

# MOSAIC vision and scenarios for mobile collaborative work related to health and wellbeing.

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## Abstract

The main objective of the MOSAIC project is to accelerate innovation in Mobile Worker Support Environments by shaping future research and innovation activities in Europe. The *modus operandi* of MOSAIC is to develop visions and illustrative scenarios for future collaborative workspaces involving mobile and location-aware working. Analysis of the scenarios is input to the process of road mapping with the purpose of developing strategies for R&D leading to deployment of innovative mobile work technologies and applications across different domains. This paper relates to one specific domain, that of Health and Wellbeing. The focus is therefore on mobile working environments which enable mobile collaborative working related to the domain of healthcare and wellbeing services for citizens. This paper reports the work of MOSAIC T2.2 on the vision and scenarios for mobile collaborative work related to this domain. This work was also an input to the activity of developing the MOSAIC roadmap for future research and development targeted at realization of the future Health and Wellbeing vision. The MOSAIC validation process for the Health and Wellbeing scenarios is described and one scenario – the Major Incident Scenario - is presented in detail.

## 1 Introduction

The MOSAIC project [1] is a specific support action whose main objective is to accelerate innovation in Mobile Worker Support Environments by shaping future research and innovation activities in Europe. MOSAIC works closely with the New Working Environments Unit of the European Commission and with their Ambient Intelligence (AMI) @ Work initiative [2] to shape future Framework Programmes and to establish communities in a number of sectoral domains. This paper relates to one of these domains, namely Health and Wellbeing.

The tasks of MOSAIC include development of scenarios and roadmaps for mobile and location-aware working, building strategies for deploying innovative mobile work technologies and applications in sector domains, and starting up initiatives for joint research and innovation.

This paper relates to one specific domain, that of Health and Wellbeing. The focus here is therefore on mobile working environments which enable mobile collaborative working related to the domain of healthcare and wellbeing services.

The most obvious interpretation of this is *support for mobile working for health (and wellbeing) professionals*. However there is another wider interpretation which is to *support the health and wellbeing of workers in any domain*. Therefore we distinguish two strands:

- A. Mobile working for health professionals
- B. Health and wellbeing for mobile professionals

including in both cases professionals who (currently) suffer an illness or disability as well as the (currently) well and able bodied. Both interpretations are represented in the scenarios.

The MOSAIC vision of future collaborative working in relation to health and wellbeing is described in Section 2 below. Section 3 lists the MOSAIC scenarios illustrating different aspects of this vision. The scenarios were contributed by a number of projects and individuals; the contributing individuals and projects are listed in Section 3. In section 4 we discuss how the scenarios were validated and Section 5 presents one of the scenarios – the Major Incident Scenario - in more detail. Section 6 offers discussion and conclusions.

## **2 Vision**

The MOSAIC vision for future Health and Wellbeing is to establish a sustainable pan-European (and ultimately global) citizen-centric care service, provided by citizen-centric Value Networks of Professionals. This vision will only be realized by appropriate application of technologies within the larger context of managed change in the health and wellbeing sector: that is, systemic innovation. In order to establish and introduce best e-health solutions the overall context of the service must be taken into account, including the healthcare organisations, their working practices and the society served. The focus should be on points which promise better deployment of resources and hence cost savings for the service; and improved quality of care, quality of life and independence for the citizen/patient. The aims include bringing safe mobility to the patient, overcoming distance in collaboration of medical teams and bringing mobility to health professionals. The objective is to provide medical care and support of wellness and well-being at high standards independent of the place and time of the players. There is a need to provide security and safety for patients with critical conditions by permanent monitoring of their health state in a way that allows the best medical specialists to collaborate and provide the best treatment based on best practice to patients independently of where they (patient and professionals) are located. This can be characterised as a commitment to ubiquitous healthcare mediated by the ambient intelligent workspace.

The main goals are:

- To empower the patient and increase safe mobility and freedom for patients by means of tele-consultation, tele-monitoring and tele-treatment services;
- To facilitate collaborative working of medical teams at a distance;
- To enable mobility of medical professionals so that virtual medical teams can be constructed on an ad hoc basis irrespective of the location of the professionals.

The vision builds on a range of emerging and future technologies including broadband communications (wired and wireless access), multimedia EMR (Electronic Medical Record), smart sensors, wearable computing, mobile devices, ad hoc networking and ambient intelligent environments to support innovative services for the mobile patient and for the mobile medical professional.

Future e-health systems should support collaboration between patients and health professionals within the new care model with the point of care able to shift seamlessly between healthcare centres, the home and the community at large, enabling global roaming for both professionals and patients without interruption of care. It should also include the patient (if able), and their family and informal network of carers, as part of the collaborating team.

Future provision should be characterised by:

*Consumer driven health, with*

- Appropriate incentives and disincentives for the health consumer
- A service environment which is created incrementally based on medical / clinical evidence

*Provider systems where*

- Healthcare professionals and healthcare organisations work in accordance with predefined Integrated Care Pathways (ICPs), and learn and adjust and improve their processes based on documented data

- A semantically interoperable infrastructure exists to access patient data (EHR), process data (DW) and knowledge repositories,
- Services can be provided anytime & anywhere.

There are several preconditions which must be met before new ideas can become innovations in the context of Citizen-centric Value Networks of Professionals. These include:

- Affordable infrastructure that is in place (standards based and generic)
- Proof-of-principle: Ideas must be shown to work in real-life situations
- Ideas must be benchmarked against existing work practices to show that they are cost-effective and efficient
- Trust (including security and privacy of patient data): Applications must comply with the relevant legislation.
- Suitable business models underpinning collaborative work in the sector need to be demonstrated.

In the following section we list the scenarios which illustrate some of the future possibilities arising from the MOSAIC vision of future care and collaboration in the health and wellbeing sectors.

### 3 Scenarios

In this section we list the MOSAIC Health and Wellbeing scenarios. These futuristic scenarios differ in the degree of technological and systemic innovation which they imply; some could (potentially) be realized relatively very soon whereas others require more evolution (of technology and/or of society and the healthcare system) and therefore must be regarded as possibilities lying much further in the future. Table 1 lists the scenarios which were selected for the deliverable. Criteria for selection included: relevance to the general themes of MOSAIC; relevance to the specific themes of the domain, Health and Wellbeing; positioning on a trajectory leading towards the vision of future care; and to give as wide coverage as possible of the care continuum.

Table 1. Health and Wellbeing scenarios

Scenarios	Authors	Source
1. Distributed healthcare-service provision	Niels Boye, Justin Meadows and Jan Weber	
2. Welfare	Paul Cheshire	Written for IST MOSAIC project
3. Active Health	Michel Demeester	
4. Major Incident (disaster response)	Val Jones	Written for IST MOSAIC project and NWE AMI@work initiative
5. Management of	Ilkka Korhonen	

resources in hospital		
6. Diabetes Management	Justin Meadows	EU Domain project
7. Mobile physical therapy workers	Chris Nester	PAINS project
8. Domestic Wireless	Armando Roy	
9. HealthSpace	Niilo Saranummi	
10. Awareness Telemonitoring	Maarten Wegdam	BSIK Freeband Awareness project
11. Awareness Assistance to Disabled	Maarten Wegdam	BSIK Freeband Awareness project
12. FRUX We-centric service for elderly environment	Ferial Moelaert	IST FRUX Project

Some scenarios were developed specifically for the MOSAIC project and/or for the AMI@work community Well Being Services. Others were contributed by other projects.

#### 4 Validation of scenarios

The scenarios have been validated; the validation by experts and stakeholder representatives is stated in the MOSAIC Health and Wellbeing Visions and Scenarios deliverable D2.2a [3]. Further validation of nine of the scenarios was conducted at a workshop held at Telematica Instituut in Enschede on April 15<sup>th</sup> 2005. The workshop was attended by 25 invited experts who represented the different stakeholder groups.

The purpose of the workshop was to gather a group of experts representing the different stakeholder groups to work on validation of scenarios and finalisation of a roadmap for research and development. Nine of the scenarios (scenarios 1, 3, 4, 6, 8, 9, 10, 11 and 12) were presented at that workshop and were subjected to scrutiny by the gathered experts. The participants at the workshop included technologists and experts and practitioners from the health and wellbeing domains. The areas of expertise represented were: clinical practice (a surgeon and several physicians), ambulance service (paramedic), government policy maker; education; economics; rehabilitation medicine; ICT research (Information Systems specialist; Communications expert, Mobile Applications); IT professional; Sociologist; Healthcare project manager; Healthcare technology facilitator; Biomedical engineer; Health care IT specialist; ICT expert; Networking expert, e-health and m-health application developers and researchers.

The feedback from the workshop was incorporated into the final versions of the scenarios and into the companion deliverable D2.2b on road mapping.

Participants were divided into three groups for breakout sessions. In these sessions each group discussed several individual scenarios. The discussion was driven by a questionnaire. Each group reached a consensus and filled in the questionnaire as a group. The questionnaire is reproduced in Appendix A. Some responses to questions relating to scenario validation are summarized in the following section.

*Questionnaire results.*

Analysis of questionnaires revealed that *business models, security and privacy of personal data* and *QoS* were regarded as critical issues.

Questions 1 and 2 asked about Plausibility and Desirability of the ICT solutions envisioned in the scenarios. Participants were asked to rate the scenarios in terms of plausibility, on a scale ranging from -3 to +3, where. -3 means totally implausible, +3 means totally plausible. A similar rating scale was used for *Desirability*. Results are shown in Figure 1 below. The black circles represent the scenarios' positions according to the rating scales. Numbers next to the circles refer to the scenario numbers. So for example Scenarios 4 and 8 scored +3 on both criteria.

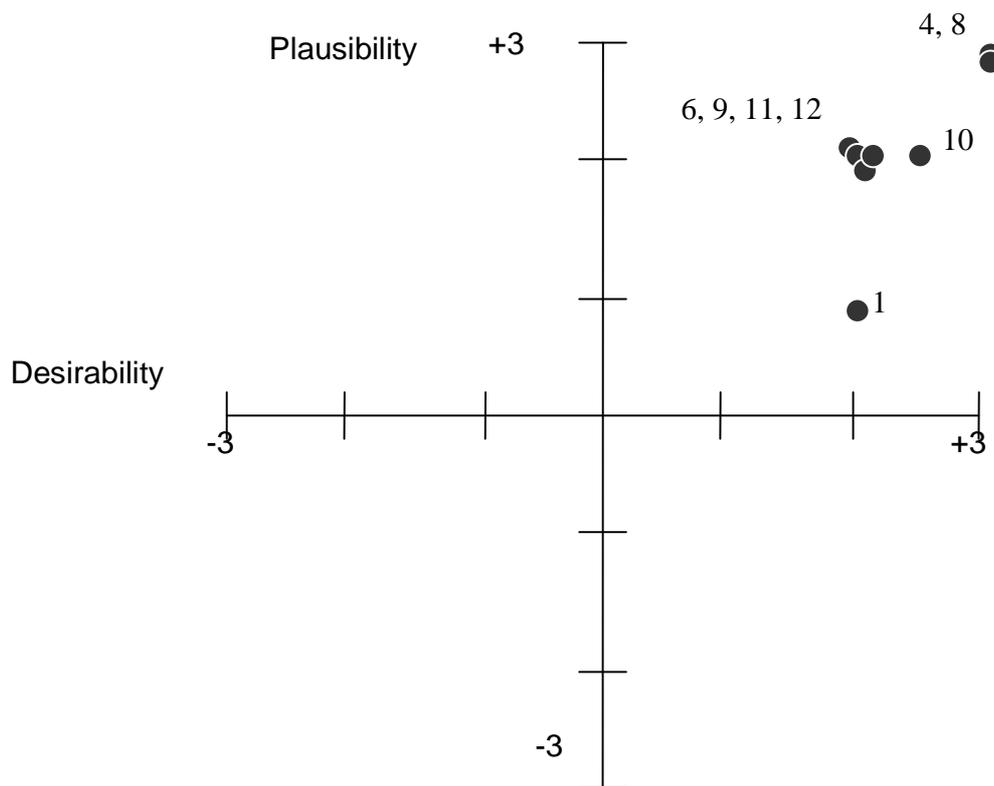


Figure 1 Plausibility and desirability of scenarios.

The questionnaires were taken by the scenario authors for incorporation of feedback into the final version of their text. The questions relating to timescales are reported in the MOSAIC Health and Wellbeing Roadmap deliverable D2.2b [4].

Assuming development of the applications, future validation steps would include prototyping and small pilots (*in vitro* and *in vivo*). If successful, these could be followed by full scale trials.

## **5 An example scenario: the MOSAIC Major Incident scenario**

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**Preamble.** The scenario relates to first response in the case of a Major Incident. Major incidents may arise through natural disasters or may be man made. Man made causes may be accidental (such as major transportation accidents) or deliberate (such as large scale acts of terrorism). Experience from around the world shows that communication and coordination are among the main challenges experienced during the first response to major incidents, eg. [5-11]. Communication and coordination are prerequisites for effective collaboration. The scenario represents an extension and evolution of earlier work of the MobiHealth project [12-26] in particular in the use of body worn sensor networks (AmI suits for emergency workers), moreover upscaling the MobiHealth trauma application to cover the other emergency services in the context of large scale incidents, with ICT support enabled by future ambient intelligent technologies.

The scenario consists of a storyline followed by analysis. The analysis shows the actors involved and the requirements and challenges raised (technological, and social and organisational). The stakeholder groups who performed the validation of the scenario are listed.

### **5.1 Motivation and Context**

This futuristic scenario concerns the emergency response in the early stages of a major incident. First response involves collaboration amongst multiple teams from different emergency services, including cross regional and cross border collaboration. The integrated emergency response is enabled by AmI technologies which support communication and coordination amongst a set of cooperating virtual teams. Monitoring of the emergency workers is also supported. Relevance to MOSAIC lies in provision of

- Communication and coordination support for paramedics and other emergency services staff (mobile workers helping casualties)
- Health and wellbeing services for mobile workers (monitoring wellbeing state of emergency personnel)

### **5.2 Scenario storyline**

At 5.02 am a loud bang wakes the city of Dorpstadt. The Mayor gets up and looks out of the bedroom window. He sees an orange glow and a plume of smoke beginning to rise from somewhere close to the centre of the city. He receives an audio call on his home AmIE (Ambient Intelligent Environment); it is a call from Anna - the city council official who is nominated as the emergency coordinator. It seems that a big explosion has

occurred (cause unknown) which rates at least as a serious incident, possibly a major incident. The Mayor gets dressed and sets off for the town hall. The town hall is to act as the regional control centre and emergency communications centre according to the regional emergency Plan. As he drives the half a kilometer to the town hall he continues his conversation with Anna via his car AmIE <PAN-PAN seamless handover, PNs> with Anna, who is also on her way to the town hall. The mayor is not surprised to see people appearing on the streets and traffic going in all directions at an hour when the streets are usually empty. As the mayor arrives he sees Anna and other members of staff arriving.

The mayor takes the decision to activate the regional emergency plan. As a first priority the Mayor and Anna need information about the current situation on the ground. Situation assessment must include an assessment of location and extent of the affected area, assessment of casualties and also an assessment of any further threat, which depends on knowing the location and cause of the explosion and awareness of any additional risk factors such as chemical- or bio-hazards in the proximity. The mayor asks the office AmIE (the ambient intelligent office environment) to call the chief constable and at the same time asks the AmIE to punch up the traffic cam outputs to the wall display screens in his office. On another screen the AmIE flips through national and local TV channels to check for news bulletins and live broadcasts but it seems no TV crews have arrived at the scene yet. The traffic cams show traffic beginning to build up at junctions. Some cams are out – their distribution on the electronic map <GISs> on another of the AmIE wall displays shows the location and extent of the worst affected area. Anna is meanwhile enacting the emergency protocol. The protocol activates the emergency command and control arrangements, the emergency communication centre and the setting up of a public information line and emergency centres for the public. Under this protocol the town hall AmIE connects to the shared emergency services communication network (a secure network routed over the Euro GRID high performance ICT facility <VPNs, GRID computing>). According to the protocol, the emergency response coordination function is distributed across the local government officers, central government, and the emergency services' control centres, with clear lines of command for overall control and for on-the-ground operations. As the protocol is activated, the AmIE wall display of the city at each centre is automatically augmented with the combined displays of the other services <information sharing>. All of them show the area is most badly affected (it soon becomes known by the locals as The Zone) as a 'dark' area where their respective communication systems have been knocked out.

Meanwhile the fire service's regional control centre has dispatched all on-call fire fighting teams from the district and the ambulance control centre is dispatching (road) ambulances to the scene and has requested the air ambulance service based 120 km away in the capital to supply all available air ambulances. These will be used to ferry in traumatologists and anaesthesiologists, also extra paramedics from other regions, and to evacuate casualties.

At the main police station the officers of the night watch view the police surveillance cams in the city centre as soon as they hear the first explosion. Like the traffic cams, some of the police cams are not sending (they have been damaged or destroyed in the

explosion). The officers get a further view by calling up high resolution satellite images <Galileo> onto one of their AmIE walls. According to the plan, police units are moving into the area and military units are on alert in case they are needed. The police units' movements are superimposed on the satellite picture <augmented reality>.

Elsewhere in the city barriers are being broken out of storage and transported to the scene. A cordon will be needed to control access in and out of the affected zone, to ensure that emergency service can get access.

The explosion has affected a half kilometer radius from the epicenter, destroying a factory, many shops and two hundred homes. It has also taken out the communications infrastructure in the area. This includes fixed telephone lines, surveillance and traffic cameras and cellphone antennas.

At 5.43 there is another loud bang. Another massive explosion has occurred. More police surveillance cams and traffic cams go black.

The police are coordinating access to the Zone for emergency vehicles whilst trying to control the public who are now converging on the Zone: some desperately trying to get into the Zone to check on their homes or to find missing friends or family members, others drawn by curiosity and the drama of the situation to view the spectacle. Press photographers and TV crews have arrived and are broadcasting live footage. Some 'walking wounded' are stumbling away from the Zone.

The positions of the police units are tracked on the AmIE walls at the police station superimposed on the satellite pictures and the city GIS map, as are the locations of the ambulances and firefighting teams who are converging on the scene. Vehicles show up as moving squares and individual team members as moving dots.

Michelle and Paul were one of the first ambulance teams to arrive at the scene. The paramedics know that more serious casualties await them closer to the epicentre of the explosion. They have audio communications built into their headsets and are talking with ambulance control and to the surgical team at the local hospital as they drive into the Zone. They can see burning buildings and thick black smoke. They are also talking to the police who are coordinating the emergency services at the scene. They come across a fire engine and the fire fighters tell them that it is not safe for the ambulance to proceed further. They stop the ambulance. Casualties are being brought out of burning buildings by the firefighters. The paramedics begin triage and treatment. (Triage is the assessment of casualties' injuries in order to prioritise and target help most effectively.)

Staff at the ambulance control centre and at the hospital are viewing the scene through 6 cameras mounted on the exterior of the ambulance and also through the paramedics' head mounted cameras; they can zoom and pan the cameras remotely to get a better view without the paramedics having to do anything. The hospital staff can give advice if requested and can make some clinical assessment to help to prepare the A&E departments to receive the casualties.

As the emergency vehicles move into the Zone the communication blackspot begins to disappear on the AmIE displays. The AmIE systems of the emergency vehicles and of the emergency staff themselves are automatically connecting to each other forming a mobile communications network <mobile ad hoc networking>, thus plugging some of the gaps in the damaged fixed infrastructure.

As they begin to help their first casualty the paramedics continue to talk to the hospital staff and have an open link to receive messages from the police coordinator. The coordinator may need to advise them to pull out because of imminent threat of further explosion. At the same time the paramedics' AmI-suits are querying the casualty's wearables and implanted devices <ad hoc networking, resource discovery> to see if they can get ID and emergency dataset and link to the casualty's EMR at the hospital. With luck the casualty may be wearing their own sensors <wireless sensor networks> which also can provide vital signs data. If not (or if damaged) the paramedics can apply a stick-on vital signs monitoring system <BAN> to the casualty. Now they can see a transparent visualisation of the vital signs as a moving holo head-up display. The vital signs are also superimposed on the hospital staff's display, showing each casualty's vital signs readouts hovering transparently over their video image <augmented reality, mixed realities>. Stretchers, neck braces and spinal boards also have built in sensors which can transmit vital signs. The paramedics' own biosignals including stress indicators are being continuously monitored by the sensors in their AmI-suits <wearable computing, smart fabrics, interactive textiles>.

Firefighter and police AmI-suits are similarly equipped with sensors and built in audio-visual communication devices. Firefighters' AmI suits also monitor their air supply and measure environmental factors including external temperature, CO and CO<sub>2</sub>, and can warn firefighters to get out of a building when flashover signs are detected for example. High resolution positioning devices in the firefighter AmI suits help remote coordination of search of smoke-filled buildings for victims and improve chances of finding and rescuing injured firefighters as well as casualties.

Off duty paramedics living close by are arriving at the scene on foot. Their body-worn AmI devices register them with the ambulance control centre <ad hoc networking, identification and authentication> and they are directed to the place they can be of most use. Traumatologists and anaesthesiologists are now *en route* to the scene in a variety of transports including cars, ambulances and air ambulances. They will operate on patients who are trapped at the scene or too unstable to be moved. In each of the transports the emergency medical staff can communicate via the in-vehicle AmIE with other members of the virtual trauma team via ad hoc networking, the highway AmI infrastructure and the Euro GRID backbone.

During eventual transfer of a casualty to hospital the AmI ambulance maintains communication between the ambulance paramedics and the distant members of the trauma team. The AmI ambulance connects <mobile ad hoc networks, B3G> with the AmI highway networks or via other AmI infrastructures (such as AmI homes) as it passes through urban or rural environments. Video of the patient can be transmitted to the

hospital from the 6 cameras inside the ambulance and the patient's vital signs continue to be transmitted during the transfer.

Because of the number of casualties some patients are taken to a hospital over the border in the neighbouring country, which has also sent its own ambulances and air ambulances. Fortunately language is no difficulty since the AmIEs can detect and simultaneously translate all EU languages (and some others).

### **5.3 Analysis of the Major Incident Scenario**

#### **5.3.1 *Actors involved***

- The public (casualties)
- Ambulance Service (ambulance paramedics at the scene and ambulance control centres)
- Hospital trauma teams
- Police (officers at the scene and coordinators)
- Fire service (officers at the scene and coordinators)
- Local government
- National government
- Military

#### **5.3.2 *Social and organisational challenges and requirements***

- Transregional/transborder/transnational coordination of emergency services
- Inter-service coordination and communication
- Inter-service information sharing (Note: police and health services sharing data could be especially sensitive)

#### **5.3.3 *Technological challenges and requirements***

- PAN, PN and BAN, based on wireless sensor networks
- Nanoscale devices (sensors, actuators) to support AMI
- Wearable computing, smart fabrics, interactive textiles
- VPNs
- GRID computing
- Augmented realities, mixed realities (including combining real time satellite imagery with GUI information, for example)
- Networking technologies B3G
- Resilient and adaptive networking in spite of destruction of infrastructure
- Mobile ad hoc networking
- location based resource discovery
- security: identification and authentication (especially in the context of mobile and ad hoc networking)
- Quality of Service
- Interoperability
- Powering mobile devices

### **5.4. *Validation of the Major Incident Scenario***

In addition to the Enschede Validation Workshop, the following stakeholders/user groups have (positively) validated the scenario:

- Surgeon, Medisch Spectrum Twente (Regional hospital and Trauma Centre)
- Ambulance paramedic
- Former director of the Information Centre "Vuurwerkcramp Enschede" (Firework Disaster, Enschede)
- Expert on Police operations and disaster response (Leeds Business School)
- Mobile and wireless Networking experts

## **6 Discussion and Conclusions**

The 12 MOSAIC scenarios for health and Wellbeing give coverage with respect to a number of dimensions.

### ***6.1 Supporting collaboration amongst (virtual) teams of health professionals***

The scenarios cover chronic and acute care, including emergency medicine. The diabetes scenarios show how patients and their families can be better supported as members of the care network which supports self-care and disease management for patients with chronic conditions. Detection of epileptic seizure in the Awareness Telemonitoring scenario shows how acute episodes may be detected and assistance sent to the patient. In the Major Incident Scenario the paramedics and the trauma team at the receiving hospital are able to collaborate together to give better quality of emergency care to the casualties.

### ***6.2 Different categories of healthcare professionals***

Different categories of healthcare professionals and clinical specialties (surgeons, physical therapists, anaesthetists, physicians, nurses...) and multidisciplinary teamwork amongst the different specialties are represented.

### ***6.3 Ubiquitous Point-of-Care.***

Different settings are represented, including hospital, homecare and the community, with patients able to roam freely (potentially globally). Mobile devices plus wireless communications enable *ubiquitous care*, where the point of care moves seamlessly with the patient (eg Awareness Telemonitoring and Teletreatment scenarios).

### ***6.4 Other Services for the citizen***

The Welfare scenario shows how social services workers can be supported by mobile technology. The Major Incident Scenario shows how inter-service collaboration and coordination between emergency services workers might be enhanced by use of advanced ambient intelligent environments and advanced networking concepts.

### ***6.5 Health and wellbeing support for workers in other domains.***

The Awareness Assistance to Disabled scenario shows how a blind person can be helped to be independent and mobile in daily life activities including work related activities. The Major Incident Scenario shows how workers in hazardous environments can have

their health and wellbeing supported by wearables which enable vital signs and environmental monitoring (firefighter, paramedic and police AMI-suits).

### **6.6 Technological ambition**

The scenarios span a range of technological sophistication ranging from use of mature existing technologies (but requiring systemic innovation in delivery and organisation of health care services) (eg. Active Health scenario using internet and web) – to very futuristic visions assuming the existence of full Ambient Intelligent Environments in buildings, vehicles, highways and wearables (such as the paramedic AMI-suits) in the Major Incident scenario.

The scenarios and their analysis were fed into the process of Road Map development for research and technological development and systemic innovation. It goes without saying that risk analyses should be undertaken, including consideration of all possible “black scenarios” ie. What happens when the system goes wrong?

Critical non-functional requirements are Security and Trust, Privacy and Safety of applications, equipment, communications, and of information. From the non-technological perspective, systemic innovation must start from a thorough analysis of existing organisational and societal factors, sector-specific work practices, workflow and business models. Consultation with, and involvement of, the stakeholders in change planning and change process is a prerequisite to public and user acceptance of both technological and systemic innovation.

The stages for innovation include the visionary stage, requirements specification, design, prototyping, testing *in vitro* (laboratory testing), *in vivo* pilots and large scale trials (Living Labs). Following prototyping the next stage for validating the scenarios would involve large scale systematic validation of the proposed technological and organisational evolutions by means of randomised controlled trials with real end users, applying trial design methods and analytical techniques from the disciplines of Health Services Research, Health Technology Assessment and Health Economics.

The full account of the Health and Wellbeing scenarios can be found in MOSIAC deliverable D2.2a [MOS2.2a].

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