SatNEx: A Network of Excellence Providing Training in Satellite Communications

(Invited Paper)

Ray E. Sheriff*, Y. Fun Hu*, Pauline M. L. Chan*, Michel Bousquet[†],
Giovanni E. Corazza[‡], Anton Donner[§], Alessandro Vanelli-Coralli[‡] and Markus Werner[§]

*University of Bradford
Mobile and Satellite Communications Research Centre
Bradford, UK

[†]SUPAERO
Aerospace Electronics & Communications Programmes
Toulouse, France

[‡]University of Bologna
DEIS/ARCES
Bologna, Italy

[§]German Aerospace Center (DLR)
Institute of Communications and Navigation
Weßling/Oberpfaffenhofen, Germany

Abstract—**Satellite communications represents a specialised area of telecommunications. While the development of satellite technology is relatively slow in comparison to wireless networks evolution, due to the need for high reliability, the services that satellites are able to offer are evolving at much the same pace as their terrestrial counterparts. It is within this context that the Satellite communications Network of Excellence (SatNEx) has evolved its initiative, the aim being to serve the engineering community with the latest technological trends, while also providing a solid grounding in the fundamentals for those new to the subject area.**

I. INTRODUCTION: SATELLITE COMMUNICATIONS, AN EVOLVING FIELD

The 21st Century citizen has a variety of different media in which to communicate for business and pleasure. As little as a decade ago, the sophisticated mobile user was essentially limited to low data rate mobile devices, as epitomised by the European second-generation standard GSM. Today, the average man on the street is faced with a wide variety of choices, with third-generation services gradually being rolled-out and W-LAN technologies appearing in hot-spot venues. Today's digital revolution is not only driven by the terrestrial community, satellites are now gradually starting to make their mark and develop niche services that could cross-over to mass market penetration.

The relentless growth in the telecommunications industry has made a significant impact on the quality of life of users and on the global economy. New ventures and services are opening up rewarding career opportunities for engineers with the appropriate skills. For the European economic area to prosper, it is essential that its workforce be armed with suitable expertise. The rapid evolution of today's technology means that there is now an ever-increasing demand for knowledge transfer and continued professional development (CPD), especially in areas that are not traditionally associated with mainstream higher education. Satellite communications represents a specialised, possibly niche, area of telecommunications engineering, which lends itself particularly to CPD. While the development of satellite technology is slow in comparison to cellular, due to the need for high reliability, the services that satellites are able to offer are evolving at much the same pace as their terrestrial counterparts. As a consequence, practicing engineers need to be regularly trained in the new evolving technologies and applications. It is within this context that the Satellite communications Network of Excellence (SatNEx) has evolved its training initiatives, the aim being to serve the engineering community with the latest technological trends, while also providing a solid grounding in the fundamentals for those new to the subject area.

II. PAN-EUROPEAN COLLABORATION IN SATELLITE COMMUNICATIONS: AN HISTORICAL PERSPECTIVE

Although SatNEx officially began its activities at the start of 2004 with a two-year contract from the European Commission (EC) under the European sixth research framework programme (FP6) Information Society Technologies (IST) Thematic Area, the history of collaborative research and training on a large, pan-European scale between many of the SatNEx partners can be traced back to the early nineties. In 1991, two new actions under the European co-operation in the field of scientific and technical research (COST) programme, COST 226: Integrated Space/Terrestrial Networks and COST 227: Integrated Space/Terrestrial Mobile Networks, began to investigate the requirements for integration between satellite and terrestrial networks from fixed and mobile perspectives. Subsequently, COST 227 formed the basis for the Third Framework Programme RACE (Research and technology development in

Advanced Communications technologies in Europe) II project SAINT: Satellite Integration in the Future Mobile Network, the first EC-funded project to investigate mobile satellite communications integration with terrestrial networks. COST, now, as then, is geared towards providing early-stage researchers with the opportunity to network with their peers and to present their preliminary research in a less-formal, workshop type environment. Over the past decade, COST 226 and COST 227 subsequently evolved into COST 253: Service-Efficient Network Interconnection via Satellites and 252: Evolution of Satellite Personal Communications from 2nd to Future Generation Systems, respectively, before finally merging into a single project, COST 272, which is today investigating the delivery of packet-oriented services via satellite. Many of the initial contributors to COST 226 and 227 serve on the Management Committee of COST 272, which is shortly to conclude its four-year programme, and participate in the activities of SatNEx.

Pan-European research into the air interface, and in particular the mitigation of propagation impairments, began in the early nineties with COST 235: Radio Propagation Effects on Next-generation Fixed-Service Terrestrial Telecommunication Systems and the EC FP4-funded CRABS: Cellular Radio Access for Broadband Sevices project regarding propagation impairment mitigation techniques (PIMT) that could be implemented in next generation terrestrial fixed-service systems. In 1996, an earth-space propagation dedicated action, COST 255: Radiowave Propagation Modelling for SatCom Services at Ku-Band and Above, began to investigate the use of PIMT as a key concept for offering acceptable availability for new satellite telecommunication systems operating at Ka-band and above. A follow-on action, COST 280: Channel Modelling and Propagation Impairment Mitigation for Millimetre Wave Radio Systems aims to improve the design and planning of present and future mm-wave broadband telecommunications systems (including broadcast) and services (especially multi-media) through the development of knowledge and tools for a refined evaluation of their performance. Several partners of the COST 255 and 280 actions participate in SatNEx activities.

Satellite communications research and development activities have been well supported by the EC, not just under the COST programme but also under the funded research and development programmes, such as Advanced Communications Technologies and Services (ACTS) and most recently, IST. Many of the partner organisations within SatNEx have benefited from the research and training opportunities created through participation in projects such as SINUS, GEOCAST, SUITED and MODIS. Such projects tend to be led by industry and are limited in the number of organisations that are able to participate in a consortium. Although collectively, many organisations may be participating in such projects, the interaction between them tends to be limited, chiefly through the EC's Concertation process, resulting in pockets of excellence across Europe. The opportunity to address this fragmentation has been tackled by the EC under FP6 through the new instrument of networks of excellence (NoEs). While it is not intended to directly replace COST actions with NoEs, there are similarities in the objectives and way of working in many respects, not least in the aim of training young researchers within the European research arena and extending knowledge.

The establishment of the SatNEx NoE represents a logical step in the support for research and training in satellite communications. SatNEx builds on the long-term collaboration between partner organisations, developed through COST, and the expertise gained through the various Framework research and development programmes, such as ACTS and IST.

III. SatNEx: A Long-Term Research Vision

A major aim of SatNEx is to rectify the fragmentation in satellite communications research by bringing together leading European academic research organisations in a durable way. The creation of the Network aims to establish critical mass and allow access to a range of expertise currently distributed across Europe. In this respect, mobility is an important aspect of SatNEx's work, with academic staff and research students being encouraged to move between institutions to allow access to specialised research equipment and to facilitate research integration. SatNEx has an activity specifically dedicated to achieving this objective (WP 1400, see Figure 1). Of course, SatNEx is not just about mobility. A key goal of SatNEx is the establishment of a common communications platform that will exploit satellite communications technology to link all partners' sites. This platform will provide SatNEx partners with a range of different opportunities for day-to-day communications, research and training. The ability to deliver interactive satellite communications lectures over a satellite link is a feature of SatNEx that is likely to be developed over the coming years. Already, several of the SatNEx partners from Italy and France have collaborated on this form of distance-learning and demonstrated its effectiveness under the COST 272 programme and it is expected that this will extend to across the SatNEx community as the technology becomes widely available to members of the Network.

European research in satellite communications requires a long-term vision from which to develop a technology and service roadmap that will drive the longer-term research programme. SatNEx aims to produce this vision, in collaboration with industry. The Wireless World Research Forum (WWRF) has already produced such a detailed vision for mobile communications. In developing the satellite vision, it is intended to work closely with the Advanced Satellite Mobile Systems Task Force (ASMS-TF) for fixed broadband, mobile, broadcast and navigation/positioning areas.

IV. The Consortium: A Pan-European Network

The SatNEx consortium is made up of twenty-two partners from nine European countries, as listed in Table I. The consortium comprises a well-balanced mix of higher education (HE) institutions and research (RES) organisations, where two of the latter also have the small & medium enterprise (SME)

TABLE I

OVERVIEW OF THE SATNEX CONSORTIUM.

1	DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V.	RES	D
2	AUTh	Aristotle University of Thessaloniki	HE	GR
3	BRU	University of Bradford	HE	UK
4	BUTE	Budapest University of Technology and Economics	HE	HU
5	CNES	Centre National d'Etudes Spatiales	RES	F
6	CNIT	Consorzio Nazionale Interuniversitario per le Telecomunicazioni	RES/SME	I
7	FhI	Fraunhofer Gesellschaft zur Förderung der Angewandten Forschung e.V.	RES	D
8	GET	Groupe des Ecoles des Télécommunications	HE	F
9	ICCS	Institute of Communication and Computer Systems of NTUA	RES	GR
10	ISARS	National Observatory of Athens	RES	GR
11	ISTI	Istituto di Scienze e Tecnologia dell'Informazione "Alessandro Faedo"	RES/SME	I
12	JSI	Jožef Stefan Institute	RES	SLO
13	RWTH	Rheinisch-Westfälische Technische Hochschule Aachen	HE	D
14	ONERA/TéSA	Office National d'Etudes et de Recherches Aérospatiales	RES	F
15	TUG	Institut für Kommunikationsnetze und Satellitenkommunikation, TU Graz	HE	A
16	UCIIIM	Universidad Carlos III de Madrid	HE	E
17	UniS	The University of Surrey	HE	UK
18	UoA	The University Court of the University of Aberdeen	HE	UK
19	UoB	DEIS/ARCES, Università di Bologna	HE	I
20	UToV	Università Degli Studi Di Roma "Tor Vergata"	HE	I
21	UVI	Universidad De Vigo	HE	E
22	UAB	Universitat Autònoma de Barcelona	HE	E

status. Partners from industry are integrated into SatNEx via the Advisory Board (see Figure 1). SatNEx is co-ordinated and managed by the Institute of Communications and Navigation of the German Aerospace Center (DLR).

V. KNOWLEDGE TRANSFER AND TRAINING: KEY OBJECTIVES OF SATNEX

SatNEx has been designed as a joint venture between research-led organisations and higher education institutions that have as their mandate the production of new knowledge and the transfer of this knowledge to industry and to society at large. Within the SatNEx work programme, this is termed "Spreading of Excellence", and encompasses activities dedicated to training, dissemination and standardisation. There are several avenues in which training of students, researchers and professional engineers are currently being explored, including:

- the hosting of a satellite communications Summer School from 2005 onwards. The intention is to establish annual events at locations within the Network, aimed at a global target audience;
- the provision of dedicated short-courses that address specific topics that are pertinent to the satellite community to facilitate CPD and promote lifelong learning activities;
- the presentation of tutorial sessions at major satellite communications conferences;
- the development of new ways of learning that take the subject out of the classroom, in particular the application of distance-learning techniques and e-learning technologies. Subject matter will range in content from

introductory to advanced concepts. The use of satellite communication platforms and the Internet in support of distance-learning applications is envisaged;

- and the publication in an international journal of a series of tutorial papers and technical notes in areas that researchers would find useful. SatNEx is able to provide opportunities for students originating from organisations outside of the Network to participate in its activities through project placement. This applies typically to Final Year Honours and Masters students that are required to perform a project as part of their degree programme. Members of SatNEx typically host projects of 3-6 months duration and any projects that are available are advertised on the SatNEx web site (`http://www.satnex.org`).

VI. WORK ORGANISATION: JOINT PROGRAMME OF ACTIVITIES (JPA)

Figure 1 shows the workpackage (WP) breakdown structure of the joint programme of activities (JPA).

- The Integrating Activities (WP 1000), led by DLR, support the jointly executed research (JER) (WP 2000) by:
  - co-ordinating the participants' research (WP 1100) and integrating research tools and testbeds (WP 1200);
  - providing a communication and collaboration platform based on satellite communications technology (WP 1300);
  - organising the exchange of students and personnel between SatNEx partners (WP 1400);
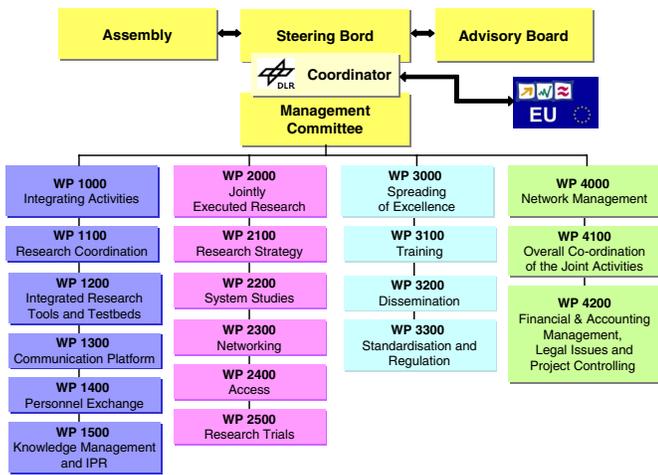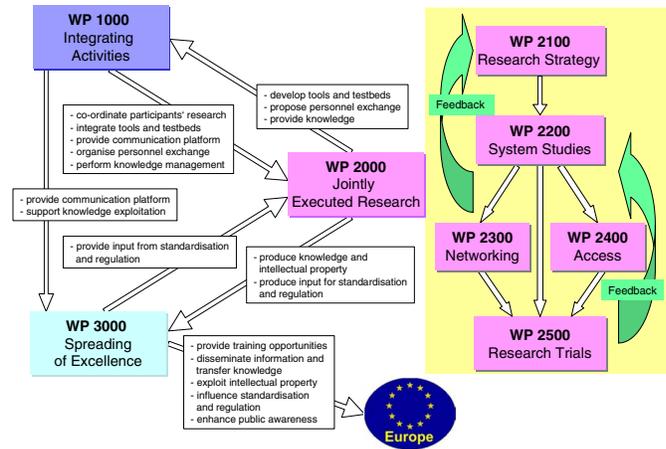
Fig. 1. Workpackage Breakdown Structure.

Fig. 2. Interdependencies between JPA Elements.

– and performing integrated management of knowledge and intellectual property (WP 1500).

- The JER activities (WP 2000), led by University of Bologna, produce new knowledge and support WPs 1000 and 3000 by:
  – developing common research tools and testbeds;
  – proposing suitable cases for personnel exchange;
  – providing new knowledge and expertise;
  – and producing technical papers of a tutorial nature.
- Finally, WP 3000, led by University of Bradford, primarily aims at the spreading of excellence to Europe and beyond. This activity:
  – provides training opportunities for students and researchers from organisations that are not members of the Network and for practicing engineers through CPD (WP 3100);
  – disseminates information and transfers knowledge through the generation of publications and supporting literature and media, including the webpage (WP 3200);
  – influences standardisation and regulation, and enhances public awareness of the benefits of satellite communications (WP 3300).

WP 4000 is the responsibility of the Network Coordinator, DLR, with input from the leaders of WPs 2000 and 3000.

A mesh of integrating relationships, as illustrated in Figure 2, interconnects the activities and workpackages of the JPA. On top of the support from integrating activities (WP 1000), there is a close relationship between the JER (WP 2000) and the Spreading of Excellence (WP 3000): WP 2000 produces new knowledge and intellectual property, which provides input for standardisation and regulation (WP 3300). One of the activities of WP 2000 is to produce technical notes and research-oriented tutorial papers, which feed into WP 3000 through the training and dissemination activities. In the other direction, WP 3000 distributes information from standardisation and regulation bodies to WP 2000. Moreover, WP 1000 supports the Spreading of Excellence (WP 3000) by providing the communication and collaboration platform. Efficient management and implementation of JER (WP 2000) is ensured due to strong relationships between the workpackages in the WP 2000 activity: the research strategy and visions (WP 2100) drive the system studies (WP 2200), which in turn have influence on the research in networking (WP 2300) and access (WP 2400), as well as on the research trials (WP 2500). The research trials are not envisaged to begin until the anticipated second phase of SatNEx from 2006 onwards.

The philosophy underlying the SatNEx approach is governed by the selection of focused actions within the broad framework described by the overall JPA, in order to capitalise on the expertise that is present within the Network and to ensure that the integration is effective and durable. These focused actions are performed jointly by the partners, and are identified as joint activitys (JAs). They include research, integration, and dissemination activities. The research activity, in particular, focuses on knowledge gaps that may be present within the Network and on extending the knowledge already made available at the start of the project by the SatNEx consortium.

The JAs are the fundamental unit in the implementation of the SatNEx JPA. A SatNEx JA is defined by a set of coherent activities, cost elements and procedures that are required to achieve a specified objective within an associated time frame. A team of SatNEx partners, termed a Joint Activity Team, jointly performs a JA. Each JA is focused on a relevant part of the JPA.

The WP structure (see Figure 1) is the organisational framework of SatNEx, setting out the scope of and also the responsibilities within the project. Whereas, the JAs are the new methods of putting the SatNEx objectives into practice - they are the elements that specify how the work is performed. Table II provides a list of the current JAs performed by SatNEx.

TABLE II

CURRENT JOINT ACTIVITIES.

Joint Activity	Description
JA-1000	Removing Barriers to Integration
JA-1100	Collective Research Portfolio
JA-1300	Networking Means for Integration and Dissemination
JA-2100	Research Strategy and Visions
JA-2230	High Altitude Platform Systems Architecture for Fixed and Mobile Communications
JA-2300	Network Performance and Protocols
JA-2330	Routing, Traffic Engineering and On-board Switching
JA-2350	Network Security and Network Management
JA-2410	Channel Modelling and Propagation Impairments Simulation
JA-2420	Flexible Waveforms
JA-2430	IP QoS and Radio Resource Management with Cross-Layer Approach
JA-3200	Conferences on Satellite Communications

VII. CONCLUSION

The SatNEx project has brought together twenty-two partner organisations from across the Europe Union with the aim of establishing strategic leadership in the area of satellite communications. This will be achieved through the performance of a joint programme of activities, which include integrating activities, jointly executed research and spreading of excellence. Training represents an important part of SatNEx's remit and is supported through a number of initiatives including the hosting of internship projects, the establishment of summer schools and the dissemination of papers of a tutorial nature. Details of the training opportunities offered by SatNEx, together with other on-going activities can be found at the SatNEx website: `http://www.satnex.org`.

ACKNOWLEDGEMENT