HYBRID SATELLITE-TERRESTRIAL BASED SOLUTIONS FOR RAPID DEPLOYEMENT OF WIRELESS TELECOMMUNICATION NETWORKS IN EMERGENCY SITUATIONS

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Abstract

In disaster situations local telecommunication infrastructures are often partially or totally destroyed, or even did not exist beforehand. Nevertheless, telecommunication services are critically needed during the early phase right after the disaster by victims looking for help and by rescue teams swiftly treating a high amount of casualties on the unsecured disaster site. Telecommunication services are also needed afterwards during the response phase when all human and technical resources have been deployed on the "almost cleaned-up" field to efficiently handle victims.

The most suitable terrestrial and satellite telecommunications technologies have thus to be combined to provide appropriate answers all along disaster phases. In this context, the Wireless Infrastructure over Satellite for Emergency Communications (WISECOM) project, co-funded by the European Commission under the 6th Framework Program, intends to demonstrate the added-value of different demonstrators based on the most common standardised wireless and satellite technologies. The proposed paper aims at presenting the architecture and main technical features of these demonstrators which will be representative of future operational communication infrastructures. They will also integrate Location-Based Services for emergency scenarios.

The portable WISECOM demonstrator used during the early disaster phase relies upon a BGAN terminal, a GSM pico cell, a WiFi Access Point, and a small computer performing all necessary interfaces, network and server functionalities. It shall be light, small, easy to carry and deploy by a single person. The transportable WISECOM demonstrator suited to the response phase has looser size, weight, and power consumption constraints. It includes collective units which may be mounted on vehicles or packed in small containers. It offers higher quality communications to a wide range of users thanks to broadband DVB-RCS and WiMax technologies.

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Introduction

Earthquakes, tsunamis, floods, terrorist attacks, toxic waste spills, hurricanes, either from a natural or man-made origin, are increasingly becoming a fact of life that worldwide governments must be prepared to face. The occurrence of disasters (in number per year) has constantly increased over the last 60 years and has almost doubled during every decade of the last 30 years. Such disasters kill one million people each decade and leave millions more homeless worldwide. Economic losses from natural disasters were greater in the 1990s than in the previous four decades combined.

In all cases, the challenges involved in responding effectively are remarkably similar:

- Quickly assessing, monitoring and commanding the situation;
- Communicating effectively with local fire brigades, rescue teams and police;
- Coordinating response efforts with state and federal agencies;
- Communicating with families and the general public

In order to address these issues, the European Commission is supporting a project called WISECOM [1]. WISECOM studies, develops, and validates by live trials the candidate rapidly deployable lightweight communications infrastructures for emergency conditions. The infrastructures will integrate several terrestrial mobile radio networks - GSM, UMTS, WiFi, and optionally WIMAX and TETRA - with satellite systems. Satellite systems, due to their very wide area coverage and the possibility of readily transportable terminals, intrinsically allow for a rapid deployment of a telecommunication infrastructure when and where a terrestrial infrastructure is not available.

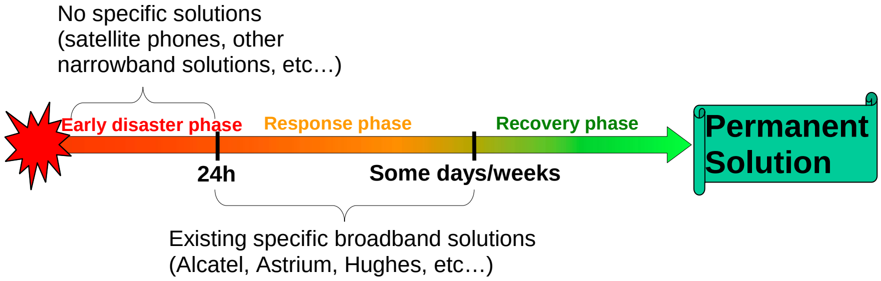
The paper is organized as follows. In the next section the different phases of crisis management are described together with the associated communication needs. This provides the necessary background for the presentation of the overall WISECOM reference architecture. The paper then focalises on the provisioning of broadband communications in the response and recovery phase through hybrid satellite-wireless solutions. A detailed description is included of the hybrid DVB-RCS/WiMAX/WiFi architecture and equipments under investigation and validation followed by concluding remarks regarding the live trial planned in May 2007.

Emergency management phases and associated telecommunication needs

One of the characteristics of emergency situations is the association of various rescue teams depending on the type and size of crisis: police, coast guard, customs, firemen, ambulance, NGO, etc. These actors have a common need of communications with other in-field responders to co-ordinate their actions on the disaster scene itself and with their organisation headquarters to get support and report on the situation evolution.

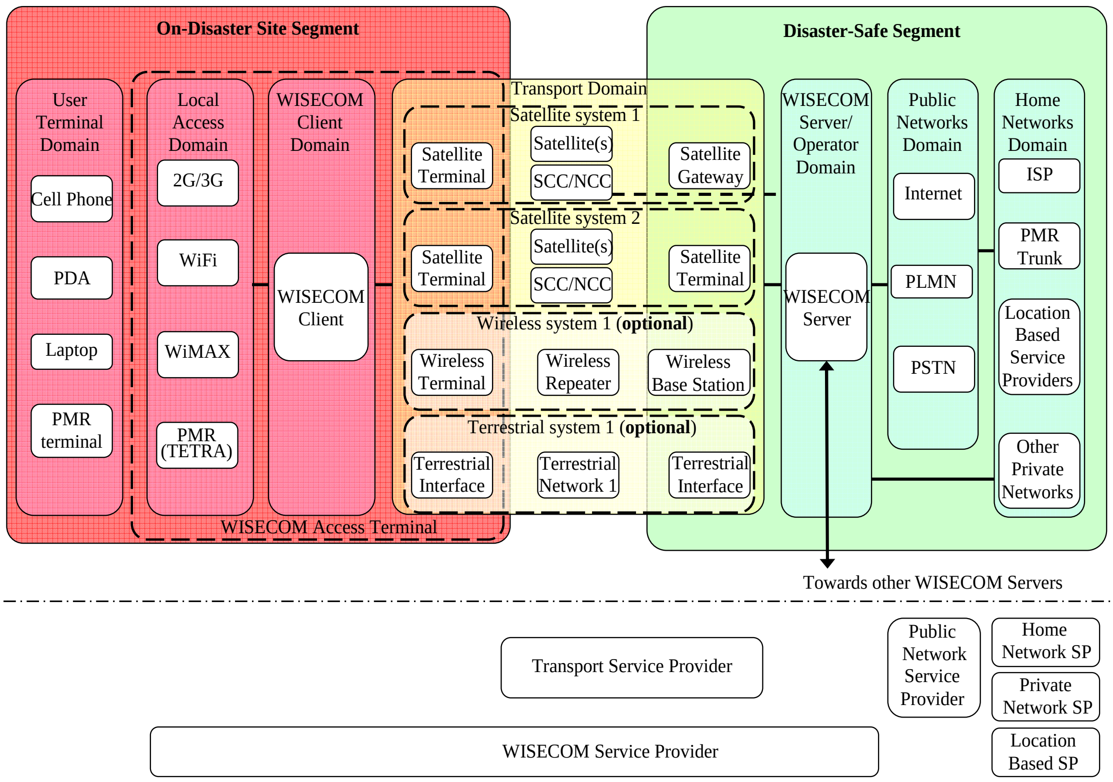
As illustrated in Figure 1, the management of a disaster is composed of different phases. In the first phase after the disaster, called Early Disaster Phase, the rescue teams are not yet well organised and casualties should be quickly identified and rescued. This is followed by a Response Phase where the disaster site has been cleaned up, casualties identified and transferred at least to field hospitals and where additional rescue material can be brought on-site. During the Recovery phase all casualties have been transferred to the appropriate specialist hospitals and infrastructures are being rebuilt.

Figure 1. Telecommunication solutions and their relation to a disaster timeline



Up to now the use of satellite communication services for emergency situations is performed on a case by case basis and is highly dependant on the means and on the equipment of the different rescue organisations. One of the biggest challenges for the future is to provide emergency rescue teams with a set of coordinated and interoperable communication tools. The aim of the work carried out in the WISECOM project is to define a standardised system architecture, enabling proper interworking of the many and heterogeeous actors, and their different equipments, operating during the different emergency phases. The WISECOM project also aims to answer the need for a fully integrated system approach: beyond the simple need of voice communications, access to real time and "before the event" data in situ improve the decisions process which in such situation is essential to save life. First responders need to be provided with pertinent and up to date information with the position of other rescue teams, satellite observation data, maps, etc.

Figure 2. WISECOM Functional Architecture.



The architecture proposed by WISECOM and illustrated in Figure 2, is based on a modular approach which allows to address the variety of needs coming from the above defined disaster phases. Two main segments are defined: the On-Disaster Segment and the Disaster-Safe Segment. The former consists of the User-terminal Domain, the Local Access Domain, the WISECOM Client Domain and the group of network elements responsible for the access to the transport domain from the disaster area (satellite terminals, terrestrial wireless terminals, etc…). The latter comprises the group of network elements responsible for the access and control of the transport domain, the WISECOM Server / Operator Domain, the Public Networks Domain and the Home Networks Domain. A WISECOM Client, able to interwork between the various access and transport solutions, as well as providing additional functionality, binds the two domains together.

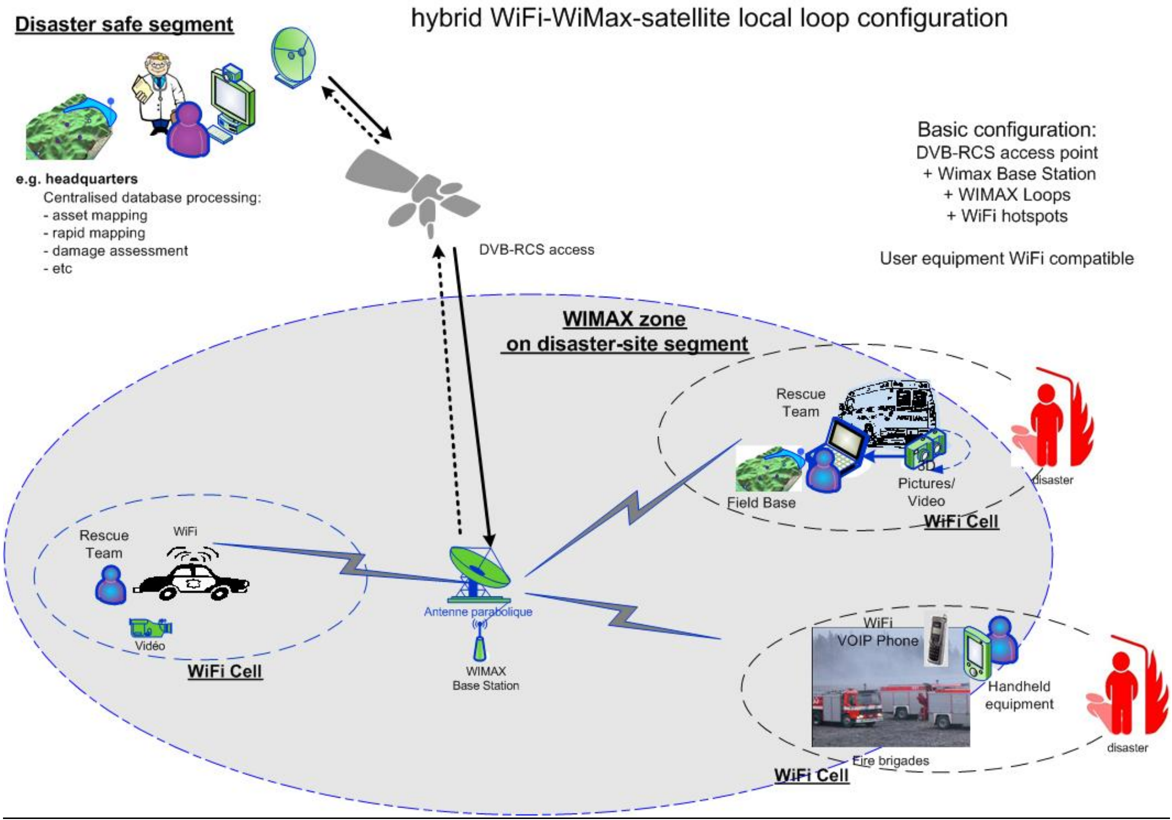
Broadband communications in the response and recovery phase

The challenge addressed here is to provide a temporary infrastructure for broadband data and secondly voice communications to end-users without dedicated end-user terminals. This can be achieved through the combination of a wireless local access loop with satellite DVB-RCS backhauling as illustrated in Figure 3.

The rescue workers and/or victims can access the wireless network using standard WiFi enabled devices such as laptops, PDAs, WiFi phones, etc through local WiFi hotspots deployed around the vehicles or ad-hoc infrastructures of the rescue workers. This allows for a coverage area up to 1 kilometer within line of sight using the licence-free 2.4 GHz band.

These wireless hotspots are in turn connected to the satellite broadband access point using point to multipoint 802.16d WiMAX links without the need for direct line of sight and over a typical cell radius of up to 5-10 kilometers. The required equipment can be easily and rapidly transported to the disaster site in the boot of a normal car or as standard luggage on a plane.

Figure 3. WiFi / WiMAX over DVB-RCS Architecture.



At the time of writing this article, March 2008, the proposed network architecture is under test at EADS ASTRIUM premises in Toulouse. A first phase of integration testing has now validated the configuration and network functionalities, followed by basic service tests to verify the correct operation of typical applications such as file transfer, web browsing, VoIP, videoconferencing and videostreaming. In the next phase performance tests will be carried out under different configurations of traffic load and QoS configuration. Detailed test results will be available at the time of the TIEMS conference in June 2008 and will be included in the presentation.

Hybrid satellite-WiMAX-WiFi demonstrator architecture

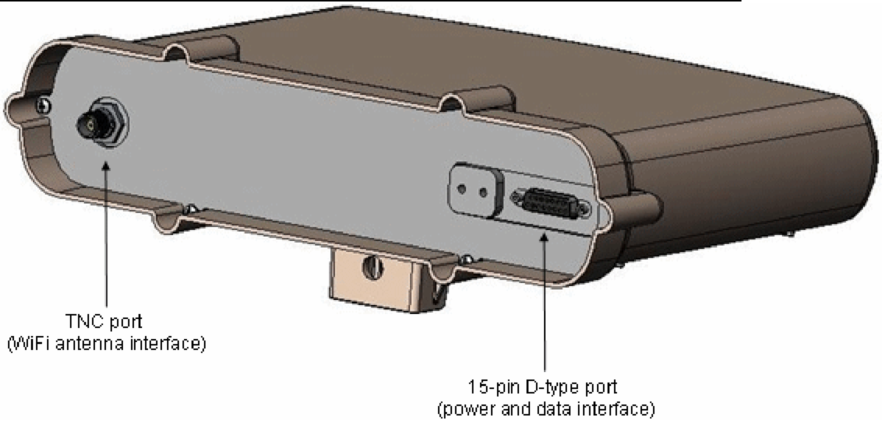
The communication solutions studied, developed and validated in WISECOM will be demonstrated at a live trial at DLR premises in Munich on 28 May 2008. For the satellite-WiMAX-WiFi solution, the following equipments will be installed on the disaster site:

- 1 Patriot Fly-away antenna and DVB-RCS satellite modem
- 1 WiMAX base station with omnidirectional antenna to be installed on a mast shared with the GSM over DVB-RCS configuration and connected to the power supply of the WISECOM car
- 2 WiMAX subscriber stations with an indoor unit with integrated WiFi antenna, to be carried in rescue teams vehicles with the antenna fixed on the roof and deployed on the disaster field

The selected WiMAX devices are working in the 5.4 GHz unlicensed band in compliance with the German regulations: output power limited to 1W, power spectral density below 50mW/MHz and Dynamic Frequency Selection (DFS) enabled to avoid interferences with other devices.

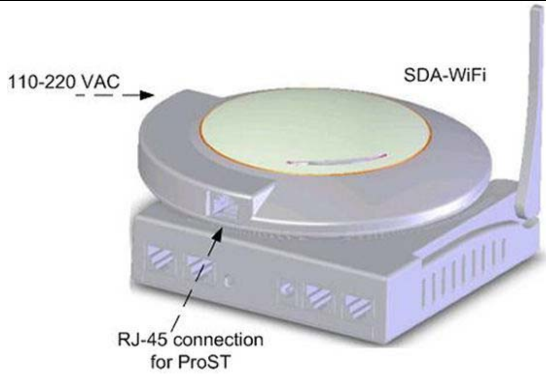
All equipments will likely be transported to the disaster site in the WISECOM vehicle. The WiMAX base station, the WiMAX subscriber stations, the WISECOM Client, the DVB-RCS indoor unit, and other equipments needed for the GSM and TETRA devices will be likely enclosed in a container. Some of the equipments are illustrated in Figure 4.

Figure 4. Wireless subscriber station and DVB-RCS antenna for WISECOM Demonstrator



WiMAX Subscriber Station outdoor unit with deported magnetic antenna fixed on car roof

Patriot Fly-away antenna



WiMAX Subscriber Station indoor unit with integrated WiFi antenna

Detailed results and feedback from the trial will be available at the time of the TIEMS conference in June 2008 and will be included in the presentation.

Conclusions

One of the biggest challenges for emergency communication networks is to provide the rescue teams with a set of coordinated and interoperable tools and services, including both voice and broadband data. Satellite by its ubiquitous and global coverage is a key element of such an integrated approach. This paper has presented the open architecture proposed by the WISECOM project with a particular focus on the integration of broadband satellite solutions with WiMAX/WiFi local loops. A live trial at DLR premises in Munich on 28 May 2008 with active involvement of medical and rescue organisations will demonstrate the solutions proposed.

References

[1] WISECOM project (Wireless Infrastructure over Satellite for Emergency Communications) http://www.wisecom-fp6.eu. Contract No. IST-2006-034673.

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Author biography

Laurent Thomasson has over 12 years experience in the Space Industry. He is currently at the Head of Marketing and R&D Coordination in the Telecom Marketing and Institutional Relations Division of Astrium. He was previously responsible for system projects and business development within the Astrium Telecom System Group. He has developed a solid experience in satcom business, system and application domains. In close cooperation with major Satellite Operators, the European Commission and the European Space Agency, he played a key role to understand and support the development of new satcom services (broadband, mobile, broadcast). He is graduated from ENST, Paris, the French leading Engineering School in the field of Information Technologies.

Sophie Deprey received a telecommunication engineering degree from Telecom Lille, France in 2006. Since this year, she has been working in Astrium on several EU and ESA projects, in particular the Twister project which developed hybrid satellite-wireless solutions. She works and studies on other hybrid projects for mobile and transportable solutions for civil protections.

Philippe Boutry is currently business development manager for Astrium satellite telecommunication. His field of activity encompasses system of systems architectures and he is coordinating within the telecommunication system department the use of satcom for security applications. He has over 25 year professional experience in the space industry. At Astrium since 1991, he held several assignments as project manager in different business units prior to joining the Telecommunication directorate in 2001.

Greet Verelst is currently responsible for business development and system projects for broadband and mobile satellite communications in the Telecom System Department. She has been the coordinator for the TWISTER EU FP6 project that has deployed hybrid satellite solutions in more than one hundred locations across Europe. She has received an electronic engineering degree from the University of Leuven and has been working in space industry since 1996.

Dr. Matteo Berioli received a Laurea degree in electronic engineering, and the Ph.D. degree in information engineering from the University of Perugia (Italy), in 2001 and 2005 respectively. Since 2002, he is with the German Aerospace Center (DLR). He wrote published 30 papers in international conferences and journals dealing with QoS and protocol analysis in IP-based dynamic networks in satellite communications and satellite integration with terrestrial networks, cross-layer techniques and packet-layer coding. He currently coordinates the European STREP project WISECOM, and chairs the satellite working group of the PSCE Forum (Public Safety Communications Europe Forum). He has also worked as expert for the European Telecommunications Standards Institute (ETSI) in the area of broadband satellite multimedia.

Dr. Nicolas Courville received the telecommunication engineering degree from the “Institut National des Télécommunications”, Evry, France in 2000, and the Ph.D degree in satellite communication from Supaero, Toulouse, France, in 2006. He has been working in Deutches Zentrum für Luft und Raumfahrt (DLR) for seven years as a technical engineer and has been involved in several European Space Agency (ESA) and European Union (EU) projects, among them the EU WirelessCabin Project, focussing on in-flight wireless communication for commercial aircrafts, and the EU WISECOM project. His research interests include terrestrial and satellite networks interworking, on-board switching (ESA ULISS project) and advanced resources management in satellite systems. He has written 25 papers about these subjects.