

Pervasive Ultra-wideband Low Spectral Energy Radio Systems (PULSERS)

Expression of Interest for an Integrated Project (Eol.FP6.2002)

Sub-Thematic Priority Area: 1.1.2.ii – Communication, Computing and Software Technologies

SUMMARY

The commercialization of short-range wireless devices based on the principles of ultra-wideband (UWB) radio technology (UWB-RT) is widely expected within this decade, given the recent endorsement in the USA and Europe's similar efforts. The possible use and benefits of UWB-RT are significant in the areas of communications, imaging, ranging, sensing and public security. Also, the spectrum overlay capability of UWB signals offers the potential to alleviate problems related to finding and allocating new spectrum resources on a world-wide scale. It is anticipated that the future Wireless World will include large numbers of "intelligent devices" in the form of wireless transceivers built into appliances, sensors, beacons as well as identification tags and the like. The envisaged scenarios of such networked "ambient intelligence" imply that many of these devices will interact among themselves but also with their environment by exchanging various types of information, including their geographic positions in support of context-aware applications, services and even routing mechanisms. The prospect of a shortage in world-wide available spectrum resources and the growing number of active wireless devices, combined with their potential to further aggravate interference and electromagnetic exposure issues, favors the introduction of license-free systems based on ultra-wide spectrum overlay concepts. UWB-RT has also been identified as a potential key technology to enable the development of dynamic wireless networks that combine robustness, high resistance to intentional attacks, communication and location features. UWB devices will help in filling the current technical gaps towards the realization of the vision of a future Wireless World in the short-range space where a variety of high data rate and/or location-centric applications interact seamlessly and wirelessly. The commercial prospects and technical challenges to be overcome when developing and deploying UWB radio systems have spurred a growing activity within the wireless industry and research institutions alike. Some IST-FP5 projects are already focusing today on exploring the potential of low-power short-range UWB radio devices; they will soon deliver indications for an initial exploitation path for this promising new technology. However, there is a real need for a thorough study of its potential interoperation and coexistence with other wireless systems. Thus, an extended and well coordinated approach to design, trial and integration activities related to UWB-RT will significantly improve Europe's chances to be at the forefront of this revolutionary technique. Such an approach can ensure that future users will enjoy the advantages and services as offered by high-speed multimedia transmission and context-aware personalized UWB and other wireless devices. Consequently, based on the strong interest of over 30 organizations, a coordinated and integrated European research and development project of sufficient technical breadth is proposed – the *Pervasive Ultra-wideband Low Spectral Energy Radio Systems (PULSERS) Integrated Project (IP)*. Besides longer-term, more "risky" research items, the primary objectives of the PULSERS-IP are defined to provide a platform that increases Europe's knowledge base, competitiveness and readiness for commercial exploitation of UWB-RT.

INTRODUCTION

Project PULSERS is concerned with specific short-range wireless devices and systems operating in the context of *Ambient Intelligence* [1], [2] and – in a very similar sense – *Pervasive Computing* environments [3], [4]. While short-range wireless applications demand ever higher data rates, we also observe an increase in the numbers of low-rate devices, such as transceivers embedded in a variety of common appliances, exchanging different information types, including their geographic or local positions. The resulting prospect of a shortage in spectrum resources calls for license-free systems using spectrum overlay concepts. UWB-RT is widely considered as a possible key technology enabling the reuse of existing spectrum bands. The commercial prospects and the technical challenges to be overcome when developing and deploying UWB radio systems have spurred a rapidly growing activity within the wireless industry and research institutions, mainly in the United States of America (USA). Home, office, healthcare and also industrial environments are becoming primary target markets for different systems supporting link distances of only a few tens of meters. While dedicated data-centric links (up to several 100 Mb/s) are envisaged for distances up to a few meters, use of low-rate links (down to several kb/s) in combination with precise position location and tracking is considered possible over 100 m and more. UWB-RT is also considered a key technology for wireless multimedia systems. In its *First Report and Order*, the FCC has stated: "*Based on our review of the record, we continue to believe that UWB technology offers significant benefits for public safety, businesses and consumers. We anticipate that the authorization of UWB technology will create new business opportunities for manufacturers, distributors and vendors that will enhance competition and the economy. We also find that the use of this technology would promote spectrum efficiency by sharing frequencies with other services without causing interference*" [5]." The FCC's decision of allowing commercial use of UWB radio devices is a fundamental step forward in regulating spectrum allocation. Based on ETSI and CEPT activities related to UWB-RT, a first European regulation for UWB radios is expected by 2004 [6], [7]; also, there are indications that Japan and other Asian countries will follow.

NEED AND RELEVANCE – OBJECTIVES AND MAIN TASKS

Need and Relevance – UWB-RT opens unique possibilities to combine data communication and positioning capabilities within a single device [8]. The PULSERS-IP provides the opportunity to drive the regulatory and standardization groups developing physical layer (PHY), medium access control (MAC) and networking functions for short-range wireless systems that inherently support context-aware and personal services. While these capabilities are not – or at best only poorly – supported by conventional narrow-band systems, exploitation of UWB-RT technology will allow their implementation and commercialization. A standardization group, the *IEEE 802.15.3a ALT-PHY Study Group* (SG3a), has started to work on a first PHY definition for the support of multimedia and location-aware applications [9]. Some USA-based developers of UWB-RT are currently leading the way in the design of PHY functions and, to a somewhat lesser degree, the MAC and higher-layer functions required to support the application scenarios described above. A few very effective pioneering individuals and companies have collectively generated an impressive amount of intellectual property, including complete concept and prototype systems that sufficiently proved feasibility and benefits of UWB-RT (e.g., see [10]). However, a large gap exists between the current level of the base technology and the ultimately desirable state of widely available and highly integrated, cost/power efficient and standardized circuits with small form factors, e.g., for integration into a variety of common home appliances as well as cell phones, personal digital assistants, laptops and other devices. Thus, the potential benefits of UWB-RT to various user groups – at the home, in public areas or at work – are significant, particularly in the areas of communications, multimedia, ranging, sensing and public security as well as in mitigating problems related to scarce spectrum resources [5]. Context-aware and multimedia services will advance the European citizens' social and technical status and will bring forward new wireless business opportunities; these are clearly major motivators and incentives to support a coordinated UWB-RT action in FP6 by means of the PULSERS-IP.

Objectives and Main Tasks – PULSERS aims at integrating UWB-RT into the daily life of a large number of European citizens by allowing new services and creating spaces for innovation and business opportunities. To achieve these challenging goals, the group will have to work hard, aiming for low-cost and low power UWB devices and protocols to allow a seamless integration and cooperation with other wireless personal area networks, for example, such as Bluetooth, IEEE 802.11a/b, and IEEE 802.15.4. The research work will be initiated by defining user scenarios and applications in the home, office and industrial user spaces. This activity will also exploit the findings and results of previous IST projects to obtain a comprehensive set of suitable network topologies, system architectures as well as system and PHY/MAC technology requirements. An important aspect of the project will be to observe, help and support the evolving UWB regulatory developments – primarily in Europe – and to contribute to (global) standardization efforts for systems based on UWB-RT. This close relationship with regulators will provide the necessary inputs for the core work areas, namely, the development of the enabling PHY and MAC technologies, including platforms for flexible design and performance evaluation in smart environments. The envisaged core activities of the project will integrate work in areas such as antenna systems, semiconductor and circuit technologies as well as design issues related to “system on chip” (SoC) or “system on package” (SoP). Core activities also include study of UWB signal propagation and modeling, the design and evaluation of signal processing and coding algorithms, the analysis of adaptive architectures and modulations, investigations on the applicability of multiple-input/multiple-output (MIMO) technology as well as quality of service (QoS) and security issues at the PHY and MAC layers alike. Network layer issues (i.e., addressing, routing, mobility and topology management) will also be considered, ideally in cooperation with related projects under FP6, e.g., projects dealing with *Ad-hoc Networking*. Some aspects related to terminal reconfiguration might be addressed in cooperation with specific *Software Defined Radio* (SDR) FP6 projects. PULSERS will build a consensus towards broadly supported positions and agreements in matters of radio regulation and standardization of UWB radio devices. Through a synergetic approach, all envisaged tasks will lead to the design, construction and demonstration of working UWB prototype systems that are integrated in pilot intelligent environments. The objectives of the PULSERS-IP will be achieved through a set of coordinated, main technical tasks:

- **User Scenarios and Applications** – Define new and perhaps unconventional user scenarios and applications which leverage the unique advantages and properties offered by UWB-RT; deduce corresponding requirements on the qualitative and quantitative PHY/MAC and higher layer specifications (e.g., for joint data and positioning applications).
- **Performance and Algorithms** – Perform a comparative performance analysis (theory, simulation and experiments) to assess the merits of various coding, modulation, multiple-access and positioning schemes for UWB radio applications; include pulsed and alternate (ultra-)wideband signaling methods, e.g., chirp [11], pulse-distance signaling and others.
- **Interference and Coexistence** – Determine interference and coexistence effects of – and on – UWB devices in heterogeneous network situations; coordinate and cooperate with related organizations (e.g., ETSI/BRAN).
- **Semiconductor and Circuit Technologies** – Advancements in the use of high-speed, mixed-signal semiconductor processes (e.g., CMOS, SiGe/BiCMOS, GaAs, InPh) and design methods, enabling high-volume, low-power and cost-effective “system on chip” (SoC) or “system on package” (SoP) solutions for UWB radio devices (e.g., [12]).
- **Implementation and Demonstration** – Implement/demonstrate selected user scenarios in terms of UWB hardware and specific software and application functions (e.g., data, positioning, sensing) in ambient intelligent environments.

- **Regulation and Standardization** – Support a broad (global) consensus on UWB radio regulation and work towards well consolidated proposals and submissions to international bodies standardizing UWB radio devices and services.

SCALE OF AMBITION AND CRITICAL MASS

Ambition – Project PULSERS intends to extend, complement and strengthen ongoing IST-FP5 projects and efforts related to UWB-RT. It will build the necessary European synergy and vital coordinated support to facilitate the introduction of unique and innovative (short-range) services offered by this new technology. The results of existing IST projects will be effectively integrated with the new ideas and extended work plans of PULSERS by following a reference roadmap and considering key criteria and requirements to ensure viable, low-power, short-range wireless solutions. Technical work will range from high-speed circuit and antenna technologies over signal processing and coding issues to medium access and ad-hoc network control. The scope of PULSERS will also extend to alternate (ultra-)wideband radio systems (e.g., [11], [12]). In addition, essential topics such as coexistence/interference issues and electromagnetic exposure concerns will be addressed to make sure that the technology can be safely and seamlessly introduced into the marketplace. Close coordination and direct cooperation between partners and related projects is a definite prerequisite for achieving significant and timely advancements towards demonstrable viable UWB radio system solutions. Project PULSERS has both the ambition and the flexibility to achieve synergetic effects among its objectives and those pursued by other IST projects related to UWB-RT. This integrated project – collecting all major interested parties in the European wireless industry, research institutions, user groups and administrations – is expected to facilitate European - and perhaps even global - solutions for the regulation and standardization of UWB radio devices. PULSERS will extend and include a variety of results and skills built within the IST projects related to UWB-RT (e.g., *UCAN* [13], *ULTRAWAVES* [14], *whyless.com* [15], [16]).

Critical Mass – The European wireless industry and associated innovative wireless multimedia and context-aware services lag behind the very significant basic technological advances made, particularly during the 1990's, by a number of USA-based pioneering developers of UWB-RT. While these early developers were initially funded by military and government agencies, they are now strongly focusing on the commercialization path. Thus the USA has already a well established intellectual property, technical expertise and development capacity in this emerging field. As of 2002, commercial UWB radio devices will be able to operate in the USA within the spectrum range 3.1-10.6 GHz. Although similar regulatory efforts have recently started to take place in Europe (e.g. within the ETSI-ERM/TG31 and CEPT/SE24 groups [7]) the USA's lead, particularly in the development of the base technology and standardization of UWB-RT, is rather significant. Europe faces the challenge to quickly develop the critical expertise and know-how that will allow effective development and deployment of UWB-RT-based services that are competitive on a global scale. Thus, an integrated and well coordinated European UWB R&D effort of sufficient size and scope appears necessary. By soliciting the active participation of academic and industrial organizations - including small and medium-sized enterprises (SME's) - project PULSERS will be able to build the critical mass for these R&D activities by providing the resources and expertise needed to achieve its ambitious goals.

NEED FOR COORDINATION AND INTEGRATION

Cooperation and synergy between PULSERS and related IST projects will increase the effectiveness in attaining the critical mass necessary for Europe, as outlined above. This can be achieved, for example, by the organization proposed in Fig. 1, based on the horizontal technical and coordinating vertical components. Besides defining reference models and assuring compatibility with the visions of the *Wireless World*, the FP6 **Coordination Function** links the PULSERS project and related IST projects to assure integration of the latter's results and the transition of their expertise into the new FP6 activities related to UWB-RT. This coordination task and establishment of synergetic roadmap definitions could be done within PULSERS itself or it could be provided by a different FP6 project entity, such as a large-scale WWRF-driven project [17], [18]. The multi-disciplinary skill base assembled within PULSERS could be leveraged by combining it with the skills, expertise and results that become available through other European projects related to UWB-RT. The participants in PULSERS – of which some are already active in existing IST projects related to UWB-RT – are willing and interested in collaborating closely to extend their influence and visions within the framework of the PULSERS-IP. Consequently, the formation of an appropriate **UWB-RT Cluster**, coordinating related IST-FP5/FP6 projects under the auspices of the European Commission, appears not only necessary but also practical and feasible (see Fig. 1). Typically, the anticipated flexible organization of the PULSERS-IP will enable industrial partners to lead in systems and prototype aspects of the proposed work while academic partners will mainly lead in base technology investigations, concept studies and educational or training activities. The need as well as the wish for close coordination and integration of UWB-related R&D activities in Europe is very well demonstrated by the rather large and well balanced number of academic institutions and industrial organizations – including SMEs and participants in related FP5 projects – that have expressed their explicit interest for an active participation in the PULSERS-IP (see Table 1).

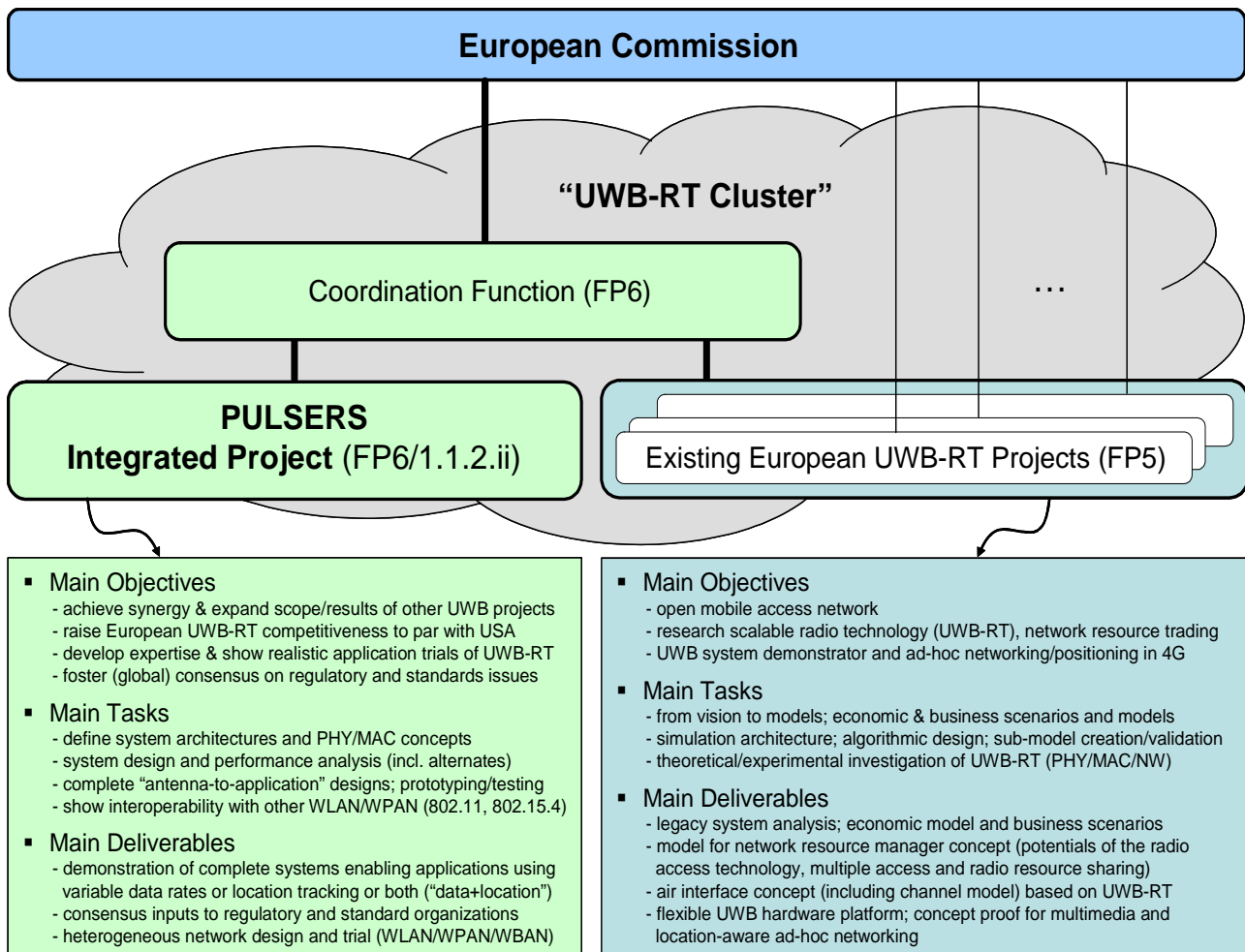


Figure 1 – Project PULSERS (FP6) and its proposed synergetic connection to existing FP5 projects related to UWB-RT, whose main objectives, tasks and deliverables are extended and complemented by PULSERS.

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Table 1 – Organizations that have expressed an interest in participating in project PULSERS
(updated preliminary list as of August 20/September 9, 2002).

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