



Contract Number 034673

WISECOM
Wireless Infrastructure over Satellite
for
Emergency COMMunications

Instrument: STREP

Thematic Priority: Information Society Technologies (IST)

Deliverable D4.2-1
WISECOM Trial Result and Analysis Report

Due date of deliverable: 15/06/2008

Actual submission date: 01/09/2008

Start date of project: 15/09/2006

Duration: 21 Months

Organization name of lead contractor for this deliverable:

TGS

Revision: 1.0

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	<input checked="" type="checkbox"/>
PP	Restricted to other programme participants (including the Commission Services)	<input type="checkbox"/>
RE	Restricted to a group specified by the consortium (including the Commission Services)	<input type="checkbox"/>
CO	Confidential, only for members of the consortium (including the Commission Services)	<input type="checkbox"/>



General

Document Info

Prepared by:	<ul style="list-style-type: none"> Markus Werner Beatrix Müller 	<ul style="list-style-type: none"> TGS
	<ul style="list-style-type: none"> Vincent Boussemart Nicolas Courville Javier Mulero Chaves Jean-Louis Fondère Magnus Vikstrøm Harald Skinnemoen Sophie Deprey Laurent Thomasson Greet Verelst Philippe Boutry Marc Moisand Jaak Laineste Hillar Tork Michael Weinlich Ingo Lukauer 	<ul style="list-style-type: none"> DLR TAS ANS ASTR RUL SFZ
Checked by:	<ul style="list-style-type: none"> Nicolas Courville 	<ul style="list-style-type: none"> DLR
Authorised by:	<ul style="list-style-type: none"> Matteo Berio 	<ul style="list-style-type: none"> DLR

Change Record

Revision	Date	Change Status	Origin
1.0	01/09/2008	1 st version of the report submitted to EC	TGS



Table of Contents

- General..... 2
 - Document Info..... 2
 - Change Record..... 2
- Table of Contents 3
- List of Figures 5
- List of Tables 6
- 1 Introduction..... 7
 - 1.1 Background and Scope of the Document..... 7
 - 1.2 Structure of the Document..... 7
 - 1.3 Related Documents..... 7
- 2 Overall Trial and Demonstration Objectives 8
 - 2.1 Introduction and Overview..... 8
 - 2.2 Rapid and Easy Deployment of the WAT 8
 - 2.2.1 Robustness and Lightweight 8
 - 2.2.2 Man-Machine Interface (MMI) 9
 - 2.2.3 Cost of the System and Terminals 9
 - 2.3 Information Platform for the Rescue Forces..... 9
 - 2.3.1 Overall Voice Communication 9
 - 2.3.2 Telemedicine at the Treatment Facility..... 9
 - 2.4 Communication with the Patients 10
 - 2.4.1 Multi-User Support 10
 - 2.4.2 Selected Access..... 10
 - 2.5 Location-Based Services..... 10
 - 2.5.1 Localizing of the Rescue Forces 10
 - 2.5.2 Triage and Tagging for Patients 10
 - 2.5.3 Video / Image of the Local Situation..... 11
 - 2.5.4 Registration at the Casualty Station 11
 - 2.6 Interworking (or Handover)..... 11
- 3 Detailed Trial and Test Results..... 12
 - 3.1 GSM over BGAN..... 12
 - 3.1.1 Objectives and Expected Outcome 12
 - 3.1.2 Test Outcome..... 12
 - 3.1.3 Evaluation 14
 - 3.2 WiFi over BGAN..... 15



3.2.1	Objectives and Expected Outcome	15
3.2.2	Test Outcome.....	15
3.2.3	Evaluation	22
3.3	GSM over DVB-RCS	23
3.3.1	Objectives and Expected Outcome	23
3.3.2	Test Outcome.....	24
3.3.3	Evaluation	25
3.4	WiMAX/WiFi over DVB-RCS	26
3.4.1	Objectives and Expected Outcome	26
3.4.2	Test Outcome.....	26
3.4.3	Evaluation	31
3.5	TETRA over DVB-RCS.....	31
3.5.1	Objectives and Expected Outcome	31
3.5.2	Test Outcome.....	31
3.5.3	Evaluation	33
3.6	Integrated Telecommunication and LBS Services.....	34
3.6.1	Objectives and Expected Outcome	34
3.6.2	Test Outcome.....	35
3.6.3	Evaluation	39
3.7	Tests related to the WISECOM Access Terminal.....	41
3.7.1	Objectives and Expected Outcome	41
3.7.2	Test Outcome.....	42
3.7.3	Evaluation	45
4	Conclusion.....	47



List of Figures

Figure 3-1: Coverage map.....	21
Figure 3-2: 4-wheel drive carrying the equipment for the DVB-RCS configuration ...	43



List of Tables

Table 2: Necessary time to transfer files using FTP 18



1 Introduction

1.1 Background and Scope of the Document

This document provides the results and an analysis of the WISECOM trials performed prior to the final demonstration.

The main objectives of the work package have been

- to evaluate the performance of the equipment;
- to process the results gathered during the trial executions;
- to derive (statistical) results of the service quality and reliability;
- to analyse/propose improvements to equipment and solutions.

Consequently, this deliverable mainly reports on these (more technical) trial results, analyses technical performance and identifies improvement potential.

Some more user-oriented assessment of the WISECOM solution has been left to WP 5 deliverables, in order to make the presentation of various project results more coherent and less overlapping in the various deliverables.

1.2 Structure of the Document

The present document is organized as follows:

- Section 2 first recalls the overall trial and demonstration objectives of WISECOM;
- the core Section 3 then reports on the detailed trial and test results as per single configuration of the trial/demonstrator set-up;
- a short conclusion of the trial results and analysis is drawn at the end in Section 4.

1.3 Related Documents

[RD-1] "Survey of Use Cases", D1.1-1, Version 2 - WISECOM, Work Package 1.1, August 2007.

2 Overall Trial and Demonstration Objectives

2.1 Introduction and Overview

The most important factors for survival are the initial treatment of life threatening disorders and time. The faster the patient can be found and brought to the final treatment, the better the chance of survival.

It should be noted that the overall issue in this disaster scenario is to improve the time until the patient receives the final treatment and to reduce the risk undergone by already involved rescue forces and other people. This can be achieved by a better rescue team management using the WISECOM system, with maps displaying the position of victims and members of rescue teams, with planned ambulance routes, non overlapping rescue team paths, identification of dangerous areas and relief areas.

After the initial call to the alarm centre, first rescue forces and the WAT will be sent to the mass casualty area. The following sub scenarios will allow showing the benefits of the WISECOM project:

1. Rapid and Easy Deployment of the WAT,
2. Information Platform for the Rescue Forces,
3. Communication with the Patients,
4. Location-Based Services,
5. Interworking (or Handover).

2.2 Rapid and Easy Deployment of the WAT

As the alarm centre knows that the amount of victims is clearly higher than 10, the WAT should be transported immediately to the location. The fastest transportation vehicle would be a helicopter, but for the demonstration a vehicle is considered enough to convey the idea.

In the early disaster phase, the WAT should be carried in back-packs of a limited amount of members of the rescue teams. In this case, the focus should be put on how easily and quickly the WAT can be deployed and provide telecommunications services. In the response phase, more cumbersome equipments should be brought on the disaster area, e.g. thanks to a truck or a van.

It is foreseen that the transition between the early disaster phase and response phase will be also illustrated in the demonstration, even if it does not represent the main focus of the demo (see later section 2.6). For the main part of the demo, the focus will be on the early disaster phase using BGAN, the handover to DVB-RCS could be shown after the main demo. At this later stage, triage support may be probably no longer necessary and LBSs are in general less important. The main objective of the second demonstration, the response phase (with the DVB-RCS terminal), is the restoration of GSM and wireless connectivity on a larger scale.

2.2.1 Robustness and Lightweight

The WISECOM system should be robust and lightweight enough to be well adapted to a disaster situation.



2.2.2 Man-Machine Interface (MMI)

The WISECOM system should be easy to use for the members of the rescue teams.

2.2.3 Cost of the System and Terminals

The WISECOM system should be affordable for the rescue team organisation and / or the governmental organisations.

2.3 Information Platform for the Rescue Forces

The alarm centre can forward satellite images (e.g. Google Earth) of the local situation with certain remarks (landing site for helicopters, route for emergency transportation, location of the treatment place and the casualty station etc.) to be forwarded to the rescue forces to a PDA or a local laptop. Information about certain dangerous zones or risks can be forwarded to the entire rescue forces e.g. by SMS.

The Google Earth pictures could contain pictures of victims. The pictures should have sufficient quality for a doctor in a remote location to support the diagnostic.

DLR and RUL will ensure that appropriate map / image data is available for the demo area.

2.3.1 Overall Voice Communication

The alarm centre will have the possibility to communicate with certain rescue forces or victims, as well as having a broadcasting possibility to reach all of the rescue teams.

2.3.2 Telemedicine at the Treatment Facility

Each patient brought to the treatment area will be triaged a second time. This secondary triage could change the colour of the patient and therefore has to be forwarded to the alarm centre, as well as the new location of the patient (located in the treatment place). These features are also part of the LBS software. The WAT will now be able to collect all the data from the treatment area, like a second web camera, data from the amount of patients and rescue forces at the treatment place, priorities of transportations etc. Telemedicine can now be installed, e.g. using the "Acuity" device by "Welsh Allyn" to monitor the vital signs of each patient and forward this information together with the patient ID to the alarm centre. Monitoring of each patient can now be done by the alarm centre staff. In the demonstration, the remote health monitoring of at most one patient with an appropriate telemedicine device should be performed.

Mobile Acuity LT Central Station Features:

- Monitor up to 12 patients on a single workstation,
- 24-hour full disclosure,
- Remote control of patient monitors from the central station,
- Alarms adjusted at patient monitor or mobile central station,
- Communication is bi-directional when patient monitor is connected to the central station - parameters, settings, alarm limits, etc,
- User-friendly, easy-to-read display, easy to deploy,



- Two screen options for displaying patient data and reviewing data,
- Mortara Instrument's VERITAS™ life-threatening arrhythmia algorithm: asystole, VFib and VTach alarms.

2.4 Communication with the Patients

Once the existence of a mobile is validated, a communication via GSM with the patient should be opened. If the patient does not answer, the mobile is either left alone or the patient is unconscious.

As it is assumed that the normal GSM system is broken down, the WAT will provide new GSM infrastructure that will allow the conscious patient to communicate with the rescue forces.

2.4.1 Multi-User Support

One of the goals is to show that the WAT and the WISECOM system are able to support a large number of users with heterogeneous telecommunication devices such as GSM phone, WiFi PDA, WiFi laptop, and optionally TETRA devices.

2.4.2 Selected Access

The main idea is to demonstrate that the WISECOM system is able to provide different telecommunication services to different types of users, (voice calls with GSM for members of rescue teams, SMS for the victims, etc...).

2.5 Location-Based Services

2.5.1 Localizing of the Rescue Forces

The ambulance cars and fire brigades, as well as the members of the rescue teams managing the patients, will be equipped with integrated GPS devices. In tracking mode, the location of the rescue forces can be viewed at the alarm centre on a map.

This should help the alarm centre to optimally manage and direct members of the rescue teams for an improved and more efficient support to the victims.

2.5.2 Triage and Tagging for Patients

Once the rescue forces have found the patient, a triage will be performed and the colour tag (red, yellow, green, black) will be assigned accordingly.

A sheet of paper with the most important information about the patient (colour code, gender, approximate age, etc...) will be attached to each patient. Simultaneously, some data about the victim (location, colour code, age, gender, additional notes) will be transferred to the alarm centre via the WAT and the WISECOM system. A unique patient ID will be requested from the alarm centre for each new triage carried out, this needs a central server to handle all patient IDs. Any changes in the patients status (e.g. from yellow to red) can be transferred to the alarm centre, including the new GPS location. This allows fast responds to provide help to the victims with highest demand.

For this purpose, a specific LBS application and an own software is being developed (technical specifications are being written).



2.5.3 Video / Image of the Local Situation

To allow the alarm centre to have a better view of the local activities, a web camera will be placed on a tripod and the signal of the web camera will be sent to the alarm centre, together with the mentioned LBS information about patients (e.g. a picture of the injury could be associated with the triage data).

2.5.4 Registration at the Casualty Station

At the casualty station with the green patients, each patient should be registered; name and birthday should be forwarded. This is part of the triage application. In general, processing of every victim within the application is finished at the moment of registration at green tent, red tent, remote hospital or morgue. The last two options, not in general being within range of the WAT, should allow information update via GPRS. A controlled transport of these people can be organized at low priority, if needed.

2.6 Interworking (or Handover)

It should be shown that the WISECOM system is composed of different independent systems adapted to the different disaster phases, and that these systems may be rapidly handed over according to the management phase of the disaster situation.

A handover between the early disaster phase and the response phase is shown; during the early disaster phase a BGAN system is used for the triage of the victims and their transfer to the adequate relief station; during the response phase the disaster situation is better managed and a DVB-RCS WISECOM system with larger capacities can be brought on the field.



3 Detailed Trial and Test Results

3.1 GSM over BGAN

3.1.1 Objectives and Expected Outcome

The trials objective for the GSM over BGAN configuration is to demonstrate that in case of emergency, the WISECOM system is able to successfully restore a local GSM coverage used to run classical or specific telecommunication services thanks to a backhauling link over the BGAN satellite system or to provide on field telecommunication services. Among these services, the most important are: GSM voice calls, voice call filtering and restriction, SMS (send and receive), broadcast SMS, per cell users positioning (optional in the demonstration), specific LBS services over GPRS.

3.1.2 Test Outcome

3.1.2.1 Basic Service Tests

- Check the reception of an appropriate welcome message (with practical information) upon registration of the mobile terminal in the restored GSM coverage area.
 - Tested OK. The configured operator/provider name can be displayed on various SIM cards.
- Check the possibility to set up a voice call from a member of a rescue team to another member of a rescue team in the local access domain (this may not necessarily be based on local switching and may involve a satellite double-hop depending on software version and hardware).
 - Call scheme confirmed with both local switching and involving satellite double-hop. (See comments under 'Evaluation' below.)
- Check the possibility to set up a voice call from a member of a rescue team to any other number on ground networks.
 - Call scheme confirmed with calls into PSTN/ISDN and PLMNs.
- Check the possibility to simultaneously set up several voice calls for members of rescue teams, for different calling and called parties.
 - Confirmed with some (temporary) limitations in BGAN satellite capacity. (See comments under 'Evaluation' below.)
- Check the impossibility for a victim to make a voice call (selective restricted service).
 - Tested successfully in lab environment.
- Check the transmission of an SMS from user terminal in the local access domain to any number (especially the co-ordination centre, to any number belonging to the ground network and to anybody in the local access domain).
 - Tested successfully (at lab level only due to a late change in ground segment / provider software BSC/MSC/SMSC).



- Check the reception of an SMS by a user terminal in the local access domain from any source terminal (co-ordination centre, ground networks, and other terminals in the local access domain).
 - Tested successfully (at lab level only due to a late change in ground segment / provider software BSC/MSC/SMSC).
- Check the transmission from the co-ordination centre of “broadcast” SMS (per cell, to the whole local access domain, only to members of rescue teams).
 - Tested successfully (at lab level only due to a late change in ground segment / provider software BSC/MSC/SMSC).
- Check the location of user per cell (database query to the GSM service provider), if feasible from the technical and management point of view.
 - The identification of location of a user per cell could be confirmed by looking into the operator/provider management software; an automatic access of such information (database query) could not yet be implemented in the project but is identified for further development; the basis approach is confirmed and agreed with the provider.
- Check of a simple GPRS application (web browsing to download map of the area).
 - Tested shortly at lab level, works in principle. No further testing done due to expensive air time.
- Check the availability of Location Based Services (LBS) from/to user terminals of rescue teams with active GPS information.
 - This functionality was provided using the WiFi component of the hybrid GSM/WiFi over BGAN WAT (see below).
- Check the triage LBS service: Check the possibility to easily transfer to the coordination centre a formatted message used in the triage phase: colour code, location, picture, gender, etc...
 - This functionality was provided using the WiFi component of the hybrid GSM/WiFi over BGAN WAT (see below).

3.1.2.2 Performance Tests

- Check the voice quality (mean opinion score),
 - Quality generally acceptable, sometimes some degradation over satellite link due to capacity issues. (See comments under 'Evaluation' below.)
- Check the voice call set-up time,
 - The call set-up time increases compared to terrestrial systems as expected, due to several signalling messages traversing the double-hop satellite link. However, no further increase than this inevitable was seen.
- Check the SMS transfer time,
 - No noticeable difference to terrestrial systems.
- Check the maximum bit rate over GPRS thanks to the download of a large file,



- Not performed due to expensive airtime. Such file transfers are assumed to be served via the WiFi component of the hybrid GSM/WiFi over BGAN WAT.
- Check the Location Based Services associated with the estimation of user position in a multi GSM cell environment, if implemented:
 - Accuracy of the user location (for members of rescue teams),
 - Periodic update of the location of members of rescue teams,
 - Display of user location on maps with sufficient accuracy, different colours for different types of users, etc... in the co-ordination centre
- No particular GSM passive localization mechanism implemented, see comments above. Provided by WiFi over BGAN (see results below).
- Check the sensibility of the previously defined services to the user position in a cell and to the propagation conditions.
- No particular dependence of location observed while well in cell and coverage; however, usual degradation with shadowing and distance.

3.1.2.3 Load Tests

- Check how many voice calls can be simultaneously carried out over the satellite link,
 - Due to capacity limitations, expensive air time, and late changes in the ground segment configuration, the limit could not be tested. However several parallel calls have been tested successfully.
- Check the typical time to transfer files (of different sizes) from the ground to a user terminal over the satellite link, at different day time (this test depends e.g. on the load over the satellite system),
 - Not performed over GPRS due to expensive airtime and resource limitations. Such file transfers are assumed to be served via the WiFi component of the hybrid GSM/WiFi over BGAN WAT.
- Assess the capabilities of the system to simultaneously support several different applications (voice calls, SMS, GPRS, LBS) with a realistic proportion.
 - Not performed due to expensive airtime and resource limitations. Moreover, some applications (data transfer, LBS) have been served via the WiFi component of the hybrid GSM/WiFi over BGAN WAT.

3.1.3 Evaluation

3.1.3.1 Positive Findings

Although deployed quite late due to some issues with satellite capacity and ground segment configuration, the GSM over BGAN configuration can comply with all basic requirements. Many limitations seen during the trial and demonstration phase have already been solved or are being addressed in the weeks/months after the WISECOM demonstration. The integration with the WiFi component in the hybrid GSM/WiFi over BGAN WAT was successful.



3.1.3.2 Improvement Potential

Performance of voice calls, both in terms of quality and quantity, should still be increased, in particular in collaboration with Inmarsat. This identified improvement potential has already resulted in direct talks and plans to collaborate with Inmarsat beyond WISECOM.

Some particular challenges of the multiplexed/compressed voice transmission over both BGAN streaming and background contexts may need cross-configuration adaptations on WISECOM and Inmarsat service side; also the emerging interactive services class/context of future Inmarsat BGAN may improve the situation further.

Local switching of calls remaining in the disaster-area cells should be further consolidated and proven to work with all SIM cards.

The register/database query for getting user per cell information should be implemented in further work, as it provides an essential feature for commercial system.

3.1.3.3 Proposed Configuration for Future Development

Due to the particular challenges of the (multiplexed and compressed) voice over the BGAN satellite link, it is proposed that resource control on the terminal side remains in the GSM component of the hybrid GSM/WiFi WAT, and integrates the basic intelligent and dynamic resource control for the WiFi services, too.

3.2 WiFi over BGAN

3.2.1 Objectives and Expected Outcome

The main goal of the trials objective and test plans for the WiFi over BGAN configuration is to demonstrate that in case of emergency, the WISECOM system is able to successfully restore a local WiFi (2,4 GHz) coverage used to run classical or specific telecommunication services thanks to a backhauling link over the BGAN satellite system or to provide on field telecommunication services. Among these services, the most important are: Web browsing, File Transfer, Email and message applications, Voice or video conferencing, per WiFi Hot Spot users positioning, specific LBS services.

3.2.2 Test Outcome

3.2.2.1 Basic Service Tests

- Check the possibility to run an HTTP application between a WiFi capable terminal in the local access domain and any server in the remote ground IP network,
- Test successfully performed. When connected to the WISECOM-PRIV Network or to the WISECOM-PUB one, using the proper user name and password, it was possible to run HTTP applications between the connected PDAs or laptops and any web server located in the remote IP ground network.
- Check the possibility to run an FTP application between a WiFi capable terminal in the local access domain and any server in the remote ground IP network,



- Test successfully performed.
- Check the possibility to send and receive emails,
- Test successfully performed.
- Check the possibility to run voice conference applications involving one or several users in the local access domain and one or several users in the disaster safe segment,
- Test successfully performed. Voice conferences were successfully established using the VoIP servers installed on both the local and remote domain. Conferences with three participants were successfully held, testing the case of remaining two participants in the local domain and one in the remote, and vice versa. From the local domain it was also possible to maintain a VoIP connection with a computer connected to the remote IP domain and also with a normal phone connected to the PSTN network at the remote side.
- Check the QoS mechanism (classification of IP datagrams, prioritization, QoS aware scheduling, etc...),
- After performing some laboratory tests where the proper performance of the QoS mechanisms was proved, no particular quantitative tests were performed with the real demonstration system. Nevertheless, the prioritization of the different services was corroborated by using different services simultaneously, like voice calls and HTTP applications, and checking if the service with a higher priority suffered from a delay or not. Particularly, when performing voice calls over the satellite link (high priority), and any other application at the same time with a lower priority, like HTTP sessions or the LBS application, the communication was performed without any additional delay, confirming that the QoS mechanisms were working properly.
- Check security mechanism (air interface encryption (WEP), Radius server, etc...),
- Test successfully performed. Two different situations have been tested according to the two different networks that can be used:
 - In case of connecting to the WISECOM-PUB network, no air interface encryption is used, in order to facilitate users the connection to the network. It has been tested that users connected to this network are not able to reach the Wide Area Network because of the use of Chillispot, and that they are redirected instead to the WISECOM Welcome Website. In case of providing a proper user name and password, it has been checked that users are allowed by the RADIUS server to use the general WISECOM services.
 - Regarding the connection to the WISECOM-PRIV network, it has been verified that it was impossible to get connected to the network without installing the proper certificate. Apart from this, it was also verified that it was only possible to connect to the network using a proper user name and password in order to be positively identified by the RADIUS server.
- Check the WiFi coverage area,



- Test successfully performed. It was confirmed that the whole area where the demonstration was going to be held was provided with WiFi coverage, but presenting some particularities, as described in section 3.2.2.2.
- Check the possibility to run video conference applications involving one or several users in the local access domain and one or several users in the disaster safe segment,
- Test not performed because of bandwidth limitations.
- Check the possibility to identify users in the WiFi hot spot,
- Test successfully performed. The way to identify users in the WiFi hot spot varies depending on the networks to which users are connected. According to this, two different situations can be found:
 - WISECOM-PUB: In order to identify users and decide whether they should be able to use all of the WISECOM services, users must be in possession of a proper user name and a password in order to positively identify them.
 - WISECOM-PRIV: When connecting to the network, users are given a specific IP address which is statically assigned to their MAC address in the WiFi access point configuration. This way, every PDA is associated to a fixed IP address which will allow the possibility to identify users when connected to the network.
- Check the availability of Location Based Services (LBS),
- Test successfully performed. Once the PDAs and also a laptop playing the role of a Control Centre on the field were connected to the proper network, it was possible to access the Location Based Services, starting the software and reaching the LBS server located in the Control Centre. In case of using a PDA, the LBS software was available either through the proper menu on the PDA, or using the proper key of the PDA, allowing a faster access to the service.
- Check the triage LBS service:
 - Check the possibility to easily transfer to the coordination centre a formatted message used in the triage phase: colour code, location, picture, gender, blood type...
 - Verify location based image communications over satellite in order to describe casualties etc.
- Test successfully performed. Both uses of the LBS service were successfully tested. First of all, it was confirmed that it was possible to send formatted messages to the control centre containing the necessary information in order to create or update victims' profiles. In addition to this, the possibility of sending location based images, using the ASIGN system, was also successfully performed, allowing users to send pictures taken on the field with the proper cameras from the local domain to the server installed on the control centre.

3.2.2.2 Performance Tests

- Check the video quality of the video conference (or call),
- Video conferences not performed due to bandwidth limitations.



- Check the set-up time of a video conference,
 - Video conferences not performed due to bandwidth limitations.
- Check the probability of blockage of the video conference (no successful set-up),
 - Video conferences not performed due to bandwidth limitations.
- Check the probability of dropped video conference (during an active video conference),
 - Video conferences not performed due to bandwidth limitations.
- Check the voice quality of the voice conference or call (Mean Opinion Score, MOS),
 - Test successfully performed. The Mean Opinion Score calculated after the different tests, was 3.9. That means that the quality was good enough to understand the conversation even though imperfections could be perceived. Those imperfections included a short delay of approximately one second due to the satellite link.
- Check the set-up time of a voice conference,
 - Test successfully performed. In case of performing a voice conference between a PDA connected to the local domain and a PDA connected to the remote side, the average set-up time obtained in the measurements is approximately 3 seconds.
- Check the probability of blockage of the voice conference (no successful set-up),
 - Test successfully performed. The occasions in which voice conferences were not successfully established were very rare in case of disposing of a stable WiFi connection.
- Check the probability of dropped voice conference (during an active voice conference),
 - Test successfully performed. In normal conditions, with a stable WiFi connection, there were very few occasions in which voice conferences were dropped. The most frequent reason for a conference to be dropped was the loose of WiFi coverage during the conversation.
- Check the time to transfer files (of different sizes) from the ground to a user terminal over the satellite link using FTP,
 - Test successfully performed. As an example of the necessary time which is needed in order to download files via FTP, the following test results are presented in Table 1:

Table 1: Necessary time to transfer files using FTP

File Size (kB)	Time (s)
105	1.5
245	2.5
815	33



- Check the average time between the sending of an HTTP request (click on a link) and the effective reception of the corresponding Web Page,
- Test successfully performed. The average time which is needed to open a web page varies depending on different factors, such as the load of the corresponding server and the amount of information included in the website. Apart from this and as long as a proxy server is installed on the local domain, the time needed to open a website is shorter if the desired page has been already visited and therefore, is included in the cache, because in this case there is no necessity to access the remote server using the satellite link.
- Check the time to transfer emails (of different sizes) from the WiFi local access domain to any user on the ground networks (or to the email server),
- Test successfully performed. In order to perform the tests, short emails were sent without any attached file. The time to transfer the emails varied from 13 to 22 seconds for the different cases.
- Check the Location Based Services:
 - Accuracy of the user location (for members of rescue teams),
 - Periodic update of the location of members of rescue teams,
 - Display of user location on maps with sufficient accuracy, different colours for different types of users, etc... in the co-ordination centre.
 - Check number of high quality location based TRIAGE images that can be transferred for the duration of the TRIAGE.
- Test successfully performed. The following results were obtained:
 - Regarding user location, it was observed that the accuracy was dependent on the number of satellites that were visible at each moment. Thus, in case of using 3 or 4 satellites, there was a shift in the location which varied between approximately 1 and 2 metres. This shift was considerably smaller in case of working with more satellites, improving the accuracy of user location, up to the maximum in case of working with 9 or more satellites.
 - User location was periodically updated according to the settings stated in the configuration files of the LBS software in each PDA. Some preliminary tests were made using a small updating time of 15 seconds. Since the LBS software gets blocked during the information update, this high updating frequency lead to a constant blocking of the system, making it impossible to work with it. Afterwards, it was decided to use an updating period of 45 seconds, which guaranteed a good trade-off between the amount of time the system was blocked and the information that could change during this updating period.
 - Regarding the coordination centre, the accuracy of user location was also dependent on the GPS signal acquired by the different PDAs. Apart from this, all the information was properly displayed on the map, i.e. the different victims were properly located and updated on the map with the proper symbol according to the importance of their injuries, the different types of users where located with enough accuracy using

different colours, the location of the WAT was also properly set on the map, and text messages were also properly received and displayed.

- It was confirmed the possibility to send a large number of high quality location based TRIAGE images during the duration of the TRIAGE.
- Check sensitivity of performance with respect to user location in the WiFi coverage and to the propagation conditions.
- Test successfully performed. In order to test if the whole area of the demonstration was provided with enough coverage, different methods have been used. In the following, the different methods are presented:
 - The management website of the WiFi access points presents an indication of the signal strength of the different clients connected to the access point. This indicator was used in order to see if the signal of every PDA connected to the access point was strong enough or not.
 - In a similar way as the method explained above, the wireless interface of each PDA provides also an indicator of the signal strength between the PDA and the corresponding base station.
 - As a more practical indicator, the VoIP client installed on every PDA was also used in order to measure the coverage on the field. Using this VoIP client and the SIP server installed on the WAT, it was possible to call to a specific number which is intended to be used to receive an echo of the ongoing conversation. This way, calling to this number and talking to the PDA it is possible to notice if the WiFi connection is established or not, checking if it is possible to receive the echo sent by the server.
 - Another method to test the coverage was to use a piece of software called “Task Manager”, which allows users to send ICMP requests (pings) to the desired IP addresses. With this software it was possible to continuously send requests to the WAT IP address and check if an answer was received. If it was not possible to receive an answer, then the WiFi connection was not properly established due to a lack of coverage in that area.
 - Apart from these methods, it has also been tested if there was coverage or not by trying to use any of the services which require a WiFi connection, such as establishing an HTTP session or connecting to the LBS server.

According to the different tests, it was possible to confirm that the whole area presented a proper WiFi coverage, with the following particularities:

- Each PDA should always be pointed to the WiFi antennas, since the presence of an obstacle between the antenna and the PDA, such as the human body, would cause a loose of the WiFi signal and therefore, a lack of coverage.
- In some areas of the field which presented several holes, the coverage was lost due to the difference of altitude. The coverage was quickly recovered when going out of the hole.

- The strength of the WiFi signal was decreasing as long as users were going further away from the antennas, but it increased when reaching an area surrounded by trees, due to the signal reflections caused by the trees.

Figure 3-1 shows a graphical description of the areas where the signal was weaker due to the holes on the ground and where the signal was stronger due to the reflections in the trees.



Figure 3-1: Coverage map

3.2.2.3 Load Tests

- Check the maximum number of simultaneous video conferences that can be carried out over the satellite link,
 - Video conferences not performed due to bandwidth limitations.
- Check the number of simultaneous voice calls that can be carried out over the satellite link,
 - Test successfully performed. The total amount of voice calls that have been performed with a proper quality over the satellite link is two, consuming each one an approximate bandwidth of 80 kbps, according to the voice codec that is being used (GSM).
- Check the possibility to run multiple parallel web browsing sessions over the satellite link,
 - Test successfully performed. In a similar way to the differences in the necessary time needed to establish an HTTP session which is already commented above, it has been checked that multiple HTTP sessions can be established using the different PDAs, but the total amount of sessions is variable, due to the fact that not all the sessions require the same satellite



bandwidth and that for some connections, the requested web sites could be already found in the cache of the proxy server installed on the WAT. According to this, it is not possible to establish an exact figure of the amount of HTTP sessions that can be established over the satellite link, but it has been corroborated that multiple sessions can be established using the different PDAs, without noticing a decrease of the quality of the connections.

- Assess the capabilities of the system to simultaneously support several different applications (HTTP, FTP, Email, voice and/or video conference, etc...) with a realistic proportion.
- Test successfully performed. According to the performed tests, several applications can be simultaneously supported by the system, without suffering a lack in the quality of the provided services. Among these applications, it was possible to assure the use of 7 simultaneous LBS sessions (6 with the PDAs and 1 with a laptop), up to two voice calls between the PDAs and the control centre, and multiple HTTP sessions performed from the PDAs and also from the laptop used as a local control centre.

3.2.3 Evaluation

3.2.3.1 Positive Findings

Generally speaking, all the different services were able to work properly using the WiFi link to reach the WAT and connect to the satellite network using the BGAN system. It was very positive to verify that users were able to enjoy the general internet services provided by the wireless networks, such as HTTP and FTP, as well as other services which are especially important in case of emergency situations, such as performing VoIP calls and using the Location Based Services. All this services were provided to users ensuring a proper quality and without overloading the system.

It is also important to remark how easy the connection to the WiFi networks is and the fact that any user can get connected to them with any WiFi capable device, such as laptops or PDAs, not only with the PDAs which have been used for the demonstration.

In addition to this, the good planning of the two WISECOM networks and the possibility to access different types of services according to the kind of user is another issue to take into account among the positive findings. The WISECOM Welcome Website which is reached by any user who wants to access internet connected to the WISECOM-PUB network is also an additional value of the WISECOM WiFi network planning which has been also well received by users, due to the fact that it provides users with useful information in case of emergency and allows them to get in touch with the control centre, which is a very important feature in order to be located and helped.

Another issue which has been appreciated is the good performing of the security mechanisms in order to allow or deny the access to the different networks according to the kind of user who is trying to get connected. This system, as well as providing security, avoids the link to be misused by users who are not allowed to enjoy the general services, reserving most of the capacity of the link to be used by the rescue teams.



3.2.3.2 Improvement Potential

According to the tests and the demonstration itself, it was generally agreed that the most important issue to be improved regarding the WiFi over BGAN configuration of the system was guaranteeing a proper WiFi coverage over the whole disaster area. The main drawbacks of the use of WiFi regarding the lack of coverage can be summarized in the following points:

- There must be a clear line of sight between the WiFi antennas connected to the WAT and the different devices willing to connect to the network. According to this, it was verified that the presence of trees or even the body of the person carrying the PDA could be an obstacle when trying to get connected to the networks.
- The quality of the WiFi signal can considerably vary due to the characteristics of the disaster area, such as differences in the altitude level between the WiFi antennas connected to the WAT and the different devices to be connected to the network, or the presence of trees or buildings in the area.

In conclusion, assuring a proper WiFi coverage over the entire disaster area is the most important improvement that should be carried out regarding this configuration of the system.

3.2.3.3 Proposed Configuration for Future Development

In order to guarantee users the wireless access to the different WISECOM services, two different approaches can be considered for a future development configuration:

- The first possibility could be extending the range of the WiFi signal deploying a network of WiFi access points working as repeaters. This option could solve the problem of the lack of visibility between the antennas connected to the WAT and the devices in some areas on the field, but it may also involve the necessity of a better planning of the WiFi coverage, in order to properly locate the different access points which are used as repeaters. Taking into account that the system is intended to be easy to deploy, this solution may lead, either to a misuse of the resources due to the presence of areas not properly covered by the WiFi access points and areas covered by several of them or to a delay in the system deployment on the field due to the necessity of planning the WiFi network.
- The second option would imply the use of a WiMAX link to let users connect to the WAT instead of using a WiFi connection. This solution, also demonstrated by WISECOM, would improve considerably all the drawbacks found in the use of the WiFi technology, but was not used as the first option due to the fact that the technology is not mature enough and there are no commercial PDAs which are able to connect to a network over WiMAX, as long as we are aware.

3.3 GSM over DVB-RCS

3.3.1 Objectives and Expected Outcome

The trials objective for the GSM over DVB-RCS configuration is to demonstrate that in case of emergency, the WISECOM system is able to successfully restore a local GSM coverage used to run classical or specific telecommunication services with a backhauling link over the broadband DVB-RCS satellite system while providing on-



field telecommunication services. Among these services, the most important are: GSM voice calls, Voice call filtering and restriction, SMS (reception and emission), broadcast SMS (optional, to be confirmed with GSM operator), per cell users positioning (optional, may not be demonstrated), specific LBS services over GPRS.

3.3.2 Test Outcome

3.3.2.1 Basic Service Tests

- Check the connection to the GSM network, possibly via the reception of an appropriate welcome message (with practical information) upon switching on of the mobile terminal in the restored GSM coverage area,
 - test outcome: success, the MCP operator logo was shown both on MCP SIM cards and could be selected with other SIM cards.
- Check the possibility to set-up a voice call:
 - From a member of a rescue team to another member of a rescue team in the local access domain,
 - From a member of a rescue team to any other number on ground networks,
 - test outcome: success. Both call set-up schemes confirmed.
- Check the possibility to simultaneously set-up several voice calls for members of rescue teams, for different calling and called parties,
 - test outcome: confirmed
- Check the possibility for a victim to make and not make a voice call (call filtering),
 - test outcome: success, tested at lab level.
- Check call reception to users in the disaster area,
 - test outcome: success.
- Check the transmission of a SMS from user terminal in the local access domain to any GSM number (especially the co-ordination centre, to any number belonging to the ground network and to anybody in the local access domain),
 - test outcome: success, SMS works as normal
- Check the reception of a SMS by a user terminal in the local access domain from any source GSM terminal (co-ordination centre, ground networks, other terminals in the local access domain),
 - test outcome: success, SMS works as normal
- Check of a simple GPRS application (web or WAP browsing),
 - test outcome: works
- Check the availability of Location Based Services (LBS),
 - test outcome: LBS services work as normal
- Check the triage LBS service:



- Check the possibility to easily transfer to the coordination centre a formatted message used in the triage phase: colour code, location, picture, gender, additional information.

➤ test outcome: tested in lab, works

3.3.2.2 Performance Tests

- Check the coverage area obtained with the configuration used,
 - test outcome: the whole test areas was covered with good margin with a small antenna.
- Estimate the voice quality of a call,
 - test outcome: All testers were satisfied with the quality
- Measure the voice call set-up time,
 - test outcome: Not noticeably different than normal
- Verify SMS transfer times not particularly affected by WISECOM,
 - test outcome: not noticeable difference
- Check the sensitivity of the previously defined services to the user position in a cell and to the propagation conditions (qualitative information).
 - test outcome: no dependence of location observed

3.3.2.3 Load Tests

- Verify that a reasonable number of calls can be supported by the WISECOM system, according to the capacity of the BTS,
 - test outcome: all call attempts successful. 7 simultaneous calls with BTS.
- Assess the capabilities of the system to simultaneously support several different applications (voice calls, SMS, GPRS, LBS) with a realistic proportion.
 - test outcome: works as usual with no satellite, except GPRS somewhat slower.

3.3.3 Evaluation

3.3.3.1 Positive Findings

The GSM over DVB-RCS worked surprisingly well, and with no problems during the trials. It was stable and the quality of the voice was good. It was further interesting and positive to see that the GSM system could interoperate and coexist with WiMAX and Wi-Fi. The tests showed and confirmed that GSM over DVB-RCS works well for WISECOM scenarios.

3.3.3.2 Improvement Potential

The GPRS data connection was slow but worked. This is a topic that could benefit from some further research. Cross-layer functionality, where the various possible voice codecs can be tuned to the capacity and characteristics of the channel is a possible option – in particular for future work with adaptive coding.



3.3.3.3 Proposed Configuration for Future Development

It is proposed that a router is intelligently configured to trade off Wi-MAX and Wi-Fi capacity with the GSM calls in a dynamic way for variably loaded systems and dynamic and adaptive channels.

3.4 WiMAX/WiFi over DVB-RCS

3.4.1 Objectives and Expected Outcome

The objective of this configuration is to demonstrate the added-value of hybrid combinations of WiMAX, WiFi and DVB-RCS which have not been tested yet for the purpose of disaster management.

A detailed analysis of available WiMAX equipment, in cooperation with the major manufacturers of this technology is currently performed by Astrium, and several solutions will be tested and validated before selecting the right one(s) for the purpose of the "WISECOM Demonstration Day". Both 3.5 and 5.4 GHz are studied.

3.4.2 Test Outcome

3.4.2.1 Basic Service Tests

- Check the availability of WiMAX terminals for both frequencies: 3.5 GHz (licensed) and 5.4 GHz (unlicensed),
 - Test successfully performed. A lot of manufacturers have available equipment in the 3.5 GHz frequency. But the use of this frequency during emergency situations is not the most appropriate one, because it is necessary to have authorisations to use equipments working in this spectrum. The market analysis was focused on the 5.4 GHz band where some equipment (base station, Subscriber stations) is available. Currently, there is no end-user equipments on the market for this band (laptop WiMAX compatible, WiMAX phone) so it was decided to use hybrid solution using WiMAX / WiFi equipments, where the WiMAX Base station is connected to the DVB-RCS point of presence, and the subscriber station receives the WiMAX signal and at the same time, this equipment is a WiFi hotspot.
- Check the availability of Hiperlan terminals for the 5.4 GHz frequency band,
 - Test successfully performed. Some Hiperlan equipment was tested at Astrium laboratory.
- Check the possibility to run an HTTP application between a WiMAX capable terminal in the local access domain and any server in the remote ground IP network,
 - Test successfully performed. For an on-field user, it was possible to use Internet and http browsing.
- Check the possibility to run an FTP application between a WiMAX capable terminal in the local access domain and any server in the remote ground IP network,
 - Test successfully performed. For an on-field user, it was possible to run FTP transfers with the WISECOM Management room and with Astrium FTP server.



- Check the possibility to send and receive emails from a PC connected behind a WiMAX Access Point,
 - Not implemented for the demo. The users can use webmails to receive and send emails.
- Check the possibility to run voice conference applications involving one or several users in the local access domain and one or several users in the disaster safe segment,
 - Test successfully performed. During the demo, a videoconference was run using Marratech tool, with 4 users: on-field user, WAT user, Command centre user and a user at Astrium premises.
- Check the possibility to identify users in the WiMAX hot spot,
 - Test successfully performed. On the Web interface of the WiFi hotspot, we can see how many users are connected to this Hotspot.
- Check the WiMAX Coverage (LOS, NLOS, rural areas, urban area, ...)
 - The WiMAX coverage was tested at DLR premises on the on-field area. But the coverage limits were not tested.
- Check the availability of WiMAX combined with WiFi equipment,
 - Tested OK.
 - Check the possibility to run an HTTP application between a WiFi capable terminal in the WiFi local access domain (using WiMAX + DVB-RCS as backhauling) and any server in the remote ground IP network,
 - Test successfully performed. For an on-field user, it was possible to use Internet and http browsing.
 - Check the possibility to run an FTP application between a WiFi capable terminal in the local access domain (using WiMAX + DVB-RCS as backhauling) and any server in the remote ground IP network,
 - Test successfully performed. For an on-field user, it was possible to run FTP transfers with the WISECOM Management room and with Astrium FTP server.
 - Check the possibility to send and receive emails from a PC connected behind a WiFi Access Point (using WiMAX + DVB-RCS as backhauling),
 - Not implemented for the demo.
 - Check the possibility to run voice conference applications involving one or several users in the local access domain and one or several users in the disaster safe segment,
 - Test successfully performed. During the demo, a videoconference was run using Marratech tool, with 4 users: on-field user, WAT user, Command centre user and a user at Astrium premises.
 - Check the possibility to identify users in the WiFi hot spot (using WiMAX + DVB-RCS as backhauling)



- Test successfully performed. On the Web interface of the WiFi hotspot, we can see how many users are connected to this Hotspot.
- Check the WiFi Coverage,
 - The WiFi coverage was tested at DLR premises on the on-field area. But the coverage limits were not tested.
- Check if the local loop equipment is manageable from the WISECOM server, using SNMP management tool or proprietary management tool.
- Not implemented during the demonstration

3.4.2.2 Performance Tests

- Check the latency of the WAT (WiMAX + WiFi + DVB-RCS),
 - Test OK. Please refer to the following point.
- Check the bandwidth, the bit error rate, the delay and the jitter,
 - Tests OK. Tests were made at Astrium Laboratory, with the same architecture as the one deployed for the demonstration.

The tests are played between a WiMAX Base Station and a WiMAX Subscriber Station; this one has a WiFi Access Point module. This test permits to measure the characteristics of a WiMAX wireless link.

A satellite access (TAS) is available in order to measure the characteristics of a hybrid system coupling a WiMAX wireless network with a DVB-RCS satellite access point. The satellite system is connected to the Base Station. The end-users are connecting to the system over the WiFi Access point at the subscriber station level.

Throughput tests are made in UDP with different packets sizes. It permits to know the maximum throughput of the equipment. Bandwidth, delay and Round trip time delays have been measured for different architectures: WiMAX only, WiMAX/ WiFi, WiMAX/WiFi with the satellite access.

- Check the video quality of the video conference (or call),
 - The video quality of the Marratech conference was quite good during the tests and the demonstration, once the parameters of the users' computer, webcams, and of the Marratech room were properly set up.
- Check the set-up time of a video conference,
 - Test OK. The video-conference can be set up quite quickly, with only the satellite latency. Once Marratech is launched, the on-field user has to wait 3-5 seconds to have a full access to the visio-conference tool.
- Check the probability of blockage of the video conference (no successful set-up),
 - Test OK. During the tests and demonstration, no blockages were observed.
- Check the probability of dropped video conference (during an active video conference),



- Test OK. During the tests and demonstration, no user was dropped of the video conference.
- Check the voice quality of the voice conference or call (Mean Opinion Score, MOS),
- The voice quality of the voice conference was quite good during the tests and the demonstration, once the parameters of the users' computer and of the Marratech room were properly set up.
- Check the set-up time of a voice conference,
- Test OK. The voice-conference can be set up quite quickly, with only the satellite latency. Once Marratech is launched, the on-field user has to wait 3-5 seconds to have a full access to the visio-conference tool.
- Check the probability of blockage of the voice conference (no successful set-up),
- Test OK. During the tests and demonstration, no blockages were observed.
- Check the probability of dropped voice conference (during an active video conference),
- Test OK. During the tests and demonstration, no user was dropped of the voice conference.
- Check the time to transfer file (of different sizes) from the ground to a user terminal over the satellite link using FTP,
- Test OK. The WiFi and WiMAX systems have a quite large bandwidth and the FTP was working well during tests between user located at the WAT and an on-field user. For complete tests including the satellite link, the FTP transfers between an on-field user and a remote user on Internet worked well. The bottleneck was the satellite point where the bandwidth was limited to 3 Mbits/s at the maximum during the demonstration.
- Check the Browsing activity: the average time between the sending of an HTTP request (click on a link) and the effective reception of the corresponding Web Page,
- Test OK. An on-field user can access to Internet and can surf on the Web. For a complete test including satellite, the browsing activity vary following the total activity on the satellite segment (others users). This browsing activity depends on the requested website. The average is about 750 ms, but it is very fluctuant.
- Check the time to transfer emails (of different sizes) from the WiFi local access domain to any user on the ground networks (or to the email server),
- Not implemented for the demo. The application used for the emails was webmail.
- Check the interface with the WISECOM server services (DHCP, billing, ...),
- The billing system was not implemented for the demonstration.
- DHCP: tests OK. The DHCP server used for the WiMAX/ WiFi system was the one located at the WAT and was working properly to attribute IP addresses to



the End-users equipments (WiMAX and WiFi equipments were attributed static IP addresses for the remote management).

- Check the QoS mechanisms (prioritisation, several classes of traffic, ...),
 - Test OK. The advantage of the WiMAX system is the possibility to classify the traffic and affect a QoS depending on the traffic. Several classes of services were defined: Voice, Videoconference (Marratech), LBS services, FTP services, and others. The problem is that the QoS is applied only on the WiMAX link and neither at the WiFi level nor at the satellite level.
- Check the Security Mechanisms: WPE, WPA, etc. offered by the equipment,
 - Test OK. The WiFi equipments were configured with WEP encryption so that the on-field users need to know the WEP key before being connected to the system.
- Check the Location Based Services:
 - Accuracy of the user location (for members of rescue teams),
 - Periodic update of the location of members of rescue teams,
 - Display of user location on maps with sufficient accuracy, different colours for different types of users, etc... in the co-ordination centre.
 - Not performed. The LBS application was not tested with the complete system DVB-RCS+ WiMAX+ WiFi. Nevertheless, the PDAs can be easily connected to the WiMAX and WiFi system for WebBrowsing and VoIP communications. We can suppose that there is no problem to use the LBS application with these PDAs.

3.4.2.3 Load Tests

- Check the number of simultaneous video conferences that can be carried out over the satellite link,
 - Test OK. The bottleneck of the system DVB-RCS + WiMAX + WiFi is the satellite point. Nevertheless, during the demonstration, four users were involved in the Marratech visio conference: 1 on-field user, 1 user at the WAT level, one at the command centre, and another on Internet. These four users had webcam streaming and voice. No problem was detected for this Marratech visioconference.
- Check the number of simultaneous voice conferences that can be carried out over the satellite link,
 - Test OK. Please refer to the previous test.
- Check the number of simultaneous HTTP applications that can be carried out over the satellite link,
 - Not performed during the demonstration. During the tests phase, the Web access was tested for several PCs with at least 4 computers.
- Check the number of simultaneous FTP transfers that can be carried out over the satellite link,
 - Not performed during the demonstration. During the tests phase, the FTP transfers were tested for transfers with at least 4 computers.



- Check the Network Activity by simulation: test the possibility of performing several activities in parallel behind the local loop (FTP download + Web Browsing + videoconference, etc...).
- Test OK. During the demonstration several activities were done in parallel: video conference with 4 users, one VoIP communication, FTP transfers and Web browsing, with a quality of Service to prioritize real-time traffic.

3.4.3 Evaluation

3.4.3.1 Positive Findings

The whole system was working well. All the applications were working during the demonstration: visio conference, voice over IP, FTP transfers, Web browsing. The extensions with WiFi modules is a good comprise today as end-user equipments are not WiMAX compliant. The packaging and the deployment of the equipment was quite easy so as to respond to the end-users needs.

3.4.3.2 Improvement Potential

The WiMAX base station was connected to a power module which is not waterproof. At the subscriber level, the WiFi is not water resistant too. A potential improvement would be having complete integrated equipment which is totally waterproof resistant so as to be easily deployed in disaster conditions.

3.4.3.3 Proposed Configuration for Future Development

Currently the manufacturers are working on end-users terminals which are WiMAX compliant. With these types of equipments, on the subscriber stations, no WiFi module has to be deployed. And the end-users can be connected to the network thanks to their laptop, phone, PDA, directly using WiMAX and not WiFi. These equipments should be available in the unlicensed band.

3.5 TETRA over DVB-RCS

3.5.1 Objectives and Expected Outcome

The trials objective for the TETRA over DVB-RCS configuration is to demonstrate that in case of emergency, the WISECOM system is able to successfully restore a local TETRA (400 MHz) coverage capable of supporting audio communication in direct mode either in local mode (field mode) or thanks to a backhauling link over the DVB-RCS satellite system (relay mode).

3.5.2 Test Outcome

The test outcomes described in this section have not been obtained during the trial since the TETRA system was not ready for this event and thus was not demonstrated on this occasion (due to late delivery from the supplier). However, integration and tests have been carried out in parallel at TAS premises in Cannes, according to the initial objectives. The results are presented below.

3.5.2.1 Basic Service Tests

- Check the possibility to set-up a voice call (TETRA direct mode):



- From a member of a rescue team to another member of a rescue team in the local access domain,
- From a member of a rescue team to any other number on ground networks.

➤ Tested OK. The TETRA equipment (BTS, BCU and antenna) was set up and two TETRA handhelds were used to establish an audio communication between two parties in the local TETRA network (field WLAN)

Then the TETRA sub-system was connected to a SIP server (Asterisk, same kind as the one used for the WAT) which was itself linked to a PABX connected to public phone networks (both PSTN & PLMN). A phone call was successfully established between a TETRA handheld and a fixed phone and then a cell phone.

- Check the possibility to use the Short Data Service (i.e. to send SMS).
- Tested OK. The equipment (BTS, BCU and antenna) were set up and two TETRA handhelds were used to successfully send a short message between two terminals.
- Check the possibility to transfer data using one or several TETRA channels (Data Transfer Service, DTS).
- Not tested because the equipment was not supplied with the appropriate modules to test this function (specific PEI interface cable and specific software for data modem emulation). A request has been sent to the supplier to ask for this specific equipment, but it has not been received at the time when this deliverable is written. However the objective remains to test this feature when the appropriate equipment will be available.

3.5.2.2 Performance Tests

- Check the voice quality (mean opinion score).
- Test successfully performed. The Mean Opinion Score calculated after the different tests, was 4.0. That means that the quality was good with minor imperfections.
- Check the voice call set-up time.
- Test successfully performed. The average time to establish a communication between a TETRA handheld and a SIP terminal (typically a ToIP) is approximately 3 seconds.
- Check the probability of voice call blockage (no successful set-up).
- Test successfully performed. No call blockage was encountered during the tests.
- Check the probability of dropped voice call (during a call).
- Test successfully performed. No loss of audio communication was encountered during the tests.
- Check the time to transfer a SMS.
- Test successfully performed. The delay to transfer a SMS is approximately 5 seconds.
- Check the time to establish a DTS connection.



- Not tested because the equipment was not supplied with the appropriate modules to test this function (cf. detailed explanation above).

3.5.2.3 Load Tests

- Check how many voice calls can be simultaneously carried out over the satellite link.
- Not tested. The scope of the tests was to validate the interoperability of a TETRA system with a SIP server limited to the disaster segment (i.e. local interoperability with SIP-based equipment deployed in the field at the WAT level). The objective here was not to reach the disaster-safe segment, but rather to validate a first step of interaction at field level.
- Check the maximum bit rate that can be obtained with the Data Transfer Service.
- Not tested because the equipment was not supplied with the appropriate modules to test this function (cf. detailed explanation above).

3.5.3 Evaluation

3.5.3.1 Positive Findings

The H323-SIP plugin of the SIP server implemented in the WAT (Asterisk) offers an easy and efficient way to implement interoperability with TETRA devices at field level. However, attention should be paid to the audio codecs available on both systems in order to achieve interoperability. Interoperability is not quite “plug-and-play” since it requires to select compatible codecs on each side. When this is possible then the interaction between the devices is good and transparent to the user. Configuration of the Thales TETRA equipment is not too complex and can be done rather easily by a non-expert technician.

3.5.3.2 Improvement Potential

It would be interesting to go one step further and check the capability to establish audio communications between a TETRA device and another one located within the disaster-safe segment (either ToIP, GSM or TETRA), though technically speaking once the SIP conversion has been done (using the H323-SIP gateway in the present case) there is no reason why that communication could not be relayed by the SIP server beyond the WAT, as this has been successfully demonstrated for pure SIP communication. Nevertheless, the testing is worth doing to assess the incidence of the satellite link over the communication in terms of voice quality and call loss.

Another interesting to address topic would be the possibility to interconnect two remote TETRA systems using a DVB-RCS satcom relay provided by two WATS (TETRA trunking). It was not possible to check this in the context of WISECOM since only one TETRA system was available, but it is nonetheless relevant.

TAS intends to address at least the first issue outside of the project and inform partners and the E.C. about the outcome.

3.5.3.3 Proposed Configuration for Future Development

In order to take full advantage of TETRA some features of the system will need to be evaluated in the context of the WAT. In particular, the capability to use the TETRA



device as a data modem could be valuable. Normally the WAT includes all the communication equipment (IP over DVB-RCS) and interfaces (Ethernet ports or Wifi/WiMax) that would allow an end-user to transfer data very easily. However in a real crisis situation all the field actors would not be in direct proximity to a WAT. WiFi is obviously a first possibility to allow remote access but TETRA offer a much larger range of action, so that an end-user equipped with a TETRA hand-held will prefer to transmit data using this device rather than moving back to the WAT if the distance is too important (several km of instance). Therefore data transmission using TETRA devices is likely a feature that would be useful for field actors. The TETRA equipment available during the project was not supplied with the appropriate modules to test this function (specific PEI interface cable and specific software for data modem emulation). A request has been sent to the supplier to ask for this specific equipment, but it has not been received at the time when this deliverable is written. However the objective remains to test this feature when the appropriate equipment will be available.

3.6 Integrated Telecommunication and LBS Services

3.6.1 Objectives and Expected Outcome

Integrated telecommunication and LBS services focus on the real-time tracking of rescue teams, the exchange of short messages or other files between alarm centre, controllers and rescue teams (geomessages, instructions from control centre) and the broadcast of received information to all rescue team PDAs, as relevant.

The main location based service offered is focused on the following set of communication actions related to the triage phase of victims (please refer to [RD-1] for further details):

- Alarm,
- Reporting of the first medical units to the alarm centre about health status of victims (colour identification, location),
- Sending of the appropriate amount of rescue team members for the triage: each victim receives a colour code according to its state and information about it is saved in a database (location, gender, type of injury and possibly send very short messages...).

The proposed solution will have to demonstrate the following requirements:

- Fully packaged solution,
- Very simple interface for use by medical teams,
- Robustness (to shocks, humidity, etc) of the proposed solution,
- Full mobility and rapid reaction of medical teams, permanent connection,
- Connection to the network in a very short time (typically around 5 minutes from the time of arrival of rescue teams on site).

Real time monitoring of victim location on the side of decision makers (located at headquarters (alarm center) and / or on-disaster side) with mapping on a map of the disaster site detailed enough to enable the deployment of additional rescue teams is also needed.



3.6.2 Test Outcome

3.6.2.1 Basic Service Tests

- Tracking of 1 team: rescue team PDA linked through WiFi or GPRS link to WAT and over satellite link to alarm centre. Configure PDA positioning update interval e.g. 30 sec, move around in the test area and observe that correct location points are registered at the alarm centre every 30 seconds. This information should also be saved locally on the PDA,
 - Test successfully performed. PDA positions were updated according to the configuration parameter which was set to every 30 seconds. In the final test prior to the demonstration, each location point was connected to the previous one, showing a track of the PDA movements. After some time however, this approach resulted in too much clutter on the screen and it was felt that it is better if the controller can see clearly which team is currently nearest to a particular victim or location. Accordingly, a last minute change was made to the software and for the demonstration itself only the current position of each PDA was displayed.
- Tracking of 2 teams: 2 different rescue team PDAs move around in the same area. Alarm centre should show both tracks on a map, using a different colour code for each team,
 - Test successfully performed. For the demo, there were both triage teams and ambulance teams, depending on what User ID was used when the PDA logged on to the WISECOM server. Triage teams were indicated with a red cross and ambulance teams with a green cross. As described in the previous comment above, continuous tracking of the teams was replaced by just showing the present location.
- Geomessaging: rescue team PDA sends a data file with geographic location information included (geomessage) to alarm centre. This is sent manually and can be sent at any time, irrespective of the tracking process,
 - Test successfully performed. The controller has the option to view a layer showing the locations of all messages received. A window shows a list with the contents of all received messages. Messages from the PDAs can be sent to any of the other units, i.e. to one or both controllers and / or to any of the other PDAs in the field.
- Instructions: Confirm sending of messages from control centre to specific rescue team,
 - Test successfully performed. The controller was able to send messages to any (or all) of the PDAs in the field. Typically the messages sent were instructions something like "Take victim 335 to green tent". The PDA operator was then able to search for the specified victim, as a result of which the PDA showed the requested victim location, therefore the team easily knew where to go next.
- Broadcast: Confirm that the alarm centre has the capability of sending updated map and tracking information and geomessages to all rescue team PDAs,



- Test successfully performed. Broadcasting of messages to any or all PDAs and controllers was demonstrated. Controllers do not themselves send geomessages, but all messages sent by PDAs contain embedded location information. The alarm centre itself does not actively send updated map and tracking information. However all such information is available on the server, in principle visible to all PDAs and controllers. In practice, the actual information visible to each PDA may be constrained if required by appropriate setting of configuration parameters.
- Test of the LBS telecommunication application for triage, according to the specifications described below:

3.6.2.1.1 Controller Side

1. When the application is started, the controller must log on. The controller logs on by means of a secure web interface; therefore he could in principle be located anywhere with Internet access.
 - Tested OK.
2. Several controllers may be logged on simultaneously.
 - Tested with two controllers OK.
3. All controllers may be presented with the same information or specific information about certain emergency field teams only.
 - Tested OK. All PDAs in the field are available as separate layers, each controller has the option to see any or all of the PDAs by selecting from a drop-down menu. Default views are assigned at login time according to the user login id.
4. After logging on, the controller is presented with a map of the disaster area:
 - For the demo the maps were pre-loaded into each PDA and on the server. The map can in principle be downloaded from a server based on the WAT position information.
5. Each PDA has the option to “update WAT position”.
 - Tested OK. Each PDA has a parameter in the configuration file that specifies whether the PDA is authorized to update WAT position or not. If not, the corresponding option in the menu is “greyed out”. When a new WAT position is notified, the WAT location is reflected on the screen of both PDAs and controller PCs, according to the configured update intervals.
6. When the triage teams start their activities, the controller is presented with their locations and a track of the route they have followed, updated every X seconds, where X is configurable:
 - Tested OK. Rather than showing the track of the locations, only the current position is shown. This change was based on user feedback and improved the usability.
7. Every time a victim is tagged by the triage team, the victim information including triage colour (=severity) code, location information and time tag (obtained via GPS), is presented to the controller.
 - Tested OK. Additional information about each victim can also be sent if required.
8. Any victim update information is presented to the controller in real time as the update is received.



- Tested OK. Victim status can be updated from each PDA, the unique victim ID has to be specified in all cases.
- 9. The controller screen shows the present known status and location of all triage teams and victims so far identified. For the triage teams also a track of their movements is shown.
 - Tested OK.
 - Each controller can select which PDAs to follow
 - Controllers see current location only
- 10. Right clicking on any of the victims' icons or dots presents the controllers with all historical information noted since the victim was first identified.
 - Tested OK.
- 11. Management of victim IDs: When a member of a rescue team locates a new victim (when he selects "new victim" on the screen of the PDA), he must also enter a unique 3-digit code as victim ID, which is communicated to the server. For the demo this victim ID is prewritten onto each triage tag used. Any further actions related to any of the victims (history, victim status update) require inputting the entire 3-digit code.
 - Tested OK. Note that this is intended for facilitating the demo only; an eventual operational system may use barcodes or RFIDs.
- 12. Once the victim has been moved to a final destination (hospital or morgue or home...) the icon or dot is no longer shown to the controller. The historical information related to the victim is nevertheless maintained and can be recalled by the controller by searching on any of the identifying fields (victim id etc).
 - Tested OK
- 13. Each controller has the possibility to send text instructions to any or all (by multicast) of the triage teams
 - Tested OK

3.6.2.1.2 User Side

1. Each WAT installed in the field will determine its own GPS coordinates and transmit these to the LBS server.
 - Not implemented for the demo, WAT position communicated by user PDA.
2. When PDA first turned on and triage application started, the user shall be presented with a login screen.
 - Tested OK. User can log in as Triage team (t1, t2, etc) or ambulance team (a1, a2, etc)
3. Login shall then be validated by the server side of the application.
 - Tested OK
4. Login may also determine the type of user, triage or fire dept or whatever – in this case the user receives a welcome message informing: „you are logged in to the triage application” or equivalent.
 - Login message not implemented, this is trivial to add if desired.
5. When application starts, it initiates a GPS positioning and communicates the results of this positioning to the control centre, together with the GPS timestamp.
 - Tested OK



6. Position information is displayed at the control centre side.
 - Tested OK
7. Position information is also relayed to the user PDA and displayed on a map on the screen.
 - Tested OK. Position update frequency depends on a parameter value that is separately configurable for each PDA
8. From this point onwards, the PDA is GPS-positioned every X seconds, where X is a configurable parameter.
 - Tested OK. X was set to 45 seconds for the demo.
9. The control centre shall be aware of the position of the user asap after the positioning has occurred and shall display this on a map on the local monitor.
 - Tested OK. User position updates were received and displayed in real time on controller screen.
10. The user's own position shall be displayed on the map on the PDA screen. A particular PDA can also view the current position of any other PDA. The PDA configuration file will include a list of the other PDAs that will be displayed, but this is disabled by default. Tracking of other PDAs is not foreseen, as this will clutter up the PDA display.
 - Feature tested OK in lab, not tested during demo.
11. Each user can at any time send text or other messages to the controller. These are always tagged with the user location coordinates and timestamp.
 - Tested OK. Messages can be sent to any or all controllers and other PDAs. Attachments can also be sent.
12. After logon, the user may choose between:
 - a) New victim found
 - OK. "New victim" button
 - b) Update victim status
 - OK. "Update victim" button
 - c) Messages
 - OK. "Messages" page has the options of "read messages" or "create new message"
 - d) Update WAT position
 - OK. If allowed in PDA configuration file
13. Under "new victim" page, the following information should be available or filled in by the member of the rescue team:
 - a) Victim ID
 - b) Colour code: green, yellow, red or black (select one of 4 buttons on screen)
 - c) Victim location and geographical coordinates (automatically filled in by the PDA with GPS) along with timestamp
 - d) Victim name (optional): may be unknown, may be easily found under some circumstances,
 - e) Victim blood group (optional): may be unknown, may be easily found under some circumstances,
 - f) Victim further info (optional): a text field, that may or may not be filled in by the member of the rescue team,



- g) Victim status: e.g. automatically set to: "Waiting for transportation",
 - h) In this phase, the most important thing is to ensure that the basic information is transmitted very simply, that it can be easily used under stressful conditions. No pointer required, use of coloured touchpads on screen to select the triage condition.
- Tested, all OK.

14. In the second option, "update victim", the following information is available:

- a) Selecting the "Update victim" button asks the user whether to "update status" or "update location". In both cases the user must enter the victim ID.
 - b) For "update status, the user is presented with essentially the same screen as in point 13 above ("New victim found" screen), any of the fields including triage status (green, yellow, red, black) can be updated.
 - c) With "update location", the user can choose between:
 - "new location", which results in a position update being sent to the server
 - "in transit", which changes the victim icon from the default triangle to a circle on the displays of all controllers and PDAs. This indicates that the victim originally found at the given location is currently being transported to a new location.
 - "final destination", which may be the green tent or other treatment center. Selection of this option results in the victim icon being removed from the displays of all controllers and PDAs.
- Tested, all OK.

- Test of the positioning of rescue team members and victims on a map with sufficient accuracy.
- Test OK. Accuracy of GPS positioning was very good during the demo, which was in an open field with no obstructions. However, when tested besides the DLR building with only a few satellites in view, the position found could be inaccurate by 10s of meters. When Galileo is eventually operational (current prognosis 2012) the positioning accuracy available will be improved and also the signal will be more robust to obstructions and other disturbing factors.

3.6.3 Evaluation

3.6.3.1 Positive Findings

In general, the LBS application worked well, and feedback from the users indicated that the application itself is very valuable for helping to improve the logistics of a chaotic situation. The possibility for the operation controllers to have a real time overview of the location and severity of injuries of all identified victims is unique and very beneficial. Also the possibility to know where ambulance teams are and to easily direct them to specific locations and victims is a definite improvement over current practice.

3.6.3.2 Improvement Potential

One of the most important aspects of the demo itself was to allow the WISECOM team to understand what areas of the system need improvement. There were some



usability and performance issues, which would need to be improved for an operational system:

- Some of the PDAs used had difficulty acquiring the GPS signal. One of the units did not acquire the signal at all; another one finally acquired the signal after more than 5 minutes. This problem is outside of the direct scope of Wisecom, as it is related to the GPS implementation in the PDAs used. This is a technical issue which is fortunately being constantly improved; therefore one can foresee that the situation will be much better in the coming years.
- The WiFi signal did not give adequate signal strength over the entire area of operation. In fact, the controller in the field was set up quite far away from the WAT and behind the only possible obstruction (a tree) on the field. This situation resulted in occasional loss of WiFi signal and depending on what operation was being carried out, the software could hang, requiring a restart. This leads to two observations:
 - Hardware: WiFi is not the optimal choice for local access. Coverage is limited and obstructions affect the signal too much. WiMAX, as also demonstrated by Wisecom, would be far better and would solve most of the local access radio connection problems. The reason it was not chosen for the demo is because the technology is not as mature as WiFi and there are currently no PDAs with inbuilt WiMAX modems that we are aware of. However, it is clear that the use of WiMAX would provide a much more robust local access link.
 - Due to the limited resources available, it was not possible to develop the software to fully commercial standards. A basic premise was that both GPS signal and the WiFi link are reliably available. For a fully operational system, the software needs to be able to elegantly handle all possible error states associated with loss of either of these signals at any time, e.g. loss of WiFi in the middle of an ftp process.
- The current solution, using a hand-held PDA is not optimal for use in the field, especially as it needs both hands of the operator, one to hold the PDA in a position where both WiFi and GPS are received and the other to enter information using the stylus. One possible improvement could be to use an external GPS receiver, for example attached to the operator's helmet, and WiMAX as mentioned above, so that signal strength is improved. The PDA could be also mounted on a special harness that does not require it to be hand held.
- The PDA screen is difficult to read in full daylight conditions. This is an issue with all such displays, some technical solutions are available.
- Currently the LBS software only displays the present location of the teams in the field, which after the preliminary trials was felt to be the most useful presentation method. A previous version showed a track of the movements of each team. It could be useful for the controller to be able to easily select one or the other view, default being current position only, but being able to select a track of any or all teams to see what parts of the disaster area have already been covered.
- For an operational system, the server should have access to detailed map and aerial photo information of all locations in the operator's area of responsibility.



Based on the WAT position, appropriate map data can then be downloaded from the server to both PDAs and controller PCs.

- The WAT itself should be equipped with its own GPS receiver and on setup in the field should itself inform the server of its location.

The PDAs used by triage teams and ambulances should be equipped with barcode readers for automatic registration of the unique victim IDs associated with any triage tag. Alternatively and preferably, future triage tags may include RFID tags, which should be readable by the PDAs or other handheld terminals used.

3.6.3.3 Proposed Configuration for Future Development

The original LBS architectural design was presented in WISECOM deliverable D2.2-1, Figure 2.9. This architecture had all the WISECOM server functions located in the WAT, and synchronized with the WISECOM server located in the disaster-safe segment. Therefore, all communications between the PDAs and WISECOM server took place over the local access link only and not over the satellite link. In order to minimise development risk for the demo, it was decided to have one WISECOM server only, which was physically located near the controller in the disaster-safe segment. As a result, all communication between the PDAs and the server went over the satellite link, which was not optimal for performance (delay issues).

The optimal configuration for future development is therefore the one originally designed, in which the server functions are mirrored in the WAT. Other improvements are possible; these are described in the previous section.

3.7 Tests related to the WISECOM Access Terminal

3.7.1 Objectives and Expected Outcome

For each previously defined hybrid configuration, several tests should be run concerning the future integration of each hybrid configuration in the WAT used during the demonstration:

- Power consumption test,
- Autonomy test, i.e. measurement of the time the WAT can autonomously run with batteries,
- Weight, size and shape test (especially for the BGAN solution, the equipments should be light and reduced in dimension),
- Mechanical robustness test,
- Inter-operability test (the hybrid configuration should be designed to be easily integrated with an other one (e.g. WiFi over DVB-RCS and GSM over DVB-RCS)),
- Installation and deployment test.

These tests should be performed for each single hybrid configuration, so that the final WAT only requires limited amount of effort to conform to a maximum amount of requirements as stated in [RD-1].



3.7.2 Test Outcome

3.7.2.1 GSM + WiFi/WiMAX + TETRA over DVB-RCS

The DVB-RCS version of the WAT has been designed to integrate in the same system GSM, WiFi/WiMAX and TETRA functionalities, although TETRA was in the end not included in the final demonstration. Taking into account this complete hybrid configuration, the following tests were performed:

- Power consumption and autonomy test,
 - Test successfully performed. In order to power up all the necessary equipment included in this system hybrid configuration, the different parts were plugged in on the socket which was available in the rack. This socket was connected at the same time to the power generator which was providing up to 1kW, which was proved to be sufficient for powering up the whole system. Regarding the autonomy of the system, it was verified that with the power generator fully loaded with petrol it was possible to run the system during 2,5 hours.

Apart from the equipment mounted in the rack, the WiMAX subscriber station was also taken into account when testing the power consumption. According to this, it was verified that it was possible to power up the system using the lighter included in the 4-wheel drive car and also with a 12V socket included in the vehicle.

- Weight, size and shape test,
 - Test successfully performed. The DVB-RCS configuration of the system is intended to be carried by a transportation vehicle, such as a 4-wheel drive car. For this reason, an important part of the tests consisted of checking that all the necessary equipment could be loaded, transported, and unloaded in an easy way by the members of the rescue teams. It must be also taken into account, that apart from the equipment included in the rack, the DVB-RCS antenna, the WiMAX subscriber station and the power generator should also be carried in the vehicle.

Regarding the size and weight of the different elements, the rack dimensions are roughly 78x51x45 cm (height, width, depth) and weights around 40 kg when it is fully loaded. The WiMAX subscriber station was mounted on a plate which roughly measured 51x45 cm. Finally, the DVB-RCS antenna had a diameter of 1,2 metres and weights around 35 kg.

During this test it was verified that all the equipment fitted in the vehicle, as can be seen in Figure 3-2, and that it was possible to load and unload all the elements in an easy way with the help of two people, which will normally be the members of the rescue teams also travelling in the vehicle.



Figure 3-2: 4-wheel drive carrying the equipment for the DVB-RCS configuration

- Mechanical robustness test,
 - Test successfully performed. All the elements mounted in the rack and in the plate where the WiMAX subscriber station was transported were fixed to the corresponding plates in a robust way. During this test, it was verified that any of the elements had the risk to be damaged or lost neither because of the transportation of the system using the already mentioned vehicle, nor during the deployment of the system on the field.
- Inter-operability test,
 - Test successfully performed. It was verified that all the different sub-systems included in this configuration, which is GSM and WiFi/WiMAX, were able to work simultaneously without interfering each other.
- Installation and deployment test.
 - Test successfully performed. It was verified that the deployment of the whole system, as well as its start-up, could be done in a reasonably short time. Specifically, the necessary time to set up all the hardware equipment, including the mounting of the DVB-RCS antenna, is around 5 minutes. In addition to this, only 5 more minutes are necessary in order to point the DVB-RCS antenna towards the proper satellite. Thereafter, 3 more minutes are necessary in order to start the software.

3.7.2.2 GSM/WiFi over BGAN

The BGAN version of the WAT has been designed to integrate in the same system GSM, and WiFi functionalities. Unlike the DVB-RCS configuration, one of the goals of



this version of the system was to provide a light-weight and easy-to-deploy system to be quickly set up just after the disaster occurs. Taking into account this complete hybrid configuration and the objectives to achieve, the following tests were performed:

- Power consumption and autonomy test,
 - Test successfully performed. It has been tested that the whole system could be powered up using rechargeable Li-Ion batteries which supply 25.9 V to the system. Using these batteries, it is possible to power up not only the WAT, but also the WiFi access point and the GSM base station, which are all included in the ruggedized box. It has also been tested that the duration of the batteries, when fully charged, is approximately 4 hours.

Apart from the batteries, the system has been designed to operate using an external AC power supply as well. The output voltage of the already mentioned power supplier is 24 V. Taking into account this operation mode, it was also tested that the system worked properly when using this external power supply.

- Weight, size and shape test,
 - Test successfully performed. As already stated above, one of the most important goals of the BGAN configuration of the system was to provide a light-weight and small system to be carried easily by the members of the rescue teams.

In order to achieve the proposed objective, all the elements of the system, except two external WiFi antennas, could be easily transported using a ruggedized and waterproof case. The dimensions of the ruggedized case are roughly 24x49x38 cm (height, width, depth), and it weights around 6.5 kg when fully loaded.

It was verified that it was easy to carry all the necessary equipment by a single person due to the light weight of the different elements and to the use of the ruggedized box.

- Mechanical robustness test,
 - Test successfully performed. It was verified that the system could be transported and deployed in a robust way, due to the fact that all the necessary equipment was carried inside a ruggedized and waterproof box. It was also checked that the equipment was not moving inside the box thanks to the metallic rack that was developed to fix the equipment. On the contrary, some equipment could have been damaged because of moving inside the box.
- Inter-operability test,
 - Test successfully performed. It was verified that all the different sub-systems included in this configuration, which is GSM and WiFi, were able to work simultaneously without interfering each other.
- Installation and deployment test.
 - Test successfully performed. It was verified that the installation and deployment of the whole system could be done in approximately 5 minutes. This time includes the time to start and point the BGAN terminal, connect the



external WiFi antennas, and start up the system, which takes around 3 minutes to be initialized. Apart from being a fast process, the deployment of the system on the system was perceived as a very easy and simple procedure by non-technicians who were involved in the tests and the demonstration.

3.7.3 Evaluation

3.7.3.1 Positive Findings

In order to evaluate the positive findings of the WAT, the two possible configurations described above must be taken into account:

- DVB-RCS configuration: Among the positive findings, the following issues can be considered:
 - The system can be powered up using a simple fuel power generator.
 - The installation of the different elements in a rack allows users to carry the system in an easy way and protects it during its transportation. Using this system, the equipment can also be loaded in the proper vehicle with the help of only two people.
 - The different sub-systems, such as GSM, WiFi/WiMAX and TETRA, can properly run with independence of the other systems. Thus, if any of the systems is not being used, the remaining services can still be used in a normal way.
 - The deployment of the system can be performed in an easy and fast way, even by non-trained people. Only the pointing of the DVB-RCS antenna requires a higher grade of experience.
 - The modular way in which the different elements are installed and configured on the WAT, allows the addition of new features or the modification of the existing ones in an easy way.
- BGAN configuration: Among the positive findings of the BGAN configuration, the following ones can be remarked:
 - Due to the use of Li-Ion batteries, all the elements of the system can be properly powered, providing the system with an approximate autonomy of around 4 hours.
 - It was possible to carry all the necessary equipment, with the exception of the two external WiFi antennas, by a single person, using a ruggedized waterproof case. This case resulted to be very useful to protect the system from external knocks and weather adversities, as well as to keep the equipment in a fixed position inside the box, to avoid it to be damaged during transportation.
 - Due to the automation of the software installation procedures, it was possible to configure and perform a fresh installation of the whole system in a short period of time. Thanks to the modular structure of the installation procedure, new features can also easily be added and configured.

- The deployment of the system on the field can be performed in a simple and fast way, even by non-trained people. This process includes also the pointing of the BGAN terminal, which can be easily performed using the compass included on it and a graduate scale displayed on the terminal screen.
- The WiFi network can be available for users with independence of the GSM features and vice versa. Thus, if any of the sub-system is not working properly, it does not affect the remaining services of the systems.

3.7.3.2 Improvement Potential

Different improvement potential must be taken into account according to the different hybrid configurations of the system:

- DVB-RCS configuration: Regarding this configuration of the system, the most important improvement would be related to the way of carrying the different equipment. Due to the fact that some equipment is not waterproof, the way of transportation should guarantee that any of the elements could be damaged in case of bad weather conditions. Accessibility to the WAT software should also be provided in order to solve any incident that could appear during the use of the system.
- BGAN configuration: According to the present status of this version of the system, some improvements could be performed. First of all, the way of carrying the elements could be performed in order to transport all the equipment in a single ruggedized box. It must be taken into account that the present version uses two external WiFi antennas which are not included in the case. Apart from that, a system for monitoring the charge of the batteries could also be used in order to let users be aware of this information and avoid a possible problem due to an insufficient charge.

3.7.3.3 Proposed Configuration for Future Development

For each of the two configurations of the system that have been performed, the following future developments are considered:

- DVB-RCS configuration: As stated in the previous section, some improvements should be done in order to make the system completely waterproof without making it excessively heavier or difficult to carry. For these reason, it should be considered a new distribution of the equipment using another type of rack. This new rack should also allow the connection to the power supply in a secure and waterproof way.

BGAN configuration: According to the improvement potential stated in the previous section, one possible future configuration should include another type of ruggedized box in order to transport all the equipment using only this box. This modification of the box implies also a modification of the internal rack included on the box in order to keep the equipment in a fix position when being carried by the rescue teams. It would also be a positive new feature to dispose of an external button on the box in order to start and stop the system, because in the present version the button is included inside the box. In addition to this, a digital display in order to monitorize the charge of the batteries would be an added value due to the fact that it will allow the rescue teams to have more information about this issue and act accordingly to it.



4 Conclusion

This document has summarized the detailed trial and tests results and provided thorough analysis, related to the following three basic WISECOM configurations:

- GSM over BGAN configuration;
- WiFi over BGAN configuration;
- GSM over DVB-RCS configuration;
- WiMAX/WiFi over DVB-RCS configuration;
- TETRA over DVB-RCS configuration;
- Integrated Telecommunication and LBS Services;
- WISECOM access terminal (WAT).

After recalling the trial and test objectives, for each configuration detailed test outcomes have been reported and commented as applicable, typically broken down into the following test categories:

- basic service tests;
- performance tests;
- load tests.

Based on these trial and test results

- positive findings have been summarized,
- improvement potential has been identified
- and a configuration for future development has been proposed

per single configuration.

The overall trial and test results are impressive and encouraging to proceed with further exploitation of various WISECOM elements beyond the project period.