International Workshop on AUTONOMICS and Legal Implications

Federal Ministry of Economics and Technology, Berlin

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Autonomous Systems and Robot Companions: Paving the Way Towards the Establishment of a 'Robolaw' Framework in Europe

Paolo Dario

The BioRobotics Institute

Scuola Superiore Sant'Anna

Pisa, Italy

paolo.dario@sssup.it

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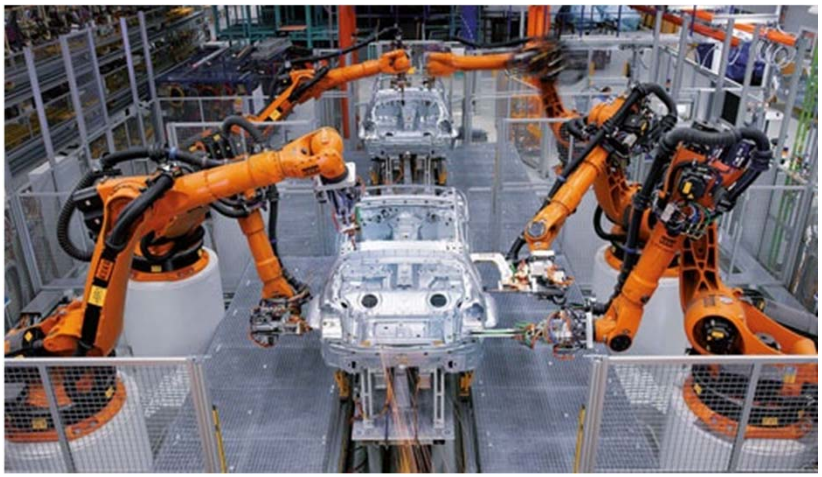
  - The case of the DustBot project
  - The FET Flagship “Robot Companions for Citizens” proposal
- Challenges to be overcome
  - Better science and better technologies
  - Social, ethical and legal issues
- Autonomy and Law
- Conclusions

Robots are among us

- From *industrial* to *service* robotics
  - Robots move closer to human beings



Robots are increasingly successful

More than ***1 million operational industrial robots in the world***, with a growth rate of **6% per year** (*Source: IFR*)

Reliability of industrial robots:
Mean Time Before Failure = 40,000 hrs
Efficiency η > 99.99875%
(*Source: COMAU*)

Around ***5 millions service robots are sold annually***
Service robots are one of the fastest growing markets (**~14% per year**)
Professional service robots account for 80% of sales value

Eurobarometer Survey (Released September 2012)

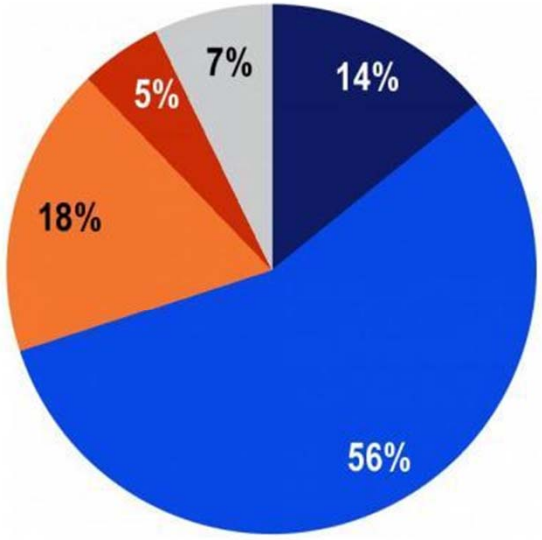
Public attitudes towards robots

- *Background:*
  - Public perceptions of robots are often influenced by misconceptions and fears
  - In order to improve the image of robots and to increase public acceptance, it is necessary to better understand public opinion about this technology
- *Representative survey in all 27 EU member states with* 26.751 respondents taking part overall
- *Fieldwork took place between February and March 2012*

Courtesy: Björn Juretzki, Unit A2 – Robotics - DG Communications Networks, Content and Technology European Commission

Majority of respondents have positive view of robots

QA4. Generally speaking, do you have a very positive, fairly positive, fairly negative or very negative view of robots?



Very positive | Fairly positive | Fairly negative | Very negative | Don't know

EU27

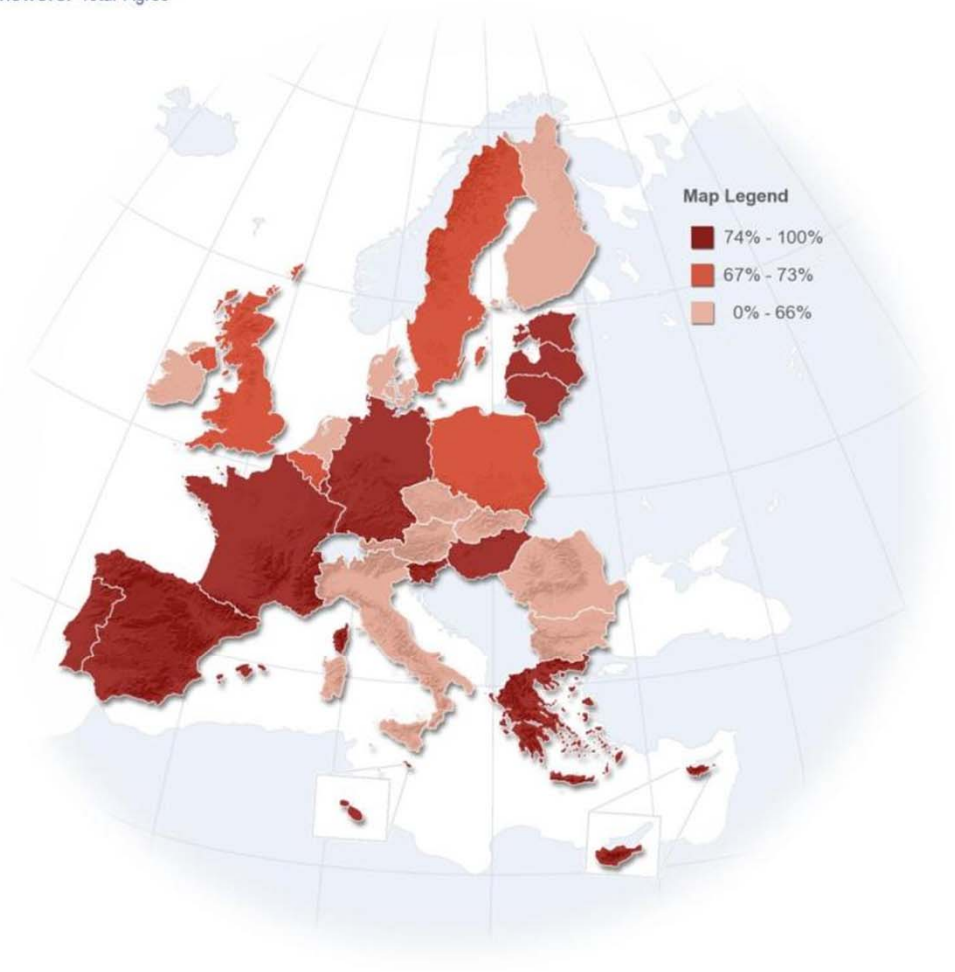
- **70% of respondents think that robots steal people's jobs**
- **Opinion least widespread in Scandinavia and Central/ South East Europe**
- **Strongest agreement in South West Europe**

PT	89%
ES	84%
EL	83%
CY	83%
MT	82%
LU	79%
LV	78%
HU	78%
LT	78%
EE	77%
SI	76%
DE	76%
FR	74%
BE	72%
EU	70%
PL	70%
SE	67%
UK	67%
IT	64%
RO	63%
IE	63%
BG	61%
CZ	60%
SK	60%
DK	59%
AT	58%
FI	55%
NL	51%

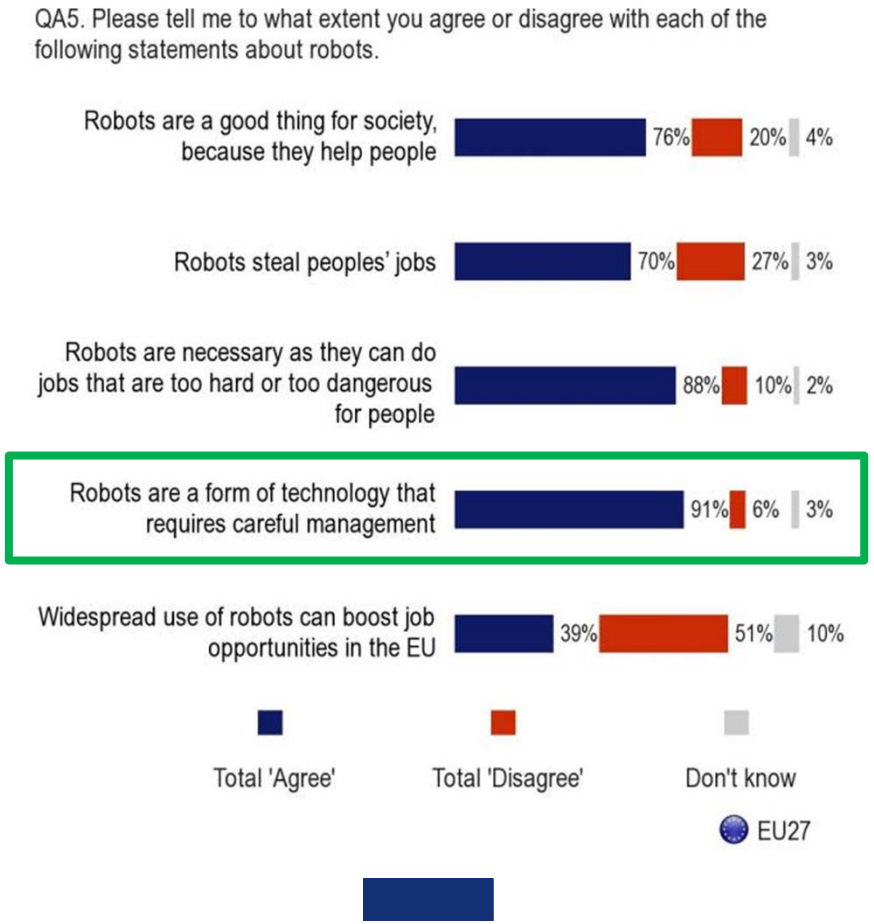
Question: QA5.2. Please tell me to what extent you agree or disagree with each of the following statements about robots.

Option: Robots steal peoples' jobs

Answers: Total 'Agree'

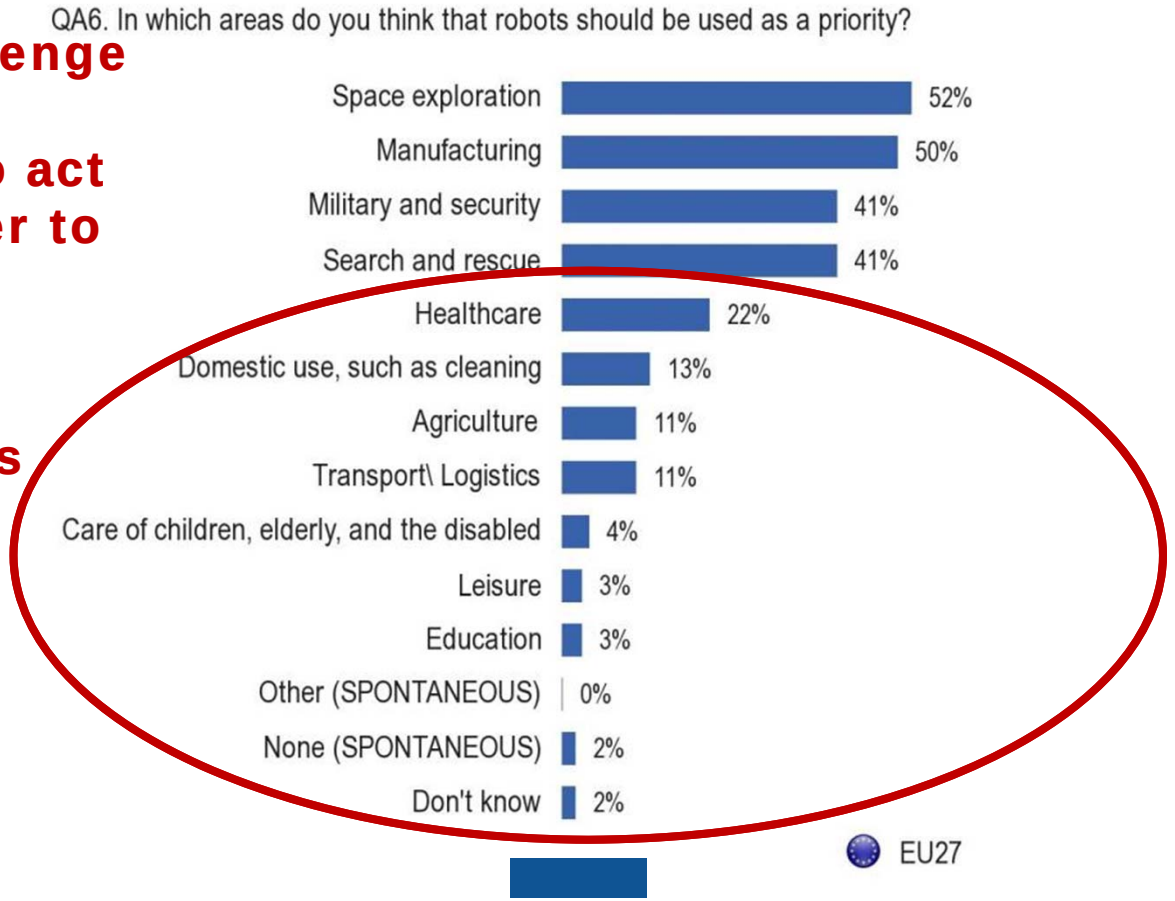


Overview of general attitudes towards robots



Respondents consider space exploration, manufacturing, military&security and search and rescue as priority application areas

A major challenge for robotics research is to act HERE, in order to raise this low perception of usefulness of service robots



Summary of Survey

- *More open attitudes towards robots in Scandinavia and Eastern Europe, more negative views in Southern Europe*
- *Interest in science has a strong positive impact on how people perceive robots (and interest in science is declining across the EU)*
- *Image of robots as job killers still widespread (especially in big countries like DE, FR and ES)*
- ***Once people get in touch with robots, their attitudes change and get more positive***

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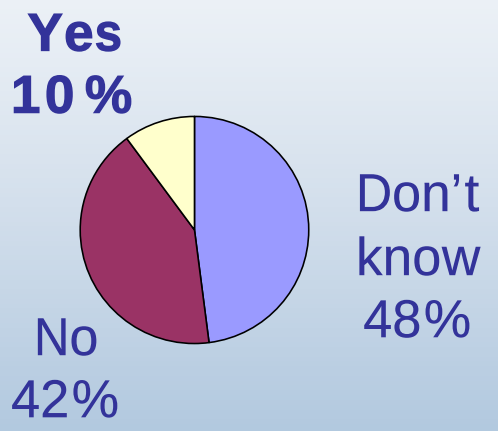
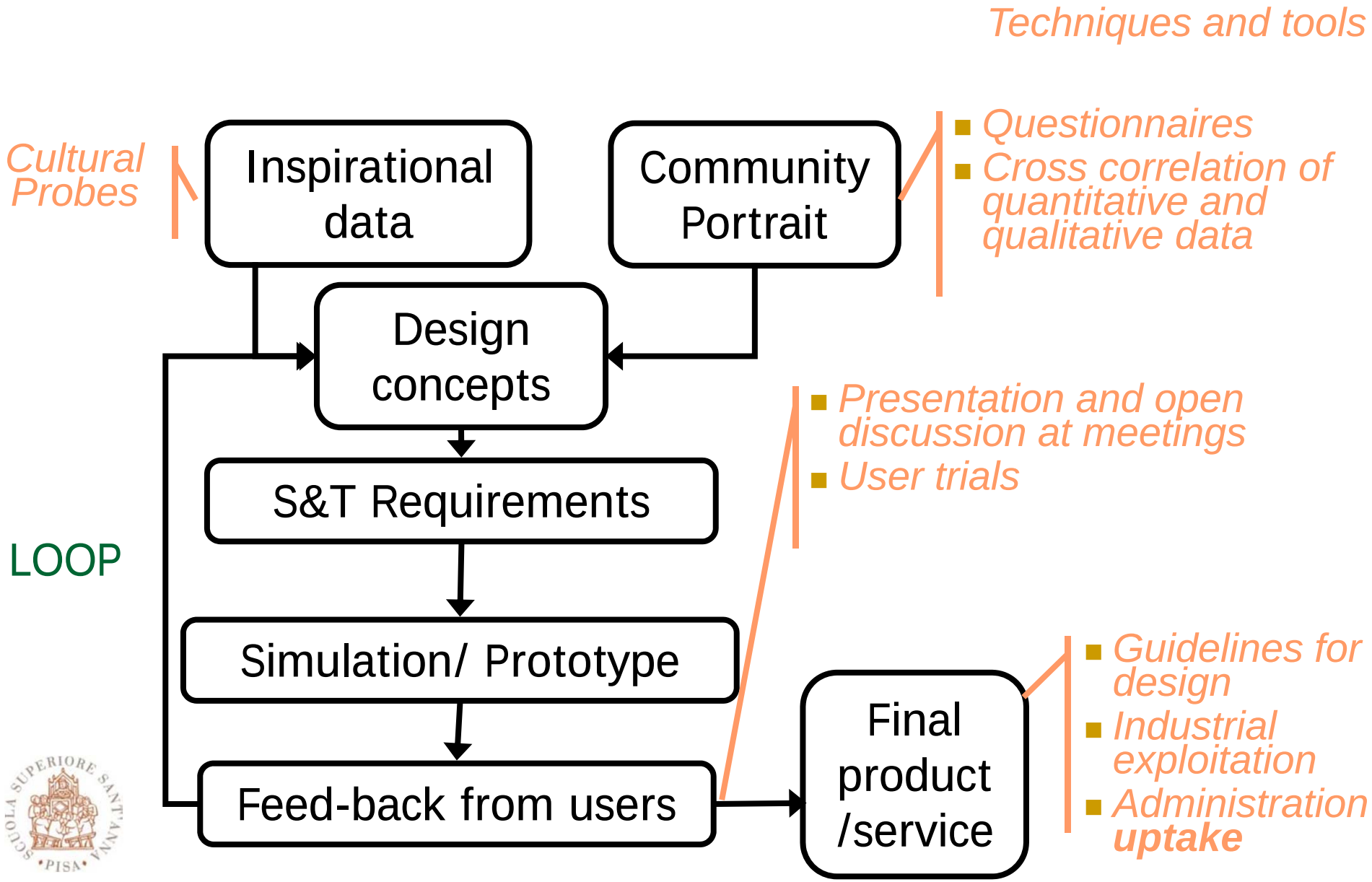
The EU MOVAID Project (**1994-1997**)

Before MOVAID

Q: Can you imagine a robotic assistant?



A pioneer experience: user-centred design methodology (1995 – 1999)



The EU MOVAID Project (**1994-1997**)

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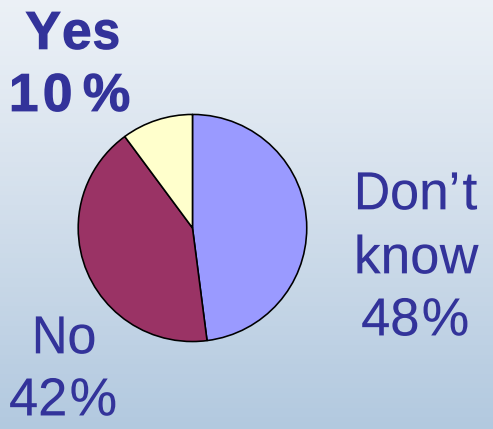


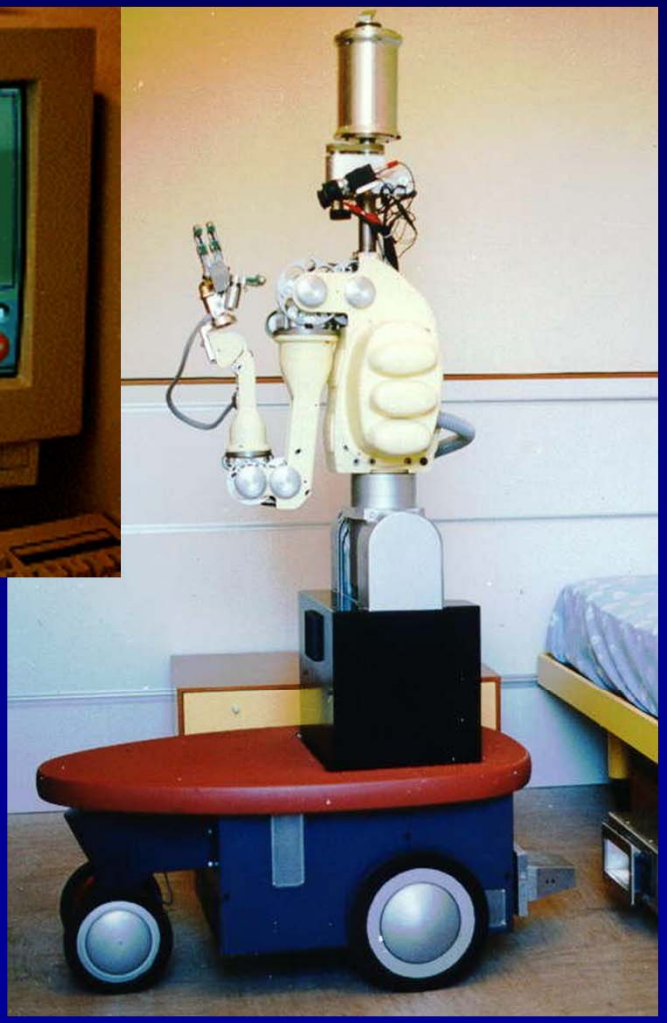
User Trials

64 users involved in user trials and demonstrations in 3 European countries

“Co-Pilot Mode”: the MOVAID Robotic System (1994-1997)

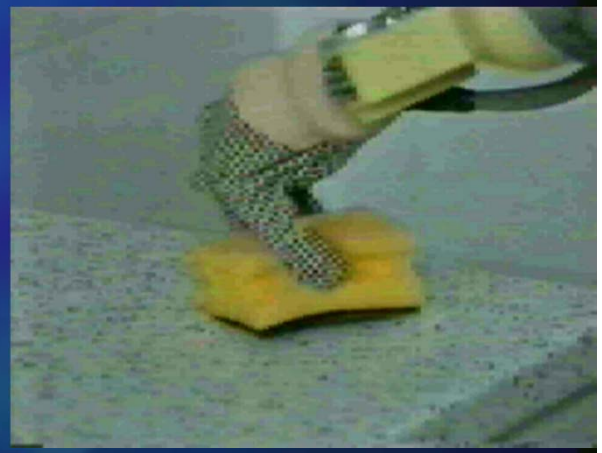
The user is involved in task execution

(i.e. in object identification and localization)



Evaluation of the MOVAID prototype

User Trials



64 users involved in user trials and demonstrations in 3 European countries

The EU MOVAID Project (1994-1997)

Before MOVAID

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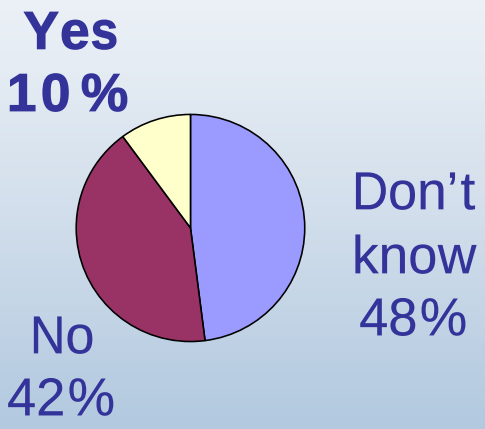
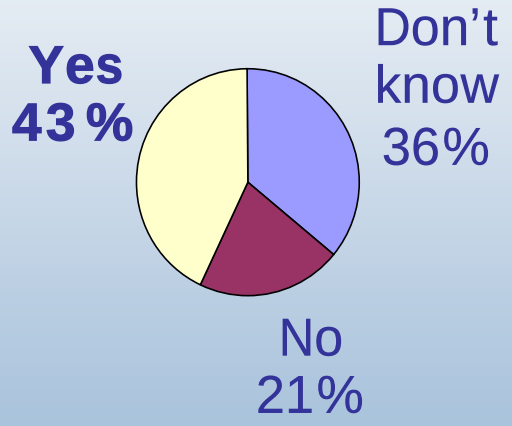


User Trials

64 users involved in user trials and demonstrations in 3 European countries

After MOVAID

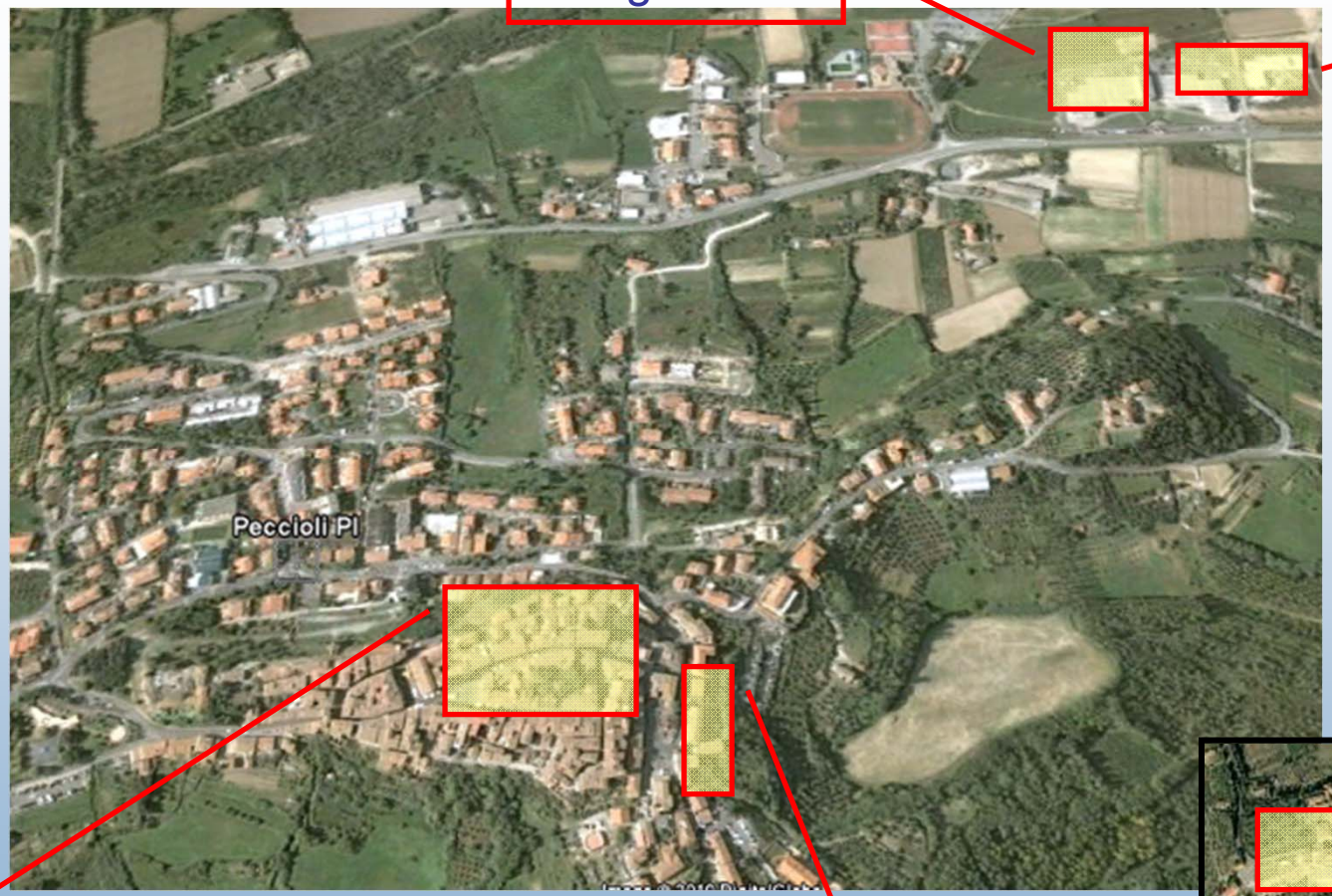
Would you like to have a robotic assistant?



Consolidating this experience and establishing "**The RoboTown**"

- **Peccioli** is a small town in Tuscany (Italy) composed of **squares and narrow streets** with slopes and ancient paving, **low populated** (about 5.000) and with a **high percentage of elderly citizens** (20% are over 65)
- Since 1995 the municipality of Peccioli has agreed with Scuola Superiore Sant'Anna and has supported the **R&D of innovative ICT- based solutions** in the field **of assistive and robotic technology** for elderly and disabled persons

Main places of activities and field tests



DomoCasa Living Lab

Industrial Area

Ghizzano Nursing Home

Peccioli town center

Social Services and Supervision

The town centre

The agreement with the municipality and institutions is crucial for availability of:

- all **infrastructures** involved in the experimentation
- **technical, administrative and financial support**
- **legal authorizations and insurance**
- the **Peccioli social service centre**

Applications and robotic services

- accompanying elderly people outdoor for walking, shopping, supporting and safety and for transporting goods in urban areas
- education and entertainment
- robots for management of urban hygiene by cleaning streets and transporting home garbage

DomoCasa

- Living lab equipped with **home automation system** and facilities to favour **experimental setting with real citizens and innovative technologies**:
  - **pervasive wireless sensor network** and **indoor robotic services**



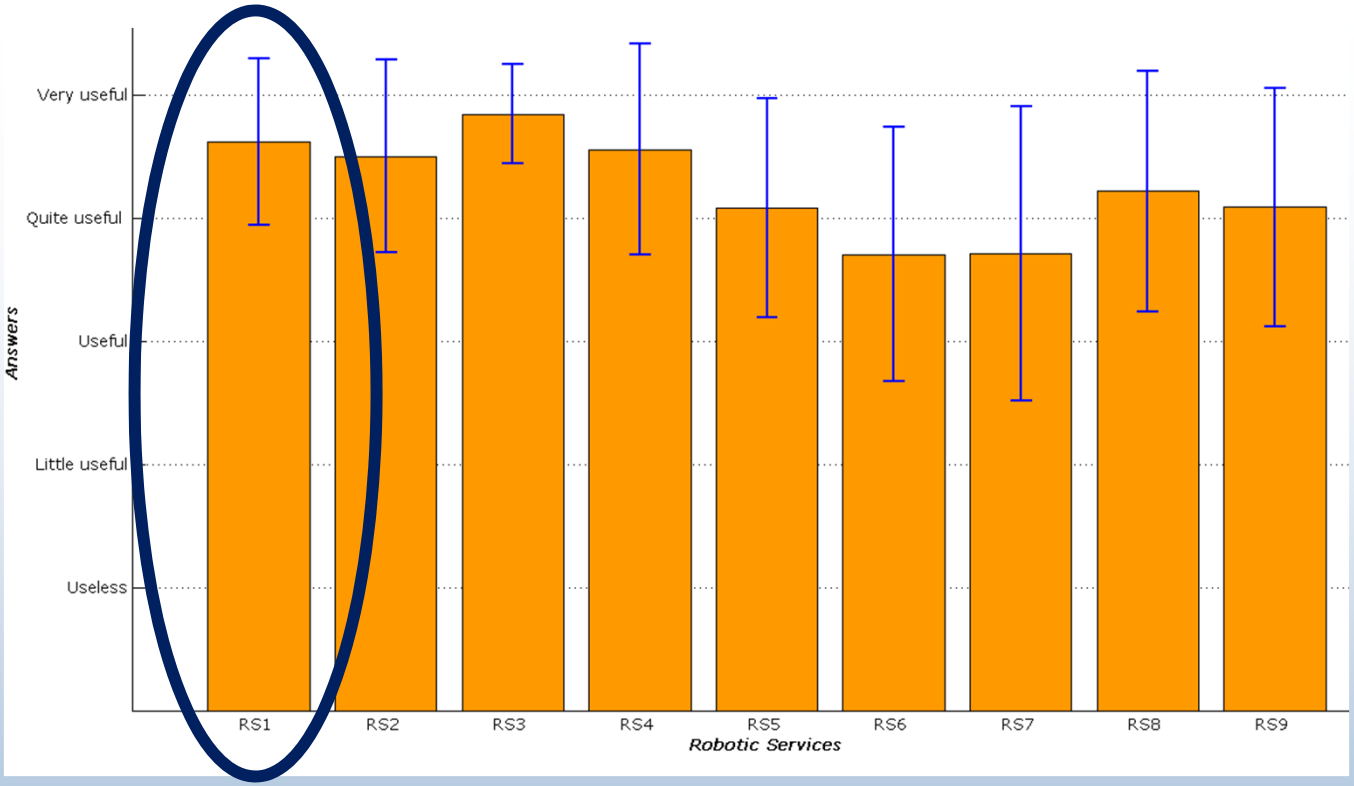



Applications and robotic services

- Companion robots for daily life assistance.
- Smart environments for assistance, monitoring, safety,…
- Tele-monitoring and internet-connected services.
- (Tele-)Rehabilitation

INFORMING, LISTENING and obtaining CONSENSUS: educational program with elementary, junior-high and high school students and teachers

Preliminary judgment about some services carried out by robots



RS1) Cleaning streets autonomously

RS2) Transporting domestic garbage

RS3) Information service in urban areas

RS4) Mini-bus transportation

RS5) Guide in Museum

RS6) Shopping bags transportation

RS7) Educational activities and assistance for children

RS8) Companion and assistance for elderly

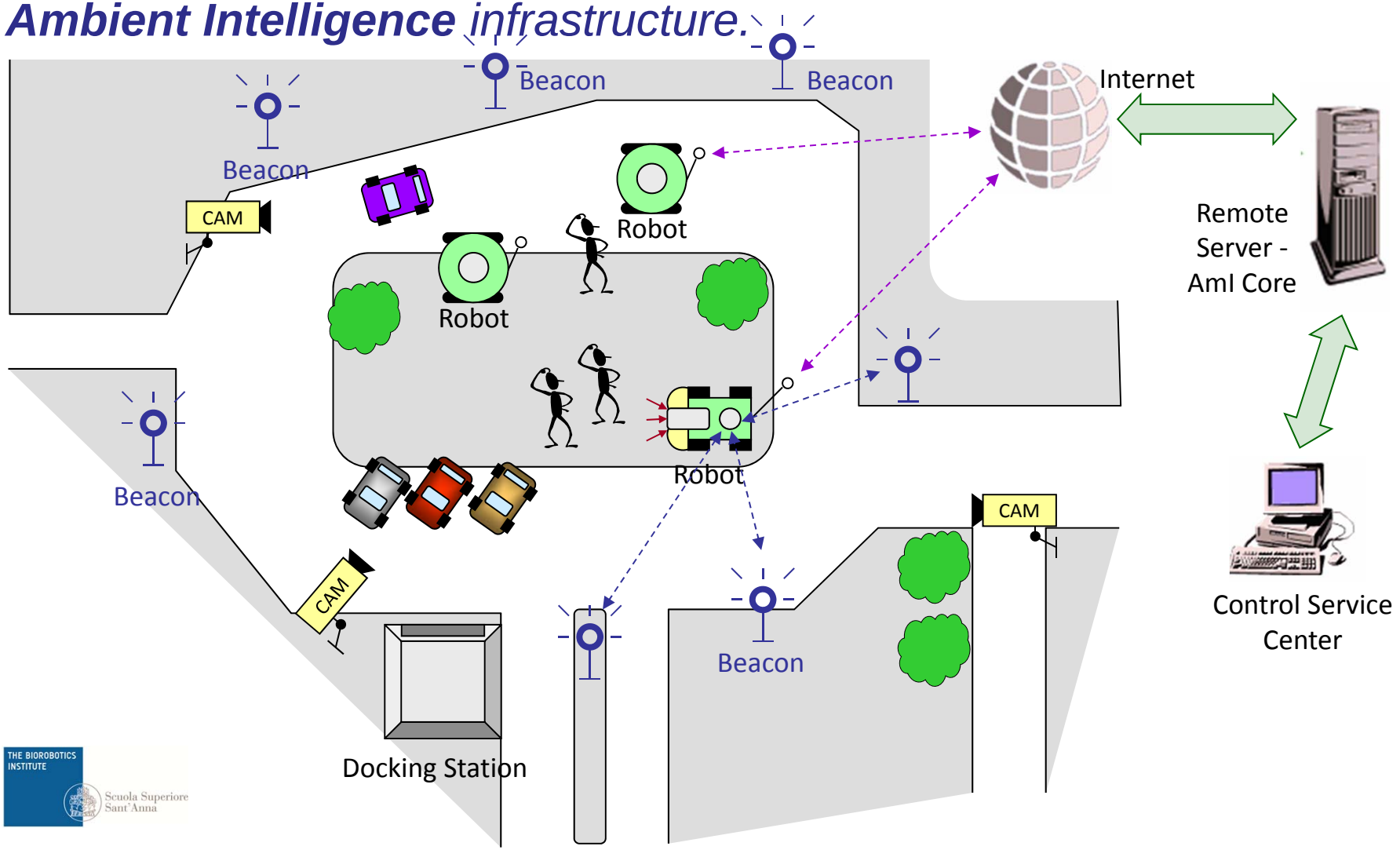
RS9) Best-practise tradition


DustBot
Networked and Cooperating Robots for Urban Hygiene
FP6-045299
The DustBot project is aimed at designing, developing, testing and demonstrating a system for improving the management of urban hygiene based on a network of autonomous and cooperating robots, embedded in an Ambient Intelligence infrastructure.
Information Society Technologies
Project Details
Start Date: 01-12-2006
End Date: 30-11-2009
Duration: 36 months
News
IROS 2010
Partnership
SSSA (I)
Paolo Dario
paolo.dario@sssup.it
RoboTech (I)
Nicola Canelli
n.canelli@robotechsrl.com
MIDRA (I)
Romeno Fantacci
romeno.fantacci@unifi.it
ORU (S)
Achim Lilienthal
achim.lilienthal@tech.oru.se
HW Communications (UK)
David Lund
dlund@hwcomms.com
Robotiker (E)
Arantxa Renteria
arantxa@robotiker.es
Synapsis (I)
Riccardo Fontanelli
r.fontanelli@websynapsis.com
HTA (CH)
René Hüsler
rhuesler@hta.fhz.ch
HEIG-VD (CH)
Stephan Robert
stephan.robert@marronnier.ch
with technical support by:
STMicroelectronics (IT-FR)
www.dustbot.org
www.dustbot.org


SERVICE ROBOT
for garbage collection
Designing the DustCart Robot
DustBot
Networked and Cooperating Robots for Urban Hygiene
EU-IST Project no. FP6-045299
www.dustbot.org

DustBot Objectives

*The DustBot Project aimed at designing, developing and testing a system for improving the management of **urban hygiene**, based on a **network of autonomous and cooperating robots**, embedded in an **Ambient Intelligence** infrastructure.*



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Scuola Superiore Sant'Anna

The methodology used to design DustCart robot physical appearance

- To identify aesthetic guidelines using Quality Function Deployment (QFD) techniques
- To design “paper prototypes” using the guidelines identified
- To test paper prototypes with potential users by group interviews
- To use results to design a new version of the robot




Collaboration with citizens and administrators

- Public assemblies and other focused meetings
- User requirements analysis

Quality Function Deployment

- To find out characteristics that could be added to the DustCart's main function as a robotic garbage collector
- To identify those users' needs that could be correlated and satisfied by modifying the robot's physical appearance.

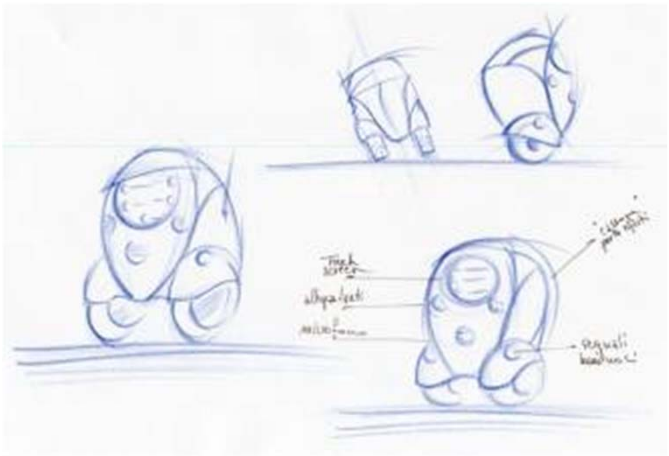
Does not hurt me	**5**
Easy to use	**5**
Facilitating garbage disposal	**4**
Friendly	**4**
Efficient	**4**
Entertaining	**4**
Beautiful	**4**
Providing information	**3**
Contributing towards roads security	**2**
Not noisy	**2**

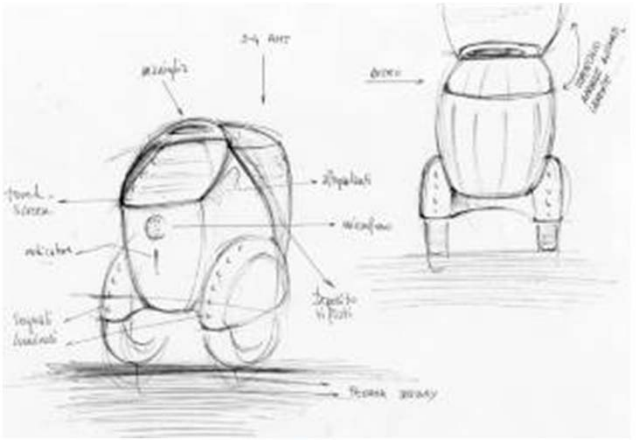
User's needs

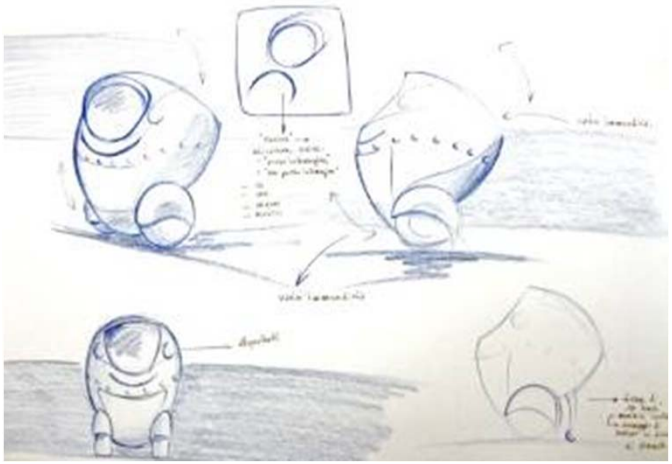
1	Feed-back and help on line	7
2	Touch-screen and GUI	8
3	Info on how to use the service: video ecc.	9
3	New material	23
4	Automatic lid opening	4
5	Icons	5
6	Level of autonomy	22
7	Expressiveness: sounds and lights signals	17
8	Biomorph appearance	15
9	Environmental info and road maps	10
10	Physical and large size buttons	6
11	Service request via telephone call	1
12	Idioms: colors and forms	16
13	Speed control	19
14	Separate waste collection	3
14	Obstacles avoidance	20
14	Light and acoustic signals system	21
15	Management of scheduling service	2
16	Tourist information	11
17	Multi-language communication	12
18	Washability	24
19	Educational vocal expressions	13
20	Friendly and pleasant appearance	14
21	Round and soft shapes	18

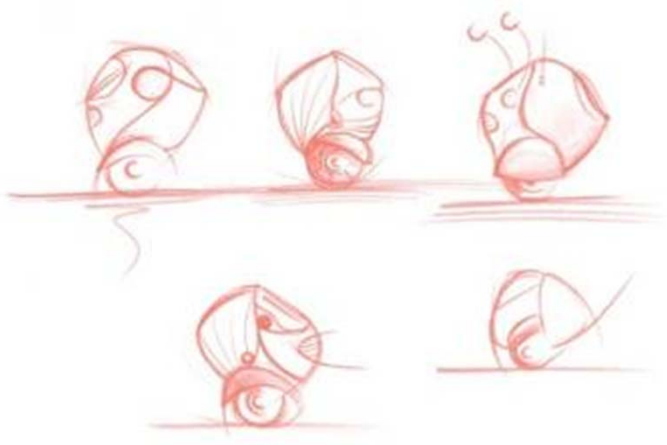
Robot's characteristics

DustBot Design

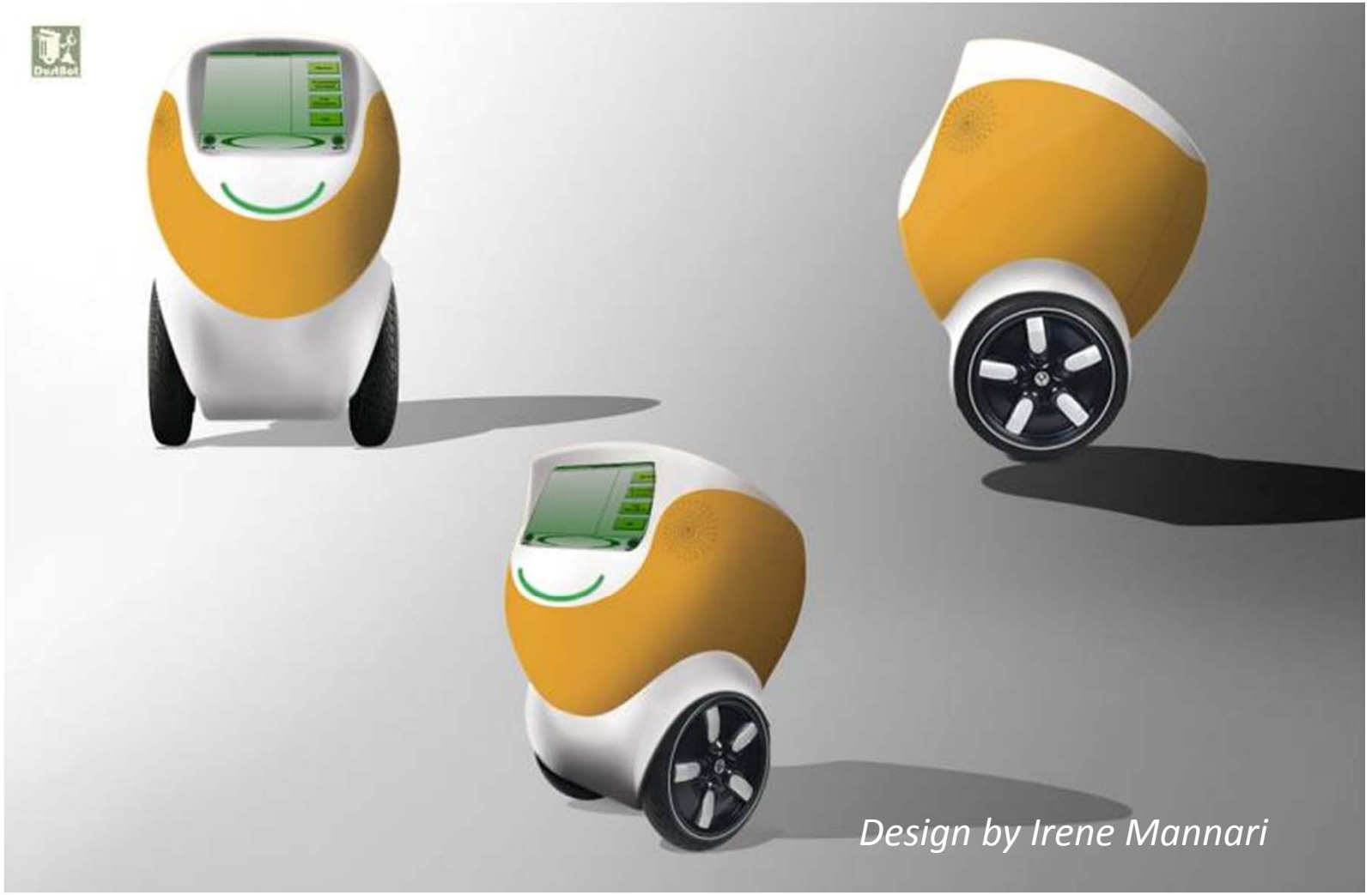




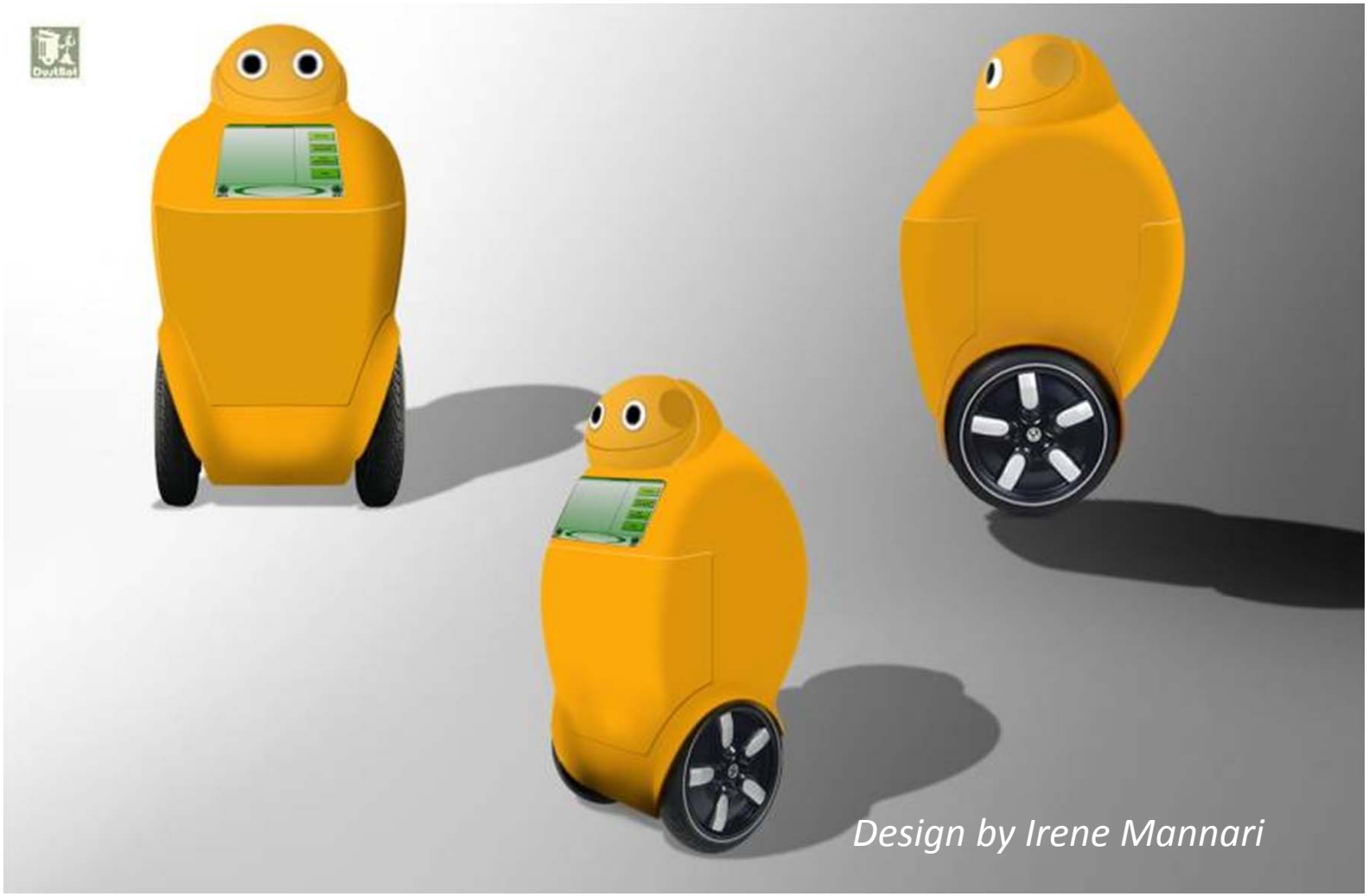




Version A: Aesthetics

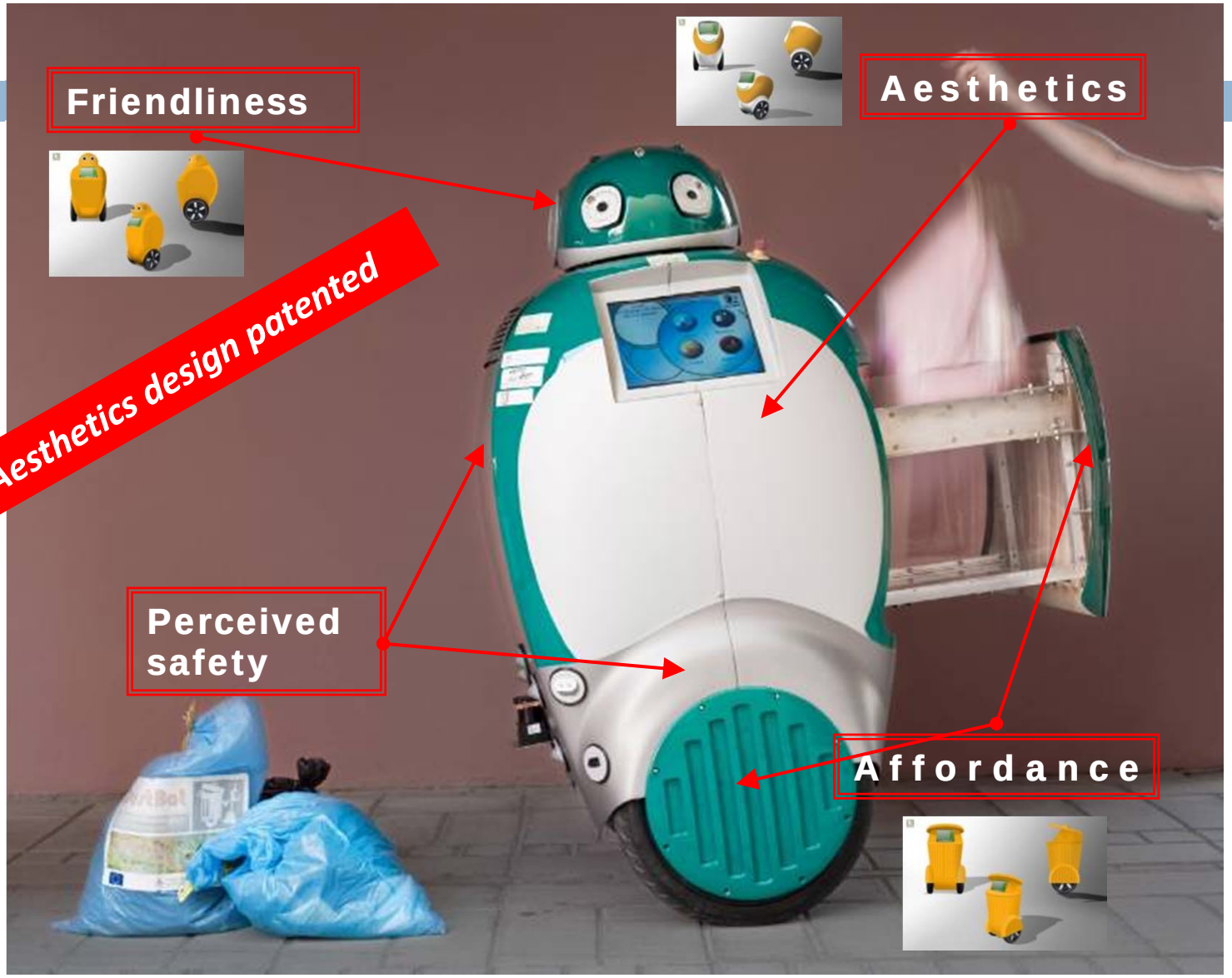


Version B: Friendliness

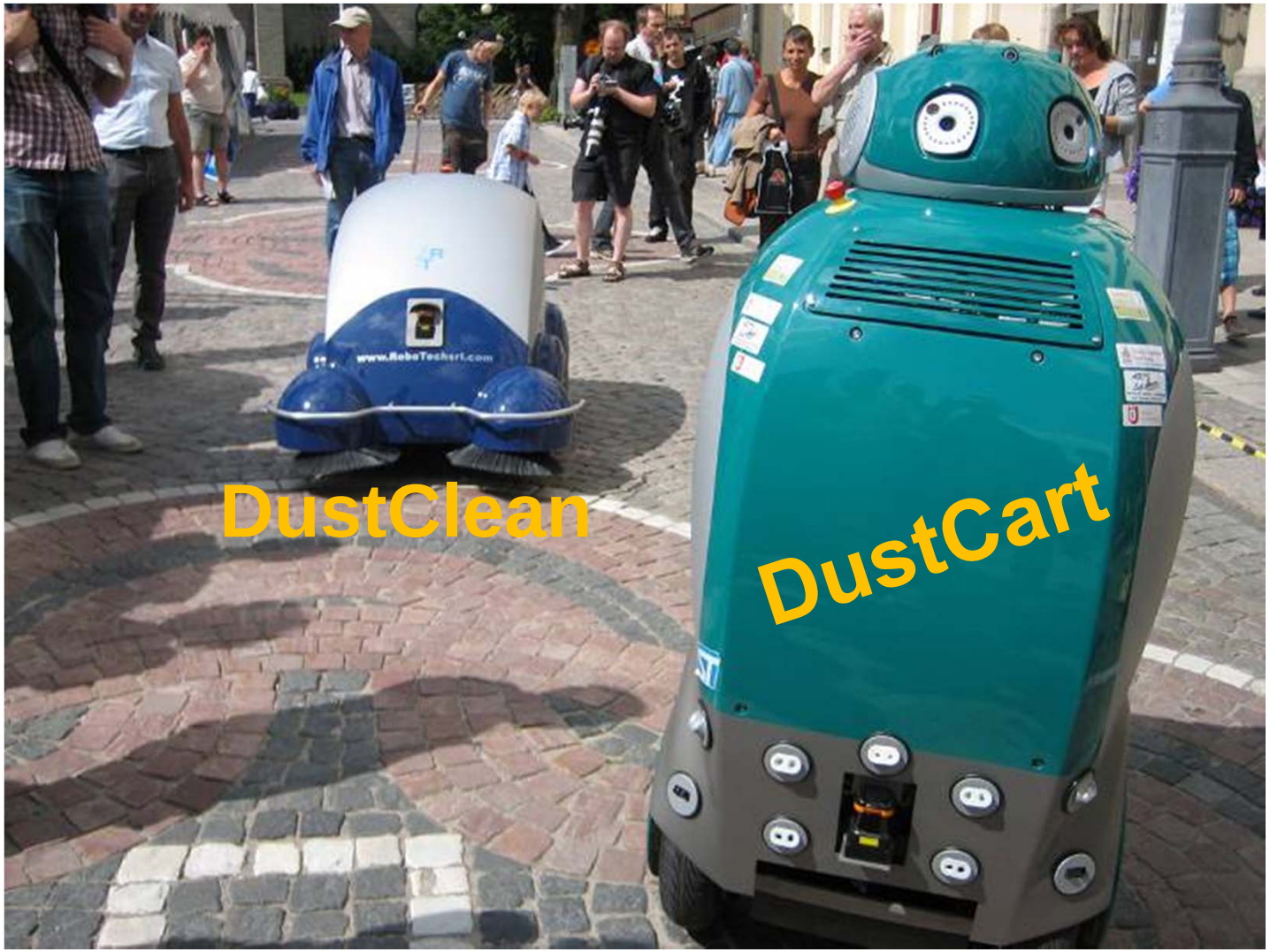


Version C: Affordance

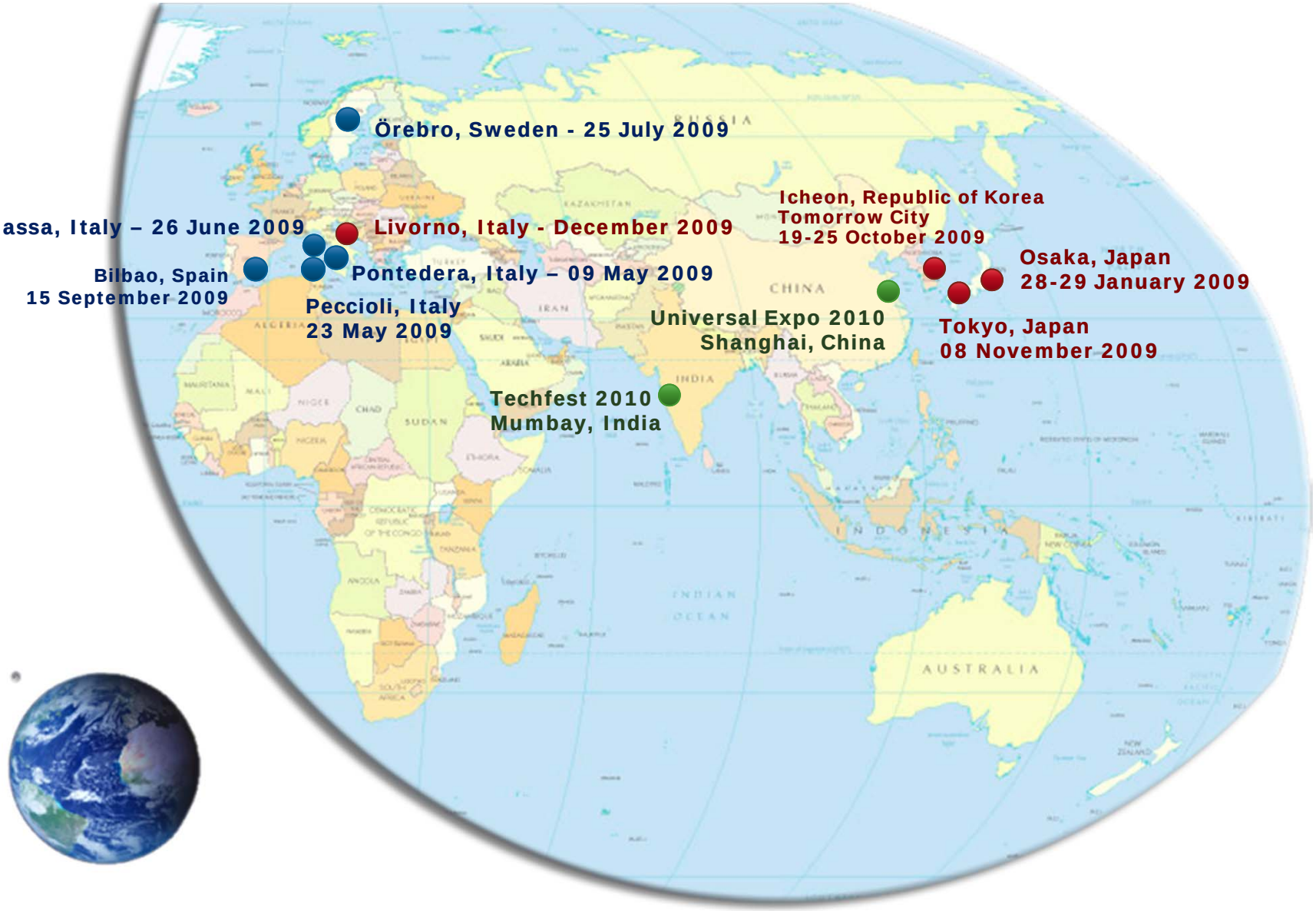
Design for acceptability



The robots



The DustBot Demos



The DustBot Passport

Osaka, Japan
28-29 January 2009

Bilbao, Spain
15 September 2009

Örebro, Sweden 25 July 2009

Pontedera, Italy 09 May 2009
Peccioli, Italy 23 May 2009
Massa, Italy 26 June 2009

Incheon, Republic of Korea
Tomorrow City19-25 October 2009

italia degli innovatori

innovazione selezionata expo shanghai 2010

DustCart@Shanghai Expo 2010
Italian Pavilion

Robots in Tuscany

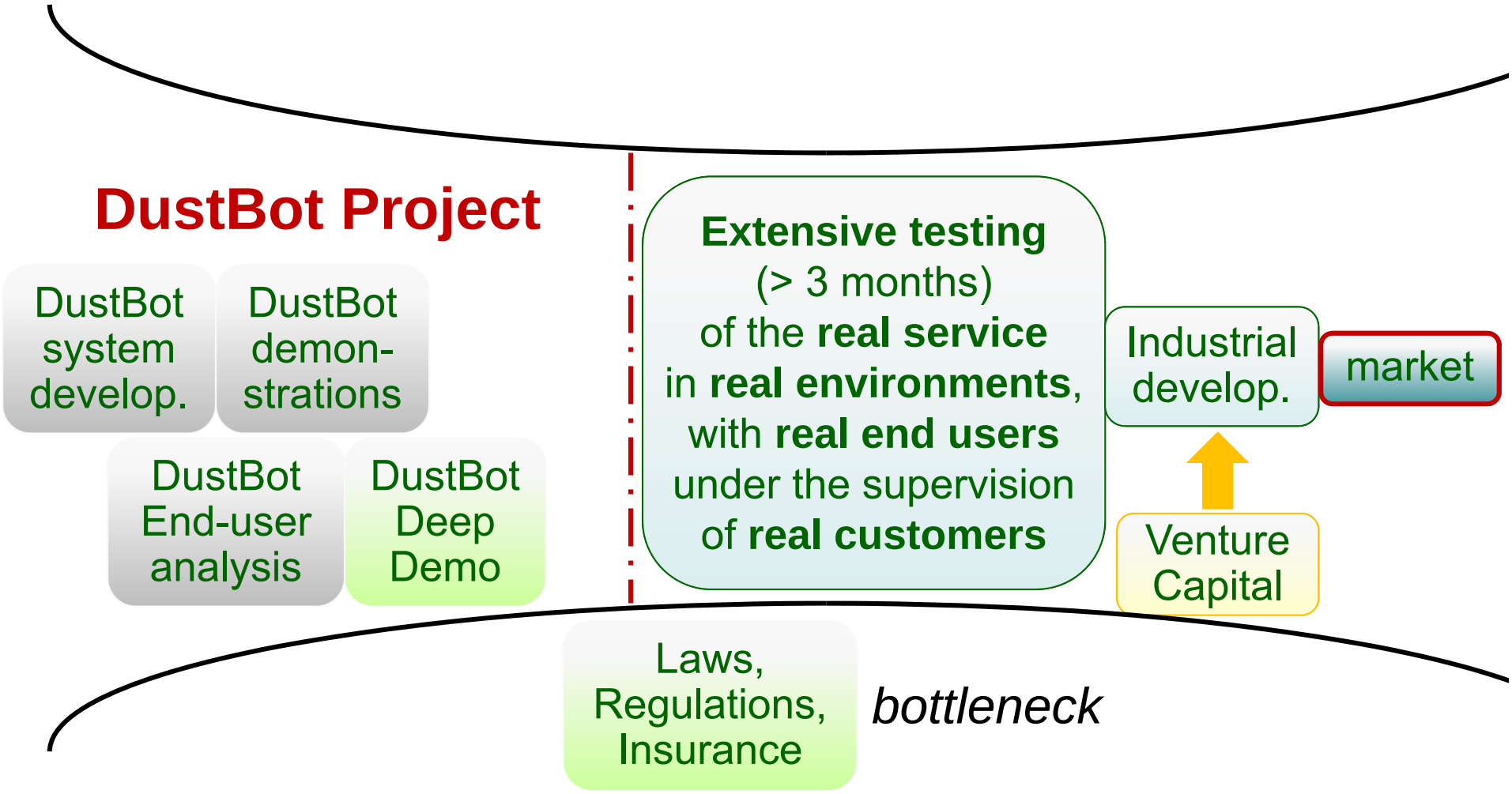
Qualità della vita in cantiere nella provincia toscana. Sopra, il vecchio spazzino è stato sostituito a Peccioli (Pi), da Dustbot, robot intelligente che trasporta rifiuti e analizza l'aria. L'ha progettato la Scuola Superiore di Sant'Anna, celebre istituzione pisana, ed è stato richiesto, tra l'altro, dal Giappone. Sotto, Effecorta, a Capannori (Lu), è il primo negozio in cui tutti i prodotti, oltre cento, sono venduti sfusi "alla spina": dal vino, alle farine, ai detersivi.

Everybody like this robot

But is this enough?

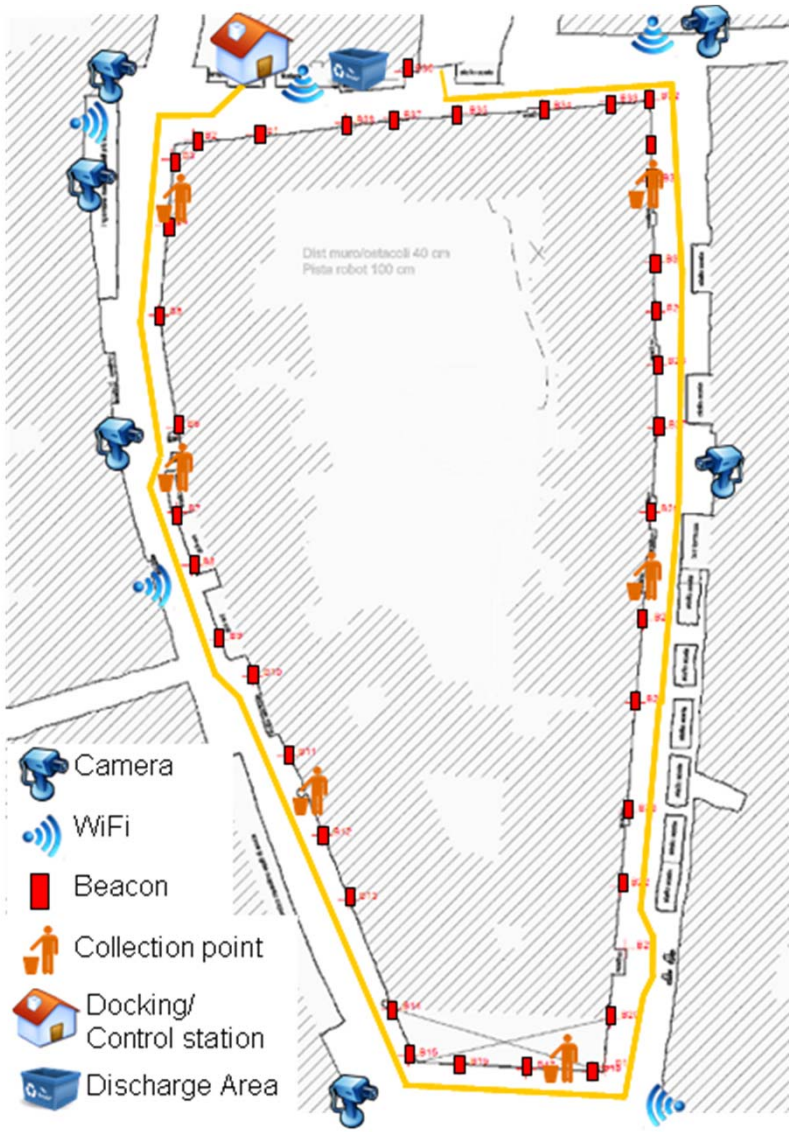
No, we want service robots to be deployed in the real world and to become real products!

DustBot Exploitation Plan



DustBot testing site in Peccioli, the RoboTown

- from June 15 to August 7, 2010
- in the very heart of the town
- with real users: 24 families and 10 business activities



DustCart : main technical modifications for the field tests

DustBot Demonstrations
April-August 2009

DustBot testing
June-August 2010

No Compass and GPS: only odometry and visual landmarks for localization

New mobile base: 4 wheels to increase stability and deal with slopes

New powerful batteries, up to 10 hours endurance

New obstacle avoidance and path planning algorithms

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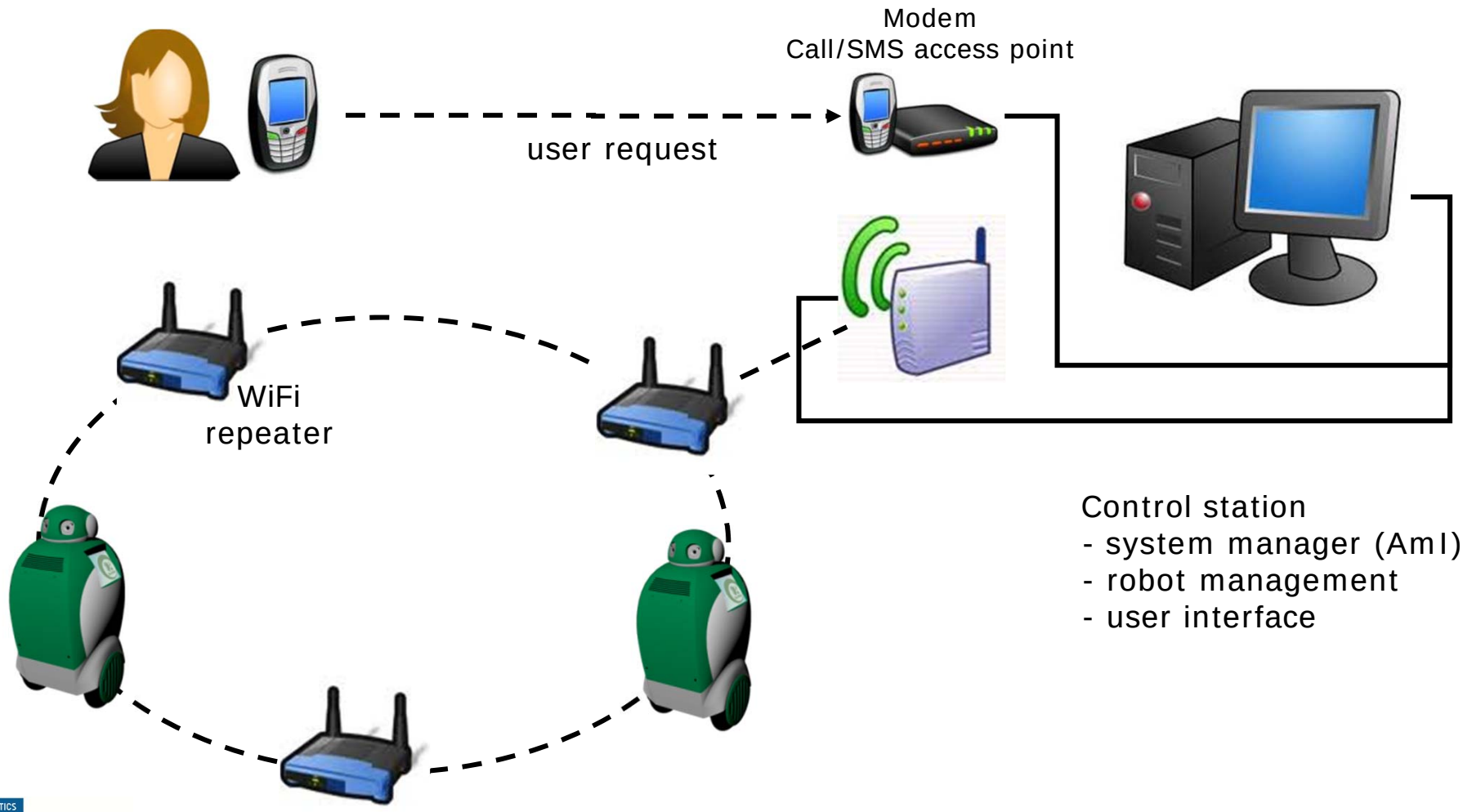
DustBot Architecture

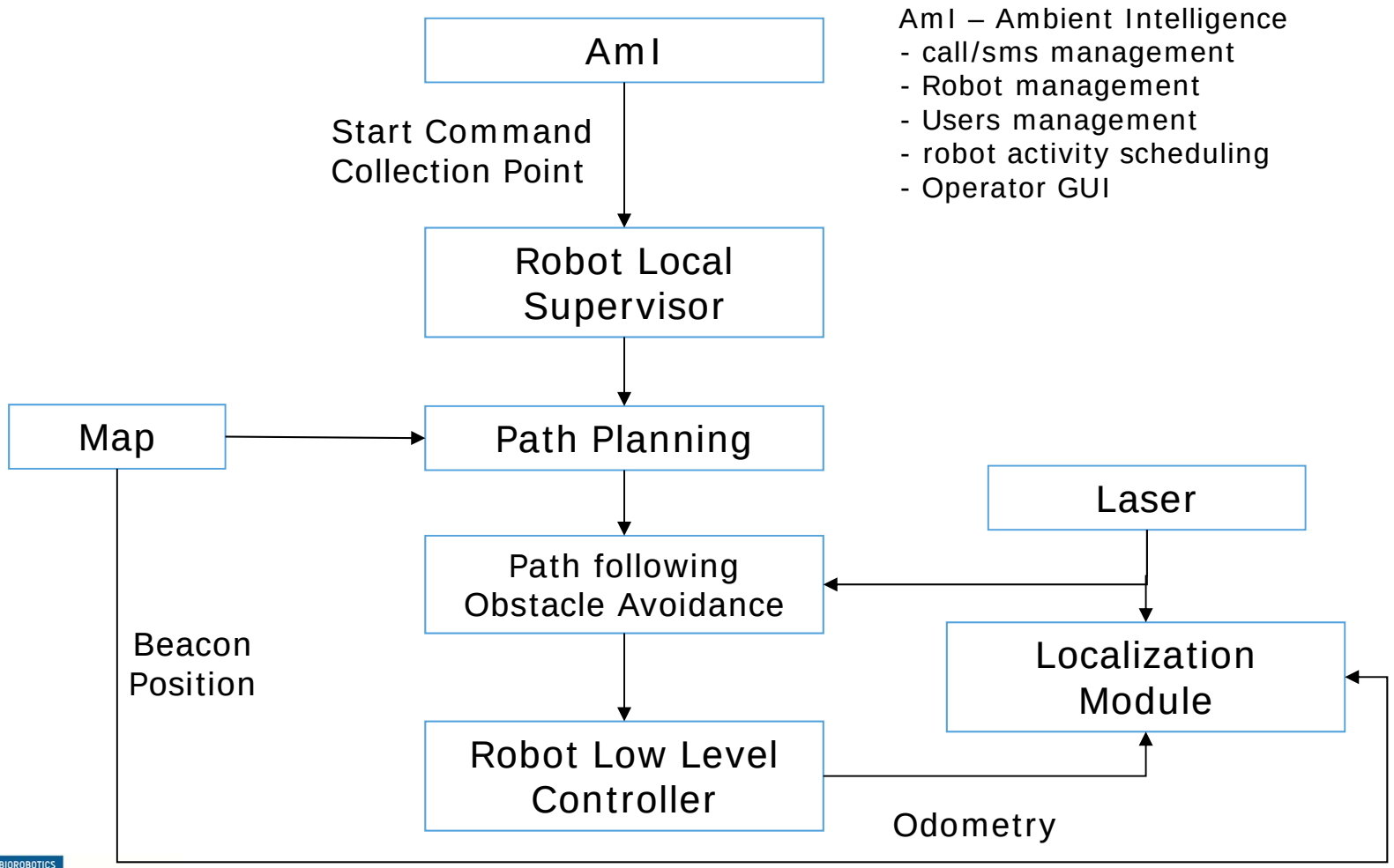


Our Design Strategy

Sharing intelligence between the robots and the environment

Clear advantages (**performance and safety**): for the robot, for the users, for the local administration….

DustBot Software Architecture



AmI – Ambient Intelligence
- call/sms management
- Robot management
- Users management
- robot activity scheduling
- Operator GUI

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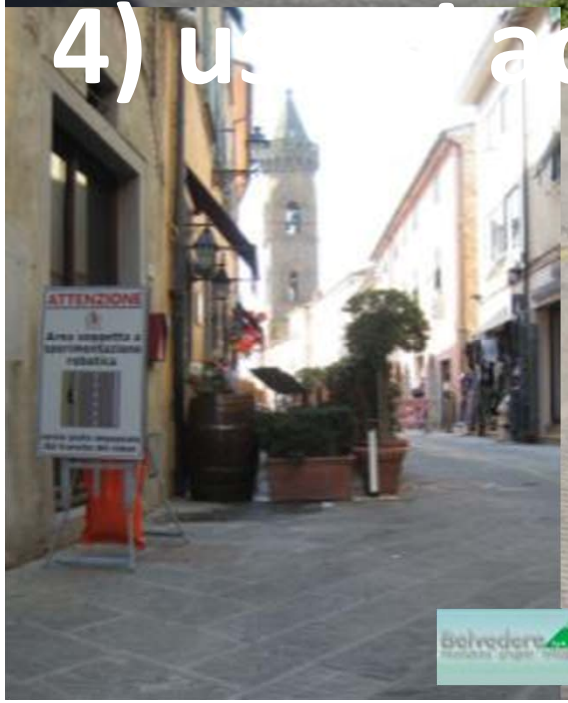
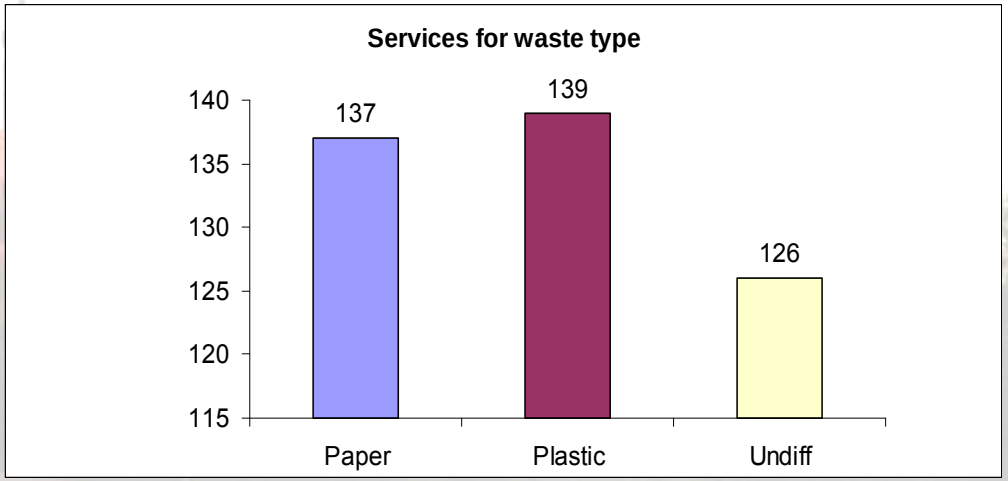
Objectives of Field Tests:

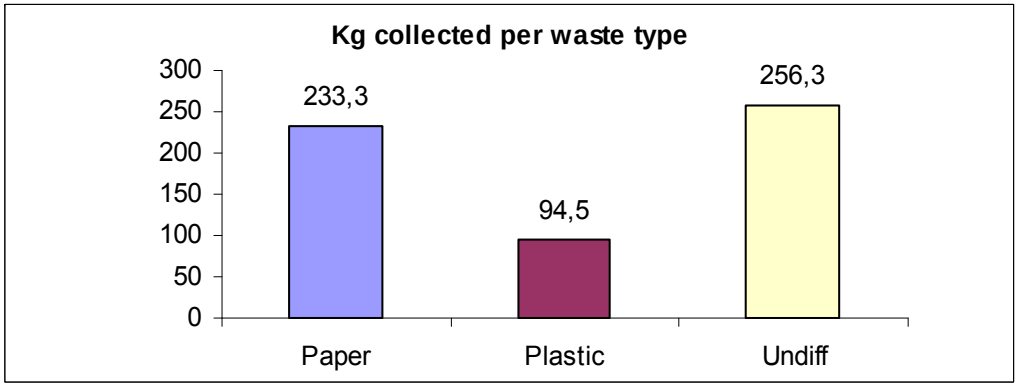
1) performances
2) usability
3) service cost
4) u[illegible] acceptance



DustBot testing results

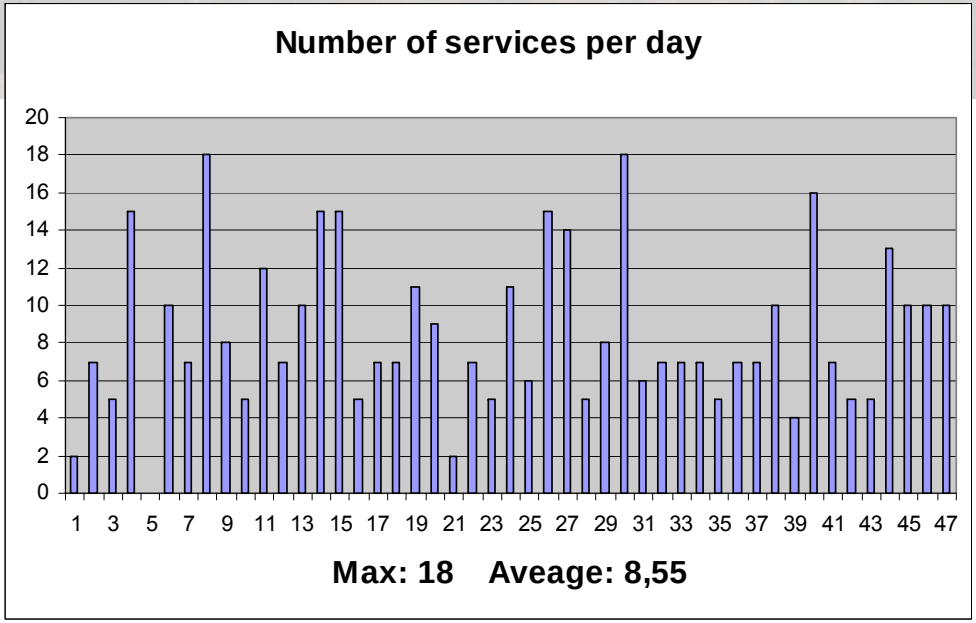
- Total service time:
  - 47 days
  - 454 hours
- Total services: 402
- Total Km covered: 120.6
- Total Kg collected: 584.1



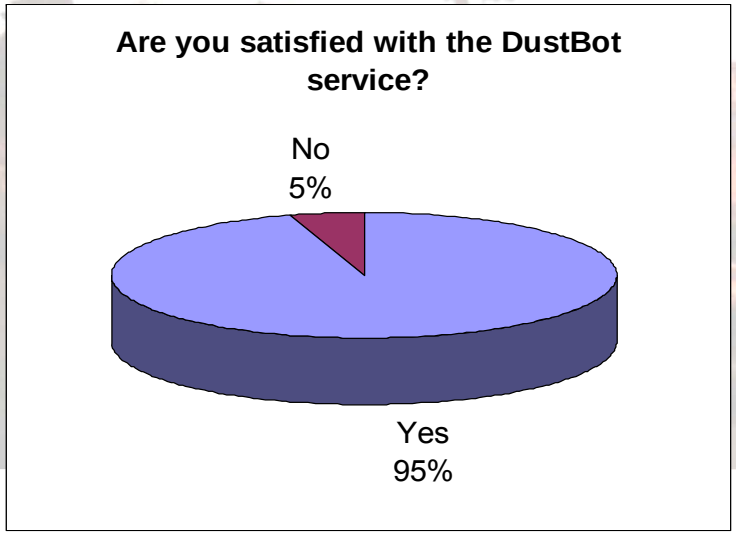


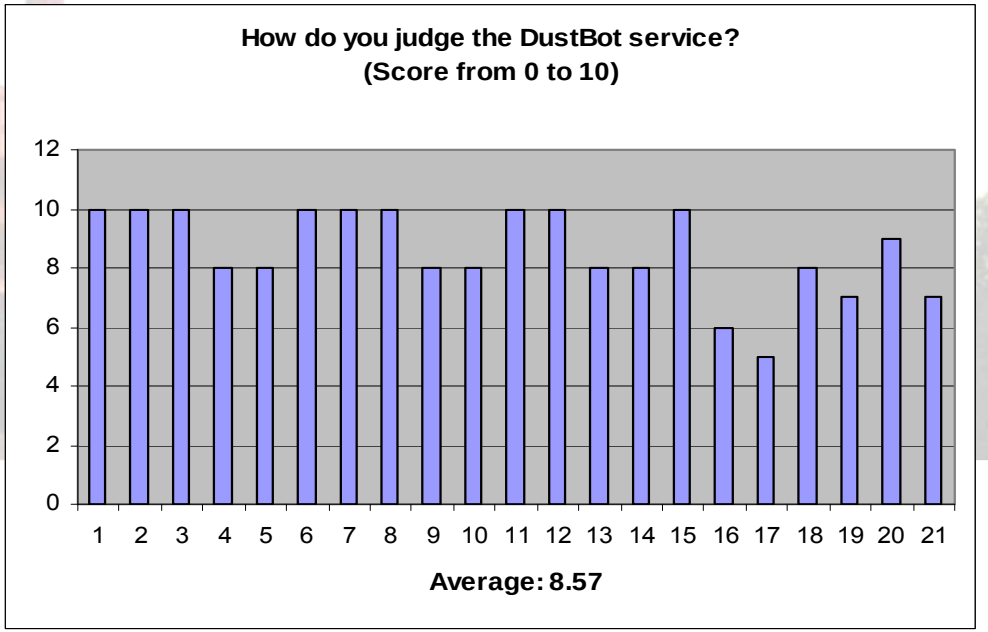
DustBot testing results

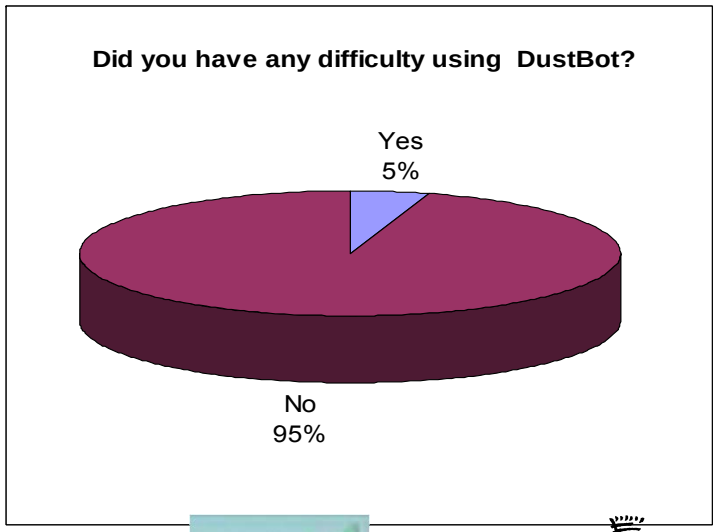
- Average duration of a collection service: 18 min
- Average waiting time from the call: 18 min
- Favorite time to call:
  - 9:00-12:00
  - 15:00-19:00



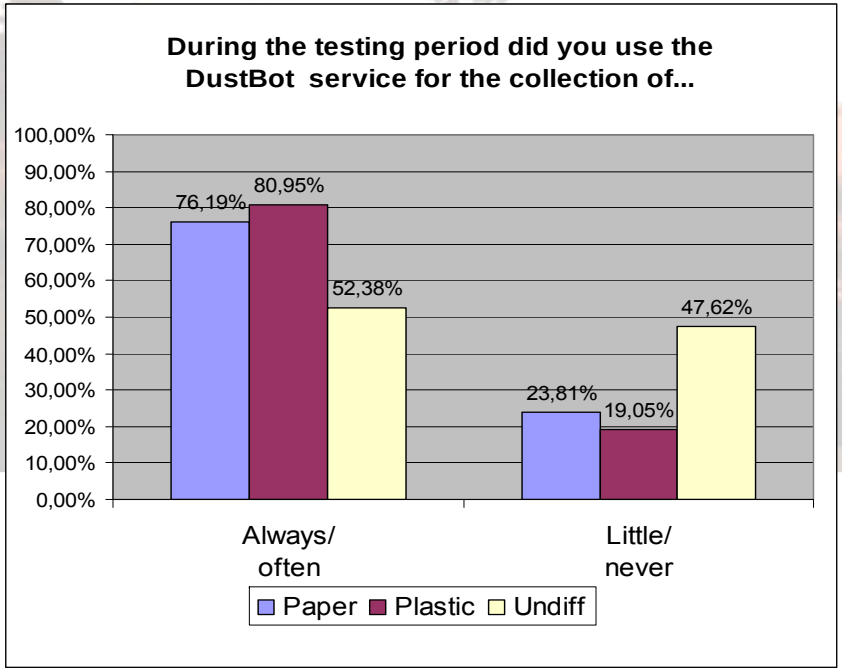
DustBot testing results
User questionnaires

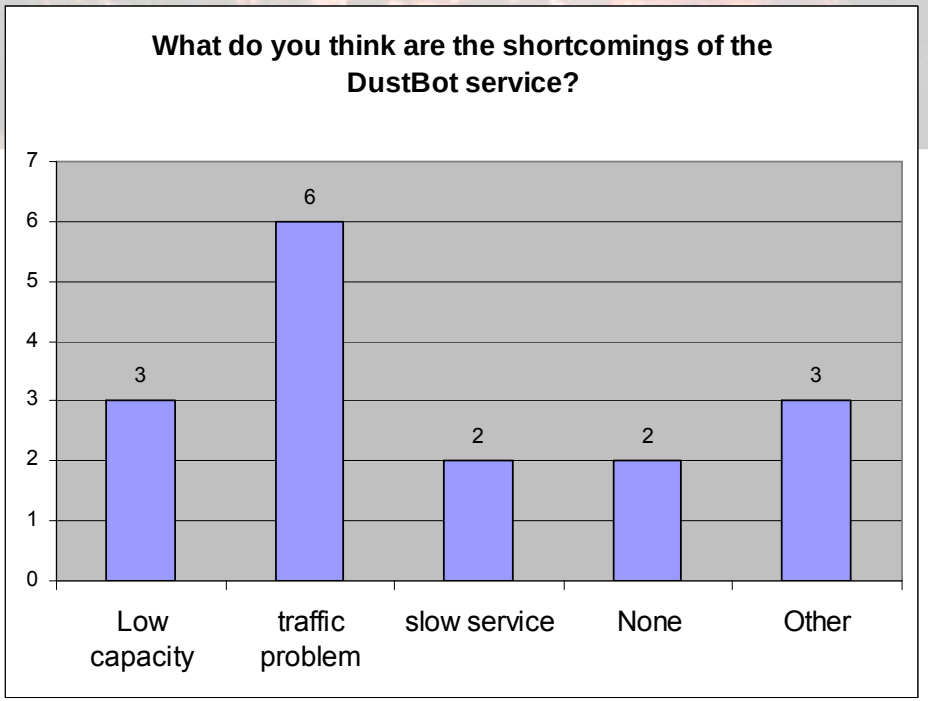


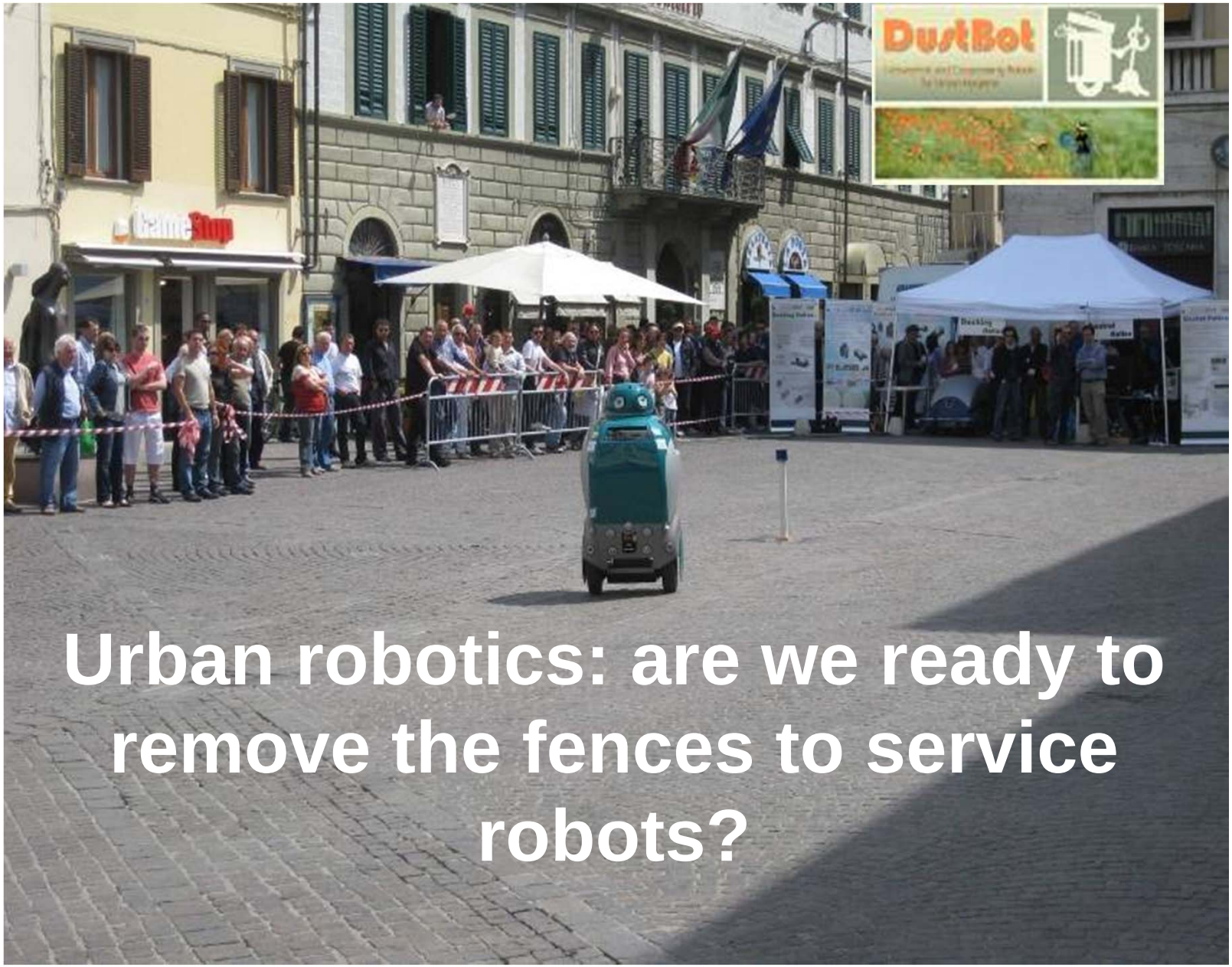




DustBot testing results
User questionnaires





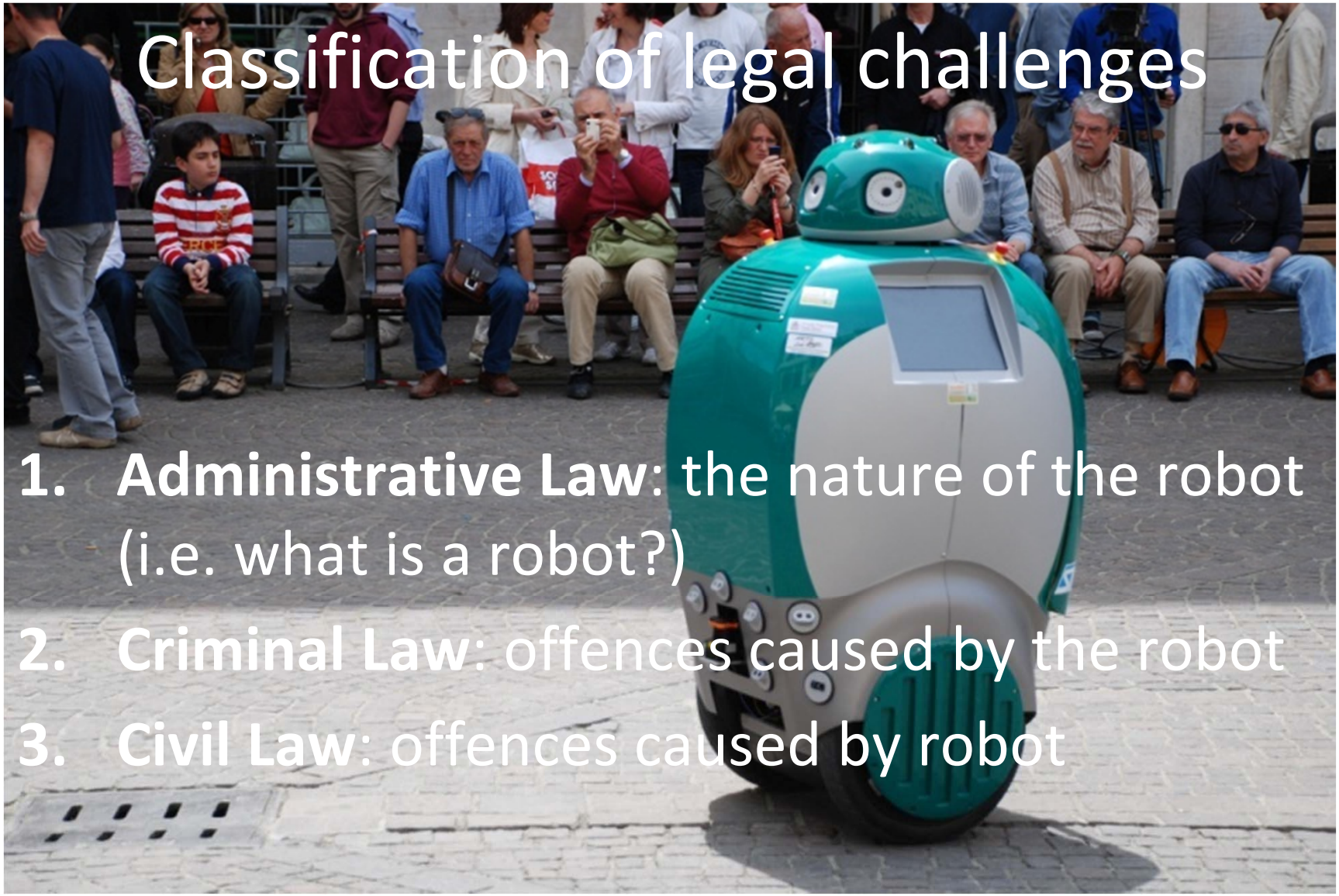


Urban robotics: are we ready to remove the fences to service robots?

Which implications for robot designers?

- *Technological challenges*: localisation, navigation, perception, obstacle avoidance, human-robot interaction issues…
- and challenges not solely related to engineering issues, such as…
  - *robot acceptance* at various levels: social, legal, and ethical

Classification of legal challenges



1. **Administrative Law**: the nature of the robot (i.e. what is a robot?)
2. **Criminal Law**: offences caused by the robot
3. **Civil Law**: offences caused by robot

Dealing with regulatory issues: dedicated *road signs*

'Attention. Area subject to robotic testing. Yellow lane used by robots'.

'Attention. Robot crossing. Yellow lane used by robots'.

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Peccioli testing: the robot lane

- The **robot lane** is a special strip, in yellow colour, drawn on the left side of the roads. It was decided that the robot should travel inside the lane, on the left side, always in the same direction of cars. The “robot lane” was meant to avoid as much as possible interferences with car traffic. Since the robot was not able to give way to cars, three stops were devised in each road in order to avoid traffic congestion.

Robots insurance

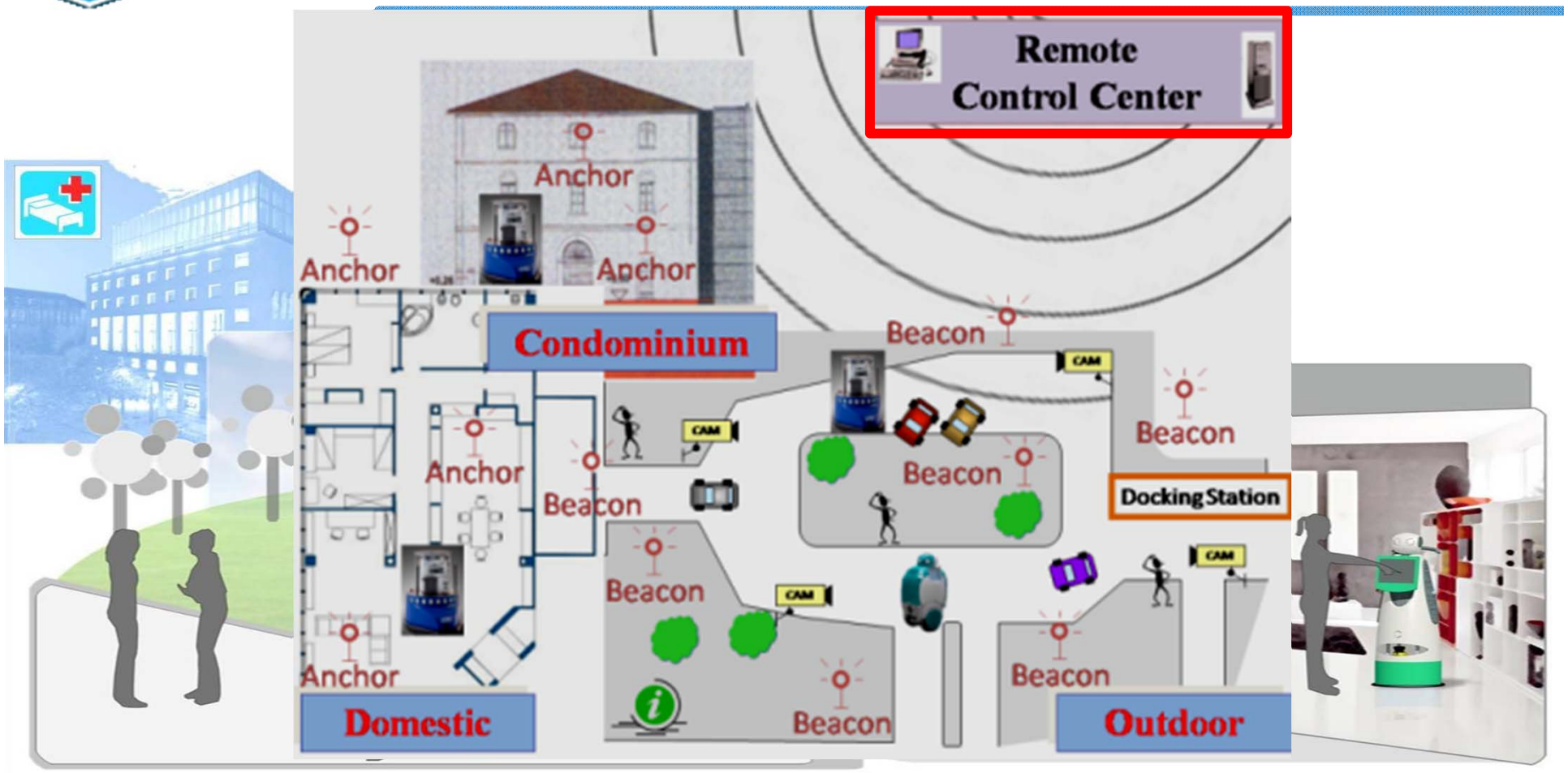
- SSSA insurance policy (**SAI company**) covers any research activities, including demos, carried out with our prototypes by the institution personnel in any place of the world

- However, due the peculiar nature of Peccioli testing, the insurance company requested the payment of an additional insurance premium (**850 € for 2 MONTHS**)
- The robots were ensured against **any liability resulting from their activities**
- **The insurance did not cover damages to the robot**

Lessons learned

- The testing of DustBot system in Peccioli indicates that:
  - service robots can be deployed and make useful work in real urban settings
  - insurance companies take the risk at a very acceptable price
  - co-existence of current robots with real people for a reasonable long period of time (2 months continuous operation) is possible with no reciprocal damages

The “living lab” concept, and the emergence of AAL-Robotics CONVERGENCE



Control Center able to supervise and guarantee safety and security for people, robots and public spaces

The Robot-Era Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 288899

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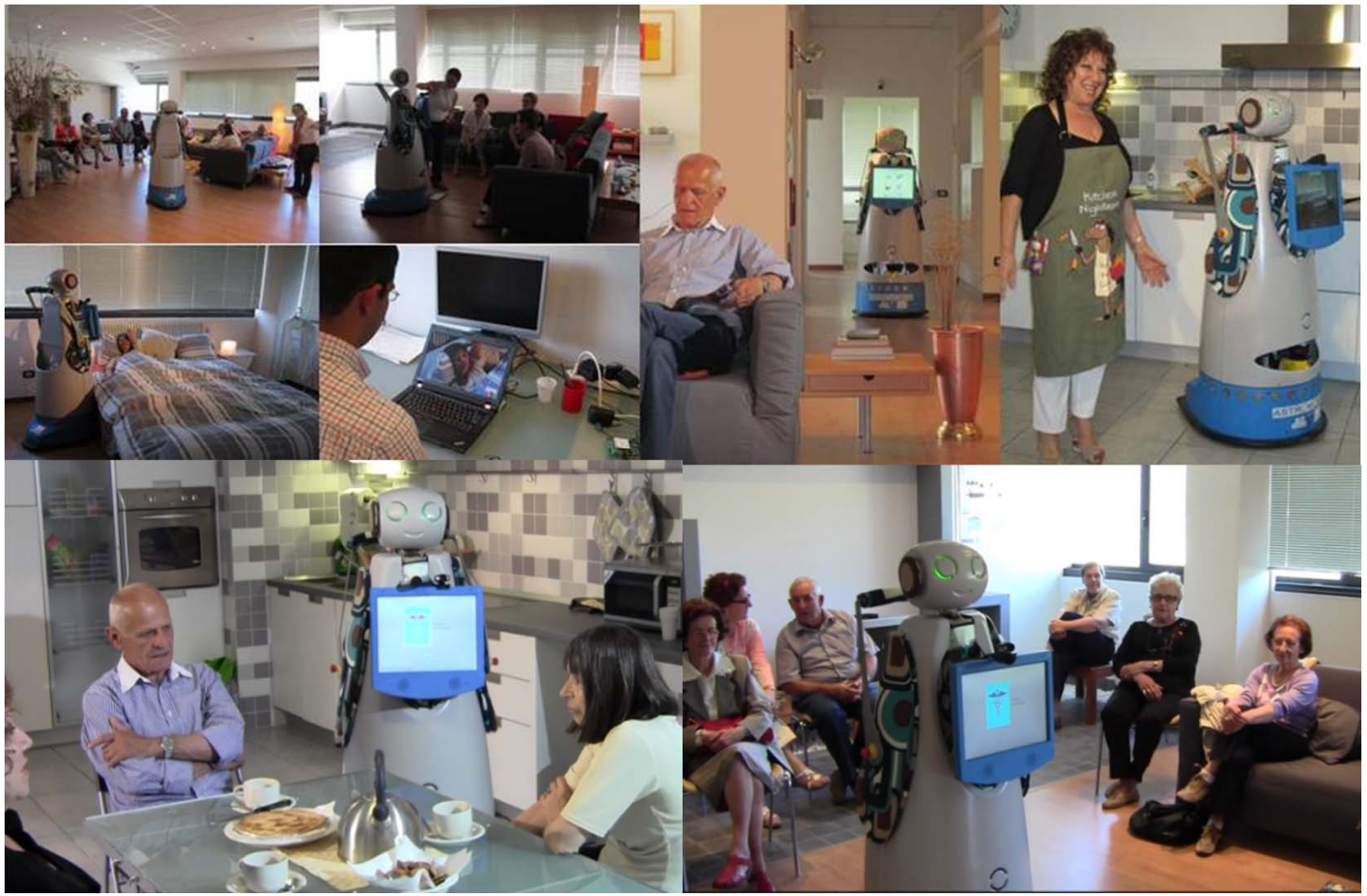
Experimentation in realistic scenarios

Experimentation with 16 elderly people 65+ (4 men and 12 women with 75 main age), including the 11 elderly of the design phase, in the Peccioli Living Lab, Italy (June 2012).



Robot-Era

Ongoing research activities in Peccioli: the FP7 EU Robot-Era Project

Cooperating robots to assist elderly citizens from private (home) to social (the town square) life

The Robot-Era Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 288899

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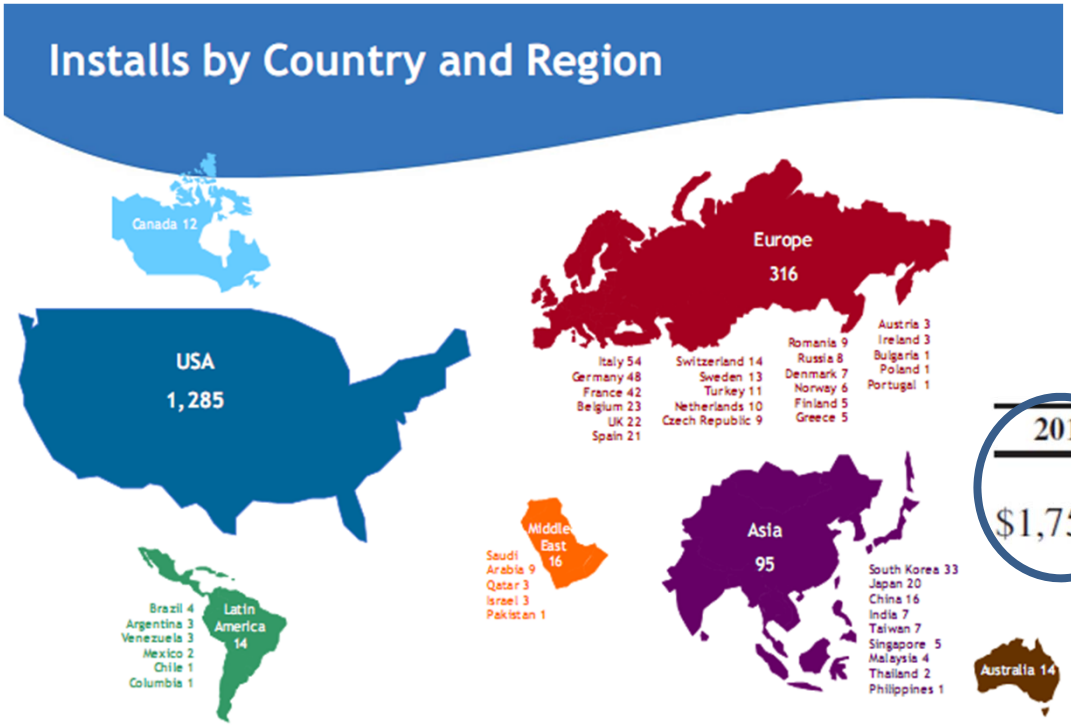
So: people love real robots!

Da Vinci Robot and Intuitive Surgical at-a-glance



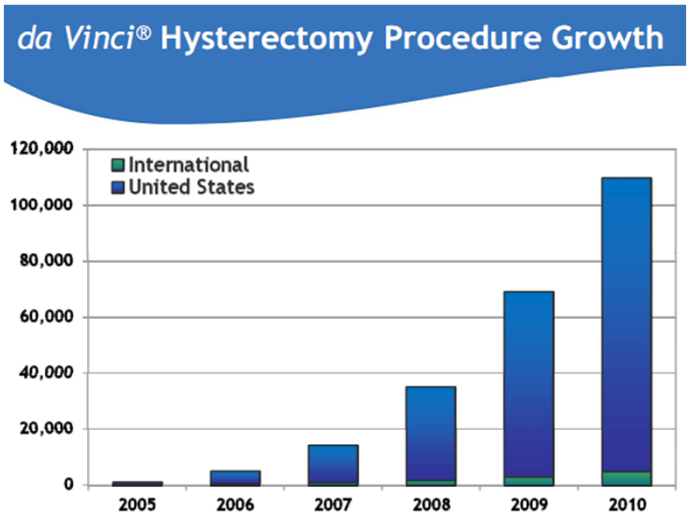
DaVinci Worldwide Installations (2010)

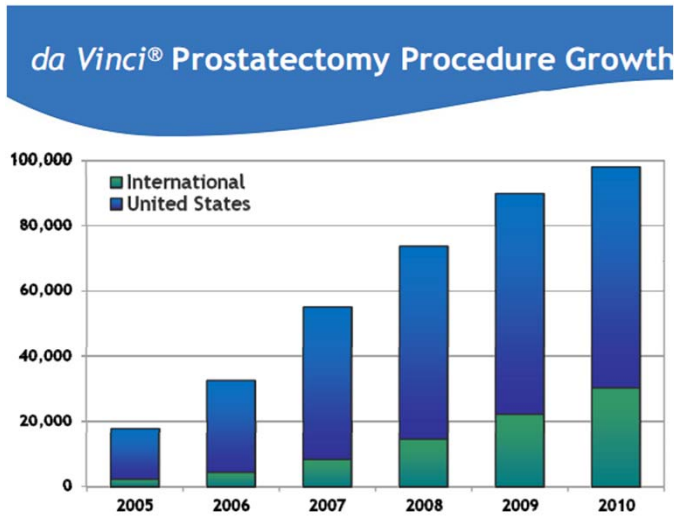
1840+ systems installed in 1450+ hospitals

1700+ employees

Revenue

Year Ended December 31, (In millions, except per share amounts and headcount)				
2011	2010	2009	2008	
$1,757.3	$1,413.0	$1,052.2	$ 874.9	





SOURCE: www.intuitivesurgical.com

...and people like robots that make useful things and that work really well

The "Secrets" of the DaVinci Robot Success: Accuracy, Dexterity, Intuitiveness

- Outstanding mechanical design
- Excellent optics (2D and 3D vision)
- Smart and friendly interfaces

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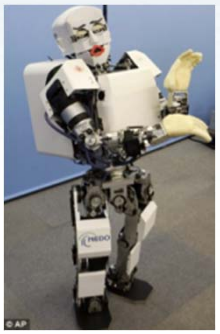
Robotics has made considerable progress

1973


WABOT-1

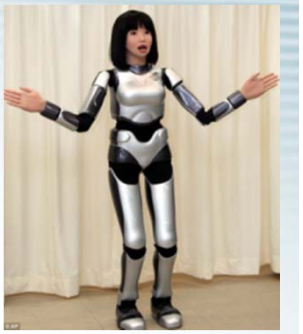

P2


KOBIAN


DB


CB


iCub


HRP-4C


WABIAN


ASIMO


HRP-2


ARMAR-III


Partner Robot


Hubo


ARMAR-IV

NAO


Justin


Lola


Robonaut


Twendy-one


Petman

Today

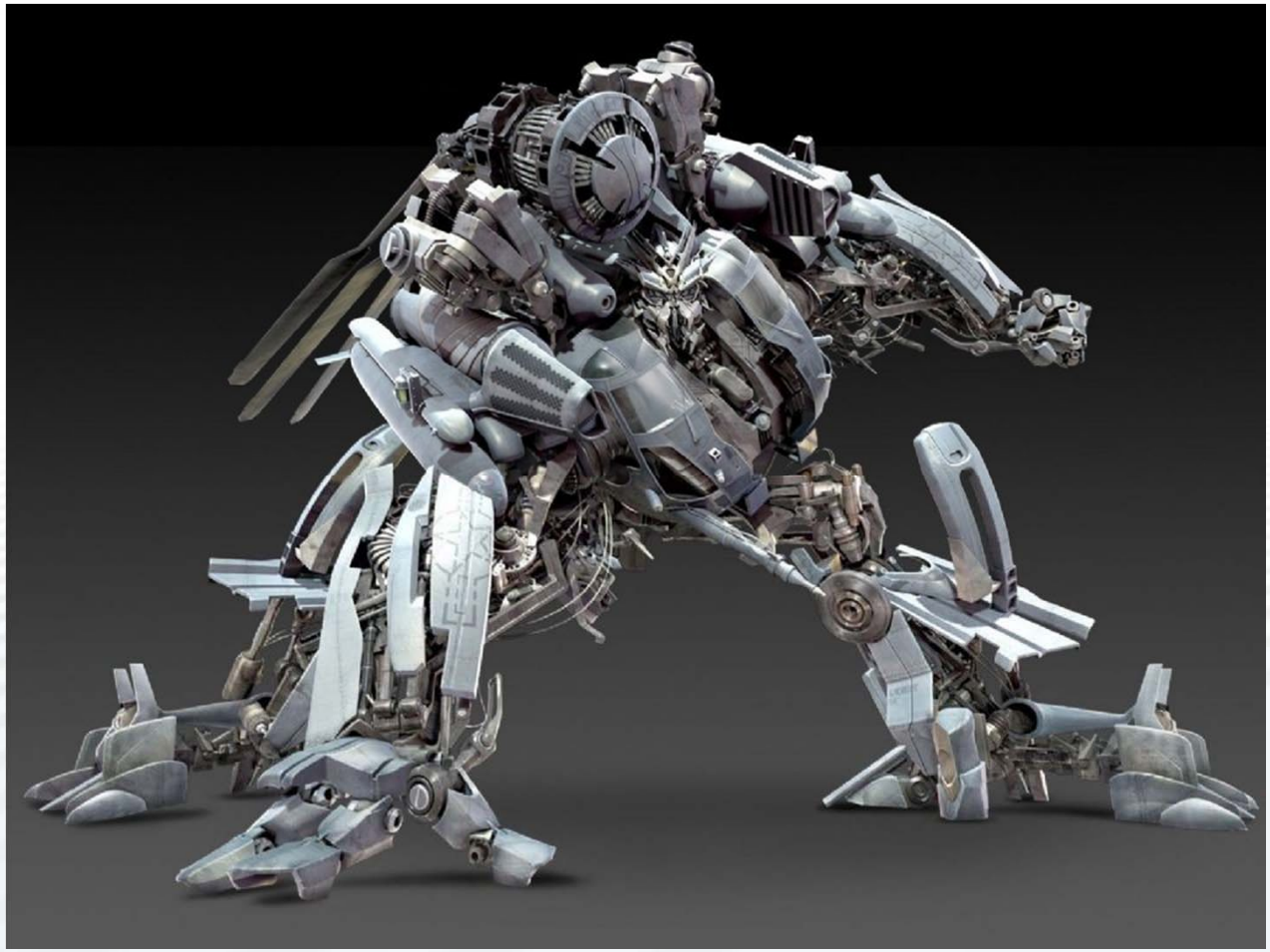
Question: is there a way to ACCELERATE this process and to develop robots that are truly:

- **acceptable**
- **affordable**
- **sustainable**
- **dependable?**

Achieving this goal is the objective of the FET-Flagship proposal 'Robot Companions for Citizens'

The robotics bottleneck

Today, more functionality means
more complexity, energy, computation, cost
less controllability, efficiency, robustness, safety



Exploring a different paradigm: **SIMPLIFICATION** and **INTEGRATION**

less **components**
higher **rubustness**
lower **computation load**
higher **energy efficiency**
higher **adaptivity**
higher **dependability**

Ultimately, lower COST

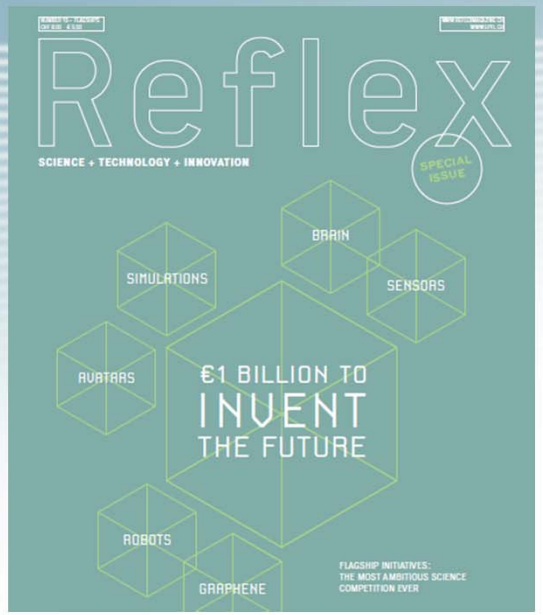
FET Flagships: a new and ambitious European initiative

The FET Flagship
“Robot Companions for Citizens”

Professor Paolo Dario
CA-RoboCom Project Coordinator
The BioRobotics Institute
Scuola Superiore Sant’Anna
Pisa, Italy

The FET Flagship initiatives

- **Ambition:** the goal should be a breakthrough, involving major challenges in S&T, and require a large federated effort and strong leadership
- **Impact:** to yield a leverage effect in terms of research, funding and economic activity affecting in the long run European competitiveness, industry, society, governance and sustainability
- **Integration:** resources and research agendas from different disciplines would need to work together toward the Flagship goal
- **Plausibility:** the different areas of research should be at appropriate level to be assembled into a roadmap with reasonable milestones

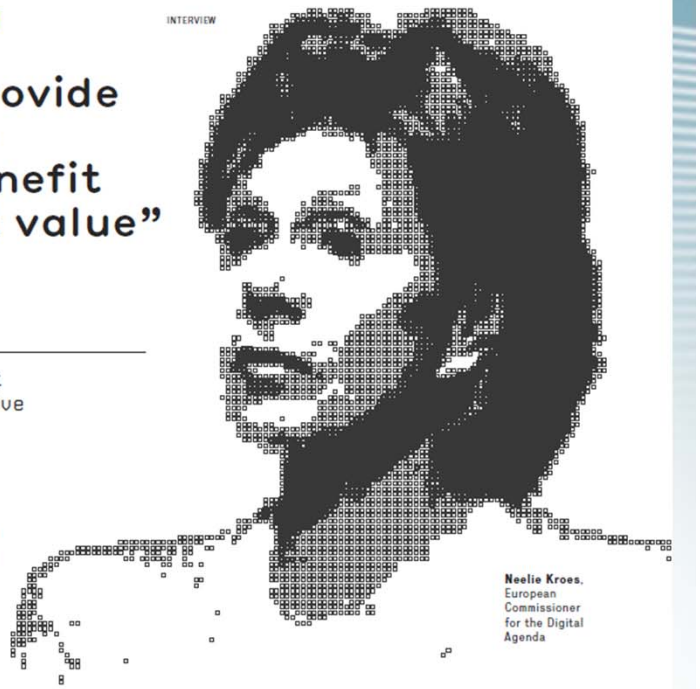


"We must provide citizens the greatest benefit for the best value"

INTERVIEW BY DANIEL SARAGA

Solving society's toughest challenges requires massive research funding, says European Commissioner Neelie Kroes.

Two European research consortia will receive €1 billion each within the Flagships program, an initiative launched by Neelie Kroes, European Commissioner for the Digital Agenda. The former Dutch politician explains why large-scale research in IT



Neelie Kroes, European Commissioner for the Digital Agenda

The race for €1,000,000,000

BY DANIEL SARAGA

With its Flagship Initiatives, the European Union has created a unique competition that will extend the horizons of science. Six research projects are now fighting for the big prize.

One hundred million euros every year for 10 years. What scientist wouldn't drool at the prospect of such generous support for his pet project? But the offer is no dream. It's what the European Union has put on the table through its Flagship Initiatives – large-scale, science-driven, research deliver on their promises, which range from predicting economic and societal crises to developing robots to accompany us in our daily lives (see box). The EU wanted revolutionary projects, and the scientists delivered with enthusiasm; their objectives are extremely to raise the level of European research in the face of rising Asian scientific powerhouses, notably India and Korea. Kafatos worries, however, that the money will be granted at the expense of direct grants to researchers. "It is critical that individual grants from the

S&T Vision, Objectives and Priorities

RCC FET Flagship as a bridge between science and sustainable welfare

Robot Companions are an enabling technology for sustainable welfare

Private environments

- Personal assistance for physical and psychological welfare

Economic environments

- Affordable economic and social welfare
- Ageing of population (at home, at work, in the society…)

Physical environments

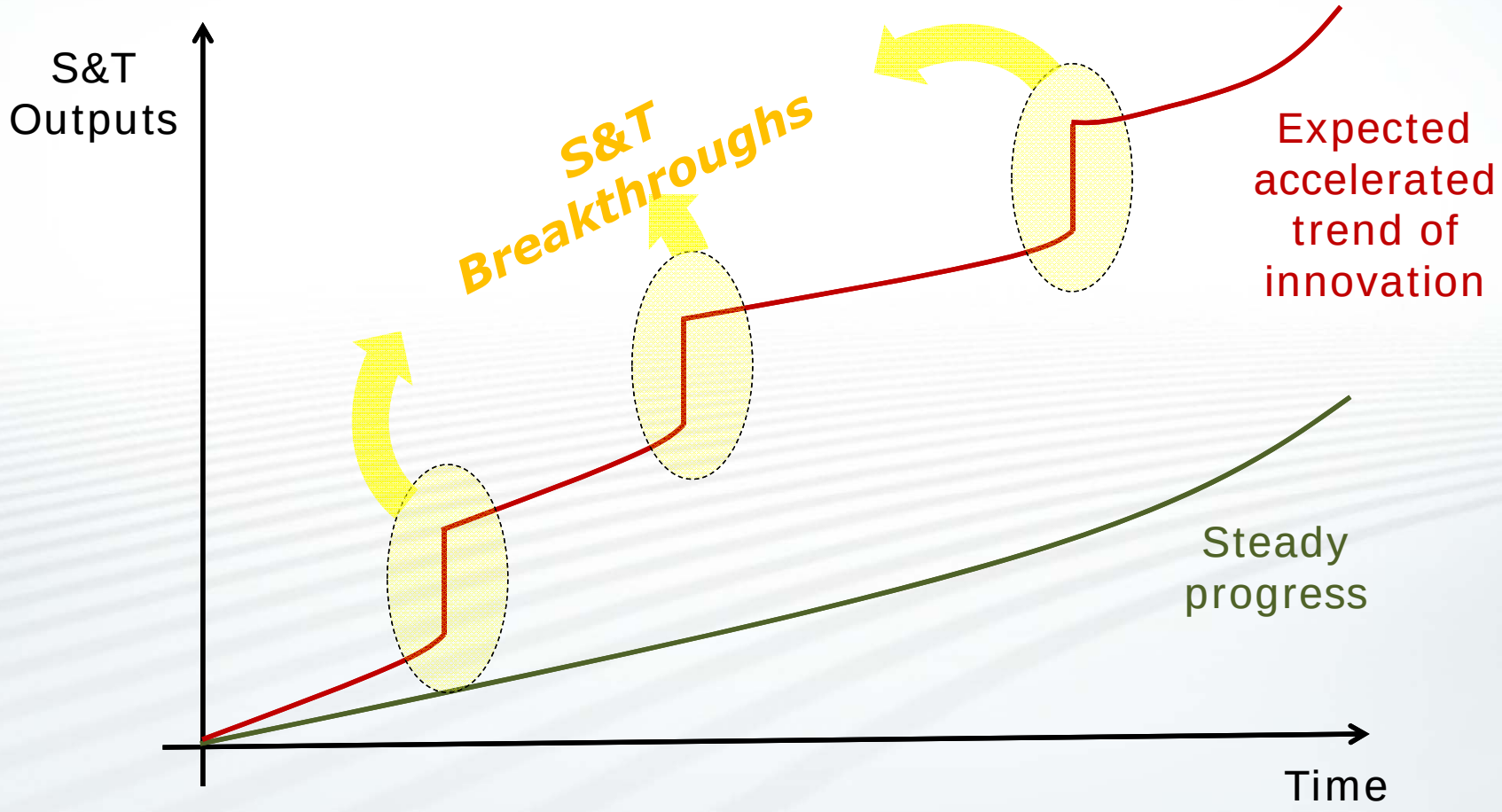
- Conserving and monitoring the planet
- Tackling natural and man-made disasters

Urban environments

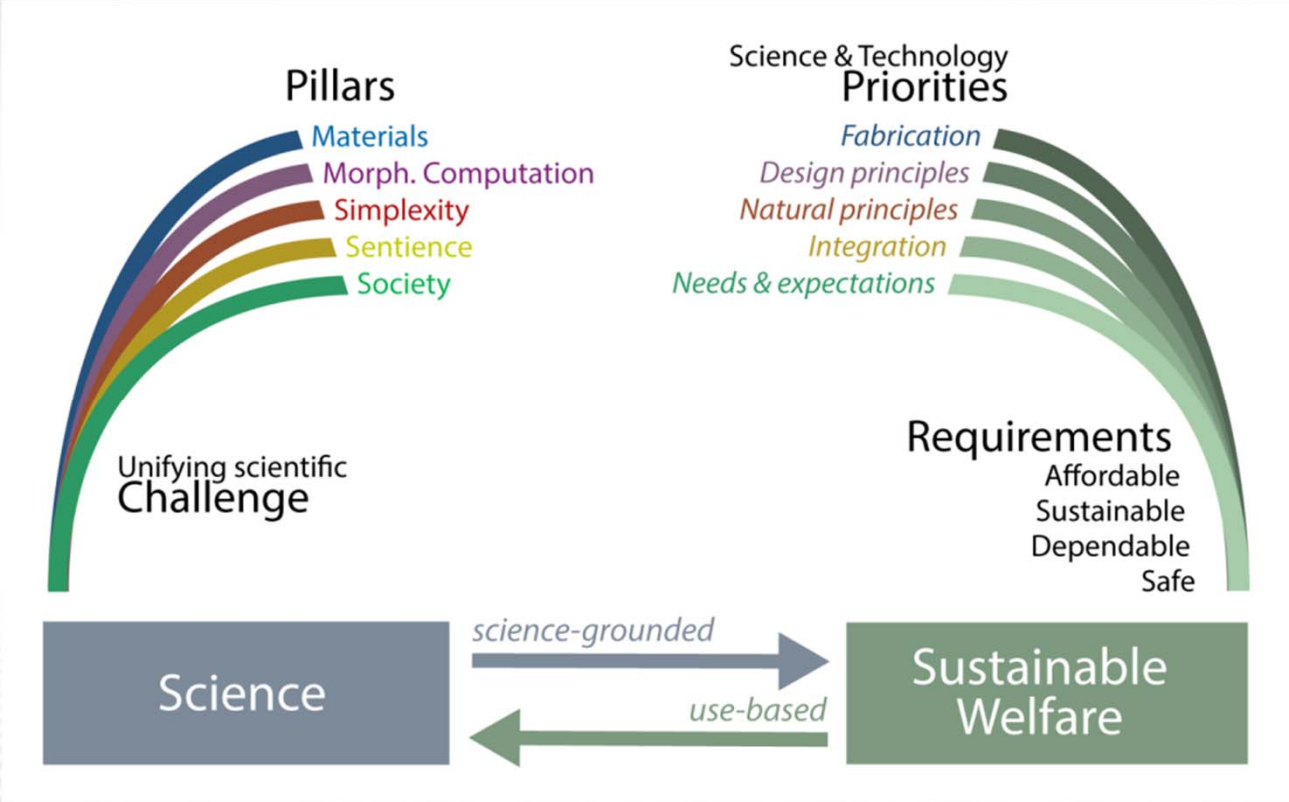
- Growing urban centers
- Maintaining the quality of life at urban scale

RoboCom will pursue systematically **invention** and **"disruptive" innovation**

- **NO well defined technical ROADMAPS, but a clear objective**
- **Partly unpredictable (but unavoidable) "quantum leaps"** of scientific and technological advancements



The RoboCom FET Flagship bridge
to link «Excellent Science» and «Societal Impact»



RoboCom: From New Scientific Knowledge to New Engineering Principles

A whole new Robotics

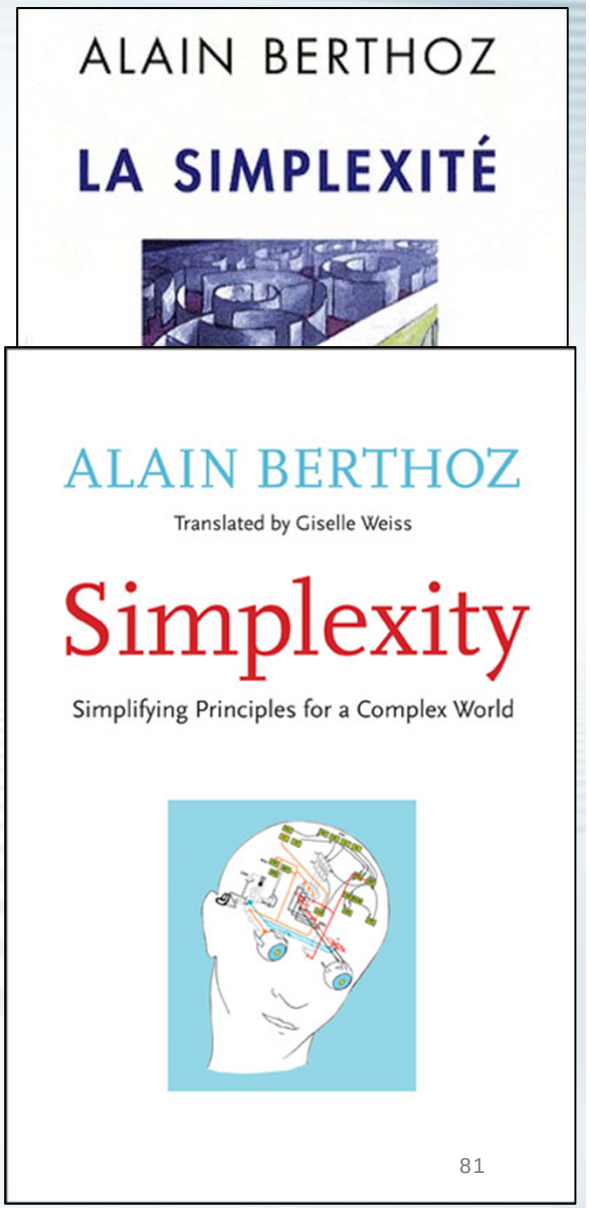
We need *simplification mechanisms and new materials*, *fabrication technologies* and *energy forms*

We want to tap
the biggest and most advanced treasure
of engineering solutions

- Studying natural organisms and understanding what makes them so smart and efficient
- Studying things only living organisms can do, and how they do it

SCIENTIFIC PILLAR 1: SIMPLEXITY

- **Simplexity** comprises a **collection of solutions (simplification mechanisms)** that can be found in living organisms
- An approach to **cope with the real world** and to **coordinate a large amount of motor and sensory data**



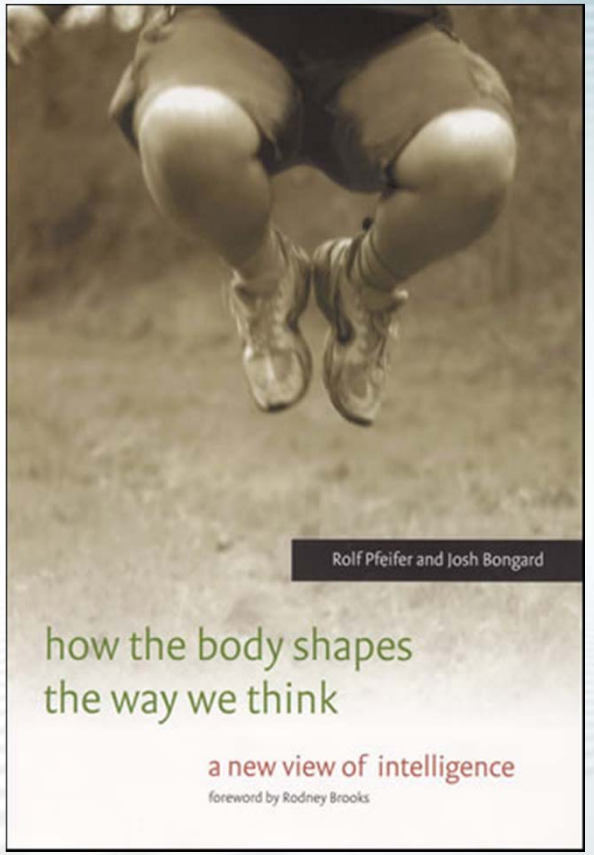
Alon U. **2007** Simplicity in Biology. ***Nature*, 446** (7135): 497.
Berthoz A. **2012** *Simplexity, Simplifying Principles for a Complex World*. Yale University Press.

SCIENTIFIC PILLAR 2: MORPHOLOGICAL COMPUTATION

Definition

Morphological computation designates the idea that ***part of the computation required for particular behaviors can be performed by the body, incorporated into the morphological and material characteristics of the agent****. The brain itself, as part of the body, also applies morphological design principles to achieve its computational tasks.*

→ **distinction: control - to-be-controlled falls apart**



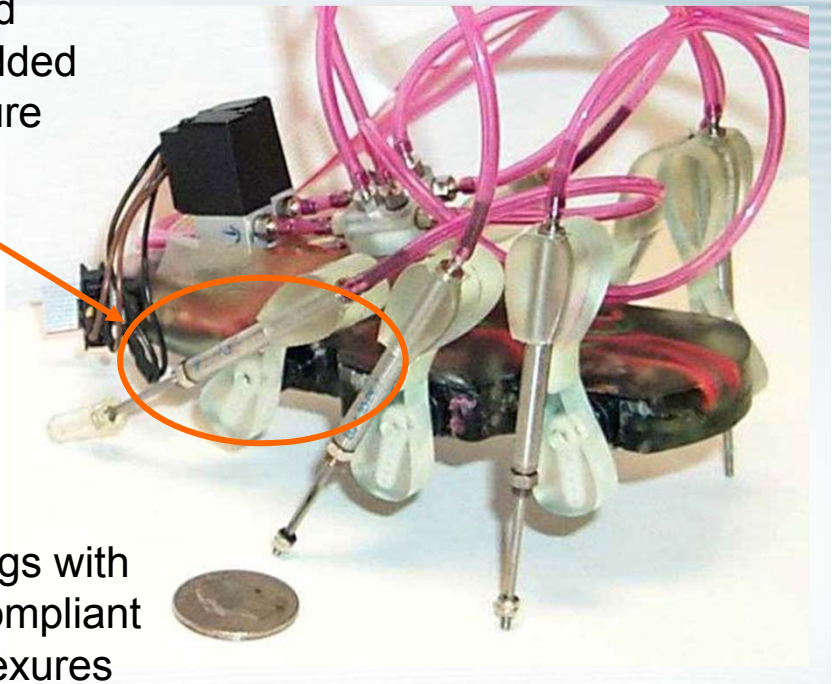
Pfeifer R., Lungarella M. & Ida F., **2007,** Self-Organization, Embodiment, and Biologically Inspired Robotics. ***Science***. **318** (5853):1088-1093.
Pfeifer R. & Bongard J.C., **2007**, *How the body shapes the way we think: a new view of intelligence*. The MIT Press, Cambridge, MA.

EXAMPLE OF MORPHOLOGICAL COMPUTATION: EMERGING BEHAVIOURS

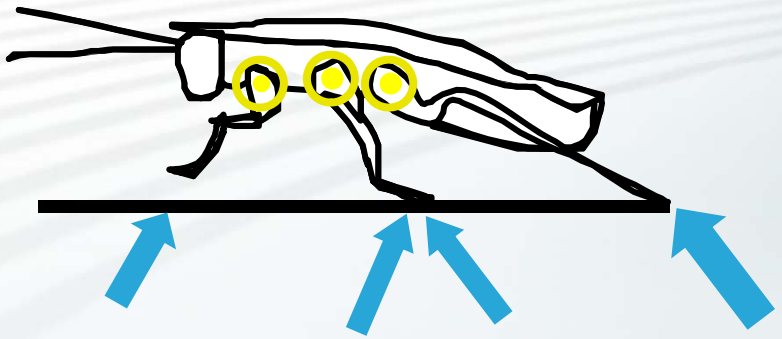
Dynamical properties and mechanical feedbacks lead to stable emergent behaviors: Adaptation in small biomimetic robots

Actuators and wiring embedded inside structure

Deflection
Passive joint



Legs with Compliant Flexures



ground reaction forces

Kim S., Clark J. E. & Cutkosky M.R. 2006 iSprawl: Design and Tuning for High-speed Autonomous Open-loop Running. ***The International Journal of Robotics Research***. **25**:903-912.

SCIENTIFIC PILLAR 3: SENTIENCE

- Sentience is integration across perception, affect, cognition and action
- Sentience creates a coherent scene in which action can be interpreted, predicted, planned, generated and communicated

Sentience is a system level feature that requires a system level theory if you want to build it (**intense cooperation with neuroscience**)

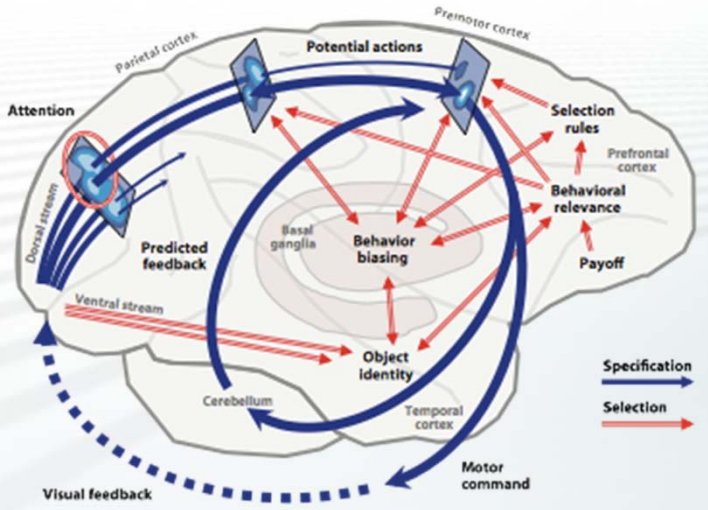
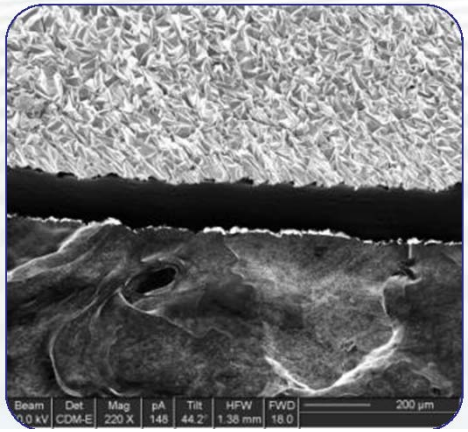


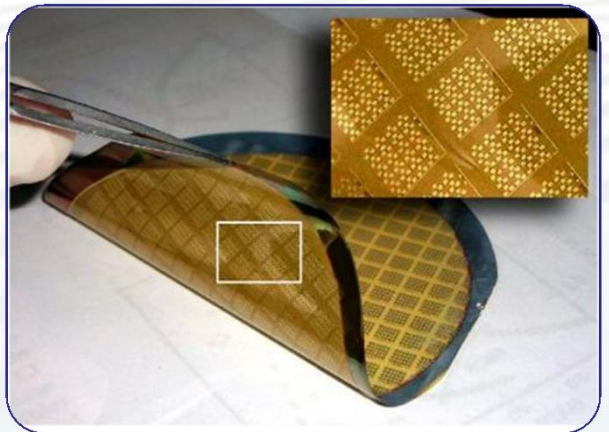
Figure 1
Sketch of the affordance competition hypothesis in the context of visually-guided movement. The primate

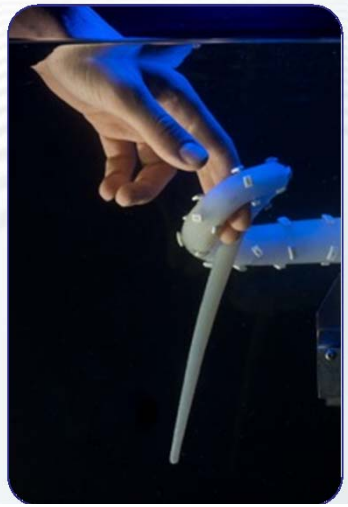
Verschure et al. 2003 Environmentally mediated synergy between perception and behaviour in mobile robots ***Nature.*** **425**: 620-624.
Tononi (1998,2008) **Science**
Friston (2010**) Nature Rev Neuro**

SCIENTIFIC PILLAR 4: MULTIFUNCTIONAL NANOMATERIALS AND ENERGY

- This pillar will enable a **brand new approach** to the fabrication of RCs endowed with **biomechanical features** and provide new multi-functional micro- and nano-fabricated materials for sensing, actuation, computation, communication, energy, exo- and endoskeletons, power storage, harvesting and generation systems, etc.
- The goal is to realize RCs with less components, higher robustness, higher compliance, lower computational load, higher energy efficiency, higher adaptability, higher dependability and ultimately lower cost







All efforts of RoboCom will be inspired by the expectations and needs and will aim at fulfilling the requirements and concerns of Citizens and Society

Citizens will ask such questions as:

- Robots will replace people – Robot Companions will work for welfare instead of maximizing profits
- It is unethical to build a robot with emotions or sentience
- Robots will develop their own dynamic evolution
- Robots will dominate me
- Dominance of technology on mankind

- RoboCom actively integrates all stakeholders, including society, ethicists and legal experts to directly address these concerns

SCIENTIFIC PILLAR 5: SOCIETY

The Society pillar will provide a driving force by:

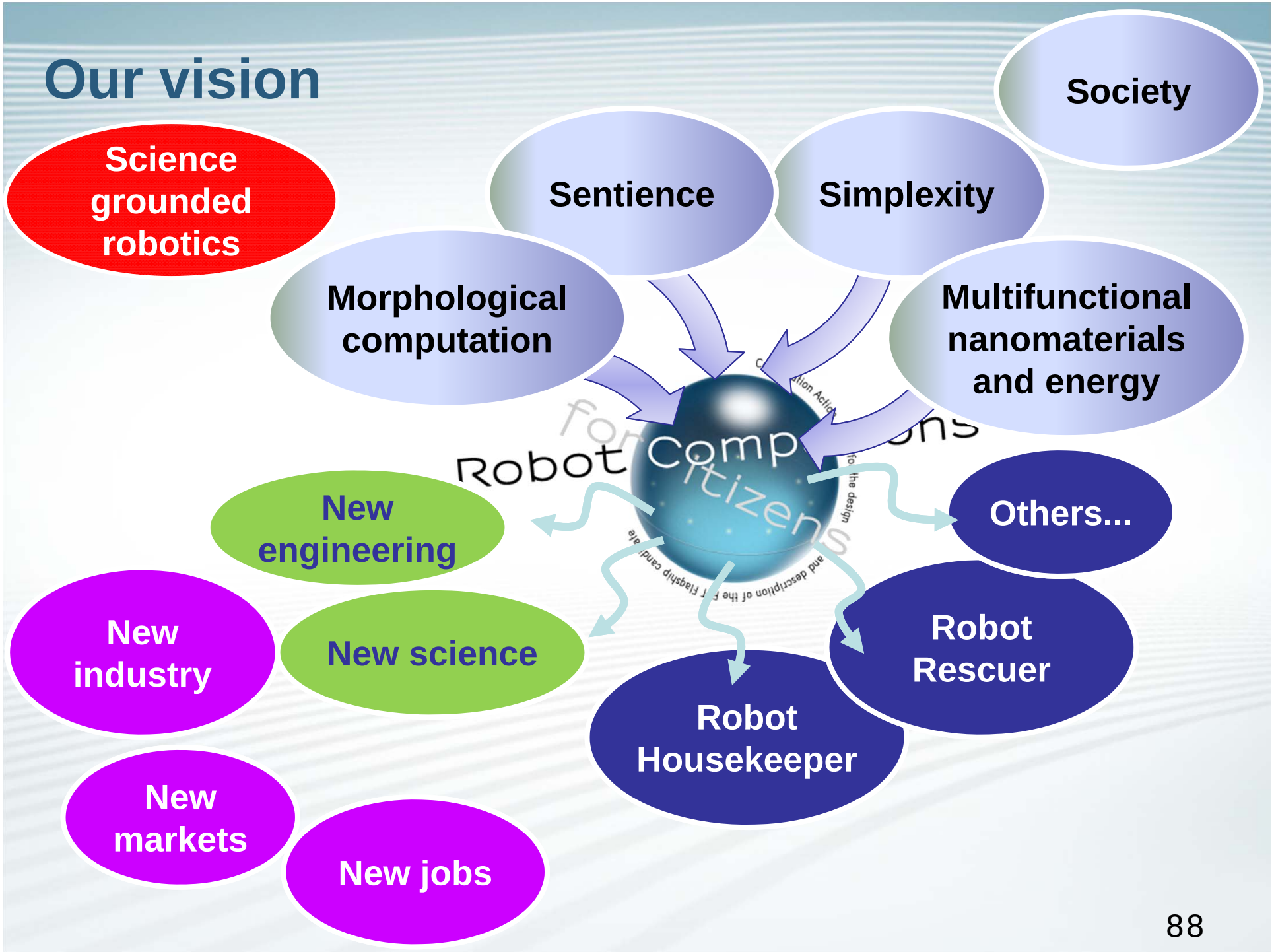
- **Understanding societal needs, attitudes, and expectations** in order to make RCs truly useful and acceptable for all citizens.

- **Developing ethical, legal and societal principles** to steer scientific and technological research and robots applications

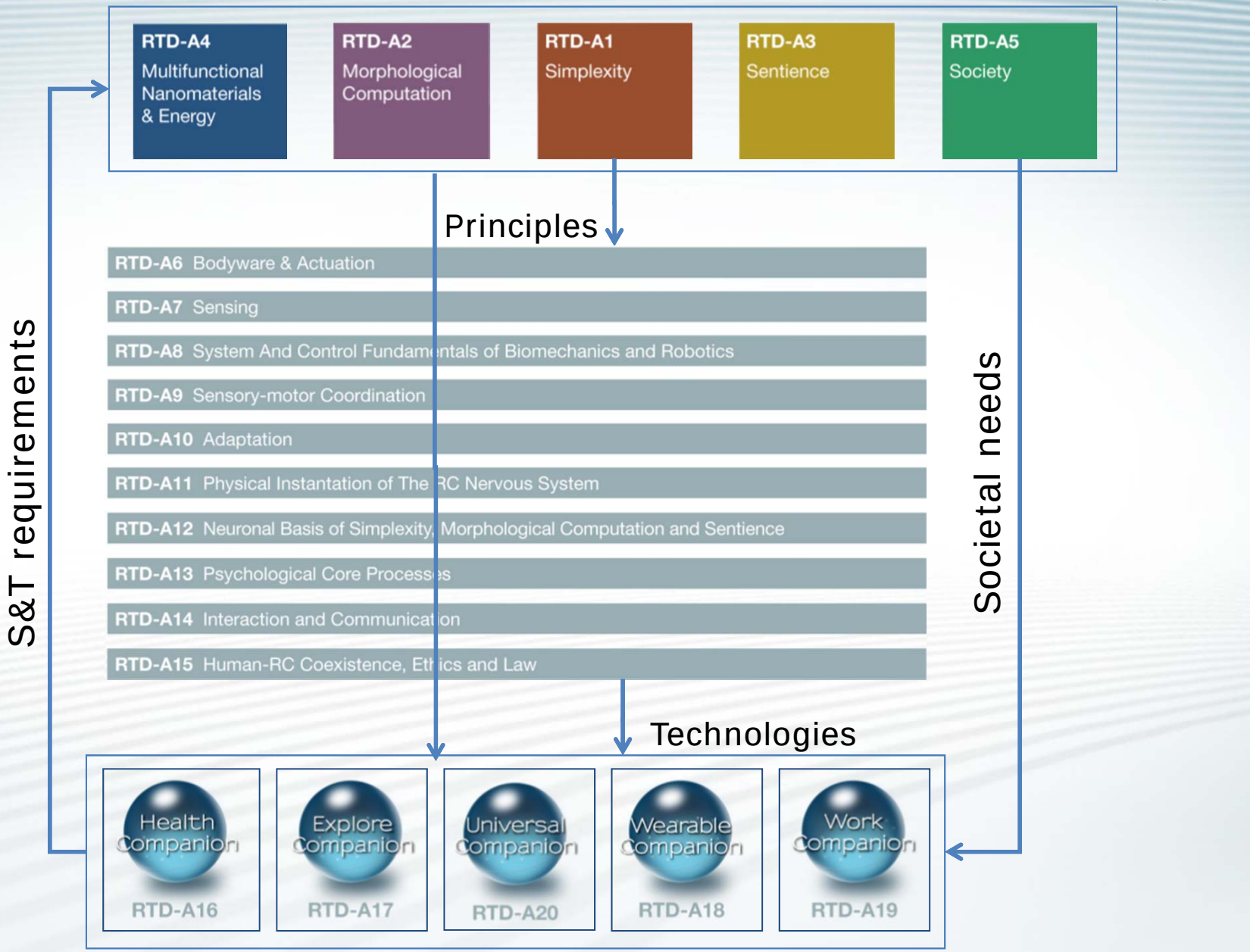
- **Designing educational programmes** to train a new generation of RCC scientists and engineers capable of turning bio-inspiration into engineering solutions and dealing with ethical, social and legal issues

- **Involving policy makers and stakeholders** to create the proper framework for RCs deployment and **industry** to realize safe, dependable, sustainable, and low-cost robotic solutions and develop new robotics-based markets and labour opportunities

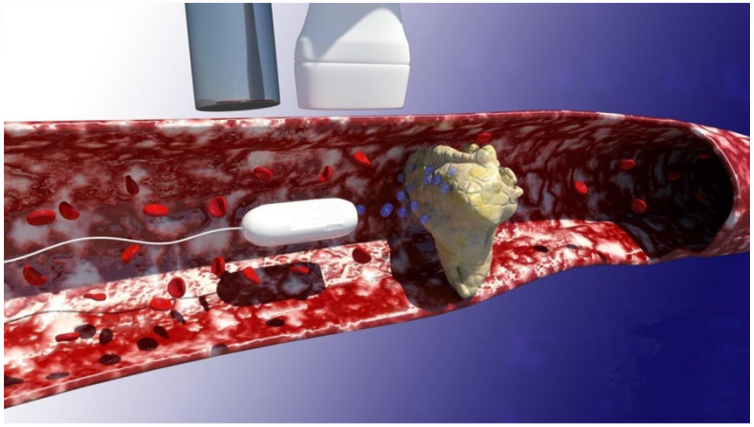
Our vision

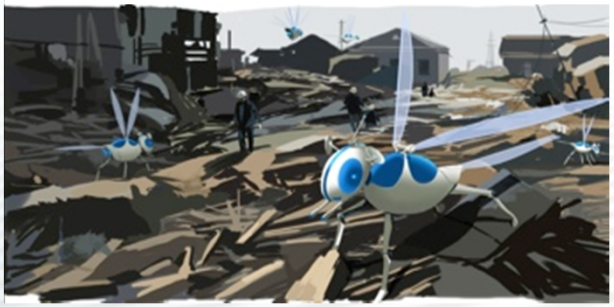

Science grounded robotics
Sentience
Simplexity
Society
Morphological computation
Multifunctional nanomaterials and energy
Robot
Comp
Citizens
New engineering
Others...
New industry
New science
Robot Rescuer
Robot Housekeeper
New markets
New jobs

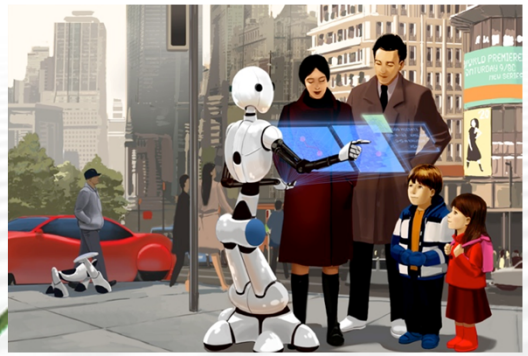
RCC Workprogramme

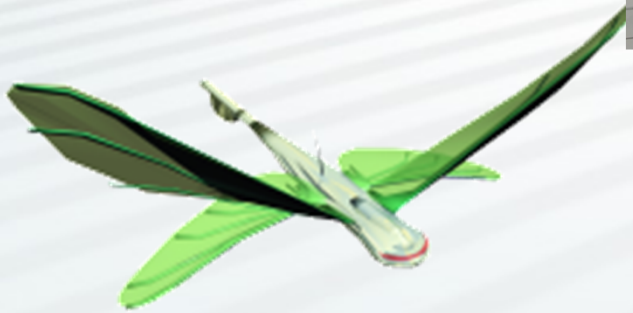


Concepts of what RCC will develop and deliver (intermediate and final results)









RoboCom Consortium

CA-RoboCom:
10 partners from 8 countries

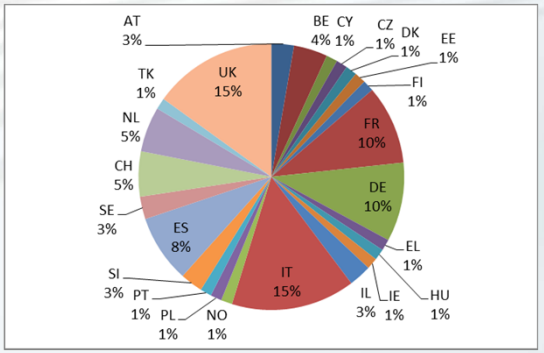
- 3 RoboCom plenary meetings with more than 200 participants
- 23 Community working group meetings
- 22 Meetings with stakeholders, decision makers and/or scientific communities

RoboCom Consortium

- **73** core partners from **24** Member States
- **109** Leaders and co-Leaders from the 73 institutions

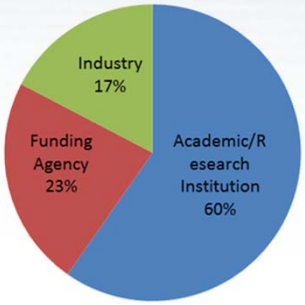
Enlargement of the RoboCom research community with Open Calls to involve **more than 240 - 280 partners**

Geographical distribution of RoboCom Core partners

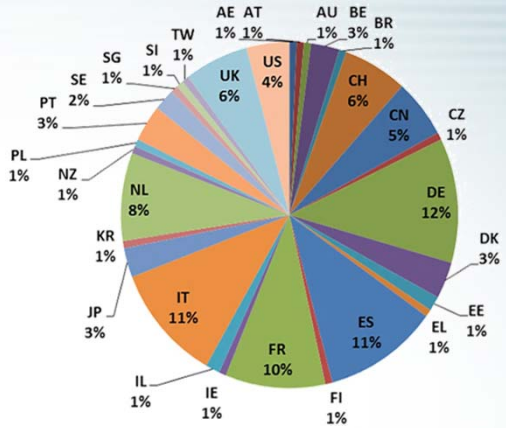


146 Endorsement letters from 30 Countries

- 85 academia, researc institutes and foundations
- 33 funding agencies
  (Central and regional governements)
- 28 industries

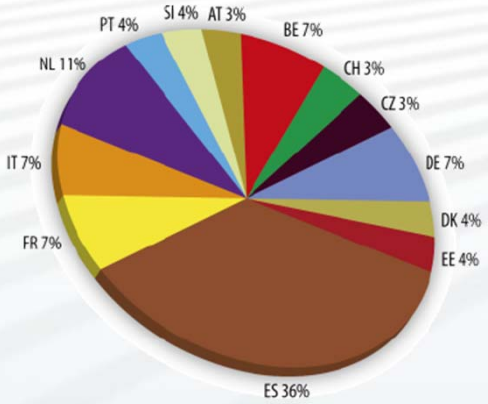


30 Countries willing to support RoboCom

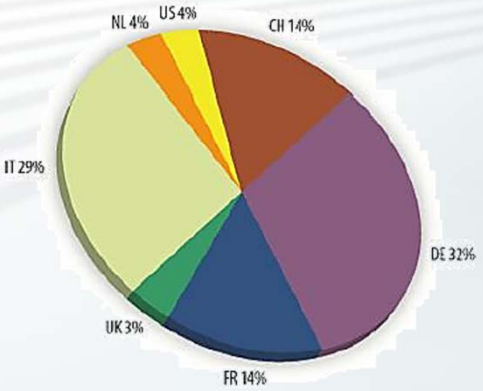


- 122 letters from EU zone (Member States+Associate Countries)
- 24 from Global Partners
  - China (8)
  - Japan (4)
  - USA (6)
  - Brasil (1)
  - United Arab Emirates (1)
  - Australia (1)
  - Korea (1)
  - Singapore (1)
  - Taiwan (1)
  - New Zealand (1)

Geographical distribution of the 33 national/regional funding agencies willing to support RoboCom



Geographical distribution of 28 industries willing to support RoboCom



RCC Worldwide view:
a European Flagship leading a global fleet and alliances

Global view of possible alliances

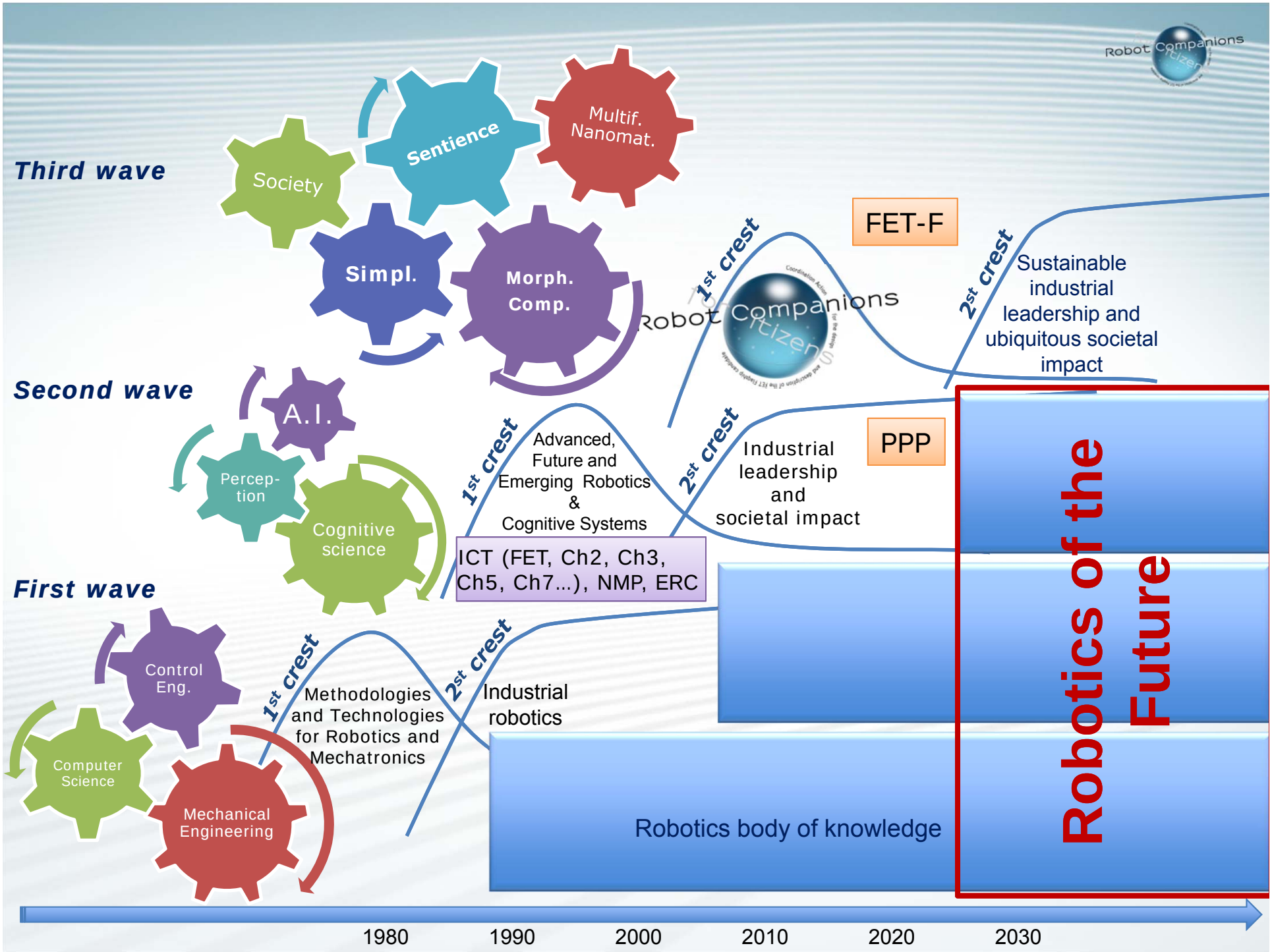
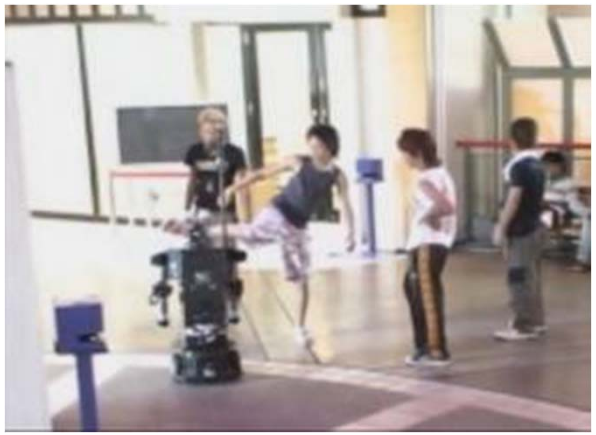

Third wave
Society
Sentience
Multif. Nanomat.
Simpl.
Morph. Comp.
Second wave
A.I.
Percep-tion
Cognitive science
First wave
Control Eng.
Computer Science
Mechanical Engineering
1st crest
Methodologies and Technologies for Robotics and Mechatronics
2st crest
Industrial robotics
1st crest
Advanced, Future and Emerging Robotics & Cognitive Systems
2st crest
Industrial leadership and societal impact
ICT (FET, Ch2, Ch3, Ch5, Ch7...), NMP, ERC
1st crest
2st crest
Sustainable industrial leadership and ubiquitous societal impact
FET-F
PPP
Robotics body of knowledge
Robotics of the Future
1980
1990
2000
2010
2020
2030

Table of contents

Social acceptance of robots

Bullying Robots



The study site

Sunken Plaze (Incheon, Replublic of South Korea)

Operative scenario:

Piero introduces DustCart to passersby by vocal messages. Piero describes DustCart functions and invites people attending to trash their rubbish by using DustCart

Scuola Superiore Sant'Anna
di Studi Universitari e di Perfezionamento

ETRI
Electronics and Telecommunications Research Institute

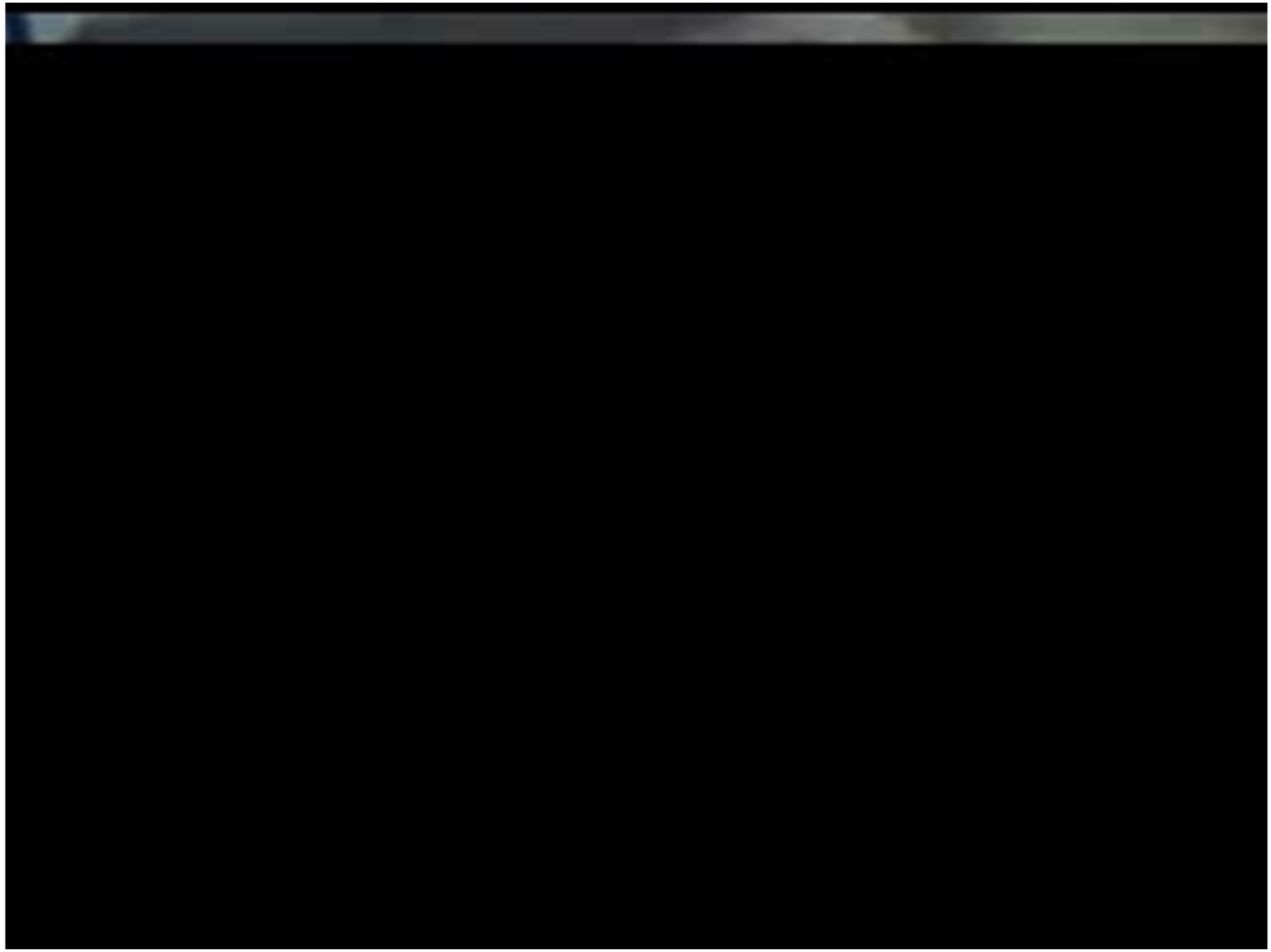
KIST 한국과학기술연구원
Korea Institute of Science and Technology

A collaborative research between SSSA, ETRI and KAIST

From playing to bullying robots the step is short

- Improper behaviour originated out of curiosity:
  - Exploring the robot
  - Testing the robot's limits (e.g. covering the robot's camera, standing in front of the robot, etc. …)
  - Playing with the robot (e.g. pushing repeatedly the robot bumpers to trigger vocal messages)

A cross cultural phenomenon



C*redits*: courtesy of ATR Intelligent Robotics and Communication Laboratories


TheDustBot system tested
in Peccioli (Italy)
IEIRION
Belvedere
ROBO
TECH srl
synapsis

After 16 years of continuous collaboration, at RoboTown this is a well established methodology

- Citizens know us and are confident in our attention and skill
- Administrators are believers and supportive
- The user-centered methodology can be smoothly adopted for different applications, exported and also offered to external users

Peccioli, the RoboTown will be a RIF (Robotics Innovation Facility) in the new FP7 CH2 Project ECHORD++ (2013-2018)

- Offering permanent test-bed for industry-university joint experiments and tests
- Performance evaluation
- Standards
- Legal requirements and constraints
- Insurance
- User satisfaction
- Market analysis

Scenarios and research foci

Scenarios	Focus 1: Key Issues in Practical Machine Cognition	Focus 2: Key Advanced Perception and Action Capabilities	Focus 3: Multiple Cooperating Mobile Manipulators	Focus 4: System Architectures, Systems and Software Engin. Processes and Tools
1: Cognitive Tools and Workers for Cognitive Factories	KIC BRL, CEA, SSSA Experiments	KIC BRL, CEA, SSSA Experiments	KIC BRL, CEA, SSSA Experiments	KIC BRL, CEA, SSSA Experiments
2: General Purpose Robotic Co-workers	KIC BRL, SSSA, CEA Experiments, PCP	KIC BRL, SSSA, CEA Experiments, PCP	KIC BRL, SSSA, CEA Experiments, PCP	KIC BRL, SSSA, CEA Experiments, PCP
3: Cognitive Logistics Robots for Industry	KIC BRL Experiments, PCP	KIC BRL Experiments, PCP	KIC BRL Experiments, PCP	KIC BRL Experiments, PCP
4: Medical Robotics	KIC SSSA, CEA Experiments, PCP	KIC SSSA, CEA Experiments, PCP	KIC SSSA, CEA Experiments, PCP	KIC SSSA, CEA Experiments, PCP
5: Agricultural Robotics	KIC SSSA Experiments	KIC SSSA Experiments	KIC SSSA Experiments	KIC SSSA Experiments

The Legal Challenges

- Two main challenges depending on:
  - what robots are
  - what robots can do

The RoboLaw Project

RoboLaw

Regulating Emerging Robotic Technologies in Europe. Robotics Facing Law and Ethics

Collaborative Project
FP7 GA 289092

www.robolaw.eu

Project Information

Co-ordinator:

Prof. Erica Palmerini

Istituto DIRPOLIS, SSSA

Scuola Superiore Sant'Anna - SSSA
Piazza Martiri della Libertà, 33 – 56127
Pisa (Italy)
E-mail e.palmerini@sssup.it

Start date: March 1st, 2012
Duration: 24 months
Total cost: € 1,890,491.20
EU contribution: € 1,497,966.00
Grant Agreement No.: 289092
Call: SiS 2011.1.1.1-3

The RoboLaw project involves **4 partners** from **4 European countries**: Italy, Netherlands, and United Kingdom and Germany

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Consortium

SSSA (I)
DIRPOLIS Institute
Erica Palmerini
The BioRobotics Institute
Paolo Dario
www.sssup.it

TILT (NL)
Tilburg Institute for Law, Technology, and Society
Ronald Leenes
www.tilburguniversity.edu

UoR (England, UK)
School of Systems Engineering
Kevin Warwick
www.reading.ac.uk

HUB (Germany)
Department of Philosophy
Volker Gerhardt
www.hu-berlin.de

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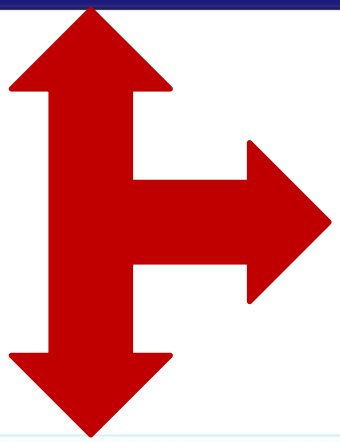
The most important outcome of the research will consist of a **White Paper on Regulating Robotics**, containing guidelines and suggestions for the European Commission in the field of regulating emerging robotic technologies, in response to the ethical concerns regarding its applications

Project main actors

Supporting External Network
1) Inomed - Medizintechnik GmbH, (medical company);
2) Disabled Peoples International (DPI) DPI Europe is the European network of
National Assemblies of Disabled
People's Organizations;
3) Stanford Law School, The Center for Internet and Society, part of the Law, Science and Technology Program;
4) Masahiro Kobayashi, Japanese Lawyer



External Advisory Board
1) Prof. Francesco Donato Busnelli: Professor Emeritus of Civil Law at the Scuola Superiore Sant'Anna of Pisa
2) Prof. José M. Galván Casas, Professor of Moral Teology Pontificia Università della Santa Croce, Roma, Italy
3) Prof. Martha J. Farah,director of Center for Cognitive Neuroscience, Uni Pennsyvania (US)
4) Prof. Stefano Rodotà: Professor Emeritus of Civil Law at University "La Sapienza" of Rome
5) Prof. Maxim Stamenov, Head of the Department of General and Applied Linguistics at IBL, Sofia University, Bulgaria.

1) Scuola Superiore Sant'Anna, Pisa, Italy
BioRobotics and DIRPOLIS Institutes

2) Tilburg University, the Netherlands
Tilburg Institute for Law, Technology, and Society

3) University of Reading, England (UK)
School of Systems Engineering

4) University of Humboldt, Germany
Department of Philosophy

Project main objectives

Integration of technology into society: Governance patterns
Studying the features of emerging regulatory tools, including soft law instruments such as ethical rules, technical standards and codes of conduct

Roadmapping Robolaw
Describing the state of the art of the existing regulations pertaining to robotics in a comparative perspective

Elaborating a taxonomy of robotics
Clarifying the differences in terms of language between the various types of technologies being considered

Philosophical, anthropological, sociological consequences arising from the use of emerging robotic technologies for human enhancement
Investigating the relationship between future technologies, human values and society

Policy recommendations defining guidelines and suggestions on regulating Robotics
Elaborating “Guidelines on Regulating Robotics” for the European Commission

THE BIOROBOTICS INSTITUTE
Scuola Superiore Sant’Anna

RoboLaw

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Autonomy and Law

- The current legal systems are not ready to deal with robots that exhibit autonomous behaviours in human-inhabited environments
  - Legal subjectivity and of legal acts by robots

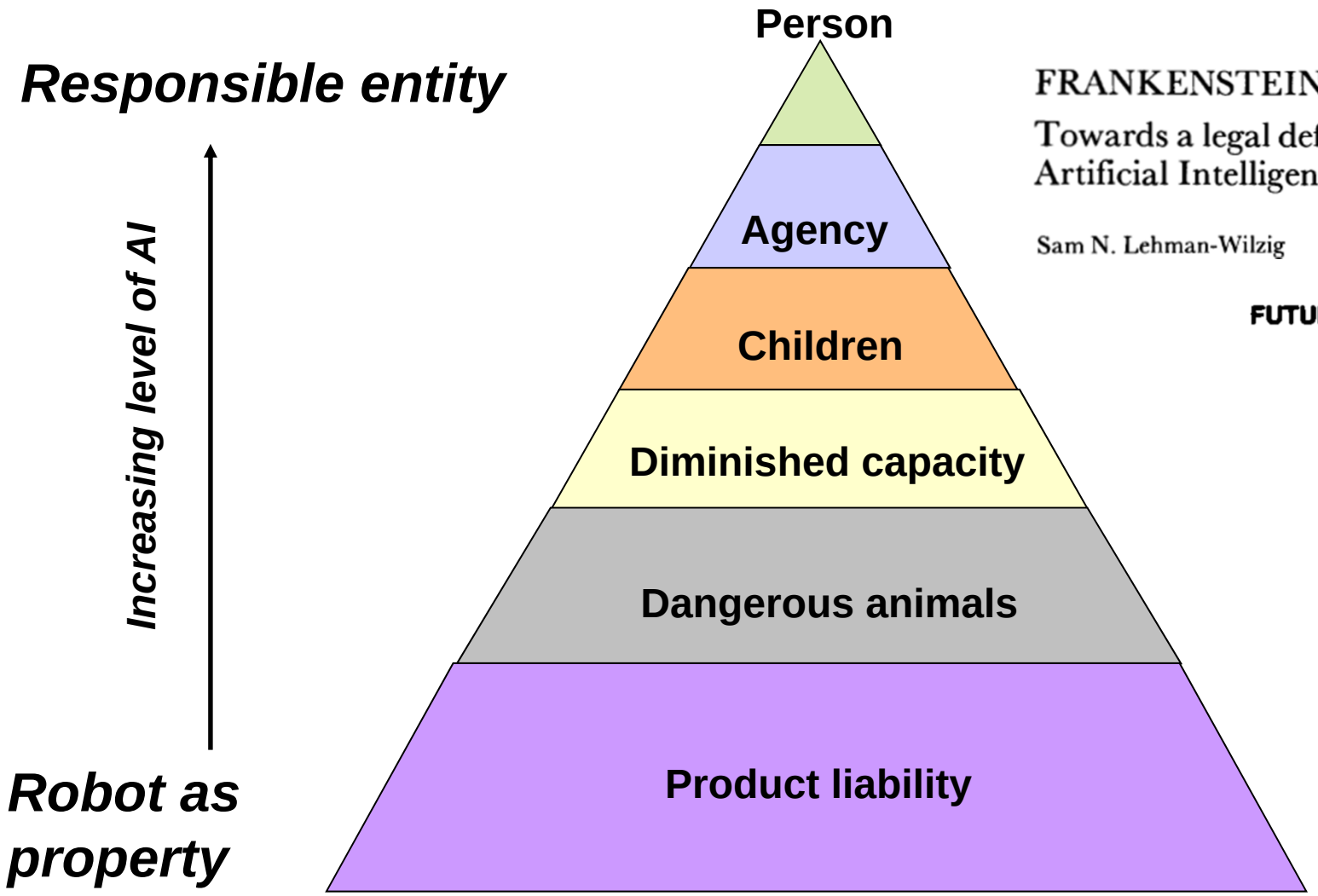
What is autonomy?

- A definition of autonomous robot:
  - 'the capacity to operate in the real-world environment without any form of external control, once the machine is activated and at least in some areas of operation, for extended periods of time' [Lin et al, 2008].

Robots and Legal capacity

- It is not a matter of ontology
- But a practical and functional solution
  - Ability to perform legal transactions (entering into a contract)

Legal categories for robots



FRANKENSTEIN UNBOUND

Towards a legal definition of Artificial Intelligence

Sam N. Lehman-Wilzig

FUTURES December 1981

Legal Issues

- Main cases of differentiation between person and subject in the European Member State Law:
  - unrecognized organizations and some kind of corporations without legal personality;
  - conceived baby before birth;
  - animals.
- Assessing the possibility to extend some of their *rationales* to the recognition of robots' subjectivity.

What about robots?

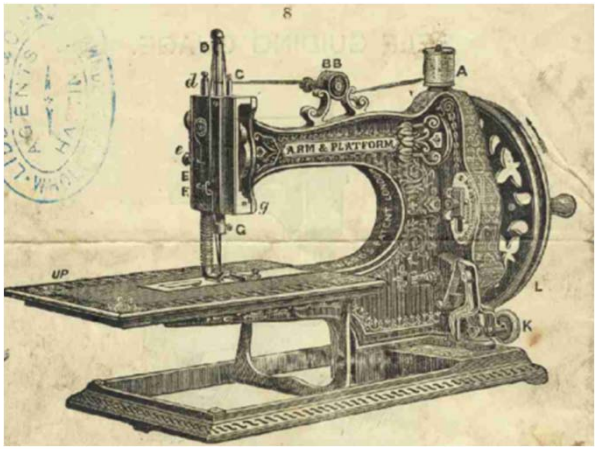
- Should the recognition of subjectivity derive from the “legal environment” in which autonomous robots are going to act?

Three possible approaches

- 1) considering robots as a sort of extension of their users' will and physical body, so that any act they execute is directly referable to the former
- 2) awarding robots full capacity
- 3) acknowledging companion robots as autonomous agents, endowed with the status of subjects, but capable of entering into transactions under certain constraints.
  - The reduced capacity of minors or of the mentally impaired, known and disciplined in the current legal systems, could be taken as a model for regulation.

Legal capacity and the issue of liability for damages

- It is necessary to consider whether:
  - the existing rules about producer's liability or liability deriving from the ownership or possession of things apply;
  - or the technology is so highly developed and advanced, provided with a certain degree of decision-making ability, that the rationale underlying those sets of rules cannot operate.
- And it is necessary to distinguish between:
  - **Traditional machines**, that can be designed and manufactured so that their behaviour will be predetermined or predictable by the constructor and afterwards mastered by their user;
  - **Sophisticated robots**, that do not correspond to this archetype.



A possible model rule

- The basic structure of most legal regimes regarding injuries caused by minors and incompetent persons could be taken as a model rule.
- These cases share some common features:
  - the limited capacity of the agent, not sufficient to held him fully responsible for the damages he has produced;
  - but also an independence of action, more or less substantial, that the agent exhibits and that accounts, at the same time, for the possibility of the guardian to be exonerated by demonstrating not to be at fault (or to have adopted every reasonable precaution in order to avoid accidents).

Privacy

- A third domain of investigation concerns privacy and data protection. Some robots will process personal data (e.g. visual imagery by surveillance drones, personal data by domestic and medical robots) and hence enter the remit of data protection.

In the loop, on the loop or out of the loop?

- Legal regulations should be used to restrict autonomy in specific circunmstances and for specific actions:
  - for instance when robots are engaging with humans, authorisations may be asked before making a decision
  - Only certain actions can be carried out autonomously
- Advancements in the performances and safety of autonomous robots systems will be determinant
- Ethical and cultural issues will also play a role in reducing resistances towards the application of autonomy

Conclusions (Part 1)

- A revolution has occurred with the advent of the web, the cloud, the social networks, and the widespread introduction of smart personal and portable devices: they are the real personal assistants
- Robots are not portable, and they must do more than communicate. However, they must be integrated and be part of the network around us
- People are ready and willing to accept and use robots, provided that they are useful, affordable, sustainable, dependable and provided that they do real and heavy work for us
- A solution: robots as supervised systems (operation according to the flight-control model)
- This will occurr anyhow. However, the progress and deployment of companion robots can be accelerated by rethinking the way robots are designed, and through a **global effort** in this direction

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Conclusions (Part 2)

- It is important and timely to get robots out the lab
- The citizens want and are ready to test advanced services
- Important lessons learned on design and acceptability of service robots in real settings
- Local administrations increasingly committed and willing to make service robotics a Flagship
- Companies eager to enter the market of service robots
- A permanent open infrastructure will be ready soon to test novel service robots with real users (ECHORD++ Project, 2013-2018)
- Legal and insurance issues can be addressed in specific and limited situations
- Investigations and actions urgently needed to formalize and systematize such work

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Acknowledgments

Many colleagues, many PhD students, many funding agencies (mostly the *European Commission*), the citizens and the administration of Peccioli, the RoboTown