European Commission

Community Research

User-friendly Information Society

ISTAG

Scenarios for Ambient Intelligence in 2010

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SCENARIOS FOR AMBIENT INTELLIGENCE IN 2010

Final Report

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February 2001
IPTS-Seville

Preface

The IST Advisory Group (ISTAG) has made consistent efforts to get a higher level of focus and a higher pace of development in Europe on Information and Communication Technologies (ICT). To give these efforts a longer-term perspective a scenario planning exercise was launched during 2000. The scenarios were developed by the IPTS (part of the European Commission's Joint Research Centre) in collaboration with DG Information Society and with the active involvement of 35 experts from across Europe. The aim was to describe what living with 'Ambient Intelligence' might be like for ordinary people in 2010.[(1)]

The concept of Ambient Intelligence (AmI) provides a vision of the Information Society where the emphasis is on greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions. People are surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects and an environment that is capable of recognising and responding to the presence of different individuals in a seamless, unobtrusive and often invisible way.

Scenarios are not traditional extrapolations from the present, but offer provocative glimpses of futures that can (but need not) be realised. Each scenario has a script that is used to work out the key developments in technologies, society, economy, and markets necessary to arrive at the scenario. With the time-scale of significant changes in the ICT industry now shorter than one year, scenario planning provides one of the few structured ways to get an impression of the future.

The central feature of the scenarios is that people (as people not just 'users', 'consumers' or 'employees') are at the forefront of the Information Society. This vision of people benefiting from services and applications whilst supported by new technologies in the background and intelligent user interfaces was essential to the ISTAG notion of Ambient Intelligence in the first place. The four scenarios underscore the ISTAG view. They contrast applications that serve to optimise efficiency (whether in business or in society) against those that emphasise human relationships, sociability or just having 'fun'. They also underline the place of Ambient Intelligence in serving society and the community as well as individuals.

Clearly, more scenarios could be conceived. For example, Ambient Intelligence has a host of important applications in industry, in the workplace and in machine to machine interactions that are not fully considered here. But the specific scenarios should not be read as end-objectives in themselves. They are rather ways to uncover the specific steps and challenges in technology, and qualitative changes and trend breaks (e.g. technology bifurcations) that have to be taken into account when anticipating the future. To put it another way, scenario planning is a tool to help us invent our future.

Change is fast and it is up to us as entrepreneurs and technologists to engage in constructing the future: these things won't happen automatically. A focussed effort is needed starting now in order to give a shape to these new technologies. The scenarios also clarify economic and societal effects, and can lead to new business and societal endeavours. But in the end it is up to us to decide our common future. This is a matter for debate and it is that debate which these scenarios primarily aim to serve.

February 2001

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(Vice-President Finmeccanica, Italy)

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(1) see http://www.cordis.lu/ist/istag.htm for further information on ISTAG, their recommendations & reports

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Scenario 1: 'Maria' – Road Warrior

After a tiring long haul flight Maria passes through the arrivals hall of an airport in a Far Eastern country. She is travelling light, hand baggage only. When she comes to this particular country she knows that she can travel much lighter than less than a decade ago, when she had to carry a collection of different so-called personal computing devices (laptop PC, mobile phone, electronic organisers and sometimes beamers and printers). Her computing system for this trip is reduced to one highly personalised communications device, her 'P–Com' that she wears on her wrist. A particular feature of this trip is that the country that Maria is visiting has since the previous year embarked on an ambitious ambient intelligence infrastructure programme. Thus her visa for the trip was self-arranged and she is able to stroll through immigration without stopping because her P-Comm is dealing with the ID checks as she walks.

A rented car has been reserved for her and is waiting in an earmarked bay. The car opens as she approaches. It starts at the press of a button: she doesn't need a key. She still has to drive the car but she is supported in her journey downtown to the conference centre-hotel by the traffic guidance system that had been launched by the city government as part of the 'AmI-Nation' initiative two years earlier. Downtown traffic has been a legendary nightmare in this city for many years, and draconian steps were taken to limit access to the city centre. But Maria has priority access rights into the central cordon because she has a reservation in the car park of the hotel. Central access however comes at a premium price, in Maria's case it is embedded in a deal negotiated between her personal agent and the transaction agents of the car-rental and hotel chains. Her firm operates centralised billing for these expenses and uses its purchasing power to gain access at attractive rates. Such preferential treatment for affluent foreigners was highly contentious at the time of the introduction of the route pricing system and the government was forced to hypothecate funds from the tolling system to the public transport infrastructure in return. In the car Maria's teenage daughter comes through on the audio system. Amanda has detected from 'En Casa' system at home that her mother is in a place that supports direct voice contact. However, even with all the route guidance support Maria wants to concentrate on her driving and says that she will call back from the hotel.

Maria is directed to a parking slot in the underground garage of the newly constructed building of the *Smar-tel Chain*. She is met in the garage by the porter – the first contact with a real human in our story so far! He helps her with her luggage to her room. Her room adopts her 'personality' as she enters. The room temperature, default lighting and a range of video and music choices are displayed on the video wall. She needs to make some changes to her presentation – a sales pitch that will be used as the basis for a negotiation later in the day. Using voice commands she adjusts the light levels and commands a bath. Then she calls up her daughter on the video wall, while talking she uses a traditional remote control system to browse through a set of webcast local news bulletins from back home that her daughter tells her about. They watch them together.

Later on she *'localises'* her presentation with the help of an agent that is specialised in advising on local preferences (colour schemes, the use of language). She stores the presentation on the secure server at headquarters back in Europe. In the hotel's seminar room where the sales pitch is take place, she will be able to call down an encrypted version of the presentation and give it a post presentation decrypt life of 1.5 minutes. She goes downstairs to make her presentation… this for her is a high stress event. Not only is she performing alone for the first time, the clients concerned are well known to be tough players. Still, she doesn't actually have to close the deal this time. As she enters the meeting she raises communications access thresholds to block out anything but red-level 'emergency' messages. The meeting is rough, but she feels it was a success. Coming out of the meeting she lowers the communication barriers again and picks up a number of amber level communications including one from her cardio-monitor warning her to take some rest now. The day has been long and stressing. She needs to chill out with a little meditation and medication. For Maria the meditation is a concert on the video wall and the medication….a large gin and tonic from her room's minibar.

Scenario 2: 'Dimitrios' and the Digital Me' (D-Me)

It is four o'clock in the afternoon. Dimitrios, a 32 year-old employee of a major food-multinational, is taking a coffee at his office's cafeteria, together with his boss and some colleagues. He doesn't want to be excessively bothered during this pause. Nevertheless, all the time he is receiving and dealing with incoming calls and mails.

He is proud of 'being in communication with mankind': as are many of his friends and some colleagues. Dimitrios is wearing, embedded in his clothes (or in his own body), a voice activated 'gateway' or digital avatar of himself, familiarly known as 'D-Me' or 'Digital Me'. A D-Me is both a learning device, learning about Dimitrios from his interactions with his environment, and an acting device offering communication, processing and decision-making functionality. Dimitrios has partly 'programmed' it himself, at a very initial stage. At the time, he thought he would 'upgrade' this initial data periodically. But he didn't. He feels quite confident with his D-Me and relies upon its 'intelligent ' reactions.

At 4:10 p.m., following many other calls of secondary importance – answered formally but smoothly in corresponding languages by Dimitrios' D-Me with a nice reproduction of Dimitrios' voice and typical accent, a call from his wife is further analysed by his D-Me. In a first attempt, Dimitrios' 'avatar-like' voice runs a brief conversation with his wife, with the intention of negotiating a delay while explaining his current environment. Simultaneously, Dimitrios' D-Me has caught a message from an older person's D-Me, located in the nearby metro station. This senior has left his home without his medicine and would feel at ease knowing where and how to access similar drugs in an easy way. He has addressed his query in natural speech to his D-Me. Dimitrios happens to suffer from similar heart problems and uses the same drugs. Dimitrios' D-Me processes the available data as to offer information to the senior. It 'decides' neither to reveal Dimitrios' identity (privacy level), nor to offer Dimitrios' direct help (lack of availability), but to list the closest drug shops, the alternative drugs, offer a potential contact with the self-help group. This information is shared with the senior's D-Me, not with the senior himself as to avoid useless information overload.

Meanwhile, his wife's call is now interpreted by his D-Me as sufficiently pressing to mobilise Dimitrios. It 'rings' him using a pre-arranged call tone. Dimitrios takes up the call with one of the available Displayphones of the cafeteria. Since the growing penetration of D-Me, few people still bother to run around with mobile terminals: these functions are sufficiently available in most public and private spaces and your D-Me can always point at the closest…functioning one! The 'emergency' is about their child's homework. While doing his homework their 9 year-old son is meant to offer some insights on everyday life in Egypt. In a brief 3-way telephone conference, Dimitrios offers to pass over the query to the D-Me to search for an available direct contact with a child in Egypt. Ten minutes later, his son is videoconferencing at home with a girl of his own age, and recording this real-time translated conversation as part of his homework. All communicating facilities have been managed by Dimitrios' D-Me, even while it is still registering new data and managing other queries. The Egyptian correspondent is the daughter of a local businessman, well off and quite keen on technologies. Some luck (and income…) had to participate in what might become a longer lasting new relation.

Scenario 3 - Carmen: traffic, sustainability & commerce

It is a normal weekday morning. Carmen wakes and plans her travel for the day. She wants to leave for work in half an hour and asks AmI, by means of a voice command, to find a vehicle to share with somebody on her route to work. AmI starts searching the trip database and, after checking the willingness of the driver, finds someone that will pass by in 40 minutes. The in-vehicle biosensor has recognised that this driver is a non-smoker – one of Carmen requirements for trip sharing. From that moment on, Carmen and her driver are in permanent contact if wanted (e.g. to allow the driver to alert Carmen if he/she will be late). Both wear their personal area networks (PAN) allowing seamless and intuitive contacts.

While taking her breakfast coffee Carmen lists her shopping since she will have guests for dinner tonight. She would like also to cook a cake and the e-fridge flashes the recipe. It highlights the ingredients that are missing milk and eggs. She completes the shopping on the e-fridge screen and asks for it to be delivered to the closest distribution point in her neighbourhood. This can be a shop, the postal office or a franchised nodal point for the neighbourhood where Carmen lives. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. She can be informed during the day on her shopping, agree with what has been found, ask for alternatives, and find out where they are and when they will be delivered.

Forty minutes later Carmen goes downstairs onto the street, as her driver arrives. When Carmen gets into the car, the VAN system (Vehicle Area Network) registers her and by doing that she sanctions the payment systems to start counting. A micro-payment system will automatically transfer the amount into the e-purse of the driver when she gets out of the car.

In the car, the dynamic route guidance system warns the driver of long traffic jams up ahead due to an accident. The system dynamically calculates alternatives together with trip times. One suggestion is to leave the car at a nearby ‘park and ride’ metro stop. Carmen and her driver park the car and continue the journey by metro. On leaving the car, Carmen’s payment is deducted according to duration and distance.

Out of the metro station and whilst walking a few minutes to her job, Carmen is alerted by her PAN that a Chardonnay wine that she has previously identified as a preferred choice is on promotion. She adds it to her shopping order and also sets up her homeward journey with her wearable. Carmen arrives at her job on time.

On the way home the shared car system senses a bike on a dedicated lane approaching an intersection on their route. The driver is alerted and the system anyway gives preference to bikes, so a potential accident is avoided. A persistent high-pressure belt above the city for the last ten days has given fine weather but rising atmospheric pollutants. It is rush hour and the traffic density has caused pollution levels to rise above a control threshold. The city-wide engine control systems automatically lower the maximum speeds (for all motorised vehicles) and when the car enters a specific urban ring toll will be deducted via the Automatic Debiting System (ADS).

Carmen arrives at the local distribution node (actually her neighbourhood corner shop) where she picks up her goods. The shop has already closed but the goods await Carmen in a smart delivery box. By getting them out, the system registers payment, and deletes the items from her shopping list. The list is complete. At home, her smart fridge screen will be blank.

Coming home, AmI welcomes Carmen and suggests to telework the next day: a big demonstration is announced downtown.

Scenario 4 – Annette and Solomon in the Ambient for Social Learning

It is the plenary meeting of an environmental studies group in a local 'Ambient for Social Learning'. The group ranges from 10 to 75 years old. They share a common desire to understand the environment and environmental management. It is led by a mentor whose role it is to guide and facilitate the group's operation, but who is not necessarily very knowledgeable about environmental management. The plenary takes place in a room looking much like a hotel foyer with comfortable furniture pleasantly arranged. The meeting is open from 7.00-23.00 hours. Most participants are there for 4-6 hours. A large group arrives around 9.30 a.m. Some are scheduled to work together in real time and space and thus were requested to be present together (the ambient accesses their agendas to do the scheduling).

A member is arriving: as she enters the room and finds herself a place to work, she hears a familiar voice asking "Hello Annette, I got the assignment you did last night from home: are you satisfied with the results?" Annette answers that she was happy with her strategy for managing forests provided that she had got the climatic model right: she was less sure of this. Annette is an active and advanced student so the ambient says it might be useful if Annette spends some time today trying to pin down the problem with the model using enhanced interactive simulation and projection facilities. It then asks if Annette would give a brief presentation to the group. The ambient goes briefly through its understanding of Annette's availability and preferences for the day's work. Finally, Annette agrees on her work programme for the day.

One particularly long conversation takes place with Solomon who has just moved to the area and joined the group. The ambient establishes Solomon's identity; asks Solomon for the name of an ambient that 'knows' Solomon; gets permission from Solomon to acquire information about Solomon's background and experience in Environmental Studies. The ambient then suggests Solomon to join the meeting and to introduce himself to the group.

In these private conversations the mental states of the group are synchronised with the ambient, individual and collective work plans are agreed and in most cases checked with the mentor through the ambient. In some cases the assistance of the mentor is requested. A scheduled plenary meeting begins with those who are present. Solomon introduces himself. Annette gives a 3-D presentation of her assignment. A group member asks questions about one of Annette's decisions and alternative visualisations are projected. During the presentation the mentor is feeding observations and questions to the ambient, together with William, an expert who was asked to join the meeting. William, although several thousand miles away, joins to make a comment and answer some questions. The session ends with a discussion of how Annette's work contributes to that of the others and the proposal of schedules for the remainder of the day. The ambient suggests a schedule involving both shared and individual sessions.

During the day individuals and sub-groups locate in appropriate spaces in the ambient to pursue appropriate learning experiences at a pace that suits them. The ambient negotiates its degree of participation in these experiences with the aid of the mentor. During the day the mentor and ambient converse frequently, establishing where the mentor might most usefully spend his time, and in some cases altering the schedule. The ambient and the mentor will spend some time negotiating shared experiences with other ambients – for example mounting a single musical concert with players from two or more distant sites. They will also deal with requests for references / profiles of individuals. Time spent in the ambient ends by negotiating a homework assignment with each individual, but only after they have been informed about what the ambient expects to happen for the rest of the day and making appointments for next day or next time.

Executive Summary

This report starts with four scenarios that illustrate how Ambient Intelligence might be experienced in daily life and work around 2010. The concept of Ambient Intelligence (AmI) provides a wide-ranging vision on how the Information Society will develop. The emphasis of AmI is on greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions. In all four scenarios people are surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects. The Ambient Intelligence environment is capable of recognising and responding to the presence of different individuals. And, most important, Ambient Intelligence works in a seamless, unobtrusive and often invisible way.

The four scenarios were constructed to provide 'food for thought' about longer-term developments in Information and Communication Technologies (ICTs). More specifically we wanted to explore the future technologies that are implied by the vision of Ambient Intelligence. This led to ideas about the research lines that might be needed to achieve these scenarios. In addition, the project considered the industrial / business, economic and socio-political implications of AmI, because these aspects become very important when technologies penetrate deeper into the daily life and work of people. The particular aim of the work was to provide a focus point for discussions around the requirements for ICT research under the Sixth Framework Programme.

The scenarios were commissioned by ISTAG (the Information Society Technologies Advisory Group) in May 2000. The project was carried out under a working group of ISTAG chaired by Dr. Martin Schuurmans (CEO of Philips Industrial Research) as a collaboration between DG Information Society and IPTS-JRC. The scenarios were constructed by a group of 35 experts, including a main group that met twice during 2000 and a preparatory group that provided assistance in the early stages of the project (see the participants list in Annex 6).

The scenarios generated a number of key results. First, if AmI is to be successful as the future techno-economic trajectory of development, it also has to be seen as a positive force for the societal and political development of Europe. Second, as a new paradigm for ICTs, AmI will open the door to major new business and industrial opportunities for the economies and firms that are creative and energetic enough to engage with the possibilities. Third, unleashing the socio-political gains and the economic potential will require significant and long term underpinning research of a focused nature. These three areas of conclusions are described in brief below and in more detail in the main report and accompanying annexes.

1. Critical socio-political factors

The scenarios provided insights that the social and political aspects of AmI will be very important for its development. A series of necessary characteristics that will permit the eventual societal acceptance of AmI were identified as a result:

- AmI should facilitate human contact.
- AmI should be orientated towards community and cultural enhancement.
- AmI should help to build knowledge and skills for work, better quality of work, citizenship and consumer choice.
- AmI should inspire trust and confidence.
- AmI should be consistent with long term sustainability – personal, societal and environmental - and with life-long learning. In essence, the challenge is to create an AmI landscape made up of 'convivial technologies' that are easy to live with.

- AmI should be controllable by ordinary people – i.e. the 'off-switch' should be within reach: these technologies could very easily acquire an aspect of 'them controlling us'. The experts involved in constructing the scenarios therefore underlined the essential need that people are given the lead in way that systems, services and interfaces are implemented.

Overall, the social aspects of AmI raise major issues that require precautionary research particularly in the areas of privacy, control and social cohesion. In addition, encouragement may be needed to develop forms of Ambient Intelligence that are sensitive and adaptive to societal development and the diversity of European social, political and cultural life.

2. Business and industrial models

It was not the task of this project to identify specific business opportunities for AmI. The identification of winning business models for AmI will be the job of coming generations of industrialists and entrepreneurs. But the rich diversity of technologies featured in the AmI landscape and the broad variety of potential applications will undoubtedly give rise to many questions about how to build upon existing and emergent socio-economic demands. The business-case for AmI is not yet self-evident, but aspects of business models are indicated by the scenarios, in the form of the following entry points to AmI business landscape:

- **Initial premium value niche markets** in industrial, commercial or public applications where enhanced interfaces are needed to support human performance in fast moving or delicate situations (such for example as Maria's).
- **Start-up and spin-off** opportunities from identifying potential service requirements and putting the services together that meet these new needs.
- **High access-low entry cost** based on a loss leadership model in order to create economies of scale (mass customisation).
- **Audience or customer's attention economy** as a basis for 'free' end-user services paid for by advertising or complementary services or goods.
- **Self-provision** – based upon the network economies of very large user communities providing information as a gift or at near zero cost.

Overall most of these developments will come through in the form of **partnerships** and complex **combinations** of different business models to deliver a packaged set of services. Investment for development of the necessary communications systems requires expectations of substantial returns in generation after generation of new infrastructures. The large sums involved points towards partnership models. We might also expect leasing and franchising models to be important in achieving a fast turnover of technological investment. Also the development of many of the AmI applications requires cross-disciplinary and cross-sectoral capabilities.

3. Key technological requirements for AmI (2010)

The technology timelines for each of the scenarios were explored. On this basis the following five technology requirements for AmI could be identified:

- Requirement 1: Very unobtrusive hardware
- Requirement 2: A seamless mobile/fixed communications infrastructure
- Requirement 3: Dynamic and massively distributed device networks
- Requirement 4: Natural feeling human interfaces
- Requirement 5: Dependability and security

4. Research clusters

On top of these largely generic technology requirements the following list of major research clusters emerged from the work of the scenario building group:

- **AmI compatible enabling hardware** – including fully optical networks, nano-micro electronics, power and display technologies.
- **AmI open platforms**: for interoperating networks based upon a corporate effort to define a 'service control platform'.
- **Intuitive technologies** involving efforts to create natural human interfaces.
- **AmI developments in support of personal and community development**: including socio-technical design factors, support for human to human interaction and the analysis of societal and political development.
- **Metacontent services developments** to improve information handling, knowledge management and community memory, involving techniques such as smart tagging systems, semantic web technologies, and search technologies.
- **Security and trust technologies** in support of privacy safety and dependability.

5. Main implications

The scenarios underscore the importance of well-focussed and world-class long-range research in Europe. *There is an urgent need to open up an ever-increasing reservoir of new ideas and creativity to help invent the future*. The current pace of the ICT industry and the scenarios indicate a high sense of urgency with a global character in the business of ICT. This implies that whatever measures are being taken in the Framework Programme (FP6) to support Europe's ICT-development, they should support fast responses, flexibility and worldwide scientific and technological co-operation, as well as entrepreneurship.

The scenario exercise indicates that the vision of Ambient Intelligence is a strong starting point for giving direction to research over the coming five years. Major opportunities to create an integrated Ambient Intelligence landscape can be built upon European technological strengths in areas such as mobile communications, portable devices, systems integration, embedded computing and intelligent systems design. A host of new business models will emerge, no matter the response by Europe. But, these new business models will be test-bedded by industry and entrepreneurs operating in the areas that provide the most fertile conditions for experimentation. The vision of Ambient Intelligence points at how to create these fertile conditions, in the technological domain and in the business environment. But all the scenarios also emphasise the social dimension of innovation, the ability as well as the willingness of society to use, absorb or adapt to technological opportunities. Alongside technological and economic feasibility, the implications for issues such as energy, environment, social sustainability, privacy, social robustness and fault tolerance may in the longer run determine the success or failure of AmI.

Context and methodology

In 1999 the ISTAG (IST Programme Advisory Group) published a vision statement for Framework Programme 5 that laid down a challenge to:

> *"Start creating an ambient intelligence landscape (for seamless delivery of services and applications) in Europe relying also upon test-beds and open source software, develop user-friendliness, and develop and converge the networking infrastructure in Europe to world-class".* [2]

Ambient Intelligence (AmI) stems from the convergence of three key technologies: Ubiquitous Computing, Ubiquitous Communication, and Intelligent User Friendly Interfaces. According to the vision statement, on convergence humans will be surrounded by intelligent interfaces supported by computing and networking technology which is everywhere, embedded in everyday objects such as furniture, clothes, vehicles, roads and smart materials even particles of decorative substances like paint. AmI implies a seamless environment of computing, advanced networking technology and specific interfaces. It is aware of the specific characteristics of human presence and personalities, takes care of needs and is capable of responding intelligently to spoken or gestured indications of desire, and even can engage in intelligent dialogue. 'Ambient Intelligence' should also be unobtrusive, often invisible: everywhere and yet in our consciousness - nowhere unless we need it. Interaction should be relaxing and enjoyable for the citizen, and not involve a steep learning curve.

Following the publication of the ISTAG vision statement in 1999, Ambient Intelligence became broadly embedded in the work programme for 2000 and 2001 and is one of the key concepts being used to develop the Information Society aspects of Framework Programme 6.

To help further develop a better understanding of the implications of an Ambient Intelligence landscape *a scenario development exercise* was launched, reporting to an ISTAG working group chaired by Dr Martin Schuurmans (CEO of Philips Industrial Research). The project was carried out as a joint exercise between DG Information Society and the Joint Research Centre's Institute for Prospective Technological Studies in Seville. The scenarios were developed and tested in two interactive workshops with over 35 experts (see Annex 6).[3]

The results are presented here as four scenarios that are used to identify key 'drivers' (technological, socio-economic and political), baselines, uncertainties, constraints, opportunities and potential points of bifurcation or convergence surrounding AmI in Europe. Time horizons are proposed for technologies, applications, services and products to arrive on the market around 2010.

The scenarios describe plausible futures, but are not predictions. They do not forecast specific trends in technologies. They are only meant as a prospective on ICTs to help provoke 'what if' games, develop technological roadmaps and discuss economic, social and political factors. The aim is to improve the collective understanding of the development of AmI and its possible future

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[2] ISTAG Orientations for WP2000 document (July 1999) <ftp://ftp.cordis.lu/pub/ist/docs/istag-99-final.pdf>

[3] Particular support was provided by Professor Ronan Sleep of the University of East Anglia and a European Science and Technology Observatory team led by Dr Kieron Flanagan of PREST, University of Manchester.

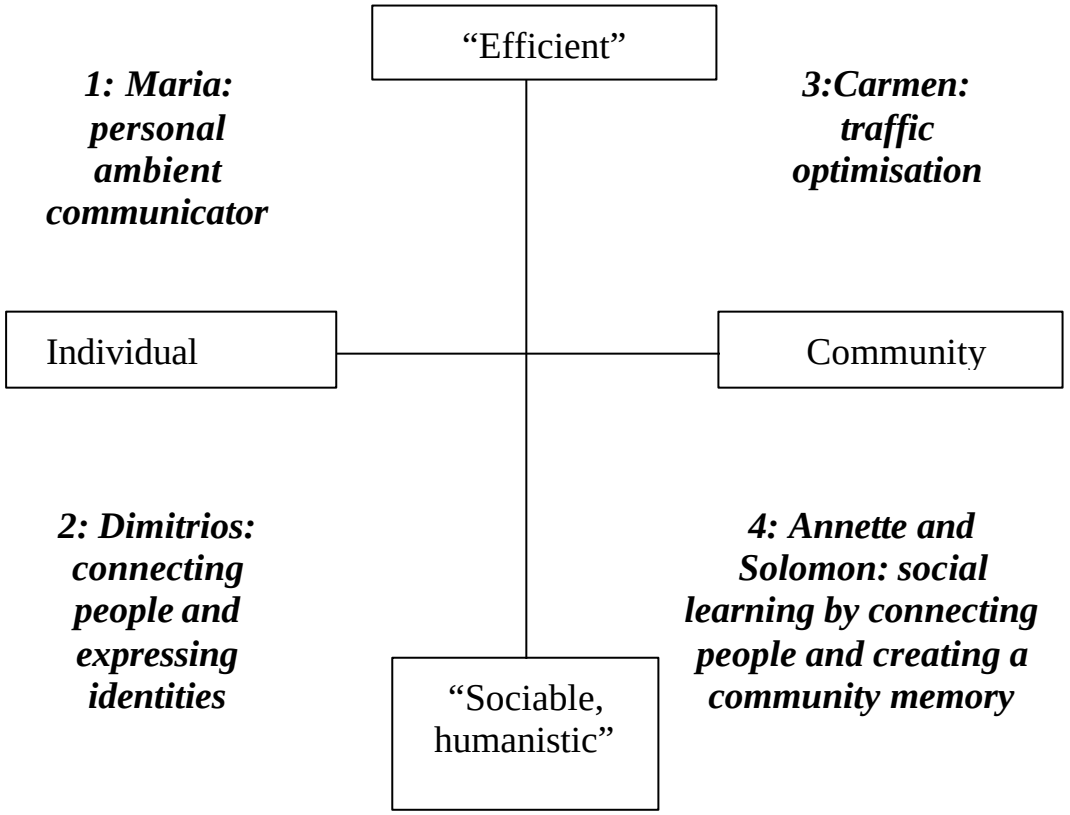
impact. This in turn helps to improve the vision and our understanding of the actions that are necessary to work towards the vision.

Four AmI Scenarios

The scenarios in this report provide a glimpse into potential futures with Ambient Intelligence (AmI). The scenarios are not 'orthogonal' in the sense of giving clearly distinct alternative trajectories. Rather they are complementary and sketch out different design emphases and pathways towards Ambient Intelligence.

The main structuring differentials between the scenarios are:

- Economic and personal efficiency versus sociability/humanistic drivers (goals);
- Communal versus individual as the user orientation driver (actors).



These two axes and the scenarios they provide a structure that isolates some of the main features and alternative development paths for Ambient Intelligence.

- *Maria* is a scenario that could be achieved relatively early. The technological and socio-economic changes are relatively incremental build outs of existing approaches. The key barriers appear to be the establishment of interoperating hierarchies of agents. The lead markets for AmI here are business sector demands (which tend to be more efficiency orientated and less price-sensitive). No large changes in behaviour are assumed.
- *Dimitrios* is also nearer term. It offers an alternative mode of use of personalised ambience. The emphasis is on play and social interaction rather than 'efficiency'. Lead markets for AmI may emerge first amongst 'alternative or youth cultures.' The changes in behaviour relate mainly to the willingness to reveal (or disguise) personality on-line. Price could be a barrier to a break through to a mass market.

- *Carmen* is further out on the time horizon than the two 'individual' scenarios not so much due to technological barriers as because it implies major infrastructural developments (i.e. highly developed networks of inter-operating sensor systems and dynamic database management systems). It describes an ambient landscape in which the joint flows of bits and atoms are optimised to create a more sustainable urban system. It also makes significant assumptions about changes in public behaviour such as accepting ride shares and traffic management systems.
- *Annette and Solomon's scenario* is probably the furthest out in terms of time as it has high demands both from a technological and socio-economic viewpoint. It implies significant technical developments such as high 'emotional bandwidth' for shared presence and visualisation technologies, or breakthroughs in computer supported pedagogic techniques. In addition, the scenario presents a challenging social vision of AmI in the service of fostering community life through shared interests.

The specific implications of each scenario in terms of technologies and economic (industrial competitiveness or product service markets) and their socio-political implications are developed in more detail in the respective Annexes 1 to 4.

The scenarios are all situated at the human interface. This emphasises a key feature of AmI, which is that the technologies should be fully adapted to human needs and cognition. AmI represents a step beyond the current concept of a 'User Friendly Information Society'.

To achieve this kind of seamless invisibility, however, an AmI landscape will also require substantial amounts of renewal in business models and technology based services. In effect of these access-level scenarios of humans in the AmI landscape are underpinned by innovations in the industrial system and its associated technologies. At a deeper level, industrial applications are in fact likely to lead the way to Ambient Intelligence, with human interface being a product of rather than the sole route towards AmI. We have not built specific industrial scenarios addressing such vanguard industrial applications. But, it is possible to illustrate the relevance of AmI to industrial environments both with a description of how AmI technologies relate to generic industrial trends and an illustration of AmI technologies applied in the construction value chain (see Annex 5).

Critical factors

This section synthesises the main conclusions that emerged from the scenario building process. It is more than simply a summary of the main messages from the individual scenarios; it reflects the reactions of the experts to the scenarios they had themselves built.

1. Critical socio-political factors

To be acceptable AmI needs to be driven by humanistic concerns, not technologically determined ones. Indeed, the very real risks of the technology scenario driving our lives provide an implicit black lining for Maria in her scenario of a high-pressure lifestyle. As Dimitrios indicates AmI could act as a facilitator of **human interaction** especially with friends, family and colleagues. It will be important that AmI builds on its **community** enhancing potential though offering opportunities for interest groups to develop their own applications (Annette and Solomon).

Second, AmI also has an important potential to enhance **education and learning** as an enabler of higher levels of consumer choice. Everyday life skills will rise because of rising opportunities and means of personal expression and interaction. At work too there are likely to be rising skills-demands. Some will be higher requirements for technological expertise, but if the AmI manifesto is to be achieved the main skills rises will be in social know-how and information manipulation. The expert group advised that the responsiveness of existing educational institutions and appropriate policies will determine whether there will be a weakening of education as a separate, identifiable activity or a strengthening of educational institutions.

Three main **sustainability dimensions** seemed to be at stake.

- Personal physical and psychological sustainability: can AmI reduce (mental) health risks from information stress, virtual identities and information overload? What precautionary evaluation is needed to avoid new health impacts of pervasive electronic radiation?
- Socio-economic sustainability: digital divides emerging from unequal developments and access to the AmI infrastructure could be related to income, education and skills, age and work.
- Environmental sustainability: there are pressures created by new growth and the material wealth associated with AmI technologies. The scenarios draw a picture of a hyper-mobile society. The embedding of computers implies considerable extension of recycling and reclamation of electronic waste – perhaps based on smart tagging. The Carmen scenario implies new efficiency gains in transport to combat congestion.

A consistently strong response to AmI is the need to build **trust and confidence**. A key aspect is management of privacy: more open systems tend to lower privacy levels. Technological developments are outpacing regulatory adjustments. To what extent can people be protected in the AmI landscape? What belief can we have that there will be effective norms of trust (in business, government, inter-personal relations) that prevent invasive/intrusive usage of AmI technologies.

Related, but important enough to merit a separate point, AmI should also be **controllable by ordinary people**. There was a consistent demand for some kind of volume control or on/off switch that would allow people to decide what level of access they have on what issue and when. But such technologies also raise concerns about a reduction of free will and choice, In essence, as with other key emerging technologies, AmI offers many potential advantages, but precautionary

research and provisions will be necessary to make sure that it has the maximum positive effect on personal life and society.

2. Business and industrial models

Economic questions abound. Who will make AmI work? Who will produce it? Who will live and consume in a world like that? Who will make money? In terms of social processes and labour conditions: what problems are we going to meet? How will AmI change the way people work, think, learn, and communicate and how will it change the settings in which they do this? What are the main uncertainties? When will they occur? How do they translate into issues for research? The sheer diversity of possible factors defeats the establishment of a common economic baseline related to major certainties and uncertainties. These questions are difficult. However a number of elements emerged from the scenario work as important for inclusion in the ten-year timeframe. Five main **drivers of demand** of AmI were rated as important:

- Improvements in the quality of life (including satisfying intangible needs such as better community life and health as well as rising material demands);
- Enhancements in the productivity and the quality of products and services, and applications in process innovations;
- New and emerging AmI firms will themselves be a key source of demand for AmI because of secondary demands for new products and services;
- Applications of AmI in industrial innovation and new products (e.g. household and office equipment, clothes, furniture);
- Applications in public services, e.g. in hospitals, schools, police or the military.

In the scenarios, demand for AmI is based on consumer added value and builds upon several of four revenue models.[4] First, **stand-alone models** build upon the processes of miniaturisation and embedding of intelligence into **personal devices**. They offer glimpses of extended versions of today's PDAs and mobiles into secure ID authentication, transmission (i.e. with embedded agents for traffic management), voice and language recognition, and maybe sensors/ actuators for behavioural and biological patterns recognition. **Embedding intelligence** into devices may provide scope for innovative SMEs as start-ups, subcontractors or spinouts of existing leading multinationals. Product design will emerge for new intersectoral **collaborations or strategic alliances** due to the multidisciplinary, multisectoral competences required and the need to spread the risk when recovering investment. For this reason, and because most devices in the scenarios are networked, it is unlikely that pure stand-alone business models will be dominant – even for consumer electronics in the AmI landscape.

Second, **access models** are currently a main way to build usage above critical mass and to get the strong multiplier effect known as Metcalf's Law i.e. the value of a network expands as the square of the number of its users. This is a major mass consumption model and is a strong driver for the Dimitrios and Carmen scenarios. Access models will be one essential means to provide widely distributed device networks and systems while offering low prices for communication. The profitability of future communication service provision remains a major question that will have to be resolved in the short-term.

A complementary approach to building market size through access is to look for higher yields from offering **premium service levels**. This is illustrated through the example of Maria where

[4] Lead sectors may actually emerge from industrial applications such as those sketched in the industrial AmI chapter (Annex 5)

high spending corporate users are accessing a package of services and demand high service quality in the form of reliable physical and service platforms in different countries. This points towards co-operation and cross-financing the development among a wide range of very different players: credit card agencies, retailers, and telecommunication operators.

In a fully developed AmI landscape the tangible and physical interface that divides humans from ICTs will be blurred. By definition, the effort required to use such computer systems should tend towards the imperceptible. Use should be as imperceptible as using our own body and brain. Workable business models for this new AmI landscape are not easy to define, but one line of development, which is already visible (see the roots of Dimitrios) is towards increased **self-customisation of content**. Further, as Annette and Solomon illustrate, media industries such as editorial, publishing, broadcasting firms may merge with other informational services such as training, education or business consultancy.

Key features of the new business landscape that emerges therefore are emphasises on:

Initial premium value niche markets in industrial, commercial or public applications where enhanced interfaces are needed to support human performance in fast moving or highly delicate situations (e.g. for Maria in her harsh business negotiations).

Start-up and spin-off opportunities from identifying potential service requirements and putting the services together that meet these new needs.

High access-low entry cost based on a loss leadership model in order to create economies of scale (mass customisation).

Self-provision models – based upon the network economies of very large user communities providing information as a gift or at near zero cost.

Overall most of these developments can be expected to come through in the form of **partnerships**. First, the development of the necessary communications systems requires expectations of substantial returns on investments in generation after generation of new infrastructures.[5] The large sums involved points towards partnership models. We might also expect leasing and franchising models to be important in achieving a fast turnover of technological investment. Also the development of many of the AmI applications requires cross-disciplinary and cross-sectoral capabilities.

3. Technology requirements

The underpinning technologies required to construct the AmI landscape cover a broad range of ICT and smart material technologies. The table below gives the 'Key Enabling Technologies' identified by ISTAG Working Group 6 under the more immediate time horizon of Framework Five.[6].

[5] Some experts suggested that new policy requirements might stem from the simultaneous need to stimulate infrastructural investment while encouraging competition in these new cross-sectoral markets.
[6] Recommendations of the IST Advisory group for Work Programme 2000 and Beyond, ftp://ftp.cordis.lu/pub/ist/docs/istag-00-final.pdf

Key Enabling Technologies

(as identified by ISTAG working group – June 2000)	
• Embedded Intelligence • Middleware and distributed systems • IP mobile and wireless • Multi-domain network management • Converging core and access networks	• Micro and opto-electronics • Trust and confidence enabling tools • Cross-media content • Multi-modal and adaptive interfaces • Multi-lingual dialogue mode

In the course of the scenario building work a wide range of different technologies were identified as key enablers of AmI. From the scenarios it is possible to develop a set of common technological requirement areas.[7] The sheer diversity of technologies involved means that neither the list nor the terminology can be definitive, but it does provide hints about the sets of technologies that will be essential for AmI and the technological trajectories that they imply.

Requirement 1: Very unobtrusive hardware

Miniaturisation is assumed to follow its historic pattern to permit the necessary enabling developments in micro and optical electronics. Molecular and atomic manipulation techniques will also be increasingly required to give advanced materials, smart materials and nanotechnologies. In addition there will have to be:

- Self-generating power and micro-power usage in objects for example as very low power radio frequency chips in order to make feasible the interoperation of chips embedded in almost anything.
- Breakthroughs in input/output including new displays, smart surfaces, paints and films that have smart properties. This is fundamental to the seamless interfaces that invisibly permit Maria, Dimitrios and so on to interact with their intelligent environment.
- Active devices such as sensors and actuators integrated with interface systems in order to respond to user senses, posture and environment or smart materials that can change their characteristics and/or performance by stand alone intelligence or by networked interaction (e.g. smart clothing).
- Nanoelectronics and other nanotechnologies that permit miniaturisation trends to extend beyond the limits of micro-devices through hybrid nano-micro devices. Nanodevices would yield lower power consumption, higher operation speeds, and high ubiquity.
- A human factors design emphasis so that the widespread embedding of computers produces a coherent AmI landscape rather than just a proliferation of electronic devices with IP addresses.

Requirement 2: A seamless mobile/fixed web-based communications infrastructure:

Complex heterogeneous networks need to function and to communicate in a seamless and interoperable way. This implies a complete integration (from the point of view of the user or network device) of mobile and fixed and radio and wired networks. Probably all the networks would be operating with some equivalent of IP technology. Core and access broadband networks are likely to converge.

To deliver the full AmI vision (e.g. the 3-D real-time holographic rendering in Annette and Solomon) there will eventually be a need to move towards ultrafast optical processing in the fixed

[7] This view is actually consistent with the ISTAG WG#6 results - the comparison points are shown as underlined text in what follows.

network, for routing first and then full optical networks. These networks will have to be seamless and dynamically reconfigurable. They will require more advanced techniques for dynamic network management (see Requirement Three).

Requirement 3: Dynamic and massively distributed device networks

The AmI landscape is a world in which there are almost uncountable interoperating devices. Some will be wired, some wireless, many will be mobile, many more will be fixed. The requirement will be that the networks should be configurable on an ad hoc basis according to a specific perhaps short-lived task with variable actors and components. Databases whether centralised or distributed should be accessible on demand from anywhere in the system.

This complexity extends well beyond the current capabilities of system software and middleware, and calls for wireless 'Plug and Play' solutions as well as dynamic, multi-domain networking. In turn these have implications for the development of new ontologies, and protocols, as well as the setting of new standards. The way to construct these networks is a major research challenge for the coming years, and the implications are numerous: new computer and communications architectures, new systems software that can adapt to a changing hardware configurations, the development of networked embedded intelligence and distributed data management and storage systems. Key to this will be the development of middleware and agent technologies (Requirement 4).

Requirement 4: A natural feeling human interface

A central challenge of AmI is to create systems that are intuitive in use – almost like normal human functions such breathing, talking or walking. On the one hand 'artificial intelligence' techniques will have to be employed for this especially dialogue-based and goal orientated negotiation systems as the basis for intelligent agents and real time middleware. The key issue will be to move from relatively narrow domain by domain and highly structured databases to families of systems that can operate across domains to very general levels. These kinds of artificial intelligence techniques will be equally important for developing intuitive machine to machine interaction.

There are also demands for supportive and technologically cognate developments user interface design that is multimodal (multi-user, multilingual, multi-channel and multipurpose) for speech, gesture, and pattern recognition. It should also be adaptive to user requirements providing context sensitive interfaces, information filtering and presentation, and cross-media content.

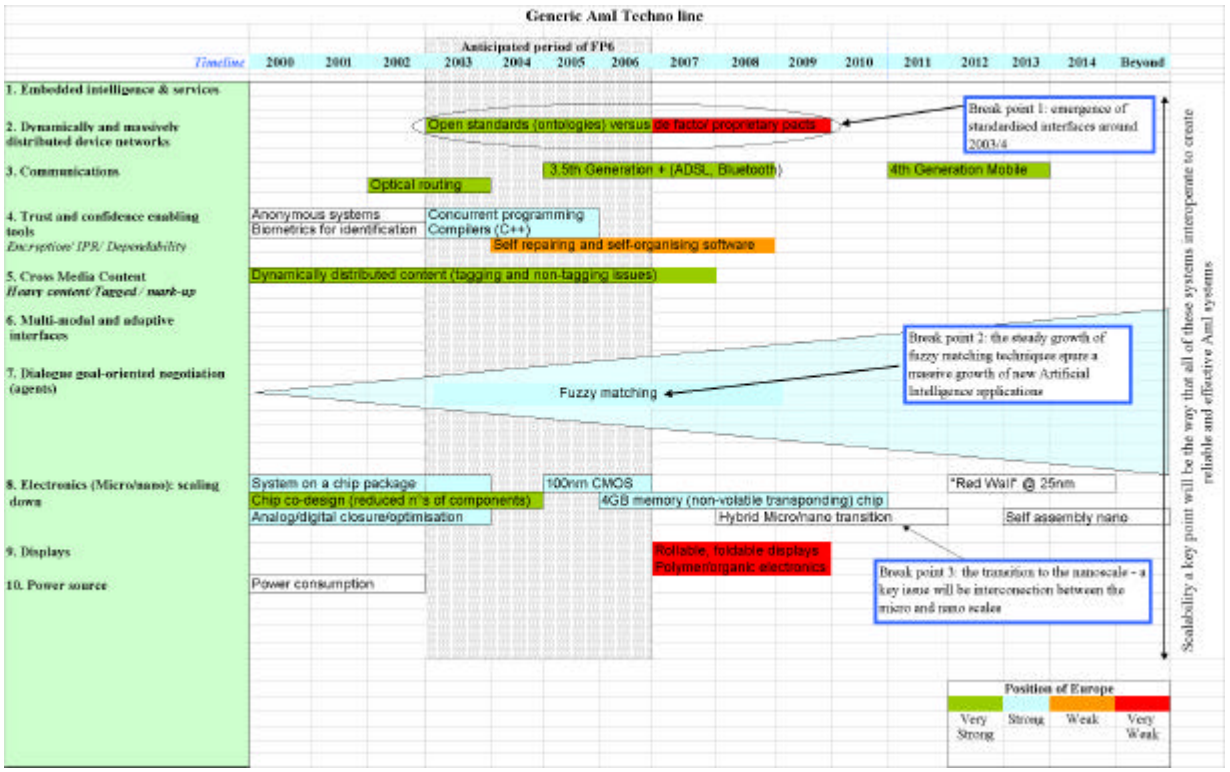
Pattern recognition (including speech and gesture) is a key area of artificial intelligence that is already evolving rapidly. Speech recognition will have a big impact on the miniaturisation of devices and augmentation of objects allowing hands free operation of personal ambient devices. In the scenarios the use of voice, gesture and automatic identification and localisation are implicitly used to synchronise systems, so that services are available on tap when people want them. According to some of the scenario experts speech instruction is likely to become more important than voice synthesis (i.e. displays will be very important as well).

Requirement 5: Dependability and security

A consistent theme of the scenario work is the requirement for a safe, dependable and secure AmI-world. The technologies should be tested to make sure they are safe for use. On the one hand this refers to physical and psychological threats that the technologies might imply. On the

other hand, the creation of a landscape of interoperating AmI devices focuses even greater emphasis on the requirement for robust and dependable software systems. For this reason there is likely to be an emerging emphasis on self-testing and self-organising software and techniques based upon software components.

It will also be important to have AmI systems that are secure against deliberate misuse. The scenarios assume techniques for secure ID authentication, micropayment systems and biometrics. These sorts of 'trust technologies' and advanced encryption techniques are strong requirements for both the dependability and the likely acceptance of nearly all of the processes, products and services described in the scenarios. Practical and widespread use of micropayment is necessary for AmI according to some scenarios in which the AmI features are accessed and used on an ad hoc basis (maybe with the aid of personal negotiating intelligent agents). But there is also the possibility that many of these transactions will be bought on a subscription basis. In computer security, biometrics will be important as a means of authentication based on measurable physical characteristics that can easily be checked (fingerprints, iris scanning or speech).



Key break points and milestones

In relation to all these requirements the scenario construction group pointed to a number of milestones and breakpoints that would be very important in shaping the form that AmI will take in Europe. These are summarised in the technology timeline above.[8] In this list of technology requirements there are a number of sine qua non developments that are almost baseline assumptions for the exercise. In particular, the availability of very low cost short-range

[8] It is important to stress that this timeline is impressionistic, based upon the work of a relative small scenario group. Neither it nor the other timelines in this report are therefore definitive statements of the set of key technologies, their timing or the strength of the European position. Their value is to stimulate a more detailed evaluation about these factors.

communications will be needed to permit devices to interoperate (almost freely). Services integrating Bluetooth and ADSL will appear at the beginning of 2002 around the same time as true 3rd Generation UMTS. The roll out of 3.5 Generation mobiles and an eventual rollout of a 4th Generation were also part of the mix of assumptions. The availability of very fast broadband infrastructures in order to provide the highways for all the information flows that AmI is generating was also a part of the implicit back up for the scenarios. However, the expert group was unable to identify convincing revenue models that would provide incentives to invest in the construction of these infrastructures and even to offer services across them.

In other key areas, a sample of which are depicted in the figure, there is evidence of considerable strengths and a few areas of relative weaknesses in Europe. In a dynamic information management such as multi-X (i.e. multiple media, channel, senses, language) content Europe is in a strong position industrially and in terms of research. The key weakness appear to be in the flat, foldable and rollable displays that are based upon polymer organics and in terms of levels of investment in self-organising and repairing software. Other key areas (although ones on which no views on strengths or weaknesses was available) concerned the issue of very low power requirements and/or use of ambient power and lightweight power packs to drive ubiquitous computing.

In addition the group identified three key breakpoints. First, under the requirement that AmI calls for a very flexible and seamless interoperation of many different devices on many different networks it is a *key requirement that there a set of common platforms or de facto standards to permit this interoperation to take place*. The group felt that this would have to happen around 2003/4 and would either be achieved through a deliberate effort to develop such open platforms or would arise from proprietary pacts between industrial suppliers. The expert group suggested that the latter approach has been most successful in Europe, whilst proprietary dominance has tended to be more successfully deployed by US-led consortia.

A second break point could occur from a *step up in the scale of know-how about using dialogue or goal orientated negotiation techniques*. This is represented in the figure as a cone shaped growth implying more of a spreading diffusion of techniques such as 'fuzzy matching' rather than a massively important single breakthrough. These techniques were regarded as pivotal to AmI technologies and services such as ad hoc and sentient networking, dynamic and distributed database management, middleware, materials resource flow planning and cross-media content production. This is a particularly important dimension of AmI given the relatively good position of European technology developers in this competence domain.

The third main break point concerned developments in hardware. Towards the end of the decade in 2008-9 it was suggested that production techniques would be fully engaged in a *transition from micro to hybrid nano-micro devices*. This would affect the techniques used to produce all sorts of solid-state and optical devices. The key technical challenges of the transition would be to achieve interconnection between these two scales. The full effect of any potential full nano-paradigm will probably have to await commercialisation of self-assembling nanotechnologies from around 2015. At the moment, Europe has as good chances to benefit from the nanotechnology breakpoint as any other leading technology region, not least because of the strengths in many of the systems on a chip, special application circuits and embedded systems that will provide the hardware technology pathways towards AmI.

Main Research Implications and Opportunities

The final step in the scenario construction procedure was to identify some large-scale research efforts that could support the emergence of a balanced pathway towards AmI. Such a list should be read as an incomplete frame of reference rather than a set of internally consistent research programs. It covers socio-economic and political as well as technological aspects and aims at offering some challenging clusters of research issues.

- **AmI compatible enabling hardware** – The fully optical network is an important milestone, even though experts had divergent opinions whether present and expectable network bandwidths would be sufficient for AmI important streams of data (i.e. Carmen) and quality video (i.e. Salomon). Additionally, they were reporting that optics in access networks needed consolidated business plans to justify investments. The expert group also underlined the importance of research efforts on near-zero cost embedded technologies, ambient power sources and compatible hardware enablers (nano-micro, sensors, power, displays) addressing social and political design and engineering factors (such as safety and health) as well as technological and economic challenges.
- **AmI open platforms** – for interoperating embedded devices; for wireless and fixed ad hoc networking; and for self organising and repairing software/middleware systems. The centrepiece would be an integrated set of 'service control planes' or 'platforms' for each major application area: e.g. in the home, mobile and vehicle, e-commerce, security. The success of such a service control platform relies on advances in information processing (agents, datamining and filtering, distributed processing).
- **Intuitive technologies** – involving efforts to create human interfaces with variable emotional bandwidth. Dialogue-based techniques and tangible user interfaces are needed in order to permit seamless human interactions. For example this might involve the creation of interactive surfaces, coupling of objects and digital info that pertains to them, enhancing of ambient media such as airflow or light. Nevertheless, significant advances in machine-to-machine (MtM) and object-to-object (OtO) communication and understanding will have to complete this humanised interfacing as to reduce thresholds of information overload for human beings.
- **AmI support for Individual and community development** – including social and psychological aspects such as human factors in design; the application of socio-technical systems approaches to developing the AmI landscape; initiatives towards community and societal-orientated AmI. The scenario experts unanimously supported the importance that the AmI vision should be built upon humanistic foundations. This implies a serious attention to socio-technical design factors especially in user interface design. There is also a need for AmI to provide tools to support human interaction such as building community memories for the social sharing of knowledge. *The expert group was adamant about further need for research programmes into the implications of AmI for societal and political development.*
- **Metacontent services** – the emphasis in the scenarios on access to information that is pre-filtered to support human dialogues and actions is predicated on considerable advances in information handling. This is necessary to support new forms of organisation based upon learning environments and community memory. An example could be an Information Factory Initiative to addresses the requirement for highly flexible and intelligent systems for information handling such as smart tagging systems, semantic web technologies, and search technologies.
- **Security and trust** – AmI technologies should support the rights to anonymity/ privacy/ identity of people and organisations, offering e.g. relevant combinations of biometrics, digital signature or genetic-based methods. Also of fundamental importance is research towards safe

and dependable large-scale and complex systems (self-testing, self-repairing, fault tolerant) to underpin the increasing reliance on ICTs implicit in the AmI landscape.

Matching this list with existing EU strengths and weaknesses offers an initial view on what might be research opportunities in the development path of AmI. In such a perspective, the ESTO network has, on behalf of the IPTS, explored and analysed existing data and offers a relevant insight[9] into this issue. A specific feature of the French Key Technologies Programme is the rating, by (French) experts, of both Europe's scientific and technological position, and its industrial and commercial position. Encouragingly, the study suggests that, contrary to some conventional wisdom, in many cases EU is neither leading nor lagging in relevant capabilities and that the technical and commercial positions of Europe are fairly evenly matched. The table reproduced below extracts those technology areas that are regarded as most relevant for the AmI vision, indicating the rating of the European position for both of these factors.

Key Enabling Technology	**Position of Europe**				
	strong		***Medium***		***weak***
(1) embedded intelligence			■		
virtual & interactive reality			■		
intelligent identifiers, autonomously communicating objects		■			
real time transmission of multimedia contents			■		
software engineering & components			■		
intelligent homes			■		
(2) middle-ware & distributed systems			■		
big server networks			■		
integration of appliances, XML & other evolved languages		■			
(3) IP mobile & wireless	■				
portable digital assistants	■				
(4) multi-domain network management			■		
quality of IP service			■		
(5) converging core and access networks		■			
high transit backbone networks		■			
(6) micro- and opto-electronics			■		
silicon micro-electronics		■			
optic-electronic & photo-components		■			
search engines & intelligent indexing			■		
micro-electronics III V			■		
batteries, micro-energy			■		
mass memories					■
flat screens					■
(7) trust and confidence enabling tools					■
(8) cross media content					■
authoring systems for creating multimedia contents					■
(9) multi-modal and adaptive interfaces			■		
virtual & interactive reality			■		
(10) multi-lingual dialogue mode	■				
linguistic & vocal technologies	■				
Legend		scientific & technical position			
	■	industrial & commercial position			

Adapted from: *Rapport Technologies-Clés 2005.* Ministère de l'économie et de l'industrie. Paris, 2000.

The recent futures-oriented issue of MIT's Technology Review, (December 2000) which, whilst focusing mainly on the US situation, does demonstrate that its authors consider certain European centres of excellence to be leaders in specific technologies which might be important for AmI applications. These include the development and use of novel materials for the manufacture of

[9] Ubiquitous computing: Towards understanding European Strengths and Weaknesses. Draft final report. December 2000, prepared by PREST, CMI, INRIA/OST, Fondazione Rosselli, ITA, VTT Electronics.

integrated circuits or display systems, and the development of powerful ‘data-mining’ techniques and ‘sentient computing’ –orientated work.

The scenario exercise indicates that the vision of Ambient Intelligence is a strong starting point for giving direction to research over the coming five years. Major opportunities to create an integrated Ambient Intelligence landscape can be built upon European technological strengths in areas such as mobile communications, portable devices, micro and opto electronics, systems integration, embedded computing, linguistic and vocal technologies, novel materials, display systems and intelligent systems design. Also the scenarios emphasise the social dimension of innovation, the ability as well as the willingness of society to use, absorb or adapt to technological opportunities. Next to technological and economic feasibility, the implications for issues such as energy, environment, social sustainability, privacy, social robustness and fault tolerance may in the longer run determine the success or failure of AmI.

These observations indicate that key fields of technological R&D are broadly shared at global level. There is currently no effective absolute leadership at company or continental level. This also underscores the importance of efforts to create well-focussed and world-class long-range research in Europe. New concepts, products and business models will in the next few years be test-bedded by industry and entrepreneurs operating in the areas that provide the most fertile conditions for experimentation. There will certainly be need for complementary and highly flexible research programmes that provide appropriate incentives for creativity in meeting the challenge of creating an AmI landscape.

Annexes

Annex 1: Scenario 'Maria' – Road Warrior

1. Background

In one model of development, a defining of feature of AmI may be its orientation towards an élite business clientele. This is likely to have a high profit potential and may be able to operate as a series of interoperating ambient intelligence pools (airports, hotels, conference centres, automobiles, smart highways).

The scenario is an extension of today's already well-developed demands for laptop computers, mobile phones and personal digital assistants. In this scenario we basically extrapolate the mobile business market. Business travellers require a lot of related services, such as hotel reservations, car hire. AmI is likely to be strongly service based, and such service providers are already in the vanguard of applications of new ICTs in order to manage client accounts (with loyalty programmes and so on). Business travellers are also likely to be a lead market in that the social groups involved have a high disposable income and/or have the market pull of the companies that they work for behind them. As a humanistic vision of AmI though the scenario leaves something to be desired. Maria is rather isolated and seems to live and work in a pressure cooker. Her own responses to her possibly stress-related health problems are not necessarily the most appropriate.

2. The script (full version)

After a tiring long haul flight Maria passes through the arrivals hall of an airport in a Far Eastern country. She is travelling light, hand baggage only. When she comes to this particular country she knows that she can travel much lighter than those days less than a decade ago, when she had to carry a collection of different so-called personal computing devices (laptop PC, mobile phone, electronic organisers and sometimes beamers and printers). Her computing system for this trip is reduced to one highly personalised communications device, her 'P–Com' that she wears on her wrist.

A particular feature of this trip is that the country that Maria is visiting has since the previous year embarked on an ambitious ambient intelligence infrastructure programme. Thus her visa for the trip was self-arranged and she is able to stroll through immigration without stopping because her P-Comm is dealing with the ID checks as she walks.

A rented car has been reserved for her and is waiting in an earmarked bay. The car opens itself as she approaches. It starts at the press of a button: she doesn't need a key. She still has to drive the car but she is supported in her journey downtown to the conference centre-hotel by the traffic guidance system that had been launched by the city government as part of the 'AmI-Nation' initiative two years earlier. Downtown traffic has been a legendary nightmare in this city for many years, and draconian steps were taken to limit access to the city centre. But Maria has priority access rights

Maria calls the P-Com her 'key of keys' because it almost invisibly unlocks the doors she meets on her trip. It allows her to move around in an ambience that is shaped according to her needs and preferences. In the past travelling involved many different and complicated transactions with all sorts of different service vendors, often with gaps and incompatibilities between the different services. In the past few years a series of multi-service vendors (MSVs) have emerged offering complete packages of services linked to the P-Com that tailor the user's environment according to their preferences. User preferences are set up during an 'initiation period' during which personal agents (personal-servants or perservs) are instructed or learn how to obey their master's wishes. These agents are in continual negotiation with those of participating service providers (such as shops, rental companies, hotels and so on).

into the central cordon because she has a reservation in the car park of the hotel. Central access however comes at a premium price, in Maria's case it is embedded in a deal negotiated between her perserv and the transaction agents of the car-rental and hotel chains. Her firm operates centralised billing for these expenses and uses its purchasing power to gain access and attractive rates. Such preferential treatment for well-heeled visitors was highly contentious at the time of the introduction of the route pricing system and the government was forced to hypothecate funds from the tolling system to the public transport infrastructure. In the car Maria's teenage daughter (Amanda) comes through on the audio system. Amanda has detected from the 'En Casa' system at home that her mother is in a place that supports real time audio communication. However, even with all the route guidance support however Maria wants to concentrate on her driving and says that she will call back from the hotel.

Maria is directed to a slot in the underground garage of a newly constructed hotel building operated by the *Smar-tel Chain*. She is met in the garage by the porter – the first contact with a real human in our story so far! He helps her with her luggage to her room. Her room adopts her 'personality' as she enters. The room temperature and default lighting are set and there is a display of selected video and music choices on the video wall. She needs to make some changes to her presentation – a sales pitch that will be used as the basis for a negotiation later in the day. Using voice commands she adjusts the light levels and commands a bath. Then she calls up her daughter on the video wall, while talking she uses a traditional remote control system to browse through a set of webcast local news bulletins from back home that her daughter tells her about. They watch them together.

Later on she '*localises*' her presentation with the help of an agent that is specialised in advising on local preferences (colour schemes, the use of language). She stores the presentation on the secure server at headquarters in Europe. In the hotel's seminar room where the sales pitch is to take place, she will be able to call down an encrypted version of the presentation and give it a post presentation decrypt life of 1.5 minutes.

The hotel offers neutral third part hosting of presentations but Maria wants to be sure for her own peace of mind that some of the sensitive material in the presentation will not sit around on a 3rd party server for prying eyes to see. To do this work, Maria is using hardware provided by the hotel, but with security clearance and access to her personal home workspace guaranteed by her P-Com.

She goes downstairs to make her presentation… this for her is a high stress event. Not only is she performing alone for the first time, the clients concerned are well known to be tough players. Still, she doesn't actually have to close the deal this time. As she enters the meeting she raises communications access levels to block out anything but red-level 'emergency' messages. The meeting is rough, but she feels it was a success. Coming out of the meeting she lowers the communication barriers again and picks up a number of amber level communications including one from her cardio-monitor warning her to take some rest now. The day has been long and stressing. She needs to chill out with a little meditation and medication. For Maria the meditation is a concert on the video wall and the medication… a large gin and tonic from her room's minibar.

3. Socio-political and economic issues

Socio-political issues

Maria's 'key of keys' will contain much of the identity of the user, so the central societal issue is one of trust and security. These notions of 'trust and security' are meant here in a variety of contexts and levels. There is first, the obvious issue of trust and security related to the protection of her private and confidential transactions from third party interference of all kinds. There is,

secondly, the issue of 'confidence' and 'security' in the dealings that this scenario implies between governmental services in one country and, even more difficult, between such services in different countries (e.g. police agencies, tax, and customs authorities). The obvious need to ascertain co-operation and intergovernmental services 'confidence building' (which will most probably be via signing of complex international treaties) is perhaps the most difficult of the socio-political issues raised by this Scenario. Show stoppers would include serious breaches of security, identity theft and identity key black outs – i.e. people get locked out of their services.

There are risks also of a digital divide. In this scenario there could be a 'key divide' based on assessments of credit ratings, purchasing muscle (as we saw with the central city cordon) or the plain refusal of some people to adopt the digital identities. Part of this divide could be age and education related – people growing up with these systems are more likely to be accepting. As services move onto the platform the costs of offering dual provision may mean that choice for AmI dissidents gets narrower with the passing of time.

There has to be user control and above all an 'off switch'. At the time of the scenario Maria is faced with a very patchy coverage of systems, some places have very complete coverage others do not and it is very frustrating for her because you cannot always guarantee that you can leave all the old fashioned electronic hardware behind. But there are times she is glad to be in a communications dead zone. Sometimes she hits the off switch and goes naked – no P-Com.

Maria may choose to have a number of different identities, here we have seen just her 'road warrior' personality with a glimpse at her private and more vulnerable sides (mother and patient), with different systems of accessibility for the external world.

Also, there are opportunities here for much more effective personal service provision. For example, health-monitoring service may signal a shift towards more effective preventive models: although we are not quite sure that Maria's response to her stress event is the most healthy way of relaxing.

Business environment

Products: Maria moves through a world of augmented objects. Her prime tool is the P-Com, which is like an extension of the mobile phone (including a much more personalised SIM card, identification chip). This is a software radio, with voice instruction and might be manufactured by one of today's mobile communication terminal suppliers –an area of European leadership. It could be that there will be scope for niche-orientated firms that offer fashion or personalisation of these devices (designer fascias etc) – after all they will be worn. Maria has perhaps various ways of wearing the P-Com (embedded in clothes, as jewellery, as a watch).

The P-Com device is merely the centrepiece of Maria's system. There is a lot of nearly invisible (but heavy-duty) network infrastructure that has been invested in by the customs office, the car rental companies, the traffic management (tolling and route guidance), the hotel and so on. Here replacement rates of devices and of building will have a critical role in determining the rate of rollout of the integrated services used by Maria. New strategic cross-sectoral alliances: 'tagged' environments investment consortia will be needed to create the physical support for Maria's virtual environment (i.e. sensors embedded in building materials).

To generate a high level of infrastructural replacement we have suggested a leasing-model economy. Not only does Maria change her P-Com quite often or have several designer versions, but leased cars, PCs and household appliances tend to have a higher rate of replacement. The

piecemeal development and partial intelligence of the ambient landscape is likely to be very frustrating, even for enthusiasts like Maria, because of its unpredictability: most of the time Maria still has to lump several portable devices along to make sure she can get her work done.

The main **services** market here is based on a premium service model using pre-packaged services targeted at a well-off leader/niche market with high wage business-oriented users. The commercial basis of Maria's story is the multi-service vendor (MSV). It might resemble a credit card organisation or loyalty programme. The set of services has to work without failure or excessive (if any) human intervention, on the basis of a mere ID recognition. Back-office support for the customer might be envisaged (hot lines), but mainly it is down to the agents. We can imagine wide branch networks of franchised retail outlets where people load their preferences on to their personal agents or 'perservs'.

This service offers access to a range of packaged solutions that can be programmed into the P-Com. The MSV competes with others in offering a balance between a range of standard services (Perservs, centralised billing, network access management, programming, personalised media content services) and access to selected partner services (such as here hotels, car rental, health services). The MSV may offer 'anonymised' services to prevent the tracking of user activities.

Maria is a teleworker. The scenario assumes the continuation of current trends towards hyper-mobility for many executive level professionals. In this scenario AmI actually accentuates this trend.

In the scenario, though, Maria's relations with colleagues are invisible- she is a lone road warrior. Given organisational trends it is perhaps more likely that Maria would be integrated in a negotiating team. Perhaps she would have continuous on-line contact to a support group– even in the closed chamber of the presentation room.

For the scenario to come about there will have to be a substantial development of agent technologies. In the scenario Maria's personal agents are leased from the MSV. But there is any number of other agents working away in the background. To continue the scenario, we might imagine that the establishment of the Agent Technology Mark-up Language (in 2004) created a massive growth of ATML start-ups (mirroring the dot.coms of the late 1990s with an associated stock-market surge). The boom was captured by the US due to their leadership in agent technologies and access to risk capital.

Risk brokerage will emerge as an important role possibly undertaken by MSVs but perhaps also by specialist firms that assess and assume the credit risks of dealing with different IDs. These sorts of services will probably rise up with the current phase of development of e-business. In the multi-vendor environment the revenue sharing model (between hardware, software and service providers) will be a critical challenge. Also, Maria faces a potential lock-in to one main MSV – because she will come to depend on the tacit support of her *perservs*, but these are actually only leased from the MSV because they exist in the network.

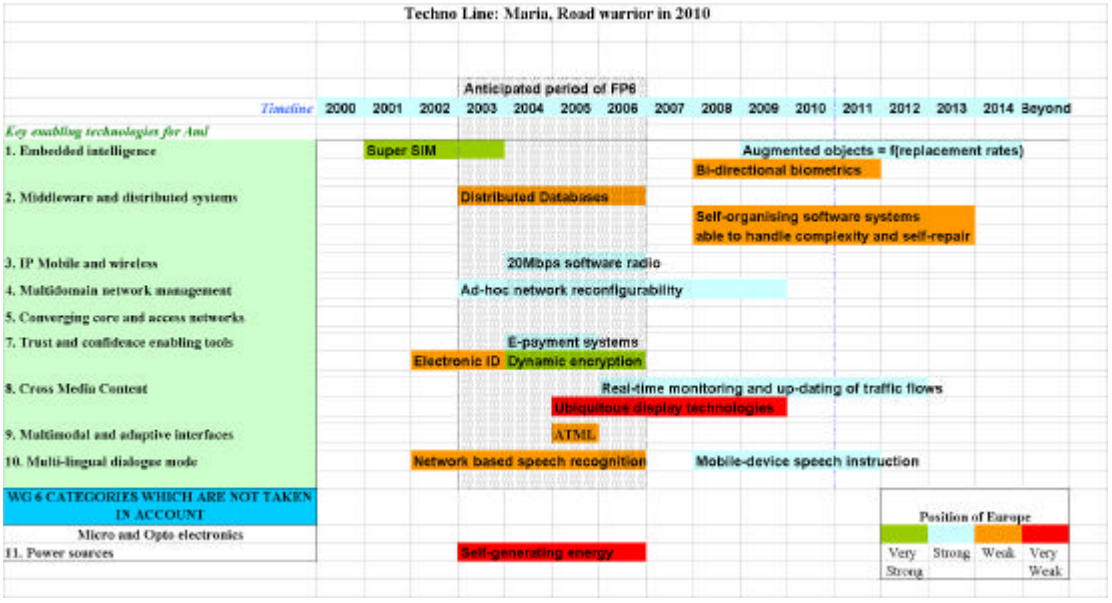
Reinforced cross-sectoral service sector partnerships can expected, e.g. airport booking systems and the construction sector which have very different life cycles and cultures. One should expect major multinational or global 'service operators' (from hotel chains, travel agencies, public authorities in charge of major tourist flows, flying and care renting companies) to emerge, integrating at a large scale the capacity of both developing physical surroundings and managing the economical ones, would it be through further alliances (with e.g. VISA or Mastercard-type companies).

Today, Europe has significant strengths in some of the services involved (travel, hospitality, credit card, facilities management, payment and billing systems). For the future being a partner

within one of the world class service sector alliances is likely to be a matter of survival in the longer term. These will be global alliances, because the customers will expect worldwide seamlessness of operation.

Scenarios such as Maria's indicate the extreme complexity of institutional arrangements when activating and billing a vast range of different services: downloading presentations, booking hotels, adapting individually an accommodation and reserving cars. Nevertheless, these business models exist already today at simpler stages (such as credit cards schemes, loyalty cards). Secondly, the scenario raises the issue of the successive billing and redistribution of revenues for all delivered services or contents. There is room here for intermediaries, directly or indirectly linked to banking activities for incorporating the financial management at global level from the very start.

4. Technological issues



The Personal communicator (or P-Com) has two central components **a micro-sized software radio transceiver** and **a personal ID 'key of keys** : '

- The software radio could perhaps operate up to 20Mbps. It would have to interoperate seamlessly with a variety of different wireless protocols GSM, UMTS, Bluetooth, possibly even satellite. For security reasons it would 'die' if separated from the personal identifier. It would have to operate on **speech commands** because a keyboard would make the device too big. One could imagine modular add-ons in order to amplify its range of possibilities (more memory, more processing power, a keyboard or a mouse). Generally, the processing power is not in the device: it borrows such power from the network.
- The key of keys can be considered as a multifunctional personal identifier. It can be conceived as a linear extension of SIM cards, but because of the wide range of personal services/information that it will unlock it should be more directly fixed to the individual. For instance, identity could be based on **biometry** or a **chip implant**.

The whole system will require very flexible **ad hoc network management**. These will be set-up by personalised agents that negotiate access to networked resources. For instance, identifying and optimising for the communication bandwidth possibilities as Maria moves from airport to car to

hotel room. In the case of Maria's presentation she uses a temporarily configured system that downloads the temporarily decrypted presentation onto a local server and assigns a projector and a keyboard to her for the presentation.

The functioning of the system will depend on substantial progress in **middleware and agent technology**, particularly to manage the reconfiguration of networks, the provision of appropriate levels of bandwidth and so on. Common agent platforms or a self-organisational capacity amongst agents would be needed for the vision to take effect.

The information sensitivity of the 'key of keys' system indicates that trust management systems will be very important. Such systems of privileges will have to be very robust because they give access to communications, health, financial, employment and personal systems.

The environment through which Maria travels in the scenario is rather artificial and mostly privately operated (airports, hotels, cars, offices). This is a deliberate feature of the scenario, because it is reasonable to suppose that in these 'oasis of intelligence' the infrastructural investments needed to create an ambience for Maria might have been made by 2010. For instance, her room in the new smart hotel is full of '**augmented objects**' (from door locks to bath taps). At a basic level all these objects have an IP address and can be instructed to perform as she wishes. One might expect a much greater level of augmentation through better design of objects and even quite new objects. But, between these oases there will be many deserts where at best there is perhaps just basic GSM coverage. The key of keys approach permits the range of services to be amplified incrementally as the environment becomes more wired and supportive of wirelessness.

5. Where is Ambient Intelligence in this scenario?

The ambience is the seamless and intuitive support that Maria has as she goes around in her high-pressure world. She does not have to negotiate each step of her trip, but she is still in control. She can adjust things as she goes. This allows her to concentrate on the real purpose of her trip, in this case: making her presentation.

Annex 2 Scenario - 'Dimitrios' - The Digital Me' (D-Me)

1. Background

Maintaining existing relationships and creating new ones is an essential feature of human life. It is a major driver in telecommunication revenues (mobile, emails). And 'communicating' has obvious mass consumption potential. The D-Me scenario offers to expand into this area of human social dynamics because of the observable contemporary trend of dispersion of human communities (e.g. smaller families, flexible work schedules, greater mobility). This 'mosaic trend' leads to a growing demand for targeted communications and relationships on the one hand, multiplied intercommunication on the other.

The Digital-me illustrates emergent communication and relation behaviours in the AmI landscape. For instance:

- *Supporting existing relations*, friend and family, communication-related professions (doctors, priests, psychologists) and communities.
- *Creating new relations,* self-expression, chatting on the net, net-games, profiling, dating and matchmaking. Associated domains of application are hype games, commercial datamining, locating people, internal security controls in buildings.
- *Participation in virtual relations* a virtual space of downloaded and processed data is created by self-help groups of digital avatars.[10]

The D-Me is a people-based, ad-hoc networking device registering, processing and offering information on private lives. It is aimed at facilitating socially based networking and relations, at offering communication interfaces and at taking decisions in specific situations on behalf of the wearer.

2. The script (full version)

It is four o'clock in the afternoon. Dimitrios, a 32 year-old employee of a major food-multinational, is taking a coffee at his office's cafeteria, together with his boss and some colleagues. He doesn't want to be excessively bothered during this pause. Nevertheless, all the time he is receiving and dealing with incoming calls and mails.

Three by three 'friends circles'…

Dimitrios has a '3P/3CAG D-Me'-it allows him to specify three privacy levels (3P) for personal data matched to three separate 'closed access group' (3CAG) memberships.

He is proud of 'being in communication with mankind': as are many of his friends and some colleagues. Dimitrios is wearing, embedded in his clothes, a 'gateway' or digital avatar of himself, familiarly known as 'Digital Me' or 'D-Me'. A D-Me is both a learning device, learning about Dimitrios from his interactions with his environment, and an acting device offering communication, processing and decision-making functionality. Dimitrios has partly 'programmed' it himself, at a very initial stage: it was, he says, a great personal experience to formalise somehow his identity and the way he envisaged his relations. At the time, he thought he would 'upgrade' this initial data periodically. But he didn't. He feels quite confident with his D-Me and relies upon its 'intelligent PDA-like' reactions.

[10] E.g. the Global Brain Project in Los Alamos is a means to share all the Internet-based knowledge in a proactive way. Each person is both consumer and producer of shared data. Hyperlinks are meant to be self-adaptive in an organic-like matrix of evolving data.

An important part of the D-Me's 'intelligence' is also based on the data gathered about Dimitrios, for the past two years, and its capacity to process this data and to interconnect at various levels with other selected D-Me's. While acquiring and storing data about Dimitrios, and making part of this data available, the D-Me has generated and linked into an ever-evolving individual database. As a permanently communicating device, the D-Me transforms Dimitrios in a moving node of an evolving space/network of individual D-Me's. Their partly shared databases generate a common shared knowledge base. This 'virtual space for matching people' offers to Dimitrios a tremendous potential for accessing new relations in many ways: network games, queries for content or services, shared interests. Furthermore, it creates a wide collective virtual space of potential human matching, triggering an unknown dimension of relation-focused hide-and-seek activity.

Dimitrios tries to ignore the loss of part of the stored data since a major server crash experienced by his provider.

At 4:10 p.m., following other calls of secondary importance – answered formally in a smoothly multilingual reproduction of Dimitrios' voice and typical accent, a call from his wife is further analysed by his D-Me. The D-Me confronts available data registered from Dimitrios' environment (voices, themes, location, other 'patched' objects) to match the situation with this private call (Dimitrios' wife's voice, theme, emotional level). In a first attempt, Dimitrios' 'avatar-like' voice runs a brief conversation with Dimitrios' wife, with the intention of negotiating a delay while explaining his current situation.

A strong recognition capacity…
The D-Me is equipped with voice, pattern and patch recognition capacity. It has to identify places and people, but also to register enough data to record the relevant events of Dimitrios' life to process it in its D-Me profile and offer it to other D-Me's.

Simultaneously, Dimitrios' D-Me has caught a message from an older person's D-Me, located in the nearby metro station. This senior has left his home without his medicine and would feel at ease knowing where and how to access similar drugs in an easy way. He has addressed his query in natural speech to his D-Me. Dimitrios happens to suffer from similar health problems and uses the same drugs. Dimitrios' D-Me processes the data available to offer information to the senior. It 'decides' neither to reveal Dimitrios' identity (privacy level), nor to offer Dimitrios' direct help (lack of availability), but to list the closest drug shops, alternative drugs and contacts to a self-help group and medical contacts nearby in case of emergency. This information is shared with the senior's D-Me, rather than with the senior himself, to avoid useless information overload. Further decision making by the senior's D-Me will target the adequate information to be communicated to the senior in the short-term. Beyond direct information, gathered from dispersed individuals and processed to solve a local problem, the D-Me has also offered to establish a new relationship.

Dimitrios' wife hates his D-Me. She suspects him living parallel lives and whatever the practical aspects, she definitely would prefer having him right away on the phone. It has been a source of conflict from the start.

Meanwhile, his wife's call is now interpreted by his D-Me as sufficiently pressing to mobilise Dimitrios. It 'rings' him using a pre-arranged call tone. Dimitrios takes up the call with one of the available 'Displayphones' in the cafeteria. Since the diffusion of D-Me, fewer people run around with mobile terminals. Public and private spaces have Display terminals and your D-Me can point at the closest…functioning one! The 'emergency' is about their child's homework. While doing his homework their 9 year-old son is meant to offer some insights on everyday life in Egypt. In a brief 3-way telephone conference, Dimitrios offers to pass over the query to the D-Me to search for an available direct contact with a child in Egypt. Ten minutes later, his son is

videoconferencing at home with a girl of his own age, and recording this real-time translated conversation as part of his homework.

All communicating facilities have been managed by Dimitrios' D-Me, even while it is still registering new data and managing other queries. The Egyptian correspondent is the daughter of a local businessman, well off and quite keen on technologies. Some luck (and income…) had to participate in what might become a longer lasting new relation.

Telcos in the background…
Managing a service while choosing the best telecommunication means for the videoconference forms part of the role of the D-Me.

3. Socio-political and Economic Issues

Socio-political issues

The D-Me scenario follows some important societal trends:

- *Human communication* has to come first; it is also a marketable aspect of life.
- The world is going *mobile*, identities become multiple, lives multiplexed
- *Families* are changing, negotiating more issues and relations at a distance
- *Time scarcity* is a general feeling: D-Me is seen as a time-saver
- Relations are in the *network*; some are embedded in new behaviours. But networking is a complex process: D-Me is a network simplifier. It helps to find the right person.
- *Cohesion* is a political goal in a 'mosaic society': being together, sharing knowledge and information. It opens window to other people.
- It may be a way of offering services to an *ageing population.*

Multiple identities…
People could 'wear' several D-Me's, offering several identities on the network. Virtual identities could multiply, together with anonymously announced profiles and queries. Hide-and-seek behaviours for fun, personal development or crime may develop raising serious ethical and legal questions.

But D-Me raises also major societal and political issues:

- *Privacy*: ownership of data, content control, and accessibility of content.
- *Authenticity*: multiple identities, 'marketed' identities.
- *Security*: exposure to viruses, hackers, 'classical' computer and network collapse.
- *Ethics*: generation impact, false identities, control environments, 'wish-technology' making children out of adults.
- *Crime*: facilitating criminal networking.
- *Digital divide*: which business model will drive the development of such devices?

Business environment

Products: Like Maria, Dimitrios has a physical personal ambient device: the D-Me. The generic technological functionality of the two scenarios is at this level likely to be quite similar, but with quite different uses in mind. Dimitrios' device is meant to be highly aware of other similar devices and of a common virtual matching space. The emphasis of his agent technologies is orientated towards the negotiation of access levels with those of other people. In both cases, clear ownership, maybe based on

Existing trends for cross-sector mergers in Media and Telecommunications could lead to new business patterns. Free devices with relational and communication services could be targeted at youth markets. Services could be based on individual profiling, personalised advertising, peer-matching opportunities, leisure and product advertising/consumption, hype, telecommunication capacities, and even some 'Tamagochi-like' capacity (evolving knowledge, 'feeding' needs.).

biometric authentication. This may affect the specific functions, the way in which the technology is modelled and marketed and so on. What is obviously similar therefore is that the same terminal suppliers are likely to be competing to supply both Dimitrios and Maria – perhaps with quite different marketing campaigns.

Physical network requirements for Dimitrios seem simpler than for Maria. Could the D-Me run on existing GSM networks, if quantitatively reinforced? The incremental communications path implies a steady private sector lead growth trajectory. At the same time special zones, with enhanced features, might emerge. D-Me's might be worn in places where people try to meet other people such as singles bars, concerts, night-clubs or supermarkets.

It is not necessarily all play, workplaces would be an obvious environment to use D-Me's (as sort of enhanced pagers) in order to control lost effort of chasing irrelevant calls.

Services: The apparent service structure is on an access model. Service volume could be built up using the 'GSM model' of virtually giving away devices. This would be particularly important for youth markets.

A key issue is the absence of a clear driver of telecommunications investment. Part or all of the traffic is based on short distance, radio-based interconnections, like Bluetooth, that are based on currently free spectra. Concentration on the 'first hop' linkages however masks the data communications traffic working away in Dimitrios' background. Decentralised voice processing, further developments of MP3-like flows, networking games and so on will expand data generation and transmission. The implication is that there will be several layers of back-up businesses offering services driven by content. However, it is open whether a content-orientated service embedded in a communicating device such as the D-Me will be accepted or rejected by the European market?

Could open-source free D-Me?
It might be that D-Me follows an 'open source' model of exchange of information both 'alternative' (developer communities) and for reciprocal sharing of personal information.

The economic viability of the D-Me depends on the free sharing of personal information and behaviour yet the ability of service providers to make a profit through information brokerage, automated purchasing and other m-commerce opportunities. But the core of D-Me is the 'matching' activity, and it is here that competitive advantages and profits are to be sought.

Public funding is not excessively mobilised in the scenario. But, social cohesion objectives in support of citizenship, community development and inclusion (e.g. of older people with health or mobility problems) might point towards some public service provision to counterbalance the uses that D-Me's might acquire if driven only by fun or hedonistic drivers.

4. Technological issues

The D-Me is expected to be:

- A stand-alone micro-sized device with an integrated data capture capacity and wireless ad hoc network communication and
- A network device that gateways to intelligent services such as virtual matching, decentralised data warehousing/ mining capacities and high end decision agents.

Possible counter-scenario…
Access, control and correction of personal data raises the major issue of the safety of offering one's life on a network. Further observation of existing behaviours on the Web may facilitate the understanding of this aspect.

Data capture relies largely on speech and speaker recognition (even identity recognition) and voice machine interaction in everyday environments. Such developments are not expected by 2010, due to difficulties with spoken language models, individual voice variation, background noise management. But major achievements are expected through incremental advances with multi-X (multi-user, -environment, -language, -mood) recognition and in biological, behavioural and emotional pattern recognition. Uploading information into 'knowledge' would be a big technological challenge. Initial input could well rely on a classical keyboard or icon-board. But, the learning 'as-you-go' devices in the D-Me concept would be registering an on-going series of events, voices, locations, behaviours, preferences and emotions. Data capture here would rely on intelligent 'patched' environments composed of intercommunicating devices. Some of these devices would be active (doors open, bulbs light up) others will be passive (electronic labelling, biosensors).

Ad hoc network communication: D-Me assumes 100% interoperability 'on the run', permanent data upload and on the spot processing of demands. Such seamless interoperability is a major issue, with devices always available. It anticipates the growing domination of IP. Intelligent agents will have to continually make choices and set priorities on issues such as protocols, spectrum capacity, costs. For this, new network architectures will be needed that can match low-power consumption and short-range wireless technologies (e.g. Bluetooth) with wide area networks (e.g. mobile and satellite).

Beyond a common operating system there is the challenge to create a new open standard architecture with for example a browser layer, ID layer, control layer and a communication layer. It would offer full interoperability with, any provider being able to plug-in its services at any level.

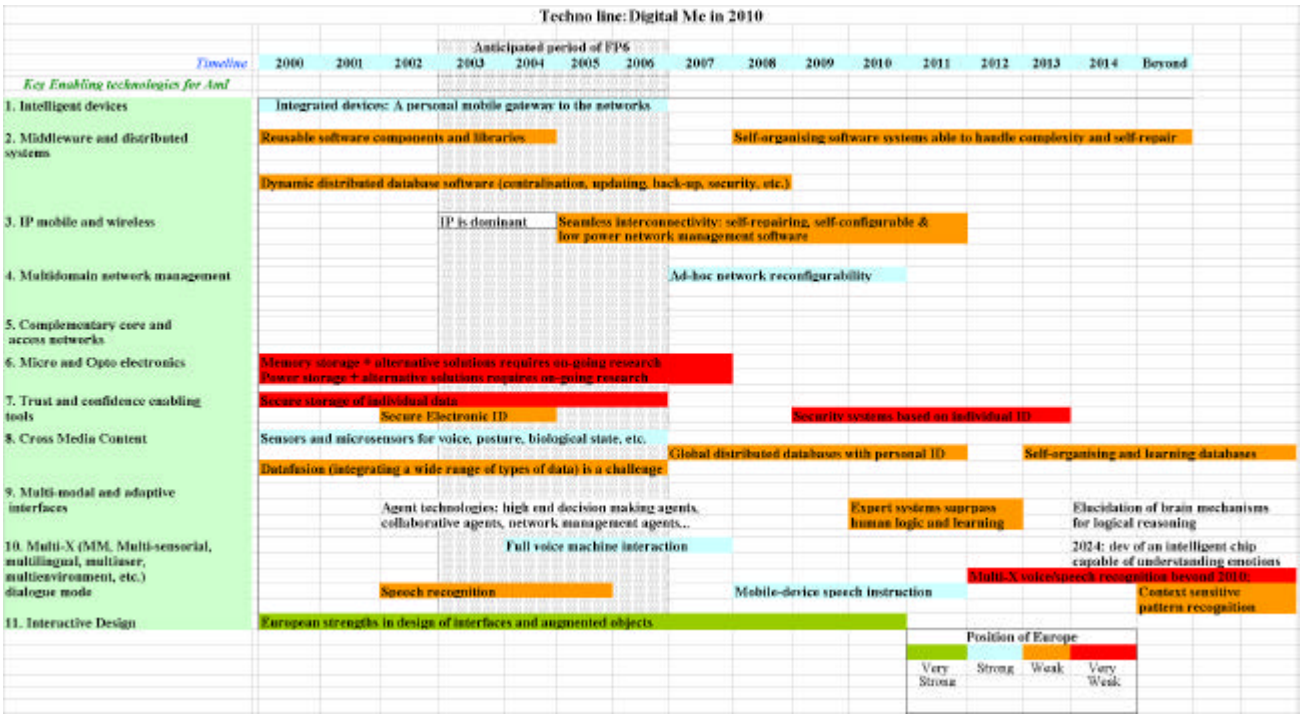
Decentralised data warehousing/mining capacities: Secure storage of D-Me data will require advances in centralisation, synchronous updating, back up and downloading of data. Decisions about where to store data (in the device, in the network or in a centralised database) are mainly societal, affecting control and security, access or long-term sustainability. But they will have effects on the complexity of data retrieval. Advanced middleware will be necessary to manage such complexity to ensure interoperability, support for the dynamic synchronisation of distributed databases, smooth and reliable routing of data.

Decision-making by intelligent agents: The cognitive capacities described in Dimitrios to present a high level of technical difficulty. *Distributed intelligence* is key, based on intelligent agents able to do high-end 'human' decisions such negotiation, inference and learning. Case-based decision-making is available today – but Dimitrios implies substantial further multi-domain progress.

A move from device to agent, from object to quasi-subject would create machines that act on their own, having an adequate notion of their owner, as designed by him.

The scenario envisions the creation of a shared intelligent virtual space - reversing usual perceptions about information processing devices.

Development paradigms: The complexity of the systems point to radical changes in systems development. Experts underlined the need for a biological or evolutionary approaches to software engineering addressing the composition of the system as a whole, adaptiveness to change, embedding of early non-functional properties.



5. Where is Ambient Intelligence in this scenario?

The system has to have a lot of intelligence: captured, processed and shared data about humans' lives, knowledge databases, decision making by agents. The seamless intercommunication of devices: D-Me's, their distributed databases and patched spaces will generate a permanent landscape of invisible data flows.

But the real ambience here is an expansion of human relationships. Mass consumption of D-Me's will create the possibility of people-based ad-hoc networks protecting us from unwarranted interference in our lives and providing possibilities of making new contacts and interactions. It develops a virtual matching space of permanently changing form where amounts of virtual relations develop, with low awareness of the effective human beings uploading this global matching brain

Annex 3 Scenario - Carmen: traffic, sustainability & commerce

1. Background

The scenario assumes that people already live in an Ambient Intelligence (AmI) environment and have changed their basic daily behaviour: the way they do their shopping and the way they move around in a city. ICT is applied fully to flows of information, people and goods.

The urban infrastructure has been upgraded to support a fully telematic transport and environmental management. Information resources are available anywhere in the urban system. Devices are unobtrusive, intuitive and secure. People already live in 'smart' houses.

The functioning of the transport network has been reconceptualised and goods distribution is based on real-time demand. Intermodality is very efficient both for transport of people and goods. At governmental level, legislation is in place to allow the city to work as an organisational system chain. For sustainability it permits optimal energy use and maximises safety.

2. The script (full version)

It is a normal weekday morning. Carmen wakes and plans her travel for the day. She wants to leave for work in half an hour and asks AmI, by means of a voice command, to find a vehicle to share with somebody on her route to work. AmI starts searching the trip database and, after checking the willingness of the driver, finds someone that will pass by in 40 minutes. The in-vehicle biosensor has recognised that this driver is a non-smoker –one of Carmen requirements for trip sharing. From that moment on, Carmen and her driver are in permanent contact if wanted (e.g. to allow the driver to alert Carmen if he/she will be late). Both wear their personal area networks (PAN) allowing seamless and intuitive contacts.

The driver is part of a car-pooling scheme of the transport management systems in the urban area where Carmen lives. Advanced payment and transactions systems are in place, which are able to calculate the amount of money that goes to the driver and the amount that goes to the transport operators.

While taking her breakfast coffee Carmen lists her shopping since she will have guests for dinner tonight. She would like also to cook a cake and the e-fridge flashes the recipe. It highlights the ingredients that are missing: milk and eggs. She completes the shopping on the e-fridge screen and asks for it to be delivered to the closest distribution point in her neighbourhood. This can be a shop, the postal office or a franchised nodal point for the neighbourhood where Carmen lives. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. She can be informed during the day on her shopping, agree with what has been found, ask for alternatives, where they are and when they will be delivered.

Objects can be tracked through radio-frequency identification tags. These e-tags are very small, maximum of the size of a grain of rice and can be embedded in everyday objects. Everyone carrying a device equipped with a reader could access additional information and services relating to the tagged item.

Forty minutes later Carmen goes downstairs onto the street, as her driver arrives. When Carmen gets into the car, the VAN system (Vehicle Area Network) registers her and by doing that she sanctions the payment systems to start counting. A micro-payment system will automatically transfer the amount into the e-purse of

the driver when she gets out of the car.

In the car, the dynamic route guidance system warned the driver of long traffic jams up ahead due to an accident. The system dynamically calculates alternatives together with trip times. One suggestion is to leave the car at a nearby 'park and ride' metro stop. Carmen and her driver park the car and continue the journey by metro. On leaving the car Carmen's payment is deducted according to duration and distance.

Out of the metro station and whilst walking the minutes to her job, Carmen is alerted by her PAN that a Chardonnay wine that she has previously identified as a preferred choice is on promotion that day. She decides to add it to her shopping list and uses the opportunity to tell her wearable when she plans to leave work and where she wants go. Carmen arrives at her job on time.

On the way home the shared car system senses a bike on a dedicated lane approaching an intersection on their route. The driver is alerted and the system anyway gives preference to bikes, so a potential accident is avoided. A persistent high pressure for the last ten days has given fine weather but rising atmospheric pollutants. It is rush hour and the traffic density has caused pollution levels to rise above a control threshold. The city-wide engine control systems automatically lower the maximum speeds (for all motorised vehicles) and when the car enters a specific urban ring toll will be deducted via the Automatic Debiting System (ADS).

In this scenario the environmental management system is not only connected to sensors that control vehicle engines or the police, which in case of accidents can transfer information to the traffic control network to re-route traffic. The system is also able to alert individuals with allergies to certain types of pollutants when a dangerous threshold is reached. Individuals will be informed of the unhealthy atmosphere and can decide whether to go out or stay home.

Carmen arrives at the local distribution node (actually her neighbourhood corner shop) where she picks-up her goods. The shop has already closed. But the goods await Carmen in a smart delivery box. By getting them out, the system registers payment, and deletes the items from her shopping list. The list is complete. At home, her smart fridge screen will be blank.

Coming home, AmI welcomes Carmen and suggests to telework the next day: a big demonstration is announced downtown.

3. Socio-political and economic issues

Socio-political issues

The scenario assumes a radical redesign of the urban systems, especially the transportation of people and goods. It does not imply that AmI applied to transport telematics will solve urban congestion and pollution, but the scenario does imply a situation that is more contained and tolerable.

The major socio-political issues relate to whether there is too much 'social engineering' in this scenario. Carmen has accepted teleshopping, telework, car sharing, park and ride systems, accident prevention systems, road pricing and even an engine-speed control to cap pollution levels. What pressures would society have to have face to accept these levels of intervention in freedom of movement? Could congestion, pollution and health worries finally precipitate such changes? Certainly the rising energy gap and fears about global warming and the limits to further increases in urban transport capacity do point towards a need for alternative approaches. There are also reasons for key industrial sectors such as the auto and electronics industries to support

such developments in order to deal with saturation of vehicles in Europe provoked by congestion and environmental curbs.

Also, on closer inspection, the scenario actually provides a lot of choices for Carmen in her daily routines – most of the changes are in the form of extra choices and advice rather than legislation or rules. Also, the AmI infrastructures seem to imply a heavy infrastructural investment programme (but further expanding the physical transport networks is also very expensive).

The key will probably be to use AmI as part of an integrated approach to resolving the pressures on urban living. As the scenario suggests, AmI will not provide a magic bullet, but it could form part of an evolutionary path towards a more sustainable city system.

Business environment

Products: Carmen might be regarded as the furthest away scenario of the four in timescales - not because of its technological challenges but because of infrastructural, institutional and behavioural barriers. There are many new devices and systems. Especially important is that the system implies large-scale investments in traffic and transport technologies. This includes in-vehicle systems (such as fitting cars with satellite positioning, further embedded computing such as remote engine management, vehicle tagging).

The biggest investment is the integrated traffic urban transport management system (beacons, sensors, actuators, variable message signs as well as physical networks and computers to store databases). There are strong implications for manufacturers of smart materials, systems integrators and mechatronics/robotics. Miniaturisation of devices and the development of nanosystems will probably be strong drivers. In addition, the implications will be encouraging for smart construction projects needed to develop the types of inter-modal transport infrastructures cited in the scenario.

Services: A large part of the added value for European producers in the physical systems will however likely be in the development of software services needed to operate these complex systems (distributed dynamic databases, small footprint operating systems, self-organising systems, self-repairing software).

Dynamic data management services might emerge, i.e. new intermediaries that offer explicit datamining-linked service level agreements for managing urban traffic (safety records, environmental targets, and traffic volumes and flow rates).

Also, the scenario points towards new avenues for e-commerce growth. The optimisation of distribution in cities will create new 'clicks and mortar' opportunities. For example, new distribution systems e.g. localised postal services. This could meet a socio-economic objective by helping to revitalise local shops through exploiting new economies of scope based on 'interconnection' of people and services.

Overall, the model implies strong requirements for public private partnerships to lead the development of this version of AmI. Especially needed would be large-scale demonstrators of 'smart cities'. Public-infrastructural investment (with the support

Widespread e-commerce is the driver of different organisational patterns to manage logistics of goods in the urban environment. There is a different relation between the supplier and the retailer of goods due to an increased mass customisation consumption. The supply of products is on-demand. The supplier is not only offering goods but also a service to the retailer by supplying just the requested amount of goods avoiding excessive stocks to the retailer and reducing the 'time to market' of the products.

possibly of shifts in the regulatory incentives) will be needed to encourage and gain positive externalities in traffic management systems and to encourage widescale adoption. This will be important in generating markets for physical devices, virtual devices and all sorts of additional services. On the other hand, it is likely to require considerable political nerve (as is implied in Maria's scenario where similar systems confronted strong political and grassroots opposition).

4. Technological issues

Carmen is a scenario in which the traffic system and goods delivery system will be an intelligent network: every vehicle is a node and all goods are tagged.

The technological challenge for PANs includes miniaturisation; low power sources; wireless; security/ encryption; bandwidth; biosensors; scalability.

At the core of the system is a completely renewed traffic infrastructure comprising a network of multifunctional and reconfigurable sensors, such as traffic beacons, biosensors, biometrics, engine control sensors. These sensors have some on-board processing capabilities in order to support dynamic networking functions. A big contrast between this scenario and the others is that the middleware is explicitly orientated towards machine to machine interaction and negotiation. For example, accident detection systems might involve a dialogue between middleware and agents in the traffic monitoring systems and a temporary network of co-operating in-vehicle sensors located in cars that are in the same traffic zone.

In terms of information processing there is an implicit and considerable development of dynamic database management and processing. The very large-scale sensor systems are all feeding information into the network. Techniques to make the system as a whole adapt to these stimuli are subject for development. Perhaps this will involve centralised super computing systems for content analysis and situation awareness to achieve real-time high-speed simulation. Perhaps, somehow behaviour norms will be given to the individual nodes so that appropriate system responses come from the swarming actions of distributed agents.

This scenario foresees the interlinking of communication networks. The scenario is based on three levels (or worlds) of communication networks. The first level is a personal area network, where different PANs are able to communicate to each other but they are also able to dialogue with the second level of the communication network. This level includes the integration of multiple communication networks able to communicate to each other (i.e. VAN (Vehicle Area Network) that can communicate to PAN, with the home network and with the office network). The third level of communication network is WAN integration of the two other levels that constitutes the Ambient Environment.

These systems will have to operate to very robust and well-defined protocols. However, such protocols are not likely to be pre-defined. The devices would be reconfigurable over the network. The interactions between the agents could be specified on a needs basis according to location, time of day, weather conditions and a hierarchy of powers possessed by different agents. For example police cars and emergency vehicles could have higher right of way powers – perhaps signalling the end of the classic film car chase sequence?

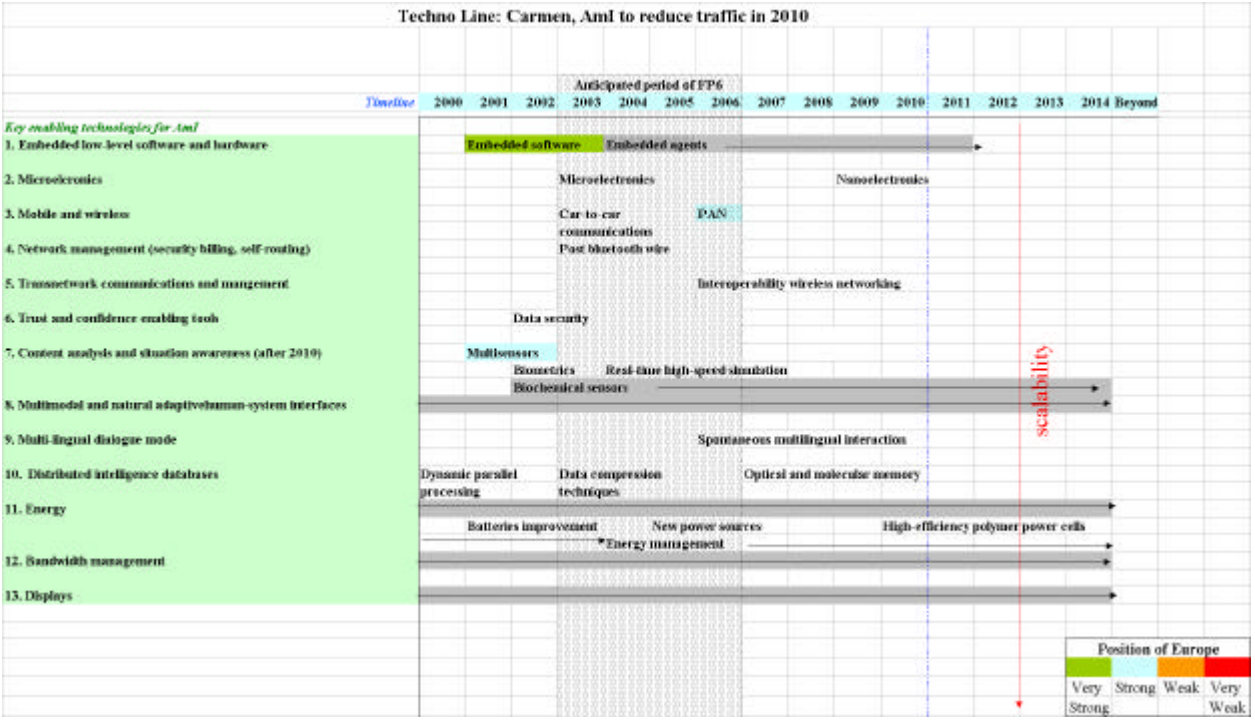
The sensors would be nodes in a mixed wired and wireless network. For the full distribution of sensors around the system further miniaturisation would be required. For fixed location wireless sensors (e.g. monitoring pollution levels or traffic volumes) there will probably be a need for autonomous power supply (e.g. able to run from storage of sun energy). In these devices and in wearables there would be widespread use of 'pico-radio technology' for Personal Area Network (PAN)/Vehicle Area Network (VAN)/WAN integration. To avoid too much loose radio transmission this wired

urban environment would perhaps rely on relatively low-power (short hop) wireless transmissions to link to mobile nodes into a dense infrastructure of wired receptor ports.

In addition to the need for agents and middleware to permit dynamically configurable networks there would also be a heavy use of recognition technologies. Speech and voice interaction with wearable devices using natural language recognition is implied. As with Dimitrios and Maria, Carmen is using a support structure of collaborative agents to undertake tasks (getting to and from work, shopping). Her agents have learnt her preferences and only bother her when there is some action needed. It would be interesting to know, however, how far Carmen has ceded responsibility for payment to her micro-payment systems: considering the incident with the Chardonnay probably not so much.

Considerable developments in enabling hardware are envisaged. Smart materials are implicit in cars and in wearable communicators. Advanced tagging of goods is almost universal.

Techonline: Carmen[11]



5. Where is Ambient Intelligence in this scenario?

Ambience here leads to a much more efficient and user friendly urban environment. It tries to optimise amongst the competing goals (e.g. individual preferences versus the good of the population) for the use of the urban space. This involves the operation of very large-scale systems and requires societal acceptance of the legitimacy of the results (i.e. automated speed controls).

[11] The group working on this scenario was not able to produce a provisional mapping of strengths and weaknesses.

Annex 4 Scenario - Annette and Solomon in the Ambient for Social Learning

1. Background

The knowledge society leads to increasing quantitative and qualitative demands on knowledge, skills and creativity. This includes for example the pressures towards life-long learning, new ways of learning-by-doing and a growing demand for communication skills or even 'emotional intelligence'. Certainly as far as children are concerned, with the growing complexity of society, learning systems increasingly play a role in processes of socialisation. Learning already has become a very complex process that builds on many different resources. It is no longer only the formal school environments that dominate the learning process, television, Internet, and also the rising levels of communication and interaction (mobile phones) also serve as major sources for learning.

Learning in the ASL is designed to fit the very different time schedules of the participants. It enhances the social character of learning by providing facilities to work together in non-real time for those who have difficulties meeting in real time. The ASL closes during the night because essential rest-hours are generally respected.

This scenario describes a learning environment - the Ambient for Social Learning (ASL). The starting point is that learning is essentially a social process. The ASL is an environment that supports and upgrades the roles of all the actors in the learning process, starting with the roles of the mentor and the students as most concerned parties. The systems that make up the ASL are capable of creating challenging and interacting learning situations that are co-designed by the mentor and students in real-time. Students are important producers of learning material and create input for the learning 'situations' of others. In other words, the ASL is both an environment for generating new knowledge for learning and a 'place' for learning about learning.

The ASL is also a physical space (a room or a group of rooms) together with all of its ambient facilities, including many linkages with similar places. Its layout and furnishing is flexible and diverse, so that it can serve the learning purposes of many different kinds of groups and individuals.

2. The script (full version)

It is the plenary meeting of an environmental studies group in a local 'Ambient for Social Learning'. The youngest in the group is 10, the oldest is 75. The group shares a common desire to understand the environment and to develop knowledge and skills relevant to environmental management activities. It is led by a human mentor whose role it is to guide and facilitate the group's operation, but who is not necessarily very knowledgeable about the subject of environmental management

The plenary 'meeting' takes place in a room looking much like a hotel foyer with comfortable furniture pleasantly arranged. The meeting is scheduled from 7.00-23.00 hours. Most participants are usually 4-6 hours present. A larger group arrives between 9.00 and 9.30 in the morning. Some are scheduled to physically work together and thus were requested to be present within a certain timeslot (the ambient has access to their agendas to do the scheduling). A late member is arriving: as she enters the room and finds herself a place to work, she hears a familiar voice asking "Hello Annette, I got the assignment you did last night from home: are you satisfied with the results?"

Annette answers that she was happy with her strategy for managing forests provided that she had got the climatic model right: she was less sure of this. Annette is an active and advanced student so the ambient says it might be useful if Annette spends some time today trying to pin down the problem with the model using the new enhanced interactive simulation and projection facilities. It then asks if Annette would be happy to give a brief overview of her work by making a presentation for the group. The ambient goes briefly through its understanding of Annette's availability and preferences for the day's work. Finally, Annette agrees on her work programme for that day. The ambient schedules a viewing for some of the other members who might be interested, but cannot be present.

During the conversation the ambient is manipulating the sound field in the room in such a way that others do not hear this conversation. Several such conversations are in progress as different members join the group: these private exchanges serve a number of functions including additional supporting evidence of the identity of the individual; establishment of the individual's view of her work and clarification of availability and work plan during the day. The conversation is supported by visual information on screen.

One particularly long conversation takes place with Solomon, who has just moved to the area and wants to join the group. During this conversation, the ambient established Solomon's identity; asks Solomon for the name of an ambient which 'knows' Solomon; gets permission from Solomon to acquire information about Solomon's background and experience in Environmental Studies. The ambient then suggests Solomon to join the meeting and to introduce himself to the group.

During this process the ambient and the mentor are also engaged in a private conversation, identifying in a broad-brush way the day's activities.

In these private conversations the mental states of the group are synchronised with the ambient, individual and collective work plans are agreed and in most cases checked with the mentor through the ambient. In some cases the assistance of the mentor is requested. When they are complete a scheduled plenary meeting begins for those who can be present with the ambient asking Solomon to introduce himself. The ambient asks Annette and some others to give brief summaries about their assignments: to help her it projects a 3-D representation of the region involved, making changes to illustrate Annette's points. A group member asks questions about one of Annette's decisions: at this point the ambient helps Annette by projecting several visualisations. During the presentation the mentor is feeding some evaluatory remarks, observations and questions to the ambient, together with William, an expert who was asked to join the meeting. Some way through Annette's explanation she asks if William - who is physically several thousand miles away - could join the group briefly to make a brief contribution: this is done. After a brief explanation and some supplementary questions William leaves the group.

The group is composed of a wide variety of students. Some of the members participate out of personal interest in environmental issues. They subscribed to participate for a certain period of time and negotiated their learning goals with the ambient. Several of them receive support from the local knowledge society fund. Others participate to build or improve their professional qualifications. In some cases their company's employability fund takes care of the costs. In many cases however the participants themselves pay. Quality basic education is considered to be highly important in the knowledge society, certainly after the skills shortages experienced in the first years of this century. It is widely accepted that the tax-paid *basic education participants* cross-subsidise *some of the ambient's further development.*

The plenary session ends with a discussion of how Annette's work contributes to that of the others, and the proposal of schedules for the remainder of the day. The ambient suggests an outline schedule involving both

shared and individual sessions. In some of the shared sessions Annette will provide inputs to the work of others.

During the day individuals and sub-groups locate in appropriate spaces in the ambient to pursue appropriate learning experiences at a pace that suits them. The ambient negotiates its degree of participation in these experiences with the aid of the mentor. Throughout, the mentor and ambient converse frequently, establishing where the mentor might most usefully spend his time, and in some cases altering the schedule. The ambient and the mentor will spend some time negotiating shared experiences with other ambients – for example mounting a single musical concert with players from two or more distant sites. They will also deal with requests for references / profiles of individuals. Time spent in the ambient ends by negotiating a homework assignment with each individual, but after they have been informed about what the ambient expects to happen for the rest of the day and making appointments for next day or next time.

3. Economic and socio-political aspects

Social-political issues

There are increased potentials for choice and differentiation by developing educational systems that can cope with the many different language and cultural backgrounds, skills-levels, interests and learning styles of people in the mosaic society. Education and education level seem rapidly to be becoming a discriminatory societal factor. To avoid such a tendency toward a digital divide in cities, nations and the world it is necessary to improve educational systems as much as possible. Another reason to do this is of course the growing demand for new skills, which result in a skills-shortage nowadays. Broad access to and usage of new technological tools has to be part of the policies and strategies in education. In the case of information technologies access refers to simple availability (zero cost) but increasingly it also refers to content. In particular in education it is important to have systems that are able to respond to the dreams and ambitions of those who are often 'left behind'.

The systems must not only be user-friendly; the main criterion for their development is 'usefulness'. In this case with a very complicated set of goals, however, it is not obvious how this usefulness has to be evaluated beforehand. The Ambient for Social Learning is therefore conceived as a 'learning system' that is growing and improving simply by using it.

The ASL could be a private initiative evolving from an educational publisher that joined in a partnership with a software company that has a strong position in knowledge management. The former book publisher/content provider is riding an already existing trend towards more user-defined production ('self-customised content'). The software consultancy brings in the necessary organisation, communications, and database skills, including there experience gained in simulation and electronic meeting facilities. The government licences to them (for a fee) a right to make contracts with existing educational institutions and to start to exploit learning experiences on a commercial basis. The fee goes to bursaries for students. This creates a trend toward lowering of entry costs for 'digital presence' and sharing of knowledge. An important business asset for the ambient publisher is the learning experiences that could be the basis for franchising the lessons about how to deliver educational content and services.

Business environment

Products: in addition to the common AmI technologies (network hardware, agent systems, sensors, smart materials) there are a number of hardware technologies that are special in this scenario. The first is the 3D-visualisation technology that will require development of real-time rendering of video imaging and projection of holographs. Also, specific is the highly demanding manipulation of sound fields so that people in shared places can have individual

conversations. These technologies will be equally important in other applications areas such as telepresence in business meetings (e.g. for research development teams, surgeons, emergency rescues or fashion shows). Sound field manipulation is also very important in business and work, e.g. for controlling health risks or to improve information transfer for workers in noisy environments (battlefields, airports, motorway police and discotheques).

Services: The major service developments here use breakthroughs in knowledge management and co-operative work techniques. In the scenario there is no obvious economic player identified. There are several possibilities. The service could be provided on a subscription basis by a private provider, as part of a community programme funded by local governments or by a common interest group (perhaps affiliated to the environmental movement). Most of the technologies however will have been developed in a business environment. The specific ASL service has to integrate these into one co-operative learning environment. It is expected that public-private initiatives will become important business models.

Customised content services imply a co-evolution between traditional media and educational organisations and new ones. New media/educational content industrial structures are at stake. New services would be: multimedia developers creating user-friendly toolboxes for self-production of content; multi skilled project-oriented teams that are available to work with grassroots groups, firms or traditional educational providers.

At the same time in the scenario new opportunities have emerged for multi-channel (web-TV, mobile) services and for on-line storage, re-processing and retrieval of content on demand. Such new roles for the content industry call also for new business models in the sector, based on customer management, on-line and interactive processing, and network externalities. If kept parallel to existing printing or broadcasting models, it implies high rates of market growth, characterized by its diversification and further market segmentation. But obviously, new skills, new work processes and new business models will be necessary. These major challenges might not be fully addressed due to a lack of investment, innovation capacities, rigid institutional structures and corporatism.

By contrast, with appropriate activation of professional norms, effective public private partnerships and political support, the media/educational content industry could turn into a major provider for publicly subsidized initiatives for Education and Lifelong Learning. Financing such an AmI-based content delivery might be considered of public interest. So far though no one has found a way to develop enough power or scale of operation to set things in motion. Most progress in ‘learning technologies’ to date is made in the private sector under the label ‘knowledge management’.

4. Technological Issues

The essence of *the Ambient* is a connected set of physical spaces equipped with objects relevant to the curriculum, in which groups of students and mentor(s) engage in collaborative tasks which will involve individual and group experiences relevant to the curriculum and tailored both to the needs of the individual and the group.

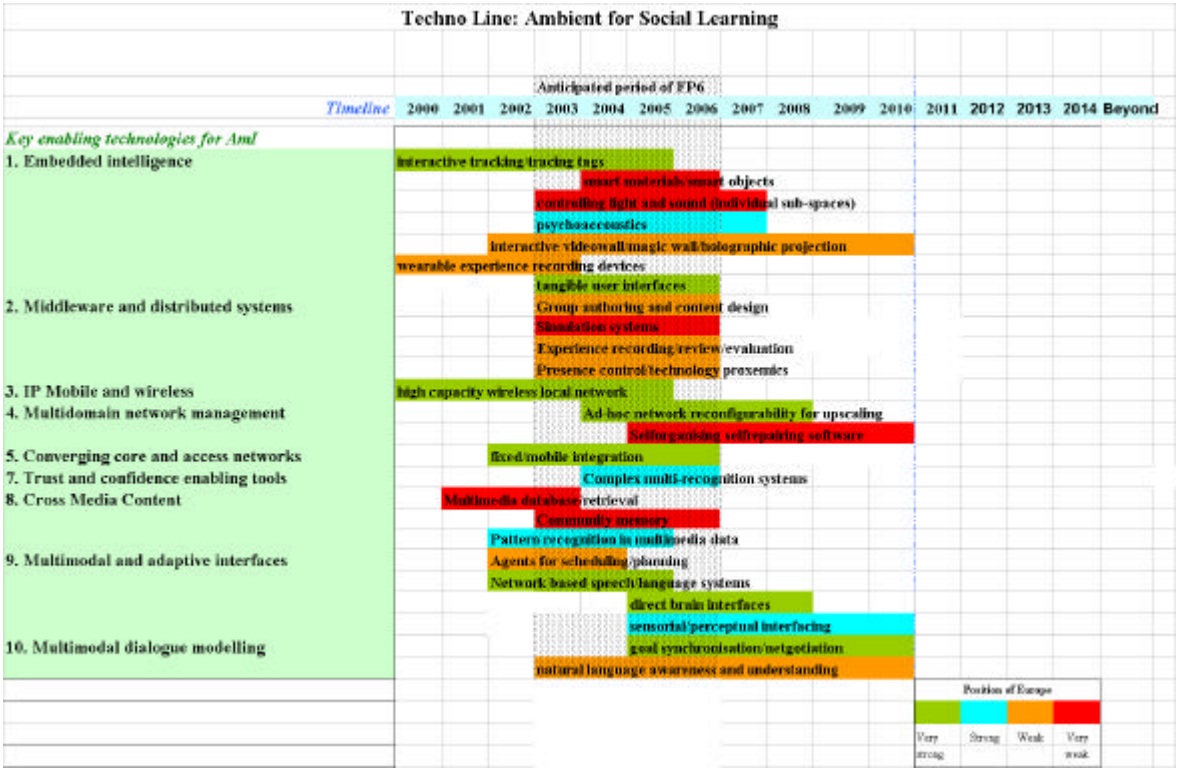
Each day’s challenges are co-designed afresh, and take account of the ambient’s corporate memory and the curriculum aims. The ambient supports group discussion and review of experiences to date. We also envisage experiences involving seamless interaction between physically distant ambients: for example, an ambient in Brussels and an ambient in Greece could co-design experiences aimed at cross-cultural immersion.

The specific technologies needed are the following:

- Recognition (tracing and identification) of individuals, groups and objects.
- Interactive commitment aids for negotiating targets and challenges (goal synchronisation).
- Natural language and speech interfaces and dialogue modelling.
- Projection facilities for light and soundfields (visualisation, virtual reality and holographic representation), including perception based technologies such as psychoacoustics.
- Tangible/tactile and sensorial interfacing (including direct brain interfaces).
- Reflexive learning systems (adaptable, customisable) to build aids for reviewing experiences.
- Content design facilities, simulation and visualisation aids.
- Knowledge management tools to build community memory.

Some other technologies can be regarded as necessary generic enablers, but are not specific to these scenarios:

- Networking: given what is already known about the future development of networks, it is expected that there will be no major difficulties, even with very large numbers of addressable objects in one location.
- Miniaturisation and nanotechnologies are seen as an important general support technology (very small camera's, sensors and actuators), in particular in combination with development of smart materials.
- Since the scenario builds on the idea of organically evolving and growing systems the software might become very complex. Advances in software engineering, maybe even more in software management systems, are necessary to turn these scenarios into viable options.



The main challenge for the ASL scenario is not in the separate technologies (however difficult this may be), but in the learning how to build useful combinations of the different technologies and how to develop these into 'a learning experiences generator'. Building the ASL is a learning exercise in itself. It cannot be blueprinted.

5. Where is Ambient Intelligence in this scenario?

The most dominant elements of the AmI-concept in this case are:

- Technologies permit greater empowerment of users, starting with mentors and students, over their own tasks and processes in a learning environment. The system provides instant feedback on many different issues, which not results from rule based systems, but from the ability to record and review (if possible quite literally) experiences of past and present participants.
- Technologies that are capable of supporting social (learning) processes. It starts with the simple provision of a network for communication and a collective corporate memory, on which gradually many different kinds of new applications can be built and new technological possibilities can be added.

Annex 5: Towards Industrial AmI applications

The four scenarios are very much at the human interface. They emphasise the way that Ambient Intelligence has a strong emphasis on making systems that are natural in use rather than just 'user friendly'. However, it is also clear that the same technologies are also extremely important for industrial and commercial purposes. Here as well, although present in scenarios such as Carmen, there is very significant potential for machine to machine applications in tagging, sensors systems and so on.

Therefore, although an industrial scenario was not developed for this exercise, the editors decided to include this annex as an indicator of industrial applications of the key technologies that are in the range of Ambient Intelligence. Perhaps it could be the starting point of a further scenario effort focused on exactly these issues.

1. Introduction

AmI technologies offer also tremendous opportunities for broad industrial change. Nowadays, a series of strong contemporary trends, acknowledged both by best practice around the world and by several foresight exercises[12], challenge many industrial sectors: networking, mass customisation, agile prototyping, knowledge management, anthropocentric process automation and other domains of modernisation. This modernisation is seen as critically important to EU industries competitiveness and viability.

While an initial AmI vision builds upon humanised interfaces, voice recognition capacities, and more generally end-user oriented applications, it simultaneously points at generic enabling technologies which encompass also object-to-object or machine-to-machine dialogue, automation, robotics, reconfigurable and agile production.

The following paragraphs aim at offering a glimpse at these aspects, introducing AmI technologies in the industrial arena and offering some insight on potential applications i.e. in the construction sector.

2. Industrial change baseline

The concept of 'industries of the future' has been around for several decades. Whether it is achievable of not, it remains an ambition for many industrial firms. AmI enabling technologies offer a unique set of interconnected technologies that could leverage or even surpass this ambition, whilst echoing most of today's leitmotivs about industrial innovation and competitiveness. In listing some of these aspects, it becomes obvious that they involve both product and process innovations.

1. From value chains to value networks

Innovatory idea: Companies have realised enormous savings by automating and integrating their internal systems. These internal savings represent a small fraction of the gains they can achieve by extending the co-ordination and integration of the company's business processes to all participants in the *value chain*. In fact, the current record expansion of the economy may be due

[12] See i.e. UK Foresight, Dec. 2000. UK Manufacturing: We can make it better. Final Report Manufacturing 2020 Panel, Department of Trade and Industry. London, UK.

in large part to more effective inventory management. With the growing trend of sub-contracting and of flexible ad-hoc networked partnerships, *Value Networks Management* is the next objective.

Increased connectivity will enable value chain management to be based on a bigger picture of individual and group needs, so that increasingly intelligent inferences can be made about the impact of human decisions on the demand for goods and services. The Value Network Concept may well continually evolve: it will reach further and further back to the sources of raw material, energy and labour, and further forward into individual and societal futures: at some point it may be possible to work with values at the 'Good of Society' level

AmI technologies requirements: Further flexibility in distributed database management especially the ability to deal intelligently with semi-structured data smart objects identification or wireless radio frequency based technologies generalised at factory floor level could favour the flexible reconfigurations necessary to meet changing market conditions, introduction of new or customised products at plant level, or changing external partnerships. Technologies for real-time monitoring of flows, reliable middleware and distributed databases are again basic ingredients for these developments.

2. Introducing mass customisation and improved customer service-orientated production

Innovatory idea: On demand and personalised product assembly, on-site control capacity, is at the frontiers of just-in-time production and mass customisation. Mass customisation offers the benefits of individually tailored products. As connectivity and the level of distributed intelligence in networks grows, it will be possible to aim for 'Just Before Time' (JBT) provision of service and goods based on anticipating the needs of individuals and groups

AmI technology requirements: Information systems that can turn customer orders into work sequences, production facilities that can switch and reconfigure will necessitate strong security technologies, secured access to companies' production process databases (including encryption), facilitated e-payments systems, possible follow-up of tagged sub-components in the production and delivery process, etc. In such mass consumption markets as IT product assembly, construction or car manufacturing, a move towards these concepts is today possible. Self-explanatory products and services which help the customer understand the limitations as well as the strengths of what's on offer, so as to engender trust. The win-all solution relies on the most ingenious combination of relevant customer-oriented services.

3. Speeding up the prototyping-to-market path and generic Knowledge Management capacities

Innovatory idea: Concurrent design and similar trends have accelerated R&D-to-market cycles, if not transformed this linear path into a more organic relation between innovation, product design and consumption. GroupWare experiments have flourished, offering mutual interdependency to dispersed multi-skilled teams inside and outside the mother companies.

AmI technologies requirements: Further developments might be to develop community memories, holographic representations and humanised interfacing to data and communication facilities could enable effective developments in this area of essential role for competitiveness of the industry. Closely linked to R&D and innovation are all generic corporate knowledge management initiatives which aim, more globally, to keep track and generate value from tacit and explicit skills and competencies in the newly established unstable business environment of today.

Virtual presence technologies, learning and reflexive systems and dialogue-based negotiation systems will heavily support these goals.

4. Favouring anthropocentric process automation

Innovatory idea Plant automation techniques that stress human factors in place of traditional 'peopleless factories of the future' are possible with AmI providing a set of enabling technologies (e.g. based on goal directed dialogues) for enhancing rather than replacing humans. This inversion of the usual 'robots do everything' places humans at the centre, making the concept much less unacceptable.

AmI technologies requirements: Robotics could further improve with higher developments in sensors and actuators technologies. Flexible automation, offering full range of devices production in one plant could be enabled by accessing distributed databases and offer opportunities for so-called relocated production units. Human-machine interaction could benefit from effectively humanised interfaces (including Tangible User Interfaces, natural language understanding), augmented objects, natural anthropocentric input/output devices. Advanced extensions of the human sensory motor system could amplify massively the power of humans to operate in difficult environments.

5. Transforming products sale in services revenues: the maintenance case

Innovatory idea: Reducing the functional separation between products and services delivery is another contemporary transformation of many industries. Efficient maintenance services are among the fastest growing areas of activity.

AmI technologies requirements: Smart intercommunicating devices could offer a wide range of intelligent services to the customer and to producer (both vendor and manufacturer): effective insights at self-diagnosis level; necessary communication with owner/ supplier maintenance plant; functional co-ordination with surrounding devices as to offer self or mutual repair or at least graceful decline.

6. End-of-life management

Innovatory idea: Reinforcing product end-of-life management responds to emerging transnational laws to take back used products and recycle most of their components. But the life-cycle data of these components appears also to be of interest for the industry. Altogether, this leads to adapt the supply and distribution chain to handle smoothly the products and take advantage of recorded data.

AmI technologies requirements: Enhanced objects, tagging, smart sensing objects and their communicating capacities with distributed and semi-structured databases are entry points for reinforcing control over logistics, as well as to develop effective end-of-life product management. This last aim should include 'ultimate' knowledge-oriented self-diagnosis/archive capacity, a logistic aspect and security dimensions in case of noxious material.

7. Developing workforce health and safety programs

Innovatory idea: Traditional safety and health programs have helped improving security at work and reducing the related health and social costs. AmI technologies can help refine these measures,

or, better, reverse logic while offering proactive surroundings generating early warnings or reconfiguring themselves to guarantee optimal conditions.

AmI technologies requirements: one or bi-directional biometrics, RF-tagging embedded personal smart devices, sensors, self-monitoring buildings and equipment which warn when unsafe, smart building materials offer a wide range of potential applications for controlling both the working environment conditions and the health of the workforce. Such settings necessitate further developments in various domains such as smart power storage, smart material with built-in sensors and analysis capability; communication middleware, distributed databases. Taking in account the important amount of dangerous production processes i.e. in chemical plants, this path of AmI development should not either be neglected even if less directly related to profitable industrial transformation.

A tentative matching grid for industrial AmI applications

Industrial applications	AmI Enabling technologies
1. From value chains to value networks	Distributed semi-structured data management Smart objects identification Secure and trusted communication Trusted high emotional bandwidth communications for establishing partnerships Legally recognized electronic negotiation and agreements Wireless radio frequency based technologies Real-time monitoring of flows Reliable middleware to interface with legacy databases
2. Introducing mass customization and improved customer service-reoriented production	ID security technologies Secured access to companies' production process databases (incl. encryption) Distributed databases (management) Intelligent and trusted user profiling Knowledge Discovery and Learning in Distributed Semantic Networks Products with semi-reflexive self-explanatory capability using natural dialog Facilitated e-payments systems Tagged sub-components in the production and delivery process
3. Speeding up the prototyping-to-market path and Knowledge Management capacities	Community memories Holographic representations Humanised interfacing to data and communication facilities Presence technologies Learning and reflexive systems Dialogue-based negotiation systems Robotics
4. Favoring anthropocentric process automation	Robotics Sensors and actuators Distributed databases Humanised interfaces (including TUI, natural language understanding, etc.) Augmented objects Natural anthropocentric input/output devices Extensions of human sensory motor system
5. Transforming product sales into services revenues: the maintenance case	Intercommunicating smart devices Self-diagnosing materials and structures Functional co-ordination Self or mutual repair Graceful decline
6. End-of-life management	Enhanced objects Enhanced infrastructure Semi-global transport and infrastructure monitoring Intelligent scheduling on a semi-global basis for efficiency and accident avoidance Dialogues for negotiating outcomes Tagging Smart objects and their communicating capacities Distributed databases
7. Developing workforce health and security programs	One or bi-directional biometrics Embedded personal smart devices Sensors Smart materials which monitor their own health Smart power storage Network management middleware Distributed databases

Annex 6: ISTAG Scenarios Participants

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KK-35-01-069-EN-C

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European Commission
Information Society Directorate-General

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ISBN 92-894-0735-2