# Consultation Workshop on

# "Personal Health Systems: the path from FP6 to FP7"

***In preparation of FP7 ICT Work Programme***

Thursday 2nd February 2006, 13:00 – 17:30

Hotel Best Western Flora, Seidenhofstrasse 5,
CH-6002, Luzern, Switzerland

***Organised by:*** ***ICT for Health Unit,***
***DG Information Society and Media,***
***European Commission***

*Rapporteur: David Wenn, iXscient Ltd (UK)*

# 1 Context and Objectives

Europe is facing the challenge of delivering high-quality healthcare to all its citizens at affordable cost. European health systems are finding themselves under increasing pressure due to nursing shortages, chronic diseases and the demographic change. According to current trends in Europe, the proportion of the population over 65 will almost double by 2050[1]. A higher number of elderly people will require prolonged medical care and assistance for independent living. Moreover, chronic diseases are on the increase and so are their management costs. European countries already spend a significant amount of their GDP (8.5%) on healthcare. At the same time, the growth of healthcare expenditure in Europe is faster than that of the economic growth itself[2]. All these factors are expected to place additional strain on healthcare systems and the emerging situation will not be sustainable. The current healthcare delivery model is far from ideal to face the challenges ahead. Changes are needed to meet requirements for increased efficiency and quality, and better access to care, at the point of need.

The much talked about "paradigm shift" from the traditional hospital-centred to ***citizen-centred*** care necessitates greater involvement of citizens in the delivery of healthcare. This shift provides promise for coping with the forthcoming challenges and for meeting the requirements mentioned above. Information and Communication Technologies (ICT) will play a decisive role in promoting the concept of citizen-centred care, given appropriate R&D support in the coming years. In combination with proper organisational changes and skills, new tools and services based on ICT will become the key enablers of shared and continuous care. This will be achieved through eHealth solutions that (a) provide the necessary *connectivity* between various distributed points of care and electronic patient health records; and (b) enable the development and implementation of ***Personal Health Systems***.

Personal Health Systems (PHS) are about ***disruptive*** eHealth solutions that place the individual ***citizen in the centre of the healthcare delivery process***. PHS can bring significant benefits in terms of improved quality of care and cost reduction in patient management, especially through ***remote monitoring and management*** applications. PHS are seen as key components for bringing ***continuity of care*** at all levels, from prevention to rehabilitation, both inside hospital settings and outside to ordinary living environments. PHS have a central role in all efforts towards a ***preventive, citizen-centred*** model of healthcare, which is characterised by:

- ***citizen education*** on health matters and ***empowerment*** to adopt an active role in managing their own health status,
- emphasis in ***preventive*** lifestyle and ***early diagnosis***,
- ***personalised care*** and ***(self-) management*** of (chronic) diseases.

PHS cover a wide range of systems including ***wearable***, ***implantable*** or ***portable/mobile*** health systems, as well as ***Point-of-Care*** (PoC) diagnostic devices. Past and current work on PHS has demonstrated the potential of several technologies, as well as the challenges which need to be overcome to reach the level of dependability that will allow their introduction in healthcare.

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[1] Eurostat news release 48/2005 - 8 April 2005
[2] Health at a Glance: OECD Indicators 2005.

This workshop aims to build upon the existing developments and experience in view of the preparation of the ICT Work Programme for FP7. More specifically, the ***objectives*** of the workshop are to:

- reflect upon, suggest and discuss visions, R&D opportunities and challenges in the area of Personal Health Systems;
- propose services and applications that would motivate and drive future R&D work;
- highlight research directions that could be taken into account in the formulation of the ICT Work Programme in FP7.

## 2 Setting the Scene

Loukianos Gatzoulis (LG) welcomed the attendees and outlined the meeting objectives. The pHealth 2006 conference was held earlier in the week and the opportunity was taken to organise this workshop the day after the conference.

A Summary of the pHealth 2006 conference was given by Andreas Lymberis (AL). The main topics of the conference were:

- Smart ICT sensor-based solutions for disease management.
- Implementation and business opportunities in personalised health (pHealth).
- State of the Art prototype pHealth systems.
- Embedded intelligence and communication systems for pHealth.
- Integrated micro-nano systems for pHealth.

AL also showed a slide of applications for different technologies/systems.

Rainer Günzler (RG) presented some information on the "Ambient Assisted Living" topic of the 6th IST call. RG stated that the Ambient Assisted Living topic in this call is the first attempt to put focus on this issue, which will probably be further highlighted in FP7. RG presented a breakdown of funding in the call and the proposal requirements.

LG presented some information in the area of *Personal Health Systems* (PHS) that could be relevant to the preparation of FP7. Potential RTD directions in FP7 could focus on:

- ***Multi-parameter physiological monitoring*** (including monitoring of vital body signals and chemical/biological substances)
- ***Non-invasive multi-parameter blood analysis*** (e.g., levels of glucose, lactate, amino acids, etc.)
- ***Substituting missing or degraded organ functionality*** (by means of closed-loop drug delivery systems and wearable/implantable/portable artificial organs)
- ***Multi-analyte screening outside hospitals*** with PoC devices.

Major enabling technologies for PHS include:

- ***Sensors for data acquisition*** (e.g., molecular and cellular biosensors, biochemical and non-contact sensors, transdermal sensors, intelligent Body Area Sensor Networks)

- ***Modelling and simulation*** (particularly useful for artificial organs - this is where links with the proposed initiative on *Virtual Physiological Human*[3] will be beneficial)
- ***Communications*** (e.g., converged fixed, wireless and mobile services facilitating remote care over web portals, interactive TV, PDAs and mobile phones)

Further technological requirements and challenges relate to wearable imaging devices, actuators, power supply & management, intelligent algorithms for decision making, user interfaces and security.

A holistic approach to the integration of PHS into healthcare delivery is required. Besides the development of technology and services, this also involves:
- Understanding the users' needs and involving them in the design, assessment and validation of new solutions.
- Connectivity to Health Information Systems and Electronic Health Records.
- Interoperability with other eHealth systems.

Next, a number of brief presentations were given by experts with recommendations on various topics relevant to PHS in FP7 (the presentations are available on the website of the ICT for Health Unit[4], together with this report). The presentations were followed by a discussion session.

# 3 Presentations and Recommendations from Experts

## *3.1 Sensors*

**Gas and chemical sensors – Krishna Persaud, University of Manchester, UK**
Various types of gas sensors are available: chemoresistive, electrochemical, field effect, metal oxide and mass sensors are some examples. Current gas sensing technology is generally quite poor. Selectivity and long term stability issues need to be addressed. There are moves towards multi-sensor array technology (arrays composed from different types of sensors) in combination with intelligent analysis algorithms (implemented in e.g., neural networks) to produce a diagnosis. These can be applied to all sample types.

**Physical and biochemical sensors – Regis Guillemaud, CEA-Leti, FR**
Physical sensors can have applications in *neurology*, i.e., electrical sensing of the central nervous system. They can be implantable devices for brain stimulation in cases of Parkinson, epilepsy and depression.
Another application area is *activity monitoring* for elderly people. Activity is a key parameter for health monitoring in daily life. Activity may be the first "parameter" with which to identify a problem in elderly people, thus allowing early diagnosis or even

[3] http://europa.eu.int/information_society/activities/health/docs/events/barcelona2005/ec-vph-white-paper2005nov.pdf
[4] http://europa.eu.int/information_society/activities/health/events/index_en.htm

prevention. Solutions can be based on fully integrated wearable sensors or smart rooms with feedback capabilities.
It is also important to be able to measure some molecules (glucose, ions, etc.) without taking blood samples, in a *non-invasive* manner. Wearable devices with such capability would be useful in the management of chronic diseases.

**Personal sensors for prevention – Andre Dittmar, CNRS, FR**
A number of application areas were presented for *non-invasive* sensors:

- Sensors for early detection of cutaneous infection in peritoneal dialysis.
- Interface pressure sensors to avoid excessive head pressure or to detect high pressure zones to avoid pressure sores.
- Non-invasive cerebral temperature sensor.

Robust and dependable multi-parametric monitoring is currently a big challenge. For the time-being, it is more likely to achieve robust and dependable monitoring with single-parameter sensing solutions.

**Non-invasive sensors – Yves Hernandez, Multitel, BE**
A number of different *non-invasive* sensing technologies were presented for glucose monitoring and measurement of heart and respiratory rate. Such measurements are possible with:

- Optical sensors (based on Near Infra-Red Spectroscopy, Raman Spectroscopy, Fibre Bragg Gratings)
- Acoustic sensors (photo-acoustic spectrometry)
- Electrical sensors (wearable piezoelectric sensors embedded in textiles)
- Radio-frequency sensors (measurement of chest movements; impedance measurements correlated to glucose levels)

The accuracy of physiological monitoring would improve by incorporating multiple and different sensing devices. Such multi-parameter monitoring calls for appropriate *data fusion and analysis*.

**PHS sensors for remote monitoring – Stephan Kiefer, Fraunhofer-IBMT, DE**
PHS should focus on monitoring of both *mental* and *physical* status. For mental health, this implies monitoring of factors and symptoms that indicate the development of a mental disease as well as well-being monitoring. Examples are the measurement of: emotions (such as frustration, anxiety, mental pressure, joy), stress factors, impact of mental therapies and relaxation exercises, as well as sleep analysis. All these will require the use of multiple sensors, data fusion and complex data analysis (e.g., sweat, bioimpedance and vital sign analysis).
This scenario of *multi-parameter monitoring* calls for intelligent, autonomous systems with the ability to *correlate* and *interpret* the collected data to enable patient self-management. Realisation of such a scenario depends on the integration of remote monitoring solutions in the healthcare process. Support to national efforts for implementing interoperable eHealth platforms in public health systems is therefore crucial.

## *3.2 Portable / Wearable / Implantable systems*

**Emerging trends – Daniel Roggen, ETHZ, CH**
This presentation emphasised that health-related quality of life is a combined factor of physical, mental and social well-being. It introduced the concept of a *Health Assistant*, which is more than just sensors and electrodes. User context (the combination of

physiological, mental, physical and social activities and also environmental context) is very central to this concept. Fusion of physiological, physical activity, social context and environmental context can give, for example, a measure of stress.
New emerging research fields are the *cognitive assistant* for people with mental disorders and the *social assistant* to help e.g., elderly people stay in touch with their loved ones.
Bio-inspired or self-organised systems can be influential in developing *adaptive health assistants*, which can adapt to changing context and environments, learn about the users and thus become a seamless part of their lives. Integration in textiles, cell phones and PDAs will make *Health Assistants* always available and in combination with enhanced user interfaces will improve their acceptance.

## *3.3 POC Systems*

**Biochips/Lab-on-a-Chip – Stefan Haeberle, IMTEK, DE**
While a drug can help a lot of patients, adverse reactions on only a few people are enough to lead to its withdrawal. There is, therefore, a desire to personalise medication. This implies that, on top of the information acquired during clinical trials, there is need for detailed *personal* information to identify that someone should not be treated by a specific drug. This requires high-content information at the patient site (Point-of-Care), which can be acquired with the help of a hand-held device. There are currently such test devices, but they only permit measurement of a single parameter and are characterised by poor precision and limited functionality. *Lab-on-a-Chip* technology, based on hybrid microfluidic systems, can enable multiple tests (at genome, proteome, metabolome levels) in a single device, which is also capable of high-content analysis. This essentially facilitates the move to modular and multifunctional diagnostic platforms for personalised medicine.

**In-vitro diagnostics – Liv Furuberg, SINTEF, NO**
In-vitro diagnostics usually implies extraction of fluid or tissue samples from the body. Diagnoses are becoming more complex, e.g., molecular analysis. Currently, these are only performed in hospitals, but it is desirable to carry them out at doctors' offices or even at home, and communicate the results to a hospital database. Future in-vitro diagnostics must be automated and give reliable results. Sensitivity and specificity are the key aspects here. Disposable chips with microarrays will allow multiple tests for molecular diagnosis of cancer, cardiovascular disease and infections. Sample preparation and processing are very important.

## *3.4 Biomedical Clothes*

**Potential Applications – Marco di Rienzo, Centro di Bioingegneria, IT**
Provision of care outside hospitals implies long-term monitoring of the most important vital signs in daily life. It is thus important to maximise patient/user compliance – there will be no help from biomedical clothes if patients do not use them. To this end, wearable sensors and biomedical clothes must be unobtrusive and comfortable. Physiological monitoring would be more effective if more vital signs like EMG and EEG were measured, in addition to ECG and heart/respiratory rate. For remote diagnosis and care (e.g., tele-rehabilitation and tele-assistance), audio and video data should also be collected and transmitted together with the physiological data. It would also be useful to explore possible synergies between wearable devices and home automation systems (ambient intelligence). Areas requiring

specific development include sensors and their power requirements as well as algorithms for signal detection and feature extraction.

## *3.5 Wireless Solutions*

**Reliability/QoS aspects – Francis Castanie, TeSA, FR**
Nomadic system architectures were described for transmission of biomedical data, including Personal Area Networks, wireless relay networks, fixed access networks and satellite connections. Data transmission is a pivotal, primary part of all telemedicine and eHealth services. Time constraints in transmission of biomedical signals lead to unavoidable loss of data. This can range between 1-10%, and can jeopardise the quality of acquired data, including risks of piracy and tapping. The *reliability of data transmission* across heterogeneous networks, from a telecoms point of view, is thus a matter that requires attention.

**Emerging Solutions – Tim Coombs, Zarlink Semiconductor, UK**
Radio-frequency (RF) communications is a key technology for new types of medical implant. An RF band has been reserved worldwide for medical implant communication systems (MICS). This band is now being extended for “medical electronic data service” (MEDS), which can also be used for communication between implant devices and sensors worn on the body. The MICS and MEDS bands do not define many aspects of the service – hence no interoperability. Therefore, there is a real need for protocol standards which can expand the market for all players. This will allow interoperability between devices from different manufacturers and enable control of multiple implants with one single controller. It was suggested that the EC fund work towards developing *protocols and open data standards* for the medical implant community.

## *3.6 Manufacturing and Business Aspects*

**Business opportunities – Jean Luprano, CSEM, CH**
The types of business that might be expected to emerge around wearable health systems include, from the general to the specific:

- Support services
- Electronic systems
- Textile components

Support services will be the ones that will create the largest revenue. Today, what is seen mostly is replacement business, and new business opportunities need to be identified. There is high potential for rapid growth of the wearable electronics market for medical, professional, sporting equipment and leisure. Initially, the biggest market may be the military, but health and medical industries will eventually become large markets too.

**Manufacturing issues – Philippe Clot, Valtronic, CH**
Experiences from the SALIWELL and INTELLIDRUG projects were presented, including the associated manufacturing issues. These relate to the use of flex boards, moulding as well as integration of batteries in medical implants. Such research projects also require interested parties to help take the developed prototypes to commercial products. This is a rather costly process and interaction between non-competing areas would be beneficial.

## 3.7 *Services and Application Aspects*

**Integration of PoC systems in healthcare – Calum McNeil, University of Newcastle upon Tyne, UK**

Various PoC systems are dispersed around hospitals and cities. The challenge is to integrate them in Local Information Systems (LIS) and Hospital Information Systems (HIS). Different products from different companies could be doing the same operation, but they do not communicate with each other or with a common base unit, through LIS or HIS. There is also no quality control of the data produced by PoC systems. This needs to be overcome with open standards to ensure commonality. There needs to be in FP7 some focus on common interfaces between lab equipment and overall quality control. Whatever the spread and use of PoC systems, there is, and will always be, interaction with the General Practitioners.

**Management of Chronic Diseases – Takis Kotis, Royal Brompton Hospital, UK**

Semantic interoperability, computing infrastructure and nanotechnologies were discussed as enabling technologies for chronic disease management. The following issues need to be addressed to facilitate a change in healthcare delivery towards new models for remote self-management and care:

- Involvement of medical personnel in the assessment and evaluation processes of new technologies
- User acceptance and patient adherence
- Public health organisation, awareness and educational strategies
- Dissemination of the "trans-cultural mobile European patient model"

It is also important that certain stakeholders are kept on board:

- Regulatory agencies
- Insurance providers
- Public health authorities
- Doctors
- Hospital administrators

**Applications for Personalised Care – Jörg Habetha Philips Research Labs, DE**

Applications of PHS can be categorised in two groups: (a) for consumers who want to stay healthy (proactive systems) and (b) for medical professionals who need to treat patients (reactive systems). The prevalence of different diseases were presented and examples of applications were given for elderly care, cardiovascular diseases, diabetes management and patient rehabilitation (e.g., following stroke). Diabetes, in particular, is a life-long disease, with no available cure at the moment, thus management is the only possible option. As such, it was proposed to have a renewed focus on patient management and remote monitoring in FP7. This can be through services and products for three different approaches:

- Prevention oriented
- Diagnostic
- Disease management

## 4 Discussion and further Suggestions

One of the first remarks was that developments in the field of PHS should be ***application-driven*** in order to deliver what the user really needs. It was also recommended that some effort be made at looking how systems should be adapted to fit with healthcare practice. It was pointed out that some FP6 projects do not go as far as clinical trials/studies. There was a suggestion that it is becoming difficult to perform clinical trials due to regulation, so perhaps better provisions are required to enable more clinical trials.

As a follow-up to the IST Call 6 in FP6, it was suggested that monitoring of the ***mental*** state of the elderly should be included in AAL or Independent Living work in FP7. Another suggestion related to elderly care was to focus on *activity* and *daily life* monitoring for prevention or rehabilitation of movement disorders. Monitoring of movement and physical activity could also involve interaction with home automation and communication systems in assisted/independent living scenarios.

Regarding the possible synergies between wearable devices and home automation systems, it could be interesting to explore possibilities for appliance aggregation architectures (through the Appliance Aggregation Architecture Group initiated by the Global Grid Forum) to address data transmission issues, including QoS. In remote sensing scenarios, devices/sensors that expose web services could be employed in order to make use of progress in ambient intelligence. To this end, the P2P (Peer-to-Peer) approach could be investigated, to allow the hosting of and interaction with Web and WSRF (Web Services Resource Framework) services within ad-hoc P2P environments.

The recommendation to place more focus on ***prevention, rehabilitation*** and ***education*** in FP7 was supported by several experts. Prevention could also be in the form of well-being monitoring, e.g., through minimum level of exercise and applications related to fitness. It was pointed out that prevention is mainly an issue of user compliance and this is not easily solved. Lifestyle management has been an area of EC funding, but it appears that the industry is currently more active in disease management rather than prevention. However, this might be changing. It is true that the amount of healthcare expenditure related to prevention in OECD countries is low (only 3% of the total healthcare spending)[5], nevertheless the benefits of preventive healthcare are well recognised.

"***Closed-loop***" systems were also discussed. There is a debate about how much can be addressed outside hospitals. Glucose sensing is an example, in which a lot of money has been invested, but which has not been solved as a closed-loop system. The stability of biochemical sensors is currently a problem, which in turn makes continuous monitoring difficult. In the short-term, a more promising application of closed-loop systems may be in motor function i.e., an application of therapeutic nature instead of monitoring and management. In certain cases however, closed-loop systems do not require continuous monitoring. It may be sufficient to have a solution which relies on *periodic monitoring* of a condition and involves a *decision support system* to help the medical professional make changes to the treatment regime in order to speed up the feedback. This is still a closed-loop system, without any need for actuators (no measurement connected directly to an infusion pump) and can be applied to e.g., monitoring and management of cardiovascular diseases. It was argued that closed-loop systems are to include the General Practitioner as well as the patient, and to *serve for management of diseases as well as therapy*.

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[5] Health at a Glance: OECD Indicators 2005.

Another discussion topic was that of ***multi-parameter monitoring and analysis systems***. These have to be very reliable. Medical professionals will not accept home-care solutions if they are not extremely confident with them. When combining data from various parameters it is important to make sure that performance and selectivity are high. An example is the measurement of the Prostate-Specific Antigen (PSA), which is always found in substantial quantities in men over 80. This does not mean that all men over 80 should be treated for prostate cancer. There are questions as to whether multi-parametric systems would complicate things too much, leading to information overload and time-consuming analysis. However, experts suggested many times in their presentations that the combination of multi-parametric physiological, physical and environmental information would be useful in prevention and early diagnosis of diseases (e.g., cardiovascular). The question then becomes which sensor data is actually useful and brings value to such approaches. This depends on the application and at the same time it poses requirements for appropriate education of physicians on the new systems. It was suggested that having a system which can adapt to the environment and the particular user profile is important. Simple to understand, adaptable, multimodal interfaces would be required in such cases. In terms of in-vitro measurements, multi-parameter diagnostics are important in detection, e.g. in genomic or proteomic testing, for personalised medicine. These tests may be used to obtain the data/knowledge required to link markers with diseases or susceptibility to diseases.

A key issue with multi-parametric monitoring and analysis systems is ***data correlation***. As different sensors may make measurements from macro-, micro- and nano-level, it is imperative to combine the sensor measurements with the expert knowledge of bio-medical staff and to research into multi-parameter correlation models. The aim of this is to develop intelligent algorithms which are able to extract and validate correlations from the sets of fused data and knowledge, and thus facilitate diagnosis, multi-parametric monitoring and autonomous support to the user. To this end, links and synergies can be seen with the fields of Biomedical Informatics and HealthGrid. Developing these intelligent algorithms, and also making them adaptive to changing parameters, measurements, environment and user profile, would enable automated data processing and analysis, while ensuring the quality of the diagnostic result. Multi-parameter monitoring and diagnosis was seen as an enabler for "homecare at your own responsibility" or "the doctor in your pocket telling when you should visit your GP before being in real trouble".

It was suggested to look at *workflow solutions* for intelligent data management, integrated data analysis and algorithms for multi-parameter correlation and interpretation. Workflows can be used to automate current decision making procedures in healthcare, both at the institutional and personal level, offering high potential to the design and implementation of PHS. The context of workflows for mobile devices is currently being investigated. Workflow systems also allow interoperability between diverse components at the data or control level.

The proposed research topic of ***artificial organs*** attracted attention too. The big need for artificial kidneys was mentioned. There are currently 45000 citizens in Europe (and approximately 40000 in the USA) waiting for a transplant. The cost of a kidney transplant is in the range of $60000. There is shortage of kidney donors and a lot of dubious activities are associated with finding suitable transplants. Such problems would be alleviated if cost-effective, robust artificial organs were available.

Another promising application for wearable systems, textiles in particular, is ***wound monitoring*** and ***wound healing***, the market for which can be considerable. Textiles for wound monitoring and healing would be useful during the transport of injured persons with ambulances to treatment centres. There are already some projects (like LIDWINE) which aim to promote healing – by knowing what is happening in the wound without taking the bandage off.

Additional suggestions also referred to ***energy scavenging*** for powering wearable or implantable sensors and to ***organic electronics*** for developing unobtrusive sensors.

# 5 Synthesis of Important Ideas and Suggestions

| No. | Description |
|---|---|
| 1 | It was suggested to have more focus on *disease prevention*, *rehabilitation* and *education* in FP7. |
| 2 | Renewed focus on patient management was suggested for FP7. This can be through services and products for: (i) *prevention*; (ii) *diagnosis* and (iii) *disease management*. |
| 3 | Developments in the field of PHS should be *application-driven* in order to deliver what the user really needs. Effort should be made at looking how systems should be adapted to fit with healthcare practice. There is need to think about solutions and how these can be improved or integrated. |
| 4 | There is need for both *remote monitoring* and *management*. To facilitate a change in healthcare delivery towards new models for remote management and care, the following issues require attention:<br>• Involvement of medical personnel in the assessment and evaluation processes of new technologies.<br>• User acceptance and patient adherence/compliance.<br>• Having important stakeholders on board: regulatory agencies, insurance providers, public health authorities, doctors and hospital administrators.<br>• Support to national efforts for implementing interoperable eHealth platforms in public health systems. |
| 5 | PHS systems should focus on *mental* as well as *physiological* monitoring, and even combine mental and physiological data with physical *activity*, *social* and *environmental* context. Related to these are the new concepts of the *Adaptive Health Assistant*, *Cognitive Assistant* and *Social Assistant*. |
| 6 | *Multi-parametric monitoring* was suggested as a promising means to prevention and early diagnosis. Multi-parametric monitoring has to be very reliable and this is currently a big challenge. It calls for appropriate data fusion and intelligent, autonomous systems with the ability to correlate and interpret the collected data to enable patient self-management. This in turn requires research into multi-parameter correlation models and *intelligent algorithms* which integrate sensor data with the expert knowledge of medical staff, extract correlations and facilitate diagnosis and user support. To this end, links and synergies can be seen with the fields of *Biomedical Informatics* and *HealthGrid*. Having a system which can also adapt to the changing parameters, measurements, environment and particular user profile is important. |
| 7 | *Ambient Assisted Living* (or *Independent Living*) will be an important topic within FP7. Activity and daily life monitoring of elderly people would be useful applications, as they could help identify a problem early (e.g., early diagnosis or even prevention of movement disorders). Daily life monitoring would also assist rehabilitation. |
| 8 | Provision of care outside hospitals implies long-term monitoring of the most important vital signs in daily life. For remote diagnosis and care, audio and video data should also be collected and transmitted together with the physiological data. It would also be useful to explore possible synergies between wearable devices and home automation systems (ambient intelligence). To this end, devices/sensors that expose web services could be employed and the P2P (Peer-to-Peer) approach |

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|---|---|
| | could be investigated, to allow the hosting of and interaction with web services. It could also be interesting to explore possibilities for appliance aggregation architectures to address data transmission issues, including QoS. Data transmission is a pivotal, primary part of all telemedicine and eHealth solutions. The reliability of data transmission is thus a matter that requires attention. |
| 9 | "*Closed-loop*" systems could also be developed, either as combination of sensor-actuators for e.g. motor functions, or as combination of monitoring and decision support systems to help medical professionals make changes to treatment and management regimes (e.g., monitoring and management of cardiovascular diseases). |
| 10 | *Lab-on-a-Chip* technology can enable multiple tests in a single handheld device that is also capable of high-content analysis. This essentially facilitates the move to multifunctional diagnostic platforms for personalised medicine. Sensitivity and specificity as well as data analysis and interpretation are key aspects. |
| 11 | There is need in FP7 for some focus on the interface of Point-of-Care devices to Hospital Information Systems. There is also need to focus on quality control of the data produced by Point-of-Care systems. |
| 12 | *Biochemical* sensors, which measure molecules *non-invasively* with no need for blood samples, could be integrated in *wearable* devices for *management of chronic diseases*. There is need for biochemical sensors with long-term stability. |
| 13 | Textiles for wound monitoring and healing would be useful in ambulatory applications and the market may be considerable. |
| 14 | Energy scavenging for powering wearable or implantable sensors is an important topic. |
| 15 | It was suggested that FP7 funds work towards developing protocols and open data standards for medical implant communications. |
| 16 | The research topic of *artificial organs* attracts attention. Artificial kidneys, for example, would help overcome shortages in kidney donors and dubious activities associated with finding suitable transplants. |

# 6 Final Programme

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|---|---|---|
| 13:00 | **Opening** | |
| | Summary of pHealth 2006 conference | Andreas Lymberis, EC |
| | Information on Call 6: “Ambient Assisted Living” | Rainer Guenzler, EC |
| | Information on preparation of FP 7 | Loukianos Gatzoulis, EC |
| 13:30 | **Sensors** | |
| | Gas and chemical sensors | Krishna Persaud, University of Manchester, UK |
| | Physical and biochemical sensors | Regis Guillemaud, CEA-Léti, FR |
| | Personal sensors for prevention | Andre Dittmar - CNRS/INSA Lyon, FR |
| | Non-invasive sensors | Yves Hernandez, Multitel, BE |
| | Sensors for remote monitoring | Stephan Kiefer, FhG-IBMT, DE |
| | **Portables / Wearables / Implantables** | |
| | Emerging trends | Daniel Roggen, ETHZ, CH |
| | **Point-of-Care systems** | |
| | Biochips / LoC | Stefan Haeberle, IMTEK, DE |
| | In vitro diagnostics | Liv Furuberg, SINTEF, NO |
| 14:30 | ***Break*** | |
| 14:45 | **Biomedical clothes** | |
| | Potential applications | Marco di Rienzo, Centro di Bioingegneria, IT |
| | **Wireless solutions** | |
| | Reliability, QoS | Francis Castanie, TeSA, FR |
| | Emerging solutions | Tim Coombs, Zarlink, UK |
| | **Manufacturing and business aspects** | |
| | Business opportunities | Jean Luprano, CSEM, CH |
| | Manufacturing issues | Philippe Clot, Valtronic, CH |
| | **Services and application aspects** | |
| | Integration of PoC systems in healthcare | Calum McNeil, University of Newcastle, UK |
| | Management of chronic diseases | Takis Kotis, Royal Brompton Hospital, UK |
| | Applications for personalised care | Jörg Habetha, Philips, DE |
| 16:00 | ***Coffee Break*** | |
| 16:30 | **Discussion and Conclusion** | |
| 17:30 | **End** | |

# 7 List of participants

| Surname | First Name | Organisation |
|---|---|---|
| Arana | Sergio | CEIT |
| Arun | Junai | TNO |
| Axisa | Fabrice | IMEC |
| Castanie | Francis | TeSA |
| Ceinos | Carmen | ECOMIT |
| Chartier | Isabelle | CEA-Léti |
| Clot | Philippe | Valtronic |
| Conforti | Domenico | University of Calabria |
| Coombs | Tim | Zarlink Semiconductor Ltd |
| de Lecea | Pablo | CEIT |
| di Rienzo | Marco | Centro di Bioingegneria - Fnd. Don C. Gnocchi |
| Dittmar | André | INSA Lyon |
| Furuberg | Liv | SINTEF |
| Gatzoulis | Loukianos | DG INFSO, European Commission |
| Gramatica | Furio | Fondazione Don Gnocchi ONLUS |
| Guenzler | Rainer | DG INFSO, European Commission |
| Guillemaud | Regis | CEA-Léti |
| Guillen | Sergio | ITACA Institute |
| Gyselinckx | Bert | IMEC |
| Habetha | Jörg | Philips |
| Haeberle | Stefan | Universirty of Freiburg, IMTEK |
| Hallberg | Josef | Luleå University of Technology |
| Hatherall | David | Zarlink Semiconductor Ltd |
| Hernandez | Yves | Multitel |
| Kiefer | Stephan | IBMT-FhG |
| Kotis | Takis | Royal Brompton Hospital |
| Kotrotsios | Georges | CSEM |
| Luprano | Jean | CSEM |
| Lymberis | Andreas | DG INFSO, European Commission |
| Mahr | Mario | ECONET |
| McAdams | Eric | NIBEC |
| McNeil | Calum | University of Newcastle upon Tyne |
| Orselli | Roberto | Smartex |
| Paradiso | Rita | Smartex-Millor |
| Persaud | Krishna | University of Manchester |
| Ranganathan | Sridhar | Kimberly-Clark |
| Rehatschek | Karin | Joanneum Research |
| Riposan | Adina | Contact Net Ltd |
| Rocchi | Laura | University of Bologna |
| Roggen | Daniel | ETHZ |
| Scully | Tony | Luleå University of Technology |
| Synnes | Kare | Luleå University of Technology |
| Walker | Nicholas | iXscient Ltd |

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|---|---|---|
| Weber | Jean-Luc | TAM Télésanté |
| Wenn | David | iXscient Ltd (rapporteur) |