Advanced Technologies and pHealth: Rational and R&D activities under European Union, ICT program

Andreas Lymberis
Research Program Officer
andreas.lymberis@ec.europa.eu

Information Society Technologies and Media, Micro-systems
European Commission, Brussels

A. Lymberis, pHealth 10, Berlin, 26-28 May 2010
• The drivers
• Micro-nano-bio-ICT systems - solutions for pHealth
• Achievements
• Framework Program 7- Opportunities
Major Socio-economic drivers

"Classical" Healthcare System

Citizen

Patient

Genetics
Biomedics

Personal Risk Management

Early detection

Hospital based healthcare

Home care monitoring

Continuity of Care

Public Health

Risk Management

Policies

“I cannot say whether things will get better if we change; what I can say is they must change if they are to get better”

Georg Christoph Lichtenberg
German physicist (1742-1799)

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Citizen Centered Health System

CITIZENS
(Stay Healthy)

PATIENTS
(better disease management)

Sub-cluster 1
Intelligent environment for Health Promotion and Disease Prevention

Continuity of care, Delivery of home care

CITIZENS
(Stay Healthy)

PATIENTS
(better disease management)

HEALTH PROFESSIONALS
(Improve resources, infrastructure and tools)

Intelligent Systems for Mobility of Health Professionals

Intelligent Systems for Minimally Invasive Diagnosis & Treatment Planning

Ethics
Standardisation
Interoperability
The EU roadmap for eHealth

1. Linking all the points of care

2. Connecting individuals with Health Information Networks

3. Towards full picture of the individual’s health status

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Step 3
Seeing the full picture of individual’s health status

Biosensors

Environmental Data

Phenomic data

EEG

N400

N100

intensity (N100)

milliseconds

Biochips

Genomic data

Integrated Health Records
Innovation: Advances in Sciences & Technologies

© Gerd Bachmann, VDI-Technology Centre, Future Technologies

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New concepts and integrated approaches and systems.

- Integration of diagnosis, treatment and monitoring
- Computer-assisted, image based intervention
- Drug-device combinations and targeted delivery of drugs and genes
- Sensor-activated (closed loop) drug delivery systems
- Integrated neuronal interfaces and muscular stimulators (epilepsy, appetite suppression, hemi- and quadriplegia, blind- and deafness...)
- Fast information about the patient’s response to the treatment is essential for its success (complex combination of IVD, imaging and information technologies).

Micro- nano systems are potent facilitators of integration.
• The drivers
• Micro-nano-bio-ICT systems - solutions for pHealth
• Achievements
• Framework Program 7- Opportunities
Progress in many therapeutic areas until now through effective drugs treatment, surgical intervention and use of implants devices.

In reality diseases still growing as more chronic and often degenerative (e.g. multi-drug resistant infections, chronic heart failure and pulmonary diseases.

Therapeutic solutions today are not optimal.
- Diagnosis lacks of sensitivity and specificity and remains invasive in most of the cases.
- Pharmaceutical treatment has non-specific action and very often inadequate dosing and kinetics.
- Surgical intervention is overly invasive, lacks of precision and causes damage to tissues.
- Medical implants have relatively poor biocompatibility and connectivity with tissues, inadequate durability, clumsy power supply - size - weight, etc.
New Generation Technology Opportunities at the Convergence of MicroNano- Bio-ICT

Highly Interdisciplinary

System miniaturization (wearability, implantability)
High volume/low cost production

New or increased functionality (DNA, protein, cell detection)

Medical research & Unprecedented possibilities

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MNBS (G2) within a global EC collaborative activity

- Microsystems
- Components & Smart system integration
- ICT for Health
- Human Physiom PHS
- Nanotechnology (ETP)
- Nanomaterials & processes

CONVERGING Micro-Nano-Bio-ICT
MNBS group of FP6 Projects: Structure, links and content

Biosensor-based MNS

MicroFluidics
Sample preparation
DNA-protein extraction-detection
Biomarkers
Surface functionalisation, immobilisation

MN Fabrication
Biocompatible materials
Sensors-actuators
Biorobotics functions

MNS interfacing with human body

Common Aspects

Projects

Projects

Power, Signal Processing, Telecoms, Packaging, Manufacturing, Standardization, Ethics, Testing-Validation, Business, IPR, Certification, Dissemination, Awareness, Education.

- 36 Projects, 2 Service Actions
- 110 M€, 390 Organisations, 27 MS & AS + China, Australia, USA, Korea, Mexico
- 60 Universities, 50 R&D Centers & Institutes, 70 companies (Research & product development)

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Non-invasive measurements

- Analysis of the voice
- Audiogram
- E.E.G, M.E.G., R.M.N.
- Breath: volume, pressure, VO₂, VCO₂

Pulmonary sound
Cardiac sound

Mucles sound
Arterial pressure

Emotional response
Vigilance, Mental charge

E.M.G.
Activity of muscles: movement, speed, power

Vascular blood flow
Doppler Ultra Sound

E.C.G.

Breath: Frequency, Amplitude, Flow...

Skin: Temperature, Resistance, Impedance, Blood Flow, Hydratation, color...
Thermic & tactile sensitivity

Cardiac frequency & fetus movement

Urinal flow

Forms of the body & dimensions
(Optic, laser, Ultra sound, X-Ray)

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Courtesy A. Dittmar, Insa Lyon, Fr
Benefits:

- Improving the quality of care
- Containing the rising healthcare costs
  - through proper and efficient use of technological capabilities

Two complementary approaches:

- Positive attitude of users towards ICT applications in healthcare (application pull)
- Convergence of ICT, biotechnologies and micro-nanotechnologies (technology push)
  - new generation of disruptive systems and solutions for healthcare
A truly Wearable Health care System?

"Now I want you to relax completely!"

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Wearable Health Systems

Non-invasive monitoring for

- Remote and continuous health status monitoring
- Early diagnosis and prevention of diseases
- Disease management
- Provision of personalised care (according to the detected individual circumstances of a patient)
- Personalised medical advice, recommendations, treatment as necessary

Emphasis so far:

- Physiological monitoring (vital signs)
- Functional stimulation (post-event rehabilitation)
- Physical activity monitoring (body-kinematics)
From Portable to Wearable: R&D prototypes (1990-2000)

M. OGAWA, T. TOGAWA  
Inst. for Biomaterials Bioengineering,  
Tokyo Med University

Electrode contacting with the leg

Pillow electrode

Marsian: a wrist device

for the monitoring of the Autonomic Nervous System (ANS) activity

Applications: vigilance study (car driver), stress study (elderly people, games, well-being), somnolence, sensorial and emotional reactivity ...

Eqipe MicroCapteurs et Microsystèmes Biomédicaux

A. Lymberis, pHe

European Commission
Information Society and Media
First PHS calls in FP7

• Aspects and areas covered:

1) Mainly *Chronic disease management*, some on *prevention*
   
   Cardiovascular diseases, Diabetes, Respiratory diseases, Renal failure, ICT-enabled Artificial Organs, Mental disorders (depression, bipolar, stress),

   *Point-of-Care diagnostics*
   
   ➢ portable or handheld systems for multi-analyte screening at primary care (e.g., celiac disease, autoimmune diseases)

2) Support Actions on:
   
   ➢ RTD roadmap on Personal Health Systems
   ➢ Roadmap on ICT for disease prevention
   ➢ Interoperability of Personal Health Systems

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Smart Systems ...intelligent miniaturised technical subsystems evolving from microsystems technology with ≥ 1 additional functionalities:

- are able to diagnose a situation, describe it and qualify it,
- mutually address and identify each other,
- are predictive,
- are able to decide and help to decide,
- enable the product to interact with the environment.

They are networked, energy autonomous and highly reliable.

FP7 Calls

- Micro Nano Bio converging Systems (In vitro testing and In vivo interaction with the human body)
- Smart Textile and Wearable flexible/stretchable systems

Smart implants, pHea, Smart RFID, Smart antenna, Smart tire
Factors that hinder or Delay execution (worldwide)

- **Knowledge gaps** (e.g. biochemical pathways)
- **Technology gaps** (MNB at early stage, integration of building blocks, power management, etc)
- **Reliability** (complex and emotive)
- **Liability issues** (much beyond technology development and application)
- **Cost and affordability!**
- **User issues - ethics**
The drivers
Micro-nano-bio-ICT systems - solutions for pHealth
Achievements
Framework Program 7- Opportunities
Brain Chips to control paralysed limbs
Sensorised garments to help paralysed people steering their wheelchair

A sensor-laden shirt could help seriously paralyzed individuals steer their wheelchairs. In this photo, a paralyzed volunteer wearing the shirt practices navigating a virtual-reality environment. The garment’s sensors, seen in black, detect movements made by the wearer that are used to control a virtual wheelchair.
Credit: Alon Fishbach, Northwestern

Matthew Nagle, a 25-year-old man who was paralyzed after a knife wound in 2001, was the first person to test out a surgically implanted electrode array. (Credit: Joshua Paul.)
MNBS: Technological and Application Areas Focus

**Biosensors & Lab on Chip Components and Systems, e.g.:**
DNA & protein arrays, LoC (e.g. MNT, surface chemistry, biomarkers, microfluidics, modelling, instrumentation, sample preparation, detection, integration/packaging and cost reduction)

**Smart Micro Nano Systems on & inside the body, e.g.:**
BioMEMS, BioRobots, Actuator-Sensor ("closed loop" systems), Drug delivery systems, Biochemical Wearable Sensing and Active low power implants

**Business and driving forces, e.g.:**
Driving applications: Healthcare/biomedicine, food, environment, security, leisure
Mass production (cost), user needs, ethical and societal issues.
From comfort and seduction
To health, risk & well being support

**WEALTHY**

- Clinical patients during rehabilitation.
- Professional personnel at risk (working alone, working in a dangerous environment, etc.).

**MyHeart**

- Healthy people doing fitness (AC)
- Post stroke patients (NR)
- People suffering of sleep disorders (TC)

**Proetex**

- Firemen and Civilian Guard

**Biotex**
Integration

- Piezoresistive textile materials
- Electrodes
- Connections

- The mechanical properties tuned according to the function required

- Comfort
- Interface body-garment
- Interface garment-external environment

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Technology Push: Development & Integration of innovative sensing, MNT, textile and ICT

Micro-communicating: sensor interface, processing and wireless

Microsystems physical sensors (attitude, fall, health, …)

Flexible displays

Nanoengineered surfaces
- Conductive fabrics
- Micro-interfaces

Point of care

Micro-energy generators

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Courtesy CSEM, CH
Smart Fabrics-Interactive Textile and Flexible Wearable Systems
A cluster of EC-funded Projects (www.csem.ch/sfit)

WEALTHY
MyHEART
OFSETH
CONTEXT

STELLA
Stretchable
electronics
Prominent area of R&D. Need to address, along with future challenges, specific needs

- Interlink between technologies and applications is vital... for both
- Various business models, with different integration levels, are emerging
- Additional requirements on flexibility, stretchability, conformability, favour developments on new materials (plastic) and new manufacturing processes (roll to roll)
- Interdisciplinarity will open new opportunities by bringing closer together the living world and ICT
- Cost efficient, robust manufacturing technologies will succeed
- Research excellence needs to be accompanied by education and technology access actions

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• The drivers
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The European policy framework

Lisbon Strategy
(growth & jobs)

Sustainable Development Strategy
(quality of life)

7th Framework Programme for Research

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The 7th Framework Programme (FP7): 2007-2013

**“Cooperation”**
Collaborative R&D, pre-defined themes, JTIs

**“Ideas”**
Frontier research, competition, individual grants

**“People”**
Human potential, mobility

**“Capacities”**
Infrastructure, SMEs, science and society

Joint Research Centre (non-nuclear)

**EURATOM**
EURATOM Programme

Total € 54.6 bn

- € 32.3 bn (65%)
- € 7.5 bn (15%)
- € 4.7 bn (9%)
- € 4.3 bn (8%)
- € 1.8 bn
- € 2.8 bn
- € 1.3 bn

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European collaborative R&D: An experience of more than 20 years

- **Collaboration is win-win**
  - Typical project: a multi-stakeholder partnership (multinationals, SMEs, research institutes & universities)
  - Provides value adding European perspective

- **Industry is ready to invest in collaborative research**
  - Public research expenditure stimulates equal amounts of private expenditure
  - Partners in collaborations are more ready to protect their knowledge

- **EU collaborative research is attractive to non-EU participants**
  - Iceland, Israel, Norway, Switzerland are associated members of the EU research programmes

Collaborative R&D: Additional findings

- Can improve human capacity in S & T
  - Transfer of skills & knowledge beyond national frontiers
  - Enables access to a wider network of knowledge/pool of partners
- Contributes to knowledge multiplier effect
  - Participants increase know-how by being exposed to different methods
  - Spill-over effects visible in consortia of highly qualified researchers
- A way to stimulate private investment
  - “Crowding-in” effect on R&D investment
  - 60-70 % research that would otherwise have not been undertaken
  - Partners in collaborations show higher percentage of product/service innovations
    - Germany: industrial participants patent 3x more often than non-participants
    - UK 2000 study: econometric contribution of Framework Programme to UK’s industrial output is much higher than the UK govt’s contribution to the Framework Programme

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Research policy objectives & instruments

- To increase public investment
- Geared towards knowledge creation & excellence
- Mainly through pan-European industry/academia collaborations

Create a “Single Market” for research
Raise R&D investment
Overcome fragmentation of R&D efforts

- To increase industrial investment
- To integrate R&D efforts at national & European levels
- To spark innovation

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Future PHS research in FP7

- Topics not adequately addressed in previous calls, e.g.:
  - Management of neurodegenerative diseases
  - Rehabilitation of cerebrovascular/neurological conditions

- Possible input to Work Programme 2011-2012:
  - From the PHS2020 project
  - From the study on Robotics for Healthcare
  - From consultation exercise
• **Increased intelligence of devices**

• **Enhanced miniaturisation and integration of devices and systems**

• **Increased integration of bioactive components as well as processes.**

• smaller, perform better, and be faster and cheaper, while still delivering highly reproducible results, exhibiting increased sensitivity and being extremely, and proven, reliable.
  
  – highly integrated, safe, active and autonomous “smart” implants;
  
  – integrated systems for rapid, sensitive, specific and multi-parametric in vitro molecular analysis/detection and cellular manipulation
  
  – autonomous body sensor and actuator based systems for non- or minimally-invasive targeted early detection, diagnosis and therapy.

• **Closer business relationships between materials, equipment and component suppliers, integrators, manufacturing plants and institutes.** Strong involvement of industry participants interacting closely with R&D organisations and users.

• **Increased European knowledge and skills at the frontier of smart component and smart systems integration, competitiveness of the European industry involved, increased attractiveness to investments and putting European research organisations in leading positions.**
Future Challenges for Personalized Health

– **BIO-INFO-NANO: The Driving Forces**
– Growing importance in prognosis, early diagnosis, high content diagnosis; **Challenges: relevance & costs**
– Towards individualized treatment
– New business models needed
  • From dominant players in specific segments → providers of “health & well being”
– Health Monitoring and feedback, Self testing
– Info handling at the POC, data integration, distributed EHR
– Support to Elderly and chronic patients

**Multidisciplinary R&D**

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Collaborative effort towards key challenging issues e.g.

- Bridging technological know-how, in areas such as DNA arrays, protein analysis, tumour cells detection and biomarkers, and clinical expertise, to address major applications such as cancer and infectious diseases diagnosis;
- Identification of relevant sub-topics e.g. electrodes (technology-materials, processing, bio-stability, biocompatibility), implants (power supply and communication in and ‘on the body’) and other body sensors and devices for collaboration and exchange of practices including ethical and regulatory issues.
- Standardisation, harmonisation and compliance with regulatory framework (for example standardisation for micro arrays reading and data classification).

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Moral and Ethical Issues Raised by Technological Success

- Should we do research in areas we may not be able to control? (e.g., genetics, cloning, nanobots, intelligent machines?)
- Will prolonging life through technology result in more disease in the overall population?
- In defeating diseases, will technology change a human into a combination of man and machine - what does it mean to be “human”?
- How will we decide who gets the technology, especially in 3rd World?
Succeed the transformation
European research on the web:

Information Society and Media:

Microsystems and Smart Miniaturised Systems:

ICT for Health
- Policy site:
- Research site:
- Interactive Portal:
  http://www.epractice.eu

Organic and large-area electronics, visualisation & display systems:

Contact:
andreas.lymeris@ec.europa.eu

The views expressed in this presentation are the personal views of the author and do not necessarily reflect the official view of the European Commission on the subject matter.

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Thank you for your attention!

Questions?