Telecommunication System for the I-GARMENT Project

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***Abstract*-This paper presents the telecommunication system developed for the I-Garment project (Integrated System for Management of Civil Protection Units). Funded by the European Space Agency [1], the I-Garment is an effort to provide emergency forces with a well protected body-suit, equipped with several sensors and an extended telecommunication system, capable of using different technologies for redundancy. The service will address the need to know where each member of the force is during an emergency and their health condition, allowing replacements to be organized in a timely fashion and teams to be moved according to the operational needs of the situation.**

I. INTRODUCTION

The concept

The I-Garment (Integrated System for Management of Civil Protection Units)[2] is a project developed by Y-Dreams [3], Miguel Rios Designer and IT (Instituto de Telecomunicações) [4] and is supported by the ESA (European Space Agency) Telecom start-up program. The I-Garment objective was to develop a full sensor-equipped body suit for emergency teams capable of providing protection from hazardous environments. Additionally, the I-Garment is connected to an extended wireless telecommunication system, which integrates technologies such as UHF, WiFi, GSM and a satellite link.

The garment

The I-Garment body suit (Fig.1) is equipped with several sensors that can monitor vital signals (heart beat sensor), positioning (GPS receiver), body movement (bending sensors) and it also has an external sound alarm for emergency situation where the operation agent is at risk (Fig.2).

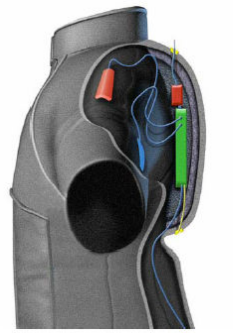

Figure 1 - I-Garment suit model

The type of fabric and integration materials allows the garment to withstand high temperatures and other type of hazards that can put the agent's life to risk. It has the capability to be water and fire-proof.

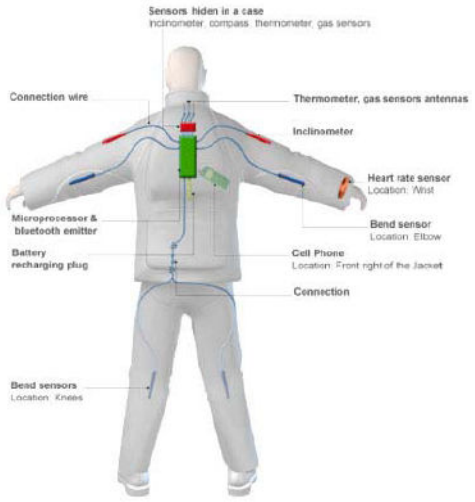

Figure 2 - I-Garment body sensor network

The suit has a built-in UHF modem that provides a reliable connectivity to a central server. The GPS and UHF antenna are put on the back of the suit to assure minimal body-loss effect and to allow movement freedom for the user.

Telecommunication system overview

The primary goal of the telecommunications system was to provide seamless connectivity between the various elements of the I-Garment project (Fig.3). The team that plays the first role in acting on the emergency scenario is named *operation agent*. These agents are equipped with the I-Garment body suit and in a typical deployment scenario there can be several agents and all are connected to a central operational unit – *operation field vehicle*. The *operation field vehicle* acts like a first line operational base and is similar to a relay server [5] that gathers all the information and status from the *operational agents*. Normally there are five to ten operational agents per operation field vehicle. The operation field vehicle can send the information gathered from the terrain to the *field manager*. This actor monitors the status of the operation agents using a PDA/Pocket PC (Fig.4). It can also access crucial data like

terrain maps, resource location (e.g.:water sources) using the satellite or a GSM link that connects the operation field vehicle to the rest of the emergency network.

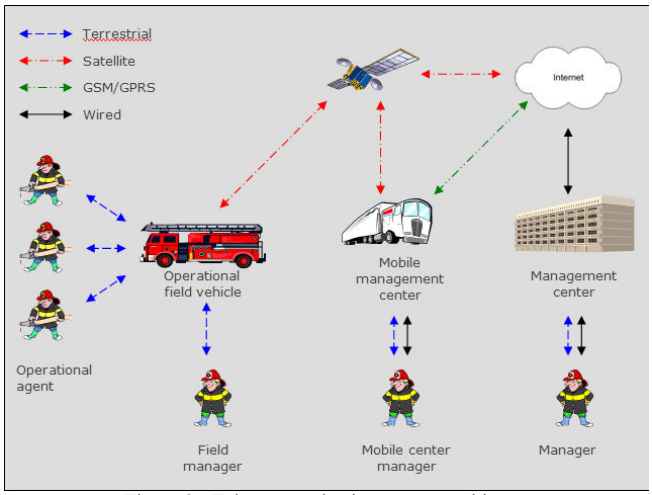

Figure 3 - Telecommunication system architecture

Normally, a *mobile management center* is used in large scale emergencies. This type of vehicle can connect easily to the rest of the network also via a satellite/GSM link. It can also access all the data collected on the terrain by the operational field vehicle. Finally, all the critical information (terrain maps, operation agent status and location, etc.) is received/sent by the *management center*. Both the management centers (mobile and fixed) can have the intervention of local actors: *mobile center manager* and *manager*.

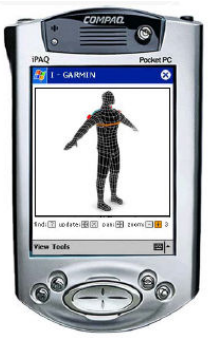

Figure 4 - PDA interface

The system components are a combination of different technologies and frequencies. In the field of operations the connectivity between the operational agents and the operational vehicle is established using UHF modems [6], to provide a long range data link. Near the operational vehicle, the wifi technology provides data access with sufficient bandwidth to the field manager. Lastly, the connection between the operational vehicle and the management center is guaranteed by a dual solution using the Globalstar[7] satellite service and a GSM/GPRS modem

II. TELECOM SYSTEM DESCRIPTION

The communication between the operational agent and the operational field vehicle will be based in a VHF-UHF modem, mainly because of the distance coverage of this type of technology. The OEM modems chosen were the B433SH-10 due to its good reliability, low power consumption, good coverage range and also its network mode of operation. The field manager will communicate with the operational field vehicle using the wifi technology. The WiFi enables sufficient bandwidth enabling the transfer of terrain maps, sensor data, etc. Globalstar is the satellite service that better suits the system requirements. This global satellite system has good coverage and sufficient bandwidth for user requirements. In order to communicate with the Globalstar satellite constellation a mobile terminal will be used, namely the Telit 550. GSM mode is also available using a GSM/GRPS modem from Wavecom. This modem provides direct connection to an ISP and proved to be reliable and of relative low cost.

The telecommunications structure was planned according to several requirements. The operation agents are exposed to a fire fighting scenario under extreme conditions. They are also being supported with modem fire fighting devices. The garment must acquire the operation agent vital and alert signals and transmit them to the management centre. The information retrieved from the operation agents is gathered at the operation vehicle server. This vehicle must be in the neighbourhood of the operation scenario (typical 100 to 300 m). The information after being gathered is relayed to the management centre. The management centre retrieves all the information of the various operation fields and merges it with geographical information located in a database. Enabled with this global view, the management instructions are returned to the field. The field officer must access the data outside the fixed unit, so the ability of displaying information in a PDA is a requirement. The communication between the field of operations and management centre can be difficult to establish since they can be far apart. This communication must be reliable and completely independent of the catastrophe running on. Summarizing the telecommunications structure, there are five fundamental connections that must be implemented:

- Operational agent – operational field vehicle
- Field manager - operational field vehicle
- Operational field vehicle – management center (Head Quarter)
- Mobile management center – management center (HQ)
- Center manager - management center – (be it on the mobile or main HQ)

TABLE I

TELECOMMUNICATION SYSTEM REQUIREMENTS

Connection	Requirements		Technology
Operation agent – operational field vehicle	Connection number	Data rate	UHF Modems
	10	2400 bps	
Field manager – operational field vehicle	Connection number	Data rate	802.11b
	1	12000 bps	
Operational field vehicle – management centre	Connection number	Data rate	Satellite GSM
	1	9600 bps	
Mobile management centre – management centre	Connection number	Data rate	Satellite GSM
	1	9600 bps	
Center manager	Connection number	Data rate	Wired/802.11b
	1	9600 bps	

The main telecommunication user requirements can be summarized as:

- Maximum coverage range (300 m)
- Maximum number of firemen per vehicle (10)
- Number of vehicles on the field (5)
- Mean time between data actualisation (2 minutes)
- Minimum bit rate requirement (300bytesx8bitsx10users/120seconds= 200bps)
- Satellite bit rate 9600 bps

The telecommunication system also has technical requirements that must be followed. The system must provide seamless communication between all the scenario intervenient. This requires reliable radio links and backup alternatives, such as GSM. The equipment used must withstand temperatures above normal values (above 30ºC). The antenna used in the Garment must be placed in a suitable location in order to avoid the negative effect of the human body in radio propagation. The server used in the operational vehicle must be autonomous minimizing human intervention. When powering up the server it must load the default configuration and software automatically. Antennas used must be easily mounted in the operation vehicle and must be able to sustain a considerable wind speed.

III. SYSTEM COMPONENTS DESCRIPTION

Main processing unit

The main processing unit is responsible for the data management and controlling radio communications in the operational vehicle. The solution chosen was the use of one of the EPIA mini-ITX boards developed by VIA. The EPIA is a compact and powerful module that suffices the data processing requirements. This PC module will be responsible for the management of all the garments on the field and the routing to the Globalstar and/or GSM networks.

There is the need for a local storage unit that gathers all critical data from all the telecommunication links. This unit is installed in the central server. The vibration produced by vehicle movement can damage a normal hard drive, so a static mass storage is required. A USB pen drive was used in order to accommodate the operating system and other specific data.

WiFi access point

A typical WiFi access point was chosen to guarantee sufficient bandwidth to the field manager. The criteria used to choose the access point relied on being easy to integrate on the system, modularity (like connecting an external antenna) and its price and reliability.

UHF modems

The connection between the operational field agent and operation field vehicle was assured using a UHF modem. There are some market solutions for an OEM modem operating in the VHF-UHF region. The solution chosen was the One-RF B433SH-10 modem, which has several characteristics suitable for a project of this kind. The B433SH-10 is a modem radio board operating that operates at 433,05-434,790 MHz frequency and has a power output of 10 dBm. The sensitivity is -94 dBm and it has a power consumption of 80 mA in transmission mode and 50 mA in reception with a 3,3 V regulated voltage supply. The radio bit rate is 40 kbits/s and the modulation used is FSK. The B433SH-10 provides various communication modes, transparent, addressed secured and network modes. The network mode is the type of operation that better suits the I-Garment project. In network mode the modem is configured either as a client or as a server (up to 16 clients per server). To each modem is assigned a network number and a client ID. This mode is based on a Dynamic Time Reservation principle in order to warranty collision avoidance as well as a fast client/server connection, so that the network mode manages automatically data sealing, addressing and security. The network mode also allows easy management of clients (i.e. creation, deletion, table updates, etc). A network is made up of one server modem and several client modems. Considering that each network has a proper and unique identification number, several networks can be installed within the same perimeter. The network mode was chosen to operate in a real fire scenario, since it allows differentiating several operational teams in the same range without interfering with each other.

Satellite connection

For providing a Globalstar connection the Telit 550 handheld mobile phone was chosen. The Telit Dual Mode SAT 550 is a hi-tech innovative satellite handheld phone that provides a familiar interface and user-friendly features similar to those of a GSM phone. It operates in a dual-mode Satellite / GSM 900 MHz, and it measures 224 x 66 x 50 mm, weighting with 1350 mAh Lithium-Ion battery. The Telit 550 uses the Globalstar

Satellite service and it has a built in modem enabling data communications. In order to provide enhancements to the GSM/Globalstar communications the Telit 550 has some accessories, namely a datakit (DT550) and a carkit (SAT551). The DTA 550 provides data transmission as well as Internet connection on the Globalstar and GSM networks at a speed of 9.6 Kbps.

GSM modem

The mobile phone Telit 550 together with the datakit (DTA 550) provides a suitable system to establish data links both in GSM and Globalstar mode. Unfortunately, integrating the carkit in this mobile communication system made the Globalstar data communications not available. This problem was known to the manufacturer, and it was necessary to make some changes in the carkit and datakit. After these changes it was possible to establish data calls in Globalstar mode, but the GSM mode was no longer available. In order to solve this problem, a GSM modem was integrated in the telecommunications system. This modem will be used as a secondary telecommunication link between the Operational field vehicle and the management center. The Wavecom Fastrack is a dual band GSM modem (EGSM900/1800 MHz) designed for data, fax, SMS and voice applications and it is fully compliant with ETSI GSM Phase 2+.

System integration

The system components were put together in a small box measuring 225 x 200 x 330 mm. The case accepts two standard sized 5.25" drive units, a standard floppy drive and a 3.5" Hard Disk drive internally. The case comes with an internal switching 110/240V 200W PSU, two internal 40mm extraction fans and 2 extra front-mounted USB 2.0 ports and Mic and Headphone port as standard. The case has sufficient space for accommodating all the system components. Figure 5 schematic shows how the components were integrated and connected in the central server.
The mini-itx box comes with an integrated 200 W power supply. This power supply was used to provide the different voltage levels to all the components in the system. Using the internal serial and USB ports it was possible to connect the access point, B433SH-10 modem, USB pen disk, datakit and the GSM/GPRS modem After making these connections, it was necessary to provide external antenna connectors to all the appropriate devices, namely the Telit 550, the access point and the modems. internal serial and USB ports it was possible to connect the access point, B433SH-10 modem, USB pen disk, datakit and the GSM/GPRS modem. After making these connections, it was necessary to provide external antenna connectors to all the appropriate devices, namely the Telit 550, the access point and the modems.

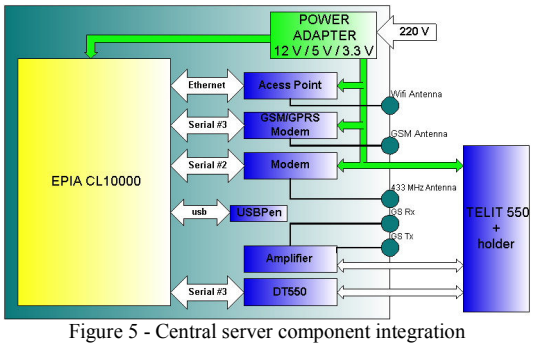

Figure 5 - Central server component integration

IV. RESULTS AND CONCLUSIONS

The system components and integration were tested to assure sufficient flexibility on a real world scenario. The wireless connectivity range was one of the key issues that had to comply with initial requirements. Radio propagation in an emergency scenario, as for example a forest fire, can be difficult due to the existence of natural obstacles. Several tests were performed in controlled environments and complied with the requirements. UHF provided sufficient range in a difficult environment and the WiFi bandwidth was crucial to assure that all the data reached the field manager. The satellite link from Globalstar, despite the low bandwidth, is a reliable asset to the system, which can act as a redundant connection from the field vehicle and the rest of the network that are not deployed in the emergency scenario. The satellite link is only established when a GSM/GPRS connection is not available, due to the mobile operator loss of coverage that can be common in a natural disaster scenario. Bandwidth usage was tested in a simulated emergency environment, and all the initial requirements were met. The I-Garment was put to real testing in simulated fire situation with the help of fire fighters that were equipped with the special developed suit. The system behaved according to expected, protecting fire fighters from the fire and high temperatures. The telecommunication system provided to be a valuable asset interconnecting all the system components retrieving information from the operational agents and necessary and crucial data to the field manager and management center.

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