DELIVERABLE 7.3

Economic evaluation

Author(s): Alexandre Duclos, Farshid Amirabdollahian

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AUTHORS & CONTRIBUTORS

Partner Acronym	Partner Full Name	Person
MADoPA	**centre expert en technologies et services pour le Maintien en Autonomie à DOmicile des Personnes Agées**	**Alexandre Duclos Hervé Michel**

SHORT DESCRIPTION

In this deliverable, an economic model is provided in order to feed D7.4, the exploitation plan. This model is designed from the Usage evaluation (D.6.7) of the ACCOMPANY project, the “Ageing report 2012” (EC), the MAR Market Domain Contribution Form Robot Companions for Assisted Living - Topic Group (RCAL-TG) 2014, an economic literature review, interviews with experts of different relevant fields (economy, robotics, healthcare, gerontology) and focus groups.

The economic evaluation considers 3 possible application scenarios and associated robot-based services that could be implemented with the functionality developed in ACCOMPANY. For each scenario / service, a detailed description of the provided functionalities, useful operation environments, associated risks and limits and required hardware components is given. In order to derive relevant economic parameters, the addressed user groups and market segments, the importance of single functionalities according to end user feedback as well as concrete costs of currently-used services and products are analysed.

The report is built as follows: it starts with the introduction, state of the art in robotics and healthcare provision as well as an analysis of relevant healthcare data and economic environments in the relevant countries. Furthermore, a description of the ACCOMPANY system is given, specifically functionalities provided by the project and required hardware components. Based on that, 3 application scenarios are derived and analysed that make use of the ACCOMPANY developments and associated services, specifically a robotic care assistant, robot companion, and robot assisted monitoring system. For each scenario, the service properties as well as associated opportunities and risks are outlined in more detail together with a description of dedicated users and operation environments. Furthermore, each section provides opinion from individual expert interviews. In order to derive economic background data, comparable services and products are analysed and a target price for the service is derived. The report further discusses business models for each of the services including the information, who would be the actual customer for the robot. Finally, the cost of existing robots that could be used for each service is analysed.

After the analysis of the single scenarios, development perspectives are discussed that allow us to

bring the existing solutions closer to market and to reduce cost discrepancies between current and target costs. Finally in the conclusion, the relevance and market potential of the three scenarios will be compared to each other with respect to user need, current and possible future (considering indicated development perspectives) implementation costs with respect to target prices, structure and access channels in the healthcare markets of the different countries. Based on this analysis, one scenario will be provided, with the best market potential, to be further considered in the exploitation plan.

This report has been written under the supervision of Robert Picard (French Ministry of Economy, Finances and Industry) with Farshid Amirabdollahian (UH).

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1. Introduction

1.1. Objective

The main goal of this report is to identify and to evaluate the economic perspectives raised by the ACCOMPANY project. More precisely, the function of this report is to provide the most suitable and profitable ACCOMPANY product-vision in the context of five markets: Germany, Italy, France, The Netherlands and United Kingdom. Those five countries correspond to the partners directly involved in the ACCOMPANY project. Using the Ageing report 2012 issued by the European Commission and others documents issued by the EC and the French ministry of Economy, Finance and Industry allows us to envisage those potential future markets (2014-2060). When the most suitable and profitable service will be identified, we will be able to build an exploitation plan (D7.4). Consequently, in this report, we shall describe the market perspectives for the ACCOMPANY project and an ACCOMPANY product-vision, the Silver Economy developments, the comparable robot, services and products. Through this economic evaluation, we will aim to answer this question: who is ready to pay what amount of money for what ACCOMPANY product?

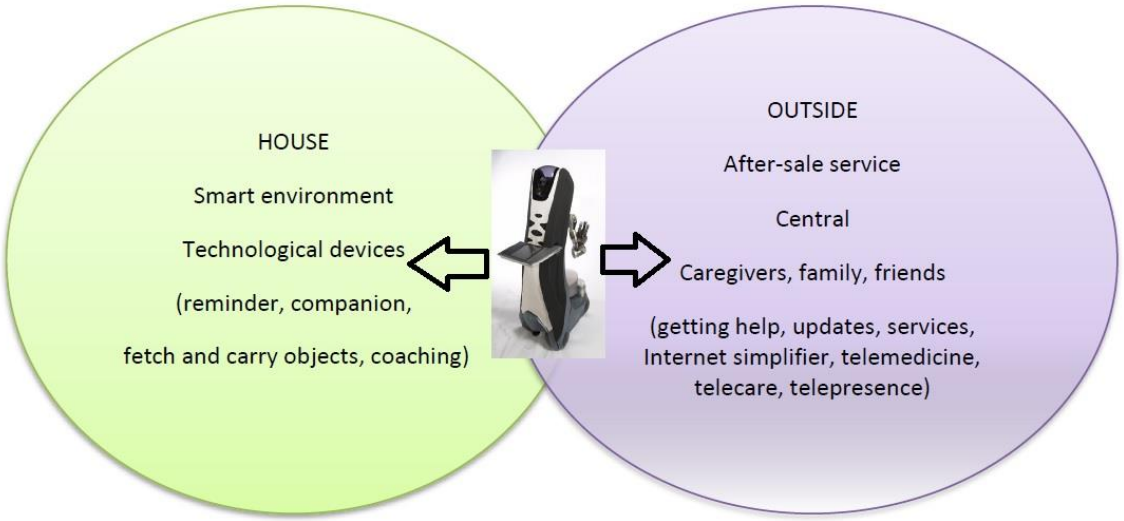
1.2. A system or a service including a mobile robot

From the beginning of the project, the objective of the ACCOMPANY project was to design a system as described below: *"The proposed ACCOMPANY system will consist of a robotic companion as part of an intelligent environment, providing services to elderly users in a motivating and socially acceptable manner to facilitate independent living at home. The ACCOMPANY system will provide physical, cognitive and social assistance in everyday home tasks, and will contribute to the re-ablement of the user, i.e. assist the user in being able to carry out certain tasks on his/her own. Services to the user will be delivered through socially interactive, acceptable and empathic interaction, building on computational models of robot social cognition and interaction. The envisaged relationship of the user with the robot is that of a co-learner – robot and user providing mutual assistance for the user not to be dominated by the technology, but to be empowered, physically, cognitively and socially[1]".*

Here, the "system" consists of a robot interacting with user(s) in a smart environment. This smart environment includes cameras, sensors, smart cup, computers but also a tablet. This tablet provided to the system a "squeeze me function", communication with the robot (propositions, demands, orders, empathic mask). We will use the notion of a "system" to describe a product that one can buy once and use autonomously. We use the notion of a "service" to describe a product solution that one can buy once, several times or by subscription and in this case, it would imply the system and a service are both considered, such as an after-sale service. If we consider an ACCOMPANY service, we can conceive the robot as being a link

[1] DOW ACCOMPANY, 2011-09-15

between, on the one hand, the user and the smart environments, and on the other hand, between the user and the outside.



The “outside” dimension was not at all included in the Evaluation Protocol ACCOMPANY (deliverable of the T6.3) and was not targeted by the ACCOMPANY project. However, this theme appears strongly during the interviews with the experts interviewed for the economic evaluation and in the identification of comparable services and product. The economic evaluation illustrates that if we want to imagine economic development for the ACCOMPANY system, it is very important to consider not only a system but also the service that will be provided within a certain context. Moreover, conceiving a service and particularly a service on subscription allows us to consider optional services and a multi-level service with, for example, three levels of service (corresponding to three or four level of subscription and three levels of prices). The Accompany system below refers to the overall system architecture required to allow operation of its subsystems, here including elements such as telecare core, individual coaching and interaction, telepresence unit, internet assistance services such as alert functions and finally the mobile manipulator platform. These are combined with After Sale Service, which is the service solution supporting the use of ACCOMPANY system and its components within each solution model.

Services

Gold service

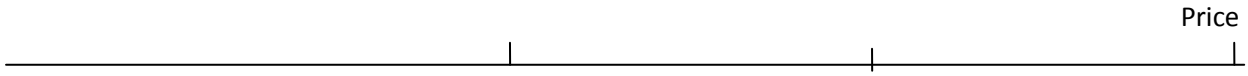
ACCOMPANY System + AS+telecare+coaching+telepresence+internet assistance+ mobile platform

Silver Service

ACCOMPANY System + AS+telecare+coaching+telepresence

Bronze service

ACCOMPANY System + AS



In this way, the system defines the basic service and the basic market price. The additional services will correspond to different levels of subscription. Similar models are used by many companies providing services (bank services) or products (cars, computers, etc.).

Multi-level subscriptions for Spotify and for the French Supplemental health insurance FNSEA[2]

	Spotify Premium *Spotify in its purest form. Learn more »*	Spotify Unlimited *No time limits, no ads. Learn more »*	Spotify Free *The best music player in the world. Learn more »*
Price	$9.99 per month	$4.99 per month	Free
Millions of tracks available instantly	✓	✓	✓
Play and organise your own MP3s	✓	✓	✓
Spotify social	✓	✓	✓
Take your music abroad	✓	✓	14 days
Artist radio	✓	✓	✓
No advertising	✓	✓	✗
Play local files on your mobile	✓	✗	✗
Play music from Spotify on your mobile	✓	✗	✗
Offline mode on your desktop	✓	✗	✗
Offline mode on your mobile	✓	✗	✗
Enhanced sound quality	✓	✗	✗
Exclusive content	✓	✗	✗
Play Spotify through music systems	✓	✗	✗
	Get Spotify Premium »	Get Spotify Unlimited »	Get Spotify »

[2] Working people, child, retired (-70 years old), retired (+70 years old), handicapped person (-60 years old)

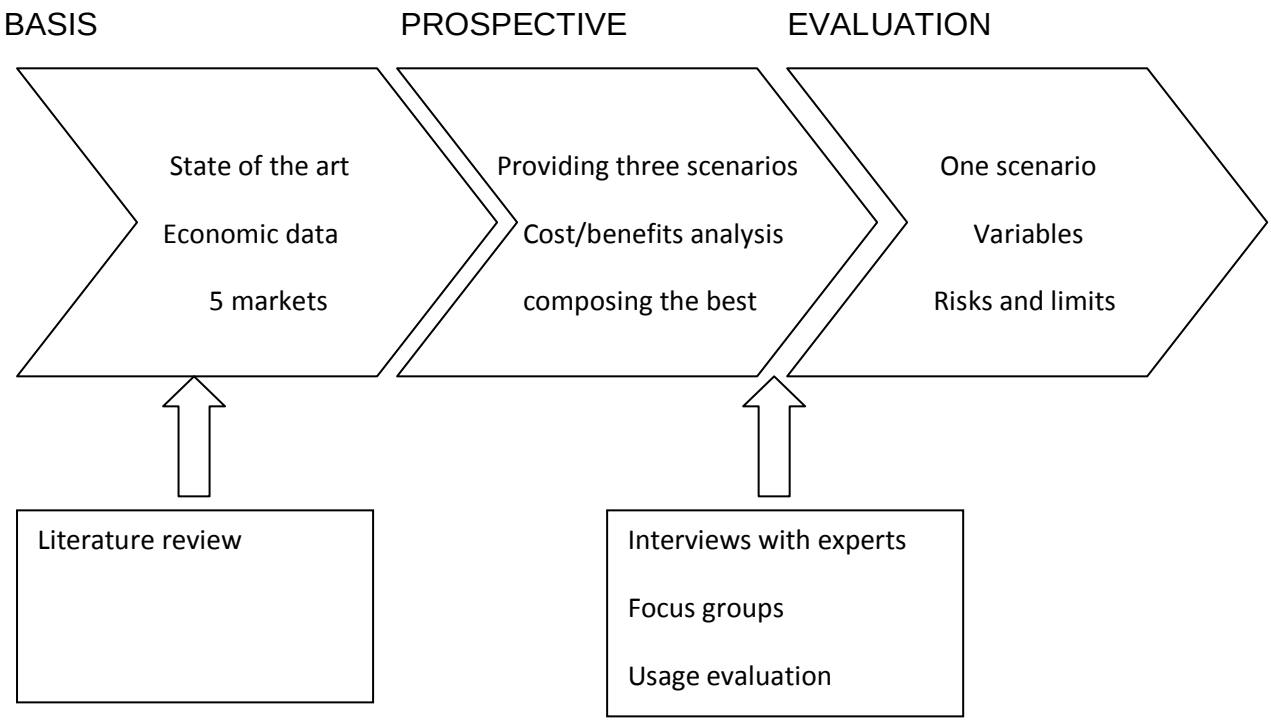
TARIF MENSUEL 2013	Bronze	Argent	Or	Diamant
Actif	32.40 €	39.55 €	43.25 €	69.00 €
Enfant	19.65 €	23.70 €	25.80 €	38.75 €
Retraité moins de 70 ans	59.30 €	70.10 €	76.45 €	122.85 €
Retraité 70 ans et plus	76.15 €	90.05 €	98.30 €	139.85 €
Adulte handicapé rattaché (moins de 60 ans)	32.40 €	39.55 €	43.25 €	69.00 €

Using this model, we will further detail the three services considered.

1.3. Evaluation structure

Prior to progressing with the valuation of system components, this section presents the process leading to provision of this economic model and its derivations. The work started with literature review providing the basis for this deliverable. It then continued to examine prospective scenarios and included cost benefit/utility analysis as well as elaborating on preferred solutions. The latter was informed by focus groups and interviews conducted with experts in healthcare technology and health economics. Finally, these are evaluated and the preferred scenario is magnified alongside other potential routes to market as well as risks and limitations.

D.7.3 Structure



Economic evaluation structure

While this deliverable covers the economic model, leading to evaluation of a preferred product/service, it links with the deliverable D7.4 where project exploitation plan is developed in-line with the findings of this deliverable.

Basis Prospective Evaluation Exploitation plan

In order to evaluate what could be an ACCOMPANY service proposed on the market, we choose to consider three prospective scenarios. Those scenarios correspond to three usages, three values and three market segments. Those three scenarios are:

- The development of a Care-system ACCOMPANY
- The development of an ACCOMPANY robot-based companion-system
- The development of a robot-based ACCOMPANY monitoring-system

Why divide the economic development of the ACCOMPANY projects into those three categories? First and foremost because those categories represent very different market segments and subsequently very different market opportunities; then because those different usages are perceived very differently by the users within the usage evaluation; last but not least because an extensive report by the French government considered a solution relevant to the present situation in industrial sector, the current potential for robotic solutions and specifically the three above market segments. The report issued by the PIPAME, which provided us with a robust demonstration of the relevance of this method. As ACCOMPANY project did not include partners with expertise in health economics, we relied on using established methods, based on advice from our project advisors with expertise in health economics, robotic industry and the health care needs of people. Thus in this case we utilized existing scenarios already considered within the governments' report.

> *« Afin de fournir à la filière et aux pouvoirs publics une vision claire de la réalité de cette industrie et de ses marchés, ainsi que de leur potentiel à moyen terme, en France et dans le monde, le PIPAME a confié au cabinet Erdyn une étude couvrant ces différents aspects. L'étude est articulée en deux parties : une première partie sur l'état des lieux de la filière, une seconde sur le potentiel de marché de la robotique de service, en particulier sur trois segments définis au démarrage des travaux :*
> *• La robotique d'assistance à la personne en perte d'autonomie,*
> *• La robotique personnelle et le robot compagnon,*

• *La robotique de surveillance et de gardiennage* [3]*».*

It is obvious that those three categories are not exclusive. A robot-companion can include a button to raise an alarm or alert someone; it can also recognize and measure activity. A monitoring system can be used for medical reasons (for example to survey an institute dedicated to persons suffering from Alzheimer's disease. To think of the value of a product, it seems to be crucial to identify what is its principal usage, what is it designed for?

[3] « Le développement industriel futur de la robotique personnelle et de service en France », Pôle Interministériel de Prospective et d'Anticipation des Mutations Economiques (PIPAME), April 2012. « In order to provide to the sector, public authorities a clear vision of this industry and of those markets, as well as their potential at middle term in France and in the world, the PIPAME asked the consulting firm to produce this report. The study is divided in two parts : assessing the present situation of this industrial sector ; a second part on the potential robotic markets, particularly on three segment market :
-Robotic assistive technologies for people with loss of autonomy
-Personal robotics and robot-companion
-Monitoring systems.

2. State of the art

2.1 Evaluation of robots

"Sans remonter aux premiers concepts de machine remplaçant l'homme dès le XVIIe siècle, la robotique est née, dans les années 1950, du croisement des besoins et des disponibilités de nouvelles technologies développées durant la seconde guerre mondiale : l'électronique, l'automatique, l'informatique… Les deux premières orientations de ces machines étaient de répondre aux besoins de l'industrie manufacturière et aux besoins de l'industrie en milieux hostiles à l'homme[4] *».*

In the industrial sector, robots have become a key factor of competitiveness and as such, the robotic sector receives massive public subsidies in Europe and in the United States. Robots were, in the 1950s, designed to achieve repetitive and automatic tasks and-or to achieve tasks in hostile environments or to manipulate dangerous materials (chemistry, explosives, nuclear industry, military industry). For instance, one of the first robotic developments was financed by the nuclear industry. The development of robotics could be described through those three steps:

-Industrial robotics

-Interventional robotics

-Mobile, (semi)autonomous robots

The development of semi-autonomous and autonomous robots has created the opportunity for personal and professional robotic services, at realistic prices (this point is clearly demonstrated by the table in ANNEXES: comparable robots). The personal services (monitoring service, telepresence, telecare, care-robots, robot-companion, activity recognition system, toy-robots) imply interactions with users and consequently the development of smart environments and therefore can be developed in very different fields (cleaning, education domestic tasks, caring, agriculture).

The ACCOMPANY service is designed for elderly people and its natural environment is an elderly person's house. This environment could be considered, in a way, as an environment characterized by the presence of risks. Risks of fall, risks to hurt the user but also risks of disturbing the frail ecosystem of the old person, risks of frightening the old person's friends and neighbours , risks of increasing the level of dependency of the old person (or to reduce their autonomy). Consequently, the ACCOMPANY service develops an assistive medium in a particular and fragile

[4] « Le développement industriel futur de la robotique personnelle et de service en France », DGCIS, PIPAME, Avril 2012. "Not starting from the first concepts of machine replacing human labor since the XVIIth century, robotics was born in the 1950s, from the crossbreeding of needs and availabilities of new technologies developed during the 2nd world war: electronics, automation, informatics. The two first orientations were to answer the needs of the manufacturing industry and to the needs of industry in dangerous zone".

environment. As it is conceived, it includes as possibilities, all the personal services required within the home environment. It is also designed to perform repetitive tasks, allowing the caregivers to save time and to use the available time differently. From this point of view, one can safely assume that this system fits in the continuum of development of robotics.

Since the beginning of the 19th century, economists have identified the potential impact of automation on labour costs, wages and the evolution of work organization[5] *"Some economists, however, including a few famous ones (Keynes, 1933; Leontief, 1982), have forecast that machines will eventually substitute for most human labor*[6]".

Such assumption is probably too simple. The development of robotics cannot be seen simply as a substitution. Robotics can create jobs and economic opportunities, robots can work in collaboration with humans, saving time and increasing the profitability of work, it might change the nature of jobs, prevent workers from the risks of dangerous environments (etc.). "*From 1811 to 1817, Luddites protested against newly developed labor-saving machinery (spinning frames, power looms in textiles). But in the long-run, employment and standards of living rose*[7]".If we want to understand the impact of robots on society and on economy, and more precisely, to be able to produce an economic evaluation of the ACCOMPANY system, we should take into account four dimensions (GOOS 2014).

-Impact on workers

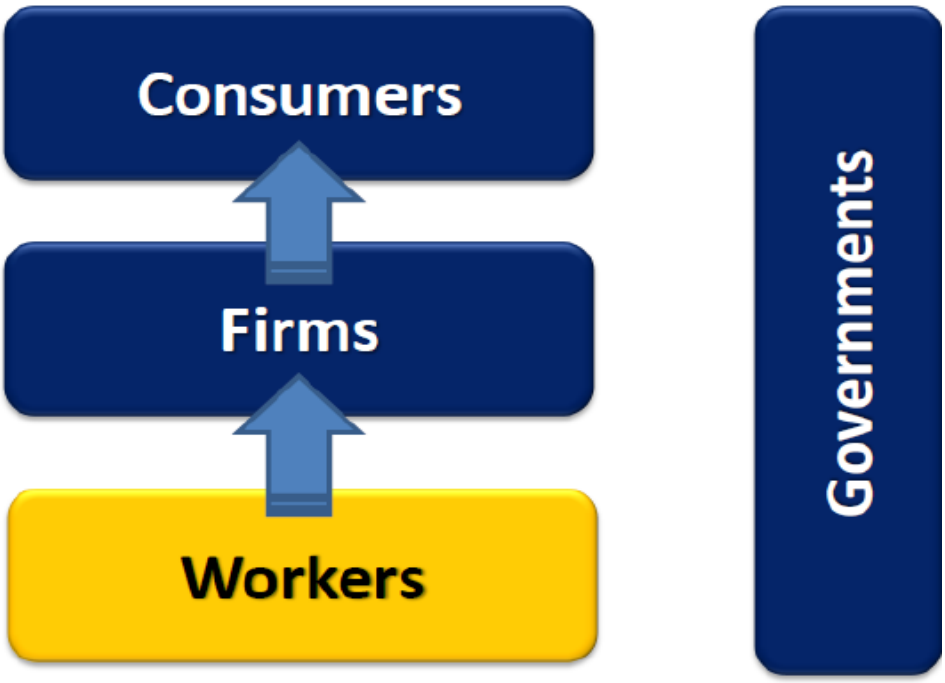
-Impact on firms

-Impact on consumers' daily-life

-Impact for Government

Here, the impact on workers originates from the ability of the robot to achieve tasks that may help formal and informal caregivers to save time or to spend time in another way (make the conversation with the old people instead of reminding her-him to take their medicine, to drink water, etc.). The impact for governments could come from new costs or savings within the healthcare spending. The impact on firms is not direct because it is changing the production of a product. It might be used as new services to be sold on the market of personal services or as a new product built by a company. It might impact the activity of the industrial provider, distributors, services, enterprises. All those developments would depend on the ability of the ACCOMPANY service to meet a demand and to prove its 'utility' in consumers' daily-life.

[5] The Principles of Political Economy and Taxation, third edition, 1821.
[6] Economic Growth Given Machine Intelligence, Robin Hanson*, School of Public Health, 140 Warren Hall, University of California, Berkeley, CA 94720-7360 USA*
[7] Communication, "The Economics of Robotics", Prof. Dr. Maarten Goos, Department of Economics, University of Leuven, 13 March 2014.



Communication, "The Economics of Robotics", Prof. Dr. Maarten Goos, Department of Economics, University of Leuven, 13 March 2014.

2.2. Evaluation of Healthcare services

The ACCOMPANY system cannot be considered as a Health service, but it includes or may include care services. Even if the system was only used as a smart environment and a robot-companion, the ACCOMPANY system is designed for the elderly people and their caregivers, and would be implemented in care-relationships. We can make the hypothesis that, as it is the case in Health Care evaluation, most of the ACCOMPANY system value will be identified in a 'cost-utility' analysis more than in a simple 'cost-benefit' analysis. A rationale to this is provided in the guideline below:

Guideline 1: The economic evaluation method[8]

"*The reference case analysis uses cost-utility analysis and/or cost-effectiveness analysis as methods of evaluation. The choice of the method to use depends on the nature of the expected health effects of the interventions under study. If the intervention is expected to have an important impact on health-related quality of life (HRQL), cost-utility analysis must be used. The health outcome to use is patient's length of life weighted by a valuation of the HRQL. The cost-utility analysis is always accompanied by a cost-effectiveness analysis which uses length of life as health outcome. If health-related quality of life is not identified as a relevant health effect of the interventions studied, cost effectiveness analysis is the required form of economic evaluation and the health outcome is measured by length of life. Any other choice must be duly justified. Cost-benefit analysis is not recommended*".

[8] « Choices in methods for economic evaluation », Department of Economics and Public Health Assessment, October 2012

However, additional support for this method emerges from the ACCOMPANY project's conception, as a series of parallel objectives to support personal independence using the utility of robots and smart-homes. The project did not embark on developing a robot, but utilised an existing research platform towards highlighting areas where advanced ICT could be utilised within this context. As throughout the project, no direct in-situ effectiveness is measured, i.e. by placing the solution in a person's home and observing the benefits on reducing needs, direct cost-effectiveness analysis is not appropriate for this case. In return, we are able to adapt the cost-utility analysis.

We will also have to consider all the different stakeholders who may be interested in the development of the ACCOMPANY system, at least users, caregivers, distributors, technology-providers, and Health Insurance companies. Besides, we must ensure to have a multidisciplinary approach.

"*While most evaluation tests are still mono-disciplinary (medical, technical, economic, sociological, etc.), BASHSHUR, in 1995, had already proposed a matrix that compiled the positioning of the various stakeholders (patient, doctor, society) and the objectives of new technologies (specifically telemedicine) at the same time, including access, cost and quality*[9]".

Table 1 - BASHSHUR (1995) matrix on telemedicine effects

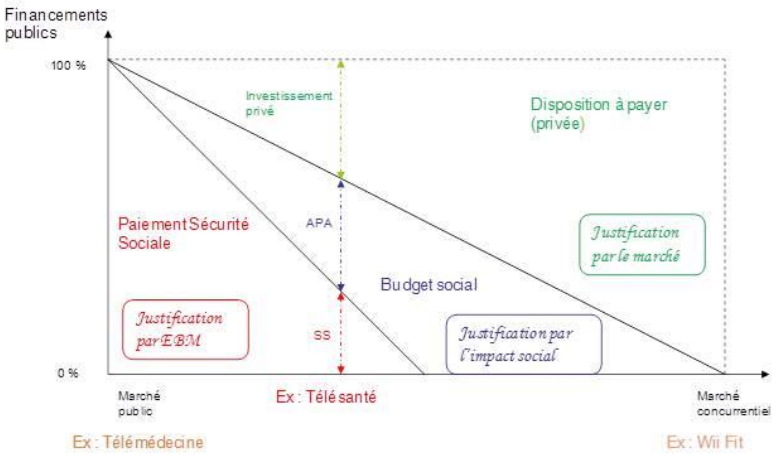
	Perspective		
Effects	Client	Provider	Society
Accessibility			
Cost			
Quality			

The figure below presents the map of different healthcare markets in the digital age. The vertical axis presents the funding source, i.e. the public procurement or private equity, depending on impact and its justification. The diagonal lines throughout the figure represent three different market segments, private, social and what is funded by the social security. The social security segment is justified by evidence-based medicine, while the social segment relies on social impact, and the private market relies on individual willingness to pay.

[9] Legoff-Pronost M., Picard R., "Need for ICTs Assessment in the Health Sector: A Multidimensional Framework", Paris, Communication & stratégie, n°83, 3Q 2011.

Picard, R. in « Le corps, nouvel objet connecté », Cahiers IP N°2, Commission Nationale de l'Informatique et des Libertés, Main 2014, p. 33

Représentation cartographique du modèle économique



Highlighting the complexity and context sensitivity of these segments, in order to take into account all those dimensions of the healthcare evaluation, we will use a grid including users, caregivers and the social system, cost, utility and benefits.

COST FOR THE USER	UTILITY FOR THE USER
COST FOR THE CAREGIVER	UTILITY FOR THE CAREGIVER
COST FOR THE SOCIAL SYSTEM	UTILITY FOR THE SOCIAL SYSTEM
GLOBAL COST	GLOBAL UTILITY

"The evaluation of a technology project should integrate not only technical, medico-economic or clinical parameters, but also organizational parameters without forgetting the dimension of usage, as is the case in the others sectors of the economy. Research on this theme should therefore be done by independent and multidisciplinary researchers who understand all the dimensions of evaluating health ICT"[10].

In this usage evaluation, we have tried to use a multi-dimensional approach, through economic experts' interviews, focus groups with professionals, usage evaluation with elderly people, professional caregivers, informal caregivers, acceptability scales, walkthrough grid. Multi-disciplinary researchers and investors were engaged on this study (sociology, robotics, economy, gerontology, philosophy, politics), as author, contributors to the ACCOMPANY project or experts.

[10] Need for ICTs Assessment in the Health Sector: A Multidimensional Framework, Myriam LE GOFF-PRONOST, Télécom Bretagne, LUSSI Department, Brest, Robert PICARD, CGIET, Ministry for the Economy, Paris, Communication & stratégie, n°83, 3Q 2011.

3. Numbers and data

3.1 The Silver economy

The European population will increase by 2060 (517 million people in 2060, 502 million in 2010). Simultaneously, the population will be much older. We can safely assume that this increase in numbers will have consequences on the market of care and healthcare. This evolution may be seen (and is actually considered by industrial or scientific actors) as an opportunity to develop robot-care, robot-companion and monitoring services. Indeed, monitoring services can be used to raise or cancel alerts at elderly people homes. The statistics provided by the European Commission allow us to consider that 30% of Europeans will be 65 or older in 2060. Two questions arise from those facts: who will pay? Who will benefit from that development? An older society doesn't mean a richer society: it simply means that new needs will appear.

If the global ageing process occurs, the economic old age dependency ratio (inactive population aged 65+ as % of employed population) will of course increase. As a consequence, one can suppose that it will be more and more difficult to recruit professional caregivers, or that the cost of labour will increase (higher demand, lower supply of labour). The percentage of 15-64 year olds is expected to decline from 67% to 56% in 2060. Consequently, it may be more and more economically relevant to develop technologies that may assume tasks that are today assumed by caregivers, that may collaborate with the caregivers (offering gains in time) or modifying positively elderly people's daily life, increasing their autonomy and their ability to stay at home.

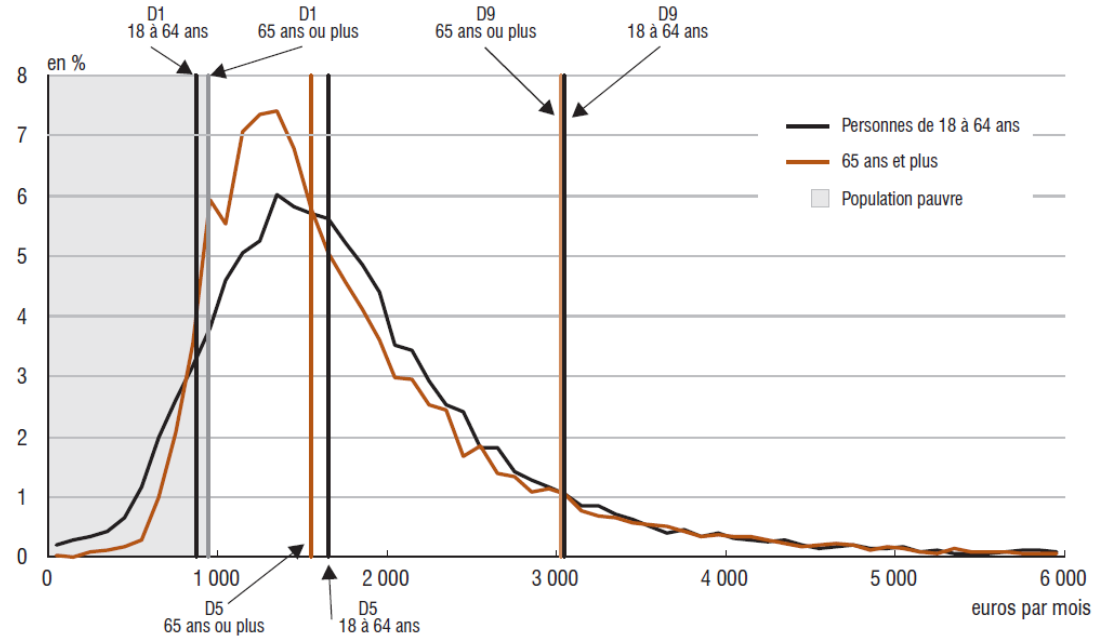
The scale and pace of population aging will depend on several factors: life expectancy, fertility and migration flows coming. That last factor will not directly influence the market segments interesting to robotic systems but could influence the labour cost and profitability of the robotic systems. But life expectancy will have a huge impact on those market segments. Obviously, the main cause of the population ageing is not a low birth rate, but an increasing life expectancy. The usage evaluation (D6.7) strongly suggests that this factor is very important to perceive the robot as a useful device. In France, people from the lower class, believing that they have a short life expectancy would say that they do not need any help (cf. D6.7, §2.2.2.4). According to them, they will stay autonomous until they die. It is estimated that life expectancy at birth is expected to increase from 76.7 years in 2010 to 84.6 years in 2060 for men and from 82.5 to 89.1 for women.

This demographic change is expected to have a significant impact on public finances in the EU. If our evaluation is based on current policies, public spending directly related to age (pensions, health care and support long-term) will increase from 25% to about 29% of GDP between 2010 and 2060, an increase of 4.1 points. Spending on pensions is expected to increase from 11.3% to almost 13% of GDP by 2060. But this does not allow us to think that consumers' purchasing power and more particularly elderly consumers' purchasing power will increase. If we consider current policies, public spending directly related to age (pensions, health care and support

long-term), the elderly population has lower income than the working population, as this figures shows in France.

Distribution of standard of living in 2009 of working people and elderly people.

1. Distribution des niveaux de vie en 2009 des personnes d'âge actif et des personnes âgées



Champ : France métropolitaine, personnes vivant dans un ménage dont le revenu déclaré au fisc est positif ou nul et dont la personne de référence n'est pas étudiante.
Lecture : en 2009, 7,4 % des personnes âgées de 65 ans et plus disposent d'un niveau de vie mensuel compris entre 1 300 et 1 400 euros alors qu'ils sont 6,0 % au sein des personnes d'âge actif (18 à 64 ans). Le niveau de vie mensuel médian est de 1 550 euros pour les personnes âgées de 65 ans et plus. 10 % des personnes âgées de 65 ans et plus disposent d'un niveau de vie inférieur à 948 euros en 2009 (1er décile).
Sources : Insee ; DGFIP ; Cnaf ; Cnav ; CCMSA, enquêtes Revenus fiscaux et sociaux 2009.

Demographic projections in the countries relevant for Accompany[11]

Life expectancy at birth (males/females)	**Ch 10/60**	**2010**	**2015**	**2030**	**2060**
France	7.2/5.5	77.9/84.6	78.7/85.2	81.1/87	85.1/90
Germany	7.2/6.2	77.6/82.7	78.5/83.4	80.8/85.4	84.8/88.9
Italy	6.6/5.6	78.9/84.2	79.7/84.8	81.8/86.6	85.5/89.7
The Netherlands	6.5/6.3	78.7/82.8	79.4/83.5	81.5/85.5	85.2/89.1
United Kingdom	7/6.7	78.3/82.4	79.1/83.2	81.4/85.4	85.2/89.1

[11] Ageing report 2012, Economic and budgetary projections for the EU27 Member States (2010- 2060) Joint Report prepared by the European Commission (DG ECFIN) and the Economic Policy Committee (AWG).

Maximum variation	0.6/1.2	1.3/2.4	1.2/2	0.8/1.6	0.7/1.1

Life expectancy at 65 (males/females)	**Ch 10/60**	**2010**	**2015**	**2030**	**2060**
France	4.5/3.9	18.5/22.7	19.0/23.1	20.4/24.4	23.0/26.6
Germany	5.0/4.8	17.4/20.6	17.9/21.1	19.5/22.6	22.4/25.4
Italy	4.7/4.4	18.1/21/7	18.6/22.2	20.1/23.6	22.8/26.1
The Netherlands	4.9/4.8	17.5/20.9	18.0/21.4	19.5/22.9	22.3/25.6
United Kingdom	4.8/5.0	18/20.7	18.5/21.2	20.2/22.8	22.8/25.7
Maximum variation	0.5/1.1	1.1/2.1	1.1/1.9	0.9/1.8	0.7/1.2

The increasing similarity must be noticed in those two tables (life expectancy and life expectancy at 65). In 2060, we can assume that the differences of life expectancy will be inferior to 1.2 years. This increasing homogeneity should be highlighted even if it doesn't prove that the economic situation in France, Germany, The Netherlands, Italy and United Kingdom will be homogeneous. This data tells us that people will face the same challenges in the five countries we are considering: to live (more or less) 22 years for males and 25 years for female after 65, to a good standard. One may safely assume that this challenge could be synthetized as follows: to stay healthy, wealthy and autonomous as long as possible.

Working age population (15/64) as % of total population	Ch 10/60	2010	2015	2030	2060
France	-7.7	64.8	63	59.3	57
Germany	-11.2	66.0	65.6	59.2	54.8
Italy	-9.8	65.7	64.6	61.7	55.9
The Netherlands	-9.8	67.0	65.3	59.6	57.3
United Kingdom	-7.7	66.0	64.3	60.8	58.3
Maximum variation	3.5	2.2	2.6	2.5	3.5

These numbers show two important things. Firstly, the working age population as% of total population will decrease in the five countries. Simultaneously, the differences between the countries will increase. The decrease of the working age population as % of total population could provoke an increase of the labour cost, and, eventually,

aid better profitability of robotic systems, the value of their task increasing[12] (if they encompass the ability to work, to do "human" tasks). But at the same time, we have to take into account that the Ageing report 2012 announces increasing differences between countries. Consequently, a robotic system value and profitability could increase in a country and decrease in another one. We see exactly the same scheme for the "Elderly population (65 and over) as % of total population and very elderly population (maximum variation in 2060 8.2 and 4.8). These are very important numbers because a society with 9.3% of very elderly people and another one with 14.1% are simply not the same. They won't have the same needs, the same development of the Silver economy; they wouldn't support the same charge for the social system. For example, the Ageing report 2012 asses that the long-term care spending as% of GDP (AWG scenario) in 2060 will be very heterogeneous in Europe. According to this report, in 2060, the Netherlands' spending should represent 7.9% of GDP, for 2.7 in United Kingdom. Talking about GDP %, a difference of 5.2% is a huge difference. We have to admit that we observe two opposite processes, increasing and decreasing differences. On the one hand, the European area or at least those five countries should become more and more homogeneous on a demographic level but more and more different on an economic level.

Elderly population (65 and over) as % of total population	Ch 10/60	2010	2015	2030	2060
France	9.9	16.7	18.7	23.4	26.6
Germany	12.2	20.6	21.6	28.4	32.8
Italy	11.4	20.3	21.5	25.7	31.6
The Netherlands	11.8	15.4	17.9	24.3	27.2
United Kingdom	8.0	16.5	18	21.4	24.6
Maximum variation	4.2	5.2	3.7	7.0	8.2

Very elderly population (80 and over) as % of total population	Ch 10/60	2010	2015	2030	2060
France	5.7	5.3	5.9	7.5	11
Germany	8.4	5.1	5.8	8.2	13.5
Italy	8.2	5.9	6.5	8.3	14.1
The Netherlands	7.1	4.0	4.4	7.1	11.1
United Kingdom	4.6	4.7	4.9	6.7	9.3
Maximum variation	3.8	1.9	2.1	1.6	4.8

Very elderly population (80 and over) as	Ch	2010	2015	2030	2060

[12] As a matter of fact, we should consider that an increase of the labor cost could also imply that the robots' price increases.

% of the elderly population (65 and over)	10/60				
France	9.6	31.9	31.6	32	41.5
Germany	16.4	24.9	27	28.9	41.3
Italy	15.6	28.9	30.4	32.1	44.6
The Netherlands	15.1	25.6	24.3	29.4	40.8
United Kingdom	9.7	28.2	27.3	31.3	37.8
Maximum variation	6.8	7	7.3	3.2	6.8

Very elderly population (80 and over) as % of working age population	Ch 10/60	2010	2015	2030	2060
France	11.1	8.2	9.3	12.6	19.4
Germany	16.9	7.8	8.9	13.8	24.7
Italy	16.3	8.9	10.1	13.4	25.2
The Netherlands	13.5	5.9	6.7	12.0	19.4
United Kingdom	8.9	7.1	7.6	11	15.9
Maximum variation	8.0	3.0	3.4	2.8	9.3

Average exit age	**Ch 10/60**	**2010**	**2015**	**2030**	**2060**
France	2.6	60.1	60.9	62.7	62.7
Germany	1.5	63.5	64.2	65	65
Italy	5.4	61.3	62.4	65.4	66.7
The Netherlands	-0.1	63.1	63.1	63.1	63.1
United Kingdom	1.8	63.5	63.8	64.6	65.3
Maximum variation	5.5	3.4	3.3	2.3	4

Economic old age dependency ratio (20-74) ***Inactive population aged 65+ as% of employed population 20-74***	**Ch 10/60**	**2010**	**2015**	**2030**	**2060**
France	25	40	45	55	65
Germany	30	43	43	57	73
Italy	25	52	55	59	77
The Netherlands	29	31	35	50	60
United Kingdom	18	34	37	45	52
Maximum variation	12	21	20	14	25

Health care spending as % of GDP	Ch 10/60	2010	2015	2030	2060
France	1.4	8.0	8.3	8.9	9.4
Germany	1.4	8.0	8.4	9.0	9.4
Italy	0.6	6.6	6.4	6.8	7.2
The Netherlands	1.0	7.0	7.2	7.9	8
United Kingdom	1.1	7.2	7.5	7.7	8.3
Maximum variation	0.8	1.4	2	2.2	2.2

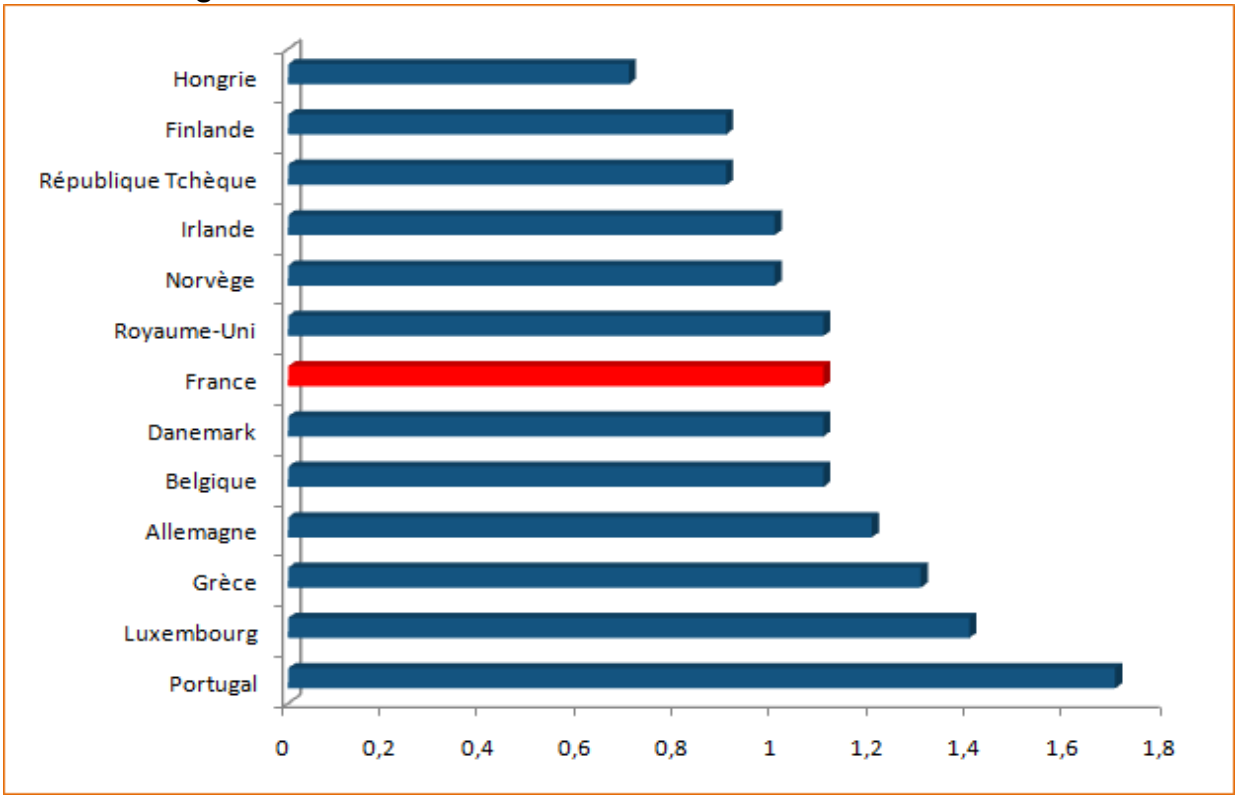
INCREASING DIFFERENCES // INCREASING COSTS

Number of dependant people (thousand) AWG reference scenario	**Ch 10/60**	**2010**	**2015**	**2030**	**2060**
France	**50.3%**	**5145**	**5474**	**6452**	**7734**
Of which receiving formal care	105.2%	1419	1578	1970	2913
Of which relying on cash benefits or informal care	29.4%	3725	3896	4482	4821
Germany	**7.8%**	**8408**	**8820**	**9453**	**9063**
Of which receiving formal care	67.7%	2216	2442	3018	3716
Of which relying on cash benefits or informal care	-13.6%	6192	6378	6435	5348
Italy	**47.7%**	**4365**	**4619**	**5351**	**6446**
Of which receiving formal care	49.2%	1048	1106	1256	1563
Of which relying on cash benefits or informal care	47.2%	3317	3514	4095	4882
The Netherlands	**48.7%**	**1037**	**1104**	**1341**	**1541**
Of which receiving formal care	98.4%	961	1055	1477	1906
Of which relying on cash benefits or informal care	-100%	76	48	0.0	0.0
United Kingdom	**42.8%**	**4663**	**4911**	**5643**	**6657**
Of which receiving formal care	75.2%	1233	1321	1617	2160
Of which relying on cash benefits or informal care	31.1%	3430	3589	4026	4498
Maximum variation	42.5%				
Of which receiving formal care	56%				
Of which relying on cash benefits or informal care	147.2%				

Long term care spending as% of GDP (AWG scenario)	Ch 10/60	2010	2015	2030	2060
France	2.1	2.2	2.4	2.8	4.2
Germany	1.7	1.4	1.6	2.0	3.1
Italy	0.9	1.9	2.0	2.1	2.8
The Netherlands	4.1	3.8	4.1	5.4	7.9
United Kingdom	0.7	2.0	2.1	2.3	2.7
Maximum variations	3.4	2.4	2.5	3.4	5.2

INCREASING DIFFERENCES

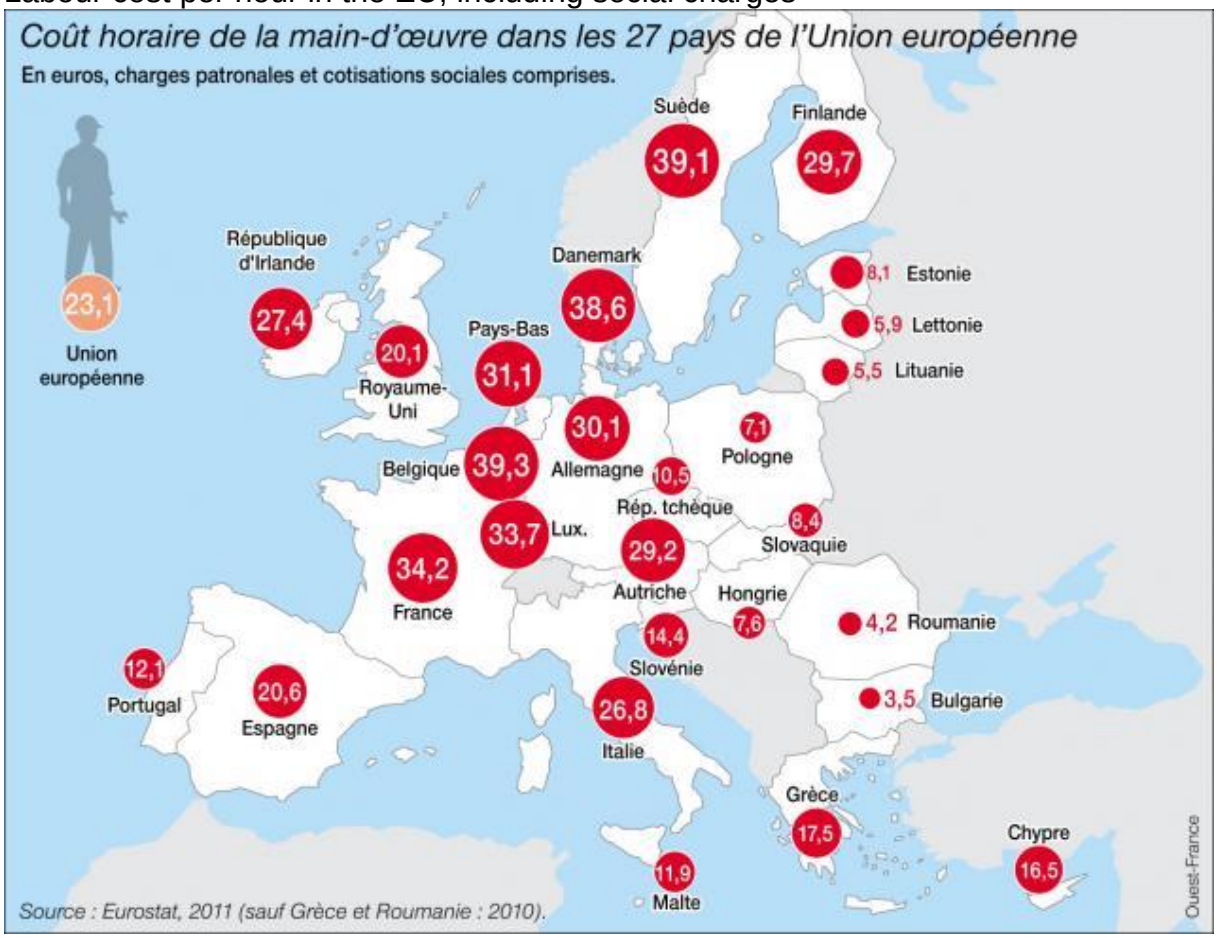
Formal caregivers : labour costs



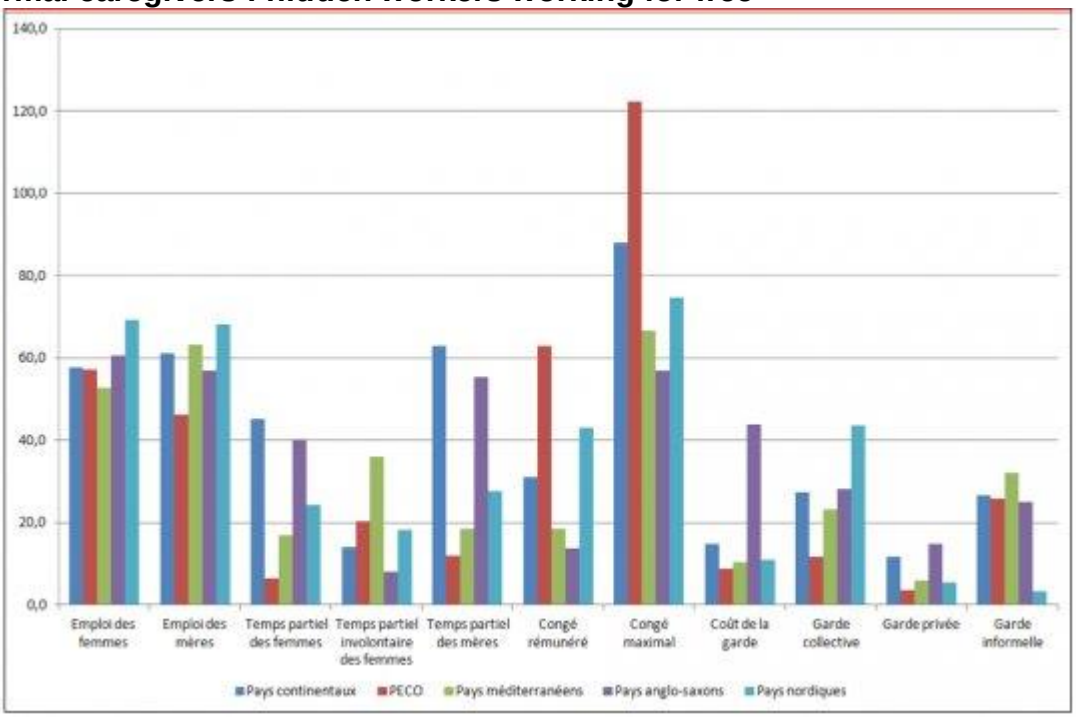
Nurses in hospitals' salary in regard of the average salary, 2007, source : Panorama de la santé 2009 : les indicateurs de l'OCDE.

This scheme is interesting because it shows the relative value of nurses' labour. Comparable tasks and competence are estimated very differently in Europe, within the EU. If we consider that the ACCOMPANY System's value should be estimated regarding the labour cost corresponding to tasks that it may ensure, then we are forced to admit that this value will almost double from one country to another, not in absolute value but in relative value.

Labour cost per hour in the EU, including social charges



Informal caregivers : hidden workers working for free



	Dépenses de protection sociale/PIB (%)	Dépenses de protection sociale par habitant - SPA (euros SPA)	Recettes de protection sociale en % du PIB - Employeurs (%)
	Social welfare spending	Social welfare spending per capita	Social welfare takings GDP%- Employers %
ALLEMAGNE[13]	2008 27,90	2008 8086.7	2009 10,97
FRANCE	2009 33,00	2008 8210.1	2009 14,13
ITALIE	2007 26,70	2007 6919.2	2008 11,30
PAYS-BAS	2008 28,50	2008 9498.7	2009 11,20
ROYAUME-UNI	2009 29,20	2009 7723.8	2010 9,78
UE 27 (MOYENNE)	2009 29,50	2009 6934.9	2008 10,55

[13] http://www.eurocompar.eu

3.2 Economic environments

3.2.1 France[14]

	Ch 10/60	2010	2015	2030	2060
Potential GDP (growth rate)	1.7	1.6	1.4	1.6	1.6

Labour cost (one hour, including charges) 2011	34.2 euros

	Ch 10/60	2010	2015	2030	2060
Life expectancy at birth (males/females)	7.2/5.5	77.9/84.6	78.7/85.2	81.1/87	85.1/90
Life expectancy at 65 (males/females)	4.5/3.9	18.5/22.7	19.0/23.1	20.4/24.4	23.0/26.6

	Ch 10/60	2010	2015	2030	2060
Working age population (15/64) as % of total population	-7.7	64.8	63	59.3	57
Elderly population (65 and over) as % of total population	9.9	16.7	18.7	23.4	26.6
Very elderly population (80 and over) as % of total population	5.7	5.3	5.9	7.5	11
Very elderly population (80 and over) as % of the elderly population (65 and over)	9.6	31.9	31.6	32	41.5
Very elderly population (80 and over) as % of working age population	11.1	8.2	9.3	12.6	19.4
Average exit age	2.6	60.1	60.9	62.7	62.7
Economic old age dependency ratio (20-74) *Inactive population aged 65+ as% of employed population 20-74*	25	40	45	55	65
Health care spending as % of GDP	1.4	8.0	8.3	8.9	9.4
Number of dependant people (thousand) AWG reference scenario	50.3%	5145	5474	6452	7734

[14] Ageing report 2012, Economic and budgetary projections for the EU27 Member States (2010- 2060) Joint Report prepared by the European Commission (DG ECFIN) and the Economic Policy Committee (AWG).

Of which receiving formal care	105.2%	1419	1578	1970	2913
Of which relying on cash benefits or informal care	29.4%	3725	3896	4482	4821
Long term care spending as% of GDP (AWG scenario)	2.1	2.2	2.4	2.8	4.2

3.2.2 Germany[15]

	Ch 10/60	2010	2015	2030	2060
Potential GDP (Growth rate)	0.8	1.2	1.2	0.5	0.8

Labour cost (one hour, including charges) (2011)	30.1 euros

	Ch 10/60	2010	2015	2030	2060
Life expectancy at birth (males/females)	7.2/6.2	77.6/82.7	78.5/83.4	80.8/85.4	84.8/88.9
Life expectancy at 65 (males/females)	5.0/4.8	17.4/20.6	17.9/21.1	19.5/22.6	22.4/25.4

	Ch 10/60	2010	2015	2030	2060
Working age population (15/64) as % of total population	-11.2	66.0	65.6	59.2	54.8
Elderly population (65 and over) as % of total population	12.2	20.6	21.6	28.4	32.8
Very elderly population (80 and over) as % of total population	8.4	5.1	5.8	8.2	13.5
Very elderly population (80 and over) as % of the elderly population (65 and over)	16.4	24.9	27	28.9	41.3
Very elderly population (80 and over) as % of working age population	16.9	7.8	8.9	13.8	24.7
Average exit age	1.5	63.5	64.2	65	65
Economic old age dependency ratio (20-74)	30	43	43	57	73

[15] Ageing report 2012, Economic and budgetary projections for the EU27 Member States (2010- 2060) Joint Report prepared by the European Commission (DG ECFIN) and the Economic Policy Committee (AWG).

Inactive population aged 65+ as% of employed population 20-74					
Health care spending as % of GDP	1.4	8.0	8.4	9.0	9.4
Number of dependant people (thousand) AWG reference scenario	7.8%	8408	8820	9453	9063
Of which receiving formal care	67.7%	2216	2442	3018	3716
Of which relying on cash benefits or informal care	-13.6%	6192	6378	6435	5348
Long term care spending as% of GDP (AWG scenario)	1.7	1.4	1.6	2.0	3.1

3.2.3 Italy[16]

	Ch 10/60	2010	2015	2030	2060
Potential GDP (Growth rate)	1.3	0.3	0.7	1.4	1.5

Labour cost (one hour, including charges) (2011)	26.8 euros

	Ch 10/60	2010	2015	2030	2060
Life expectancy at birth (males/females)	6.6/5.6	78.9/84.2	79.7/84.8	81.8/86.6	85.5/89.7
Life expectancy at 65 (males/females)	4.7/4.4	18.1/21/7	18.6/22.2	20.1/23.6	22.8/26.1

	Ch 10/ 60	2010	2015	2030	2060
Working age population (15/64) as % of total population	-9.8	65.7	64.6	61.7	55.9
Working age population (15/64) as % of total population	11.4	20.3	21.5	25.7	31.6
Very elderly population (80 and over) as % of total population	8.2	5.9	6.5	8.3	14.1

[16] Ageing report 2012, Economic and budgetary projections for the EU27 Member States (2010- 2060) Joint Report prepared by the European Commission (DG ECFIN) and the Economic Policy Committee (AWG).

Very elderly population (80 and over) as % of the elderly population (65 and over)	15.6	28.9	30.4	32.1	44.6
Very elderly population (80 and over) as % of working age population	16.3	8.9	10.1	13.4	25.2
Average exit age	5.4	61.3	62.4	65.4	66.7
Economic old age dependency ratio (20-74) *Inactive population aged 65+ as% of employed population 20-74*	25	52	55	59	77
Health care spending as % of GDP	0.6	6.6	6.4	6.8	7.2
Number of dependant people (thousand) AWG reference scenario	47.7%	4365	4619	5351	6446
Of which receiving formal care	49.2%	1048	1106	1256	1563
Of which relying on cash benefits or informal care	47.2%	3317	3514	4095	4882
Long term care spending as% of GDP (AWG scenario)	0.9	1.9	2.0	2.1	2.8

3.2.4 The Netherlands[17]

	Ch 10/60	2010	2015	2030	2060
Potential GDP (Growth rate)	1.3	1.1	1.6	1.1	1.3

Labour cost (one hour, including charges) (2011)	31.1 euros

	Ch 10/60	2010	2015	2030	2060
Life expectancy at birth (males/females)	6.5/6.3	78.7/82.8	79.4/83.5	81.5/85.5	85.2/89.1
Life expectancy at 65 (males/females)	4.9/4.8	17.5/20.9	18.0/21.4	19.5/22.9	22.3/25.6

	Ch 10/60	2010	2015	2030	2060

[17] Ageing report 2012, Economic and budgetary projections for the EU27 Member States (2010- 2060) Joint Report prepared by the European Commission (DG ECFIN) and the Economic Policy Committee (AWG).

Working age population (15/64) as % of total population	-9.8	67.0	65.3	59.6	57.3
Elderly population (65 and over) as % of total population	11.8	15.4	17.9	24.3	27.2
Very elderly population (80 and over) as % of total population	7.1	4.0	4.4	7.1	11.1
Very elderly population (80 and over) as % of the elderly population (65 and over)	15.1	25.6	24.3	29.4	40.8
Very elderly population (80 and over) as % of working age population	13.5	5.9	6.7	12.0	19.4
Average exit age	-0.1	63.1	63.1	63.1	63.1
Economic old age dependency ratio (20-74) *Inactive population aged 65+ as% of employed population 20-74*	29	31	35	50	60
Health care spending as % of GDP	1.0	7.0	7.2	7.9	8
Number of dependant people (thousand) AWG reference scenario	48.7%	1037	1104	1341	1541
Of which receiving formal care	98.4%	961	1055	1477	1906
Of which relying on cash benefits or informal care	-100%	76	48	0.0	0.0
Long term care spending as% of GDP (AWG scenario)	4.1	3.8	4.1	5.4	7.9

3.2.5 United Kingdom[18]

	Ch 10/60	2010	2015	2030	2060
Potential GDP (Growth rate)	1.9	1.2	2.0	1.9	1.8

Labour cost (one hour, including charges) (2011)	27.4 euros

	Ch 10/60	2010	2015	2030	2060
Life expectancy at birth (males/females)	7/6.7	78.3/82.4	79.1/83.2	81.4/85.4	85.2/89.1
Life expectancy at 65	4.8/5.0	18/20.7	18.5/21.	20.2/22	22.8/25.7

[18] Ageing report 2012, Economic and budgetary projections for the EU27 Member States (2010- 2060) Joint Report prepared by the European Commission (DG ECFIN) and the Economic Policy Committee (AWG).

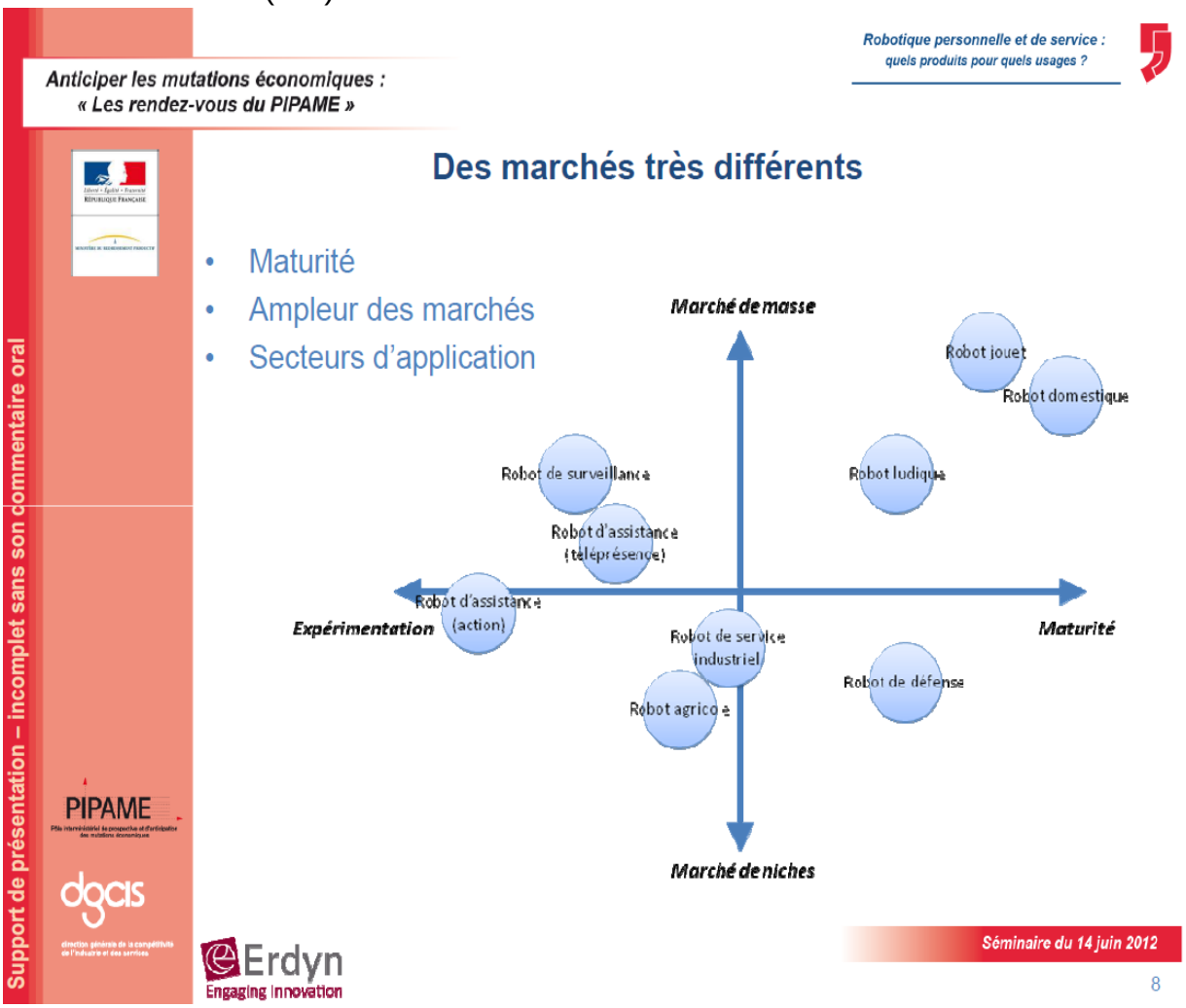
(males/females)			2	.8	

	Ch 10/60	2010	2015	2030	2060
Working age population (15/64) as % of total population	-7.7	66.0	64.3	60.8	58.3
Elderly population (65 and over) as % of total population	8.0	16.5	18	21.4	24.6
Very elderly population (80 and over) as % of total population	4.6	4.7	4.9	6.7	9.3
Very elderly population (80 and over) as % of the elderly population (65 and over)	9.7	28.2	27.3	31.3	37.8
Very elderly population (80 and over) as % of working age population	8.9	7.1	7.6	11	15.9
Average exit age	1.8	63.5	63.8	64.6	65.3
Economic old age dependency ratio (20-74) *Inactive population aged 65+ as% of employed population 20-74*	18	34	37	45	52
Health care spending as % of GDP	1.1	7.2	7.5	7.7	8.3
Number of dependant people (thousand) AWG reference scenario	42.8%	4663	4911	5643	6657
Of which receiving formal care	75.2%	1233	1321	1617	2160
Of which relying on cash benefits or informal care	31.1%	3430	3589	4026	4498
Maximum variation	42.5%				
Of which receiving formal care	56%				
Of which relying on cash benefits or informal care	147.2%				
Long term care spending as% of GDP (AWG scenario)	0.7	2.0	2.1	2.3	2.7

3.3 Robotic markets

The delineation of the different markets of robotics is crucial, because it is the basis of the method adopted in this evaluation report. Indeed, we base our evaluation of the ACCOMPANY system on three scenarios, corresponding to three kinds of services, three types of value but for the first time, this division has been chosen regarding three different markets of personal robots: care-robots, robot companion and robot-based monitoring system. Here, we follow the analysis of a report issued

by the French Ministry of Economy, Finances and Industry[19] based on World Robotics statistics (IFR).

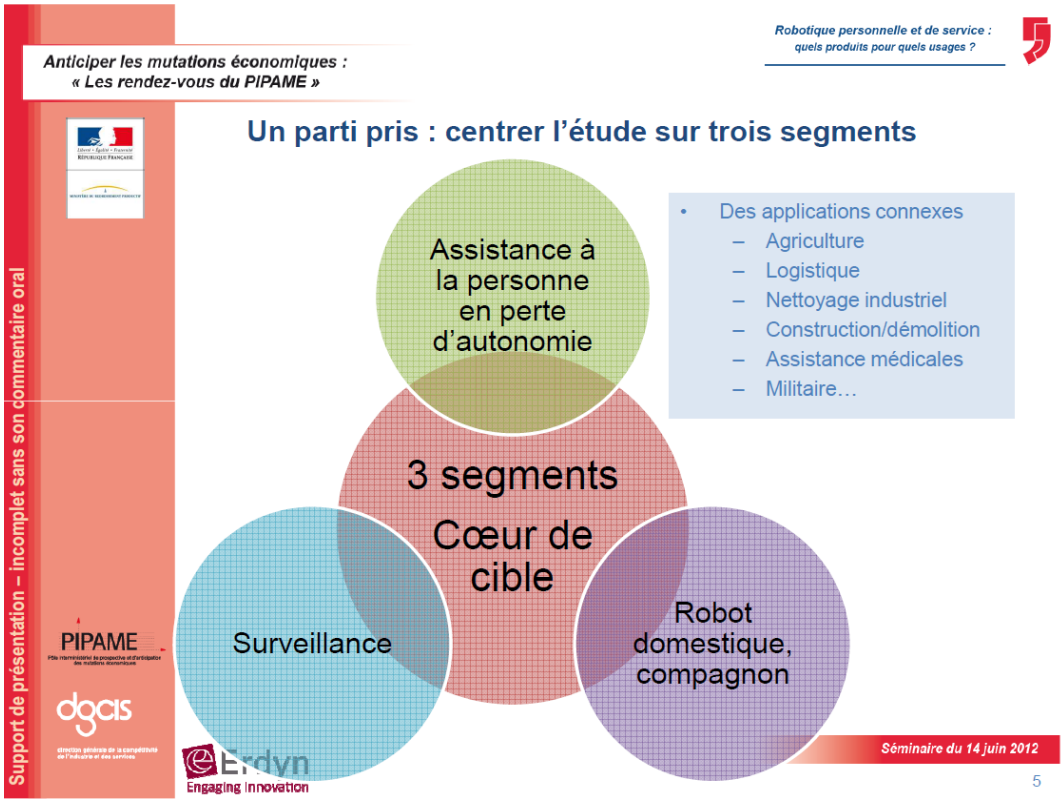


This scheme distinguishes the markets on two axes: niche-market/mass market and the TRL (experimentation-maturity). We can see that the only two kinds of products, dedicated for the mass market and with a TRL9 are the robot-toys and the robots for domestic tasks (robotic vacuum cleaner for example). On the contrary, the robot-based monitoring systems and telepresence robots are clearly less ready. For example, the GIRAFF robot is sold but within certain circumstances, to laboratories and research departments for research and development and with a price far from the market (6000 euros). The robot based monitoring system MOSRO costs 14 000 euros.

Though we are considering different markets, we have to admit that the concerned functionalities may be associated in one system as it was the case in the ACCOMPANY experiment, and especially in usage evaluation (D6.7). For example, the robot was able to remind participants of the necessity of hydration and carry a glass of water (care), it was able to express emotion (companion) and to provide a

[19] « Le développement industriel futur de la robotique personnelle et de service en France », Pôle Interministériel de Prospective et d'Anticipation des Mutations Economiques (PIPAME), April 2012.

memory prosthetic as well as coaching and reablement features (reablement). Moreover, we can assume that the value chain could be the same for the three products, including research centers, distributors, technology-providers, public funding, key technologies markets, etc.



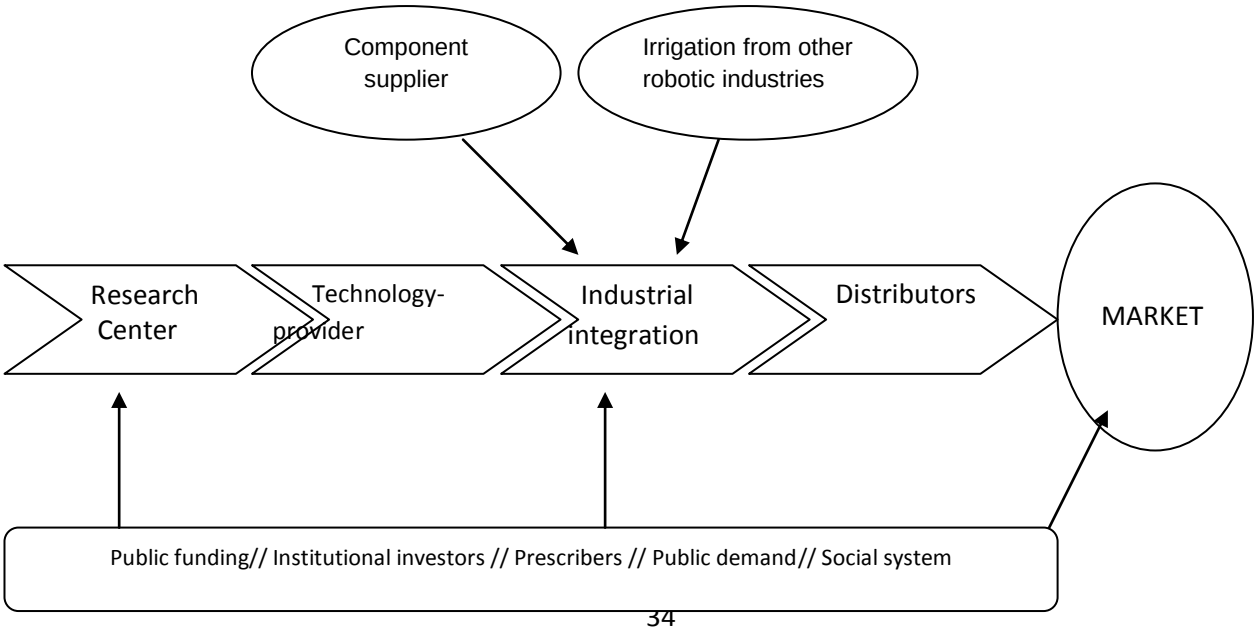
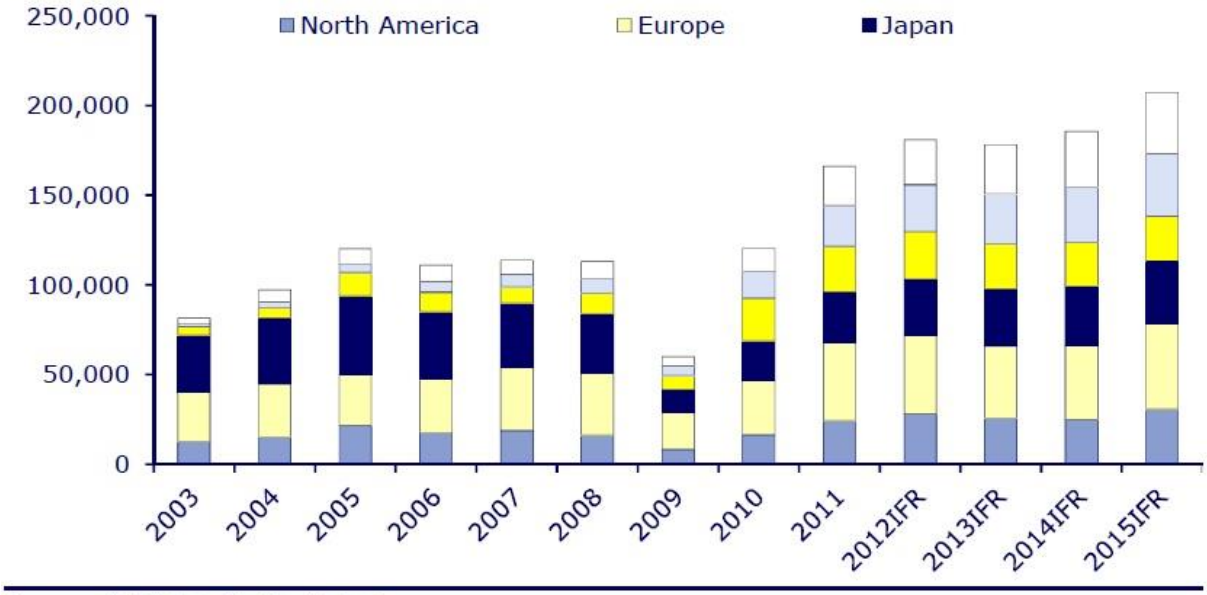


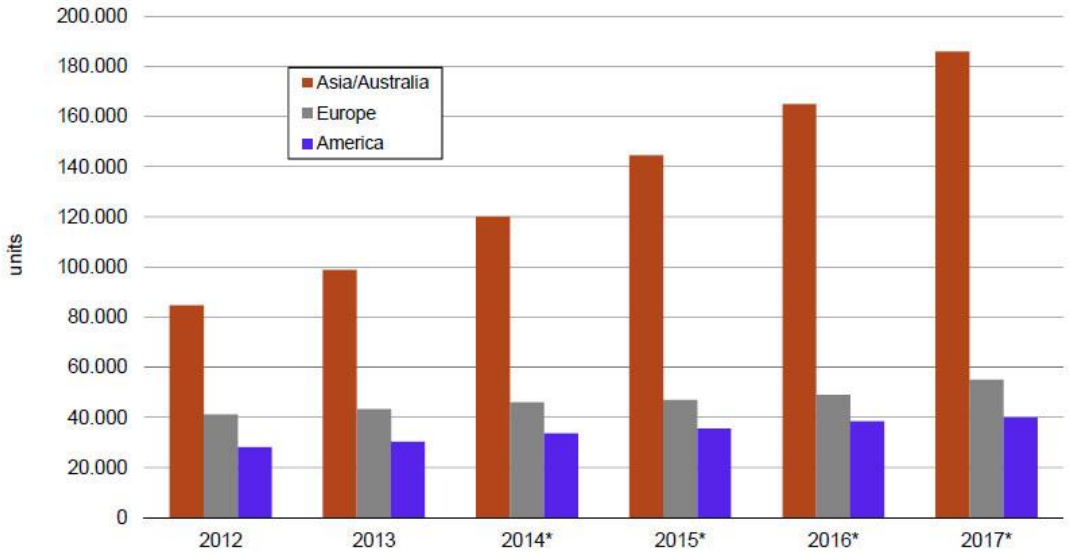
Figure 5

IFR forecasts for global robot demand



Source: CLSA Asia-Pacific Markets

Annual supply of industrial robots
2012-2013 and forecast for 2014-2017



* Forecast

Source: IFR World Robotics 2014

4. The ACCOMPANY system

4.1 Functionalities provided by ACCOMPANY

"*The target users of ACCOMPANY are elderly people who the ACCOMPANY system may help to live in their own homes independently for longer. The target application domain is a robot as a home companion as part of an intelligent home in order to support independence of its users by delivering physical and cognitive assistance, as well as by providing motivation and advice for re-abling users in skills that they have been losing, and doing so in a socially interactive, acceptable and empathic manner, encouraging physical, cognitive and social activities of the user. The project will combine all of these functionalities in the multifunctional ACCOMPANY system – with the robot companion as an embodied entity and focus of interaction with the user and mediation with the intelligent environment in the home*"[20].

The ACCOMPANY system was composed of a Care-O-bot 3 (mobile platform, arms, gripper, internal sensors, software), a tablet and a smart environment (external sensors, computers, software). During the usage evaluation, participants were using the tablet to interact with the robot in a smart environment. Within the evaluation of the scenario (part 5. of the present report), we will consider functionalities' costs but in this chapter, our goal is to describe the tasks and furthermore the services that were associated to the functionalities within the ACCOMPANY experiment with the users.

Transporting objects: with its mobile platform, its two arms (one with a tray, one with a gripper), its sensors, the Care-O-bot 3 was able, in a smart environment, to transport a parcel or cup from the kitchen to the living room in an autonomous way, alone or following the participant. It was also able to catch the cup and to deliver it in an autonomous way.

Fetching objects: the ability to search and find objects was not shown in the usage evaluation but as in the second scenario, the system was able to fetch objects equipped with RFID chips.

Empathy: during the evaluation, an empathic mask on the tablet expressed the "feelings" of the robot.

User-Information: the Care-O-Bot communicates by changing colors of it torso and small movements its "head".

Activity recognition: recognition of activities that are relevant for the household chores, based on fused data from the sensing system on the robot and the sensor network in the far space of the home (that is not directly perceived by the sensors on the robot)

[20] DOW ACCOMPANY

Decision making: computational episodic memory is developed allowing relevant events from the HRI history to be “remembered” to assist companion robot’s planning and decision making.

Controllability: the robot was partially remote-controlled during the usage evaluation. The speed can be modified with the Squeeze-me function. Big red buttons on both sides of the robot allow the participant to stop the robot at any time.

Communication: the ACCOMPANY system allows the participant to communicate with the robot through the tablet. The robot proposes actions. The participant gives an answer (or not) by touching the screen of the tablet. In addition with the tasks prescribed by the protocol, in France, the robot speaks to the participant at the end of the experiment.

Telepresence: The participants may see themselves on the tablet, as the robot “sees” them. They are able to see through the robot eyes, when the robot is not co-located with them, thus providing a sense of telepresence.

Reminder: within the experience, the Care-O-bot 3 reminds the necessity of good hydration. The system could also remind the necessity to take pills or the agenda.

4.2 Users’ acceptance and indicated needs

User’s acceptance over the ACCOMPANY system and long term acceptance of robotic systems have been studied in the project. Acceptability results reflected from acceptability questionnaires considered variables such as social presence, enjoyment, trust, self-efficacy and anxiety (n=36). Generalisation of findings from a multi-centre evaluation highlighted a varying level of acceptance for the technology, France mainly offering lower level of acceptance than the Netherlands and the United Kingdom, while scoring higher in self-efficacy assessment compared to the two countries. However, scores highlighted high level of enjoyment and trust, and acceptable level of social presence. Methodology and results of those studies are further detailed in D6.3 and D6.5.

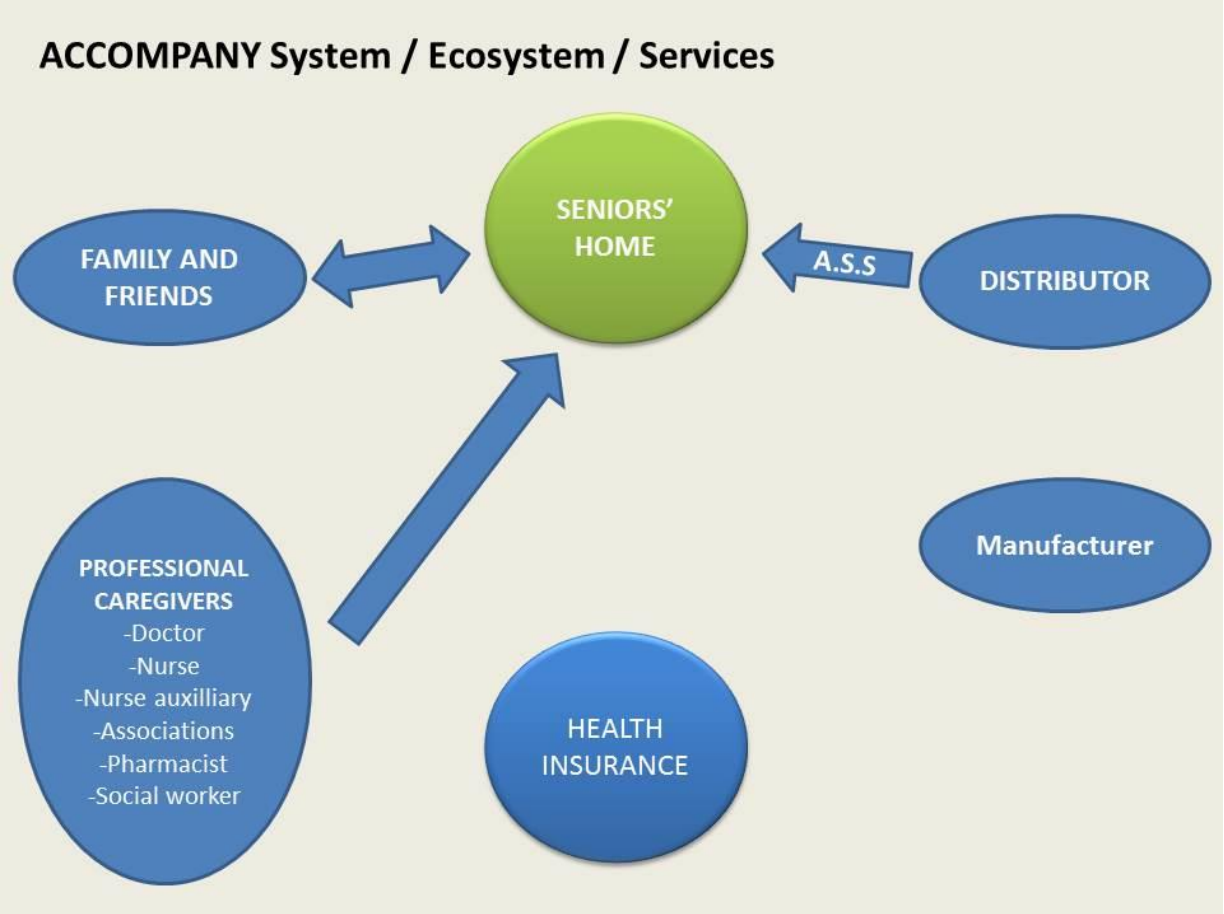
4.3 Prices in the ACCOMPANY project

The table below is produced to allow costing different system components. Prices used are are today’s (Sep 2014) market prices of partially hand-made components – these are not mass-production prices, especially for arms, and grippers. It is conceivable that larger produced numbers will result in cheaper components and cheaper end product.

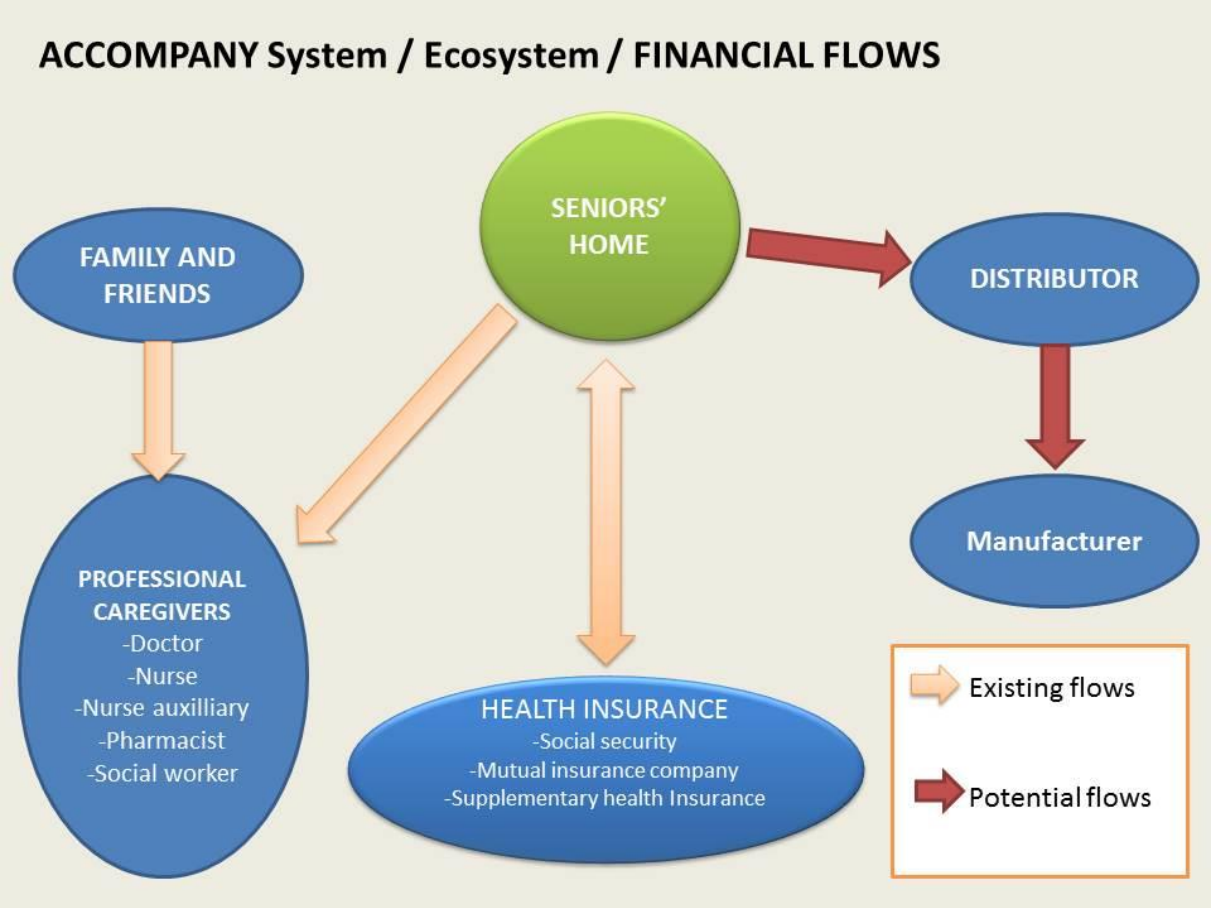
Functionality	Details	Mobile platform	Articulated Arm(s) and / or body	Gripper(s)	Sensors mounted on robot	Sensors mounted in environment	Interaction device(s) mounted on robot	External interaction device(s)	PC and control electronics	Cost fo functio alone (
Costs (K€)		50-75	30-75	50-75	7-25	1-15	2-5	1-5	10-20	
Transporting objects	to be placed on the robot by the user	omnidirectional base, load below 50 kg, size (diameter) ca. 1,5 m: 50-75 k€			navigation sensors, e.g. laser scanner: 5 k€				x	65-105
Fetching objects	grasping objects autonomously		1 redundant (7 DOF) lightweight arm, load up to 10 kg, reach up to 1,5 m: 50-75 k€	3 finger gripper with integrated tactile sensors: 50-75 k€					x	160-26
Medical skills	ability to align medical needs into daily interactions such as hydration and medicine intake as well as monitoring physiological functions				3D sensors to localize objects / for safe arm motion: 1-15 k€				x	110-18
Empathy & Emotion	robot behaviour, display, LEDs etc.		Articulated body, 3-4 DOF: 30-50 k€		3D sensor to localize and detect state of user: 1-15 k€	3D sensor to localize and detect state of user: 1-15 k€	Tablett / touch screen, speakers, microphones: 2-5k€		x	14-105
Activity recognition	analysing and interpreting user data				3D sensor to capture user data: 1-15 k€	3D sensor to capture user data: 1-15 k€			x	12-50
Memory	recording user data								x	12-50
Decision making	autonomy (based on sensor readings / activity recognition), eventually also on memory								x	10-20
Alert	user: needs to do something, based on memory				3D sensor to localize and detect state of user: 1-15 k€	3D sensor to localize and detect state of user: 1-15 k€	Tablett / touch screen, speakers, microphones: 2-5k€		x	12-50
Communication	with relatives / nurses, with internet				2D camera for image transmission: 1-5 k€			PC, speakers, microphones : 1-5 k€	x	14-35
Telepresence & Controllability	control robot remotely, access / adapt memory data base				2D camera for image transmission: 1-5 k€				x	14-35

4.4 ACCOMPANY Ecosystem

Considering a product or solution within its intended ecosystem, allows us to better place the product within its intended market place, while considering is co-evolution, alongside the ecosystem. Accompany system has an ecosystem mainly consisting of older person, his/her family and friends, professional care givers and finally manufacturer and distributors. These are presented in the figure below.



And we can further consider the financial flows within the ecosystem towards further identification of potential routes to market. The figure highlights some existing financial flows. It is subject to some variance within different European countries but a large number have existing financial flows between care service provision and individuals, as well as individuals link with the health insurance. Potential new flows can be considered between end-user, distributor and manufacturer, when a standalone system is considered.


ACCOMPANY System / Ecosystem / FINANCIAL FLOWS
SENIORS' HOME
FAMILY AND FRIENDS
DISTRIBUTOR
Manufacturer
PROFESSIONAL CAREGIVERS
-Doctor
-Nurse
-Nurse auxilliary
-Pharmacist
-Social worker
HEALTH INSURANCE
-Social security
-Mutual insurance company
-Supplementary health Insurance
Existing flows
Potential flows

5. Prospective scenarios (robot-based services)

5.1 The Care-system Accompany

5.1.1 Design of the service (informed by usage evaluation)

General description

This service is conceived as a support for the informal and formal care givers. It includes, in its gold version, a mobile platform, internal and external sensors, and a tablet to remote-control the robot and to communicate. This service may be useful for persons partly or significantly dependent to care delivery. It is used simultaneously by the caregivers and the person.

That service may provide:
-Gain of time for caregivers
-More comfortable living for the patient and offer of independence
-Reassurance for the family and friends

The robot can remind users of medication or good practices in a sympathetic (or authoritarian if needed and appropriate[21]) way.

During the experiment in France, several caregivers highlighted elements that could make such a service useful to them. If an elderly person lives alone and cannot walk alone anymore, with a reliable system in place, the caregivers could reduce the number of visits from 4-5 visits a day to 2 visits. The robot could help the elderly to get up and to sit down. That allows him or her to go to the toilet while the nurse is not present. It may help the elderly person to have a shower in a safe condition. It would remind him or her to drink during the day. It may help the elderly person to call for help if it is necessary. The cameras could help the nurse to check the situation remotely. In the context of an old man suffering from Alzheimer's disease, a nurse explains that the robot could remind him what he can do and what he cannot (this person should not walk without his walker). The tablet could be used as a "notebook" often used by doctors, nurses and informal caregivers to collect all the important medical information available at the elderly person's home. The robot could also interact with the patient, offering health games on the tablet and reacting to the scores by performing empathic gestures or offering engaging and motivating feedback.

So in essence, this system and its service are a means for a nurse or a caregiver to interact with a patient when she or he's not present in the patient's house.

[21] The ethical debate on whether a care support system should provide authoritarian and paternalistic approach has been extensively considered in D6.4 and D6.6.

Individual services[22]

-Help to get up and to sit down, to go the toilet or to go in the bathtub
-Reminder (medication, good practices)
-Help to fetch and carry things (help for hydration)
-Help to prevent falls
-Telecare (possibility to communicate with a nurse, ability for the nurse to see the patient, anywhere in the flat)
-Stimulation (memory, collaboration with the robot)
-Raising / cancelling alerts / alarms
-Measuring health parameters such as speed of walking and gait, etc

Operation environment

There will be a camera and ambient sensors at the apartment. The robot can go to the living-room and to the kitchen. If it's not the case, a fridge should be installed in the living room. Indeed, it is crucial for that service to have images and data from all the parts of the apartment. In most cases, the flats are not adapted to the robot movements (stairs) so it is important to limit its movement to the area of living (where the old person spends most of his-her time).

The service will be particularly useful and welcome in the suburbs and the countryside, because those environments imply more journeys for nurses and professional caregivers. In those environments, the service could allow important gains of time.

Risks and limits

According to the usage evaluation, it appears clearly that the value of a visit cannot be reduced to an efficient act, or several efficient acts. The elderly participants clearly expressed that they value human presence and human relationships. This indicates that the care-system (more than the care-robot) should not be designed to replace a human presence but to enrich it, to make it last. If a nurse visits twice a day 10 minutes to a patient's place and if the patient has been to the toilet, has been drinking enough, she or he could use those 10 minutes in a better way, talking with the elderly person, providing advice, observing the situation more carefully could be a better and more appreciated use of her/his time.

Functionalities

Bronze system: tablet, software, ACCOMPANY platform

Silver offer: tablet, software, mobile platform (remote-controlled), AS

[22]All those services have been suggested or evoked by the users during the usage evaluation. The users were interacting with the Care-O-Bot 3 in a smart environment. They were able to see what was possible and what could possible in a short range of time.

Gold service: tablet, software, mobile platform (autonomous), two arms (tray-gripper), gripper, internal and external sensors, speakers and microphones

The hardware required for this service and the associated functionalities includes a mobile platform, internal and external sensors, and a tablet to remote-control the robot and to communicate.

5.1.2 Market segment

The market for robotic care-systems for people losing autonomy is increasingly seen as a promising field for robotic and ICT services. It covers diverse application fields, such as telemedicine, telecare, rehabilitation and assistance, monitoring systems, alert systems. Today, few commercially viable applications exist and a large number of ongoing projects consider different tools and technologies for this market. The French Ministry of Economy evaluates that market (robotic care-system for people losing autonomy) between 1 and 2.5 billion euros by 2018[23].

5.1.3 Comparable care-robots (competitors)

RP-VITA	CARE-ROBOT (see in Annexe pp. 77)	3000-4500 € (for a hospital)

5.1.4 Comparable services and products

An ACCOMPANY care-system could be compared to several services (paid and free) but in most cases, the product covers only a small part of the envisaged system. For instance, a smart phone can help to measure activity or to raise an alert, passive walker frames can help to walk but they are not as global as the care-system ACCOMPANY: social workers, nurses or nurse auxiliary working at home, with the elderly. The labor cost of a social worker is 9.43 euros in France per hour, and if we have to consider a daily one hour service – a full service cost per year of 3441 euros is incurred (365x9.43 = 3441 euros for one hour a day, one full year of service). This is while the ACCOMPANY system could be used every day, every hour, each day of the year, for one year.

We should also consider that the informal caregivers provide many of the services that can be included in an ACCOMPANY product-vision (help to get up, reminder, help to fetch and carry things, raising and cancelling alerts, etc.)

[23] « Le développement industriel futur de la robotique personnelle et de service en France », Pôle Interministériel de Prospective et d'Anticipation des Mutations Economiques (PIPAME), April 2012.

5.1.5 Listening to the experts

Stephen Von Rump (Sweden)

Stephen Von Rump is Giraff's CEO. Stephen agreed to be interviewed for this report. According to him, there a simple way to assess the viability of a care technology designed for the elderly people. Does this technology allow cost savings within the first year. To him, the adequate time frame for the elderly people to assess cost savings should be approximately one year. The three scenarios are valid from his point of view but at different levels. He thinks that an ACCOMPANY monitoring system should be really cheap because one can find existing monitoring systems very cheaply on the market. There would be no real added-value with this type of product. There is a need for companion robot but here again, there is an offer already existing on the market (from Aibo to Siri or Nao). Consequently, we should conceive an ACCOMPANY Care system that allows elderly people to live in a more independent way and allows cost savings within the first year. Now, a Care-Robot able to increase significantly the seniors' autonomy should be able to fetch and carry objects (that is to say should have an arm and be able to move more or less autonomously in the house) and cannot be a cheap robot. Stephen Von Rump thinks that the labor cost of social workers is not sufficient to provide a relevant price for the robot. 3440 euros per year, corresponding to one hour per day, each day of the year is relevant data but Stephen Von Rump is not considering the price of "staying at home" independently. He considers the price of one year in a nursing home. More precisely, his calculations are:

-If staying at home costs 10 000 euros per year
-If staying in a nursing homes costs 50 000 euros per year
-A placement in nursing home represent a spending of 40 000 euros per year
-To be profitable from the first year, the system should cost less than 40 000 and approximately 30 000 euros.

We asked him to fill in the grid also provided during the Focus group presented later. The instructions were:

-Please offer a price for the necessary function, what you would be happy to pay?

-Please, highlight functions that you see as necessary, scoring them from 5 (most necessary) to 1 (not necessary).

-Please prioritize what is the most important functions for you, 5 being most important and 1 being least important.

General solution				
		System	Service	
Functionalities	Necessary	Price	Price	Priority
Transporting objects	5	30 000 Euros	Should be included in the system price	5
Fetching objects	5			5
Medical skills	5/1[24]			5
Empathy & Emotion	5			4
Memory	3			3
Activity recognition	5			4
Decision making	3			3
Communications	1			2
Alert	3			2
Controllability	5			4
Telepresence	1			1

This is a particularly interesting and a difficult diagnostic. Indeed, one can assume that nursing homes' cost, in Germany, France, Italy, The Netherlands and United Kingdom range from 30 000 to 50 000 euros on average[25]. But there are very different prices, depending on nursing home's location and quality and more importantly, one should delineate the global price into its components, the contribution for the old person, the price for the health insurance and the price for local authorities. For example, in France, prices are delineated as follows: hosting price, care-service price, dependence price. Hosting price is paid by the beneficiary, care-service prices are paid by the Health Insurance and the dependence service is partially paid by the local authorities through the APA (Aide personnalisée pour l'Autonomie-Personalized Help for Autonomy), the beneficiary paying a *Patient's contribution* (*ticket modérateur*) of 6 euros.

According to the French institution ATIH[26] (Technical Agency for Information on Hospitalization), a year in a nursing home cost, on average, 34 707 euros per year, 2892 per month and 95 euros per day. On average, the beneficiary would pay 60% of the price and the Health Insurance and the APA would pay 40% (the dependence price changes with the GIR). On average, a beneficiary would pay 20824 euros per year (60% of 34 707) and the Health Insurance and the APA 13 883 euros.

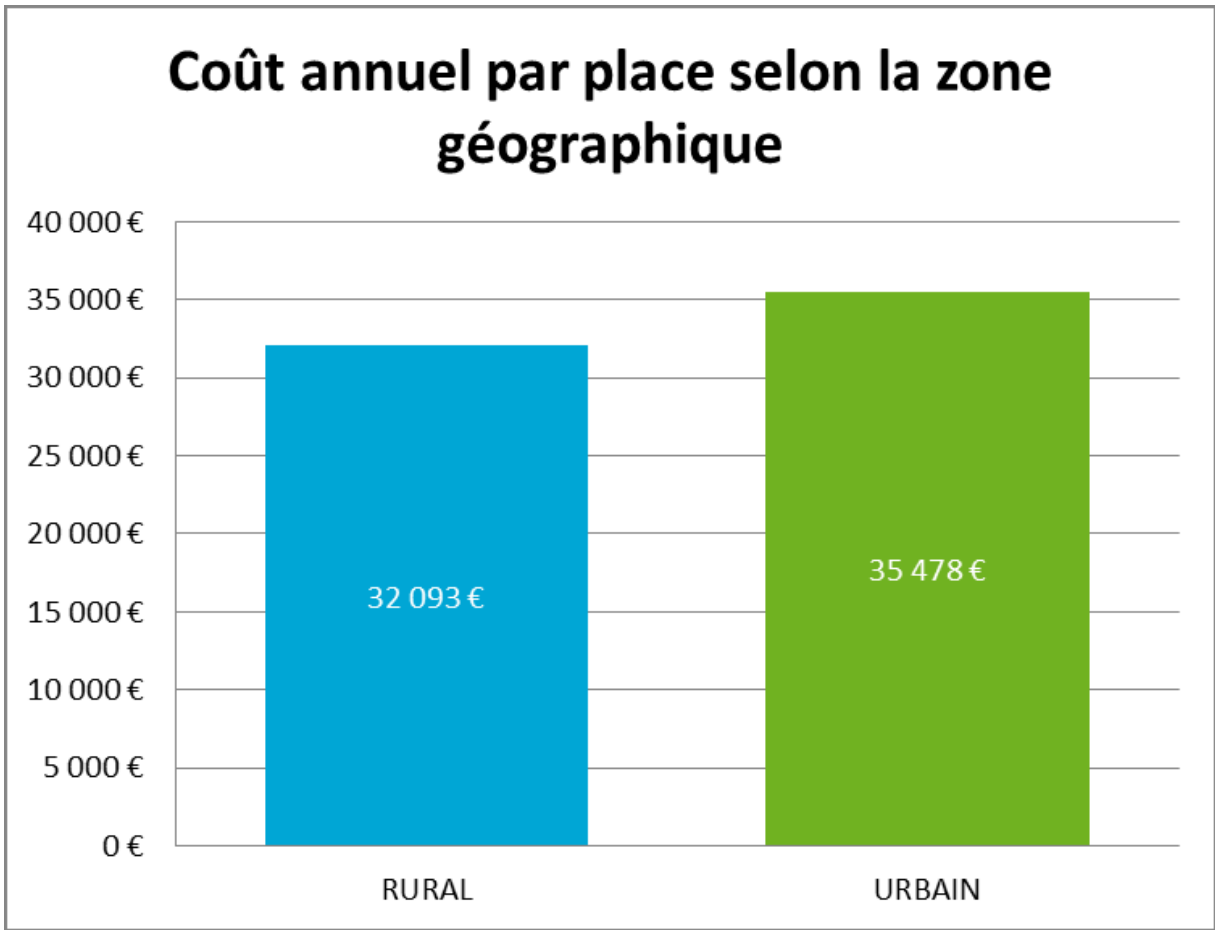
[24] Depending on social acceptability. The society would not be ready to accept a prescribing robot but only a support function in the care process.

[25] Those data are particularly hard to find. For that reason, we will build our demonstration on available data on French EHPAD (Etablissements hospitaliers pour les personnées âgées et dépendantes – Hospital for elderly and disabled people).

[26] ATIH, Enquête de coûts en EHPAD : Présentation des résultats 2012, 2 juillet 2014.

[27]

Cost for a year in a nursing home in France, in urban zone (green) and countryside (blue)



[27] Costs of the Nursing home Maisons des Soeurs Augustines, Versailles, France.

Nursing homes in other European countries can be lower (Poland) comparable or much more expensive, as shown by this table (Ireland).

NURSING HOMES SUPPORT SCHEME MAXIMUM AGREED PRICES WITH PRIVATE AND VOLUNTARY NURSING HOMES

Date Modified: 16/09/2014

Nursing Home Name	Address 1	Address 2	Address 3	County	Telephone	Maximum Agreed Price (per week) Single room €	Shared room €
Co. Carlow							
Hillview Convalescent & Nursing Home	Tullow Road	Carlow		Co. Carlow	059 9139407	830	830
Riverdale Nursing Home			Ballon	Co. Carlow	059 9159299	810	810
Borris Lodge Nursing Home			Borris	Co. Carlow	059 9773112	825	825
Beechwood Nursing Home	Rathvindon		Leighlinbridge	Co. Carlow	059 9722366	830	830
Glendale Nursing Home	Shillelagh Road		Tullow	Co. Carlow	059 9181555	795	795

DATE MODIFIED 22/03/2011

EFFECTIVE FROM 1st AUGUST 2010 to 31st JULY 2011

Name of Public Unit	Address 1	Address 2	Address 3	Telephone	Average Weekly Cost €
Carlow					
Sacred Heart Hospital	Old Dublin Road	Carlow	Co. Carlow	059-9136300	1,088
Cavan					
Ballyconnel Community Services	Breffni Care Unit	Ballyconnel	Co. Cavan	049-9526782	1,059
Dr. Jack Sullivan Memorial Home	Cathedral Road	Cavan	Co. Cavan	049-4331262	1,491
Lisdarn Unit for the Elderly	Lisdarn	Cavan	Co. Cavan	049-4373186	1,084
Virginia Community Services	Dublin Road	Virginia	Co. Cavan	049-8546240	1,056

Dick Van der Pilj (The Netherlands)

We have interviewed Dick Van der Pilj, Research & Development manager at Focal Meditech. He clearly estimates that the best way for the ACCOMPANY system to find its market is to focus on the care functions. According to him, the main value of a robotic system at home consists of task execution, especially tasks that allow seniors to stay at home autonomously and tasks that will support activity. He also insists on manipulation and transportation of objects in a safe way. He clearly distinguishes companion robot and care-robots, saying there is no need for a companion-robot. Referring to the smartphones, he says:

"*We have companions already in our pockets*".

According to him, it's not easy to put it all in one device and one has to make two services and two devices. Care robot can communicate but it should be a supporting function. He insists on the fact that he considers robots as machines and not as companion or person (which resonates with the findings of D6.7, D6.5 and D6.3).

We asked him to complete the grid also similar to the previous expert.

General solution				
		System	Service	
Functionalities	Needed?	Price	Price	Priority
Transporting objects	5	30/40 K for a global	Annual basis 2K	5
Fetching objects	5			5

Medical skills	1[28]	service	subscription	1
Empathy & Emotion	1			3
Memory	2			3
Activity recognition	1			1
Decision making	4			3
Communications	4			4
Alert	1[29]			4
Controllability	4			5
Telepresence	4			4

Consequently, if a Care-system ACCOMPANY was to be developed following Pr. Van Der Pilj's advice, the system should focus on care tasks, leaving telepresence, telecare or telemedicine to other communication systems and monitoring tasks to a very specialized product (for people with dementia). Considering ACCOMPANY's costs, this would create a very expensive device, not very appealing but allowing old people to stay at home autonomously without the need for additional care.

[28] But Dick Van der Pilj insists on the ability to give elderly people the energy to "get up and do things".

[29] *"But he would give a five for people with dementia"*.

5.1.6 Target price

In order to offer a target price for the system and service, to offer a comparable baseline for supporting care service as highlighted earlier, we considered different derivations of system components supporting the Care-system.

	Care ACCOMPANY-System		
Service	BRONZE OFFER	SILVER OFFER	GOLD OFFER
Presence	X	X	X
Reminder (pills, good practices)	X	X	X
Telepresence	X	X	X
Coaching	X	X	X
Quantified-self function	X	X	X
Intellectual stimulation	X	X	X
Empathy	X	X	X
Activity recognition	X	X	X
Monitoring system (Including a central)		X	X
Telemedecine		X	X
Coaching with external advisor		X	X
Raising and cancelling alerts		X	X
Staying autonomous Internet simplifier (AS)		X	X
Audiobooks reader		X	X
Monitoring system including a mobile platform			X
Staying autonomous Help to fetch objects			X
Staying autonomous Help to carry objects			X
Staying autonomous Help to store objects			X
Staying autonomous Help to get up Help to sit down			X
GLOBAL PRICE	Price:	Price :	Price : <30 000

	< 700 euros (single payment)	30-50 euros per month <1000 euros per year	

5.1.7 Cost-utility analysis

The table below considers the cost and utility alongside each other for the system derivation considered, here the care-system ACCOMPANY.

COST FOR THE USER	UTILITY FOR THE USER
Between 700 and 30 000	Healthcare services Possible savings 20824 euros per year (60% of 34 707) corresponding to one year on a Nursing Home. The system would be profitable after two years, allowing to save 11648 euros, if the beneficiary is the only one to pay the robot.
COST FOR THE CAREGIVER	UTILITY FOR THE CAREGIVER
0 Or 700>30 000 if the informal caregiver pays for the service	Reduction of the caring tasks Time saving
COST FOR THE SOCIAL SYSTEM	UTILITY FOR THE SOCIAL SYSTEM
0>30 000	13 883 euros saved for the Health Insurance and the APA (France) corresponding to 40% of 34 707 (average for one year in a nursing home in France) and the Health Insurance if the beneficiary is the only one to pay the system.
GLOBAL COST	GLOBAL UTILITY
700>30 000	Better healthcare system saving caregivers' time Benefits for the companies sailing the service

5.2 The Robot companion Accompany

5.2.1 Design of the service (informed by usage evaluation)

General description

This service is conceived on the one hand as a playful and pleasant presence and on the other hand as a robot-companion that could help an elderly person in daily-life activities. It is mostly designed for elderly people who are autonomous and healthy but it could be used by anyone. This means that a dependent person, a professional or informal caregiver or a child can be a user, separately or simultaneously.

This service is clearly inspired by what the participants of the ACCOMPANY experience have suggested.

In this service, the robot is clearly more a robot-companion than a care-robot. This service is not focused on care relationships and implies modularity. In this service, the user can teach the robot new practices, he/she can use it one way or another. The usage of the robot can change with time. To put it briefly, the service would be flexible enough to be co-designed with the users. The service offers a companion, a technical device partially autonomous, partially remote controlled. A monitoring service is available but optional. The user can design the service, choosing who can access the data and what kind of data. The robot is able to recognize some movements and to adapt its behaviour (e.g. going to the kitchen if some help is needed there).

Services identified by participants to the usage evaluation[30]

Boardgames with the robot-companion
Karaoke
Presence
Voice reminding the agenda (to do, meetings)
Access to internet and to an after-sale service
Reader (read audio-books)
Alarm-clock
Open-close the door for the dog (or cat)
Camera (leisure)
Animation for the visitors (childs, neighbors)
Help to dress the table
Help to cook
Help to carry objects
Help to open-shut the shutters
Help to switch on-of the light
Help to catch objects uneasy to reach

[30] All those services have been suggested or evoked by the users during the usage evaluation. The users were interacting with the Care-O-bot 3 in a smart environment. They were able to see what was possible and what could possible in a short range of time.

Teach-me program (co-learning)
Coaching (memory or physical experience)
Telecommunication via the tablet
Polite welcome for the visitors
Checking what happens in another room with the camera and the tablet
Serving coffee or tea when the user is alone
Serving coffee or tea when there are visitors
Interact with the pet (remote-controlled)
Expressing feelings
Raising alerts
Cancelling alarms
Measuring activity
Sextoy - galant

Environment

There will be cameras and sensors throughout the apartment. The robot can go to the living-room and to the kitchen. If this isn't the case, a fridge should be installed in the living room. Indeed, it is crucial for the service to have images and data from all the parts of the apartment. In most cases, the flats are not adapted to the robot movements (stairs) so it is important to limit its movement to the area of living (where the old person spends most of his-he time.

The service will be useful and welcome in suburbs, countryside, or in city centres. The usage evaluation tends to suggest that such a service will find more clients in certain conditions: a triad with different persons (informal caregivers, professional caregivers, and elderly people) as a more favourable context due to the system's ability to bridge between different stakeholders, thus providing maximum benefit.

Functionalities

Bronze system: tablet, software, platform

Silver offer: tablet, software, mobile platform (remote-controlled), AS

Gold service: tablet, software, mobile platform (autonomous), two arms (tray-gripper), gripper, internal and external sensors, speakers and microphones

5.2.2 Market segment

Companion robots can compensate the loss related to ageing and disabilities for daily-living. They might be useful for the realization of simple tasks allowing the elderly people to stay autonomous at home. Consequently, it might reduce human intervention on simple and repetitive tasks. In a social context, they can provide a means to be socially engaged and avoid boredom. This market segment includes several types of robot, toys robot (like Aibo), teaching robot (like Nao, teaching mathematics), telepresence robot, robot proposing entertainment (dancing like

ASIMO or Pepper, singing, playing karaoke like the Care-OO-bot 3), a playing robot (like Nao). As such, it can be designed for different types of users, child, elderly people, working people. It appears clearly that a little robot companion like Pepper, produced by Aldebaran (target price = 1400 euros) could be used, in the same house, by all the members of a family, even if it wouldn't be able to perform care tasks for an elderly people (it might, perhaps, be used as a reminder and perform cognitive exercise).

5.2.3 Comparable robots

EMOX	ROBOT-COMPANION	700 €
PEPPER	ROBOT-COMPANION	1400 €
AIBO	ROBOT-COMPANION	2000 €
LUNA	ROBOT-COMPANION	2100 €
IROBI	ROBOT COMPANION	3500 €
NAO	ROBOT-COMPANION	6000 €
JAZZ	ROBOT-COMPANION	7400-14 000 €
ENON	ROBOT-COMPANION	45 000 €
EVE-R-1	ROBOT-COMPANION	244 000 €
HRP 4C	ROBOT-COMPANION/ ROBOT-LEISURE	300 000 €
PR2	ROBOT-COMPANION	400 000 €
ASIMO	ROBOT-COMPANION/ROBOT-ASSISTANT	1.9 millions €

5.2.4 Comparable services and products

To what kind of services could we compare the ACCOMPANY robot-companion product-vision? Based on our usage evaluation studies (D6.7), comparable services are provided by informal caregivers, family, friends, neighbors and associations. They come to the old persons' homes to talk with them, to play with them, to drink or to eat with them, to clean the house. Those services are often provided for free. The comparable product might be the smartphones, the television, the Internet. One must make an exception with the cleaning of the house: a robotic vacuum cleaner can do the task of a social worker. The iRobot Roomba (vacuum cleaner) cost 729 euros which represent 77.3 hours of work for a social worker in France (9.43 per hour). Considering this data, we might make the hypothesis that a robotic vacuum cleaner could become profitable within a year with a caveat that a person might outperform

robot's vacuum cleaning quality. The Usage Evaluation results indicates that having several users, several usages in the same home clearly increases the added-value of the robot and is a favorable context for the implementation of the system.

5.2.5 Listening to the experts

Gérard Cornet[31], Gerontologist (France), has been interviewed for insights on functionalities and prices.

General solution				
Functionalities	Needed?	System price	Service Price	Priority
Transporting objects	3	<700 euros*	30 euros**	
Fetching objects	5	<700 euros*	30 euros**	5
Medical skills	3	<700 euros*	30 euros**	4
Empathy & Emotion	3/5	<700 euros*	30 euros**	
Memory	5	<700 euros*	30 euros**	
Activity recognition	4	<700 euros*	30 euros**	
Decision making	3	<700 euros*	30 euros**	
Communications	5	<700 euros*	30 euros**	5
Alert	4	<700 euros*	30 euros**	
Controllability	5	<700 euros*	30 euros**	4
Telepresence	5	<700 euros*	30 euros**	4

(*)Price for the global system including several or all the functionalities, this is, according to G. Cornet the maximum market price for a robotic- system designed for individual use and targeting individual consumers.

(**) Price per month for a subscription for a basic subscription. Optional services could be added.

Considering the ACCOMPANY program, Gérard Cornet conceives the best product possible is a « *friendly companion, a friendly presence facilitating the daily-life of the elderly* ». The system conceived by Gérard Cornet is designed for elderly people, including frail people but it aims to help people to stay autonomous. In order to stay autonomous, old people have to maintain a social life and the robotic system should help them to do that. The system should include a reminder, but it should remind

[31] Gerontologist, economist, member of the SFTAG, Société Française des Technologies pour l'Autonomie et de Gérontechnologie, International Society for Gerontechnology and of the CNR TIC Santé Autonomie.

recipes, meetings as well as procedures of daily-life, it should also help to find friends or, for example, bridge partners and provide a service of telepresence. He is actually working on the impact of playing bridge on health conditions. Here, the robot has to be a companion for two reasons:

-A friendly presence will be appreciated by the elderly, it will enhance the system's acceptability and will be an elementary form of relationship.

- A good companion system is inevitably a care system because social relationships, games and (joyful) leisure activities are health assets for the elderly people.

Gérard Cornet invites us to consider the double value of a robot-companion: it is simultaneously a caregiver and a companion because a friendly presence is care.

Christelle Ayache, Project manager, R&D, CAP DIGITAL (France).

Christelle Ayache offers a second view point:

General solution				
Functionalities	Needed?	System price*	Service Price**	Priority
Transporting objects	3	<1000 euros*	5 euros	
Fetching objects	4	<1000 euros*	10 euros	5
Medical skills	3	<1000 euros*	5 euros	
Empathy & Emotion	4	<1000 euros*	10 euros	5
Memory	2	<1000 euros*	2 euros	
Activity recognition	4	<1000 euros*	10 euros	5
Decision making	3-4	<1000 euros*	10 euros	
Communications	4	<1000 euros*	10 euros	5
Alert	2	<1000 euros*	30 euros	
Controllability	4	<1000 euros*	30 euros	5
Telepresence	4	<1000 euros*	30 euros	5

(*)Price for the global system including several or all the functionalities, this is, according to C. Ayache the maximum market price for a robotic- system designed for individual use and targeting individual consumers.

(**) Price per month for a basic subscription. The global service could cost 50 euros or less.

Christelle Ayache insists on three points:

-She stresses the difficulty to identify “needs” and to distinguish “needs” from “priorities”. In other words, priorities, in her opinion, are defined by users’ desires and those desires should correspond to the needs.

-She mentions that it is very difficult to identify a price for the services. She bases her evaluation of the prices on the price of applications for smartphones.

-She insists on the difficulty to achieve a good care-robot, referring to the ongoing project ROMEO (Aldebaran). She believes that the security of the elderly is so difficult that it will slow down the potential development of care-robots, notably because a care-robot should be perfectly safe and secure.

5.2.6 Target price for a robot-companion

	THE ROBOT-COMPANION ACCOMPANY		
Service	BRONZE OFFER	SILVER OFFER	GOLD OFFER
Presence	X	X	X
Reminder	X	X	X
Boardgames	X	X	X
Audiobooks reader	X	X	X
Expressing feelings	X	X	X
Telepresence	X	X	X
Coaching	X	X	X
Teach-me program	X	X	X
Internet	X	X	X
Internet simplifier (ASS)		X	X
Coaching with external advisor		X	X
Monitoring system		X	X
Help to fetch objects		X	X
Telepresence (mobile platform)		X	X
Help to carry objects			X
Help for cooking			X
Help to set the table			X
Help to store objects			X
Interact with pets			X
Switch on-off the light			X
Open-close the door			X
Open-close the shutters			X
Help to get up Help to sit down			X

GLOBAL PRICE	Price: < 700 euros	Price : 30-50 euros per month <1000 euros	Price : 3 440[32] euros per year (subscription)

5.2.7 Cost-utility analysis

COST FOR THE USER	UTILITY FOR THE USER
700>3440	Extension of autonomy Pleasure of companionship
COST FOR THE CAREGIVER	UTILITY FOR THE CAREGIVER
0	Reduction of the caring tasks
COST FOR THE SOCIAL SYSTEM	UTILITY FOR THE SOCIAL SYSTEM
0	X
GLOBAL COST	GLOBAL UTILITY
700>3440	Benefits for the companies selling the service

[32] This maximum price wasn't indicated by the experts. It corresponds to the labour cost of social worker (9.43 euros in France), each day of the year, for one year (365x9.43 = 3441 euros). It corresponds to the price of the Irobi (robot-companion), when NAO costs 6000 euros and Pepper should cost 1400 euros. Comparing to existing monitoring system, it is cheaper than the robotic systems (MOSRO, 14 400 euros) but twice as much as the BlueHomecare service (cf Comparable services and products, ANNEXES). One hour for a social worker may represent two or three visits.

5.3 Robot assisted monitoring

5.3.1 Design of the service (informed by usage evaluation)

General description

This monitoring service uses all the possibilities provided by the sensors embedded in the environment. It can help to raise or cancel an alert, to measure activity or to communicate with professional and informal caregivers. The elderly person has the choice to authorize one or several people to have a look inside the house in case of an alert. The system is able to identify critical situations, in particular falls and to raise an alert. It allows the caregivers the option to judge what kind of help is needed and its urgency.

Services identified by participants to the usage evaluation[33]

-Raising alerts
-Cancelling alerts
-Measuring activity
-Coaching

Environment

This service could be installed anywhere (home, enterprises, shops, malls).

Risks and limits

This service already exists on the market at very competitive price and many variations.

Functionalities

Bronze system: tablet, software, platform

Silver offer: tablet, software, mobile platform (remote-controlled), AS

Gold service: tablet, software, mobile platform (autonomous), two arms (tray-gripper), gripper, internal and external sensors, speakers and microphones

[33] All those services have been suggested or evoked by the users during the usage evaluation. The users were interacting with the Care-O-Bot 3 in a smart environment. They were able to see what was possible and what could possible in a short range of time.

5.3.2 Market segment

The market for robots supporting monitoring systems is an experimentation field, with initiatives in prison systems in Korea, projects for surveillance of extended zones or borders in United States of America, in Europe or Israel, robots monitoring buildings (Jazz Gostai) or domestic robots (Wowee). But no system has for the moment found its market. The essential issues are related to the costs of those systems, efficiency and safety. However, those projects still face technical constraints. The French Ministry of Economy estimates that this market could represent 3500 systems for professional applications and 50 000 for domestic applications.

5.3.3 Comparable systems

MOSRO	MONITORING ROBOT	14 400 €
T63 ARTEMIS	MONITORING SYSTEM	21 700 € per year

5.3.4 Comparable services and products

BlueHOMECARE	MONITORING SERVICE including camera, sensors and a central that can be reached any time if needed and which will react in an appropriate way if there is an alert (raising and cancelling alerts)	1500 and 50 € per month

5.3.5 Listening to the experts

All the experts came to the same conclusion on this scenario. Monitoring services may be a complementary function but they cannot be the heart of the product-vision. Indeed, there are too many monitoring services already available on the market, with competitive prices.

5.3.6 Target price for a monitoring system

	Care ACCOMPANY-System		
Service	BRONZE OFFER	SILVER OFFER	GOLD OFFER
Measuring activity	**X**	**X**	**X**
Reminder (pills, good practices)	**X**	**X**	**X**
Raising alerts	**X**	**X**	**X**
Monitoring system	**X**	**X**	**X**
Coaching	**X**	**X**	**X**
Quantified-self function	**X**		

Intelectual stimulation	X	X	X
Communication with the user or with an intruder	X	X	X
Raising and cancelling alerts		X	X
Communication with the caregivers		X	X
Telepresence		X	X
Telemedecine		X	X
Coaching with external advisor		X	X
		X	X
Empathy			
Staying autonomous Help to fetch objects		X	X
Internet simplifier (ASS)		X	X
Monitoring system Mobile platform			X
Help to carry objects			X
Help to store objects			X
Help to get up Help to sit down			X
	Price: < 700 euros	Price : 30-50 euros per month <1000 euros	Price : 3 440[34] euros per year (subscription)

Here, the gold service including fetch and carry functionality is really not “needed” because the basic service is a Monitoring system. However this function may have a real added-value and we try to understand the best way to find the market. Care system, companion robot and monitoring system can be considered as gateway to the market but eventually, the gold version of those three services should be really comparable, because a gold service has to be as complete as possible.

[34] This maximum price wasn’t indicated by the experts. It corresponds to the labour cost of social worker (9.43 euros in France), each day of the year, for one year (365x9.43 = 3441 euros). It corresponds to the price of the Irobi (robot-companion), when NAO costs 6000 euros and Pepper should cost 1400 euros. Comparing to existing monitoring systems, it is cheaper than the robotic systems (MOSRO, 14 400 euros) but twice as much as the BlueHomecare service (cf Comparable services and products, ANNEXES). One hour for a social worker may represent two or three visits.

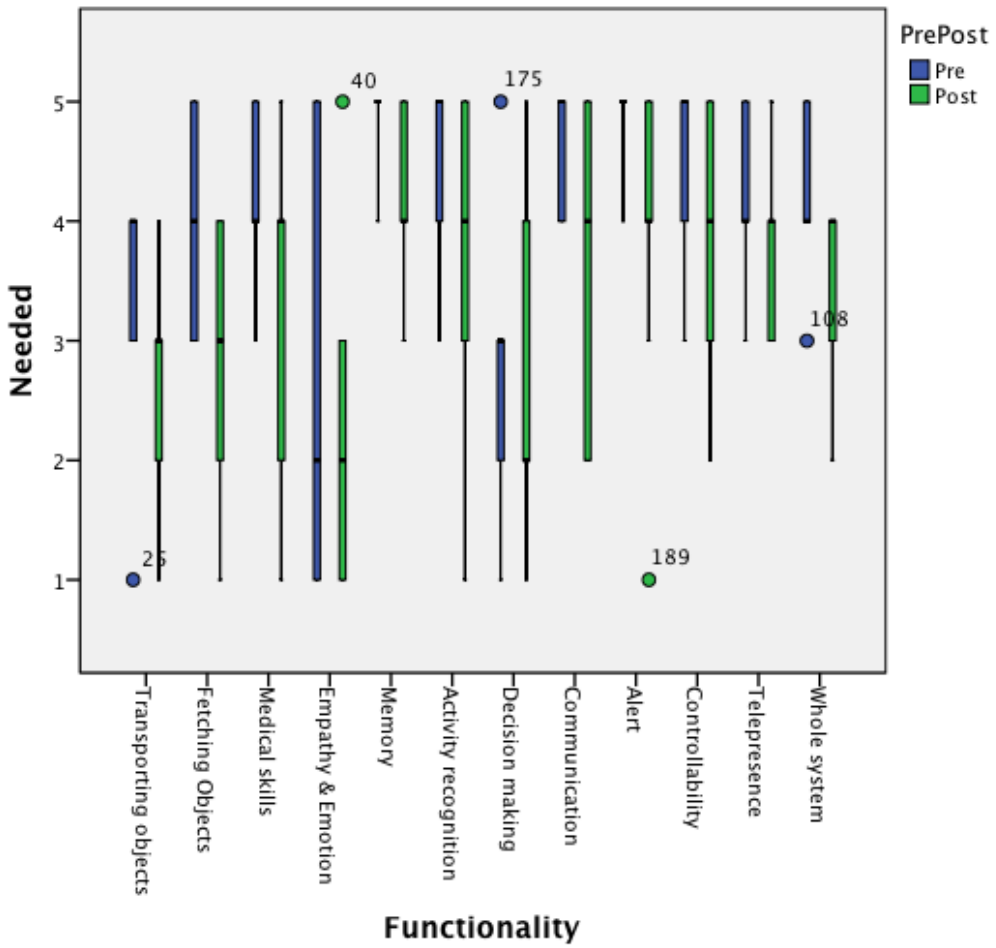
5.3.7 Cost-Utility and cost-benefit analysis of an ACCOMPANY monitoring system

COST FOR THE USER	UTILITY FOR THE USER
700>3440	Better protection Better health
COST FOR THE CAREGIVER	UTILITY FOR THE CAREGIVER
X	Time saving, ability to identify urgent situation and provide rapid response
COST FOR THE SOCIAL SYSTEM	UTILITY FOR THE SOCIAL SYSTEM
X	X
GLOBAL COST	GLOBAL UTILITY
700>3440	Increasing safety for the elderly people Benefit for companies implied in the development of the service

5.4 Results from the focus group

A workshop with care professionals involved in care service delivery was conducted with 8 participants. This was led by the the University of Hertfordshire (09/09/14). Two other similar workshop/focus groups were conducted with health care professionals the London School of Economics and in France, with economic specialists. The results are consistent, allowing us to draw some first conclusions on flagging value propositions.

A grid, similar to the one shown to interviewed experts, was presented to the participants. Initially, a series of functionalities were listed without any explanations regarding the ACCOMPANY system. Participants were taken through the functionalities and each offered a rating between 5-1, 5 being most needed and 1 being least needed function for a system that can help with independence of the elderly in their home. Once this table was filled, a video of the Accompany scenario 2 was presented and participants were asked to refill the table, as well as to answer whether a care, companion or monitoring solution would be best suited in their opinion.



This graph shows the results from the workshop, highlighting important functions seen as needed as well as providing insight on how ACCOMPANY's solution could

affect the pre-judgment of individuals involved. Results highlight that a better than 4 score was offered to the whole system before the video presentation, which was subsequently lowered to score of 3 after the video presentation. Participants commented on the fact that what they had imagined was far more developed and more versatile than the ACCOMPANY system.

Based on pre-judgement, only system's decision making abilities (authoritarian and paternalism as offered in D6.4 and D6.6) is seen as less needed, with empathy and emotion scoring a variety of points. At the post-judgement, two functions are identified as less necessary: *Transporting objects* and *Empathy and Emotion*. Participants commented on slow speed of robot and its limited manipulation speed, while for empathy and emotion, participants commented regarding our modern technologies not being able to replace human empathy and emotion.

Noting the study's limitation, small number of very specialist group of participants, the more prominent of the results related to the whole system is considered as favourable and in-line with the findings from our acceptability studies in D6.3 and D6.5.

5.5 ACCOMPANY product vision

Instead of choosing one of the scenarios as product vision, we find more relevant to compose the best possible scenario using all the inputs from the three scenarios.

5.5.1 *Intermediate conclusions*

- The comparable services and products and the experts interviews leads us to identify the target price of the basic service at 700 euros or 30 euros per month and the maximum price to 30 000 for a gold care-service. Multi-level services can increase the goodwill of the product vision.

- The robot within the ACCOMPANY system might have two identified values. A friendly presence on the one hand and on the other hand, a mobile platform fetching, grapping and carrying objects, the second function being clearly more expensive. The monitoring system might be included in all possible systems at a lower cost (Care system and companion robot). Consequently, the optimal service seems to be a basic and low cost companion-robot service, setting out options (middle service and premium service) which might allow the service to ensure monitoring tasks and care services.

- Within the ACCOMPANY system, the robot should be a friendly presence simplifying the daily-life of the elderly-people.

- An after sales service and-or a central service is much needed, in order to offer a service (for updates, coaching, telemedicine and telecare, simplified internet use). This consideration has not been included in the pricing of the current ACCOMPANY system and is subject to further exploitation planning.

5.5.2 Product vision for the exploitation planning

Throughout this report, we have identified three main added-values of a robotic system in elderly people's home.

ADDED-VALUE 1: a friendly presence simplifying the daily life of the elderly.

ADDED-VALUE 2: an after sales service and-or a central service offering updates, coaching, telemedicine, telepresence, and telecare, simplified internet use.

ADDED-VALUE 3: a care-system helping the elderly people to stay at home in an autonomous way, and preventing them to go in a Nursing home, helping them to get up and sit down, fetching and carrying things, having medical skills (measure, reminder, alerts).

This corresponds clearly to three levels of price and three technological readiness levels (see 6.4).

ADDED-VALUE 1: <700 euros (current readiness level: TRL7)

ADDED-VALUE 2: <700 + a subscription (30/50 euros per month) (current readiness level: TRL 6)

ADDED-VALUE 3: <30 000 euros (current readiness level: TRL 3)

Environment of the ACCOMPANY product vision

The ACCOMPANY product-vision should be designed for all apartments built on one floor, in urban, suburban or rural environments.

Functionalities of the ACCOMPANY product vision

Bronze system: tablet, software, platform (700 euros)

Silver offer: tablet, software, mobile platform (remote-controlled), AS (+ a subscription (30/50 euros per month)

Gold service: tablet, software, mobile platform (autonomous), two arms (tray-gripper), gripper, internal and external sensors, speakers and microphones, <30 000 euros.

6. Development perspectives

6.1 Development opportunities

Through this economic report, we have identified three main development opportunities:

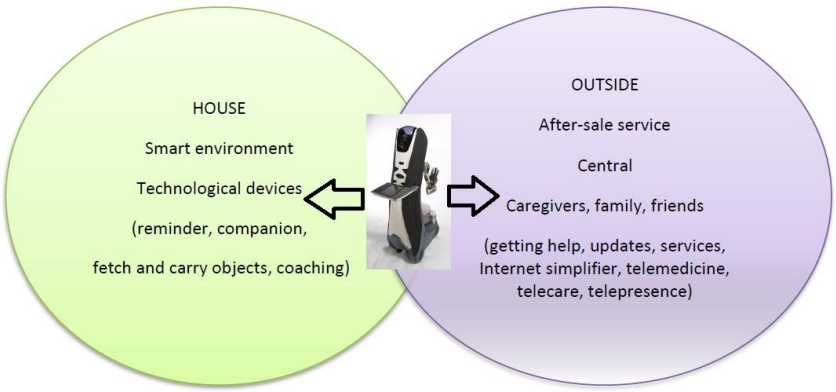
- **Ageing (sustain autonomy, re-ablement)**
- **Shared funding**
- **Jobs' improvement (professional caregivers)**

Ageing: this item has been widely developed in the present report**.**

Co-funding

If we consider the example of nursing homes in France, funded by the senior (60%), the Health Insurance and local authorities –APA- (40%), we can conceive global funding of a system allowing seniors to stay at home instead of going into a nursing home. As this model would imply savings for all the stakeholders (states, region and patient), it might be seen as a development opportunity.

ACCOMPANY care-system co-funding model



LIVING HOME	HEALTHCARE	DEPENDENCE
SENIOR	HEALTH INSURANCE	APA
60% (20 880 euros on our model)	40% (13883 euros in our model)	

6.2 Variables

The main variables within ACCOMPANY product-vision are

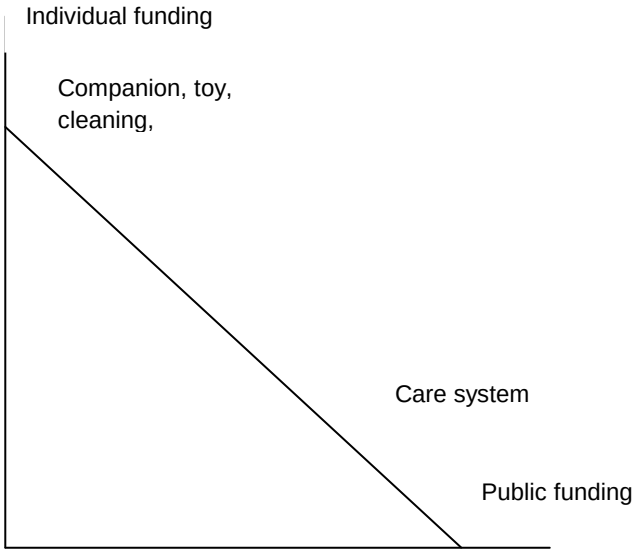
1. Autonomy of the senior // dependence of the senior
2. Staying at home // going in a nursing home
3. Individual usage of the system // collective usage of the robot
4. Substitution to human work // supporting human work
5. Individual funding // collective funding // social funding

Main variables impacting on the sustainability of the ACCOMPANY product-vision

- Potential GDP (Growth rate)
- Labour cost
- Life expectancy at birth
- Life expectancy at 65
- Average exit age
- Economic old age dependency ratio
- Health care spending as % of GDP
- Long term care spending as % of GDP
- Technological readiness level
- Impact of robotics on labour markets
- Impact of robotics on labour costs
- Public funding of robotic researches
- Private investment on robotic development
- Impact of the robot-based systems on the ecosystems
- Ability to maintain elderly people at home

- Profitability of “staying at home” versus going to a nursing home
- Development of collective use or individual use of robotic systems

Variables : an example



6.3 Areas of uncertainty

- Purchasing power of the elderly people in the coming years.
- Ability or willingness of the Health Insurance system to recognize and refund robotic based care-system.
- Reliability of robotic based care-system in a domestic environment.
- Durability of robotic based care-system in a domestic environment.
- Safety of robotic based care-system in a domestic environment.
- Reactions of professional caregivers and social workers toward the robot.
- Reactions of family, friends and neighbors toward the robot.
- Social acceptance of the medical skills or the medical role of a robot-based care system.

6.4 Technology readiness level (TRL[35])

The "Robotics 2020, Multi-Annual Roadmap" proposes a definition of the 9 TRL adapted to robotics. If we consider the whole ACCOMPANY system as it was used during the ACCOMPANY experiment, a level 6 has been reached. For the ACCOMPANY product vision, step 6 needs to be reached because the association of technologies and the services offered change the system that has to be tested. Yet, the TRL 6 implies that the project is developed enough so that "*selected customers can carry out tests, when accompanied by developers*". If the function "help to get up and to sit down" is to be included, the whole product vision would reach a TRL2. In the exploitation plan, we shall discuss the different TRL and asses what kind of service could be provided, at what price, today, in three years, six years or ten years.

Level 1 - Basic Principles Observed (REACHED)
Idea: Basic technology research.
Document elaborated which describes a product / feature idea and/or potential market requirement: Functional description, customer benefit, ideas for realization.

Level 2 - Technology Concept Formulated (REACHED)
Concept Formation: Basic technology research.
Proof of principle developments including algorithm development and simulations.
Concept formulated with details on potential development risks, including coarse resource planning.

Level 3 - Experimental Proof of Concept (REACHED)
Experimental Development: Technology development.
Realization of parts of the Concept to visualize the product / feature idea;
proof of concepts, first components and interfaces developed;
lab experiments carried out; future technical scope of work identified.

Level 4 - Technology Validated in Laboratory (REACHED)
Experiment: Technology development.
Testing of system or major sub-systems; validation against established benchmarks;
Testing of internal and external inter-connectivity.
Initial normative testing with trained users possible.

Level 5 - Technology Validated in Relevant Environment (REACHED)
Lab prototype: Internal technology demonstration.
Main functionality of product / feature idea can be demonstrated.
Major risks for the realisation of a future product / feature have been documented as part of the description of the Demonstrator / realisation.

Level 6 - Technology Demonstrated in Relevant Environment (REACHED)
Functional model/First Field Trials: External technology demonstration.
Main functionality of product / feature idea is realised at a degree that selected customers can carry out tests, when accompanied by developers.

[35] "Robotics 2020, Multi-Annual Roadmap", For Robotics in Europe, Call 1 ICT23 – Horizon 2020, Initial Release B 15/01/2014. The titles for each TRL level are taken from the definitions in agreed Horizon 2020 documentation that can be found here:http://ec.europa.eu/research/participants/data/ref/h2020 /wp /2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf). These titles are not obviously applicable to the robotics domain and so the following represent an expansion of terminology and are followed by a series of basic examples to clarify the intent at each level.

Level 7- System Prototype Demonstration in Operational Environment (TO DO)
Engineering Prototype
Development of prototypes with final technology sub-systems or close analogues in a close to complete form factor.
All identified functionality is capable of being demonstrated.
Customer verification trials (independent of developer support) possible.

Level 8 - System Complete and Qualified (TO DO)
Production Prototype
Development of prototypes with final functionality and form factor.
Sufficient for end user testing in limited launch markets.
Initial batch production of the products.

Level 9 - Actual System Proven in Operational Environment (TO DO)
Series production and sales.

	ACCOMPANY SYSTEM (Used in the experiment)	ACCOMPANY Product-vision	ACCOMPANY Product-vision *including help to get up and to sit down*
TRL 1	Reached	Reached	Reached
TRL 2	Reached	Reached	Reached
TRL 3	Reached	Reached	To do
TRL 4	Reached	Reached	To do
TRL 5	Reached	Reached	To do
TRL 6	Reached	To do	To do
TRL 7	Partially reached	To do	To do
TRL 8	To do	To do	To do
TRL 9	To do	To do	To do

7. Conclusions

Further to intermediate conclusion made in this study, the ACCOMPANY system has been evaluated, in order to provide an ACCOMPANY product vision that could be submitted towards a positive exploitation plan. This economic evaluation report provides rich material and a scenario that allows us to lead the exploitation plan (D7.4): a state of the art, reflections on the scenario based on workshops, focus groups, experts interviews and the usage evaluation, multi-level offers model, identification of the TRL, analysis of the ecosystems, cost-utility analysis, multi-sources funding and an analysis of the economic and demographic data based on the Ageing report 2012 issued by the European Commission (30% of Europeans will be 65 or older in 2060).

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The evaluation was based on three scenarios identified by the French Ministry of Economy, Finances and the Industry, corresponding to the market segment: robot companion, care-robots and robot-based monitoring system. The evaluation lead us to compose an ACCOMPANY product-vision taking the best from the three scenarios, and allowing us to produce a product-vision close to the market.

The main findings highlighted three different added values, a companion robot with a friendly presence; a care service with embedded sensors and variable set of add/remove components such as situation updates, coaching, telepresence, and simplification of service use by means of easier to use interfaces; and finally a further to achieve fully autonomous care companion which we currently estimate at TRL2.

The report highlighted the ecosystem surrounding a potential product, alongside the view of evolution of needs due to ageing trends highlighted. It provides a rationale to believe that in the coming decade, systems such as ACCOMPANY and its derivation into care, companion and monitoring, would play a larger role in everyday care and within the ecosystem. This is further supported by increase in number of projects in this area, and number of robots and advanced ICT solutions that emerge due to large number of elderly and growth of their population, being linked with an unprecedented purchasing power.

The methodology, discussed with Robert Picard from the French Ministry of Economy (CGIET) may be useful in other European projects such as (TERESA), as well as the huge number of documents and resources collected to lead this evaluation.

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Appendices

Appendix 1, Comparable robots, services and products

Robots

Name	Category	Price
EMOX	ROBOT-COMPANION	700 €
PEPPER	ROBOT-COMPANION	1400 €
AIBO	ROBOT-COMPANION	2000 €
LUNA	ROBOT-COMPANION	2100 €
IROBI	ROBOT COMPANION	3500 €
NAO	ROBOT-COMPANION	6000 €
JAZZ	ROBOT-COMPANION	7400-14 000 €
WAKAMARU	ROBOT-COMPANION	1600 €
ROBO-VIE R3	ROBOT-COMPANION	30-40 k €
ENON	ROBOT-COMPANION	45 000 €
EVE-R-1	ROBOT-COMPANION	244 000 €
HRP 4C	ROBOT-COMPANION/ ROBOT-LEISURE	300 000 €
PR2	ROBOT-COMPANION	400 000 €
ASIMO	ROBOT-COMPANION/ROBOT-ASSISTANT	1.9 millions €
Robot MiP WowWee	ROBOT-LEISURE//ROBOT TOY	99 €
RP-VITA	CARE-ROBOT	3000-4500 € (for an hospital)
MOSRO	MONITORING ROBOT	14 400 €
T63 ARTEMIS	MONITORING SYSTEM	21 700 e per year
ROVIO	TELEPRESENCE ROBOT	114 €
GIRAFF	TELEPRENCE-ROBOT	2283 €
HERCULE	EXOSKELETON	40 000 € (2017)
ROOMBA	ROBOT-VACUUM CLEANER	729 €

.Non-robotic products and services

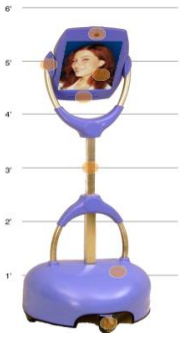
Non-robotic products		
Otolift	ELEVATOR (stairs elevator)	3500 to 9000 €
BlueHOMECARE	MONITORING SERVICE	1500 and 50 € per month
Non-robotic services		
Social worker : 9.43 euros per hour in France		

Comparable robots (description)

	Description of the service	**Price**
	**Robot MiP WowWee Silverlit** Silverlit ROBOT-LEISURE//ROBOT TOY -Moving device -Following movements (hands) -Avoiding obstacles -Playing with a tray	99 €
	**Irobi** Yoojin Robot TEACHING-ROBOT//ROBOT COMPANION -Teaching -Singing and talking to children -Moving autonomously -Connecting to Internet -Detecting fire -Detecting strangers	3500 €
	**Luna** RoboDynamics robotics ROBOT-COMPANION -Moving autonomously -Walk the dog (in a smart environment) -Helping to read mail -Recognizing its owner voice -Carrying things on a tray	2100 € Expected price (650 €)

	**EVE-R-I** Kokoro Dreams and Osaka University of Japan ROBOT-COMPANION-ACTROID -Recognizing vocal questions -Answering questions with facial expressions -Answering questions with voice -Following eyes	244 000 € 321 000 $
	EMOX Awabot ROBOT-COMPANION -Moving and avoiding obstacle autonomously -Identifying persons, ages -Reacting to facial expressions -"Running after a ball" -Interacting with the user	700 €
	**JAZZ** Gostai ROBOT-COMPANION -Telecare -Telesurveillance -Communication -Moving by remote-control (from inside or outside the house).	7400 €- 14 000 €
	**RP-VITA** Irobot CARE-ROBOT -Telecare -Moving autonomously -Communication	3000-4500 € (for an hospital) 4000-6000$ per month
	**MOSRO** Robowatch MONITORING ROBOT -Detecting problems (intruder, fires) -Raising alerts -Moving autonomously	14 400 €

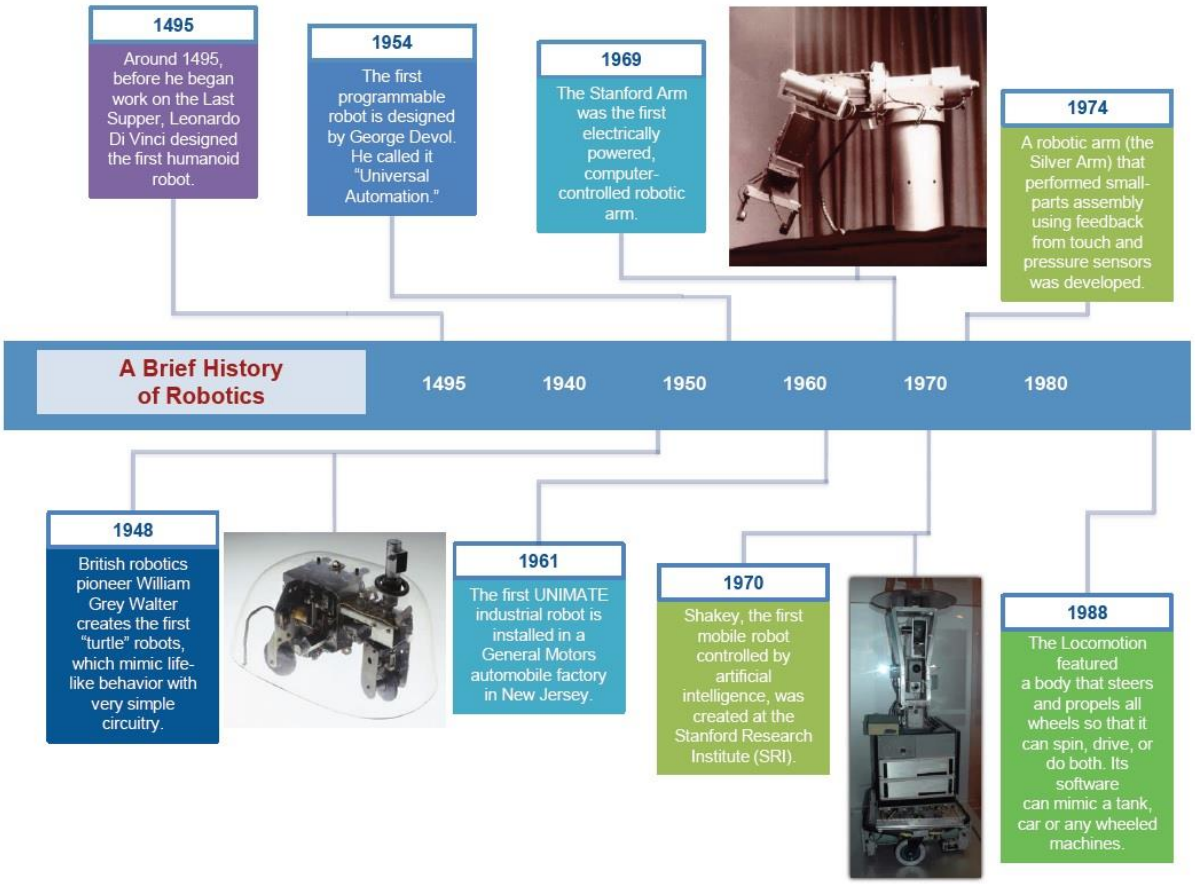
	**T63** **Artemis** TMSUK MONITORING SYSTEM -Patrolling autonomously -Communication -Speakers and microphones -Raising alerts -Detecting persons -Detecting fire	21 700 € per year (with an insurance and an after sales service)
	**ROVIO** WowWee TELEPRESENCE ROBOT -Moving webcam	114 €
	**Enon** Fujitsu corporation ROBOT-COMPANION - Moving autonomously - Speech recognition - Fetching and carrying (500 grams) - Teaching	45 000 €
	**NAO** Aldebaran ROBOT-COMPANION -Speaking -Speech recognition -Person recognition -Teaching -Interaction -Playing --Moving autonomously in a smart environment	6000 €

	**PEPPER** Aldebaran ROBOT-COMPANION -Speaking -Speech recognition -Person recognition -Teaching -Interaction -Playing -Emotional movements (interacting) --Moving autonomously in a smart environment	1400 € JPY 198,000
	**ROMEO** Aldebaran ROBOT-COMPANION-CARE-ROBOT -Speaking -Speech recognition -Person recognition -Moving autonomously in a smart environment -Interacting with people -Reminder -Fetching and carrying objects -Playing -Giving advices	(?) The program cost 28 000 000 €.
	**AIBO** Sony ROBOT-COMPANION -Speech recognition -Moving autonomously -Playing -Co-learning	2000 €
	**GIRAFF** GIRAFF TELEPRENCE-ROBOT -Moving autonomously in a smart environment -Communication -Helping for emails	2283 € (3000 dollars)

	**Hercule** RB3D EXOSKELETON -Helping to move -Helping to carry heavy objects	40 000 € (2017)
	**HRP 4C** National Institute of Advanced Industrial Science and Technology ROBOT-COMPANION/ ROBOT-LEISURE -Speech recognition -Speaking -Singing -Facial movements -Human like movements	300 000 €
	**ASIMO** Honda ROBOT-ASSISTANT/ROBOT-COMPANION -Recognizing objects, movements, postures, gestures -Moving autonomously -Interacting, synchronizing with human -Walking, running, dancing -Pushing a cart -Carrying a tray	2.5 millions dollars 1.9 millions € 160 000 dollars per year
	**PR2** Willow Garage ROBOT-COMPANION -Moving autonomously in a smart environment -Fetch and carry things -Playing snooker -Doing laundry	400 000 €
	**Irobot roomba** Irobot ROBOT-VACUUM CLEANER -Moving autonomously	729 €

Non-robotic products		
	**Otolift** Otolift Elevator -Helping to move autonomously -Helping to stay at home	3500 to 9000 €
	**BLUEHOMECARE** BlueLinéa MONITORING SERVICE -Complete monitoring service with an after-sale service and a central to raise and cancel alerts.	1500 € and 50 € per month

Appendix 2, A brief history of robotics[36]



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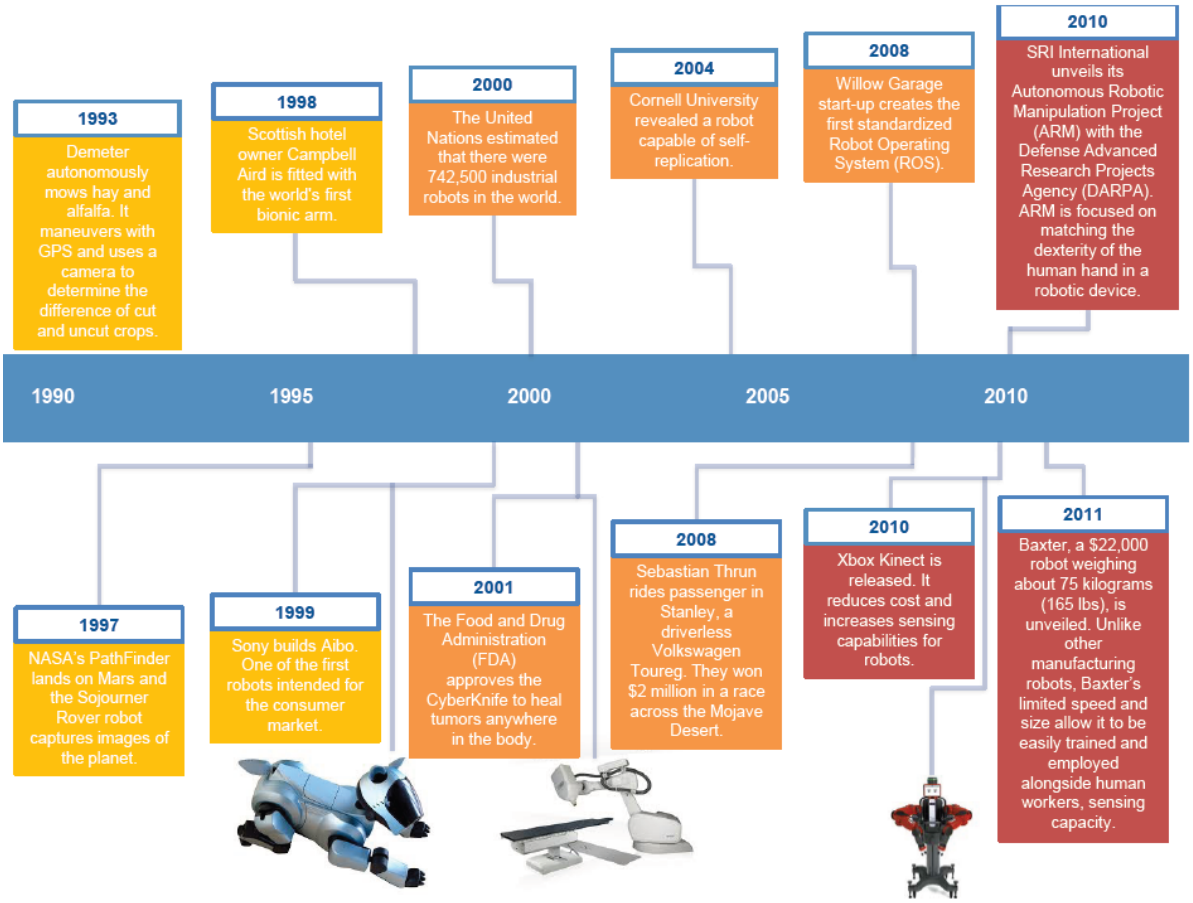
1993
Demeter autonomously mows hay and alfalfa. It maneuvers with GPS and uses a camera to determine the difference of cut and uncut crops.
1998
Scottish hotel owner Campbell Aird is fitted with the world's first bionic arm.
2000
The United Nations estimated that there were 742,500 industrial robots in the world.
2004
Cornell University revealed a robot capable of self-replication.
2008
Willow Garage start-up creates the first standardized Robot Operating System (ROS).
2010
SRI International unveils its Autonomous Robotic Manipulation Project (ARM) with the Defense Advanced Research Projects Agency (DARPA). ARM is focused on matching the dexterity of the human hand in a robotic device.
1990
1995
2000
2005
2010
1997
NASA's PathFinder lands on Mars and the Sojourner Rover robot captures images of the planet.
1999
Sony builds Aibo. One of the first robots intended for the consumer market.
2001
The Food and Drug Administration (FDA) approves the CyberKnife to heal tumors anywhere in the body.
2008
Sebastian Thrun rides passenger in Stanley, a driverless Volkswagen Toureg. They won $2 million in a race across the Mojave Desert.
2010
Xbox Kinect is released. It reduces cost and increases sensing capabilities for robots.
2011
Baxter, a $22,000 robot weighing about 75 kilograms (165 lbs), is unveiled. Unlike other manufacturing robots, Baxter's limited speed and size allow it to be easily trained and employed alongside human workers, sensing capacity.