WIRELESS DEPLOYABLE NETWORK SYSTEM FOR FUTURE PUBLIC SAFETY –WIDENS PROJECT

Adrian Boukalov [1], Vania Conan [2]
[1] Communications Laboratory , Helsinki University of Technology
Otakaari 5, Espoo, P.O. Box 2300 FIN-02015 HUT, Finland ,
Adrian.Boukalov@hut.fi
2 Thales Architecture Framework Centre, F-92704, Colombes cedex, France
Vania.Conan@fr.thalesgroup.com

Abstract

Presented paper discusses the background, content and objectives of Framework 6 IST project WIDENS. Project focuses on development of system concept and technology for rapidly deployable ad hoc broadband public safety network. WIDENS project will provide demonstrator to validate the technology developed in the project and will contribute the specification development of transatlantic project MESA. The WIDENS project is presented in the content of joint efforts to support R&D activities to establish internationally harmonized cross standard public safety integrated system which is the key objective of the MESA project.

Keywords: public safety, MESA, ad hoc network, rapidly deployable.

1. INTRODUCTION

The development of rapidly deployable interoperable communication system for future public safety is becoming increasingly important in today world. This system is an essential part of any disaster relief operation that could require multinational efforts and rapid deployment. Rapidly deployable interoperable communication system is a key component of peace keeping operations and deployable sensors networks could be efficiently used for implementation of preventive antiterrorist measures.

Historical notes

The previous work in the area of rapidly deployable network design had been mainly carried out by military .

DARPA was among the first who had initiated Packet Radio Network (PRN) program [1] in 1972. In 1983 it had launched the Survivable Radio Networks (SURAN) program [2] that had enhanced scalability feature, and could use small, low cost, low power radio with more sophisticated packet radio protocols.

In 1994 DARPA has initiated Global Mobile (GloMo) Information Program [3] which was recently concluded. It aimed to provide office-environment, Ethernet-type multimedia (voice, video, images, etc.) connectivity any time anywhere for handled devices.

The future generation of adaptive, multi-band, multimode radios - the Joint Tactical Radio System (JTRC) [4] will offer improved flexibility over half-duplex, single-channel radios at higher layers of the system because of the ability transmit and receive on different bands and using different waveforms. The next important step in JTRC development will be the integration of broadband transmission capabilities in the systems.

MESA Project

Professional mobile radio (PMR) communities in Europe and US have been showing an increased interest in next generation internationally harmonized public safety broadband band ad hoc and wireless network with capability of rapid deployment.

In May 2000 Telecommunication Industry association (TIA) and European Telecommunication Standardization Institute (ETSI) launched a transatlantic project MESA [5] that has its main goal to develop an internationally harmonized specification of future broad band public safety communication system. It was expected that the project will continue work started by APPCO Project 25/34 [6] toward developing broadband capabilities.

As an international project with more than hundred partners from different areas of the world MESA is creating a platform for new segment of PMR market by developing system specification for the next generation of globally harmonized public safety system.

Besides the introduction of new technology for PMR market MESA provides an opportunity for military communication systems manufactures to apply their experience in survivable ad hoc network design, network security techniques, software defined radio (SDR), wearable network, sensors and displays design in the area of public safety.

Meanwhile some of European manufactures of cellular systems indicating an increased interest to apply existing well proven technologies and to reuse some of available hardware and infrastructure in public safety communication network.

The successful integration of interests of PMR manufactures and users, military communication industries and cellular system manufactures for benefits of public safety users are the key factors of project MESA success.

Adrian Boukalov is a Chairman of MESA TSG SYS project
Vania Conan is a coordinator of WIDENS project

The high complexity of communication network requires strong international R&D efforts. For that reason an efficient collaboration between MESA and international research community is essential to achieve technically justified balance between existing and new technologies and to optimize communication system design according to public safety user requirements.

The IST FP 6 research project WIDENS is the first successful step in this collaboration. Project is focused on the development of technology and system concept of MESA rapidly deployable broadband network component.

Presented paper provides an overview of WIDENS project and presents its key research areas. The goal of the publication is to present WIDENS and to provide information that could help to facilitate cooperation between WIDENS and other IST FP6 research projects.

KEY FEATURES OF THE WIDENS PROJECT

Rapidly deployable network

Rapidly deployable interoperable public safety networks will play an important role in future public safety communications systems. They could be deployed in the areas where there is no available communication infrastructure to support emergency or peacekeeping operations. The rapidly deployable network could be used as a stand-alone system to provide communications in remote areas while being connected to backbone network or/and command and control center via satellite or airborne platform (Fig.1). WIDENS systems could also be used as a "healing overlay network" for the areas where there is a lack of network capacity to support emergency related traffic or in the area where communication infrastructure has been destroyed.

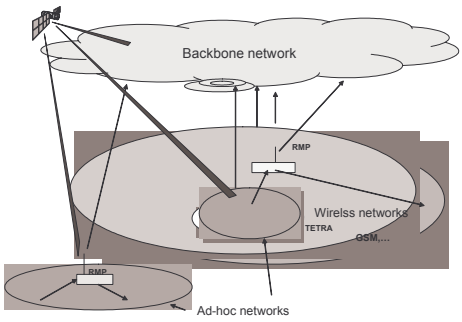

Fig 1. Rapidly deployable network component in public safety communication system

Broad band communications to support new applications and services

The WIDENS broadband communication capabilities will enable new emergency communication applications and services. They will include:

- real time video transmission that will be exploited by telemedicine applications, applications that will provide surveillance for police and security forces, applications that will support remotely controlled robots and small remotely controlled flying platforms for access to hazardous or dangerous areas.
- fast download and transmission of large files that could include: finger prints, X-rays and geographical data.

The introduction of these applications might require head-up displays and advanced methods of information collection and exchange with different type of sensors including wearable networks.

System approach in public safety ad hoc network design

WIDENS system is an ad hoc network that is optimized according to public safety user requirements. It will allow communication between different public safety users and sensor data collection without any fixed infrastructure (Fig. 2). The system approach will allow optimization of system level algorithms like topology management, clustering, prioritization of services, network partitioning, according to different types of emergency scenarios.

Cooperation with public safety users

The study of public safety user requirements is an essential part of the project activities. The user requirements obtained as a result of international user studies will be presented in systematic form and translated into technical system requirements. This work will be carried out in cooperation with MESA SSG that is focused on development of MESA user requirements. The WIDENS system level studies, applications development for prototype and field trials will be carried out in cooperation with public safety user from different countries.

Input into standardization

WIDENS project aims to provide input into MESA standardization process. The technology developed in WIDENS will be presented at MESA meetings and joint workshops. It could be expected that the technology developed in WIDENS will be considered as a platform for MESA specification development.

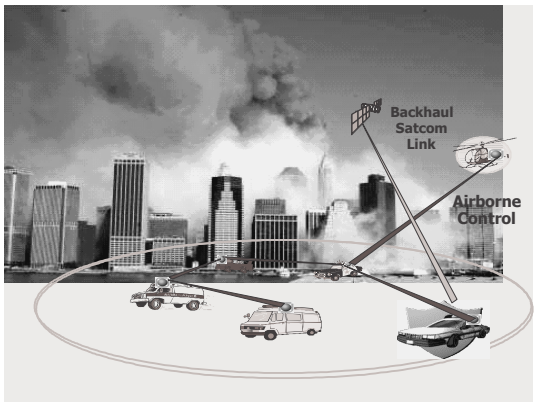

Fig 2. WIDENS- an ad hoc infrastructureless public safety communication network

WIDENS PROJECT OJECTIVIES

General objectives

Europe has an important role in private mobile radio (PMR) equipment manufacturing – WIDENS will help to maintain the competitiveness of European industry in a global market by setting the technological agenda for the next generation systems, both by carrying scientific studies and by providing a prototype of a fourth generation mobile ad hoc network. In this way public safety, emergency and disaster applications will be enhanced with a high data rate hot spot complementary and interoperable with existing infrastructures (TETRA, Tetrapol)

Project will develop a network that will provide broadband communication capabilities and will support communication between nodes with wide range of mobility levels. The position of project WIDENS on the evolution map of different wireless system and technologies is presented on the Fig 3

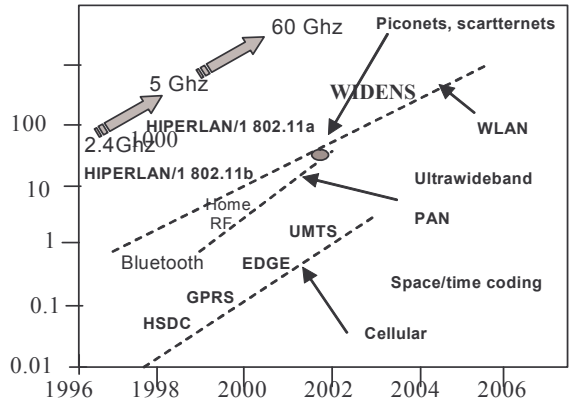

Fig 3. Position of WIDENS on the evolutional map of wireless communication technologies and standards

WIDENS project will facilitate discussion with public safety user to achieve better understanding of their vision and needs in rapidly deployable broadband communication system and broadband services.

WIDENS system concept and technology will play an important role in the joint efforts of European public safety official, regulators, industrial and research organizations to develop internationally harmonized integrated public safety communication and information system.

Technical approach

WIDENS project focuses on providing a high data rate (2 Mbit/s) hot spot communications with complementary / interoperable with existing infrastructure networks (TETRA, Tetrapol). The WIDENS ad hoc network is composed of terminodes: a terminode is a versatile software defined radio communication node with mixed enhanced handset terminal and IP router features (Fig. 4). It plays the role of:

- a wireless node to extend the coverage area, supporting advanced ad-hoc relaying features, up to the IP layer.
- an end user terminal when it runs an application, delivering enhanced Services: Voice, Data, Image; the distributed applications based on the suite of internet protocols over TCP or UDP are supported on a larger scale.
-a gateway toward a backbone network or other terminals.

All distributed applications based on the suite of Internet protocols over TCP or UDP are supported on a larger scale Gateway toward a backhaul Network or other terminals

The PHY, MAC & NETWORK will be more closely integrated in WIDENS network. It will achieve global optimization of the system deployment capabilities, scalability and overall efficiency. Each versatile terminodes will be able to play the best role depending on its relative position within the network and the requested services.

Key research topics of the project

The key research areas of WIDENS include:

- reviewing and adapting the proposed ad hoc routing protocols
- QoS support in ad hoc network in heterogeneous , dynamic environment
- analyzing and defining security policy framework
- MAC and network layer optimization for supporting the ad hoc mode
- topology control and clustering algorithms optimization

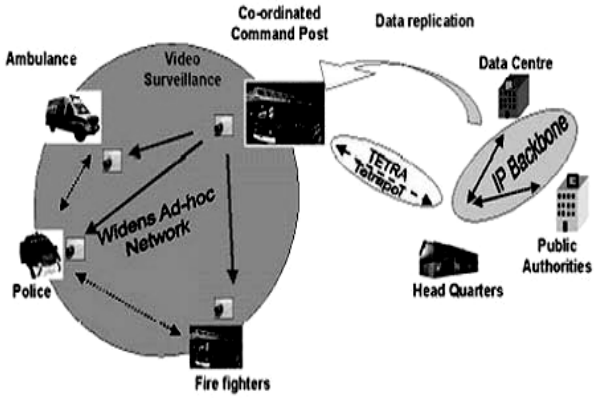

Fig 4. WIDENS technical approach. Interoperability.

Technical challenges of the project

WIDENS project presents considerable technical challenges. The number of wireless ad hoc network features such as dynamic topologies, bandwidth-and energy constrained asymmetric links with variable capacity and conflicting issues related to QoS, mobility and security are making the WIDENS system design task more difficult.

Project has to define a tradeoff between centralized and distributed algorithms considering different emergency scenarios and strengthen public safety user requirements.

The wireless mobile ad hoc network of terminodes must:

- be easy to deploy in the case of unusable infrastructure
- interoperate with existing core networks and support seamlessly communicating applications
- demonstrate high throughput for data intensive and video applications
- tackle dynamic node topology and multi-hop communications
- consider bandwidth constraints and variable link capacity (due to multipath fading, noise, interference variations)
- alleviate energy constrained nodes (depletion of batteries of mobile terminodes)
- include security services for authentication (at device/user levels) and confidentiality (at link/transport levels)

Technical objectives

The key technical objectives of the project include:

• Develop a system for an easily deployable IP wireless ad hoc network in the absence of infrastructure

• Design a scalable, reconfigurable, reliable and secure system introducing ad-hoc adaptations and reusing current WLAN standards

• Demonstrate enhanced services of audio/video real time communication, data exchange and replication

• Disseminate project technical results and results of user studied to MESA (Mobility for Emergency and Safety Applications)

• Experiment with real time PC based platform

• To propose a global optimization of the system in terms of deployment, scalability and overall efficiency of the communication links (air interface, relaying, security and QoS)

• To allow each terminode to play the best role depending on its relative position within the network and the requested services.

• To support interoperability with other communication and network systems at the IP layer.

• To satisfy the specific QoS and security emergency services requirements

Project structure

The project consists of the following technical work-packages (Fig. 5) with a top-down approach from system to technology demonstrator:

- WP2 covers all aspects of system engineering aspects of the innovative developments. The outputs are system requirements for the WP3, WP4 and WP5 and technical specification of the prototype system.
- WP3 covers the study of a scalable reconfigurable full IP network in accordance with WP2 requirements and its implementation on a software real-time platform.
- WP4 covers the study of an ad-hoc access scheme (PHY + MAC) in accordance with WP2 requirements and its implementation on a software real-time platform.
- WP5 covers the integration of WP3 and WP4 platforms within one single platform in accordance with WP2 requirements, prototyping an ad-hoc terminode. Network field trials of duplicated terminodes will be carried out by WP5.

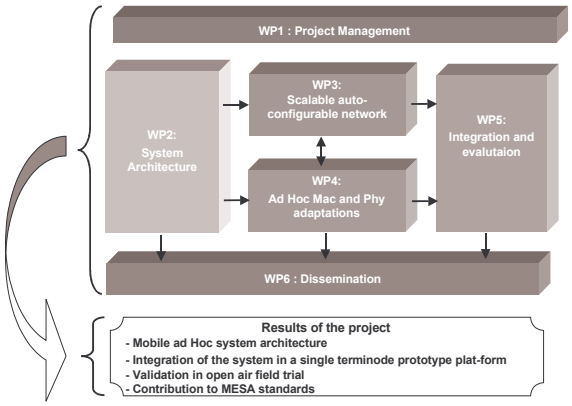

Fig 5. WIDENS project structure

Project schedule

The project is organized in two major phases: the system studies and architecture specifications will take place in 2004. The prototype will be validated with data replication and video surveillance in late 2005.

Project partners

The WIDENS consortium consists of:

- three industrial partners involved in the public safety market. EADS and Thales are manufacturers and integrators of the private radio systems TETRAPOL and TETRA. Telefonica is operating TETRA systems in Spain and provides the end-users view in terms of new services the WIDENS system should offer.
- one research centre as the real-time platform provider. Eurecom provides an open source real time platform, on which the components developed by the other partners will be integrated
- three universities with scientific background in radio mobile system design. The University of Antwerp, the Technical University of Catalonia and the Helsinki University of Technology have built their scientific excellence in the field from numerous nationals at European projects and international co-operations.

The responsibilities both in terms of technical leadership and in terms of domains of expertise are shared among partners, as shown in the Table 1.

Table 1. WIDENS project partners

Partner	Profile	Responsibility	WP leader	Count
THC	Industry	Project leader	WP1, WP3	F
UoA	Univ.	System design	WP2	B
UPC	Univ.	Ad hoc routing		E
EADS	Industry	Security		F
EUR	R&D centre	Ad hoc MAC/ PHY platform	WP4	F
HUT	Univ.	Dissemination	WP6	Fin
TID	Industry	Trial and application	WP5	E

ACTIVITIES OF WIDENS WORK PACKAGES

System architecture design

The objective of WP2 is to define system architecture of a rapidly deployable and scalable communication system based on ad hoc network technologies that meets system requirements with respect to robustness, reconfigurability, performance, QoS support, security and interoperability with existing systems. This work includes several sub-tasks.

User requirements study. Mapping into system requirements.

The public safety user requirement will be studied to provide set of WIDENS technical requirements. This work is supposed to be carried out in cooperation with project MESA SSG and include international public safety user studies in different countries. The user studies will include:
- typical reference scenarios studies (topology, mobility)
- applications and service studies
- operational requirements studies
- user interface study

High level specification of the technical platform

This subtask is focused on the research and selection of PHY/MAC layers and ad hoc routing protocol to adapt the quarantined QoS, security level and match users requirements. The link between routing function and PHY/MAC is the part of this activity.

Security analysis for ad hoc systems

This study will identify the optimum end- to-end security scheme taking into account the dynamic topologies, vulnerable wireless links, roaming in dangerous environment. The key security services that will be addressed in the project are:
- denial of service protection
- intrusion detection
- securing of routing protocols

System studies

The system studies will include interoperability studies, network architecture design and optimization according to different types of public safety scenarios. Performance studies will be carried out by means of simulations with realistic scenarios, services models and operational structures obtained by user studies. Particular focus will be on topology control and clustering algorithms, prioritized QoS, network partitioning and its optimization according to different types of scenarios.

Scalable configurable ad hoc network

The activity of the work package is focused on the development of the IP network layer of WIDENS prototype, in relation with the research activities carried out in WP2. The WP3 activities are based on results of system requirements (public safety user requirement study) and system architecture design in WP2.

The results of the work package activities consist of:
- detailed specifications and documentation
- a real time implementation of the prototype,
- input to standardization and dissemination activities

The issues of
- ad Hoc routing
- quality of service
- management and reconfigurability

are considered by this WP.

Ad hoc MAC/PHY layers adaptation

The objective of this WP is development of physical (PHY) and medium access control (MAC) layer of WIDENS prototype system, in relation with the research activities carried out in WP2. The results of the WP activity will be:
- detailed specifications of PHY and MAC layers,
- real time implementation of the prototype,
- input into standardisation and dissemination activities.

The implementation framework will consist of embedded PC-based (Laptop, PC/104-plus, or panel PC) software radio nodes. The nodes will consist of:
- 5 MHz channels, TDD RF front- Real-time data acquisition system
- Real-time software (RTLinux) development environment for fully-reconfigurable PHY/MAC
- Dual-antenna (TX + RX) capability
- IPv4/IPv6 interconnect
- WLAN interoperability (using commercial WiFi hardware)

The software/hardware architecture for the WIDENS prototype (Fig. 6.) is based on the proven PC-based real-time EURECOM software radio architecture used by the FP5 IST Mobydick and RNRT PLATON/RHODOS WCDMA platforms.

In WIDENS the architecture will be modified for the new PHY and MAC adapted for PMR systems. In addition, the format will be integrated into embedded PC form-factor to allow for practical mobility scenarios during the field trials. It will resemble a touch-screen LCD panel-PC with

an additional radio box, and include high-resolution graphics and sound capabilities. 4-5 GHz Propagation characterisation (typical delay-spread, path-loss, fading models for outdoor P2P links) will be carried out to dimension PHY parameters, (e.g. cyclic prefix length and sub-carrier granularity.)

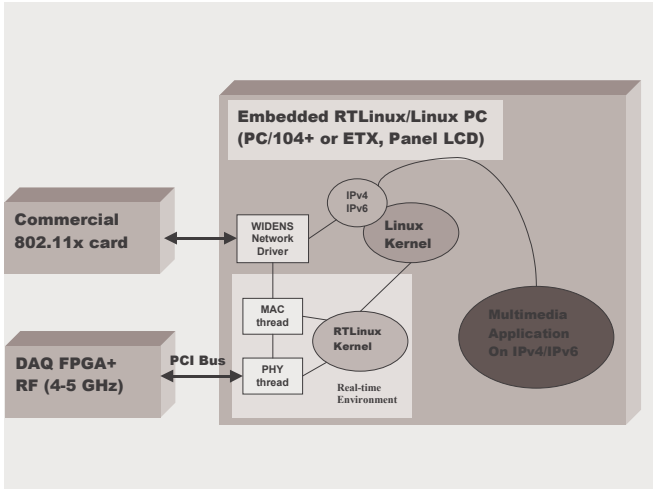

Fig. 6. Prototype architecture

Integration and evaluation

The main objective of WP is to integrate the work made in the rest of the packages and to develop an end-to-end applications as an example of the services that can be added to the network. Finally, it also includes a trial of the whole system. There are three subtasks in WP5:

End user Applications
Technical platform integration
Field trial

The first task covers the development of end-to-end applications. The applications considered in this task are:

- a database replica of the critical information stored in control room databases of one of the emergency services.
- a video surveillance application, and testing of video/audio streaming over the WIDENS network.

One of the key challenges of the project is to demonstrate the benefits of the tight vertical integration of PHY, MAC and NETWORK layers of the terminode for mobile ad hoc network scalability, reliability and efficiency. All components will be integrated within the implementation framework. The architecture of the integrated terminode is shown on the Fig. 7.

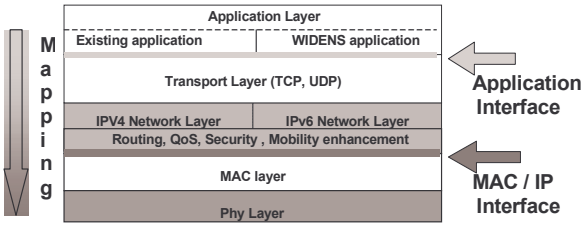

Fig. 7. WIDENS terminode integration

Dissemination, exploitation and standardization

The main objective of this WP is to carry out dissemination activities, in particular to contribute the project MESA standard specification development and to prepare future exploitation plan.

The project will establish a close link with European and global standardization activities in the area of public safety and broadband wireless communications. WIDENS will contribute different phases of MESA specification development as it presented by technology development plan (Fig.8). The contributed areas will include also:

- user requirements definition and mapping into reference scenarios and technical requirements
- reference architecture definition and architecture components identification
- MESA technology development

The liaison agreement between projects WIDENS and MESA will be established.

The project will contribute ITU (www.itu.ch) activities in three areas of public safety, BRAN project (www.etsi.org/BRAN/BRAN.html), IEEE 802 LAN/MAN Standards Committee (http://ieee802.org), Wireless LAN alliance (www.wia.org) and others.

The results of these activities will be presented in a form of input documents and as a WP6 deliverables. A number of joint workshops with project MESA will be organized by the WP6 at ETSI.

The WP will support dissemination activities, will develop an exploitation plan and will organize a number of workshops and seminars.

WP will support the exchange of information with other IST projects.

The WP provides secretarial and study supports for the European Forum for Public Safety Communications Officials (EPCCO) that is currently in its establishing phase. WP. Forum focuses on the international harmonization in the area of public safety communications and on development of European public safety functional user

requirements. Among other activities, of EPPCO it will provide platform for discussion of public safety user requirements, dissemination activities and research cooperation between different research projects in the areas relevant for public safety communications.

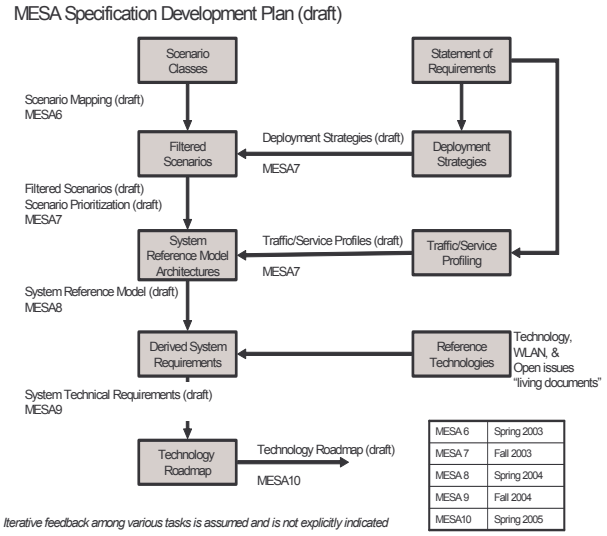

Fig. 8. MESA project road map

EXPECTED RESUTS AND IMPACT

WIDENS project will produce technology specification and system concept of rapidly deployable broad band public safety communication system. The project results will be verified by field trials with participation of public safety users.

Project will provide deliverables specifying system, architecture, describing different elements of developed technology, results of system enhancement and system performance studies, report on user studies, application and prototype software documentation, dissemination activities report. The contribution to standards will be presented in the relevant documentations including MESA specification documents.

It is expected that WIDNES project will facilitate the development and shaping of future of public safety communication market, will create platform for development of new applications, facilitate discussions and cooperation between public safety users an industries, contribute the European harmonization in the area of public safety communications.

CONCLUSION

WIDENS project is the first European IST project in the area of future public safety communication and information systems. It is targeting several new multidisciplinary areas of research. The project will contribute to the development of future integrated European public safety system development by providing system concept and technology platform for ad hoc broad band rapidly deployable network.

Taking into consideration the WIDENS focus on integration of different technologies under umbrella of system concept optimized according to the requirements of public safety users, it is important to establish a regular discussions and information exchange with other IST projects that are focused on:

- wireless network system aspects and interoperability, ambient network architectures, integration of broadband services, reconfigurability, system adaptivity, heterogeneous networks
- cross layer optimization, including joint cross layer optimization over IPv6 and QoS-RRM optimization in heterogeneous networks
- radio interfaces for systems B3G and multi-carrier transmission techniques
- system integration of communication supported by non-terrestrial platforms such as satellite and airborne
- integration of indoor and outdoor positioning systems
- sensors network

The discussion forum established by WIDENS web pages at www.widens.org could provide support for the exchange of information and news between projects.

Acknowledgement

The authors would like to thank the participants of the WIDENS consortium: H. Aiache, J. M. Barceló, C. Blondia, L. Cerdà, J. Delaigle, F. Filali, J. García, X. Gonzalez, G. Guibe, R. Guimaraes, J. Karvo, R. Knopp, E. Lara, N. Nikaein, S. Masson, J. Meessen, S. Mekrazi, V. Meriläinen, J. Morillo, C. Parisot, A. Pérez-Neira, M. Realp, S. Romaszko, E. Santos, C Sieux, M. Voorhaen ….

REFERENCES

[1] W. Fifter , F. Bruno, The Low –Cost Packet Radio, Proceedings of IEEE 75(1): Jan.1987, pp.33-42

[2] C.E.Perkins (editor), book "Ad hoc Networking", Addison-Wisley,2000, ISBN-0-201-30976-9, pp.33-35

[3] B. Leiner, R. Ruth, , A.R. Sastry, Goals and Challenges of the DARPA GloMo Program, IEEE Personal Communications, Dec. 1996, pp. 34-43.

[4] Cooper, D.M.; Prill, R.; Horihan, G.; JTRS applications to DoD programs: technology and implementation, MILCOM 2002. Proc., vol.2, pp.1427 - 1432

[5] www.projectmesa.org

[6] www.project25.org