Wavecom Blue Paper No. 2 :

Implementing eCall: Vehicle Emergency Communication

Date: **January 2007**

OPEN AT

wavecom
Make it wireless

Operating Systems | Integrated Development Environments | Plug-Ins | Wireless CPUs | Services

Executive Summary

The European Union is promoting *eCall* to reduce the number of roadway fatalities by minimizing the response time when an accident has occurred. *eCall* is a combination of an In Vehicle System (IVS), a device with a GSM cell phone and GPS location capability, and a corresponding infrastructure of Public Safety Answering Points (PSAPs). When the device detects an accident it calls a PSAP, transmits the vehicle location and other data, and leaves a voice connection established.

This Blue Paper discusses some design considerations for manufacturers desiring to implement *eCall* systems. It treats the areas of cost reduction, GSM receiver sensitivity, power consumption, software integration, real-time response, field software upgrades and automotive industry requirements. For each of these areas we discuss the *eCall* requirements and how the implementer can meet them cost-effectively. Specific features of Wavecom products are noted as they apply to this application.

Introduction

eCall is the pan-European in-vehicle ***e****mergency* ***Call*** project. It is part of an initiative by the European Union to establish a Europe-wide location-enhanced emergency-response network based on the emergency phone number 112. *eCall* is a component of the goal of the E.U. directive stated in 2003 to reduce the number of highway fatalities in the European Union by one half by the year 2010. The 112 number is accessible from virtually all wired and mobile phones in Europe, and in most places is accessible even from GSM phones without a SIM card.

Emergency calls arrive at a “Public Safety Answering Point” or PSAP; emergency response units are dispatched from the PSAP. One conclusion is that “several thousands of lives could be saved in the EU by improving the response times of the emergency services and post-impact care in the event of road traffic accidents.” The *eCall* system proposes to include location information with the emergency call. This information is to be gathered by an in-car device and transmitted with the call. A study has concluded that “an *eCall* system that relays the accurate location of the accident to the PSAP and the emergency services will allow a reduction of response time to the accident of about 50% in rural areas and up to 40% in urban areas.”

It is expected that *eCall* may be mandatory by 2010 for all new cars sold in the EU. Over the longer term, the *eCall* project is expected to drive the introduction of GSM-enabled equipment in all cars, making possible new services ranging from simple hands-free car kits to telematic services including remote diagnostics, fleet management, Pay-as-You-Drive insurance options, stolen vehicle tracking (SVT) and electronic fee/toll collection (EFC) to name a few. The *eCall* in-vehicle system (IVS) is the first phase of vehicles with embedded wireless communication capabilities being standard in Europe.

Overview

This Blue Paper is intended for executives, designers, and suppliers in the automotive industry who may be considering how best to implement *eCall*. We present several considerations that bear on the design of an in-vehicle system. In particular, we discuss the following areas:

<u>Cost Reduction:</u> Because the *eCall* IVS will be present in *every* new car, economy as well as luxury models, cost reduction is a priority.

<u>GSM Reception Sensitivity:</u> The *eCall* IVS must provide sensitive and reliable reception since it will be in a protected location inside the car and may need to use an embedded antenna.

<u>Low Power Consumption:</u> The *eCall* IVS should have low power consumption, especially in standby, to avoid draining battery power when the car is immobile for a long time.

<u>Easy Software Integration</u>: Software components from GSM module manufacturers, Tier I suppliers and third party software companies should be easy to integrate.

<u>Real Time Capabilities:</u> The *eCall* IVS gathers vehicle information through the car’s CAN (Controller Area Network) bus; this may require responding to interrupts with a low latency.

Easily Upgradeable Software: The *eCall* platform will probably host new applications in the future; secure software downloads and patching should be easy - without recalling the car.

Automotive Requirements: The IVS must be designed and manufactured to stringent automotive industry standards as well as the particular reliability requirements of the individual car maker.

In the remainder of this paper we will discuss each of these areas in more detail.

Cost Reduction

Functional architecture

The eCall IVS function is to :

- Collect data from the vehicle network and from vehicle sensors, and maintain an up-to-date GPS-fix of the vehicle's location.
- Automatically detect a crash based on car-sensor information.
- Call a PSAP automatically when a crash is detected, or when the driver presses a dedicated *eCall* button. Each call has 2 main parts:
    - Establish voice contact between the car's occupant and a PSAP operator to provide assistance to the driver.
    - Transmit a Minimum Set of Data (MSD) to the PSAP, including the current GPS position and direction the car was heading.

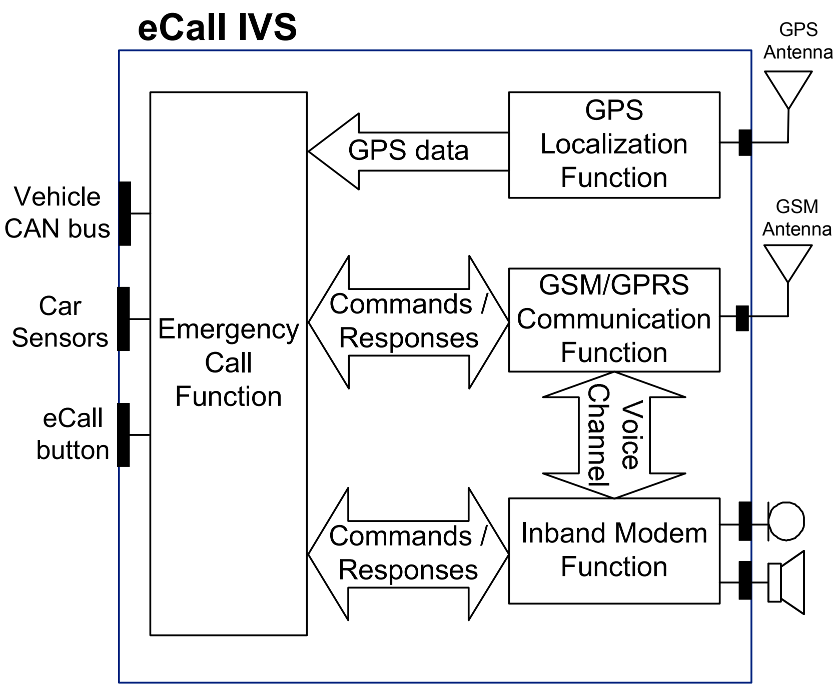

Figure 1: eCall IVS functional architecture.

Figure 1 depicts the architecture of an *eCall* IVS. Its functional blocks are:

- Emergency Call Function: This is the *eCall* application. It gathers vehicle information through the CAN bus or other sensors and geo-location information from the GPS function. In case of a crash, it sends an emergency message to the PSAP through the GSM/GPRS function.
- GPS: The GPS function is responsible for gathering information from GPS satellites and processing this information to accurately compute the vehicle's geo-location.
- GSM/GPRS: The GSM/GPRS function is responsible for establishing and maintaining a GSM call to the PSAP so that the crash information can be sent and a voice connection established between the car occupants and an operator.
- In-band Modem: Among a few technologies to send data to the PSAP (SMS ,GPRS or in-band modem), the most likely to be used is the in-band modem. This technology uses the

voice channel; typically a special processing unit in the audio path encodes/decodes messages.

Architectural components

In Figure 2 we have expanded the level of detail of Figure 1 into what we may call a "Reference *eCall* IVS." We discuss implementation of each of its architectural components in turn.

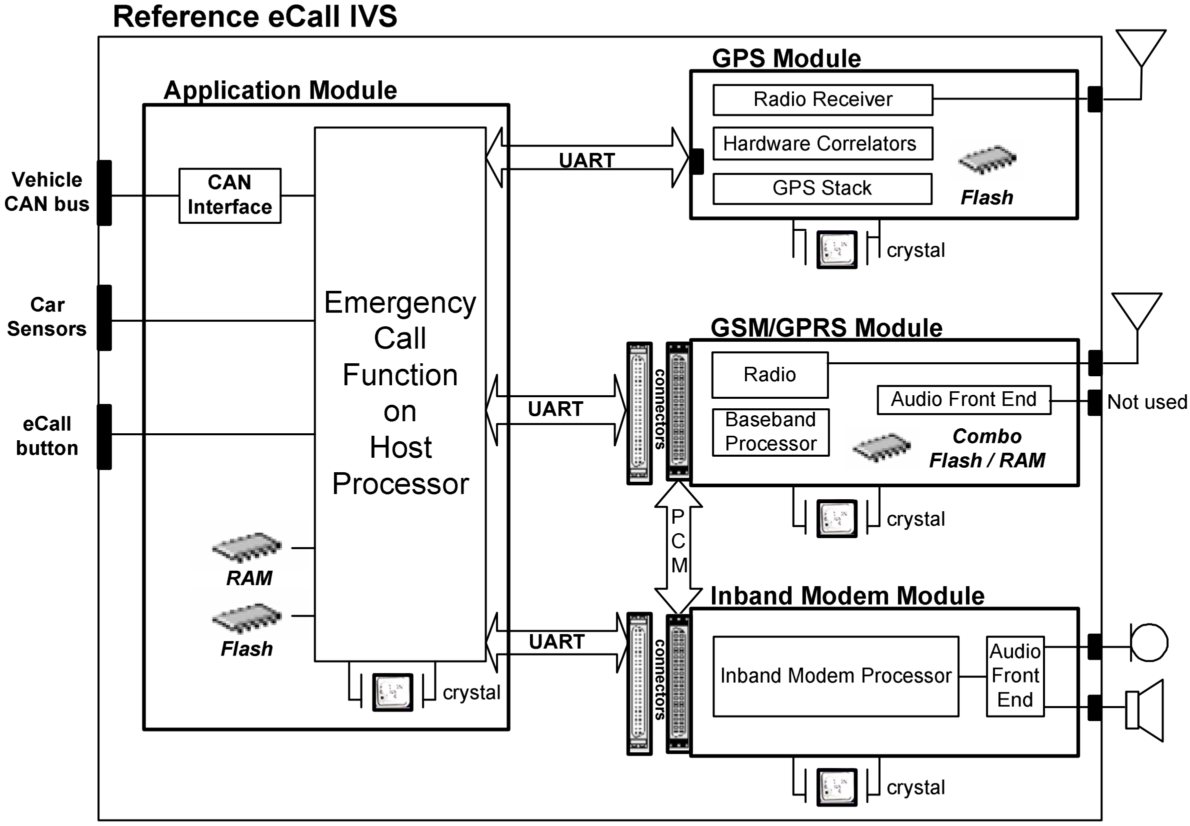

Figure 2: eCall IVS reference hardware architecture.

Previously, each functional block in Figure 2 typically required its own separate hardware module, each with its own crystal (for clock generation), processor, flash and random-access memories (RAM):

- Application Module: A typical processor for such an application is an ARM7 or ARM9, even if the *eCall* application has low processing power requirements. And where a processor is required, so are Flash and RAM for storing its program and data.
- GPS Module: The GPS module gathers information from GPS satellites, and processes it to compute the vehicle position. A GPS chipset typically has a dedicated processor and flash memory.
- GSM/GPRS Module: The GSM/GPRS module typically hosts an ARM7/ARM9 processor for managing the GSM/GPRS stacks, with some processing power left unused. GSM modules also embed an audio front-end to convert the digital audio signal to analog for speakers and microphones. For *eCall*, this audio front-end will likely be unused since the in-band modem module (below) has its own embedded audio front- end.
- In-band Modem Module: As mentioned, in-band modem technology will likely be used to send crash data to the PSAP. In-band modem functionality is typically performed by a processor external to the GSM module with a link carrying pulse-code modulation (PCM) audio samples. It processes audio samples in real-time to code data sent to the PSAP and decode acknowledgements.
- Connectors: GSM/GPRS and in-band modems modules are typically subassemblies fastened to a motherboard and connected electrically through (mechanical) connectors. GPS functions may

be available with a chip that can be soldered in place. Additional connectors are needed for the external GSM and GPS antennas.

Elimination of components

Examining the reference architecture with a cost focus, the following opportunities appear readily:

Cost Optimization opportunity #1:

Merge all four CPUs into a single one. All applications (eCall, GSM, GPS, in-band modem) would share this single CPU.

Chipset evolution allows for embedding more and more powerful CPUs. The four CPUs in Figure 2 all exceed what their respective applications require. Typically just one provides more than sufficient power for all four applications. Each processor eliminated also eliminates a crystal.

Cost Optimization opportunity #2:

All software (eCall, GPS, GSM, in-band modem) can share a single FLASH and a single RAM.

Each processor uses a separate Flash and RAM. Because these chips can rarely be sized exactly (available as 2 Mbits, 4 Mbits, 8 Mbits, etc.), memory would be wasted in each module. Therefore, savings usually can be derived if all applications share a single Flash and a single RAM. This is synergistic with running all applications in a single CPU, as suggested above.

Cost Optimization opportunity #3:

Discrete Flash and RAM components allow using PSRAM rather than SRAM.

PSRAM (pseudo-SRAM) memory technology has the same interface as widely-used SRAM (static random-access memory) but a much lower cost for large memories. Designers should be free to choose their own trade-offs between (cheaper) discrete PSRAM FLASH and RAM or combo SRAM.

Cost Optimization opportunity #4:

Avoid external connectors where possible.

Connectors are a significant cost. Market prices range from 1US$ to 2US$.

Eliminating components also reduces the size and weight of the unit and its housing.

Putting opportunities together

A package like Wavecom's ***Wireless Microprocessor***® exploits all these cost-saving opportunities, as shown in Figure 3, the architecture of an *eCall* application based on it.

- Wavecom's ***Wireless Microprocessor***® uses a 32 bit ARM 9 processor embedding both Data and Instruction Tightly Coupled Cache Memory (DTCM/ITCM) clocked at 104MHz. It has enough CPU power for all the applications mentioned above and more. The package includes the GSM stack. The Wavecom companion GPS (***C-GPS***) solution uses the ***Wireless Microprocessor***® to run Wavecom's ***C-GPS*** software Plug-in. This allows using a lower-cost ***C-GPS*** radio chipset. Inband modem software needs to be implemented or acquired, as does the principle application, the Emergency Call Function.
- The ***Wireless Microprocessor***® does not embed Flash or RAM, but provides its Address/Data bus as output pins, as any other microprocessor. Therefore, hardware designers are free to implement whatever Flash and RAM best suits their requirements.
- The ***Wireless Microprocessor***® supports PSRAM as well as SRAM. It also supports booting on NAND Flash for further savings where large flash size is required.
- The ***Wireless Microprocessor***® includes GSM radio and audio front-end hardware, eliminating these connectors. It is itself packaged in ball-grid array (BGA) technology, i.e., does not require connectors and can be assembled by automatic placement machines for high volume manufacturing.

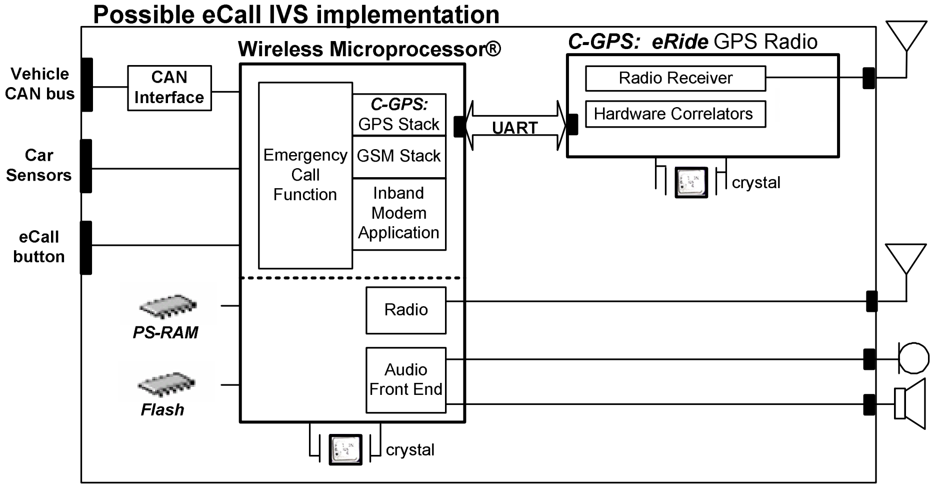

Figure 3: Wireless Microprocessor®-based eCall IVS

The cost savings of the Figure 3 architecture relative to the 'Reference *eCall* Application' in Figure 2 depends on parameters including the types of microprocessor and GPS chipset, the size of Flash / RAM, connectors, etc.

Signal Reception Sensitivity

The *eCall* IVS is intended to be in a hidden location inside the vehicle - under the dashboard or seats, in the trunk or glove compartment. In addition, it cannot rely on an external antenna, because a crash may break it. Therefore the *eCall* IVS may need to cope with reduced GSM signal strength relative to an outdoor receiver and its receiver sensitivity becomes an issue. Poor reception may cause bit errors sufficient to require retransmission of some messages. During call establishment, retransmitted signaling messages increase the call setup time. Once the call is established, the MSD will be sent to the PSAP, probably with an in-band modem in the voice channel. The modem may be sensitive to Bit Error Rate (BER) also, leading again to increased transmission time, or, for a poor quality RF link, even transmission failure. This could cause a problem in the *eCall* application, since the GSM Europe (GSME) interest group recommends the message transfer time be less than 4 seconds.

Potential sensitivity problems:

Reception sensitivity of the GSM/GPRS solution should be studied carefully as poor sensitivity may translate into longer call setup time, longer duration of MSD transmission, and could lead to failure of call setup and/or MSD transmission in case of a crash.

Wavecom Wireless Microprocessor®s provide best-in-class reception sensitivity required in adverse indoor environments. Typical reception sensitivity is much better than the GSM specifications. Further, Wavecom Wireless Microprocessor®s allow for antenna diagnostics and antenna switching. They can detect an antenna failure (e.g., after a crash) and automatically switch to an internal antenna.

Similarly, in choosing a GPS receiver the designer needs to consider reception sensitivity. High reception sensitivity improves positioning success. A GPS module with excellent reception sensitivity will be able to receive signals from satellites even in poor radio conditions. Since the e-call IVS will be installed under the dashboard, it will probably be equipped with an internal GPS antenna. The system designer must consider the fact that a GPS receiver with poor reception sensitivity would be completely unable to compute a position if the GPS signal is not strong enough and therefore would not be able to perform its function in the event of an emergency.

Wavecom's C-GPS Plug-In provides some of the highest reception sensitivity available on the mrket today.

Power Consumption

Power consumption by the *eCall* IVS is a concern when a car is parked for a long time (months). Low power consumption could be achieved by shutting down the *eCall* IVS while the car is parked, but it must be awakened if activity is detected in the car, either through the vehicle bus or through some external sensor. This requires the CPU to keep running in a low power mode to detect events and wake up the IVS software application.

Power consumption requirements:

The *eCall* IVS modules should provide at least two low-power modes:

- *Low power mode 1: processing is stopped, but an external car-related event can wake the module.*
- *Low power mode 2 (for future use): all processing except GSM is stopped, but the module can receive a wireless communication (GSM or GPRS or SMS) to initiate added-value services.*

Value-added applications may be embedded onto the *eCall* IVS in the future. Some of these require awakening the *eCall* IVS with an SMS - remote door unlock service, for instance. This means that the GSM stack must keep running while the car is off, with as little power consumption as possible.

Wavecom ***Wireless Microprocessor®***s implement these capabilities, and more advanced power management functions as well. ***VariSpeed*** and ***VariPower*** features allow modifying the CPU clock depending on the application requirements, allowing it to adapt its power consumption to the application. As illustrated in the cost-reduction example, Wavecom's highly integrated solution reduces the number of processors, automatically reducing the overall *eCall* IVS power consumption.

Software Integration Requirements

Designing the most efficient *eCall* IVS requires integrating core competencies from different industries onto a single processor. This introduces two main software constraints on the platform.

Software Integration Requirement #1:

The *eCall* platform must provide the basic functions of a real-time operating system like processes, inter-process messaging (mailboxes), priority-based scheduling and Interrupt Service Routines (ISR).

Third party applications to be embedded in the platform are typically developed in the C language on a light real-time operating system. They use basic multi-tasking functions like those above. The software platform must have these functions to allow easy porting.

Software Integration Requirement #2:

The *eCall* platform software should allow easy integration of multiple third party software applications.

As outlined previously, the *eCall* IVS must be GSM-capable, requires in-band modem software, must read the vehicle CAN bus, and needs accurate GPS positioning. These distinct functions, typically coming from different suppliers, must be integrated to work smoothly together.

Wavecom Wireless Microprocessor®s provide these software capabilities through the Open AT® OS. The Wavecom Open AT® IDE, an Eclipse™-Ready integrated development environment, facilitates integration, allowing third-party applications to be run directly on the Wavecom processor. All of the Real Time Operating System capabilities are available to third-party applications. The Wavecom Wireless CPU® integrates the aqLink® in-band modem software from Airbiquity.

Real-Time Requirements

As explained above, the main *eCall* IVS processor will likely host software applications developed by different sources, each having specific constraints.

Real Time requirement:

The *eCall* software platform must allow servicing interrupts with a low latency while providing full GSM/GPRS functionality.

The GSM application itself makes use of the CPU and must service interrupts with a very low latency to remain synchronized with the GSM infrastructure. The other applications will typically be assigned a lower priority than the GSM application; nevertheless, most of these applications need to have immediate access to the CPU after some external event has been detected - most often through an interrupt. Responding to interrupts quickly without impacting GSM behavior is challenging.

The latest ***Wavecom Open AT® OS*** allows applications to implement their own Interrupt Service Routines. Therefore, third party applications can implement very low level software routines having very stringent time-response constraints. This is possible because Wavecom has developed its own GSM software stack; the stack is adapted so that only critical parts are executed in the "high priority" interrupt context, the remainder running at a priority lower than third party Interrupt Service Routines.

Easy Software Upgrades

In the future, a software modification may be required in every car, e.g., because of new legislation. Additionally, new applications may be introduced. Deploying these modifications and new applications could involve software upgrade procedures involving costly recalls. Ideally, the *eCall* IVS platform should provide the ability to upgrade software remotely that will avoid recalls. A Download Over The Air (DOTA) service solves this potential problem by allowing devices to managed remotely.

Software Upgrade requirement

The *eCall* software platform must allow Over-The-Air upgrades of all its software, ideally with small download size to reduce transfer cost and error risk.

Wavecom's ***DOTA I, DOTA II and DOTA III*** features allow over-the-air upgrades of third-party applications and the GSM software itself. Wavecom DOTA III can download only actual changes to software rather than sending the whole software image. This saves air time and reduces risk of error.

Automotive Requirements

The *eCall* IVS will be embedded into the car and must meet the stringent requirements of the automotive industry with respect to both its design and manufacture.

Selection of components and suppliers is important. Conformance to requirements for temperature and humidity, mechanical vibration and shock, and emission of and sensitivity to electromagnetic radiation must be checked in detail for a new product design.

Software must be developed according to a detailed and widely-accepted methodology.

Tools (like FMEA : Failure Mode & Effect Analysis) are to be used during the product design stage. "Return of experiment" data must be gathered during the design and manufacturing introduction phases and fed back into the design and manufacturing process to qualify the development as defined by the automotive industry requirements. Additionally, these results will allow defining the right control plans for the maintenance phase so the product will comply with automotive reliability expectations.

The data gathered during the return of experiment phase will also be used to identfy any special means or tools for the production line to achieve the parts-per-million reliability levels expected by this industry.

Finally, a traceability process shall be put in place for these products in order to support the car manufacturers in a timely manner if and when problems are detected in the field.

Wavecom has provided solutions to car manufacturers for over 8 years and has shipped millions of modules that are installed in cars on the road today. Its teams have developed extensive experience in designing and manufacturing products for the car industry. This expertise includes both using specific methodologies and having dedicated manufacturing lines.

Conclusion

We have highlighted some key design considerations of an *eCall* In Vehicle System (IVS), and illustrated below Wavecom's ability to help its customers design a successful solution:

Item	Requirement	*Wavecom Answers*
Cost Optimization	• Host all applications in a single CPU • Use discrete Flash and RAM • Use PSRAM rather than SRAM • Remove connectors	√ ***Wireless Microprocessor®*** √ ***C-GPS***
Reception Sensitivity	• Excellent GSM reception sensitivity since *eCall* IVS will be installed in a hidden location inside the car • Excellent GPS sensitivity to improve localization success rate	√ ***Wireless Microprocessor®*** √ ***C-GPS*** √ ***Antenna Diagnostic*** √ ***Antenna Switching***
Power Consumption	• At least two low power modes with the ability to be awakened with any car-related event. • One low power mode should also allow to awaken the module by an incoming GSM SMS or Voice Call	√ ***Wireless Microprocessor®*** √ ***Varispeed*** √ ***Varipower***
Software Integration	The eCall software platform shall provide the capabilities of a Real Time Operating System and allow easy integration of several third party software modules.	√ ***Open AT® OS*** √ ***Open AT® IDE***
Real Time	The eCall software platform must servicing interrupts with low latency, but full GSM/GPRS functionality.	√ ***Open AT® OS***
Software Upgrade	The eCall software platform shall allow upgrading of all software Over The Air, ideally with small download size to reduce both transfer cost and error risk.	√ ***DOTA I, DOTA II, DOTA III***
Automotive Requirements	Product design and manufacturing shall follow a very stringent process as defined by the car industry.	√ ***Wavecom experience in the car industry***

As a leader in the automotive telematics industry, Wavecom is committed to continuously introducing new ideas, features and products, allowing its customers to innovate as their markets demand.

Links

www.eSafetySupport.org

www.ictsb.org/ITSSG_home.htm

http://www.3gpp.org See specification TR 22.967.

www.eride-inc.com/

www.airbiquity.com

www.wavecom.com