electronics, and especially mobile applications, will drive the market for MEMS sensors. In particular, motion sensors in the form of accelerometers and gyroscopes for mobile handsets, laptop HDD protection, anti-shake in digital still cameras, and providing realistic gaming interfaces will enjoy double-digit growth. Indeed, mobile phones will feed the MEMS market with a range of sensors at an impressive overall CAGR of 21.6% over a six-year period ending in 2012 (figure 1).

To date, mainly single sensors have been shipping in consumer products, e.g. a 3-axis accelerometer in a mobile phone or a gyroscope in a digital camera for image stabilization. One could hardly speak of smart Microsystems in this case. But this is chang-

ing, and iSuppli is noticing a clear trend towards multi-sensor modules for consumer products - with increased functionality and intelligence - so that one can speak of Smart Microsystems.

Here are a few of these Smart Microsystems, in order of increasing functionality:

Electronic compasses from companies like AKM have been available for a couple of years. These devices combine 3-axis magnetometers and 3-axis accelerometers. The accelerometer recalibrates the magnetometer if the compass is not held flat.

IMUs While the added value of the accelerometer is still limited in today's electronic compass, future modules will evolve into "real" Inertial Measurement Units. Used as a pedometer, the accelerometer can measure distance, calories burned, and so on. With the addition of a gyroscope, IMUs can recognize changes

in direction and provide a dead-reckoning function for real inertial navigation, e.g. for indoor navigation, or to compensate for losses of GPS signal in cities with tall buildings. The next step is to incorporate a pressure sensor, which will act as an altimeter. A mandate is under consideration in the US to include pressure sensors in cell phones that assist emergency services that receive calls from tall buildings. Stepping back from the crystal ball, iSuppli already notes that simple IMUs are already in use in the Sony PS3 game controller. This combines an accelerometer from Kionix or HOKURIKU with a gyroscope from Murata. New generations of cable TV remote controllers are also based on motion sensing from accelerometers and gyroscopes.

Multi-function in single package: Some sensor combinations are even more surprising: in future cell phone applications, accelerometers will be integrated in the same package as MEMS microphones, although the



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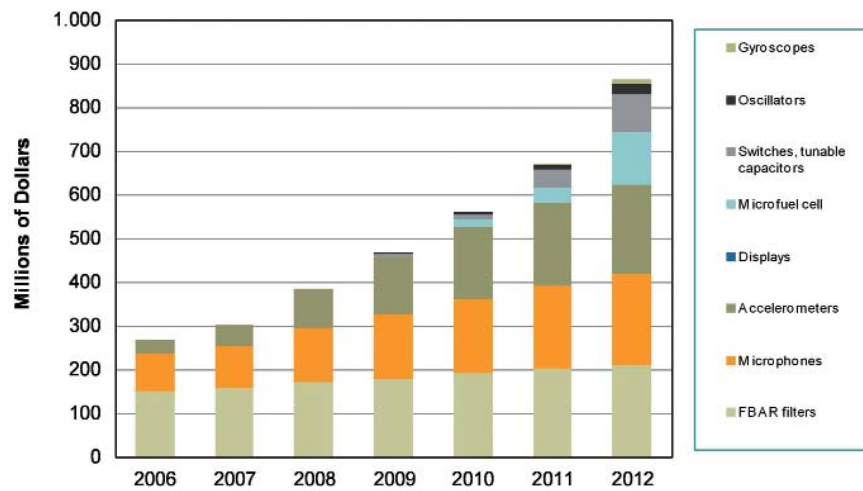


Figure 1: MEMS Sensor Market for Mobile Phones 2006-2012 (Source: iSuppli)

combination serves to reduce package and cost in this instance.

WSN: Worthy of mention is the case of wireless sensors featuring additional functionalities. The company Virtus has just presented a so-called "Micro Sensing Mote" containing battery, accelerometer and Bluetooth transceiver. An even smarter version contains a data recorder for logistics, industrial, and environmental research purposes. It can measure vibration and the handling environment of distribution packages, as well as temperature and humidity during transportation, and also performs process monitoring for maintenance and troubleshooting applications in manufacturing plants.

Challenges and opportunities of smart microsystems

On paper, combining multiple sensors in a smart system makes sense. However, achieving this goal in reality is not a straightforward proposition in the consumer and mobile phone arena. There are several chal-

lenges associated with developing smart Microsystems, and associated opportunities for those who provide solutions:

Smart packages: In order to meet the strong constraints of low cost, size and power consumption, especially for portable electronics applications, new manufacturing and integration schemes are required to integrate multiple sensors. Smart packages featuring 3D integration schemes are currently under development for MEMS and should help to combine various kinds of sensors with ASICs and packages. Originating in the semiconductor field, Though Silicon Vias (TSVs) start to impact the MEMS industry, being one of the solutions envisioned for 3D stacking of multiple functions. Most sensor manufacturers are currently evaluating TSVs, including ADI, ST, Freescale, and Infineon...

Standards: While standards do not yet represent a reality across the MEMS industry, they will start to appear at the company level. To be

profitable with multiple sensor devices, it has become urgent to break the MEMS "one product = one process" habit, and companies are trying to create manufacturing platforms where common "bricks" can be re-used. Large companies like ST are taking this

route, but some smaller companies whose IP is not primary in the device but in the process like Invensense (the Naisiri process) or Akustica (iSuppli suspects its process is not only for microphones but other kinds of MEMS sensors in future).

Interfaces: Combining various sensors in the same system means dealing with different signals from different sensing principles (capacitive, piezoelectric...). Companies like Semtech have recognized this issue and marketed a data acquisition module that helps solve the interface issues of multi-sensor solutions in consumer electronics.

Algorithms: The first combinations of magnetic sensors and accelerometers do not yet exploit all the possibilities of inertial navigation. The reason is the complexity of creating motion recognition algorithms that use input from several sources, e.g. acceleration, magnetic field, gyration, pressure... Companies like Point Research (acquired by Honeywell) specialize in these algorithms.

Testing of these multi-sensor modules is not trivial. In some cases, the various sensors are interfering with each other. While IMUs are tested and calibrated individually for defense applications using dedicated equipment from companies like Acutronic, less costly solutions need to be found for consumer applications at wafer level.

From components to Smart Systems: who will supply what?

As the business model for sensors in consumer electronics and especially mobile phones shifts from a component business towards a Smart System approach, suppliers must evolve.

Additional sensors: make or buy?

Suppliers that have specialized in one type of sensor must be able to include additional sensors to provide a smarter system. There are two options: 1) the company can purchase the missing components in their portfolio, or partner with other manufacturers and integrate these devices into modules, and 2) the company can invest in adding new device technologies to their portfolio.



Figure 2: wireless motion-sensing unit (courtesy of Virtus)

Experience shows that most companies prefer to develop new kind of components in-house to better control the integration schemes, their IP and their margins. Analog Devices recently introduced MEMS micro-phones to the market, which is a significant departure from their existing inertial MEMS sensors offerings that have been the mainstay in the last 15 years. Meanwhile, STMicroelectronics has recently introduced a gyroscope to its family of devices and Bosch Sensortec is expected to add new MEMS sensors types to the traditional portfolio of Bosch.

Algorithms and application software: make or buy?

The algorithm that fuses the signals from various sources and transforms them into a function in a mobile phone, personal navigation device or game controller can be described as

a science in itself. Will these key puzzle pieces be left to the component supplier, to the OEM, or to specialized companies?

- Most component suppliers have developed their own algorithm and application software expertise. This is the case not only with the large semiconductor companies like Bosch Sensortec or Freescale, but also smaller companies like Kionix, which now have more employees in the software and applications group than the sensor part.
- Specialized software companies such as FullPower Technologies and MOVEA are emerging and partner both with sensor suppliers and OEMs.
- In some cases, the OEM wants to keep the application software competency in-house as a way to

differentiate from the competition.

Smart Systems no longer represent a "buzz word" but amount to a reality that has already started to impact the supply chain, from sensor suppliers to OEMs. This happens not only in sensors for consumer electronics applications, but this field is where the challenges are the toughest due to inherent constraints on cost, size and power consumption. This is also where the reward will be the highest for those who provide the right solutions!

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