



Centre
Tecnològic
de Telecomunicacions
de Catalunya

annual report **2004**

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1. Vision and Mission

The Vision

CTTC is the first supra-university research center in Spain from a public initiative, with a high degree of self-financing and open to the participation of other public and private bodies. It is a basic and applied research center with professional scientific management, a critical mass of researchers and projects, real possibilities of growth and establishment of durable links with industry and business sectors, and with the capacity of participating as leader in technological projects, both national and international. CTTC contributes significantly to consolidating Barcelona's position as an important center of technology, helping expand Spain's role within the European telecommunication research and industry arenas.



The Mission

CTTC aims at acquiring an international reputation in its scientific and technical activity. This reputation, shaped in terms of scientific production, will have its basis in the conception, design and implementation of R&D projects that must produce innovative results in all their development phases, both in scientific and engineering terms. CTTC must contribute as well to the economic generation and growth of the Catalan industrial context in the telecommunications sector, helping balance business and technological industrial activity. Last but not least, CTTC must offer a pre and post doc training environment in R&D, defined as experimental in R&D activities in telecommunications and as highly reputed both in science and engineering technology. This environment should contribute to reduce the existing gap between graduate training and industry. Moreover, CTTC must open a way to training towards a productive environment where R&D is the main activity. The long-term objective is to contribute decisively to the presence of researchers in the private sector.

2. Statement of the Director




Prof. Miguel Ángel Lagunas, **Director**

Dear readers,

The Centre Tecnològic de Telecomunicacions de Catalunya (CTTC) constitutes the first initiative in Spain to establish a research institute in communication technologies where both Research and Technology Development (RTD) and Technology Transfer activities take place under the umbrella of a shared pool of human resources and common infrastructures.

In order to play a major role in the R&D arena, CTTC aims at becoming an excellence center, both in terms of research background and scientific production. In such an environment, researchers will find favourable conditions for the development of their R&D career or, alternatively, a bridge leading them from the academia and PhD training stages towards their integration into the industry. CTTC is also intended to boost the competitiveness of the local industry by either participating side by side with them in telecommunications projects (always featuring a strong technological component), or by establishing long-term cooperation agreements with specific members of the industrial community. In the long term, this strategy is expected to help increase the number of active researchers per inhabitant and, by doing so, contribute to the revitalization of the telecommunications sector resulting from the establishment of big corporations in its geographical area and/or the creation of start-ups, SMEs or new companies.

In the telecommunications sector where the time elapsed from technological innovation to market exploitation is becoming shorter and shorter, the existing barriers between scientific research and economic growth can only be overcome when the appropriate human resources are available. Certainly, not only are strong scientific skills needed, but also a remarkable engineering perspective. In other words, a perfect balance between scientific production and know-how in terms of technology transfer towards the industry is a must.

Bearing this in mind, CTTC is organized into five distinctive research areas, namely, Communications Subsystems, Radio Communications, Access Technologies, IP Technologies and Optical Networking, each dealing with different aspects of communication technologies. In a complementary way, the Engineering Unit provides the applied research flavour and, hence, focuses its work on the development of pre-competitive testbeds and demonstrators, where the psychological frontier between research and industrial innovation vanishes to a large extent.

During year 2004, we have witnessed a remarkable increase of the scientific activity of the Center. On the one hand, CTTC has got involved in a number of new RTD projects funded both at the international (IST: ACE, ANWIRE, NEWCOM, NOBEL, WINNER; EUREKA: MARQUIS, TBONES) and national level (GIRAFa, Integrated Actions). On the other, several Technology Transfer contracts (FREEDOM, QUETZAL, SIRMA) have started as well. Accordingly, the technical staff has experienced a sustained growth both at the researcher and engineering levels and, also, in terms of visitors and PhD candidates. Interestingly enough, more than one research area of the Center have participated in each of the above-mentioned projects, this evidencing their complementarities and synergies. Besides, a substantial effort has been made in order to foster the international projection of the Center. In particular, a number of Framework Agreements have been signed with other research centers, universities and companies all over Europe and the United States. In addition, the CTTC has organized two major scientific events: the IEEE-SAM'04 workshop (on Sensor Array and Multichannel Signal Processing topics) and HTSHFF'04 (on high-temperature superconductors applications). Concerning testbed development, substantial progress has been made in all fronts: ADRENALINE (an all-optical testbed with a GMPLS control plane and DWDM technology), GEDOMIS (a reconfigurable MIMO testbed), EXTREME (multi-purpose testbed for mobility and networking aspects), QUETZAL (a UWB demonstrator). Accordingly, our lab facilities have been upgraded. Finally, we have almost doubled our publication record in terms of papers in journals, international and national conferences.

To summarize, we are in the process of consolidating, in close alignment with our mission and vision, a fertilised environment for applied research in telecommunication. We firmly believe this project will substantially contribute to take Catalonia and its local industry to a forefront position in the competitive scenario of communication technologies.

3. History and Objectives

In September 1999, the Autonomous Government of Catalonia (Generalitat de Catalunya) decided to boost research, development and innovation activities in the Spanish region of Catalonia through the start-up of several research institutions. Among them, and in the context of the 3rd Research Plan of Catalonia (2001 – 2004), there was a research center in telecommunications technologies. Then, the creation of such a research center was approved in 1999 by the Generalitat in order to increase the number of researchers in telecommunications and to fill the gap between University and industry in terms of research and development (R&D).

The constitution of this center, named **Centre Tecnològic de Telecomunicacions de Catalunya** (CTTC) and located in the Barcelona area, was approved by the Generalitat in April 2001 and constituted as a private non-profit organization in June of the same year. CTTC started its activities in November 2001, with the objective of becoming this advanced research center in telecommunications technologies. So, CTTC has support from the Generalitat as well as research and development partnership with industry.

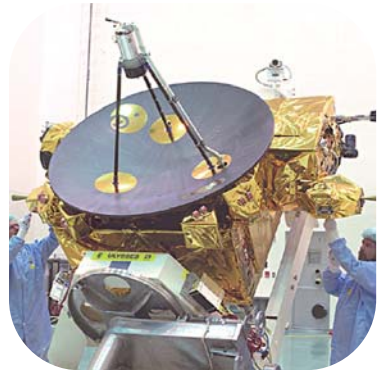
Main activities at CTTC consist of long-term research and development projects related to the physical, data link and network layers of communications. Apart from the excellent research facilities available, the center also provides opportunities for collaborative research with other research institutes and universities. Besides basic and applied research, CTTC also has engineering capabilities to develop pre-competitive demonstrators and testbeds.

The Opportunity

The metropolitan area of Barcelona, when the electronics instrumentation sector was the basis for the development in communications in the decade of the 70s, achieved such preponderance at European scale that it grouped together the biggest concentration of manufacturers of the electronics instrumentation sector at the turning of that decade. Unfortunately, the commercialization of the first microprocessors at the end of the 70s along with the unwillingness of that period to invest in technological development for new generations of products resulted in the electronics instrumentation sector being almost completely vanished.

If one bears in mind that recovering a technological positioning in communications cannot be left exclusively in the responsibility of the binomial University-industry and that both need the help and complementarities of other R&D agents in their extraordinary effort, it is in this context that different initiatives in conception and operation become clearly necessary. Just as in other fields, the lack of balance between the R&D activity in telecommunications in the public and private sectors becomes obvious. One could think that, when facing an opportunity in technological development in communications, the R&D structure is not yet ready and runs the risk of staying in the volatile and to a certain extent virtual business sector, instead of moving forward to the solid and useful sector of technological production.

There are in Catalonia, still, not many enterprises linked to the production of telecommunication equipment. This situation is a key factor in the creation of this center, since there is a real need of generating the conditions to make it possible to create and consolidate a technological and business sector related to Information and Communication Technologies (ICT), seeking to strengthen and to energize the Catalan economy, as well as to become a prestige reference in the development of the Information and Knowledge Society. Thus, the participation of industry in the CTTC is a basic objective and a determining factor of its regular operation.



The positioning of Catalonia in terms of training for technical and professional human resources is very high. For example, the Telecommunications School (*Escola Tècnica Superior d'Enginyeria de Telecomunicació*) of the *Universitat Politècnica de Catalunya* (UPC) and its homonymous, *Enginyeria La Salle* of the *Universitat Ramon Llull* (URL), have been repeatedly qualified as the best ones in Spain in the public and private sectors respectively.

This reputation results in the fact that both schools are among the main engineering providers within the telecommunications R&D European space. Even if this situation can be considered as too short a supply for the Catalan technology industry, it does not strictly result in an inadequate technological positioning.

It is only its traditional implementation in other technological sectors along with its fear of the competitive whirl within the telecommunications sector that slows down the technological activity growth in Catalonia.

As for big corporations, if the current situation is qualified as crisis, the investment necessity in basic R&D involves a strong externalization of research, which usually entails the best periods of prosperity for the technology industry and the engineering centers or institutes with capacity for technological development. Thus, the current crisis involves difficulty for the operators and prosperity for technology providers.

While the technological demand is elaborated in the business sector, that is, the communications operators, no significant contributions are produced. It is when operators decrease their expectative that engineering makes their demands feasible. In other words, a crisis of operators entails returns to technological development and the so-called contents or value-added proceedings result in the development of contributions in the basic levels of the communications technological development.

Strategic Objectives 2003 – 2005

In order of priority, the first mission of CTTC is to acquire an international reputation in its scientific and technical activity. This reputation, shaped in terms of scientific production, will have its basis in the conception, design and implementation of R&D projects. These long-term projects must produce innovative results in all their development phases, both in scientific and engineering terms. The combination of a scientific coordination with technological perspective and an engineering development capacity will be the pattern for the staff of this Center.

Secondly, the CTTC must contribute to the economic generation and growth of the Catalan industrial context in the telecommunications sector. Thus, it must contribute to a wished balance between business and technological industrial activity. As for big corporations of this sector, CTTC must contribute to fix their activity and at the same time to root R&D in Catalonia for the mentioned activity. Moreover, the Center must contribute through its reputation to convince these corporations that its proximity guarantees a partner of solid reputation in technological R&D, and at the same time a provider of knowledge and human resources for their R&D centers.



Last but not least, the start-up of CTTC and its activities must offer a pre and post doc training environment in R&D. This environment should be defined as experimental in R&D activities in telecommunications and as highly reputed both in science and technology, and should contribute to reduce the existing gap between graduate training and industry. Moreover, the CTTC must open a way to training towards a productive environment where R&D is the main activity. The objective at long term is to contribute decisively to the presence of researchers in the private sector.

In order to achieve the mentioned objectives, CTTC has been created as a supra-university research center, from a public initiative and with a high degree of self-financing, as well as open to the participation of other public and private bodies.

The CTTC is a basic and applied research center with professional scientific management, a critical mass of researchers and projects, real possibilities of growth and establishment of durable links with industry and business sectors, and with the capacity of participating as leader in technological projects, both national and international.

The mission of CTTC is split into five strategic objectives for the period 2003 - 2005:

- Acquisition of international reputation in CTTC's scientific and technical activity.
- Contribution to the economic growth of Catalan industry in telecommunications.
- Development and consolidation of a pre and post doc training environment in R&D.
- Design, building and provision of infrastructure to headquarters for hosting CTTC's scientific and technical activity.
- Development and consolidation of an organizational and managerial structure specialized in R&D in telecommunication.

4. Organization and Management

Organization

The CTTC has been created in juridical terms as a Foundation, with the following organs:

The **Council**, the most important management organ formed by the three promoting institutions. An **Executive Commission** represents the Council.

The **Scientific Advisory Committee**, responsible for orientation and scientific evaluation of the Center. This Committee ensures external advice concerning the adequateness of CTTC's research strategy and the scientific quality of the work performed. The Scientific Advisory Committee was established in 2003, its members being:

Thomas A. Saponas	R&D Consultant
Antonio Manzalini	Telecom Italia Lab
Pedro Mier Albert	Mier Comunicaciones SA
Giovanni Colombo	Telecom Italia Lab
Ángel Cardama Aznar	Universitat Politècnica de Catalunya
Pedro Pintó	R&D Consultant
José Jiménez	Telefónica I+D
Lloyd J. Griffiths	George Mason University
Markus Dillinger	Siemens AG
Riccardo de Gaudenzi	European Space Agency
John M. Cioffi	Stanford University



The **Business Advisory Committee**, through which partner enterprises participate in the Center, and its industrial involvement. This Committee will be established in 2005.

The **Director**, elected after an open selection process.

The **Manager**, responsible for the internal operation of the Center.

Due to the major role played by Universities in the existing R&D in Catalonia, CTTC's **Council** is constituted by the two most important technical universities in Catalonia, the *Universitat Politècnica de Catalunya* (UPC) and the *Universitat Ramon Llull* (URL), which have wide and proven experience in providing engineers in the telecommunications field, as well as and the Department for Universities, Research and Information Society (DURSI) of the *Generalitat*.

Internally, CTTC is currently organized in three core structural units:

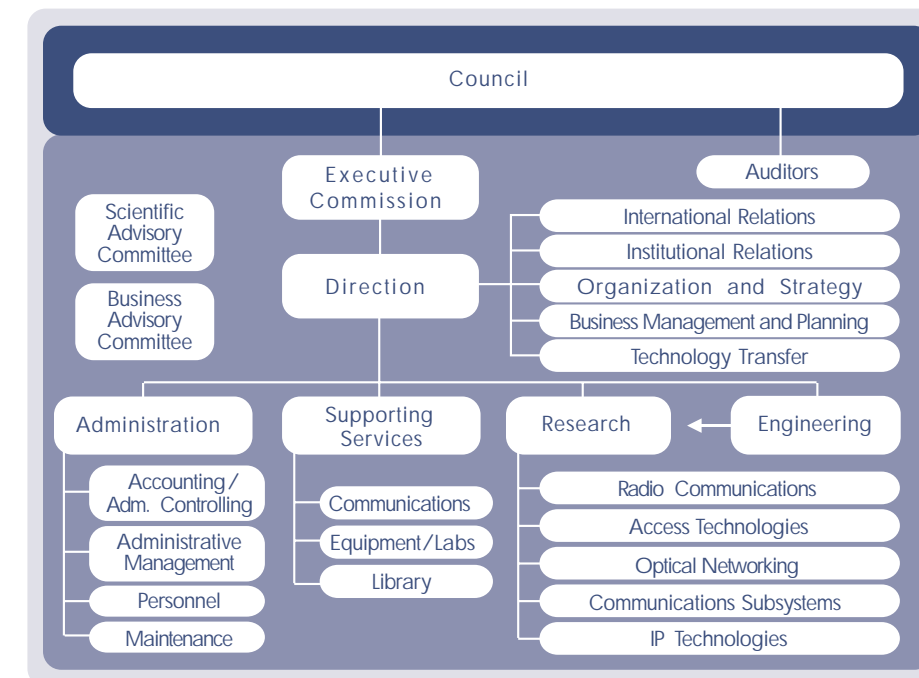
Direction, under the responsibility of the Director and with the following areas: institutional relations, international relations, strategy and organization, technology transfer, and business promotion and planning.

Director: Prof. Miguel Ángel Lagunas

Director of Technology Transfer: Albert Sitjà

Director of International Relations: Dr. Carles Antón

Director of Institutional Relations: Carolina Pinart



Administration, under the responsibility of the Manager and with the following areas: administrative planning and control, administrative organization, financial management, accounting and acquisitions, personnel, maintenance and security.

Manager: Dr. Simó Aliana

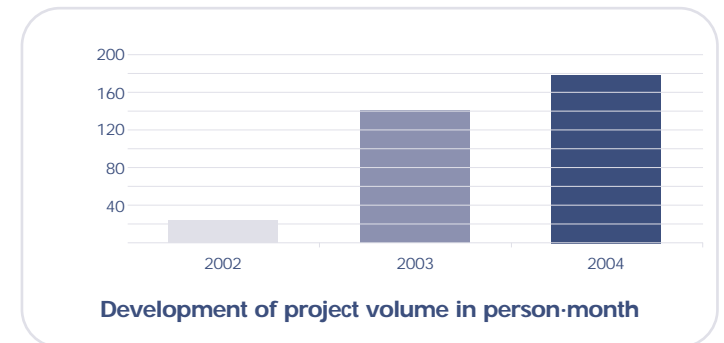
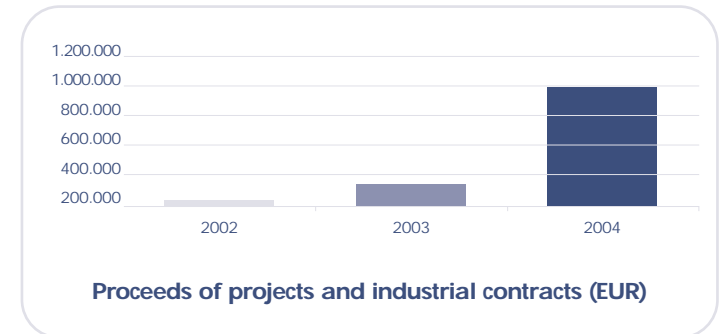
Research is the most specific unit within CTTC and has the following areas: Radio Communications, Access Technologies, Optical Networking, IP Technologies and Communications Subsystems. Each area has a coordinator, who is responsible for the research staff. Moreover, there is a manager for each research project.

5. Business Development

Project Volume

During 2004 the project volume of CTTC increased considerably, with a total of 181 person-month, nearly 80% of the Center's capacity in research and engineering. CTTC started its activities in late 2001, and in 2002 two projects started (23 person-month). In 2003, the project volume increased considerably- 50 person-month/quarter. The year 2004 represented the kick-off of 4 projects of the Information Society Technologies (IST) programme, as well as 4 industrial contracts, consolidating CTTC as an excellence center in communications technologies.

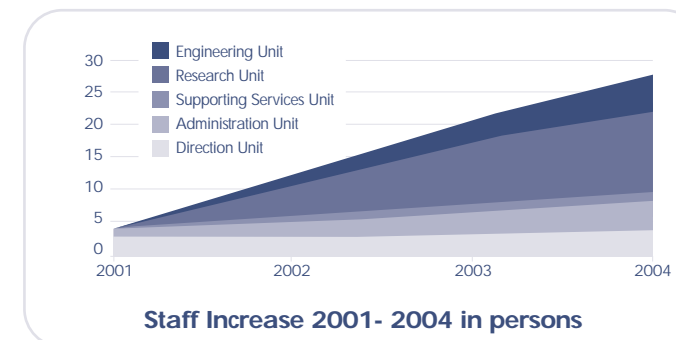
These projects include European initiatives, such as IST or the market-oriented EUREKA, National funds, as well as project assignments, expertises and industrial contracts. The total proceeds increased from 59.000€ in 2002 to 1,05 million€ in 2004, which corresponds to an increase of 1600% in three years.



Staff

The development of recruitment for researchers and engineers proves CTTC's attractiveness as an employer in advanced telecommunications research.

As of December 2004, CTTC counts 22 employees. In addition, 3 researchers from partner universities are involved in CTTC projects, 4 researchers are visiting CTTC and 9 doctoral students are pursuing their theses at the Center.



The personnel increase was distributed as uniformly as possible over the research areas, with a significant proportion of junior researchers. This reflects CTTC's emphasis on the advanced training of scientists.

Another positive aspect is the increasing percentage of researchers from abroad (around 40%), which give CTTC its international flair. Moreover, the numerous job applications from abroad demonstrate CTTC's international reputation.

Area coordinators are:

Radio Communications: Dr. Xavier Mestre
 Access Technologies: Dr. Carlos F. Bader
 Optical Networking: Dr. Abdelhafid Amrani
 IP Technologies: Dr. Josep Mangués
 Communications Subsystems: Dr. Jordi Mateu

The activities of these units are supported by two other units:

Engineering, which supports all research areas in terms of development and demonstration.

Coordinator: Antonio Mollfulleda

Supporting Services, which provides technical support to the overall activities of the center, with the following areas: computer and communications systems, technical equipment maintenance and library.

System Manager: Jordi Cebrià

Human capital

The knowledge that CTTC capitalizes upon is derived from individuals and is made accessible by several means that aim at promoting knowledge exchange among CTTC's staff as well as employees of our partners. Since March 2002, CTTC organizes open Weekly Seminars (<http://www.cttc.es/training/seminars/>). In these seminars, the speakers are researchers working at or visiting CTTC, as well as invited researchers from outstanding universities and research institutions. Moreover, CTTC participates in lectures, seminars and discussions (see Chapter 9). Another dissemination method is conference attendance, along with subsequent internal dissemination of conference papers.

Besides these methods, CTTC also encourages communication on an informal basis within the Center. Working together at the same time and within the same offices encourages spontaneous discussions about scientific problems within projects and also among research areas. Mobility of staff is a key factor for research organizations in general, and for CTTC it is particularly positive. In this context, there are several aspects to benefit from:

- New members of research areas and the Engineering Unit bring new knowledge, experience and ideas.
- CTTC gains access to the existing networks of new colleagues.
- Knowledge is transferred between CTTC and its partners.
- New relationships and cooperation are established.

6. Research and Demonstration

Research at CTTC deals with the physical, data link and network layers of communications systems. So far, five distinctive and complementary research areas have been identified in the **Research Unit**:

- Radio Communications,
- Access Technologies,
- Optical Networking,
- IP Technologies and
- Communications Subsystems.

Out of the above areas, CTTC performs basic and applied research, as well as pre-competitive demonstration. These activities are performed in three kinds of projects, which are open to all CTTC members:

Applied research projects encompass activities designed to solve practical problems of communications systems. **Demonstration** projects are devoted to technological dissemination and/or pre-competitive demonstration. Last but not least, **strategic projects** deal with basic research, that is, pure innovation.

Strategic projects are funded by the Center because they are the right environment for research lines of great strategic importance, whereas applied research and demonstration projects are usually funded by competitive funds (national and international) or by companies through industrial contracts.

Moreover, an **Engineering Unit** has been identified to support the above-listed research areas in terms of development and pre-competitive demonstrators, as well as technology-oriented research.

Highlights

Radio Communications

- Development of different spatial scheduling techniques that combine fairness and throughput maximization (ACE and MARQUIS projects).
- Design of robust beamforming, detection and signal processing techniques for finite sample size situations (NEWCOM project).
- Design of flexible and scalable MIMO architectures with partial channel state information. Enhancement of a link-layer and system-layer simulator for WLAN with multiple antenna transceivers (MARQUIS project).

- Development of several co-authored works with the Royal Institute of Technology (KTH), the Israel Institute of Technology (Technion) and the Forschungszentrum Telekommunikation Wien (FTW).
- Training: three PhD Theses (under development, two with the advanced research diploma), 7 Masters Theses and 3 Visitors.
- Publication of 4 papers in journals, 1 in magazines, 21 in conferences. Organization of one PhD course and five weekly seminars.
- Participation in 6 R&D projects: 1 technology transfer (QUETZAL), 4 European (IST ACE, NEWCOM and WINNER, and EUREKA/MEDEA+ MARQUIS) and 1 Spanish (GIRAFa). Participation in 1 technology transfer project proposal (R@ILNET) to be started in early 2005.

IP Technologies

- Realization of the first measurements in the EXTREME testbed to assess the validity of common simulation assumptions in wireless studies. Experimental assessment of the repeatability of tests in a real wireless environment.
- Design of a wireless channel emulator card that takes into account path loss, shadow and fast fading to be used in any wireless scenario of EXTREME requiring a control wireless channel, thus improving repeatability.
- Setup of various mobility scenarios allowing the assessment of the performance of applications when various types of handoffs occur (e.g. layer-2, layer-3, intra-domain, inter-domain).
- Experimental evaluation of layer 2 and layer 3 (using mobile IPv6) handoff performance with controlled traffic.
- Setup of different VoIP scenarios based on Session Initiation Protocol (SIP) and other architectures such as Skype. Evaluation of the performance impairment introduced to VoIP flows due to transcoding in various scenarios (FREEDOM project).
- Evaluation of the performance of distributed and centralized IPv6 router address autoconfiguration mechanisms.
- Training: 3 PhD Theses (under development), organization of 3 seminars related to IP Technologies, 1 postgraduate course on Mobility and QoS taught at University Mohammed V – Agdal.
- Participation in 1 technology transfer project (FREEDOM).

Communications Subsystems

- Study of non-linearities in superconducting microwave devices, and analysis of UWB systems (NEWCOM project).
- Development of an UWB radio subsystem (QUETZAL project).
- Coorganization of the conference HTSHFF 2004.
- Training: 2 PhD Theses (under development), 3 Master Theses and 1 exchange (NIST, Colorado, USA).
- Publication of 7 journal papers, 8 international and 1 national conference papers.
- Participation in one Spanish R&D project proposal about the use of ferroelectric materials in multifunctional devices for UWB applications, and one industrial proposal about non-linearities.
- Collaboration with the US National Institute of Standards and Technology (NIST) in the field of electromagnetic properties of new materials, and the development of devices for microwaves and telecommunications industry. One-month stay of a CTTC researcher at the NIST, and preparation of a two-year Fulbright post-doc at the NIST.
- Participation in 2 R&D projects: 1 technology transfer (QUETZAL) and 1 European (IST NEWCOM).
- Participation in 1 technology transfer (NLDHTS) and 1 Spanish (SURFCOM) project proposals, to be started in early 2005.

Optical Networking

- Design of distributed GMPLS-based control schemes and algorithms (RWA and TE) for all-optical wavelength-routed optical networks in multi-domain environments: RSVP-TE signalling for automated provisioning and protection/restoration (wavelength-continuity constraint), and OSPF-TE routing for automated topology and resources dissemination (physical impairments, wavelengths).
- Management in GMPLS-based all-optical transport networks: user-driven provisioning (SOAP/XML, SNMP), hybrid performance monitoring (in-service spectral and time-domain measurements to guarantee SLAs) and distributed management system.
- Design and evaluation of the ADRENALINE testbed, based on the distributed control and management of a DWDM transparent transport network.
- Training: 3 PhD Theses (under development, two with the advanced research diploma), 1 Master Thesis and 2 Visitors.

- Publication of 1 journal paper, 10 international conference papers, 1 national conference paper, 1 international workshop paper, and organization of 2 weekly seminars.
- Participation in 4 R&D projects: 2 European (IST NOBEL, EUREKA/ITEA TBONES), 1 Spanish (R-MPLS) and 1 strategic (NetCat). Participation in 1 European R&D project proposal (EUREKA/CELTIC PROMISE) to be started in early 2005.

Access Technologies

- Analysis of scheduling algorithms for multiple antenna systems based on cross-layer information (GIRAFa project).
- Development of baseband transceiver architecture for UWB radio system (QUETZAL project).
- Development of an adaptive OFDMA scheme with iterative decoding. Evaluation and development of concepts for spectrum sharing for heterogeneous services with systems beyond 3G (WINNER project).
- Analysis of requirements for spectrum sharing, interference tolerance in primary bands, and spectrum liberalization and leasing following the open spectrum paradigm (FREEDOM project).
- Application of cross-layer techniques to increase bandwidth efficiency of multi-beam satellites.
- Training: 2 PhD Theses (in progress) and 5 Master Theses.
- Publication of 1 book chapter, 17 international conference, 2 national conference, and 3 workshop papers, and organization of 6 weekly seminars.
- Participation in 7 R&D projects: 2 technology transfer (FREEDOM, QUETZAL), 3 European (IST WINNER, NEWCOM and ANWIRE), and 1 Spanish (GIRAFa).

Engineering

- Testbed development:
 - Software development for 9-node control plane based on GMPLS, SOAP/XML/SNMP-based management plane, and hardware development for the transport plane (ADRENALINE).
 - Initial version of the auto-configuration tool, integrating wireless capabilities to the testbed. Development of a channel emulator, and an autoconfiguration framework to minimize the time elapsed from scenario conception to its availability to carry out tests (EXTREME).

- Design, validation and integration of multi-FPGA circuits and a 4-channel digital-to-analog converter board. In addition, the FPGA programming task has been started with the development of blocks such as FFT, interpolator, etc. (GEDOMIS).
- Impulse radio demonstrator to work with modern UWB communication systems. Definition of the testbed architecture, specifications and requirements, as well as the design of an UWB pulse generator (QUETZAL).
- Design of a reduced area multi-antenna RF front-end to work on both WLAN bands 5.2GHz and 2.4 GHz, the design of synchronization algorithms multi-antenna WLAN receiver, as well as the analysis of implementation impairments of a generic multi-antenna OFDM system (MARQUIS project).
- Specification of an UWB system with capabilities of measuring range and location, as well as the transmitter design task (QUETZAL project).
- Training: 2 Master Theses.
- Upgrading laboratory facilities to provide partner industrial companies access to leading-edge equipment.
- Participation in 2 R&D projects: 1 technology transfer (QUETZAL) and 1 European (EUREKA MARQUIS).

Public-funded projects

IST-2001-38835 ANWIRE

Project type: NoE of IST- 5FP

Duration: 24 months

Volume: 138,7 PM

Budget: 1.262.962 €

Funding: 100% from IST

Partners:

University of Athens (UoA)

University of Catania

Université Paris 6

University of Surrey

CTTC

Universidad Politéc. de Madrid

THALES Communications

THALES Research Ltd

University of Helsinki

Technical Institute of Lisbon

Kings College of London-KLC

Ecole National Supérieure des Télécommunications (ENST)

University of Cyprus

NEC Germany

Aachen University (RWTH)

Project Manager:

Prof. Lazaros Merakos (UoA)

CTTC Team:

Prof. M. A. Lagunas (Direction)

Dr. Carlos Bader (Access Technologies)

Carolina Pinart (Direction)

Miquel Payaró (PhD Candidate)



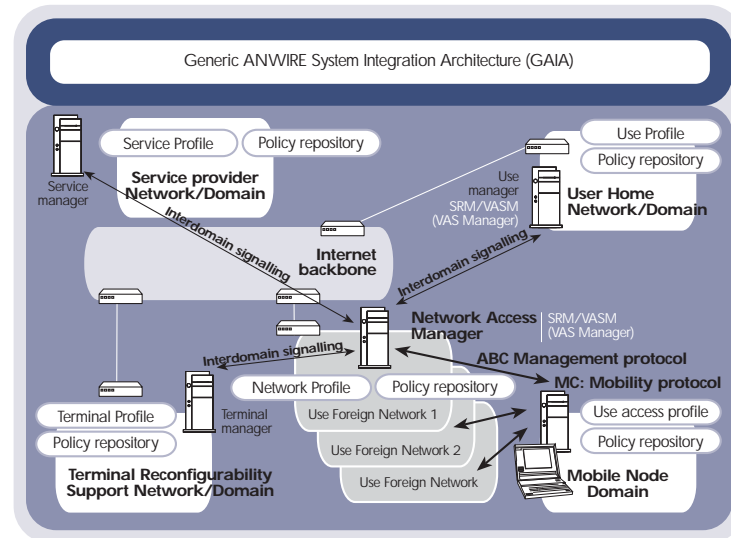
Academic Network for Wireless Internet Research in Europe (ANWIRE)

ANWIRE is a thematic network established by academic and research institutions from various countries of the EU acting in two main overlapping research tracks: *Wireless Internet* and *Reconfigurability*. ANWIRE aims at organizing and

coordinating parallel actions in key research areas of Wireless Internet and Reconfigurability, in order to encompass research activities towards the design of a fully integrated system; and at promoting and disseminating Wireless Internet and Reconfigurability solutions, in order to make them available to the research and industrial community.

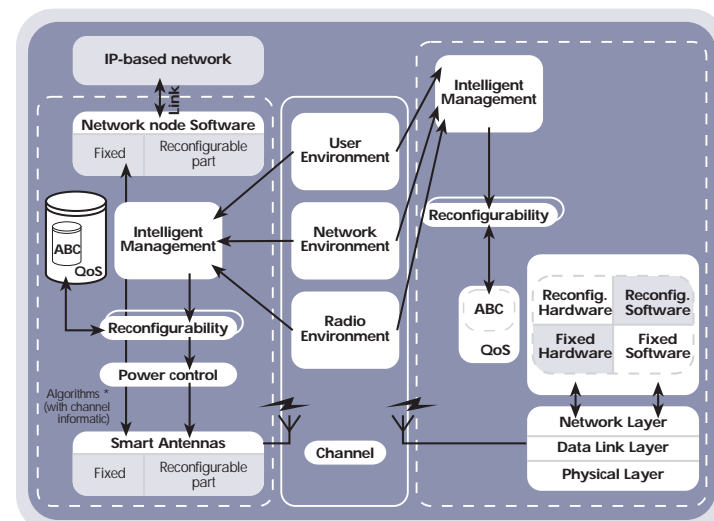
Wireless Internet aims at changing the way wireless communication networks work, in order to offer new advanced services to the users in the most efficient way. Reconfigurability, on the other hand, has been heralded as potentially offering a pragmatic solution to systems integration and flexible service provision to mobile users.

The main research work performed by CTTC deals with adaptability and reconfigurability in lower communication layers, user requirements for next generation networks, and integrated thematic efforts related to system concept. These concepts are defined and developed in **TF1 (Generic Requirements and System Concept)**. "Always Best Connected" mechanisms with horizontal reconfigurability are proposed by CTTC in **TF2 (Always Best Connected)**. In TF2, CTTC aims at achieving interactions between different functional entities. Besides the description of top-level and low-level entities, further dedicated mechanisms, structures and interfaces are chosen to explore and describe the **"Generic ANWIRE system and service Integration Architecture"** (GAIA) properties, of which CTTC specializes in system integration concerning both PHY & MAC layers,



along with a migration map regarding wireless communication systems and services integration. The work developed within ANWIRE gives an overview on the simultaneous use of services and systems and points out respective steps and integration issues in order to realize them with the proposed GAIA architecture. This research is tackled in **TF5 (System Integration)**.

Moreover, CTTC also participates actively in the dissemination of concepts and results developed and obtained towards the scientific community through participating actively in ANWIRE's International Workshops and Graduate Schools, publication of scientific papers and maintaining an ANWIRE chapter in its web site (www.cttc.es).



IST-2002-508009 ACE

Project type: NoE of IST-6FP
Duration: 24 months
Volume: 846 person-month
Budget: 7.019.000 €
Funding: 100% from IST

Partners:
 47 partners from Italy, Belgium, Denmark, Finland, France, Germany, Greece, Portugal, Spain, Sweden, Switzerland, Netherlands and United Kingdom.

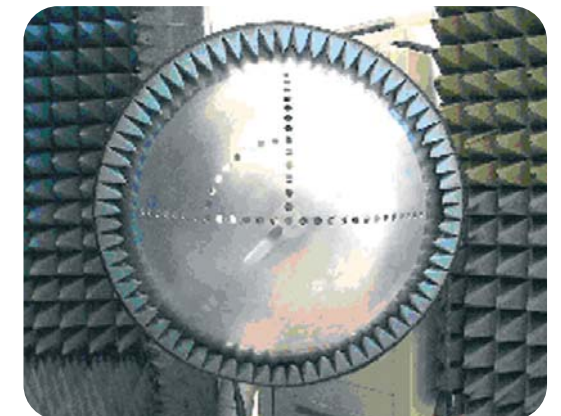
Project Manager:
 Bruno Casali (IDS - Ingegneria dei Sistemi S.p.A.)

CTTC Team:
 Prof. Miguel A. Lagunas (Direction)
 Dr. Carles Antón (Direction)
 Dr. Xavier Mestre (Radio Communications)
 Dr. Mònica Navarro (Radio Communications)
 Dr. Christian Ibars (Access Technologies)
 Miquel Payaró (PhD Candidate)
 José López (PhD Candidate)
 Francisco Rubio (PhD Candidate)



Antenna Centre of Excellence (ACE)

The ACE Network proposes to structure the fragmented European antenna R&D, reduce duplications and boost excellence and competitiveness in the key area of antenna engineering. Sophisticated antennas are a strategic multi-application technology for emerging communications, navigation and sensing services for the Information Society, for Aeronautics & Space, for transport, security, de-mining and tele-medicine.



The ACE Network plans horizontal integration by selecting, perfecting and regrouping for dissemination world level courses, documentation, software and test resources. This integration is organized in four horizontal activities:

- Antenna software tools
- Antenna measurements and facility sharing
- Training and education
- Dissemination and knowledge transfer management

On the other hand, the Joint Research Programme (JRP) provides vertical integration, fostering university-industry cooperation and focusing research to support Europe's competitiveness and to limit duplications in four key areas:

- Millimetre wave antennas (Integrated, Meta-material based...)
- Small terminal antennas (Miniaturised, using MEMS...) and Smart Antennas systems
- Broadband antennas
- Re-configurable antennas

CTTC work in the project focuses on the design and evaluation of re-configurable smart antennas. In particular, CTTC is workpackage leader of WP2.2-3 Advanced, Reconfigurable MIMO Transceivers, and is also participating actively in WP2.2-4 System Level Smart Antenna Strategies. Within WP2.2-3, CTTC is developing scalable techniques for MIMO transceivers under partial channel state information constraints at the transmitter. The work in WP2.2-4 is devoted to the application of cross-layer approaches to the design of system-level smart antenna strategies, with special emphasis on spatial scheduling techniques.

Integrated action with the University Mohammed V – Agdal

Project type: MCYT
Duration: 2 years

Partners:
 UPC-CTTC
 Univ. Mohammed V – Agdal

Project Manager:
 Josep Vidal (UPC)

CTTC Team:
 Dr. Josep Mangues (IP Technologies)

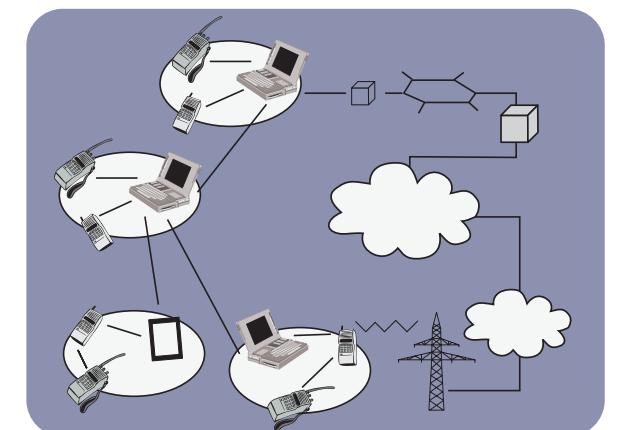


Integrated action UPC-CTTC with University Mohammed V – Agdal in Rabat (Morocco)

The growth of wireless communications and, in particular, WLANs for transmitting all kinds of data is stimulating research around these topics. Promising approaches may be found at multiple layers in the protocol stack, e.g. advanced physical layer techniques (such as multiple antennas or cooperative transmission), medium access control techniques (packet scheduling or radio resource management), and network layer techniques (mobile IP, quality of service). Their tight interaction and joint optimization should allow designing more efficient wireless systems capable of providing certain service guarantees to data flows.

The aim of this integrated action is to transfer knowledge around the above topics from CTTC and UPC researchers to the Groupe Signaux Communications et Multimédia, to consolidate joint research lines allowing young Moroccan researchers to know European research trends, and to guide PhD students in their doctoral work.

In the framework of this integrated action a lecture was given at the University Mohammed V in September 2004.



Integrated Action with the Universität Stuttgart

Project type: Integrated action
Duration: 21 months
Budget: 3000 €
Funding: 100%, by the Generalitat de Catalunya (ACI2003-11)
Regions and Consortia:
 Baden-Württemberg (Germany), Catalonia (Spain)

Partners:
 CTTC and Institut für Nachrichtenübertragung, University of Stuttgart

Project Manager:
 Prof. Dr.-Ing. Joachim Speidel (University of Stuttgart)

CTTC Team:
 Dr. Stephan Pfletschinger (Access Technologies)
 Dr. Carlos Bader (Access Technologies)
 Dr. Xavier Mestre (Radio Communications)
 Dr. Carles Antón (Direction)
 Dr. Francisco Rubio (PhD Candidate)



ACI2003-11 Integrated Action with the University of Stuttgart

The CTTC and the Institut für Nachrichtenübertragung of the University of Stuttgart share knowledge in the areas of techniques for array processing in MIMO systems, adaptive modulation for OFDM and MC-CDMA, and iterative algorithms for efficient receiver implementation.

The objectives of this integrated action are the following:

- Know-how and expertise transfer.
- Provide a framework from which future research collaborations will arise.
- Exchange points of view on trends and hot topics for research.
- Strengthen collaboration links.
- Provide guidance to young scientists in the pursue of their PhD degrees.

In the framework of this integrated action, on 18/19 October 2004, a two-day workshop was organized at the University of Stuttgart.



TIC2002-04594-C02-02 GIRAFa

Project type: CICYT (National)
Duration: 36 months
Volume: 90 person-month
Budget: 233.874 €
Funding: 116.900 €
 (contract TIC2002-04594-C02-02 of the Spanish Ministry of Science and Technology, MCYT)

Partners:
 Universitat Politècnica de Catalunya (UPC), Spain
 CTTC, Spain

Project Manager:
 Dr. Ana I. Pérez Neira (UPC)

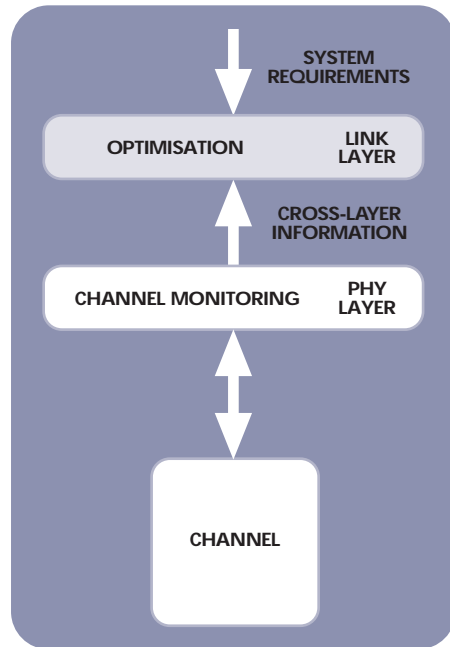
CTTC Team:
 Prof. M. A. Lagunas (Direction)
 Dr. Carlos Bader (Access Technologies)
 Marc Realp (Radio Communications)
 Jordi Cebrià (Supporting Services)



Intelligent Radio Resources Management for High-Speed Ad-hoc Networks Through the Development of Techniques of: Fuzzy Logic, Signal Processing and Media Access Control protocols (GIRAFa)

GIRAFa is a R&D project in the field of mobile and wireless networks, devoted to intelligent management of the radio resources in high-speed ad-hoc networks by developing techniques involving fuzzy logic, signal processing and medium access control protocols. Existing ad-hoc systems obviously provide the connection availability among the mobile terminals belonging to the network, but they are not capable of offering high capacities nor can they satisfy the needs for multimedia applications. The performance of this kind of networks is severely interference-limited, both inner-cell and from other systems. Note that the band in which ad-hoc networks are usually located is the so-called ISM band that can be deployed almost worldwide without any license. This project deals with the above-mentioned interference problem in a new way, i.e. the intelligent radio resource management.

Intelligent management involves: on the one hand, not only using traditional signal processing techniques or classical medium access protocols, but also the deployment of fuzzy logic techniques. On the other hand, the development of adaptive/reconfigurable algorithms depending on the scenario, which may adapt the requirements on Quality of Service (QoS) without losing the communication and, finally the joint resource optimization between physical and link layers.



Joint resource optimization entails two parts. First, the identification and exchange of the suitable cross-layer information in order to help each layer to develop advanced techniques. Second, the design of procedures (algorithms and protocols) that jointly combine two or more layers. For instance, antenna arrays may supply the PHY layer with the multi-packet reception capability.

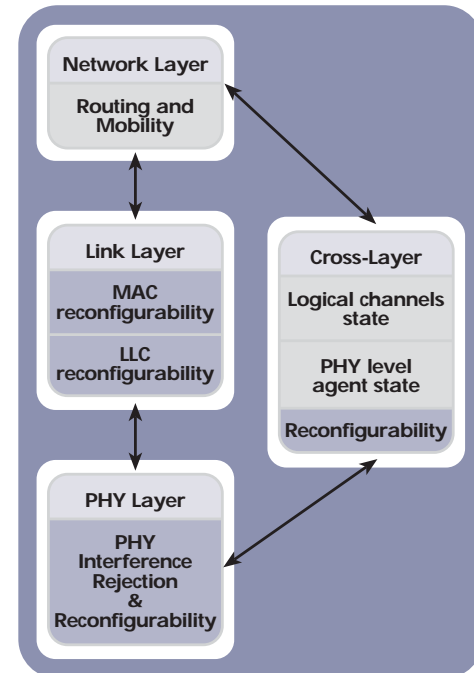
Several techniques of automatic recognition of channels are to be implemented by UPC and CTTC. Based on automatic classification processes of the channels undertaken by the receiver, it will be possible to update dynamically the forming parameters, as the number of temporal coefficients taken into account, or how the frequency bands are grouped etc. More precisely, techniques based on Bayesian classification and based on fuzzy logics will be studied. These developments are tackled in **WP1 (Reconfigurable System at the PHY layer)**.

CTTC's research in **WP3 (Cross-Layer Optimization)** aims at developing an inter-layer dialog between the PHY and MAC layers using multipacket reception (MPR), modifying the Dynamic Queuing Protocol (MDQP) as a preliminar step before adopting coss-layer strategies. Different methods are taken into account to

allow dynamic reconfiguration of systems based on the CDMA scheme with an ALOHA access mode, to a TDMA-CDMA access mode while the traffic network increases. Also, new MAC algorithms are to be developed for centralized systems.

Analysis of common-use networking software (i.e. OPNET, NS, NSII) is done based on degree of flexibility, computational cost, complexity and potential ability in simulating real environments with different standards.

This is tackled in **WP6 (Development of software platform)**. In 2004, **WP4 (MAC Merging)** and **WP5 (Network Layer Management)** will start, and in 2005 **WP7**, which concerns fuzzy hardware architectures, will study the available for high computational hardware architectures in the electronics market in order to apply fuzzy techniques. CTTC disseminates all the obtained results towards the scientific community over the official website of the project (www.cttc.es/projects/girafa/) as well as within the IST Thematic Network ANWIRE.



MEDEA+ A111 MARQUIS

Project type: EUREKA/MEDEA+
Duration: 27 months
Volume: 144 person-month
Budget: 1.031.686 €
Funding: 50% (contract FIT-070000-2003-257 of the Spanish Ministry of Science and Technology, MCYT)

Partners:

- PTI, Portugal
- IT, Portugal
- Option, Belgium
- OMP, Belgium
- UCL, Belgium
- IMEC, Belgium
- Agilent Technologies, Belgium
- CTTC-UPC, Spain,
- Telefónica I+D, Spain

Project Manager:

Michael Dieudonné (Agilent Technologies)

CTTC Team:

- Dr. Xavier Mestre (Radio Communications)
- Dr. Ana I. Pérez-Neira (Associate Researcher CTTC-UPC)
- Marc Realp (Radio Communications)
- Antonio Mollfulleda (Engineering)
- Xavier Nieto (Engineering)
- Diego Bartolomé (PhD Candidate)
- Miquel Payaró (PhD Candidate)
- Toni Morell (Visiting PhD Candidate)
- Antonio Pascual (Visiting PhD Candidate)



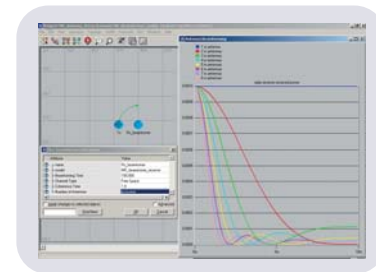
Multi-Antenna tRansceivers for QoS, Ubiquitous and Improved wireless Systems (MARQUIS)

The use of multiple antennas both at the transceiver and receiver promises a significant improvement of data rate, quality of service but also reduced radiated power. These facts are well known, however the techniques are far from commercial use. Algorithms for MIMO, SIMO and MISO systems are theoretically well studied but their practical and cost efficient

implementation is not. It is the goal of this project to show which MIMO algorithms can really be implemented efficiently and what their performance benefit really is. This will be achieved by the development of essential building blocks for MIMO receivers (antenna, front-end, baseband processing, and MAC layer support) and their integration in demonstrators. As air interfaces we target WLAN with their MIMO extensions because these systems will be choice for the next generation mobile systems.



To achieve these goals, a consortium was formed which covers algorithmic, implementation and demonstration aspects with proven experience. Among the partners, there are major European semiconductor companies, top research institutes and universities. The work starts with a state-of-the-art review of MIMO algorithms, to develop an end-to-end system model that is used for performance evaluation. These results are used to define system architecture. For this architecture, IP blocks are specified and developed. These blocks are later on integrated in demonstrators to show the performance improvement of MIMO systems and also their interoperation. Demonstrators are ready to incorporate the multi-antenna air interfaces of the upcoming beyond 3G standards. To make sure that the proposed concepts are competitive, cost measures to compare the proposed MIMO solutions to other proposals and also to SISO systems are developed.



The **MARQUIS** project complements the MEDEA+ projects UNILAN and 4GRadio. The key point in MARQUIS is the use of multi-antenna systems in base stations and terminals whereas UNILAN aims at reconfiguring WLAN systems and 4GRadio aims at the development of IP block libraries for next generation mobile systems.

The project's goals are: 1) improving the performance, reliability and security of mobile wireless communication systems through the use of multi-antenna techniques; and 2) facilitating the introduction of these multi-antenna techniques in forthcoming and emerging mobile wireless communication systems, especially but not only at the terminal side.

The R&D work performed by CTTC within **MARQUIS** is tackled in **WP1 (Algorithms and modeling)**, **WP2 (IP blocks)**, **WP3 (Demonstrators)** and **WP4 (Standardization and Dissemination)**. The main objectives of CTTC within the project are:

- To build a link-level and a system-level simulator for WLAN communication systems operating with multiple antenna transceivers, including end-to-end system modeling.
- To propose new scalable and robust multi-antenna algorithms and techniques, with an engineering perspective.
- To optimize the interactions between the (multi-antenna) physical layer and MAC layer, with support for Quality of Service (QoS).
- To build a demonstrator with multiple antennas at the transmitter and the receiver for indoor WLAN (GEDOMIS demonstrator).

HU-2002-0032 MERCURE

Project type: Integrated action

Duration: 24 months

Budget: 20.000 €

Funding: 100% (Spanish Ministry of Science and Technology, MCYT, and Österreichischer Austauschdienst)

Partners:

Forschungszentrum Telekommunikation Wien (FTW)
CTTC

Project Managers:

Dr. Carles Antón (CTTC)

Dr. Christoph Mecklenbräuer (FTW)

CTTC Team:

Dr. Xavier Mestre (Radio Communications)

Dr. Mònica Navarro (Radio Communications)

Dr. Ana Pérez (Associate Researcher CTTC-UPC)

Dr. Stephan Pfletschinger (Access Technologies)

Diego Bartolomé (PhD Candidate)

Antonio Mollfulleda (Engineering)

Marc Realp (Radio Communications)

Miquel Payaró (PhD Candidate)

MERCURE



Multi-Element tRansceiver dEsign with Channel measurements and Resource management (MERCURE)

MERCURE is aimed at exchanging background knowledge, expertise and researchers between the FTW and the CTTC, in relation with the following topics:

- Techniques for advanced transceiver design: multi-user detection, joint multi-user decoding, antenna arrays, space-time coding, etc.
- Receiver implementation and MIMO (Multi-Input Multiple Output) channel sounding and modeling.

The methodology adopted in **MERCURE** encompasses 1) a set of on-line activities, and 2) the exchange of researchers.

For the purposes of on-line activities, the groupware solution “Web for Groups” is used for document sharing, on-line discussions, organization of e-mail lists, and common calendar management.



Researcher exchange consists in the realization of several short visits to the peer institution. During those exchanges, activities to be conducted by FTW and CTTC members include, but are not limited to, coordination on priority research topics, work towards jointly-authored journal and conference papers, tutorial presentations on their respective fields of expertise, round tables on the research activities being conducted by both groups, sharing points of view on organizational issues and commenting trends, sharing points of view about test bed definition, HW design, control SW under development, measurements to be conducted, etc. In addition to that, informal meetings are also held during conferences that researchers from both groups attend.

Ultimately, as a result of the collaboration within **MERCURE**, the following goals are pursued:

- To provide guidance to young scientists in the pursue of their PhD degree.
- To transfer know-how and expertise.
- To provide a framework from where future collaborations in the realization of R&D activities could arise.
- To exchange points of view on trends and hot topics for research.
- To strengthen collaboration links.

ITEA 02024 TBONES

Project type: EUREKA/ITEA

Duration: 24 months

Volume: 96 person-month

Budget: 1.031.686 €

Funding: 50% (contract FIT-070000-2003-936 of the Spanish Ministry of Science and Technology, MCYT)

Partners:

Alcatel Bell, Belgium
Alcatel CIT, France
Atos Origin, France
CTTC, Spain
IMEC, Belgium
Telefónica I+D, Spain

Project Manager:

Dr. Bela Berde (Alcatel CIT)

CTTC Team:

Dr. Abdelhafid Amrani (Optical Networking)
Dr. Martin Maier (Optical Networking)
Dr. Josep Mangues (IP Technologies)
Raül Muñoz (Optical Networking)
Carolina Pinart (Direction)
Ricardo Martínez (PhD Candidate)



Transparent Backbone Optical Network Simulator (TBONES)

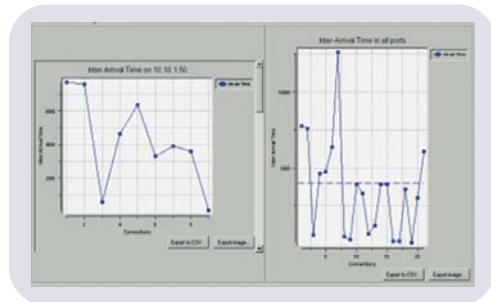
Optical networking is one of the key growth technologies that will drive the long-term success of the networking industry. Network operators and industry in general are currently showing high interest towards the development of optical transport networks using wavelength multiplexing (WDM) technologies and all-optical components. These “transparent” elements allow for routing, adding, dropping, converting, and regenerating optical signals without optical-electronic-optical (O/E/O) conversion. However, in this evolution path several approaches are debating the optimized ways to undergo this transformation. Current needs, future demand, cost, maturity of technologies, return on investment, deployed infrastructure, smooth evolution and standardization are among the hot-spot considerations paving the way to this breakthrough progress.

The trend in optical networking is to remove the overlaying of multiple technologies over the photonic layer and replacing it by an intelligent optical network that is able to carry directly multiple technologies and services with the use of all-optical



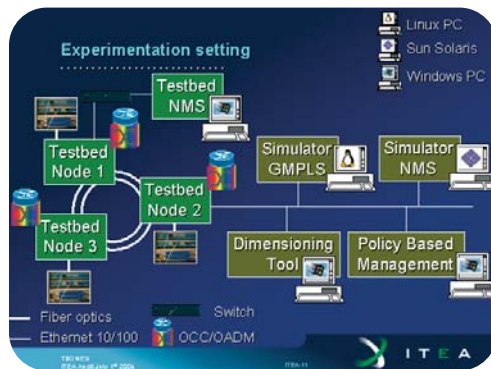
technologies, making the most optimal use of resources in a dynamic, automated and fast way. In this vision, an optical control plane (such as the new Generalized Multi-Protocol Label Switching, GMPLS) is considered as a cornerstone and IP traffic (the current and expected most bandwidth-demanding phenomenon), is envisaged to run directly over optical networks. Moreover, traditional centralized management, currently running on the transport elements, will need to evolve to a new paradigm to accommodate to changes in the transport layer, as well as the advent of new services and intelligence functionalities of future optical networks.

TBONES is a R&D project in the field of transparent optical communications' networks. The aim of the TBONES project is to design and to implement, for the first time, a simulator for scalable, multi-granularity switching capable, and transparent backbone optical networks, which operates a decentralized GMPLS control plane as well as an accommodated management plane. The unique software-based simulation platform will make it possible to create a full operational model with enhanced dynamics for the whole transparent network of a multi-Terabit capacity scale. In addition, TBONES will innovate in the strategy adopted in the introduction of transparent network products.



The main research work performed by CTTC deals with IP/MPLS over OTN architecture definition and requirements, as well as to deduce external specifications for the TBONES software platform to be developed within. This research is tackled in **WP1 (Requirements and analysis)**.

Moreover, CTTC also participates in the detailed specifications of the **TBONES'** platform data, control and management plane features, protocols and algorithms. This research is tackled in **WP2 (Control and data plane simulator)** and **WP3 (Management plane simulator)**.



In **WP4 (Evaluation and experimentation)**, CTTC participates in defining validation scenarios to demonstrate the feasibility of transparent backbone networks and to benchmark the different alternatives. CTTC also contributes to performing and enhancing experiments and validation of the software platform through interconnecting it with CTTC's real ASON/GMPLS DWDM metro ring testbed. Last but not least, CTTC contributes to **WP5 (Dissemination and exploitation)**, especially in the dissemination of concepts and results towards the scientific community.

2003/XT/0037 R-GMPLS

Project type: Thematic Network
Funding: Generalitat de Catalunya

Partners:

- CTTC, Spain
- Univ. de Girona (UdG), Spain
- UPC- CCABA, Spain
- UPC-TSC, Spain
- Universidad de Málaga, Spain
- Univ. de Extremadura, Spain
- UPC-Telemàtica, Spain
- Univ. Castilla la Mancha, Spain
- UPM, Spain

Project Manager:

José L Marzo (UdG)

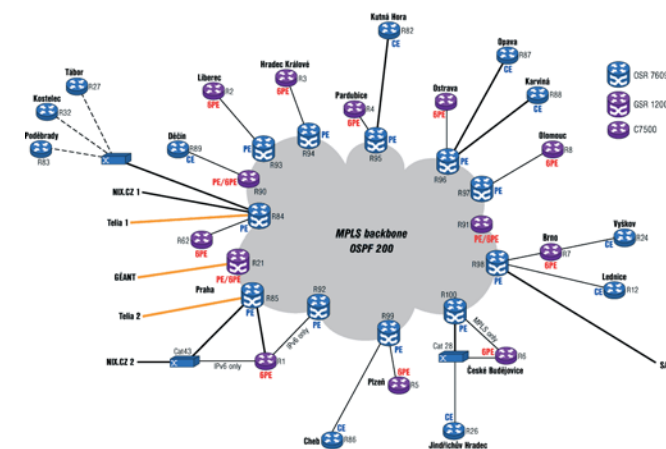
CTTC Team:

- Raül Muñoz (Optical Networking)
- Carolina Pinart (Direction)
- Ricardo Martínez (PhD Candidate)



Management of circuit-switched IP networks (R-MPLS)

The Thematic Network **Management of circuit-switched IP networks**, partially funded by the Catalan Government (contract 2003/XT/00037), has started on January 1 2003. The aim of this project is to integrate research on GMPLS/MPLS done in Spanish research organizations. The project organizes the Workshop MPLS networks annually.



IST-2002-507525 NEWCOM

Project type: NoE of IST-6FP
Duration: 30 months
Volume: 1445.2 person-month
Budget: 8.624.308 €
Funding: 100% from IST

Partners:

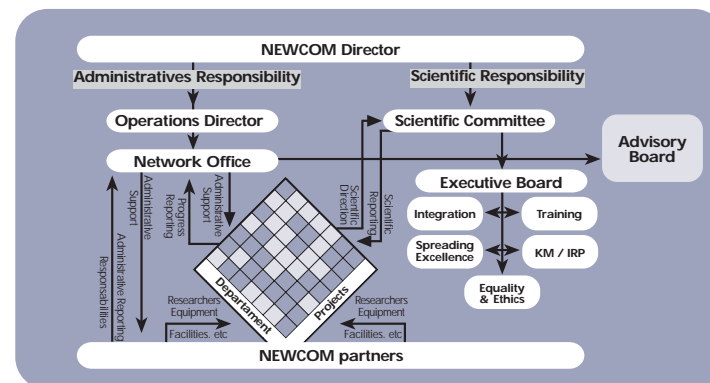
61 partners from Italy, Greece, Israel, Turkey, Spain, France, Austria, Switzerland, Germany, Finland, Hungary, Poland, Belgium, Netherlands, Sweden, Denmark, Norway, United Kingdom and Portugal.

Project Manager:

Sergio Benedetto
 (Istituto Superiore Mario Boella-Politecnico di Torino)

CTTC Team:

Prof. Miguel A. Lagunas (Direction)
 Dr. Carles Antón (Direction)
 Dr. Carlos Bader (Access Technologies)
 Dr. Xavier Mestre (Radio Communications)
 Dr. Mònica Navarro (Radio Communications)
 Dr. Stephan Pfletschinger (Access Technologies)
 Dr. Jordi Mateu (Communications Subsystems)
 Antonio Mollfulleda (Engineering)
 Xavier Nieto (Engineering)
 José López (PhD Candidate)
 Francisco Rubio (PhD Candidate)
 Marc Realp (Radio Communications)



Structure of NEWCOM

Priority Thematic Area of IST. The main dimensions of the NEWCOM vision are:

- Strengthening, development and integration of research in the field.
- Empowerment of groups and individuals via dissemination activities.
- Effective use of produced knowledge via exploitation-commercialisation-standardization strategies.

To achieve these dimensions, NEWCOM implements an elaborated plan of initiatives which revolve around the key notion and strategic choice of a Virtual Knowledge Centre: NEWCOM effectively acts as a distributed (decentralised) university, organised in a matrix fashion.

The columns represents the seven NEWCOM (Disciplinary) Departments, characterised by basic research on well-established topics and grouping leading European researchers active in those topics. The rows represents NEWCOM Projects, identified by important, "hot" problems whose solution requires multidisciplinary skills drawn from NEWCOM Departments and aggregated in a meaningful way to promote the problem solution.

The Joint Programme of Activities involves researcher exchanges, organisation of workshops and conferences, the preparation of graduate courses coordinated with the PhD programs of the academic partners to be diffused via NEWCOM high-speed network, the broad dissemination of scientific results, the promotion of entrepreneurship among its researchers, by setting up a policy of IPR encouragement and their exploitation through the creation of start-ups inside its distributed campus.

The technical work performed by CTTC within NEWCOM is developed in the following workpackages:

- **Integration:** Infrastructure, coordination and management issues.
- **Research:** Research Integration for Department 1 "Analysis and Design of Algorithms for Signal Processing at Large in Wireless Systems", Research Integration for Department 3 "Design, Modeling and Experimental Characterisation of RF and Microwave Devices and Subsystems", and Research Integration for Project E "Cross Layer Optimisation".
- **Spreading-excellence:** Workshops and Conferences, NEWCOM Dissemination Days, NEWCOM Electronic Newsletter and bulletin, and journal special NEWCOM issues, Continuous education and training and creation/maintenance of publicly available databases.

Network of Excellence in Wireless COMMunications (NEWCOM)

NEWCOM aims at creating a European network that links in a cooperative way a large number of leading research groups addressing the Strategic Objective "Mobile and wireless systems beyond 3G", a frontier research area of the

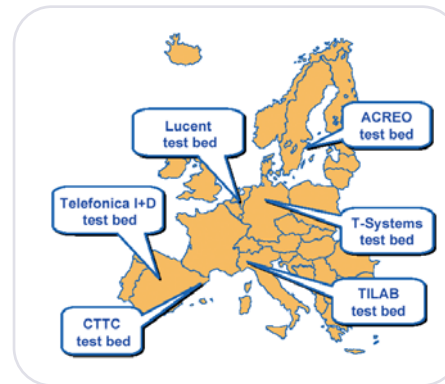
IST-2003 -506760 NOBEL

Project type: IP of IST- FP6
Duration: 24 months
Volume: 45 person-month
Budget: 315K €
Funding: 50% from IST

Partners:
 31 European companies, network operators, universities and research institutes, led by Telecom Italia Lab.

Project Manager:
 Antonio Manzalini
 (Telecom Italia Lab)

CTTC Team:
 Raúl Muñoz (Optical Networking)
 Carolina Pinart (Direction)
 Ricardo Martínez (PhD Candidate)



Testbeds of the NOBEL project.

The objectives of the NOBEL project are the following (CTTC is contributing to WPs 4 and 8):

- Definition of architectural aspects, network solutions, evolutionary guidelines and requirements for core and metro optical networks to support broadband end-to-end services (WP1)
- Study and development of traffic engineering & resilience techniques and the analysis and assessment of important techno & socio-economic issues (WP2)
- Identification of solutions for advanced packet/burst switching (WP3)
- Definition of strategies and solutions for network management and control/protocols (WP4)
- Identification of solutions and technologies for physical transmission in transparent optical networks (WP5)
- Definition of multiservice/multilayer node architectures and prototype realizations of selected node functionalities (WP6)
- Assessment of existing technologies, components and sub-systems
- Integrated test bed and related experimental activities (WP8)

Next Generation Optical Networks for Broadband European Leadership (NOBEL)

The main goal of the IST Integrated Project NOBEL is to carry out analysis, feasibility studies and experimental activities on innovative architectures, technologies solutions and for core and metro networks supporting broadband services. The project started on February 2004 and it is 2-years long. The EC funding is about 13.7 Millions Euros. The NOBEL Consortium consists of a large number of European global players of the telecom industry, network operators and research institutes

NOBEL is contributing to the VIth FP IST strategic objective 'Broadband for All' thus enhancing European competitiveness in the development of IP/Optics core and metro optical networks. Specifically the project is aiming at: reaching a critical mass in demonstrating architectures and solutions for a market-mass adoption of broadband and optical connectivity; enhancing EU leading-edge R&D on low-cost optical technologies; reinforcing EU position in Standardisation Bodies and Fora (ITU, OIF, IETF) in order to create a consensus view on a common European network vision with advanced and innovative solutions for broadband for all.

IST-2003-50707581 WINNER

Project type: IP of IST- FP6

Duration: 2 years

Effort: 1992 person-month, of which 32 allocated to the CTTC

Budget: 21 218 256 €, of which 231 374 allocated to the CTTC

Funding: 50% from IST

Partners:

38, including all major manufacturers in mobile communications

Project coordinator:

Dr. Werner Mohr (Siemens AG)

CTTC Team:

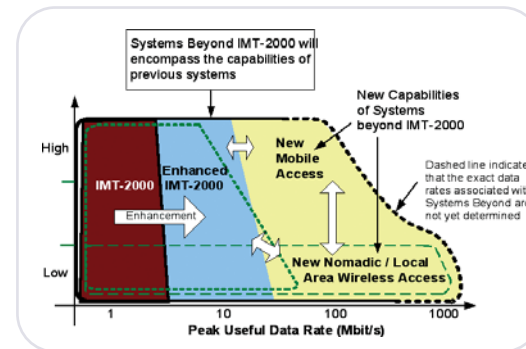
Dr. Carles Antón (Direction)

Dr. Mònica Navarro (Radio Communications)

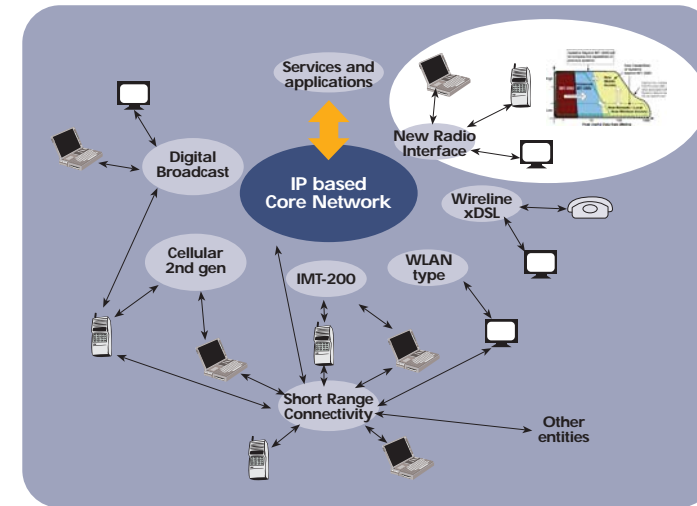
Dr. Stephan Pfletschinger (Access Technologies)

Dr. Christian Ibars (Access Technologies)

Diego Bartolomé (PhD Candidate)



Capabilities of IMT-2000 and systems beyond IMT-2000, from M.1645



The focus of the WINNER project is the development of this radio access system by taking into account the interworking with other systems. The main objectives of WINNER are to:

- Identify and analyse challenging user and usage scenarios to derive requirements for the WINNER radio interface
- Define radio interface technologies needed for a ubiquitous radio system concept
- Define radio network topologies and deployment concepts for the provision of a ubiquitous coverage area
- Define radio level co-operation mechanisms between different Radio Access Networks (RANs)
- Define a single ubiquitous radio access system concept, scalable and adaptable to different short range and wide area scenarios
- Investigate the propagation conditions and to develop related radio channel models
- Develop methods for efficient and flexible spectrum use and spectrum sharing contribute to the development of spectrum demand estimation methods in preparation for the 2007 World Radio Communication Conference (WRC)

Wireless World Initiative New Radio (WINNER)

Mobile and wireless communication has seen a tremendous growth in the last years. According to the ITU, the number of mobile subscribers worldwide has increased from 215 million in 1997 to more than 1000 million today. It is predicted that by the year 2010 there will be more than 1700 million terrestrial mobile subscribers worldwide. The number of portable handsets has already exceeded the number of fixed line telephones. This growth has, up to now, been dominated by voice-oriented services.

Future growth of mobile and wireless communications is expected mainly from data-oriented services and applications. User expectations are continuously increasing with regard to the variety of ubiquitous services and applications across a range of devices. There will be a corresponding change from predominantly circuit-switched to packet-based delivery to allow more efficient delivery of services and “always on” without high cost. Many future services will require higher data rates and, therefore, higher bandwidth in order to provide suitable user satisfaction. For this reason, new and more efficient radio access technologies will be needed. In addition, there is an ongoing paradigm shift driven by the user who expects ubiquitous communication providing higher performance at a suitable cost-benefit-ratio without having to take care of the underlying technology.

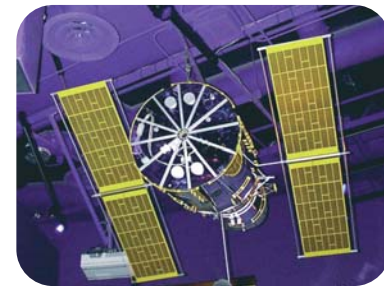
Technology transfer projects

EADS/CASA Espacio

Project type: Technology Transfer
Duration: 6 months
Volume: 6 person-month
Budget: 6.000 €

Company:
 EADS/CASA Espacio

CTTC Team:
 José Rubio (Engineering Unit)



System of Control for the IRMA antenna (SIRMA)

Satellite systems have evolved from broadcast or point-to-point communication to versatile networks offering interactive services. The design of physical and MAC layer algorithms to fully take advantage of current technologies such as multi-beam antennas and on-board processing is a very active research area. Commercial viability of space-based mobile systems has suffered due to limitations in current technology and to the unprecedented success of cellular systems. However, it is believed that the integration with terrestrial networks, together with development of new technologies and the fact that a truly ubiquitous worldwide network must rely on satellite technology will result in great success of such systems in the future.

The aim of SIRMA is to develop a module for controlling the In-orbit Reconfigurable Multibeam Antenna (IRMA), which is a satellite communications antenna.

FREEDOM - Grupo AUNA

Project type: Technology Transfer
Duration: 36 months
Volume: 108 person-month
Budget: 540.000 €

Company:
 AMENA/Grupo AUNA

Project Managers at CTTC:
 Dr. Josep Mangues
 Dr. Carlos Bader

CTTC Team:
 Albert Sitjà (Direction)
 Marc Cardenete (IP Technologies)



Research on mobility (FREEDOM)

The availability of ubiquitous connectivity for any user, anytime, anywhere is inherently linked with an efficient management of the mobility of all network elements. The final goal of this vision is expressed by means of an expression coined by the European Commission: Ambient Intelligence, in which the user interacts in a natural way with the environment, which integrates all sorts of devices (computers, PDAs, phones, but also fridges, lamps or sensors, among others).

But before attaining this long-term scenario, some problems must be solved, which are the ones dealt with in the **FREEDOM** project. Towards this goal, basic mobility management mechanisms in wide areas (i.e. macromobility) as well as those complementing the former in smaller areas (i.e. micromobility) are studied.

Additionally, the convergence of data networking, telecommunications and audiovisual areas towards a single global transport infrastructure based on the Internet Protocol (IP), implies the need to handle very different requirements imposed by each service type traveling through the network. This characteristic requires rethinking the working philosophy of the current Internet, based on the best-effort delivery of packets. Best-effort offers no guarantees of delivery and just tries to do its best at any time instant. In this sense, the provisioning of quality of service mechanisms tackles two main problems. First, they guarantee to the user that the requested resources will be available end-to-end. And second, it provides an efficient management of network resources allowing a shorter run of the investment.

With respect to the first point, a type of communications that are generating a lot of interest due to its conceptual novelty are those following the peer-to-peer paradigm. They are often confronted to those following client-server schemes, in which most previous communications were based. This paradigm shift allows end-users to exchange and share networked resources without the need for centralized servers requiring costly infrastructure and management. The support of this kind of communications provided by the network is also of interest to the project.



Real-time applications are also of interest due to the stringent requirements they pose over the network. This is particularly true for Voice over IP (VoIP) applications, due to the sensitivity of voice to losses and delay-related variations. Furthermore, if these applications run over wireless channels, the research task becomes even more challenging.

And last but not least, being a research center, the CTTC is in an excellent position to observe new technology trends. In this direction, **FREEDOM** has an activity of monitoring open spectrum technologies, including spectrum management policies, spectrum use, and usage of unlicensed bands, among others.

QUETZAL

Project type: Technology Transfer
Duration: 18 months
Volume: 134 person-month
Budget: 1.181.917 €

Companies:
 Investigación Total Ware SA (ITOWA),
 Montajes Cerezo

Project Managers at CTTC:
 Antonio Mollfuleda
 Dr. Christian Ibars

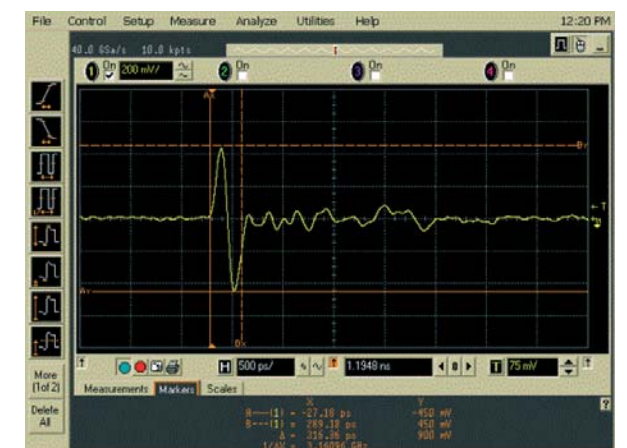
CTTC Team:
 Dr. Jordi Mateu (Communications Subsystems)
 Dr. Xavier Mestre (Radio Communications)
 Dr. Mònica Navarro (Radio Communications)
 Dr. Montse Najar (Associate UPC/CTTC)
 Joan-Anton Leyva (Engineering Unit)
 Pavel Miskovsky (PhD Candidate)



Qualified Ultra-wideband Testbed for Reduced Data Rates and Location (QUETZAL)

Ultra-wideband (UWB) technology uses very low power, very large bandwidth signals to transmit information. The nature of UWB signals allows them to overlap in frequency with narrowband signals without causing interference. In addition, UWB signals allow very precise time of flight measurements, providing accurate location capabilities.

The development of UWB technology at CTTC is carried out within the QUETZAL project. A hardware testbed for data transmission and ranging is under development, which contains novel UWB hardware technology. Communication, location and ranging algorithms are under development and will be tested in the hardware platform.



Strategic projects

NetCat

Project type: Strategic
Duration: Since Q4 2003
Volume: 30 person-month
Budget: 12.000 €
Funding: CTTC

Partners:
 CTTC, Spain

Project Manager:
 Raül Muñoz (Optical Networking)

CTTC Team:
 Carolina Pinart (Direction)
 Jordi Cebrià (Supporting Services)
 Ricardo Martínez (PhD Candidate)



NetCat is based on the ARENALINE testbed, an outgrowth of the demonstrator developed in the EMPIRICO project. Netcat develops a distributed GMPLS-based control plane and a distributed management plane combining the industry standard Simple Network Management Protocol (SNMP) with user-friendly XML based tools to allow users the dynamic provisioning of lightpaths. Distributed technologies are the most suitable to allow user management of lightpaths, due to the inherent decentralization of triggering the provisioning process if users are to be in control of lightpath establishment and deletion. NetCat clients may request optical connections in two ways: if they are UNI enabled they may request provisioning directly to the control plane by sending appropriate messages to the OCC they are linked to and otherwise, they may request services through the optical management plane either locally or remotely.

Demonstrators

ADRENALINE

All-optical Dynamic RELiable Network hANDLING IP/Ethernet Gigabit traffic with QoS is a generic optical network with DWDM technology and a GMPLS control plane to allow real-time dynamic configuration of optical channels between multiple clients (ASON). Distributed management is as well deployed. **ADRENALINE** is an extension of the **EMPIRICO** project's demonstrator, built to provision dynamic, end-to-end connectivity for IP/Ethernet traffic.

ADRENALINE is a hybrid platform composed of real and emulated optical nodes/links whose topology can be configured dynamically. The main research lines of **ADRENALINE** are the implementation and experimentation of a GMPLS-based distributed control plane and a distributed management plane containing user-friendly web-based tools. **ADRENALINE** comprises 9 Linux-based routers which emulate Optical Connection Controllers (OCC) for the GMPLS-



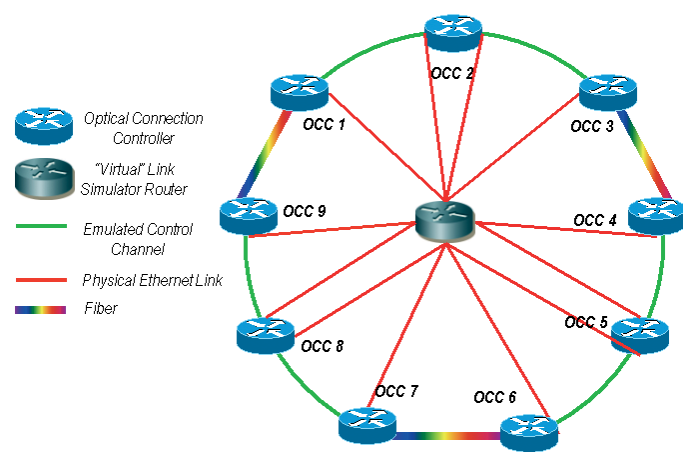
Intelligent optical network for advanced services in Catalonia (NetCat)

The accelerating growth of Internet traffic, together with its bursty pattern is motivating the research on not only high-bandwidth transport networks but also on dynamic transport networks based upon recent advances in optical networking technologies such as Wavelength Division Multiplexing (WDM), reconfigurable Optical Add Drop Multiplexers (ROADMs) and Optical Cross Connects (OCCs), capable of providing reconfigurable high-bandwidth end-to-end optical connections. The automation of the future optical networks can be achieved by means of a distributed optical control plane (i.e. routing and signaling), which can be based in the Generalized Multiprotocol Label Switching (GMPLS), an extension to MPLS for fiber, wavelength, waveband and TDM switching.

Moreover, new applications based on Grid have recently emerged require huge bandwidth (e.g lambdas) between universities, hospitals, schools, etc, such as tele-surgery, tele-astronomy, etc. Therefore there is an increasing interest in allowing the user the control over the optical network infrastructure through a user-friendly interface. User management of lightpaths can be achieved with or without the "presence" of network operators. In the former, operators maintain end-to-end network state using a distributed control plane and interfacing with the user through signaling (User-Network Interface, UNI) and/or via the management plane (with distributed technologies such as the eXtensible Markup Language, XML). In the latter, Customer Premises Equipment allows users to create end-to-end optical Virtual Private Networks across domains in which state is maintained at the edges, through the use of service oriented technologies such as Globus Toolkit or Jini/JavaSpaces.

based distributed control plane, and 3 Windows-based PCs which emulate the Distributed Optical Managers (DOM) for the management plane.

ADRENALINE testbed also counts with optical hardware such as 3 reconfigurable optical add-drop multiplexers (OADMs), being capable of adding or dropping up to 8 wavelengths, and 2 optical cross-connects (OXC), composed by a 32x32 optical switch each one, as well as 3 SNMP-based DWDM transport monitors and 3 optical links of 35km each. This optical hardware is only used for control and management validation, therefore it does not have a fixed structure and is only configured in function of control and management experiments that will be carried in specific tests.



The real links are 3 optical fiber links implemented according to the in-fiber, out-of-band approach. Control messages are based on Fast Ethernet (100Mb/s) links carried over a separate channel at 1310 nm that shares the physical optical link. Each optical link is composed of by bobbins of 35 km. Each fiber can carry up to 8 wavelengths (up to 10Gb/s). The emulated links are implemented out-of-fiber. We employ a network emulation software installed on a centralized Linux-based PC that allows to emulate fixed packet delays, packet losses, bandwidth limitations, etc between each pair of nodes of the network. These links can be configured dynamically allowing several types of network topologies.

In a GMPLS-based distributed control plane, each optical node needs its own connection controller for making its own decisions. These OCCs have been implemented through Linux-based PCs acting like IPv4 routers with a Pentium IV 2,6 GHz processor and with three Gigabit Ethernet Cards which allow VLANs. Currently, **ADRENALINE** connection controllers only support Lambda Switching Capability (LSC), being equipped with the UNI (User Network Interface), E-NNI (Exterior-Network Network Interface) I-NNI (Interior-Network Network Interface), NMI (Network Management Interface) and CCI (Connection Control Interface). The signaling protocol employed is GMPLS RSVP-TE, and the routing protocol is OSPF-TE. For management SNMP is used, and a proprietary protocol is used for the CCI.

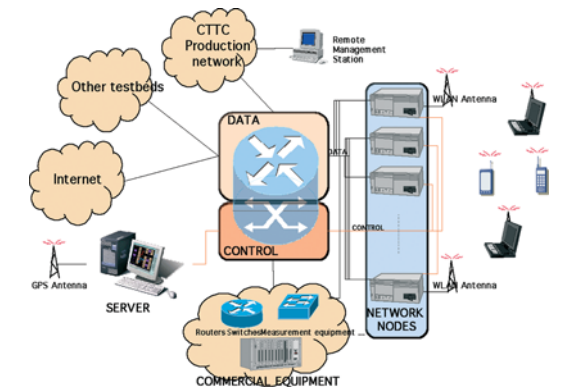
As for interfacing with the distributed management plane, user-driven provisioning of an optical service encompasses combining existing and emerging technologies, adapting optical network elements and making protocols and communication mechanisms cooperate, the goal being that a user, agnostic to optical network resources and management, can "point and click" a service. Therefore, in the management plane SNMP is used as part of the classical management-agent paradigm, existing in nearly all networks, whereas XML is used for distributed communications. SNMP is the protocol of the management interface, as well as the local user to management interface, which communicates edge client equipment with the management plane to request soft-permanent connections and to obtain IP metrics for performance management purposes.

EXTREME

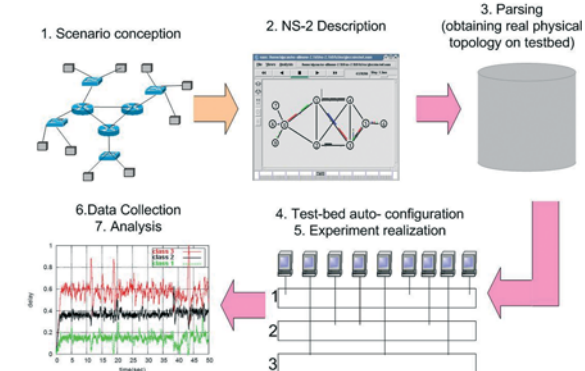
EXperimental **T**estbed for **R**esearch **E**nabling **M**obility **E**nhancements is an advanced testbed architecture based on the Emulab experience in the University of Utah.

EXTREME is a multi-purpose fully reconfigurable testbed that serves the purpose of validating proposals on real or close-to-real networking scenarios. As seen in the right figure, **EXTREME** is composed of several all-purpose nodes, which could potentially behave as any communications or end-user equipment depending on the operating system (mainly open source) image loaded from the server.

The reconfigurable interconnection between the nodes is attained by means of the switch router. The testbed is also designed taking into account the monitoring needs of any experimental network as well as its external connectivity and expandability with new equipment.



The advantage of using **EXTREME** is that it highly reduces the time transition from the conception of a scenario to its final deployment, thus smoothing the path between research and commercial deployment. This is attained by providing tools that automate image loading and node configuration. In this sense, the CTTC is developing tools that will allow experiments to be defined using a high level description (ns-2 simulator), which **EXTREME** automatically translates into a physical testbed architecture and an experiment process. In this way, the experimenter is freed from having to configure the internal details of the nodes and the topology, a very time-consuming task. The figure below shows the life cycle of an experiment. Furthermore, the use of ns-2 is expected to ease the comparison of results obtained through simulation and those obtained over **EXTREME**.

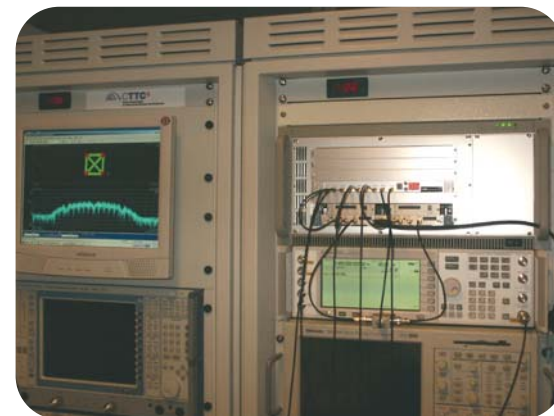
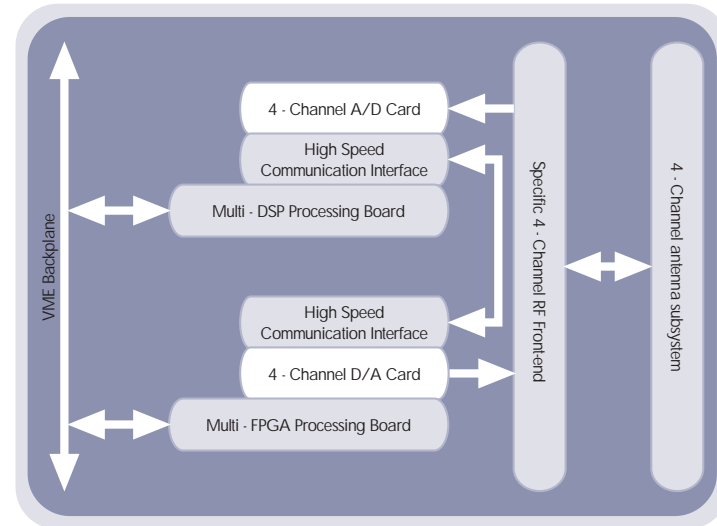


Interesting capabilities of **EXTREME** include the possibility of adopting new emergent technologies in the automatic configuration structure and the ability of seamlessly interacting with other deployed testbeds (e.g. optical or satellite networks). One of the initial design goals has been introducing WLAN capacities to the testbed. Different channel emulation techniques are being engineered to accommodate WLAN studies to the size of an experimental laboratory.

GEDOMIS

The use of multiple antennas both at the transceiver and receiver promises a significant improvement of data rate, quality of service but also reduced radiated power. This is why **MIMO** (multiple-input multiple-output) systems have emerged as a key technology for wireless systems, including wireless local area networks (WLAN), wireless metropolitan area networks (WMAN) and cellular mobile communication systems (3G and 4G). However, algorithms for MIMO systems, which are theoretically well studied, are far from practical use because they require a costly implementation.

This testbed is a **GE**neric hardware **Dem**onstrator for **MIMO** Systems (**GEDOMIS**), which will be used to implement any wireless or cellular communication system. Therefore, **GEDOMIS** is a heterogeneous and reconfigurable Software Defined Radio (SDR) platform. The hardware platform to develop in this project is a mixed DSP/FPGA platform that works on a VME backplane. The demonstrator is composed of two VME based cages, one for the receiver and one for the transmitter. Each cage includes both of them, multi-DSP and a multi-FPGA circuits to cope with complex baseband processing algorithms, as well as reconfigurable Intermediate Frequency (IF) circuits to perform a digital up/down-converter. The RF front-end will be designed specifically for each application. In addition each processing board is fully controlled through Ethernet connection by a personal computer (PC), which offers the user an interface to test, debug and control the demonstrator. Thus, **GEDOMIS** will provide an SRD platform to show which **MIMO** algorithms can really be implemented efficiently and what their performance benefit really is.



GEDOMIS will be used in CTTC's projects related with **MIMO** wireless communication systems and thus, it is expected to be upgrading the demonstrator during the following years as a permanently open activity. The main activities with the development and maintenance of the demonstrator are listed:

- Requirements of heterogeneous platforms.
- Development of baseband processing platform based either on DSP or FPGA technologies.
- Development of IF processing circuits including generation and acquisition of IF signals.
- Development appropriate RF front-end. This part will be developed specifically for each wireless system evaluated on this demonstrator.
- Integration of hardware platform of the demonstrator.
- Provide an easy-to-use interface to design and implement common signal processing operations.
- Development of synchronization algorithms according to signal characteristics.
- Efficient algorithm implementation and integration.
- Performance evaluation and experimentation.

Within the context of the MARQUIS project (see Chapter 6), **GEDOMIS** upgrades the RF front-end to target the main WLAN standards (IEEE802.11a/b/g). It will also include the development of essential building blocks for **MIMO** receivers (antenna, front end, baseband processing, and MAC layer support) and their integration in the demonstrator.

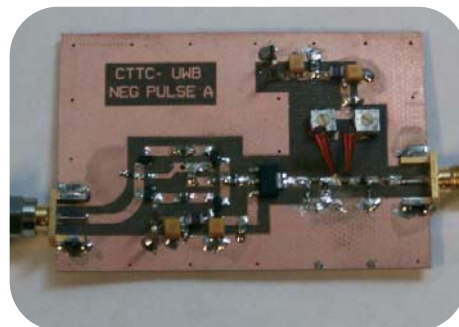
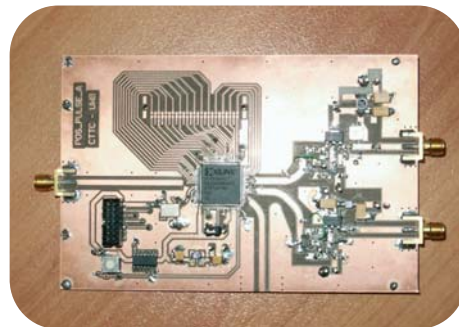


QUETZAL

'Qualified ultra-wideband testbed for reduced data-rates and location' (**QUETZAL**) is being designed by the CTTC as an Ultra-Wide Band (UWB) technologies platform to develop and validate an impulse-radio transmitter compliant with the FCC mask for communications and incorporating channel information capabilities. Generally speaking, the **QUETZAL** demonstrator will allow for the exploration of new architectures of digital receivers for impulse radio communication systems, the evaluation of the implementation impairments of UWB communication systems based on impulse radio, and the setup of a demonstration environment to evaluate the localization capabilities of an impulse radio UWB communication system.

The **QUETZAL** transmitter will be based on a completely analog pulse generator. In order to maximize the radiated power below the mask, the following specifications are currently taken into account: 1) modulation 2-PPM, with re-configurable bit rates, and 2) TH-SS and DS-SS spreading codes. The combination of both of them will minimize the power losses with respect to the UWB mask. In a first stage, the **QUETZAL** receiver will be designed according to a simple pulse detection approach. Note, however, that a receiver based on the assumption that the channel is composed of a single path will have a significant performance loss when applied to the dense multi-path channel encountered in typical indoor environments. For this reason, in a second stage, **QUETZAL** will be enhanced through the design and development of a receiver platform that considers and exploits, to some extent, the multi-path channel. The two main challenges identified for the transmit module follow. First, in order to improve the BER in the communication, the total transmitted power should be maximized. Since the FCC mask limits the radiated power spectral density, it is very important

to optimize the efficient usage of the allowable transmission spectrum. Therefore, the design of analog circuits for generating a pulse with the spectrum comprised in the FCC band is a very important challenge. Second, a pulse whose spectrum is comprised between 3.1 and 10.6 GHz, has very short duration (less than 100 ps). On the other hand, the timing jitter of the clock source introduces a random fluctuation in transmitted pulse position. From the spectrum point of view this can be advantageous, in the sense that a spectral peaks are flattened out. However, it is well known that the overall quality is very sensitive to the presence of jitter. Hence, a transmitter design with a very low jitter is required.



At the receiver, the challenges encompass accurate channel estimation and compensation techniques are required. It can be shown that the performance of the overall impulse radio systems suffers a significant degradation in the presence of channel estimation errors. A receiver with good channel compensation capabilities is therefore required in order to facilitate the detection of UWB signals, and consequently relax the strict power requirements at the transmitter. And secondly, circuits with an input bandwidth of about 7 GHz to operate in the FCC band for communication systems must be developed. Particularly, matching networks with such a bandwidth is still an important challenge on microwave circuit design.

Impulse-radio techniques have been widely used over the last three decades. Time-domain reflectometry, radar and UWB systems have covered most of the attention of these techniques. A number of emerging commercial applications have revived significant technological innovation techniques for generating narrow pulses and UWB signals. The work on of the UWB circuits based on impulse radio gives rise to new research and technical problems, particularly on analog RF front-end for impulse radio signal. Therefore, the **QUETZAL** demonstrator aims at:

- Developing a pulse generation circuit, which maximizes the energy radiated below the FCC band and minimizes the peak to average ratio in the power spectral density, as well as a pulse acquisition circuit.
- Implementing channel estimation and compensation algorithms
- Implementing synchronization algorithms.
- Provisioning a digital receiver for impulse radio compliant with the FCC regulations.

The work performed so far has been focused on the development of the fully analog pulse generator compliant with the FCC mask, together with the design of the antenna subsystem. The figure shows the first prototype of the pulse generator, which is based on Step Recovery Diode. The circuit on the right side includes a CPLD and a positive pulse generator. The CPLD uses time-hopping spread spectrum codes in order to improve the radiated power below the FCC limitations. The circuit on the left side of the figure is a negative pulse generator, which is connected to the first circuit. In addition, other technologies are being evaluated for the transmitter circuit, such as non-linear transmission lines for pulse compression, shaping networks to design the pulse waveform or the use of SiGe technology for picosecond pulse generation. Concerning the receiver, architectures for digital implementation using low sampling rate are being evaluated and investigated jointly with research areas.

7. Training activities

CTTC offers a training environment defined as experimental in R&D activities in telecommunications and highly reputed both in science and technology. This environment is aimed at contributing to reducing the existing gap between graduate training and industry. Moreover, CTTC strives to open a way to training towards a productive environment where R&D is the main activity. This is approached both at graduate (research) and undergraduate (development) levels through CTTC's Research Internships and Trainee programs. Moreover, visitors are welcome for short to mid range pre- and post-doc stays.

Post-Doc

The following **researchers** have visited CTTC during 2004:

- Prof. Alexander E. Geyer, University of Odessa, Visiting Professor.
- Dr. Christoph Mecklenbräuker, Forschungszentrum Telekommunikation Wien (FTW), Visiting Researcher of the MERCURE project (see Chapter 6).

Pre-Doc

Three kinds of graduate candidates exist: CTTC staff, CTTC research fellows and visiting PhD students. CTTC has their own PhD Fellowship Program, which grants up to 4-year doctoral studies.

In 2004, **2 MPhil Degrees** (Diploma d'Estudis Avançats, DEA) were obtained:

- R. Muñoz, Experimental Distributed Control Schemes for Dynamic GMPLS Lightpath Establishment in Metro-DWDM Unidirectional rings. Advisor: Prof. G. Junyent.
- C. Pinart, Management integration in control plane enabled metro WDM networks for service provisioning. Advisor: Prof. G. Junyent.

The following **graduate students** have visited CTTC during 2004:

- Diego Bartolomé, CTTC PhD Candidate. January - December 2004.
- Antonio Pascual Iserte, Universitat Politècnica de Catalunya, Visiting PhD Candidate. January - December 2004.
- Antoni Morell, Universitat Politècnica de Catalunya, Visiting PhD Candidate. January - December 2004.
- Hongji Xu, Shandong University, Visiting PhD Candidate. September - December 2004.
- Martin Herzog, Technische Universität Berlin, Visiting PhD Candidate. April - May 2004.

In 2004, CTTC started a **Graduate Trainee Program**:

- L. Ventura (Universitat Politècnica de Catalunya), "Research on radio access technologies". Graduate trainee (CTTC Program). Supervisors: Prof. M. A. Lagunas (CTTC), Dr. C. F. Bader (CTTC) and Dr. M. Nájar (UPC). Duration: May 1 - December 31 2004.
- J. Sorribes (Universitat Politècnica de Catalunya, UPC), "Software development of GMPLS signalling". Graduate trainee (ITEA 02024/FIT-070000-2003-936). November 1 2003 - December 31 2004.

Last but not least, **3 graduate tutorials** were taught in 2004:

- "Random matrices". Sessions: Probability, measure and convergence of random variables / Random matrices: asymptotic properties / Free probability. Applications. 6-hour tutorial taught at the CTTC, 7-9/07/2004.
- Σ ● "Multiple access technologies for future wireless communication systems". 2-hour tutorial. Taught at the 9a Setmana de la Ciència. 8/11/2004.
- Σ ● "Theory of random matrices: applications to communication theory". 2-hour tutorial. Taught at the 9a Setmana de la Ciència. 9/11/2004.

Undergraduate

In 2004, **5 undergraduate trainees** were performed in the context of the research activities of the Optical Networking Area:

- J. Olmo (Universitat Politècnica de Catalunya, UPC), "Software development of SNMP based agents for optical nodes". Undergraduate trainee (ITEA 02024/FIT-070000-2003-936). May 10 2003 - December 31 2004.
- D. Cascante (Universitat Politècnica de Catalunya, UPC), "Programming of dynamic optical connections' requests". Undergraduate trainee (ITEA 02024/FIT-070000-2003-936). November 1 2003 - December 31 2004.
- I. Martínez (Universitat Politècnica de Catalunya, UPC), "Software development of optical node controllers". Undergraduate trainee (ITEA 02024/FIT-070000-2003-936). November 1 2003 - December 31 2004.
- A. Kwin A'Kum (Technische Universität Berlin), "Optical protection in ring-star networks". CTTC Undergraduate Program. September 1 - November 30 2004.
- C. Linares (Universitat Politècnica de Catalunya, UPC), "Software development of SNMP based agents for optical nodes". Undergraduate trainee (ITEA 02024/FIT-070000-2003-936). November 2003 - April 2004.

8. Partnerships, Cooperation and Communication

PARTNERSHIPS

University and academia



Technology transfer



R&D institutions



Other



Finally, **11 Diploma Thesis** were successfully completed in 2004:

- J. Moreno, "Adaptive Modulation techniques in MIMO wireless channels". Supervisor: Prof. M. A. Lagunas (CTTC/UPC). Advisor: M. Payaró (CTTC). Date: December 20 2004.
- R. González, "Adaptive pilot patterns for OFDM-CDMA systems". Prof. M. A. Lagunas (CTTC/UPC). Advisor: Dr. F. Bader (CTTC). Date: November 18 2004.
- C. Solé, "IEEE802.11e model in OPNET Modeler 10.0". Supervisor: A. Zaballos (URL). Advisors: M. Realp and D. Bartolomé (CTTC). Date: November 11 2004.
- J. Pozo, "HTS delay lines with Hilbert fractal geometry". Supervisor: Prof. J. O'Callaghan (UPC). Advisor: Dr. J. Mateu (CTTC). Date: July 23 2004.
- F. Paredes, "Microstrip Diplexor for UMTS base Stations". Supervisor/advisor: Dr. J. Mateu (CTTC/UAB). Date: July 12 2004.
- I. Gutiérrez, "Game theory applied to power control in CDMA systems". Supervisor: C. Vilella (URL). Advisor: D. Bartolomé (CTTC). Date: July 5 2004.
- A. Causi Giménez, "Graphic-tool for indoor wireless system planning". Supervisor: Dr. Luis Alonso (UPC). Advisor: Dr. Ch. Verikoukis (CTTC). Date: June 29 2004.
- M. A. González, "Multi-channel baseband up-converter at IF for SDR platforms". Supervisor: J. A. Chávez (UPC). Advisor: A. Mollfulleda (CTTC). Date: June 23 2004.
- S. Puigardeu, "Design of a multi-FPGA board for MIMO signal processing". Supervisor: X. Revés (UPC). Advisor: A. Mollfulleda (CTTC). Date: June 22 2004.
- A. Szodenyi, "Evaluation of transparent optical node architectures for WDM metro networks". Supervisor: Maroszak Tamas (BUTE). Advisors: Dr. A. Amrani (CTTC) and C. Pinart (CTTC). Date: January 28 2004.
- A. J. Polo, "Power control based on game theory. Application to CDMA uplink". Supervisor: A. Pascual Iserte (UPC). Advisor: D. Bartolomé (CTTC). Date: January 22 2004.

COOPERATION

Apart from former partnerships, CTTC cooperates with other scientific institutions and their experts through international networks, such as the Wireless World Research Forum (WWRF), the IPv6 Forum, European initiatives, such as the IST Thematic Network ANWIRE, or the EUREKA MARQUIS and TBONES projects (see Chapter 6) and research exchanges, such as the Integrated Action with the Universität Stuttgart or the MERCURE project (see Chapter 6). Moreover, through the Association of Catalan Research Centers (ACER), CTTC has built up relations to other competence centers boosted by the Autonomous Government of Catalonia.

In 2004, CTTC obtained **three credentials**:

- Technologic Innovation Center (Centro de Innovación Tecnológica, CIT). CTTC is registered with number 85 in the Spanish CIT Registry.
- NATO Commercial and Government Entity Code (NCAGE).
- European Space Agency (ESA) Potential Bidder.

COMMUNICATION

CTTC's trilingual homepage plays a preponderant role in our communication strategy, because it offers an up-to-date, extensive source of information for partner organizations and other interested parties. This is illustrated by the number of applications we receive in response to online job, pre-doctoral fellowships and Diploma Thesis offers, as well as the increasing number of visits to www.cttc.es.

On a yearly basis, the Center issues a new volume of the "CTTC Scientific Publications Series". Currently, Volume 1: Publications 2001-2002, Volume 2: Publications 2003 and Volume 3: Publications 2004 are available for free to researchers, industry and academia under e-mail request at info@cttc.es.

CTTC's bilingual information folder is also a key feature of our communication strategy. It offers a simple but yet comprehensive overview of the Center and the research and development activities carried out.

Since March 2002, CTTC organizes open weekly seminars on Information and Communications Technologies, in which the speakers are researchers working at or visiting CTTC, as well as invited researchers from outstanding universities and research institutions. In 2004, more than 40 talks were given at the Center by staff, graduate students and invited speakers from industry (Intel Research, UMTS Forum), research institutions (FTW,) and academia (UPC, Chalmers University of Technology, Shandong University, University of Thessaly, IST-TUL, Universität Kalsruhe, University of Illinois at Chicago, UAB, NTUA, TU-BERlin, etc.).

Last but not least, since April 2004 CTTC organizes industry-oriented seminars on Information and Communications Technologies, performed by invited speakers from outstanding companies and organizations in telecommunications. The objective of these events is to create relevant information communication opportunities between invited speakers and CTTC research and engineering staff.

9. Publications

Books or Book Chapters

F. Bader, S. Zazo, **Synchronism Loss Effect on the signal Detection at the Base Station Using an OFDM-CDMA System**. Published in the book Multi-Carrier Spread Spetrum, pp. 421-428, edited by K. Fazel and S. Kaiser. Kluwer Academic Publishers Boston (2004), ISBN 1-4020-1837-1.

A. Pérez-Neira, J. Bas, M. A. Lagunas, **A Neuro-Fuzzy System for Source Location and Tracking in Wireless Communications**. Published in the book Neuro-Fuzzy and Fuzzy-Neural Applications in Telecommunications, pp. 119-148, edited by P. Stavroulakis. Signals and Communication Technology, Springer (2004), ISBN 3-540-40759-6.

Publications in Journals

J. Manges-Bafalluy, A. Cabellos-Aparicio, R. Serral-Gracià, J. Domingo-Pascual, A. Gómez-Skarmeta, T. P. de Miguel, M. Bagnulo, A. García-Martínez, **IP mobility. Macromobility, micromobility, quality of service and security**, Journal of the Council of European Professional Informatics Societies (Upgrade ISSN 1684-5285, Novática ISSN 0211-2124). Special issue on "Wireless Networks - Telecommunications' New Age", Vol V., No. 1, pp. 49-55, February 2004.

R. Muñoz, C. Pinart, R. Martínez, A. Amrani, G. Junyent, **An experimental ASON based on OADM rings and a GMPLS control plane**, Journal of Fiber and Integrated Optics (Taylor & Francis), Vol. 23, Nb. 2-3, pp. 67-84, March-June 2004.

A. Pascual-Iserte, A. I. Pérez-Neira, M. A. Lagunas, **On power allocation strategies for maximum signal to noise an interference ratio in an OFDM-MIMO system**, IEEE Transactions on Wireless Communications, Vol. 3, No. 3, pp. 808-820, May 2004.

C. Fan, M. Maier, M. Reisslein, **The AWG | PSC Network: A Performance Enhanced Single-Hop WDM Network with Heterogeneous Protection**, IEEE/OSA Journal of Lightwave Technology, Vol. 22, No. 5, pp. 1242-1262, May 2004.

D. Pérez Palomar, M. A. Lagunas, J. M. Cioffi, **Optimum linear joint transmit-receive processing for MIMO channels with QoS constraints**, IEEE Transactions on Signal Processing, Vol. 52, No. 5, pp. 1179-1197, May 2004.

C. Collado, J. Mateu, J. M. O'Callaghan, **Comparison between nonlinear measurements in patterned and unpatterned thin films**, Superconductor Science and Technology, Vol. 17, May 2004.

J. Mateu, C. Collado, O Menéndez, J. M. O'Callaghan, **Nonlinear performance characterization in an eight-pole quasi-elliptic bandpass filter**, Superconductor Science and Technology, Vol. 17, May 2004.

Ch. V. Verikoukis, **An adaptive hidden Markov model for indoor OFDM based wireless systems**, Journal of Telecommunications and Information Technology, Vol. 2, pp. 61-65, June 2004.

M. Herzog, M. Maier, M. Reisslein, **Metropolitan Area Packet-Switched WDM Networks: A Survey on Ring Systems**, IEEE Communications Surveys, Vol. 6, No. 2, pp. 2-20, Second Quarter 2004.

Ch. V. Verikoukis, Z. Mili, P. Angelidis, **Developments of the Telecommunications Regulation Framework in Southeastern Europe**, IEEE Communications Magazine/Global Communications Newsletter, vol. 42, issue 7, pp. 23-24, July 2004.

M. P. McGarry, M. Maier, M. Reisslein, **Ethernet PONs: A Survey of Dynamic Bandwidth Allocation (DBA) Algorithms**, IEEE Communications Magazine, Vol. 42, No. 8, pp. S8-S15, August 2004.

H.-S. Yang, M. Herzog, M. Maier, M. Reisslein, **Metro WDM Networks: Performance Comparison of Slotted Ring and AWG Star Networks**, IEEE Journal on Selected Areas in Communications, vol. 22, no. 8, pp. 1460-1473, October 2004.

X. Mestre, A. I. Pérez-Neira, **Asymptotic performance evaluation of space-frequency MMSE filters for OFDM**, IEEE Transactions on Signal Processing, vol. 52, pp. 2895-2910, October 2004.

M. Maier, M. Reisslein, **AWG Based Metro WDM Networking**, IEEE Communications Magazine, vol. 42, no. 11, pp. S19-S26, November 2004.

A. Pascual Iserte, A. I. Pérez-Neira, M. A. Lagunas-Hernández, **An Approach to Optimum Joint Beamforming Design in a MIMO-OFDM Multiuser System**, EURASIP Journal on Wireless Communications and Networking, Special Issue on Multiuser MIMO Networks, Volume 2004:2, pp. 210-221, December 2004.

Invited Presentations

R. Muñoz, C. Pinart, R. Martínez, G. Junyent, A. Amrani, M. Maier, **NetCat. Intelligent Optical Network for advanced services in Catalonia**, invited speaker at the panel "Lambda networks: new research experimental networks". Joint 6th Internet Global Congress and 13th ISOC INET (INET/IGC 2004). Barcelona (Spain), May 10-14 2004.

J. Mateu, O. Menéndez, C. Collado, J. M. O'Callaghan, **Nonlinear performance characterization in a 8-pole quasielliptic bandpass HTS filter**, High-Temperature Superconductors in High Frequency Field (HTSHFF 2004). Girona (Spain), May 26-29 2004.

J. C. Booth, K. Leong, S. A. Shima, C. Collado, J. Mateu, J. M. O'Callaghan, **A Unified Description of Nonlinear Effects in High Temperature Superconductor Microwave Devices**, High-Temperature Superconductors in High Frequency Field (HTSHFF 2004). Girona (Spain), May 26-29 2004.

M. Barra, A. Cassinese, C. Collado, J. Mateu, J. M. O'Callaghan, A. Prigobbo, R. Vaglio, **Space filling curves for HTS filters**, High-Temperature Superconductors in High Frequency Field (HTSHFF 2004). Girona (Spain), May 26-29 2004.

Publications in Conferences

R. Muñoz, R. Martínez, J. Sorribes, G. Junyent, **Experimental demonstration of the impact of label contention on GMPLS bidirectional connections over unidirectional OADM rings**, 8th Working Conference on Optical Network Design and Modelling (ONDM 2004), pp. 481-496. Ghent (Belgium), February 2-4 2004.

C. Pinart, G. Junyent, **On implementing a management plane for service provisioning in IP over reconfigurable WDM networks**, 8th Working Conference on Optical Network Design and Modelling (ONDM 2004), pp. 465-480. Ghent (Belgium), February 2-4 2004.

B. Berde, O. Audouin, D. Colle, S. De Maesschalck, P. Demeester, I. Lievens, D. Papadimitriou, B. Rousseau, C. Pinart, R. Muñoz, R. Martínez, J. González, J. Jiménez, P. Arozarena, R. Theillaud, V. Piperaud, **Service-oriented transparent optical backbone networks in the ITEA TBONES project**, 8th Working Conference on Optical Network Design and Modelling (ONDM 2004), pp. 445-463. Ghent (Belgium), February 2-4 2004.

M. Navarro, A. Graell i Amat, **Punctured Space Time Turbo Trellis Codes: Rate Adaptation and Optimisation Issues**, IEEE Wireless Communications and Networking Conference (WCNC 2004). Atlanta (USA), March 21-25 2004.

J. Mangles Bafalluy, **The evolving field of peer-to-peer networking**, in Proc. Joint 6th Internet Global Congress and 13th ISOC INET (INET/IGC 2004). Barcelona (Spain), May 10-14 2004.

H. Chaouchi, G. Pujolle, I. Armuelles, M. Siebert, F. Bader, I. Ganchev, M. O'Droma, N. Houssos, **Policy Based Networking in the Integration Effort of 4G Networks and Services**, IEEE Semiannual Vehicular Technology Conference (VTC Spring). Milan (Italy), May 17-19 2004.

Ch. V. Verikoukis, Z. Mili, Ch. Panagiotou, P. Angelidis, **Mobile Telecommunications Evolution in Southeastern Europe**, IEEE Semiannual Vehicular Technology Conference (VTC Spring). Milan (Italy), May 17-19 2004.

D. Bartolomé, A. I. Pérez-Neira, **Performance Analysis of Scheduling and Admission Control for Multiuser Downlink SDMA**, IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2004). Montreal (Canada), May 17-21 2004.

A. Pascual-Iserte, A. I. Pérez-Neira, M. A. Lagunas, **A Maxmin approach for robust MIMO design: combining OSTBC and beamforming with minimum transmission power requirements**, IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2004). Montreal (Canada), May 17-21 2004.

J. López-Vicario, C. Antón-Haro, **Transmit antenna selection for rate adaptation in HSDPA systems**, Wireless World Conference (WWC 2004). San Francisco (USA), May 25-28 2004.

J. Mateu, O. Menéndez, C. Collado, J. M. O'Callaghan, **Nonlinear performance characterization in a 8-pole quasielliptic bandpass HTS filter**, High-Temperature Superconductors in High Frequency Field (HTSHFF 2004). Girona (Spain), May 26-29 2004.

J. C. Booth, K. Leong, S. A. Shima, C. Collado, J. Mateu, J. M. O'Callaghan, **A Unified Description of Nonlinear Effects in High Temperature Superconductor Microwave Devices**, High-Temperature Superconductors in High Frequency Field (HTSHFF 2004). Girona (Spain), May 26-29 2004.

M. Barra, A. Cassinese, C. Collado, J. Mateu, J. M. O'Callaghan, A. Prigobbo, R. Vaglio, **Space filling curves for HTS filters**, High-Temperature Superconductors in High Frequency Field (HTSHFF 2004). Girona (Spain), May 26-29 2004.

M. Barra, C. Collado, J. Mateu, J. M. O'Callaghan, **Hilbert fractal curves for HTS miniaturized filters**, IEEE International Microwave Symposium (IMS 2004). Forth Worth (USA), June 6-11 2004.

J. López-Vicario, C. F. Mecklenbräuker, C. Antón-Haro, **Reduced-complexity Methods for Throughput Maximization in MIMO Channels**, International Communications Conference (ICC 2004). Paris (France), June 20-24 2004.

S. Pfletschinger, F. Sanzi, **Iterative demapping for OFDM with zero-padding or cyclic prefix**, International Communications Conference (ICC 2004). Paris (France), June 20-24 2004.

A. Mollfulleda, F. Casadevall, **Partial Filter Duplication: A Solution for Noise Tolerant FIR Filter**, 2nd International Conference on Communications, Circuits and Systems (ICCCAS 2004). Chengdu (China), June 27-29 2004.

S. Pfletschinger, M. Navarro, **A Low Complexity MIMO System Based on BICM with Iterative Decoding**, 13th IST Mobile and Wireless Communications Summit. Lyon (France), June 27-30 2004.

C. Hennebert, P. Rosson, D. Bartolomé, A. Pascual-Iserte, Ana I. Pérez-Neira, **Practical Implementation of Space-Diversity Receivers in OFDM Systems: Structure, Performance, and Complexity**, 13th IST Mobile and Wireless Communications Summit. Lyon (France), June 27-30 2004.

A. Mollfulleda, F. Casadevall, **Noise Tolerant low-pass filter for IF processing**, 13th IST Mobile and Wireless Communications Summit. Lyon (France), June 27-30 2004.

A. Pascual-Iserte, M. Payaró, A. I. Pérez-Neira, M. A. Lagunas, **Robust Adaptive Modulation for Throughput Maximization in MIMO Systems Combining OSTBC and Beamforming**, 13th IST Mobile and Wireless Communications Summit. Lyon (France), June 27-30 2004.

R. Martínez, R. Muñoz, M. Requena, G. Junyent, **Architecture and implementation of a resilient control plane for optical networks based on GMPLS OSPF-TE**, 9th European Conference on Networks & Optical Communications (NOC 2004). Eindhoven (The Netherlands), June 29 – July 1 2004.

D. Bartolomé, A. I. Pérez-Neira, **Multiuser Spatial Scheduling in the Downlink of Wireless Systems**, 3rd IEEE Sensor Array and Multichannel Signal Processing Workshop (SAM 2004). Sitges (Spain), July 18-21 2004.

X. Mestre, M. A. Lagunas, **Estimating the Optimum Loading Factor Against the Finite Sample Size Effect in Minimum Variance Beamformers**, 3rd IEEE Sensor Array and Multichannel Signal Processing Workshop (SAM 2004). Sitges (Spain), July 18-21 2004.

A. Pascual-Iserte, M. A. Lagunas, A. I. Pérez-Neira, **Robustness Criteria for Transmit Spatial Diversity Systems in Frequency Selective Channels**, 3rd IEEE Sensor Array and Multichannel Signal Processing Workshop (SAM 2004). Sitges (Spain), July 18-21 2004.

J. López-Vicario, C. Antón-Haro, **Joint Transmit Antenna Selection and Adaptive Modulation in Cross-Layer Oriented Designs for HSDPA Systems**, 3rd IEEE Sensor Array and Multichannel Signal Processing Workshop (SAM 2004). Sitges (Spain), July 18-21 2004.

M. Realp, A. I. Pérez-Neira, **Multipacket MAC for Multiple Antenna Systems: A Cross-Layer Approach**, 3rd IEEE Sensor Array and Multichannel Signal Processing Workshop (SAM 2004). Sitges (Spain), July 18-21 2004.

Hongji Xu, Ju Liu, M. A. Lagunas, **Beam Space-Time Block Coding Communication System based on ICA Blind Detection**, 3rd IEEE Sensor Array and Multichannel Signal Processing Workshop (SAM 2004). Sitges (Spain), July 18-21 2004.

M. Navarro, A. Grant, **Beamforming with Imperfect Channel Knowledge: Performance Degradation Analysis based on Perturbation Theory**, 3rd IEEE Sensor Array and Multichannel Signal Processing Workshop (SAM 2004). Sitges (Spain), July 18-21 2004.

C. Pinart, G. Junyent, **Experimental test of management integration in GMPLS enabled metro WDM networks for service provisioning**, 30th European Conference on Optical Communication (ECOC 2004). Stockholm (Sweden), September 5-9 2004.

C. Bock, J. Prat, J. Segarra, G. Junyent, A. Amrani, **Scalable Two-stage Multi-FSR WDM-PON Access Network Offering Centralized Dynamic Bandwidth Allocation**, 30th European Conference on Optical Communication (ECOC 2004). Stockholm (Sweden), Sept. 5-9 2004.

C. Pinart, R. Muñoz, G. Junyent, **Experimental implementation of distributed management for service provisioning in an ASON/GMPLS testbed**, 9th IEEE International Conference on Communications Systems (ICCS 2004). Singapore, September 6-8 2004.

S. Pfletschinger, **Iterative Demodulation of Zero-Padded OFDM with MMSE Equalization using A Priori Information**, 12th European Signal Processing Conference (EUSIPCO 2004). Vienna (Austria), September 6-10 2004.

D. Bartolomé, A. I. Pérez-Neira, **BER-based vs. Game-theoretic Power Allocation Strategies for Multiuser MISO Systems**, 12th European Signal Processing Conference (EUSIPCO 2004). Vienna (Austria), September 6-10 2004.

M. Realp, A. I. Pérez-Neira, **Generalized multipacket reception model for heterogeneous networks**, 12th European Signal Processing Conference (EUSIPCO 2004). Vienna (Austria), September 6-10 2004.

M. Payaró, M. A. Lagunas, **Adaptive modulation in MISO wireless systems with discrete low-rate power feedback**, 2th European Signal Processing Conference (EUSIPCO 2004). Vienna (Austria), September 6-10 2004.

X. Mestre, **Designing good estimators for low sample sizes: random matrix theory in array processing applications**, 12th European Signal Processing Conference (EUSIPCO 2004). Vienna (Austria), September 6-10 2004.

J. López-Vicario, C. Antón-Haro, **Transmission rate adaptation in multi-antenna HSDPA systems using cross-layer criteria** (original title in Spanish), XIX Simposium Nacional de la Unión Científica Internacional de Radio (URSI 2004). Barcelona (Spain), September 8-10 2004.

J. M. González Arbesú, P. Miskovsky, J. Romeu, **Prefractal antennas independent of frequency** (original title in Spanish), XIX Simposium Nacional de la Unión Científica Internacional de Radio (URSI 2004). Barcelona (Spain), September 8-10 2004.

I. Gutiérrez, D. Bartolomé, C. Vilella, **Study of different methods for power control in CDMA based on game theory** (original title in Spanish), XIX Simposium Nacional de la Unión Científica Internacional de Radio (URSI 2004). Barcelona (Spain), September 8-10 2004.

C. Ibars, M. Tan, Y. Bar-Ness, **Equal SNR Power Distribution for Generalized DFE Structures**, 7th International Symposium on Wireless Personal Mobile Communications (WPMC 2004). Abano Terme (Italy), September 12-15 2004.

M. Payaró, A. I. Pérez-Neira, M. A. Lagunas, **Achievable rates for generalized spatial Tomlinson-Harashima precoding in MIMO systems**, 60th IEEE Vehicular Technology Conference (VTC Fall 2004). Los Angeles (USA), September 26-29 2004.

J. Mateu, C. Collado, O. Menéndez, J.M. O'Callaghan, **Nonlinear Distortion in a 8-pole Quasi-Elliptic Bandpass HTS Filter for CDMA**, IEEE Applied Superconductivity Conference (ASC 2004). Jacksonville (USA), October 3-8 2004.

J. Mateu, C. Collado, J.M. O'Callaghan, **Nonlinear Models of Coupled Superconducting Lines**, IEEE Applied Superconductivity Conference (ASC 2004). Jacksonville (USA), October 3-8 2004.

O. Menéndez, C. Collado, C. Santos, J. Mateu, J.M. O'Callaghan, **Performance Projection of Electro-Optic Modulators for Radio-over-Fiber in 2 GHz Cryogenic Front-End Receivers**, IEEE Applied Superconductivity Conference (ASC 2004). Jacksonville (USA), October 3-8 2004.

C. Pinart, A. Amrani, G. Junyent, **Monitoring service "health" in intelligent, transparent optical networks**, IFIP Optical Networks & Technologies Conference (OpNeTec 2004). Pisa (Italy), October 18-20 2004.

R. Muñoz, R. Martínez, J. Sorribes, G. Junyent, **An experimental GMPLS-based wavelength reservation protocol for flooding global wavelength information in uni-ring-based MAN**, IFIP Optical Networks & Technologies Conference (OpNeTec 2004). Pisa (Italy), October 18-20 2004.

R. González, F. Bader, M. A. Lagunas, **Analysis of the behaviour of different 2D interpolation techniques using a adaptive-pilot symbol aided OFDM wireless system**, IEEE Symposium on Trends in Communications (SymptoTIC'04). Bratislava (Slovakia), 24 – 26 October 2004.

M. Payaró, X. Mestre, M. A. Lagunas, **Optimum transmit architecture of a MIMO system under modulus channel knowledge at the transmitter**, IEEE Information Theory Workshop (ITW 2004). San Antonio (USA), October 24-29 2004.

D. Bartolomé, A. I. Pérez-Neira, C. Ibars, **Practical Bit Loading Schemes for Multi-Antenna Multi-User Wireless OFDM Systems**, Asilomar Conference on Signals, Systems, and Computers. Pacific Grove (USA), November 7-10 2004.

C. Ibars, S. Pfletschinger, **Iterative Multiuser Receiver for Multi-resolution Broadcasting**, Asilomar Conference on Signals, Systems, and Computers. Pacific Grove (USA), November 7-10 2004.

C. Pinart, A. Amrani, G. Junyent, **Service monitoring in intelligent, transparent networks** (original title in Spanish), XIV Jornadas Telecom I+D. Madrid (Spain), 23-25 November 2004.

I. Armuelles Voinov, T. Robles Valladares, C. Pinart, C. Bader, H. Chaouchi, M. O'Droma, I. Ganchev, M. Siebert, **System integration model for the development of 4G mobile communication networks** (original title in Spanish), XIV Jornadas Telecom I+D. Madrid, 23-25 Nov. 2004.

S. Pfletschinger, M. Navarro, **A Low-Complexity MIMO System with Soft Interference Mitigation**, IEEE Global Telecommunications Conference (Globecom 2004). Dallas (USA), 29 November - 3 December 2004.

M. Realp, A. I. Pérez-Neira, **Cross-Layer MAC Scheduling for Multiple Antenna Systems**, IEEE Global Telecommunications Conference (Globecom 2004). Dallas (USA), 29 November - 3 December 2004.

R. Muñoz, R. Martínez, J. Sorribes, G. Junyent, **Experimental demonstration of two new GMPLS lightpath setup schemes for soft-permanent connections over Metro-DWDM DPRing implemented on EMPIRICO ASON testbed**, IEEE Global Telecommunications Conference (Globecom 2004). Dallas (USA), 29 November - 3 December 2004.

M. Payaró, X. Mestre, M. A. Lagunas, **Ergodic capacity of a 2x2 MIMO system under phase uncertainty at the transmitter**, 11th IEEE International Conference on Electronics, Circuits and Systems (ICECS 2004). Tel Aviv (Israel), December 13-15 2004.

D. Bartolomé, A. I. Pérez-Neira, **A Unified Fairness Framework in Multi-Antenna Multi-User Channels**, 11th IEEE International Conference on Electronics, Circuits and Systems (ICECS 2004). Tel Aviv (Israel), December 13-15 2004.

10. Financial Report

A. Income Statement

	2004	2003	2002
<i>Expenses</i>			
Personnel	1207331	728562	289083
Working expenses	571283	439903	273516
Depreciation	262970	173618	31373
TOTAL	2041584	1342083	593972
<i>Income</i>			
Projects: direct contracts	25500	16600	0
Projects: competitive funds	744504	239156	116900
Subsidies to R+D activities	1244140	1070491	465329
Other current income	27440	15836	11743
TOTAL	2041584	1342083	593972

B. Balance Sheet

	2004	2003	2002
<i>Assets</i>			
Fixed Assets	4582418	1414449	492053
Current Assets	3612742	2063228	715883
TOTAL	8195160	3477677	1207936
<i>Liabilities</i>			
Foundational Equity	90152	90152	90152
Income to be assigned	2969500	1529636	952092
Long-term Debt	2248053	898053	0
Accounts payable	2887455	959836	165692
TOTAL	8195160	3477677	1207936

All amounts are in Euros