PROJECT FINAL REPORT

Grant Agreement number: 243473

Project acronym: WEAR-A-BAN

Project title: Unobtrusive wearable human to machine wireless interface

Funding Scheme: Research for SME associations

Period covered: from M1 to M29

Name of the scientific representative of the project's co-ordinator[1], Title and Organisation: Marianna Vari, RTD TALOS

Tel: +35722454333

Fax: +35722660009

E-mail: mv@talos-rtd.com

Project website address: www.wearaban.eu

[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement.

Table of Contents

1. Executive summary

The Wear-a-BAN project is co-funded by the European Commission through the "Research for the benefit of specific groups" instrument in particular for the Associations of Small and Medium sized Enterprises (SMEs). Wear-a-BAN will contribute to enable EC policies such as eHealth for better healthcare in Europe, i2010 for fostering better inclusion of disabled people through ICT, eLearning for speeding up changes in education and training, and EU Health and Safety at work for enabling safer interaction for machine or robot operators.

The objective of Wear-a-BAN is to investigate and demonstrate ultra-low-power wireless body-area-network (WBAN) technologies for enabling unobtrusive human to machine interfaces (HMI) into SME-driven market segments of smart fabrics / interactive textiles (SFIT), robotics for augmented reality assistance and rehabilitation, and natural interfacing devices for video gaming.

The proposed research will generate high societal and market impact for the European SMEs, and will enable major technological breakthroughs in the areas of ultra-low-power radio system-on-chips (SoC) and of textile-oriented system-in-package (SiP) platforms for miniature wearable antennas, wireless and sensor electronics and digital signal processing.

Natural HMI will be enabled through the development of unobtrusive wearable sensor and wireless body-area-network (BAN) communication concepts.

The wireless technology required for BAN-based natural HMI needs to be low power to operate from a very slim size battery, and miniaturised in order to fit into the strongly space-limited environment of smart fabrics / interactive textiles (SFIT).

Today, wireless technology does not meet all of these requirements, and the major challenge of Wear-a-BAN is to improve the personal sensing capabilities with the use of unobtrusive, wearable long-lifetime BAN through the following requirements for the wireless sensors:

- the motional and emotional sensor nodes must be ultra-miniature, in order to fit within very tiny/slim/thin embodiments amenable for embedding flexible sensors inside clothes,
- the wireless link must be ultra-low-power, for enabling multi-hour and multi-day autonomy using small and low-cost battery technologies,
- the antenna and radio must adapt to variable around-the-body propagation due to various placements on the body and movements of body parts,
- a high performance data-processing unit is needed to process sensor data, do data fusion of multiple sensors placed around the body and extract relevant features to be transmitted,
- the radio, antenna, sensors and digital electronics shall be integrated into a wearable system-in-package platform to allow flexible, unobtrusive and improved user experience.

1.1 Summary description of the project context and the main objectives

The objectives of this innovative project was to investigate and demonstrate ultra-low-power wireless body-area-network technologies for enabling unobtrusive human to machine interfaces into market segments such as smart and interactive textiles, robotics for augmented reality assistance and rehabilitation and natural interfacing devices for video gaming. Wear-a-BAN enables major technological breakthroughs that will generate strong societal impact by increasing the comfort, health and security for a wide category of users in the European population.

Communication between man and machine, also known as Human-Machine-Interface (HMI), could become more intuitive or natural by integrating motional and emotional information, parameters which are difficult to express with standard HMI devices. Indeed, in man to man communication, a large part of the information is transmitted naturally through non-verbal communication (body language, intonations, etc). Such a paradigm shift requires a move from classical computer peripherals towards natural interfaces that mimic the natural human interaction. With recent advances in microelectronics, embedded signal processing and software technologies, more natural HMI solutions are within reach, which will enable new gaming, medical rehabilitation and robotics interfacing paradigms and require very short and intuitive learning curves for anyone.

The Wear-a-BAN project, with the active participation of the consortium members, consists of leading research organizations, universities, associations of SMEs and SME participants from all over Europe, including the Robotics Society of Finland, Cap Digital Paris Region, Ateval, Ramon Espi S.L., Movea SA, Deltatron Oy, Wizarbox Ltd., SignalGeneriX Ltd., Voxler, Aitex, CSEM SA, Technical University of Berlin, VTT, CEA-LETI and the coordinator RTD TALOS Ltd.

Wear-a-BAN will enable major technological breakthroughs in the areas of ultra-low-power radio system-on-chips and of textile-oriented system-in-package platforms for miniature wearable antennas, wireless and sensor electronics and digital signal processing, resulting in significantly increasing the competitiveness of the SME associations participating in the project.

Create a network of smart sensing nodes around the human body was the goal of this Wear-a-BAN project. Starting from SMEs requirements, a wearable node has been fabricated, the elementary bricks are:

- Dedicated ultra-low-power RF system-on-chip based on its icycom technology, with best in class RF power consumption as well as on-chip digital signal processing and power management.
- Off the shelf sensors like magnetometer, accelerometers, gyroscopes and microphone.
- Textile antenna

- Embedded software including sensing management and network ultra-low power RF protocol.

This electronic node of 2x3 cm^2 is then used either into the textile antenna (motional node, to left image with opened textile antenna) or into the headset for audio features (emotional node, right images).

Figure 1: Textile antenna including the Wear-a-BAN electronics, open (upper left), closed on test subject's wrist (lower left) and the headset node antenna (right)

The performances of the node and its antenna are proven to be sufficient to create a sensor network, working on small coin cells. And when integrated into textile, the network is human wearable, allowing precise movement detection (smart node allows some data pre-treatment on board.).

Four scenarios have been set up by SMEs in order to show the utilisation of the BAN in real applications. The main achievement in this project has been the final demonstrators of four different application scenarios demonstrating the viability and versatility of Wear-a-BAN technology.

Integrating the developed body area network (WAB nodes) into textiles, the connexion among them and the different specifics software and the right treatment of the obtained information, WBAN technology has been able to monitor the human activity at home; to show the right rehabilitation movement in injured limbs; and goes beyond the current state of gaming interfaces allowing, without cameras, play video games by means of legs and arms movement in real time.

Wear-a-BAN based SFIT demonstrator

When looking at results that demonstrate the usefulness of creating intelligent textiles that help in the realistic monitoring of movement, it is important to bear in mind garments that have already been developed and integrated into each scenario and form part of the overall project demonstrators.

Figure 2: Wrist, ankle bands, sleeve, and garments details

All of these garments, regardless of the scenario, have been designed to be washable throughout their life cycle (which could be years), even after each use (which is recommended). This includes the flexible pockets containing the nodes and which need to be easily removed before each wash, as well as the material type and its components which may have been altered slightly to adapt to each scenario.

The gaming demonstrator combines basic leg and arm movement monitoring with real-time synchronization to play a video game; it includes a microphone for voice control. The use of intelligent textiles in this case has centred on the development of wrist and ankle bands that can accept the integration of the WAB modules and antenna to avoid the need of wearing special clothing for game control that cannot be exchanged between players easily. The garment itself is the controller and can be worn comfortably, avoiding the need for hand-held controllers. The system is Velcro-fixed to allow easy removal.

Wear-a-BAN daily life activity monitoring demonstrator

There were two main objectives to achieve in this scenario through the demonstrators:

- ***Energy Expenditure control***

The services presented in this scenario are proposed during daily activity of a person. Energy expenditure (EE) is an important indicator to assess if a person has physically solicited enough his body during the last days or weeks.

One of the functions provided in the scenario is the EE spent by a person wearing the sensors. As we are using motion sensors (no heart rate sensor), the device is only supposed to measure mechanical energy.

- ***Physical activity recognition***

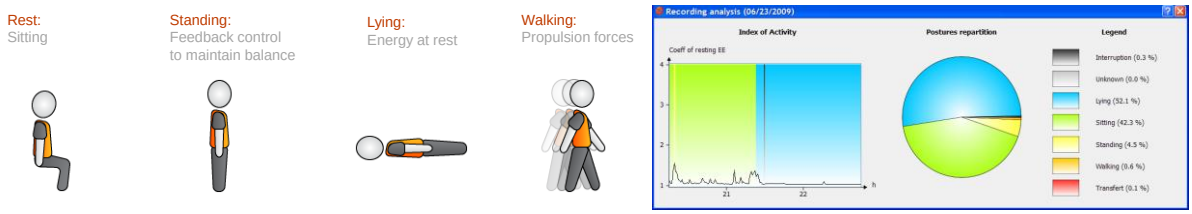

Figure 3: Main Activities in daily life

The technological developments can be concluded that are successful regarding the scenario requirements: Integration of many challenging components has been done entirely. The on-body node is flat, and flexible enough to make future product design credible and possibly integrated in the textile. Radio circuit and protocol is highly flexible. It is not just a piece of hardware, it's also a kit, a platform to produce new product scenario. The range of the radio/antenna was not an issue for the scenario, since to implement two modes had been decided: a recording mode and a radio mode (when the user is back home).

A video featuring the daily life activity monitoring demonstrator is available at: http://www.youtube.com/watch?v=sg503Z-SzY0&feature=BFa&list=PLASh6DaIfspv5kTFxdzTLc1-1RAGO7CVW

Wear-a-BAN gaming demonstrator

The services presented in this scenario are proposed during playing a music video game. Music video games and especially singing or dancing video games let the players interact with their favorite music and have fun. The WAB network is capable to send motional and emotional data to the video game in order to establish dancing and singing scores. It provides a compact unobtrusive interface that the player can use seamlessly, so that playing the video game in a natural interface.

Most music video games are based on comparing the performance of the player with a reference performance. In the case of a singing or dancing video game, the player's performance is compared with the singing of the reference singer and the dancing of the reference singer.

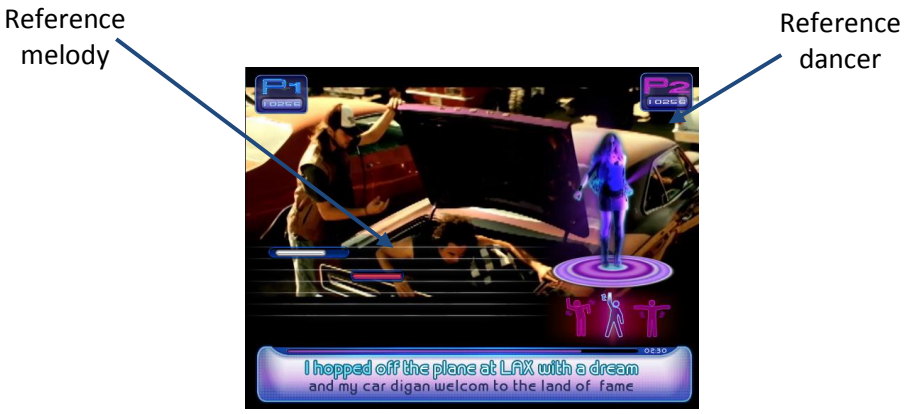

Figure 4: Dance and sing game screen shot

A headset coupled with a motional sensing network, worn in simple clothes let the player completely free to dance and sing. The realization of the game shows:

- Integration of many challenging components has been done entirely both for the motion sensor and for the microphone. The on-body node is flat, and flexible enough to make future product design credible and possibly integrated in the textile.
- The range of the radio/antenna is not an issue for the gaming scenario, since the distance between the player and his TV is limited to a few tens of meters.

A short video has been prepared about the gaming demonstrator which can be accessed at the link:
http://www.youtube.com/watch?v=bckH28dtH9M&feature=BFa&list=PLASh6DaIfspv5kTFxdzTLc1-1RAGO7CVW

Wear-a-BAN robotics-for-rehabilitation demonstrator

The purpose of this task was to validate the performance of the Wear-a-BAN nodes network in a medical scenario. This scenario was dealing with robot based rehabilitation of stroke patients.

Robo and Delta developed the concept with the guidance of rehabilitation professionals at the Kuopio University Hospital. The concept was designed in CAD-environment and especially the connection to the upper limb of the patient was in focus. The concept is designed using the most potential robot arm type LWR by Kuka Roboter AG, Germany. This robot type has 7 degrees of freedom, allowing the robot to reach the patient from different angles in order to avoid possible collision between the robot arm and the patient. The safety aspects are taken into account by allowing the robot run only within safety speeds. The robot also reacts to collisions by withdrawing by control system means, thus making the physical contact more "natural with human body.

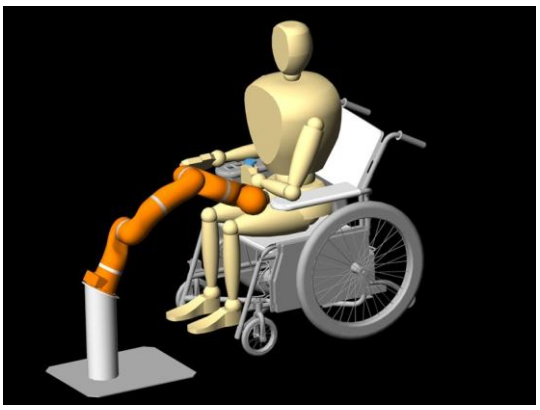

Figure 5: The rehabilitation scenario in real scale with the use of the slim industrial robot not to frighten a patient whose upper limb is seamlessly tied to the robot arm.

The conclusions of this task show this scenario has in reality a good potential of this developed wireless technology in the vicinity of human body. The limb movements can be monitored and various product concepts can be generated based on this Wear-a-BAN technology. The potential end- users of this robot based rehab scenario are interested to further develop and test-run the robotized rehabilitation concept. The developed technology has now been proven to work in this environment.

Robo and Delta tested the developed sensor nodes against the rehab application specs. The video material is available at:
http://www.youtube.com/watch?v=-oZY-jh6n6A&list=PLASh6DaIfspv5kTFxdzTLc1-1RAGO7CVW&index=1&feature=plpp_video

The simulation video on the robotics scenario with the mirror therapy concept, developed by Robo and Delta, is available at: http://www.youtube.com/watch?v=XSaUNlEsrnM

1.2 Description of the main S & T results/foregrounds

The technical work has been decomposed in specific workpackages (WP) with the following work:

WP1 User requirements and specifications

The work performed within WP1 was completed during the first year of the project. Driven by the end-user SMEs, four use-case scenarios were identified and described, namely "Scenario 1: Robotics based rehabilitation", "Scenario 2: Wear-a-BAN based SFIT in a garment", "Scenario 3: Daily Life Physical Activity Monitoring" and "Scenario 4: Wear-a-BAN based gaming".
Within the Description of Work a total of three tasks with five deliverables were defined for WP1:

- T1.1 for the collection of user requirements for the 4 demonstrators and market needs. This task had D1.1 as a deliverable with the definitions of 4 demonstrators.
- T1.2 for functional specifications definitions with 2 deliverables: D1.2.1 for draft specifications (functional specifications derived from the scenarios) and D1.2.2 for the final version.
- T1.3 for technical specifications definitions with 2 deliverables: D1.3.1 for draft specifications (detailed technical specifications for the technology bricks) and D1.3.2 for the final version.

The Description of Work defined four main markets with strong commercial potential for the technology to be developed by the Wear-a-BAN project, namely:

- ***Scenario 1: Robotics***
  It describes the requirements and high-level specifications of a robotics man-to-machine application. These are of interest of SME-AG ROBO and SME DELTA participants from Finland. It is foreseen that the rehabilitation of an injured arm or leg is conducted at home/medical center with the help of a rehabilitation robot based on the forced rehabilitation (extra power is brought to conduct the exercise by the robot).

- ***Scenario 2: Smart fabrics and interactive textile***
  The textile end-users SME-AG ATEVAL and RAPIFE have envisioned to embed movement sensors in a shirt and/or pants for detection of maximum amplitude of joints movements in patients in rehabilitation. The main markets will be sports and military quality textile-based equipment.

- ***Scenario 3: Health***
  It is based on a "daily activity monitoring" concept by MOVEA and SME-AG CAPDIGITAL, which comes in the form of a patch that would be applied to a patient for long duration motion monitoring (MotionPatch™). The users of the monitoring system are the medical teams, the patients or the persons that wears the patch. The goal is to get a continuous and consistent motion data information during daily life.

- ***Scenario 4: Gaming***

  It is driven by PLAYALL/WIZARBOX and SME-AG CAPDIGITAL, and combines all movement detection and emotional voice sensors. The voice analysis sensor will analyse the singing performance and expressivity of the players, and speech recognition will be implemented additionally to manage the complete interface of the game prototype (no Gamepad required to navigate menus, select songs, etc.). Movement sensors will be used to classify dance movements of a player. When all combined we can create a singing and dancing game with merged scores.

The main results were thus the specification of the use-cases, the technical specifications to enable to launch the technology developments in WP2 through WP6, and the specifications of the demonstrator prototypes for WP7.

WP2 Radio and DSP IC

The main tasks in WP2 concerned first the delivery of CSEM's existing icycom platform to the partners for launching the software developments, secondly to design, fabricate and characterize the Wear-a-BAN System-on-chip (WAB SoC), and thirdly to provide the partners with a baseline low-level software abstraction layer destined to support the software running on the icyflex1 embedded processor, managing the on chip components.

The main deliverables were:

- ***D2.1: WAB System On a Chip (SoC)***

The delivery of the pre-existing icycom platform allowed the partners to start their own technology developments in the meantime of the design and fabrication of the WAB SoC. As the latter uses the same icyflex1 DSP as icycom, the WAB software development could be launched efficiently by CEA and SG once the target specifications from WP1 were available. CSEM provided icycom samples, the icycom hardware and software development kits, and training to the partners.

The development of the WAB SoC started with the establishment of the WAB SoC specifications, starting from the technical requirements from WP1. In particular, it was confirmed that a large part of the existing icycom background could be re-used for the targeted use-case demonstrations. Three main additional functionalities tailored for Wear-a-BAN were also specified, firstly concerning the WAB SoC radio's Power Amplifier (PA) with reduced output power and consumption, secondly the antenna tuning mechanism using a capacitor bank for allowing to compensate antenna de-tuning artefacts for optimal propagation, and thirdly the digital PDM (pulse-density-modulation) peripheral to be used with a microphone for the emotional sensor (a new microphone arrived in the meantime is simply accessible through standard I2S).

The final HDK and associated HAL have been successfully provided. Figure 6 shows the JTAG_extender (on the left), plugged into the battery holder of the daughter card (below the white square marked “238” is the WAB chip). This battery holder has been re-used for the WAB node, and this kit is directly used as base station of the BAN, on the PC side.

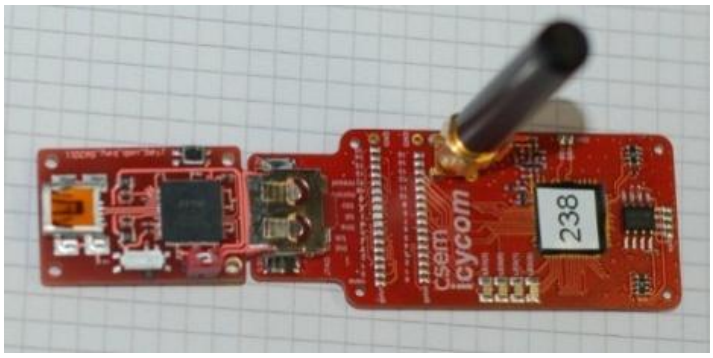

Figure 6: Hardware development kit (HDK)

This chip has been successfully designed, fabricated, tested, and delivered to partners. It is fully functional. Furthermore, industrialization of that chip has been proposed to end users.

- ***D2.2: low-level software library, to give a simplified software access to the WAB SoC***

The development of the Baseline software library was also launched and completed efficiently by CSEM. This piece of software allowed the other partners (mostly CEA, SG, VOXLER) developing the applicative layers of the Wear-a-BAN software without needing to code at very low-level, thanks to the usage of a developed Hardware Abstraction Layer (HAL) specific for the WAB SoC.

This software piece has been provided and maintained all along the project. It is available on a centralized server (sub-version) at CSEM. All partners and end users have used this server to share theirs software developments.

WP3 Antenna and propagation

The main tasks in WP3 have been to assess propagation in WBAN context, perform the preliminary design of antenna prototypes, and design the tuneable antenna interface. The work in WP3 was conducted in close interaction with the partners in charge of SiP in WP5 (TUB and AITEX) and with WP2 for the interfacing aspects from antenna to WAB SoC (CSEM).

The main deliverables were:

- ***D3.1: propagation reports***
- ***D3.2 and D3.3: miniature tuneable antenna reports.***

In the first year, the textile antennas were tested with dummy electronics inside the antenna. Also preliminary propagation testing was conducted with textile antennas and rather large and bulky VTT data logger. In the second year, textile antenna and on-body

propagation testing was carried out, totally wireless propagation measurements were carried out with actual Wear-a-BAN electronics implemented inside the antenna and specially designed propagation testing software. No disturbing cables of objects were thus in the vicinity of the antenna. The testing was carried out with both versions 1 and 2 of the WAB chip.

First, the frequency sweep tests were conducted in order to fine tune the antenna interface and verify the textile antenna gain. Next propagation on different movement scenarios and environments were tested. The results were good: about -50 to -60dB links were recorded in all the scenarios, which leaves 20dB margin in the Wear-a-BAN link budget -80dB. Also, in the free space at least 5m distances could be achieved in all the movements and antenna locations, even if the antenna was shadowed by the person or there were some indoor walls. In addition, channel modelling was conducted with the measured on-body propagation data. The links could be well described with Nakagami distribution.

In addition to the textile antenna, headset node antenna was designed, implemented and tested in Wear-a-BAN scenarios. In all the scenarios from -53 to -73dB links were recorded, which fit well within the link budget. In Figure 6, the textile monopole antenna as well as the headset node monopole made out of flexible copper foil are presented.

Figure 7: Textile antenna including the Wear-a-BAN electronics, open (upper left), closed on test subject's wrist (lower left), and the headset node antenna (right)

The main results are first, that a comprehensive propagation study was conducted, and allowed identifying two best-suited antenna approaches (vertical loop and monopole) with conclusions about propagation characteristics vs antenna parameters. Secondly, two antenna structures (vertical loop and monopole elements above the ground plane) were optimized, implemented in textile and measured, leading to very promising path loss measurement results. Thirdly, a specific antenna tuning structure was designed within the WAB SoC (jointly with WP2) and includes the schematic for the impedance matching between the antenna and the radio front-end.

With the achievements cited above, the next step has been to put the different pieces together (antenna in textile & WAB SoC & WAB module) and run propagation tests in order to fine-tune and adjust the antenna characteristics for the final version.

WP4 Sensors and communication

The main tasks in WP4 consisted in development of the hardware and software technology bricks for the sensor signal processing, and software technology brick for the wireless communication.

The main deliverables were:

- ***D4.1: node design and sensing embedded software***

Concerning the sensor signal processing, the main results were the following: the icycom platform was efficiently delivered by CSEM and used by SG to realize the first sensor signal acquisition hardware as an add-on board. The on-the-shelf sensors were identified for the motion sensing platform (accelerometers, gyrometers and magnetometers) and for the emotional sensing platform (voice processing using a microphone). First pieces of software were also written for supporting the proper link with the pre-existing icycom HDK (ultimately with the WAB SoC).

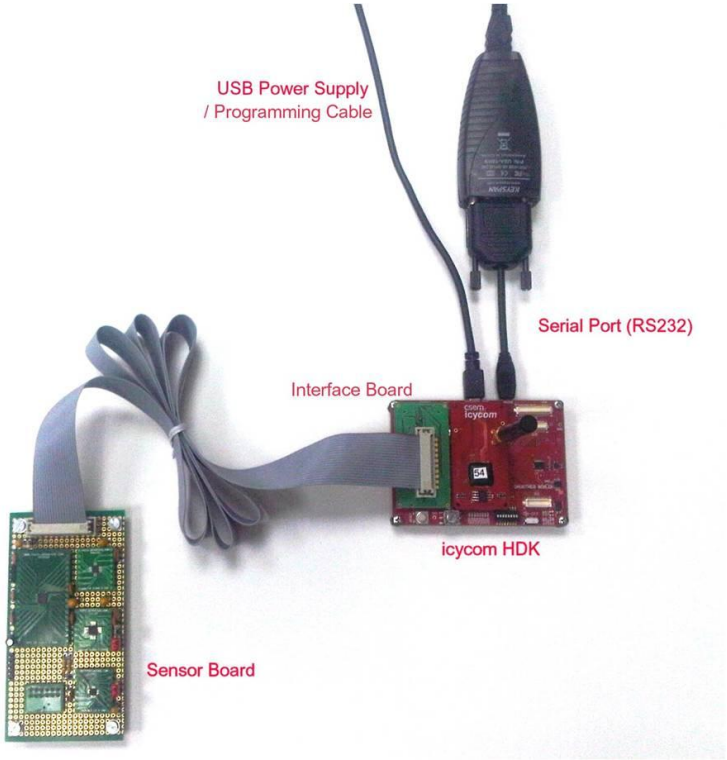

Figure 8: first prototype assembly

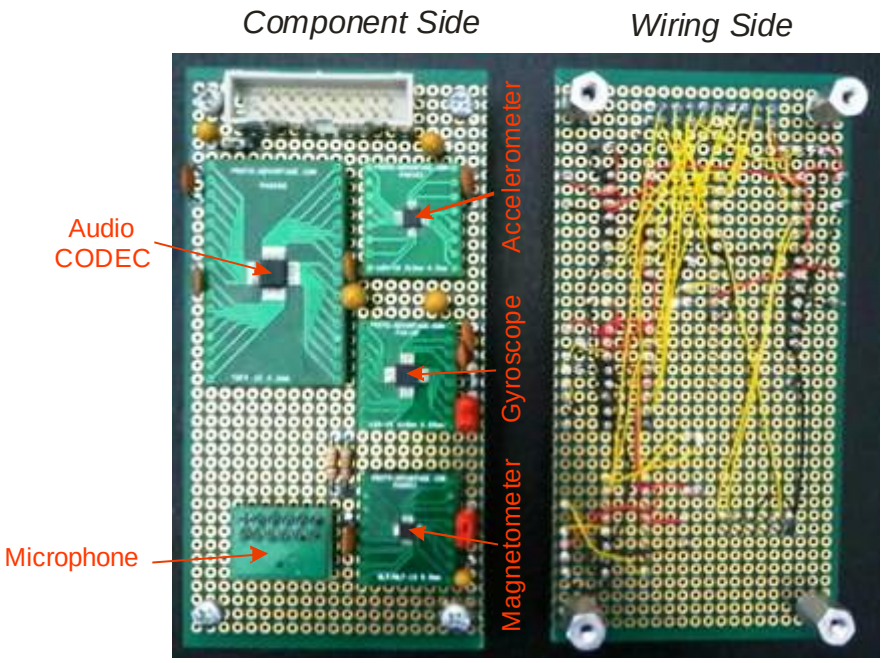

Figure 9: details of the first prototype sensor board.

Following these first steps, the design of the generic WAB node was started, and the WAB node's PCB was fabricated and will embed the motion sensors, the WAB SoC and the battery holder plus the RF interface to the antenna. The following figure shows the equivalent hardware to the first prototype assembly.

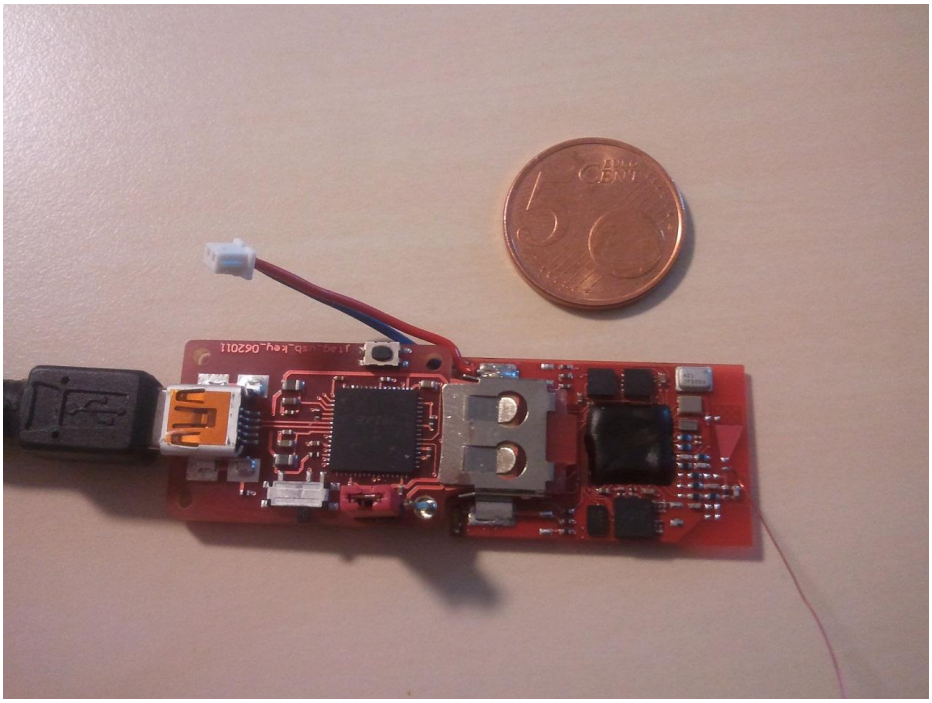

Figure 10: WAB node electronics with Jtag_extender plugged into the battery holder

This WAB node electronics has been the base brick of the motional (see WP5) and emotional nodes:

Figure 11: Emotional WAB node

The corresponding embedded software, based on the HAL has been provided in library format on the SVN server. It is divided into three categories:

- Sensor Interface/Communication

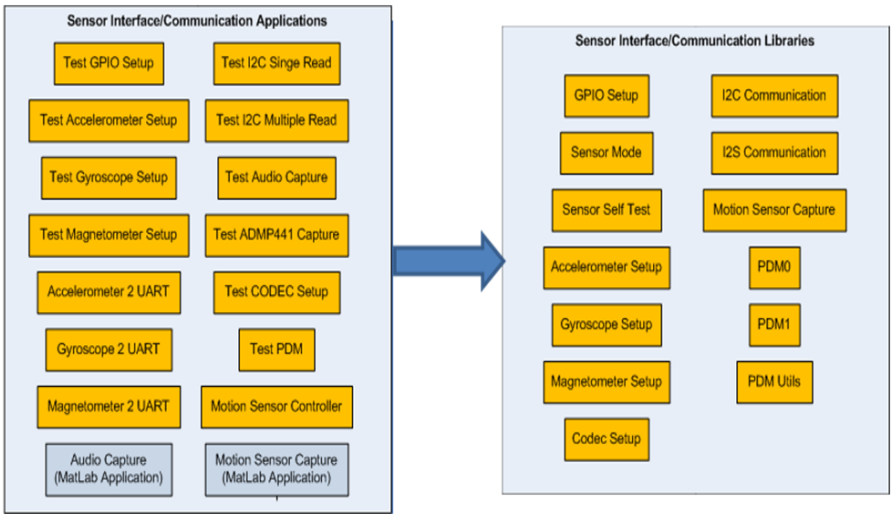

Figure 12: Sensor Interface and Communication Software Blocks

- Data Processing

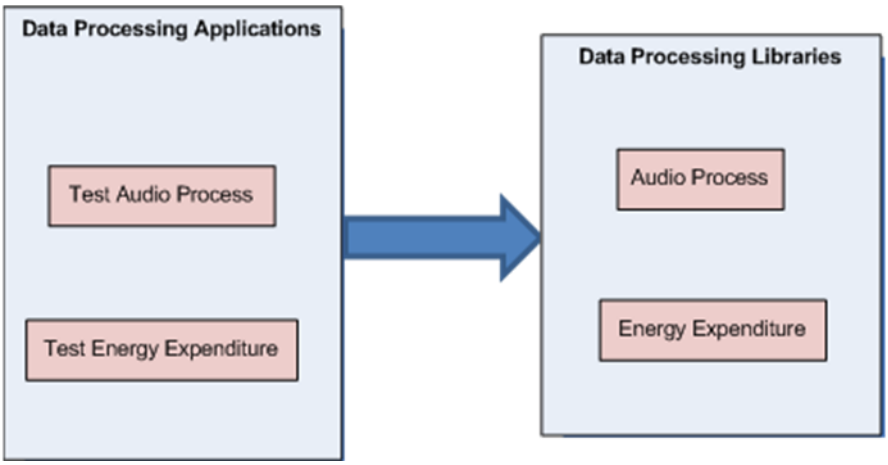

Figure 13: Data Processing Software Blocks

- MAC (see next section).

- ***D4.2: embedded MAC protocol software (RF network)***

Concerning the wireless communication software, the main results were the following: The custom MAC protocol has been defined and will be based on the TDMA access scheme. It is well suited to the star topology with a central node of most BAN application and scenarios and among them those of the Wear-a-BAN project. A preliminary implementation of the MAC protocol was also started, and is currently made available to the other project partners.

The next step has been to take these pieces and combine them with the WAB SoC and WAB module. This allowed fine-tuning, testing, characterizing and finalising the sensor and communication technology bricks for Wear-a-BAN.

The corresponding embedded software is available on the SVN server, as library.

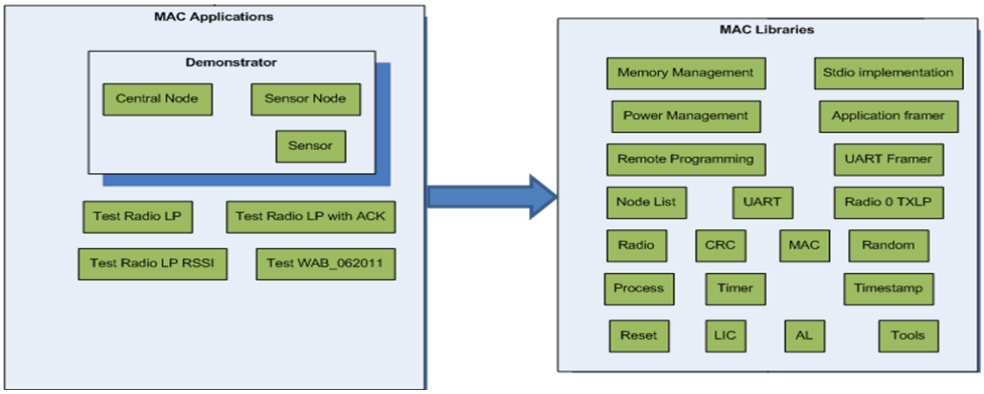

Figure 14: MAC Software Blocks

WP5 Miniaturized packaging

The main tasks in WP5 consisted in developing the SiP (system in package) platform first for the electronics components assembly (electronics SiP) and secondly for the assembly with the textile antenna (textile SiP).

WP5 is a critical workpackage in the sense that it is a “system integration” package which needs to collect and iterate around individual technology bricks delivered by the other WP’s. WP5 triggered intensive cooperation among the SiP partners (TUB, AITEX) and the other partners for the antenna (VTT) and the WAB module (SG, CSEM, CEA), and has delivered very interesting SiP solutions.

The main deliverables were:

- ***D5.1: SiP modules***
- ***D5.2: Textile antenna SiP***

The main results are the following: a strategy for designing a removable textile node was devised, and an elegant first design was realized. This design proposes to realize a textile antenna which is folded on top of the WAB node. This concept was validated using dummy modules in anticipation of the final WAB node, and the study included the definition of the manufacturing process having in mind industrialization.

Figure 15: Textile, bendable and lightweight UHF antenna attached to the module

During the second part of the project WAB nodes have been assembled with real electronic and successfully tested (bending, humidity etc.). The reliability tests (temperature cycling, steady state temperature humidity test, and bending) have shown that the assembled nodes resisted all kinds of applied stress. The antenna soldering shows very good results and reliability.

The final task within this work package concerned the emotional (headset) node. To realize the emotional node the same electronic module has been used. Additionally, a small microphone PCB was developed. The microphone PCB consisted of the microphone, one pull-up resistor, and one capacitor.

Figure 16: Microphone PCB

WP6 WBAN platform integration

This WP was responsible for the realization of the BAN prototype and the validation at system level that the co-integration of the technology bricks - WAB hardware, software, SiP - delivered from the previous WP's enables to realize the foreseen BAN concepts.

The first objective has been to embed the Wear-a-BAN SoC (WP2), the compact antenna (WP3) and the signal processing software (WP4) onto three selected platforms prototype using the SiP assembly technology (WP5).

The second objective has been to do the laboratory-level performance evaluations of the Wear-a-BAN prototypes.

The last main objective has been to provide WP7 with the core building blocks of unitary components for further integration and test in modules within WP6. Also WP6 has checked that the current Wear-a-BAN module mock-up satisfies the SMEs and SME-AGs.

The main deliverables was:

- ***D6.1: embedded software validation for the WAB node***
- ***D6.2: validation and test of the textile antenna***
- ***D6.3: Body Area Network validation***

WP6 has to get all unitary components from:

1. WP2 for the radio chip and the low layer hardware.
2. WP3 for the textile antenna and the radio-antenna matching interface module.
3. WP4 for the sensor modules, sensor processing functions and the communication protocol stack.
4. WP5 for the module and textile antenna assembly and packaging.

To be able to build the four project demonstrators in WP7, several components need to be integrated together.

Moreover, WP6 partners have checked that the foreseen Wear-a-BAN module mock-up and components comply with the end-user SMEs and SME-AGs requirements and expectations, by both cross-checking the WP1 specifications and by a specific workshop.

Four types of Wear-A-BAN nodes have been defined:

- The central node or HDK WAB V2 Daughterboard
- USB JTAG extender to program the node

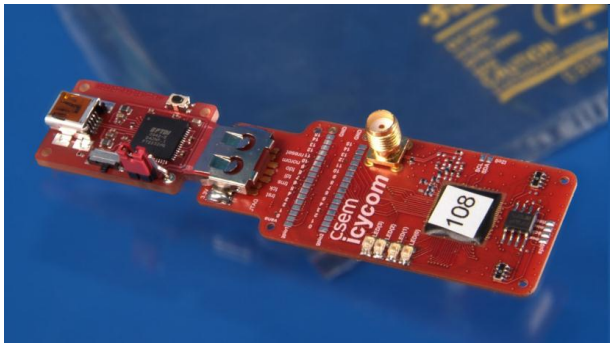

Figure 17: HDK WAB v2 daughterboard (right) with jtag_extender (left)

- WAB nodes V2 with textile antenna

Figure 18: WAB Node V2 with textile antenna

- WAB headset V2

Figure 19: Headset V2 with microphone

All final Wear-a-BAN nodes have been distributed to partners, in order for them to develop the final demonstrators.

A view of the Communication protocol stack components is given on the figure below. The communication protocol is composed of low level hardware drivers, an abstraction layer to make the upper layers as much independent on the actual HW implementation as possible, a medium access control which forms the core part of the networking protocol, a link layer control to convert and arbitrate application data into data flows with different QoS

requirements and profiles to implement the end user application requirements in terms of network topology, sensor use, etc.

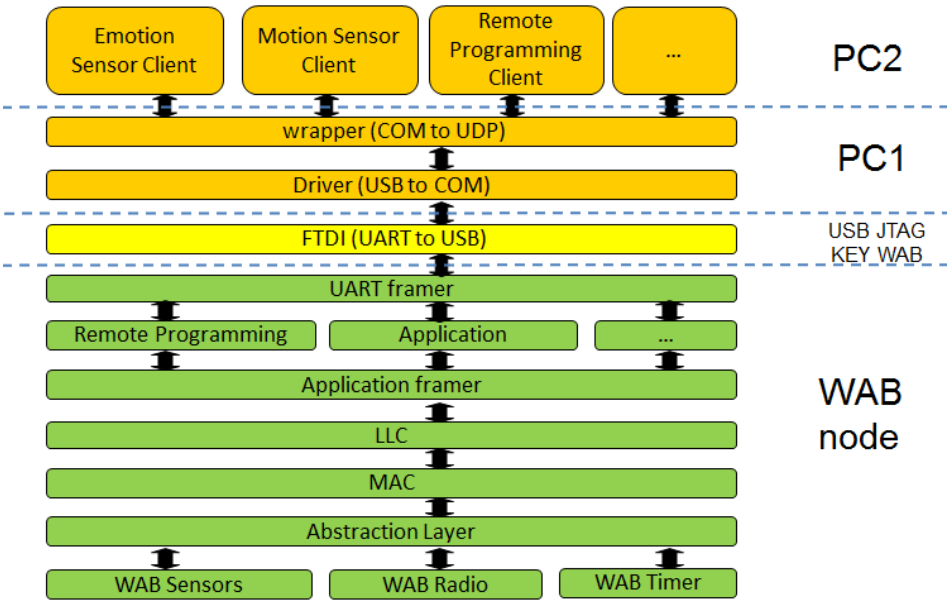

Figure 20: Communication protocol stack components for the Wear-a-BAN module

WP7 WBAN testing and end-user validation

The main goal achieved in this Work Package, has been the final demonstrations in the development of four different application scenarios for demonstrate the viability and versatility of WBAN technology.

In this way, through integration of the developed nodes into textiles, the connexion among them and the different specifics software and the right treatment of the obtained information, WBAN technology has been able to monitor the human activity at home; to show the right rehabilitation movement in injured limbs; and goes beyond the current state of gaming interfaces allowing, without cameras, play video games by means of legs and arms movement in real time.

In order to achieve those objectives, four scenarios demonstrators were planned to be developed. Each demonstrator represented one task in the project.

- ***Task T7.1: Wear-a-BAN based SFIT demonstrator***

When looking at results that demonstrate the usefulness of creating intelligent textiles that help in the realistic monitoring of movement, it is important to bear in mind garments that have already been developed and integrated into each scenario and form part of the overall project demonstrators.

Figure 21: Wrist, ankle bands, sleeve, and garments details

All of these garments, regardless of the scenario, have been designed to be washable throughout their life cycle (which could be years), even after each use (which is recommended). This includes the pockets containing the nodes and which need to be easily removed before each wash, as well as the material type and its components which may have been altered slightly to adapt to each scenario.

The morphology of each pocket has also been studied, resulting in the design of flexible pockets which mold themselves to the node to hold it firmly in place; this includes the velcro-closed flaps that protect the device but allow it to be easily removed.
Involvement in the daily life activity monitoring demonstrator has required the development of two types of garments. A polo shirt that has an unobtrusively-integrated WAB node on the lower side which guarantees that the type of exercise the WBAN wearer is engaging in will be faithfully recorded, including the position of the body and if the person has suffered a fall for example.

The garment is made with 100% high-quality cotton with a weight of 220 grams per square meter, which is easily washable, perfect for all seasons and hard-wearing.

As an alternative, an easy-to-wear elastic belt has been produced containing a pocket to hold the WAB unit. To complete the scenario, an elasticated, non-slip sleeve has been developed using a blend of 98% polyamide 30/ 2% elastene monofilament that grips the arm comfortably without pressure to form a material weighing only 115 grams per square meter, lighter than the polo sweater and which, in addition to being non-slip, maintains all the properties of breathability, durability and wash-resistance.

The sleeve contains two node pockets, located as near as possible to the joints in the shoulder and elbow, as is required by the scenario.

For this rehabilitation demonstrator a sleeve of a similar design to that already described has been developed: the differences being in the number of pockets for the movement-monitoring devices to monitor movement in the entire arm, including hand and wrist movements, allowing every angle of each joint to be measured in a limb which is undergoing a course of rehabilitation, in order to ascertain whether the treatment is being successful as well as the patient's progress.

The gaming demonstrator combines basic leg and arm movement monitoring with real-time synchronization to play a video game; it includes a microphone for voice control. The use of intelligent textiles in this case has centred on the development of wrist and ankle bands that can accept the integration of the WAB modules and antenna to avoid the need of wearing special clothing for game control that cannot be exchanged between players easily. The garment itself is the controller and can be worn comfortably, avoiding the need for hand-held controllers. The system is Velcro-fixed to allow easy removal.

- ***Task T7.2: Wear-a-BAN daily life activity monitoring demonstrator***

There were two main objectives in to achieve in this scenario through the demonstrators:

Energy Expenditure control

The services presented in this scenario are proposed during daily activity of a person. Energy expenditure (EE) is an important indicator to assess if a person has physically solicited enough his body during the last days or weeks.

One of the functions provided in the scenario is the EE spent by a person wearing the sensors. As we are using motion sensors (no heart rate sensor), the device is only supposed to measure mechanical energy.

Physical activity recognition

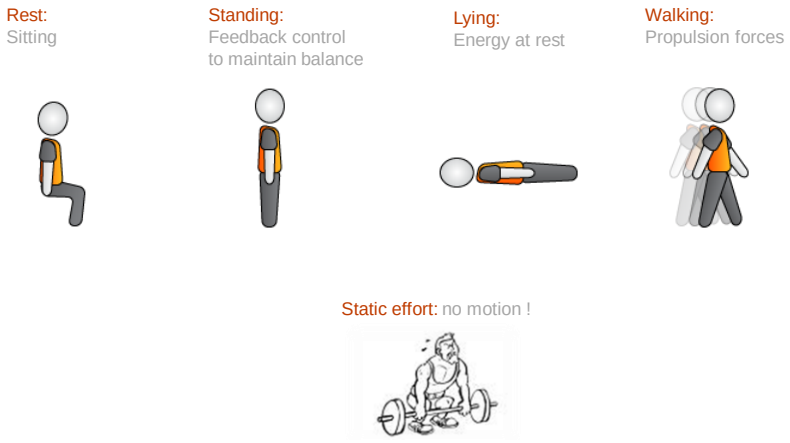

Figure 22: Main activities in daily life

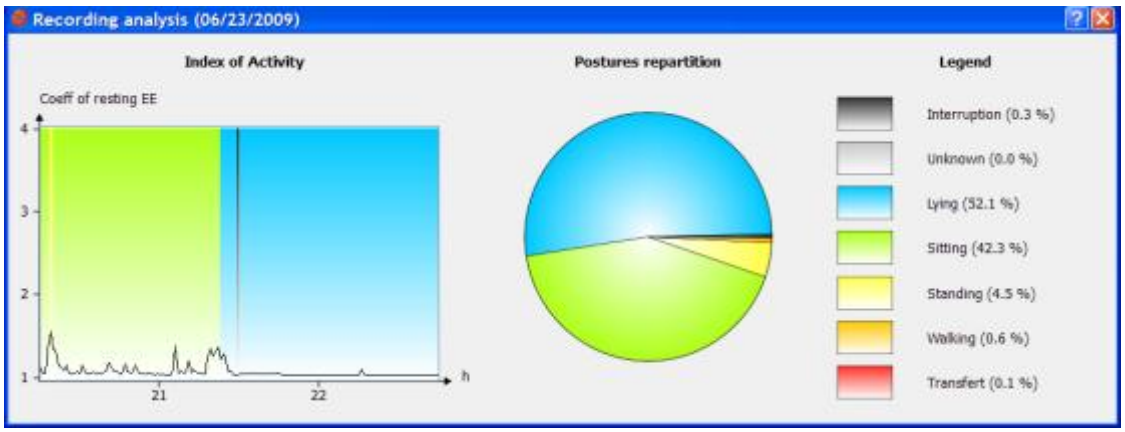

Figure 23: Activity monitoring

The technological developments can be concluded that are successful regarding the scenario requirements:

- Integration of many challenging components has been done entirely. The on-body node is flat, and flexible enough to make future product design credible and possibly integrated in the textile.
- Radio circuit and protocol is highly flexible. It is not just a piece of hardware, it's also a kit, a platform to produce new product scenario.
- For demonstration purpose, UDP was a good way to accelerate integration phases
- The range of the radio/antenna was not an issue for the scenario, since to implement two modes had decided : a recording mode and a radio mode (when the user is back home)

- ***Task T7.3: Wear-a-BAN gaming demonstrator***

The services presented in this scenario are proposed during playing a music video game. Music video games and especially singing or dancing video games let the players interact with their favorite music and have fun. The goal of the WAB scenario #3 is to show that the WAB network is capable to send data to a video game to control it and provide a compact unobtrusive interface that the player can use seamlessly so he can play a video game with a more and more natural interface.

Most music video games are based on comparing the performance of the player with a reference performance. In the case of a singing or dancing video game, the player's performance is compared with the singing of the reference singer and the dancing of the reference singer.

Figure 24: dance and sing game screen shot

To get a dancing and singing game prototype based on the WAB sensors the following steps were needed:

- Capture the information from the WAB sensors and receive them as an entry to the video game scoring engine
- Compute the signal and compare it to a reference through a dance model and a sing model and feedback a score information (Scoring engine)
- Display the scoring information in a video game prototype
- The video game prototype shall also display the basic information needed for the player to be able to interact (lyrics and melody that the player is supposed to sing and dance indications that the player is supposed to follow).

The prototype developed shows one specific case of game: A singing and dancing game. Nevertheless, once the technology is deployed the games that would be able to use it are limited only by the imagination of the game designers. The types of game could include for instance:

- Sports game, with a potential connection to the scenario 2 as several convergence can exist between a sports video game and body movement analysis for the sports market
- Action games
- Party games

In the demonstrator, the player is wearing the motion sensor on the arm, which is the place where the dance moves are the more characteristic. The player is also wearing the microphone. Each dance move, and respectively each singing note, is calculated and the aggregated data are sent to the game which displays a score/and or a comment on the performance of the player. Additional sensors could be added so that the user gets more accurate data:

- Second sensor on the second hand
- Third and fourth sensors on the feet

The technological developments can be concluded that are successful regarding the scenario requirements:

- Integration of many challenging components has been done entirely both for the motion sensor and for the microphone. The on-body node is flat, and flexible enough to make future product design credible and possibly integrated in the textile.
- The range of the radio/antenna is not an issue for the gaming scenario, since the distance between the player and his TV is limited

- ***Task T7.4: Wear-a-BAN robotics-for-rehabilitation demonstrator***

The purpose of this task was to validate the performance of the Wear-a-Ban nodes network in a specific scenario. This scenario was dealing with robot based rehabilitation of stroke patients. The scenario was chosen due to the following considerations:

- Commonality of stroke illnesses in Europe
- Short time window for good rehabilitation results
- Shortage of personnel for the rehabilitation work
- Flexible use of robot work envelope
- Robot intelligence to adjust easily by software to human body dimensions and limb movements

Robo and Delta developed the concept with the guidance of rehabilitation professionals at the Kuopio University Hospital. The concept was designed in CAD-environment and especially the connection to the upper limb of the patient was in focus. The concept is designed using the most potential robot arm type LWR by Kuka Roboter AG, Germany. This robot type has 7 degrees of freedom, allowing the robot to reach the patient from different angles in order to avoid possible collision between the robot arm and the patient. The safety aspects are taken into account by allowing the robot run only within safety speeds. The robot also reacts to collisions by withdrawing by control system means, thus making the physical contact more “natural with human body.

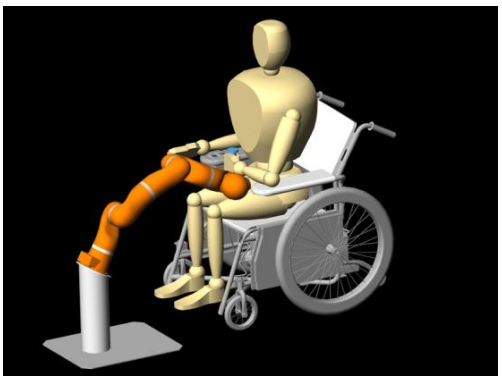

Figure 25: The rehabilitation scenario in real scale with the use of the slim industrial robot not to frighten a patient whose upper limb is seamlessly tied to the robot arm.

The basic findings of the sensor prototype hardware and software have been:

- All three sensors in one node worked according to their specifications
- The wireless radio range was more than expected over 5 meters and also well through the human body and inner walls of the house.
- The battery capacity was totally not within the written specifications, lasting only 15-20 minutes with the 1220 coin battery.
- The accelerometer signal noise with low speeds (<0,5m/s) was remarkable and caused some troubles with reliable communication.
- The sensor node software architecture developed still needs very detailed advice how to run the system.
- The software development platform was not totally stable enough for developer needs.

The software matching with different Windows operating systems has been realized and a thorough installation guide has been compiled.

The conclusions of this task show this scenario has in reality a good potential of this developed wireless technology in the vicinity of human body. The limb movements can be monitored and various product concepts can be generated based on this wear-a-ban technology. The potential end- users of this robot based rehab scenario are interested to further develop and test-run the robotized rehabilitation concept. The developed technology has now been proven to work in this environment.

1.3 Potential impact

Communication between man and machine, also known as Human-Machine-Interface (HMI) is central for the development of smart electronics, robots, appliances, games and next generation internet, where the classical computer peripherals (mouse, keyboard or joystick) encounter limitations in terms of ease-of-use and user comfort. To be efficient, communication between man and machine has to be natural by integrating motional and emotional information. Indeed, in man to man communication, a large part of the information is transmitted naturally through non-verbal communication (body language, intonations, etc). A new generation of natural and user-friendly HMI is thus profiling by combining emotional and motional recognition.

Wear-a-BAN has achieved to collect multiple real-time motional and emotional sensors information, and transmit it in wireless fashion towards dedicated devices, machines, computers or the internet placing them in nodes at different places of the human body, all being connected in a wireless BAN structure. More specifically, the achieved results of the project are:

- **Result 1: Generic WBAN module prototype**: The generic WBAN module is the core element of the WBAN system: it embeds the system-on-chip (radio, micro-processor, generic sensor interface, tuneable antenna interface), a software package (APIs, programming and configuration tools, MAC software) and the associated documentation to enable further evaluation and application-dedicated SW development.

- **Result 2: Prototype of the SiP embodiment of the WBAN module with the textile compatible antenna**: The flexible System in Package process to embed the complex SoC (and its external passives) with textile interconnection technology is applied to the WBAN module prototype. The antenna-in-textile technology is enclosed as well, together with the body-antenna-radio self-adaptation technology. The overall result is a packaged WBAN module prototype on flexible substrate, interconnected with the antenna-in-textile (Includes result 1 SW and documentation).

- **Result 3: Prototype of textile embodiment of the WBAN module with two sensor-customized versions using SiP technology**: The system in Package process to embed devices is also applied to sensors within the same package than the SoC. A first realisation combines the SoC with a 3D accelerometer using the nominal packaging process. A second realisation combines the SoC with a miniature microphone which requires a specific packaging process (includes result 2).

Wearable demonstrators have been developed in the project, which interconnect different WBAN nodes containing the SiP technology with the compatible antenna. The technology created in the frame of the project shows an incredible potential impact; it can revolutionize different markets which need to know human movements and positions in real time,

enabling new gaming, medical rehabilitation and robotics interfacing paradigms that require very short and intuitive learning curves for anyone.

Based on this potential, partners have concluded an Exploitation Agreement where they confirmed the joint ownership regime as has been already agreed in the Consortium Agreement. The Exploitation Plan serves as the basis for the post-project exploitation activities of the partners and draws the framework for future cooperation between the partners.

The main dissemination activities are summarized in section 2.

The address of the project website is: www.wearaban.eu

2. Dissemination activities of the project

The dissemination activities of the project have been consistent with the originally planned dissemination activities of the project proposal as well as with the Dissemination Action Plan (D8.3.1, submitted at M6). The partners, as depicted in Table 1 below, have used an array of mediums and tools in order to successfully disseminate the project to the relevant audience. The presentation of prototypes and other relevant technology has been available for partners and has been promoted to customers, and through networks of local authorities. In order to raise public awareness of the proposed technology, the partners have performed pre-marketing stimulation activities such as editorials, conference papers, sales and marketing contact with potential customers internationally, through the use of trade press, trade bodies and plant suppliers, approvals bodies, consumer groups and regulatory authorities. Activities include technology demonstration events, major exhibitions, stimulation events, presentations and conference papers, databases and the distribution of project promotional material. The SME-AGs involved in the project have also effectively disseminated the project to their members.

Table 1 consists of a detailed list of all dissemination activities (publications, conferences, workshops, web sites/applications, press releases, and flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, and posters).

Table 1: List of Dissemination Activities

List of dissemination activities performed during the project							
No.	**Type of activities**	**Main leader**	**Title**	**Date**	**Place**	**Type of audience**	**Countries addressed**
1	Web	AITEX	Wear- a- BAN description and link to the project website	September, 2010	Alcoy	Industry	Europe
2	Flyers	AITEX	Wear-a-BAN summary and objectives	October, 2010	Alcoy	Industry, Scientific Community, Civil Society, Policy Makers, Medias	Europe
3	Conference	AITEX	IV International Textile Congress Competitive innovation, research and technology-based solutions	October 26th -28th, 2010	Alcoy	Scientific Community, Civil Society, Policy Makers, Medias Industry	Spain, Belgium, Italy, Poland, EEUU, Rep. Congo, England, France, Portugal
4	Web	AITEX	News in Textile Vigilance www.observatoriotextil.com	January 8th, 2011	Alcoy	Industry	Spain
5	Exhibition	AITEX	1st Congress on bounds and healings./ organization stand	February 2nd - 4th, 2011	Madrid	Scientific Community (higher education, Research)	Europe
6	Publication	AITEX	AITEX magazine n. 37	January, 2011	Alcoy	Industry	Spain
7	Congress	AITEX	I Bounds and Healings International Congress	February 2nd -4th 2011	Madrid	Medical audience, professionals, doctors, geriatric professionals.	Worldwide
8	Workshop	AITEX	Smart Textiles salon 2011 and Work shop Intelligent Textiles	April 21st, 2011	Ghent University	Smart textile researchers and companies	Worldwide
9	Conference	AITEX	Successful stories	March 31st, 2011	Alcoy	Industry	Spain
10	Conference	AITEX	Annual Conference of the Textile Technology Platform	March 31st-April 1st, 2011	Brussels	Industry, Scientific Community, Policy Makers	Europe
11	Article	AITEX	Wear-a-BAN project presentation	January 2011	Alcoy	Textile industry and professionals	Spain
12	Press Release	AITEX	Aitex website: Wear-a-BAN project presentation	September 2010	Alcoy	Media Industry, Scientific Community, Civil Society, Policy Makers,	National Audience
13	Fair	AITEX	Techtextil	May 24th -26th 2011	Frankfurt	Industry	European audience

No.	Type of activities	Main leader	Title	Date	Place	Type of audience	Countries addressed
14	Fair	AITEX	HABITAT Valencia	18-20/09/2012	Valencia	Textile stakeholders	World wide
15	Conference	AITEX	Infoday presentation of textile masters AITEX	30/06/2012	Alcoy	Textile stakeholders	Spain, Colombia
16	Fair	AITEX	ITMA	22-29 /09/2011	Barcelona	Textile stakeholders	World wide
17	Conference	AITEX	Infoday Textile Market Surveillance	30/03/2012	Alcoy	Textile stakeholders	Spain
18	Web platform	AITEX	Trends Surveillance Platform	01/11/2011	Alcoy	Textile stakeholders	EU countries. South America
19	Fair	AITEX	Techtextil – Avantex	24-26/05/2011	Frankfurt	Textile stakeholders	EU
20	Magazine	AITEX	Wear a BAN	30/10/2012	Alcoy	Textile stakeholders	Spain
21	Fair	ATEVAL	UIB II- R&D Project brokerage	February, 2011	Turkey	Textile Industry	Worldwide
22	Article	ATEVAL	ATEVAL magazine	February, 2011	Spain	Journal Textile Information	Worldwide
23	Website	ATEVAL	Wear-a-BAN	February, 2011	Spain	Textile Industry	Worldwide
24	Fair	ATEVAL	Evteks	May 2011	Istanbul, Turkey	Textile Industry	Worldwide
25	Fair	ATEVAL	R&D brokerage event	February 2011	Istanbul	Industry	Worldwide
26	Fair	ATEVAL	R&d Brokerage event	29-31/08/2011	Shangai	Industry	Worldwide
27	Fair	ATEVAL	R&d Brokerage event	13-15/09/2011	Brussels	Industry	Worldwide
28	Fair	ATEVAL	R&d Brokerage event	21-23/09/2011	Russia	Industry	Worldwide
29	Fair	ATEVAL	HABITAT Valencia	20-24/09/2011	Valencia	Industry	Worldwide
30	Fair	ATEVAL	ITMA	September 2011	Barcelona	Industry	Worldwide
31	Fair	ATEVAL	EVTEKS	16-20/05/2012	Turkey	Industry	Worldwide
32	Fair	ATEVAL	HABITAT Valencia	18-22/09/2011	Valencia	Industry	Worldwide
33	Conference	ATEVAL	V Jornada AIN: Aplicaciones Industriales de la Nanotecnologia	June 2011	Barcelona	Industry	Worldwide
34	Conference	ATEVAL	Wearable Technologies Conference (ISPO Fair)	January 2012	Munich	Industry	Worldwide
35	Press Release	ATEVAL	Final results of the project: WEAR A BAN	October 2012	Ontinyent	Scientific Community, Industry, Civil Society, Policy makers, Medias	Worldwide
36	Web	ATEVAL	Final results of the project: WEAR A BAN	October 2012	Ontinyent	Industry	Spain
37	Article	ATEVAL	ATEVAL's Annual Report 2011	June 2012	Ontinyent	Industry	Spain

No.	Type of activities	Main leader	Title	Date	Place	Type of audience	Countries addressed
38	Conference	RAPIFE	Europeans Funds – SME	28/06/2012	Paterna	Industry	Spain
39	Press Release	AITEX, RAPIFE, ATEVAL	Fashion Mag, Wear-a-BAN project presentation	October 18th, 2010	Cololmbia, Bolivia	Industry	National and South America audience
40	Press Release	AITEX, RAPIFE, ATEVAL	Las Provincias: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry \ Scientific Community, Civil Society, Policy Makers	National and South America audience
41	Press Release	AITEX, RAPIFE, ATEVAL	Madrid Industrial Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry Scientific Community,	National and South America audience
42	Press Release	AITEX, RAPIFE, ATEVAL	Facebook, by Noticiero Textil: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Civil society	National and South America audience
4	Press Release	AITEX, RAPIFE, ATEVAL	Podisle seguros: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry	National and South America audience
44	Press Release	AITEX, RAPIFE, ATEVAL	Fedit: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry Scientific Community, Policy Makers,	National and South America audience
45	Press Release	AITEX, RAPIFE, ATEVAL	Pinkermoda: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry Scientific Community,	National and South America audience
46	Press Release	AITEX, RAPIFE, ATEVAL	Blog of the Valencia Telecommunication Engineers Agroupation: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry Scientific Community	National and South America audience
47	Press Release	AITEX, RAPIFE, ATEVAL	Ara Multimedia: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry, Scientific Community, Civil Society, Policy Makers,	National and South America audience
48	Press Release	AITEX, RAPIFE, ATEVAL	Interempesas.net: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry, Scientific Community,	National and South America Audience
49	Press Release	AITEX, RAPIFE, ATEVAL	Ateval strategic survey: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Scientific Community policy makers	National and South America audience

No.	Type of activities	Main leader	Title	Date	Place	Type of audience	Countries addressed
50	Press Release	AITEX, RAPIFE, ATEVAL	Bejar.biz: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry	National and South America audience
51	Press Release	AITEX, RAPIFE, ATEVAL	Info-FEDIT: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry policy makers	National and South America audience
52	Press Release	AITEX, RAPIFE, ATEVAL	Centro tecnológico del mueble y la madera: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry, Scientific Community	National and South America audience
53	Press Release	AITEX, RAPIFE, ATEVAL	Vitsalud: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Civil Society	National and South America audience
54	Press Release	AITEX, RAPIFE, ATEVAL	Economia de hoy: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry	National and South America audience
55	Press Release	AITEX, RAPIFE, ATEVAL	Innovation companies in mobility: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Industry, Scientific Community	National and South America audience
56	Press Release	AITEX, RAPIFE, ATEVAL	Includes: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Civil Society	National and South America audience
57	Press Release	AITEX, RAPIFE, ATEVAL	Science and technology review: Wear-a-BAN project presentation	October 18th, 2010	Murcia Region	Scientific Community	National and South America audience
58	Press Release	AITEX, RAPIFE, ATEVAL	Picotea.com: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Civil society	National and South America audience
59	Press Release	AITEX, RAPIFE, ATEVAL	Newsbrief: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Civil Society	National and South America audience
60	Press Release	AITEX, RAPIFE, ATEVAL	Orbitando.com Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Scientific community	National and South America audience

No.	Type of activities	Main leader	Title	Date	Place	Type of audience	Countries addressed
61	Press Release	AITEX, RAPIFE, ATEVAL	La informacion.com: Wear-a-BAN project presentation	October 18th, 2010	Alcoy	Civil society	National and South America audience
62	Conference	CAPDIGITAL	FGO 2010: Video Game Innovation	September 9th -10th , 2010	Paris, France	Industry	Worldwide
63	Conference	CAPDIGITAL	NEM summit	September 9th -10th 2010,	Barcelona, Spain	Industry	Worldwide
64	Conference	CAPDIGITAL	Forum du Cultura Digital Brasileira	November 15th-17th, 2010	Sao Paulo, Brazil	Industry	Brazil and South America
65	Congress	CAPDIGITAL	European Business Network Annual Reception	January 24-25th 2011	Brussels	Industry	Worldwide
66	Conference	CAPDIGITAL	D-Media Network	March 29th-30th, 2011	London	Industry	Worldwide
67	Conference	CAPDIGITAL	Bits	May 10th-11th, 2011	Porto Alegre, Brazil	Industry	Brazil and South America
68	Exhibition	CAPDIG	European Brokerage Event at Futur en Seine 2012. WBAN project was promoted on a European Lounge together with two other EU projects.	14-17/06/2012	Paris	Professionals from the digital industries during the week and Public audience during the weekend	France (public audience); Spain, Northern Ireland, Sweden, Belgium, France, Israel for the professionals
69	Workshop	CAPDIG; VOXLER	Workshop with the Video Games and Robotics communities in CAPDIG to present the WBAN project and results and raise SMEs awareness about the IPR	07/11/2011	Paris	Members of the Video Games and Robotics communities in CAPDIG	France
70	Press Release	ROBO	ROBO members' magazine	September 2010	Helsinki, Finland	Industry	Worldwide
71	Presentation	ROBO	Simulation presentation produced of the rehab use case and distributed for evaluation	February 2011	Helsinki, Finland	Rehab professionals, Industry	Finland
72	Seminar	ROBO	Feedback seminar based on simulation presentation material	April 2011	Helsinki, Finland	Rehab professionals	Finland

No.	Type of activities	Main leader	Title	Date	Place	Type of audience	Countries addressed
73	Seminar	ROBO	Seminar with robotics researchers concerning the application of the project's technologies	November 2010	Helsinki, Finland	Robotics' researchers	Finland
74	Newsletter	ROBO	Wear-a-ban technology update	4/9/2012	Helsinki	ROBO members	Finland
75	Exhibition	DELTA	Automatica 2012 robotics fair	23.24/5/ 2012	Munich	Robot arm manufacturers	Germany, Sweden, Italy, Switzerland
76	Newsletter	DELTA	Wireless sensor available for tests	15/9/2012	Helsinki	DELTA customers	Finland
77	Web Link	MOVEA	R&D projects	June 2010	Grenoble France	General	Wordwide
78	Conference	MOVEA	Medica 2011	November 2011	Dusseldorf	Medical	Worldwide
79	Presentation	MOVEA	Movea webcast	December 2010	San Francisco	Industry	Worldwide
80	Exhibition	MOVEA	Consumer Electronic Show 2011	07-11/01/2012	Las Vegas	Industry	Worldwide
81	Workshop	MOVEA	JADE workshop Grenoble 2012 Smarter Rehabilitation	06-09/03/2012	Grenoble	Research and industry	Europe
82	Webinar on YouTube	MOVEA	Enabling Next Generation Motion Solutions for Consumer Electronics (private in end of 2010 to public audience in June 2011)	03/06/2011	http://www.youtube.com/watch?v=C97vtEbOiSU	Medias	Worldwide
83	Web	MOVEA	Elderly patient and activity monitoring	01/01/2012	http://www.movea.com/applications/e-health-and-wellness/activity-monitoring	Medias	Worldwide
84	Conference	Voxler	E3	June 2010	Los Angeles	Industry	Worldwide
85	Conference	Voxler	Gamescom	August 2010	Koeln	Industry	Worldwide
86	Conference	Voxler	Game Connection EU	November 2010	Lyon	Industry	Worldwide
87	Conference	Voxler	Game Connection US	March 2011	San Francisco	Industry	Worldwide
88	Conference	Voxler	GDC US	March 2011	San Francisco	Industry	Worldwide
89	Exhibition	VOXLER	E3	June 2011	Los Angeles	Industry/Media	World Wide
90	Exhibition	VOXLER	GamesCom	August 2011	Cologne	Industry/Media	World Wide
91	Exhibition	VOXLER	Game Connection EU	December 2011	Paris	Industry	World Wide

No.	Type of activities	Main leader	Title	Date	Place	Type of audience	Countries addressed
92	Exhibition	VOXLER	Game Connection US	March 2012	San Francisco	Industry	World Wide
93	Exhibition	VOXLER	E3	June 2012	Los Angeles	Industry/Media	World Wide
94	Exhibition	VOXLER	GamesCom	August 2012	Cologne	Industry/Media	World Wide
95	Conference	CEA	ISMICT	March 27th-30th, 2011	Montreux, Switzerland	Scientific Community, Civil Society, Policy Makers, Media, Industry	Worldwide
96	Press Release	CEA-Leti	Sensors Mag	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
97	Press Release	CEA-Leti	Nanowerk	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
98	Press Release	CEA-Leti	New Electronics	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
99	Press Release	CEA-Leti	Wireless Design&Development	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
100	Press Release	CEA-Leti	PC Semiconductor's blog	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
101	Press Release	CEA-Leti	Wireless Design Online	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
102	Press Release	CEA-Leti	Generation NT	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
103	Press Release	CEA-Leti	Euro Investor	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
104	Press Release	CEA-Leti	Info Tech Spotlight	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide

No.	Type of activities	Main leader	Title	Date	Place	Type of audience	Countries addressed
105	Press Release	CEA-Leti	CNBC	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
106	Press Release	CEA-Leti	Euro Investor	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
107	Press Release	CEA-Leti	Earth times	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
108	Press Release	CEA-Leti	istock Analyst	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
109	Press Release	CEA-Leti	daily Herald	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
110	Press Release	CEA-Leti	Yahoo Finance	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
111	Press Release	CEA-Leti	Newsblaze	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
112	Press Release	CEA-Leti	NSTI	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
113	Press Release	CEA-Leti	Melodika	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
114	Press Release	CEA-Leti	Forbes	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
115	Press Release	CEA-Leti	Bio optics	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide

No.	Type of activities	Main leader	Title	Date	Place	Type of audience	Countries addressed
116	Press Release	CEA-Leti	Utilizer	July 19th, 2010	Web	Industry, professionals, stakeholders, wider audience, academia	Worldwide
117	Press Release	CSEM	CSEM and European partners launch "Wear-a-BAN" project – Unobtrusive wearable human to machine wireless interface	July 26th, 2010	Neuchatel, Switzerland	Media Industry, Scientific Community, Civil Society, Policy Makers,	Worldwide
118	Press Release	CSEM	CSEM and European partners launch "Wear-a-BAN" project – Unobtrusive wearable human to machine wireless interface	July 27th, 2010	Web: CSEM website	Industry, professionals, stakeholders, wider audience, academia	Worldwide
119	Press Release	CSEM	Wear-a-BAN - Unobtrusive wearable human to machine wireless interface	July 19th, 2010	Web: Nanowerk	Industry, professionals, stakeholders, wider audience, academia	Worldwide
120	Press Release	CSEM	CSEM and European partners launch unobtrusive wear-able human to machine wireless interface	July 20th, 2010	Web: EE Times Europe	Industry, professionals, stakeholders, wider audience, academia	Worldwide
121	Press Release	CSEM	CSEM startet das Projekt «Wear-a-BAN»	August 12th, 2010	Web: Polyscope	Industry, professionals, stakeholders, wider audience, academia	Switzerland
122	Press Release	CSEM	More Natural Human-Machine Interface May Benefit Medical Rehabilitation Devices	July 28th, 2010	Web: Medtech Insider	Industry, professionals, stakeholders, wider audience, academia	Worldwide
123	Press Release	CSEM	CSEM and European partners launch unobtrusive wear-able human to machine wireless interface	July 28th, 2010	Web: Microwave Engineering Europe	Industry, professionals, stakeholders, wider audience, academia	Worldwide
124	Press Release	CSEM	Lancement du projet "Wear-a-BAN", solution miniature de communication sans fil homme-machine	October 15th, 2010	Web: Alliance Actions	Industry, professionals, stakeholders, wider audience, academia	Worldwide
125	Press Release	CSEM	CSEM, European Partners Launch Wear-a-BAN Project	July 29th, 2010	Web: Printed Electronics Now	Industry, professionals, stakeholders, wider audience, academia	Worldwide

No.	Type of activities	Main leader	Title	Date	Place	Type of audience	Countries addressed
126	Press Release	CSEM	Le CSEM et ses partenaires européens lancent le projet « Wear-a-BAN »	July 29th, 2010	Web: Cluster Précision	Industry, professionals, stakeholders, wider audience, academia	Switzerland
127	Clustering meeting	CSEM	ELAB- Electronic Laboratory for the EPFL (Swiss Federation Insitute of Technology)	January 19th , 2010	Switzerland	Industry	Worldwide
128	Clustering meeting	CSEM	Meeting with academia	December 10th, 2010	Bern University of Applied Sciences Switzerland	Academia	Worldwide
129	Publication	CSEM	Scientific Report 2010 http://www.csem.ch/docs/show.aspx/14868/docname/CSEM-STR-10.pdf	Q1 2011	Neuchatel	Website, made for CSEM's clients and partners	Worldwide
130	Exhibition	TUB	Techtextil – Avantex	24-26/05/2011	Frankfurt	Industry	Worldwide
131	Conference	TUB	3. International Workshop on Flexible and Stretchable Electronics	15-17/11/2011	Berlin	Industry, Scientific	
132	Flyer	TUB	Textile-Integrated Electronic Systems	06/2012	Berlin	Industry, Scientific	NA
133	Conference	TUB	iMAPS 2012	09-13/09/2012	San Diego	Industry, Scientific	Worldwide
134	Video	VTT	YouTube & Wear-a-BAN website		http://www.youtube.com/watch?v=3m2hhdI8I-w	Scientific Community, Medias	Worldwide

Table 2: List of Scientific Publications

Three scientific (peer reviewed) publications relating to the foreground of the project have been prepared:

List of scientific (peer reviewed) publications, starting with the most important ones									
NO.	**Title**	**Main author**	**Title of the periodical or the series**	**Number, date or frequency**	**Publisher**	**Place of publication**	**Date of publication (dd/mm/yyyy)**	**Relevant pages**	**Permanent identifiers (if available)**
1	Cost effective and miniaturised System-on-Chip based solutions for portable medical & BAN applications	Dragan Manic (CSEM)	Proc. Of 5th International Symposium on Medical Information and Communication Technology	ISMICT 27-30 March 2011	IEEEXplore, Conference pulications	Switzerland	2011	15-19	http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5759787&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5759787
2	A Novel Packaging Concept for Electronics in Textile UHF Antennas	Christian Boehme (TUB)	Proc. of 45th International Symposium on Microelectronics	September 2012	iMAPS – International Microelectronics And Packaging Society	USA	2012	425-432	
3	On-body Propagation Performance with Textile Antennas at 867MHz	Mervi Hirvonen (VTT)	IEEE Transactions on Antennas and Propagation		IEEE		2012		