The Provision of Applications and Services through Satellite for Security and Emergency Management

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1 Abstract

Satellite systems can play an irreplaceable role in providing services to governmental bodies to satisfy a large set of requirements. In this frame, two aspects claim particular attention: security and emergency management. In fact, the former is relevant to keep information integrity and confidentiality while the latter represents a peculiar activity typically under governmental responsibility.
The Italian Space Agency (ASI) is funding a project aiming at identifying all the possible applications and services useful for public institutions, defining service requirements, defining models and operational scenarios, addressing interoperability among different systems, verifying the capability of operational systems to meet the demand, evaluating scenarios, evaluating service evolution and finally identifying a suitable architecture both at system and components level.
The paper describes in detail the project and presents the main achievements.

2 Introduction

The project named TIES (Telecommunications for Institutions for Emergency and Security) is being carried on by a team of seven partners (Telespazio, Alenia Spazio, PXL, Sisma, Aersat, University of Rome Tor Vergata, University of Rome La Sapienza). The team is in charge to identify the main service requirements, such as coverage areas, with particular attention to rural and remote areas not served by terrestrial systems, including urban in case of emergency, and to identify the more suitable services such as data and messaging broadcasting, wideband multimedia services, data gathering. The user terminal shall be portable or easy to install, mounted on vehicles equipped with automatic pointing system. Furthermore, interconnection with terrestrial systems must be cared. Thus, the user terminal will be equipped with GSM, UMTS, Tetra, WiFi extension to allow to create remote cells and distribute proper services.
To achieve his result TIES project moves on two orthogonal axes: the market needs and the technologies. The first concerns the service aspects, therefore the applications designed and provided to the Customers of the project (to this aim some potential customers have been contacted and interviewed about their main telecommunication needs in the field of security and emergency); the second concerns technological aspects and possibilities offered us from the TLC branch.

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3 Scenario

The current scenario of the applications for Emergency and Security Management has been analyzed, identifying the state of the art of the technology, the areas of interests, the institutional and private actors, the regulatory and legal aspects, and last, the national strategic scenario. The market scenario has been considered as the starting point, that will be continuously monitored thanks to the continuous interaction with the potential users. This strict information exchange with the users allows for a more detailed definition of the service requirements, reducing the potential risks associated with the innovative objectives. To this aim the main initiatives both at national and international level have been classified. Table 1 and Table 2 show a list of projects at Italian national level and world-wide respectively.

Initiative	Institution	Coverage	Status	Objectives and Tlc Systems Utilized
Obiettivo Sud	Ministero degli Interni - Dipartimento della Pubblica Sicurezza	Italian Southern regions	Implementation	VHF, GPS, multisensorial mobile system
D.G.R. n. 45 5231 (4.2.2002)	Civil Protection Regione Piemonte	Regional	Study	Radio, GSM Satellite
POLIFEMO	Civil Protection Friuli Venezia Giulia	Regional	Operational	Audio/video data Transmission over TCP/IP protocol

Table 1: Italian national initiatives

Initiative	Institution	Coverage	Status	Objectives and Utilized Tlc Systems
MESA PROJECT	No profit consortium ETSI + TIA	Europe, USA	Study	Identification of standard for tlc and broadcasting
SATELLITE SECURITY SYSTEMS	Private company	USA, Canada Mexico	Operational	Satellite IONIT, GPS
SAFECOM	U.S. Department of Homeland Security	USA	Study	Wireless communications
EMERGSAT	Indra (Spain)	Europe	Study	Satellite communication system for emergency management
ESA/Inmarsat agreement	ESA, Inmarsat, EMS Satcom ltd., Logica CMG, NERA ASA	Europe	Implementation	BGAN, satellite mobile voice and data services, 3G cellular terrestrial systems
Satellite Data Link System (SDLS)	European consortium leaded by Alcatel	Europe	Experiment	Satellite based radio communication system - Air/Ground Communications
REMSAT Real-time Emergency Management via Satellites	ESA	Europe	Implementation	Use of real-time services (satellite communications, localization, earth observation, meteorology) in emergency
I-GARMENT	Y-Dreams; Miguel Rios Designer; IT (Portuguese telecom Institute)	Portugal	Study	service for the Portuguese Civil Protection to manage the human resources on the field in near real-time

Table 2: International initiatives

Table 3 summarizes the Institutional entities of interest for the TIES project. A further level of selection will identify a restricted number of Institutional entities, which will drive application selection and requirement definition.

Institution	Department
Council Presidency	Cabinet, Civil Protection
Ministry of Internal Affairs	Fire Dept., Public Rescue, Civil Defense, Public Security Internal, Homeland, immigration Affairs
Ministry Foreign Office	Crisis Unit
Ministry of Agriculture	Rangers
Ministry of Economy	Revenues Officers
Ministry of Defense	Carabinieri, Navy, Army, Air Force
Club Alpino Italiano	Corpo Nazionale Soccorso Alpino e Speleologico
Ministry of Justice	Jail Police
Tech. Innovation Ministry (MIT)	Rupa Technical headquarter
Local Public Administration	Regions, Districts, Municipalities
Others	Red Cross, Banks, mail service, Oil companies, Maritime transportation

Table 3: Selected Italian institutions

4 Technology Identification

4.1 Analysis of enabling Technologies

The selected systems and technologies have been categorized in two main groups:

- Broadband Communications
- Narrowband Mobile Communications

The utilization of broadband systems for fixed communication can offer an enhanced set of services in conjunction with the utilization of IP common platforms with simple and easily deployable user terminals. Skyplex technologies, which further simplifies the ground terminals, can provide additional advantage. Furthermore, the L/S band systems can represent an useful complement to broadband systems for mobility communications.
Particular attention has been devoted to the interoperability aspects between satellite and terrestrial networks dedicated to the emergency services as for example Simulcast, WiFi, GSM and TETRA networks.
As far as technological aspects, the DVB-RCS technologies offer the advantage of the IP platforms suitable for the technological convergence with terrestrial networks. Alternatively the CDMA technologies can provide an higher level of secure communications.

4.2 Application and Technologies evolutionary trends

The investigation of evolutionary trends covers the following topics:

- New standards for image coding
- Evolution of protocols aimed at enhancing security and QoS
- Evolution in communication systems
- Interoperability
- New architectures for emergency coordination and management centers

All these topics have a common substrate: the integration of the supplied services into IP protocol. It is common to a wide range of networks and telecommunication systems and is selected for a large number of applications.
H264/MPEG-AVC and JPEG2000 are analyzed in order to exploit the benefits of these new coding standards for moving and still images in emergency applications. TCP/IP enhancement for satellite networks, the evolution of DVB-RCS standard, QoS in heterogeneous communication networks, the improvement of IPSec security performances and a series of protocols that can enhance performance on heterogeneous and wireless networks such as sRTP and MIKEY for multimedia applications, ROHC and Ipv6 have been approached.
The study also covered the evolutionary trends in communication systems such as On Board Processing in new generation satellite systems, Software Defined Radios and integrated multi-

standard terminals, satellite systems for mobility services and the automatic satellite tracking and pointing of the antenna in mobile terminals.
Finally, the study analyzed the architecture of an emergency coordination and management center that fulfills the requirements of emergency applications transparently using a large number of communication media, from satellite to terrestrial, that allows interoperability between emergency agencies, and follows an open architecture in order to integrate services from different kinds of suppliers (meteo bulletins, maps, geographical info, satellite images).

5 Market Analysis

The category of users that will be taken into account is the public Users and specifically institutional. In this list of user we can find Prime Minister and Board of Ministers, Civil Protection, Ministry of the Internal affairs, Ministry of Defense etc. On this basis a preliminary estimation of the potential of the addressed market has been carried out (Table 4).

Institution	Main Organizational Levels	Numerical Incidence
Council Presidency	Ministry Council	15-20 remote terminals in mesh topology for multiconference 1 regenerative access - tens of Mbit/s 10-20 transportable terminals for videoconf. and voice ptp
	Civil Protection Department	20-40 Multifuncional Relocatable Satellite Terminals up to 20 Regional Service Centres for the management of sensitive data and of the pre-post-event phases) up to 1000 mobile multifunctional terminal (SDR) 1 National Coordination Center (Presidenza del Consiglio) 1 Network Coordination Center (Telespazio) 2 Regenerative Transponders 2 Transparent Transponders
Ministry of Internal Affairs	Public Security Department	some relocatable multifuntional terminal stations few tens of geolocation anc st coneectivity terminals
	Fire department, Public Rescue and Civil Defense	up to 100 Multifunctional Relocatable satellite terminals up to 100 Remotized Mini Control Centres up to few thousands of remote mobile multifunctional terminals 1 National coordination center (Ministaro degli interni) 1 network coordination center (telespazio) 2 Regenerative Transponders 2-4 Transparent Transponders
	Dep. Internal affairs	few hundreds of mobile multifunctional terminals
	Dep. Immigration	few hundreds of mobile multifunctional terminals
Ministry of Foreign Office	Crisis Unit	1-10 star or point to point connectivity, on existing satellites
Ministry of Agriculture	Rangers	tens of terrestrial terminals for accessing data bases for the boundaries control
Ministry of Economy	Revenues Officers	hundreds of mobile broadcast terminals for the surveillance and alarm detection or reception from the observation points
Ministry of Defense	Navy	13 Operational Centers in the maritime offices 50 Fixed satellite terminals in the Capitanerie di Porto Hundreds of mobile broadcast terminals for the patrolling units for the surveillance and the control of the immigration
Ministry of technological innovation (MIT)	Rupa Operational center	up to 60 broadband satellite IP terminals as backup of the terrestrial connectivity (evolv-e) up to 450 broadband IP terminals as backup of the RIPA
Others	Italian Red Cross	tens of relocatable terminals tens of satellite fixed terminals
	Banks	hundreds of remote terminals
	Mail Service	hundreds of remote terminals
	Oil Companies	tens of remote terminals
	Maritime companies	tens of remote terminals
	Energy Transportation	tens of relocatable terminals

Table 4: Potential market

6 User Requirements Definition

Public Protection and Disaster Relief activities involve a wide range of actors as *Civil protection authorities, Humanitarian relief organizations* (from various organizations at local, regional and national level) and citizens. These various actors need to be able to cooperate.
The identified satellite services seamlessly integrate with terrestrial emergency networks and complement them in terms of coverage, bandwidth, connectivity, redundancy and broadcasting capability.
The voice service is the most important communication mean to be restored for the rescue personnel, supporting real-time co-ordination in emergencies, and for population involved in the disasters. Voice and data compression is performed to make the most effective usage of the satellite power and bandwidth resources. As far as real-time data services**,** these are virtually provided via the Internet network. For this reason the fixed and deployable terminals shall provide an Internet access. In particular electronic messaging certainly could represent a key application in case of disaster events as an alternative service to the voice. Furthermore videoconference and telemedicine are other potential applications that deserve a particular regard, bringing a new dimension to first aid.
Regarding these applications, the trend is to provide more efficient video communication services utilizing MPEG-4 coding techniques integrated with IP standards as defined in the H264 standard.

7 Executive project

To outline the Executive Application Project we aim at: *i)* identifying the most suitable technologies to meet the requirements and goals of satellite based security and emergency management applications and services, also in view of an evolutionary path that shall not be neglected in order to sustain national development and R&D and *ii)* performing trade-off activities and functional characterization studies to design the end to end satellite system architecture.
A number of key technology families has already been identified as follows:

- Software Defined Radio, suitable for the D&D of low cost reconfigurable Ku/Ka satellite terminals
- Navigation supported antenna platforms for Ku/Ka broadband in mobility
- Payload and OBP for regenerative meshed communications in DVB (RCS, S2) GEO satellite
- Security and Crisis Management applications and the relevant service centers for operation in multi-application domains.

7.1 Description

The system architecture analyzed and implemented, is based on the applications and on the enabling technologies identified during the first phase of the preliminary project. This solution should be based on a payload dedicated to mobile communications, in L/S band, and on a payload in Ku/Ka band for broadband communications, both fixed and relocatable, managing the resources in both regenerative and transparent way. The DVB technology will be preferred, both in downlink (DVB-S) and in uplink (DVB-RCS), because of the high level of integration with the IP network and the availability of low cost terminals. However the CDMA access will be considered too, above all for its advantages in terms of security aspects. The integration with the existing access technology will be taken into account, in particular addressing the interoperability between the satellite systems and the terrestrial networks, such as IP, 2G and 3G cellular systems and WLANs (Figure 1 and Figure 2).

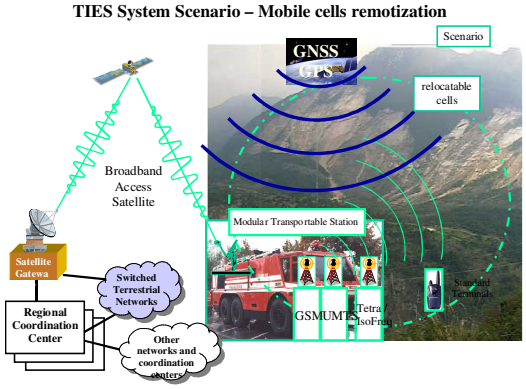

Figure 1: System scenario 1

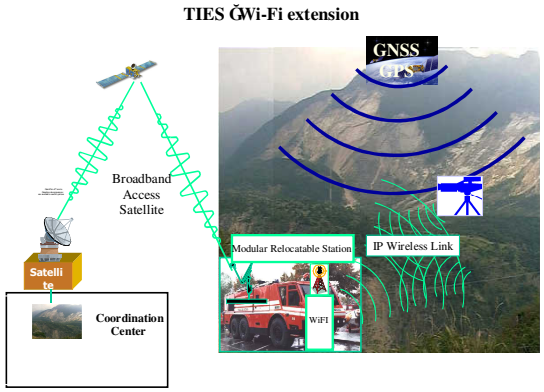

Figure 2: System scenario 2

7.2 System architecture

The second target is to identify the payload family that will be possibly targeted by the Executive Application Project. To this goal, the results of system architecture and evolutionary technology overview have been processed to determine a suitable mix (if any applies) between a mission devoted to mesh connectivity on regenerative payload and a mission devoted to star connectivity on transparent payload. To this purpose, the selected applications are classified according to their suitability to either mesh and/or star satellite topologies:

- ❖ TLC Applications for Security and Crisis Management requiring mesh satellite connectivity:
  - Virtual Private Networks and Closed User Groups
  - Backup and Gap Filler networks for Critical National Infrastructures
  - E-Health (humanitarian organizations, red cross, …)
  - E-Learning (training to armed forces or specialized operators)
- ❖ TLC Applications for Security and Crisis Management requiring star satellite connectivity:
  - Bidirectional voice/data communications to external networks
  - Data bank access and information retrieval
  - Dissemination in multicast and broadcast to external networks (e.g. alarms)
  - Trunking to ‘isles’ of external networks

The estimated bandwidth requirements and network element composition for the star and meshed architectures are summarized in the Table 5. By summarizing, it results a rough bandwidth requirement estimation of about 780 Mbit/s via satellite, apportioned between the mesh and the star payloads as described in the Table 6. Based on these preliminary figures we will proceed to define the functional architecture of the payload and of the traffic and control elements in the ground segment. The preliminary result is the significant need for a hybrid satellite system, involving a twin payload architecture and presenting significant requirements for flexible switching in real time of capacity between the meshed and the star topologies (back and forth), according to the specific operational conditions.

8 Cost Benefit Analysis and Preliminary Business plan

8.1 Costs

A preliminary Business plan will take into account all these factors for the TIES project. An early development phase of 2-3 years is foreseen which will require a budgetary funding of

about ten Million Euros, mainly provided by Governmental Space Entities. This early development phase will conclude with a demonstration of the application functionalities with actual technology. The second phase development, relevant to product consolidation and market deployment, foresee a larger scale investment of Governmental, Industrial and Customer entities in the project. The second phase is foreseen to last 3-5 years, requiring a funding budget of hundreds of Million Euros, including the launch of a specific satellite and scale production of ground applications, control centers and re-locatable equipment.

	Application	Hub	Network Operation Centre	Satellite Terminals	Service Centre	Capacity Mbit/s
Meshed Regene-rative Payload	VPN		One	Some hundreds at medium to high data rate (fixed, mobile)	Some units	At least some tens up to some hundreds of
	CNI		One	Some thousands at low to medium data rate (fixed, mobile)	Few	Some tens
	E-Health, E-Learning		One	Some hundreds at medium to high data rate (fixed, mobile)	Some Units	At least some tens of up to some hundreds
Star Transparent Payload	Two Way Voice/Data, Trunking	Some Units		Some tens of mobile terminals,some thousands of fixed terminals medium data rate		Some hundreds
	Multicast, Broadcast	Shared with other applications			Some Units	Few hundreds of kbit/s
	Data bank access	Some Units		Some tens of hundreds at low data rate	Some Units	At least some tens up to some hundreds

Table 5: Detailed system requirements

	Minimum Capacity Requirement	Average Capacity Requirement	Maximum Capacity Requirement
Meshed Regenerative Payload	150 Mbit/s	300 Mbit/s	420 Mbit/s
Star Transparent Payload	360 Mbit/s	480 Mbit/s	630 Mbit/s

Table 6: Bandwidth requirements

8.2 Benefits

The benefits relevant to TIES project can be grouped in four main classes of incidence:

- **Market benefits**, relevant to how the market of satellite based systems will grow due to technological improvements
- **NewCo/PMI benefits**, relevant to how much the induced industry blossom and grow due to the innovation of the specific project
- **Public benefits,** in terms tax (VAT on equipment and services) and incidence for the creation of new job
- **Social benefits**, in terms of convenience for Italy and Europe to undertake the project outcomes that relies not only on clear and substantial strategic advantages due to the control of new frontier technologies, but also on a very significant growth of social welfare, security and safety of life within the enlarged European Community.

9 Risk analysis

9.1 Risks of new technologies

Any new technological development for space applications brings inherently a risk of not reaching the performance and space qualification objectives according to the plan. The major negative consequence is to be late in the commercial service roll-out or in the mission deployment, and so failing irremediably the market objective.
Another aspect that we emphasize, is the necessity for back-up solutions, in the case of delayed development of key components, which however do not jeopardize the roll-out of the new services, both in terms of minimum performances guaranteed to the users and in terms of market opportunity (the back-up solutions should not impede the smooth transition to the new-technology based solutions, once they reached the needed maturity). Generally development risk can be mitigated by basing any new development on the heritage of previous successful and well proven technologies.

9.2 Risks due the competing market environment

As far as Space is concerned, C-Band and Ku-Band frequencies are well established all around the world, (but in Europe Ku-Band is prevailing) while a migration is started towards Ka-Band in order to face the growing demand for broadband access services. Within the space communication sectors, the user terminals also have to be taken into account.
Terminal manufacturing and sales are capital intensive and should play an important role, since the demand for satellite broadband data services will likely be heavily dependent on their value proposition. The price of Ku-Band terminals for broadband interactive services (typically DVB-RCS) ranges in €1,500-€5,000, which is considerably higher than C-Band.
A technique for risk reduction is that service providers could subsidize the terminal price in order to stimulate the initial demand. Although the terminal price subsidization will make such equipment more affordable to the users, it will be costly to fund. In the longer terms the cost related to the new technology should go down as the production volume increase.
An additional element of risk is due to presence in the communication market scenario of sectors already garrisoned by other satellite systems, and that very likely the telecom operators, service providers and final user will be unwilling to simply migrate to new technologies. Besides the competition from space sector, a dangerous competition comes from the terrestrial communication sector.
As far the risk of the services based on the new technologies are concerned, due to the competing market, a service road map is drawn with objective of identifying actions to take and the critical mass of users for firm take-off and diffusion of services.

Conclusions

The project TIES is in charge to analyze emergency communication scenarios and develop an innovative and cost effective architecture to meet the identified requirements.
The paper has presented the present state of the study phase, planned to totally last six months, in terms of user requirements, technology identification, market analysis, technological innovation, system dimensioning and cost benefit analysis.