The European Research and Funding Landscape

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Big Thanks to

- Alessandro Saffiotti (AICoR)
- David Bisset (euRobotics)
- Giorgio Metta (IIT)
- Herman Bruyninckx (KU Leuven)
- Tamim Asfour (KIT)
- Uwe Haass (euRobotics)

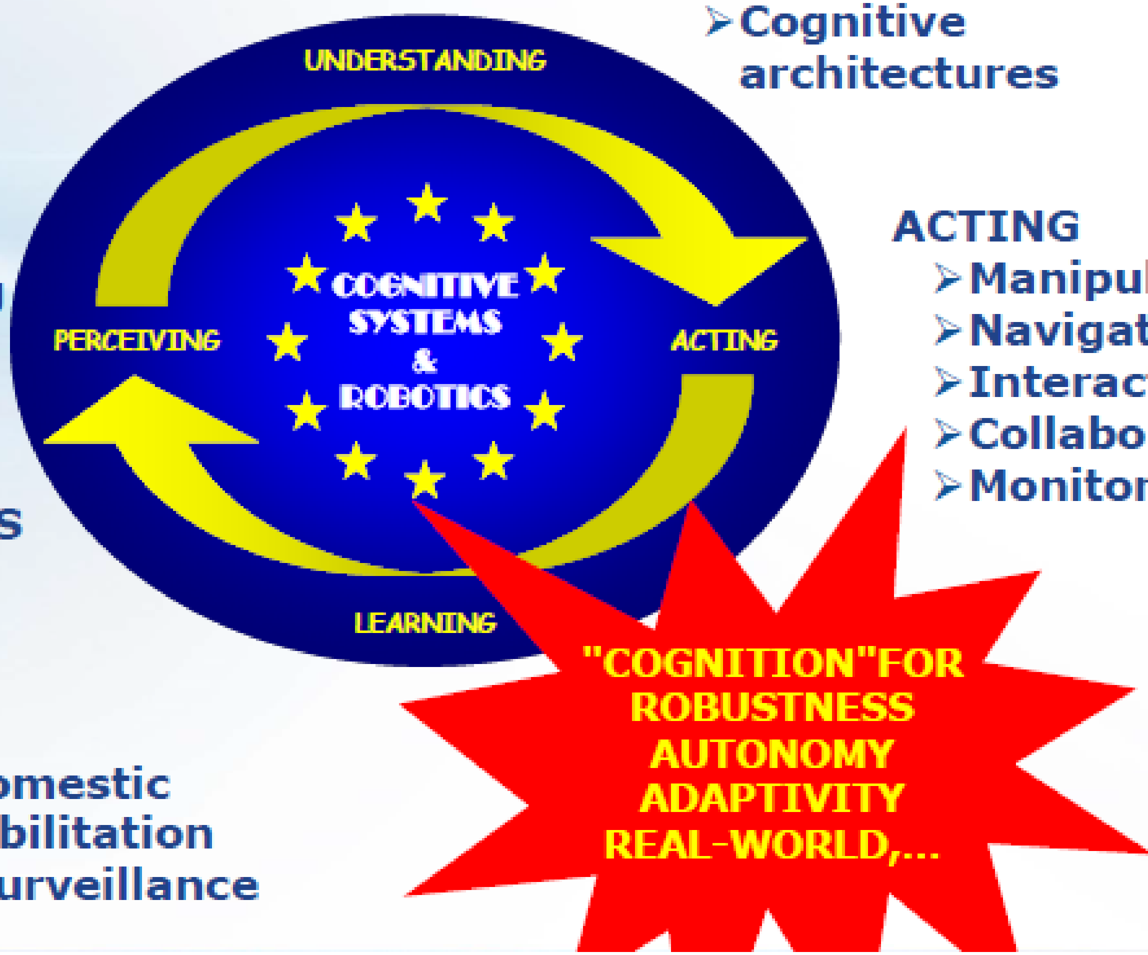
Content

- euRobotics – European Robotics Union
- SRA – Strategic Research Agenda
- MAR – Multi-Annual Roadmap
- SPARC – Public Private Partnership in Robotics
- TG – Topic Groups
- SOD – Strategic Orientation Document
- LEIT – Leadership in Enabling and Industrial Technologies

Background: Project Portfolio

UNDERSTANDING
- Recognising
- Interpreting
- Adapting
- Modelling
- Cognitive architectures

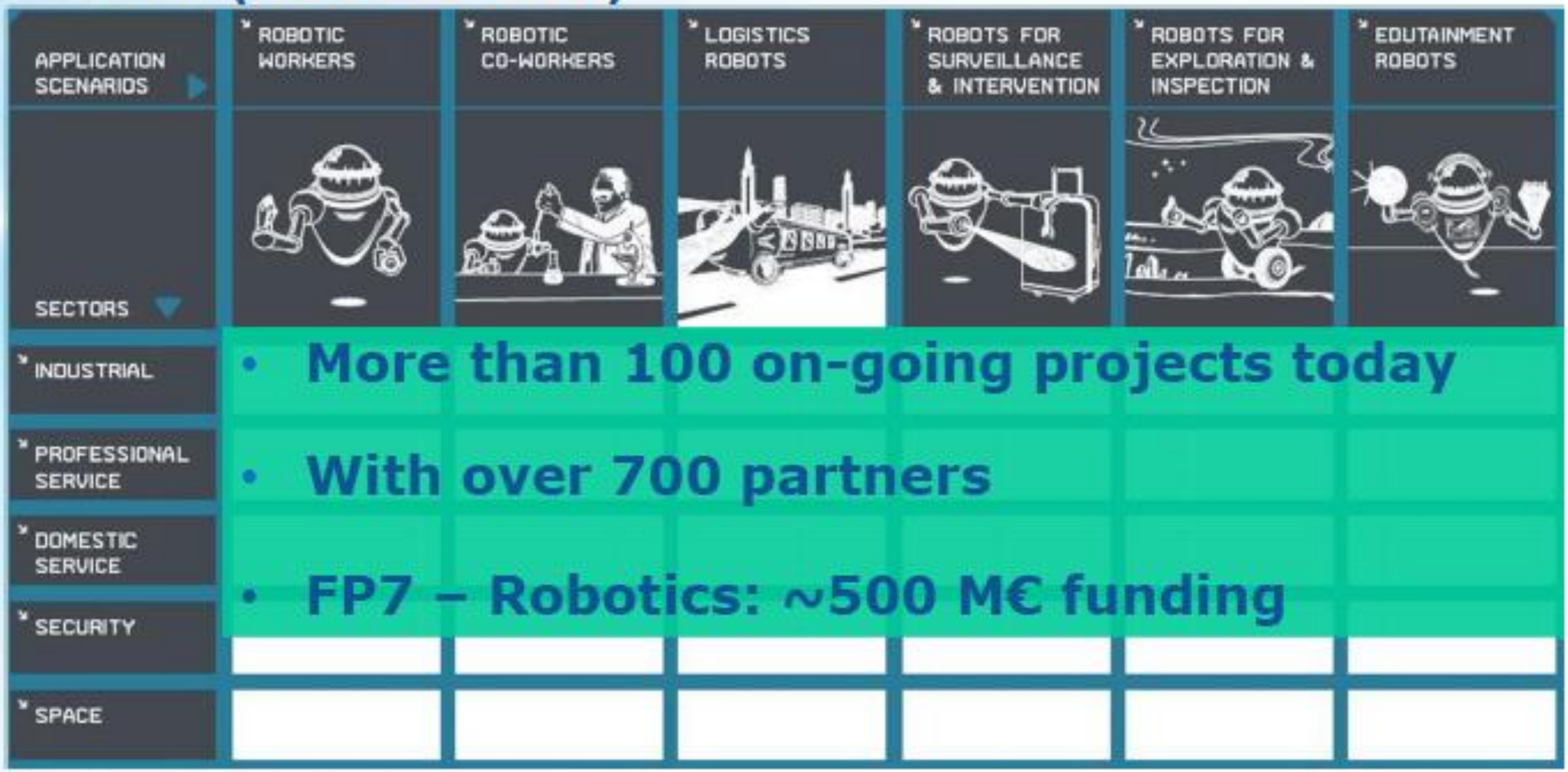
PERCEIVING
- Touching
- Seeing
- Hearing
- Advanced sensing



ACTING
- Manipulating
- Navigating
- Interacting
- Collaborating
- Monitoring

APPLICATION AREAS
- Aerial
- Underwater
- Industry and manufacturing
- Professional & domestic
- Medical and rehabilitation
- Monitoring and surveillance

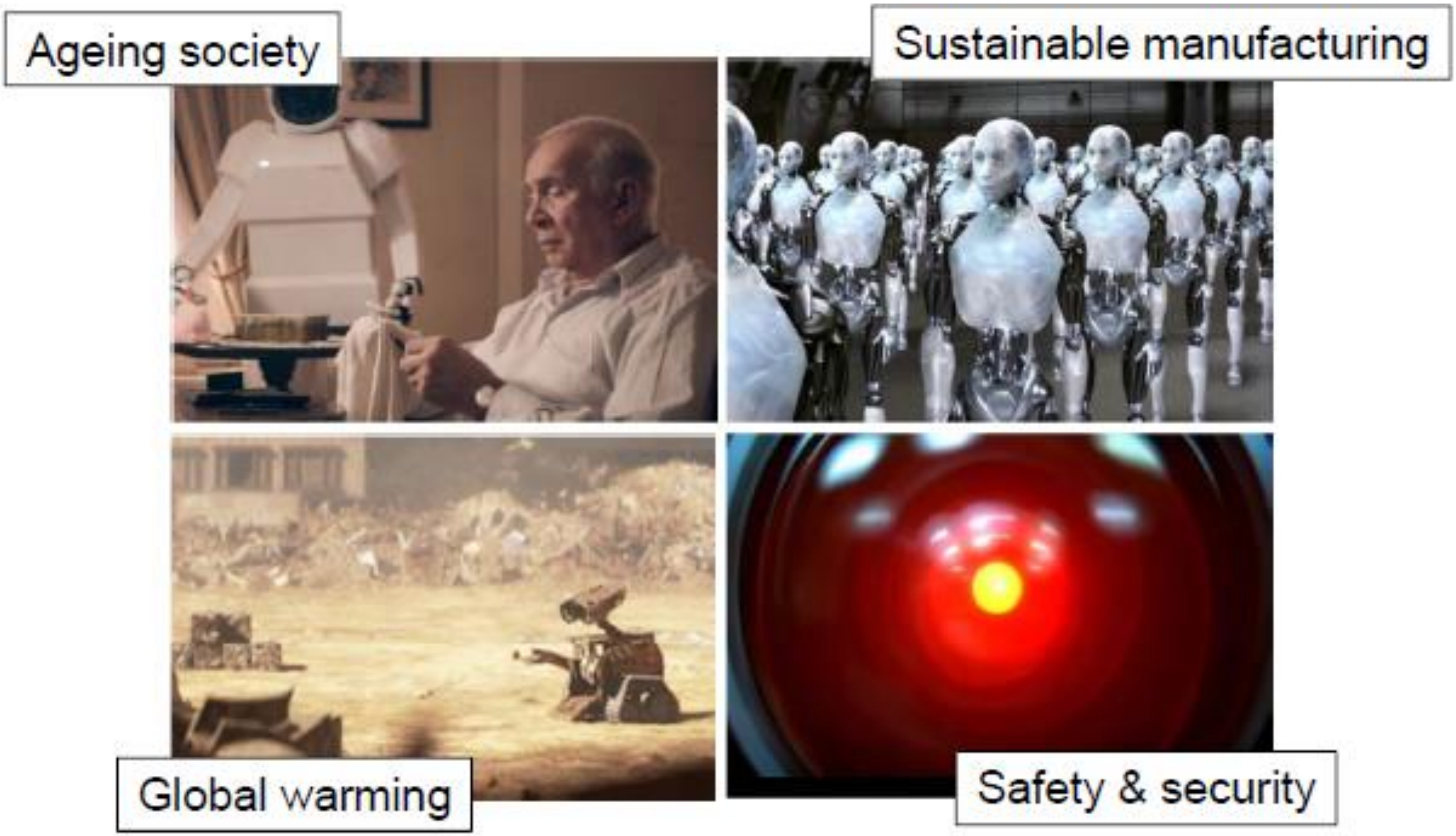
Background: EU Robotics programme in FP7 (2007–2013)



- More than 100 on-going projects today
- With over 700 partners
- FP7 – Robotics: ~500 M€ funding

Societal Challenges

How Robotics Can Contribute



One of the Tools to Make Fiction Reality

The Recipe

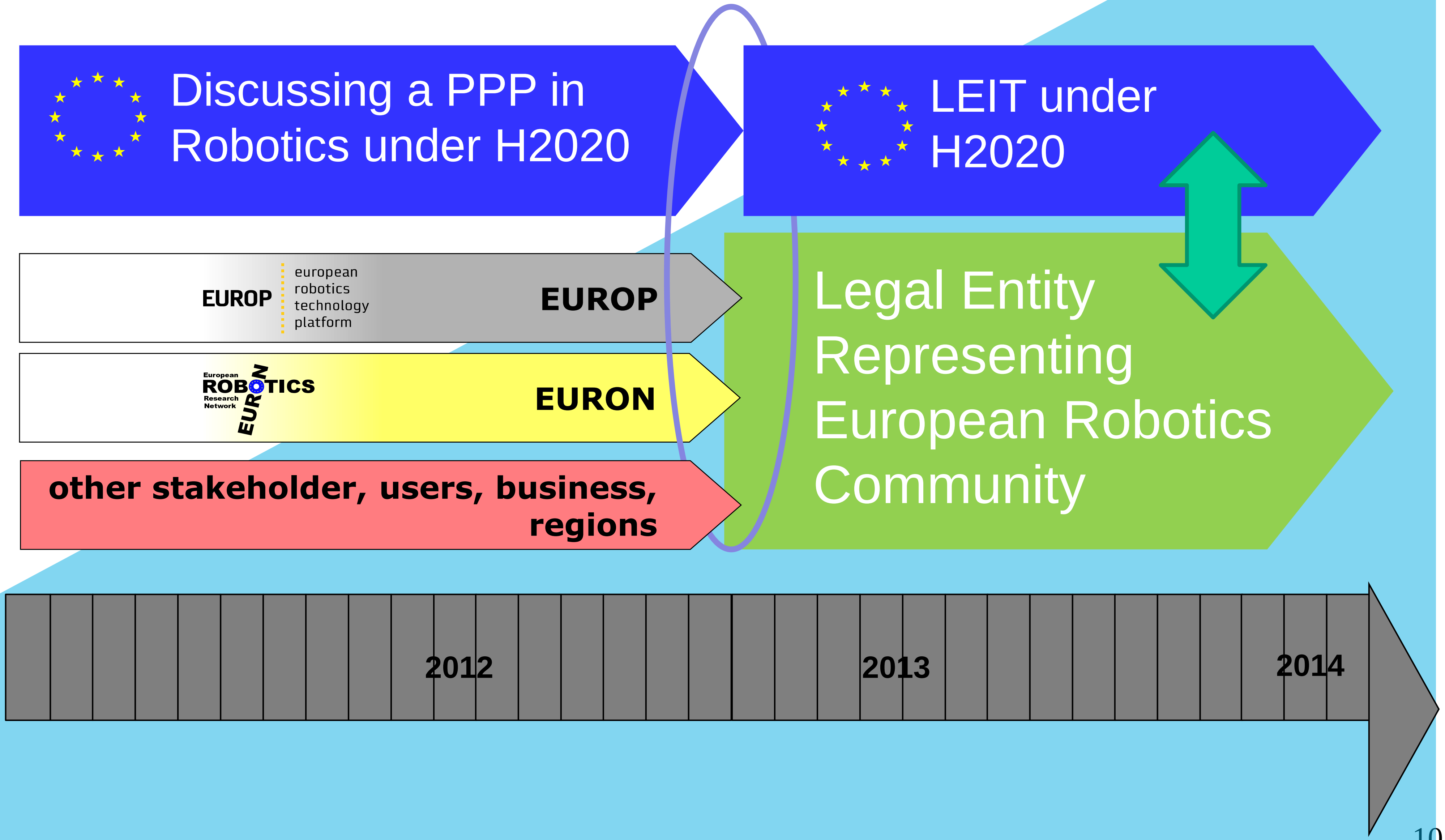
Expert input

…ends up in a roadmap

…that leads to focused projects

…and progress

The way towards the Robotics PPP



Public Private Partnership (PPP) in Robotics

- … required the **establishment of a legal entity** on the "private side": euRobotics AISBL in Brussels

17 Sep. 2012: Founding of euRobotics AISBL

18 Sep 2012: MoU with Commission

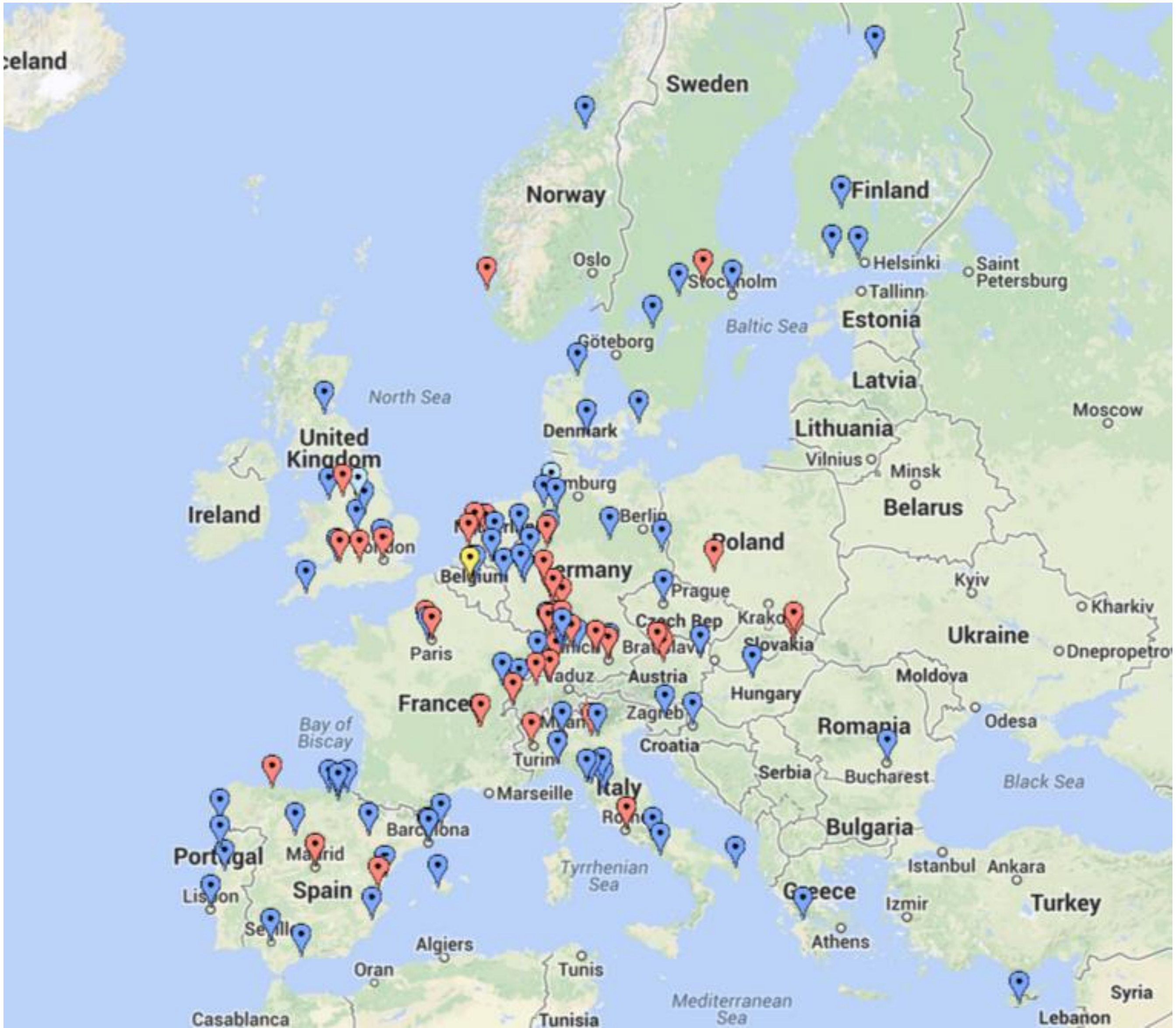
17 Dec 2013:
Contract with Commission
after acceptance of Proposal

- Legal Entity presenting European Robotics Community

- http://www.eu-robotics.net

- In download area:
  - SRA, MAR, PPP-flyer
  - Membership application form, bylaws, statutes
  - Newsletters

195 euRobotics aisbl Member Organisations



Legend:

- Industry (65)
- Research (120)
- Associate (10)
- Seat of euRobotics AISBL

- **European Robotics Week**
  24 to 30 November 2014
- Annual event
- European wide contributions
- euRobotics week 2013
  - 334 events, 24 countries
  - 46.000 attendees
  - 1st time in Finland, Turkey, Cyprus and Macedonia

euRobotics Forum 2014

- „The“ European Robotics Event
- Networking, robot exhibition, workshops, entrepeneur events, etc. – ERF is not a conference
- ERF 2014 – Rovereto: 463 participants + 45 students

Industry	**134**	**28,94**
Academia	329	71,06
Students	45	9,72

euRobotics AISBL

euRobotics Forum 2015

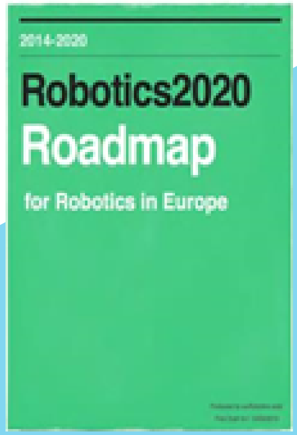
11-13 March 2015

Vienna, Austria



2 Documents Members Produce(d) with Support from the Whole Community

- High level document
- Broad readership
- “SRA”



- Technical detail, updated each year
- Multi-annual Roadmap, “MAR”

17 Sept. 2012, Leuven – Roadmapping Workshop

For example

Better Action and Awareness: Cognition

Cognition provides a robot with the ability to understand its environment – even from partial knowledge – now and in the future, and to use this understanding for action. Cognition breaks free of the present in a way that allows the robot to act reliably and safely, to adapt, and to improve. This is needed for robots to act in a goal-directed way in unstructured environments, such as in everyday environments. In such environments, robot tasks can only be incompletely or vaguely specified and the robot must use common sense reasoning to fill in the necessary detail based on the current context and goals.

Many robot technologies exploit cognitive processes and techniques, including perception, planning, navigation, and human-robot interaction. All of these will benefit from improvements of the cognitive technologies listed here.

Cognitive Architectures

A cognitive architecture determines the organisation of the system's cognitive functions. It provides the infrastructure for embedding knowledge, acquiring new knowledge, and using that knowledge to understand the world, to act purposefully, and to anticipate the need for action. It can also provide a framework to allow new skills to be developed through experience.

State of the Art

General-purpose cognitive science architectures such as Soar and ACT-R are well established. Contemporary research in cognitive architectures is increasingly targeted at robot platforms.

2020 Target

To establish standardised, well-engineered, and re-usable cognitive architectures that facilitate integration and sharing of knowledge from disparate sources, including humans, robots, and the internet. To incorporate a developmental capacity for acquiring and honing robot skills, especially those concerned with adaptive and prospective control of actions. To exploit models of embodied cognition. To integrate autonomic processes that cater for self-diagnostic, self-correcting regulation of system performance.

High level document:
- Overview of opportunity.
- Overview of technology.

4.7 Cognition

4.7.1.1 Description

Cognitive robots are able to express adaptive anticipatory behaviour in real time on the basis of the contingent situation, past experience, and inferred future conditions. Cognition is the system-wide process that provides an agent with the ability to understand, given only partial knowledge, how things might possibly be, not just now but at some point in the future, and to use this understanding to influence action. Predicting the future requires the robot to remember past, so learning is critical to all cognitive systems. Cognition breaks free of the present in a way that allows the system to act proactively, reliably, to adapt, and to improve.

Many of the other technologies exploit cognitive processes and techniques, and vice versa, including sensing, planning, navigation and human-robot interaction (HRI). All of these will benefit from further improvements in cognition and in turn cognition depends on them.

4.7.1.2 Key Techniques and Methods

Knowledge representation and reasoning (KR&R)

KR&R is a wide and mature field of AI, which is pivotal to high impact application domains like data mining, search engines and recommendation systems. The main assumption behind KR&R is that knowledge should be represented in the system in an explicit, machine-readable form, to provide the ability to reason from this knowledge and about this knowledge, and to prove formal properties about the knowledge and about the reasoning mechanisms. This concerns both descriptive — declarative— knowledge ("know-what") and prescriptive — procedural— knowledge ("know-how"), particularly important in robotics. More generally, knowledge can be of many different types, including ontological, causal, deontic, procedural, temporal, spatial, and still others. Accordingly, different KR&R formalisms have been developed, each one being typically geared toward one type of knowledge. Formalisms have also been developed to deal with the uncertainty that may affect knowledge, including those based on probability theory, Dempster-Shafer theory, and fuzzy logics. Reasoning in the above formalisms is often done by logic-based methods, and a great attention is put in the formal and computational properties of these methods, like soundness, completeness, decidability and complexity. A plethora of tools for KR&R are available, both commercially and in the open source community. Some languages produced in this community have become standard, like the OWL family.

KR&R in Robotics.

The issues addressed in the field of KR&R have recently started to be also addressed by the robotics community, as a means to endow robots with the ability to represent and use higher level knowledge. Notable examples are the representation of higher level concept in semantic maps, and the use of ontologies to enable robots to elicit information from the web. Ensuring a high level of communication and synergy between robotics and the field of KR&R is essential in order to leverage the large body of knowledge, experience and tools acquired in the former, and in order to make this knowledge and tools suitable to the needs of robotics systems.

Technical detail:
- Updated each year.
- Tracks trends.

Why are they important?

- SRA provides the terms of reference for roadmapping
  - hence for the EC calls
- MAR is meant to be used:
  - to identify topics (proposals should point to it)
  - to identify step changes as targets (proposals should point to it)
  - to inform evaluators (currently a “guidance”, may become stronger)

SRA – Strategic Research Agenda

- High level strategic overview for the robotics community
- Introduction for non-robotic specialists, policy makers, entrepreneurs and industries
  intending to use or work within the robotics market

SRA – Strategic Research Agenda

- Gives an overview of the status and potential of robotics.
- If you are a policy maker, investor, or entrepreneur trying to understand the robotics market in Europe
  → you should read this document
- If you are an innovator, technologist or researcher you may find the detail you are looking for in the “Multi-annual Roadmap MAR”

MAR - Multi-annual Roadmap

- Companion to the SRA providing a greater level of technical and market detail
- Identifying expected progress within the community
- Providing a detailed analysis of medium term research and innovation goals
- Updated annually as priorities, technologies and strategic developments shape European research development and innovation (R&D&I)

MAR - Multi-annual Roadmap

- Generated by robotics experts (volunteers)
- Driven by euRobotics
- Open consultation
- Annually updated
- Produced for every Call
- Guideline document for proposers and reviewers

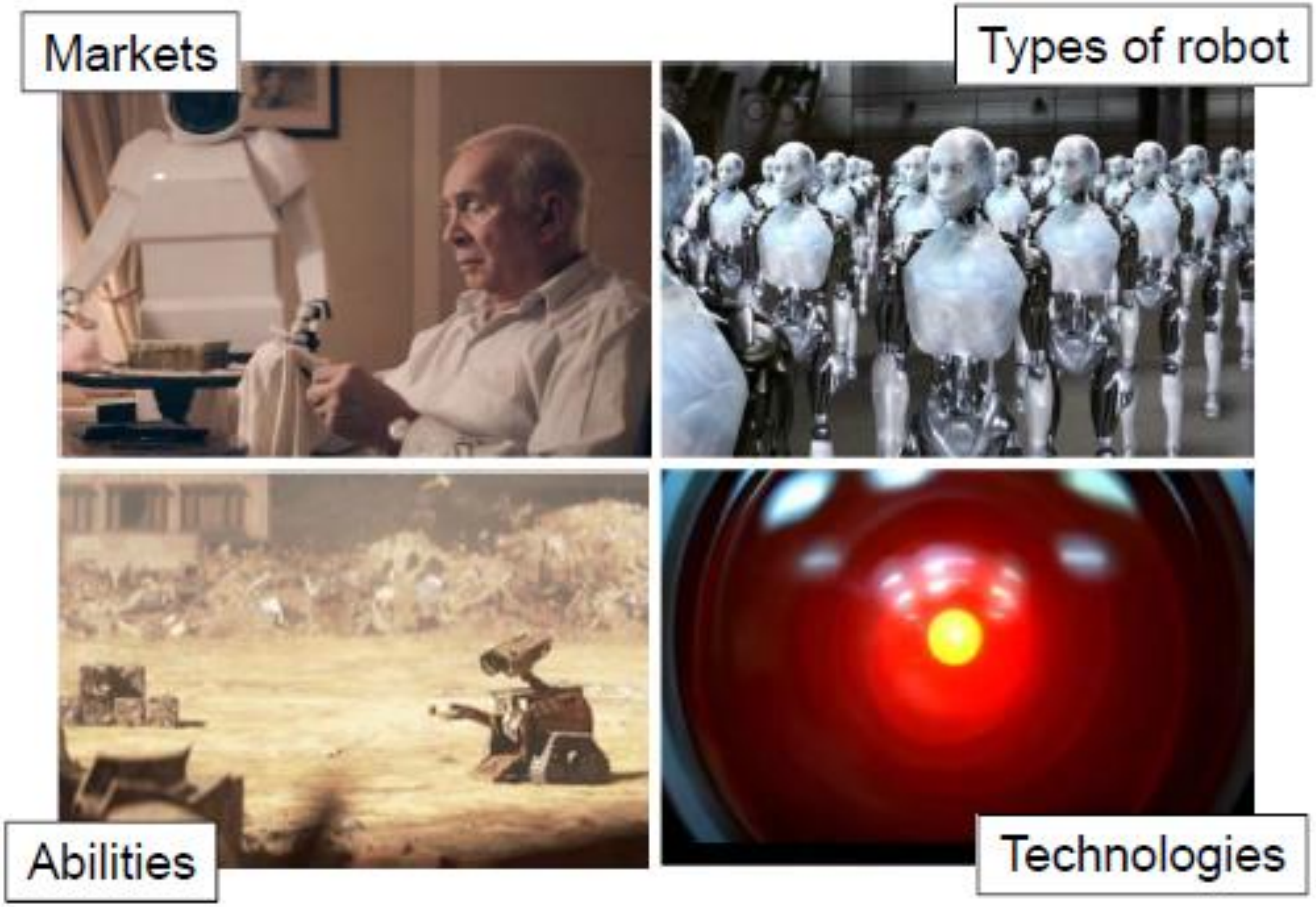
Robotics 2020
Multi-Annual Roadmap

For Robotics in Europe

Call 1 ICT23 – Horizon 2020

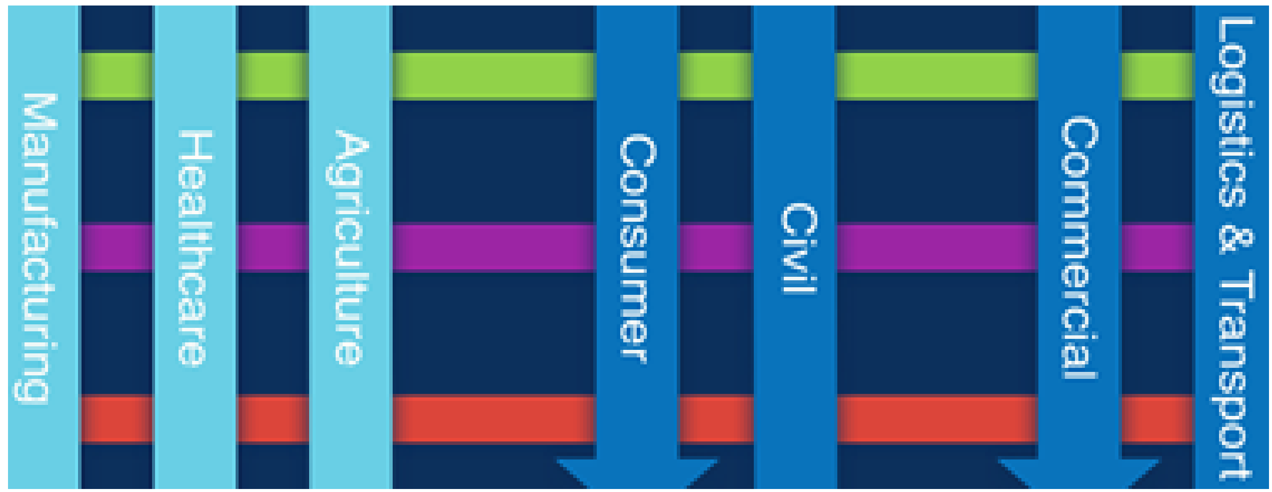
Initial Release B 15/01/2014

SRA, MAR – Underlying Scheme

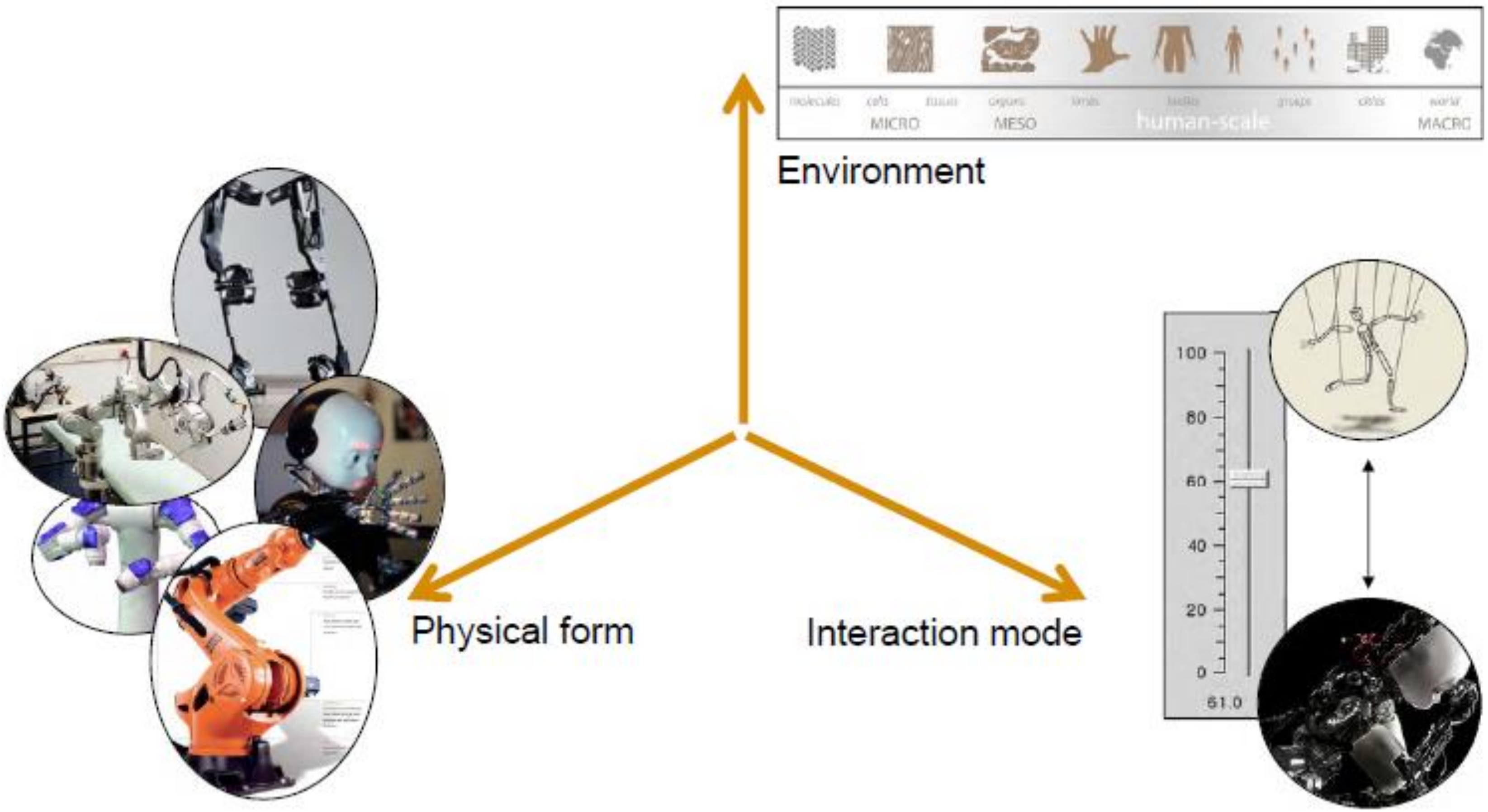


Markets

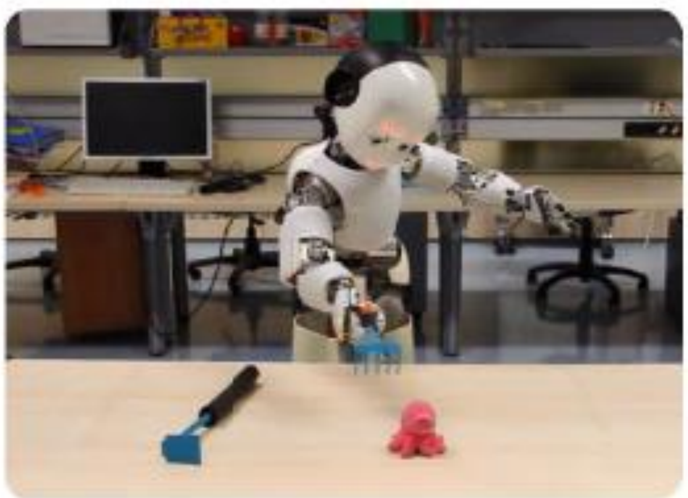
- Manufacturing
- Health care
- Agriculture
- Consumer
- Civil
- Commercial
- Logistics and Transport



Types of Robots (you are not left out)



Abilities



- Robots may deliver ability
- Market requirement for ability
- Need to identify barriers caused by ability mismatch

Exemples of Missing Technologies

- Understanding and interpretation
  - Scenes, contexts and situations
- Object categorization
  - Daily objects
- Grasping any object
  - Pin, book, …, beer box
- Navigation in every environment
  - Home, street, super market

Enter Horizon 2020

Background – Horizon 2020

- **Horizon 2020: stronger focus on innovation and bringing research closer to the market**
- **Simplified access for all companies, universities, institutes in all EU countries and beyond**
- **New instruments to foster innovation, for example Pre-Commercial Procurement or the SME Instrument**
- **Three priorities:**
  - —Excellent Science
  - —Industrial Leadership (this is where robotics will be situated)
  - —Societal Challenges

EUROPEAN COMMISSION HORIZON 2020

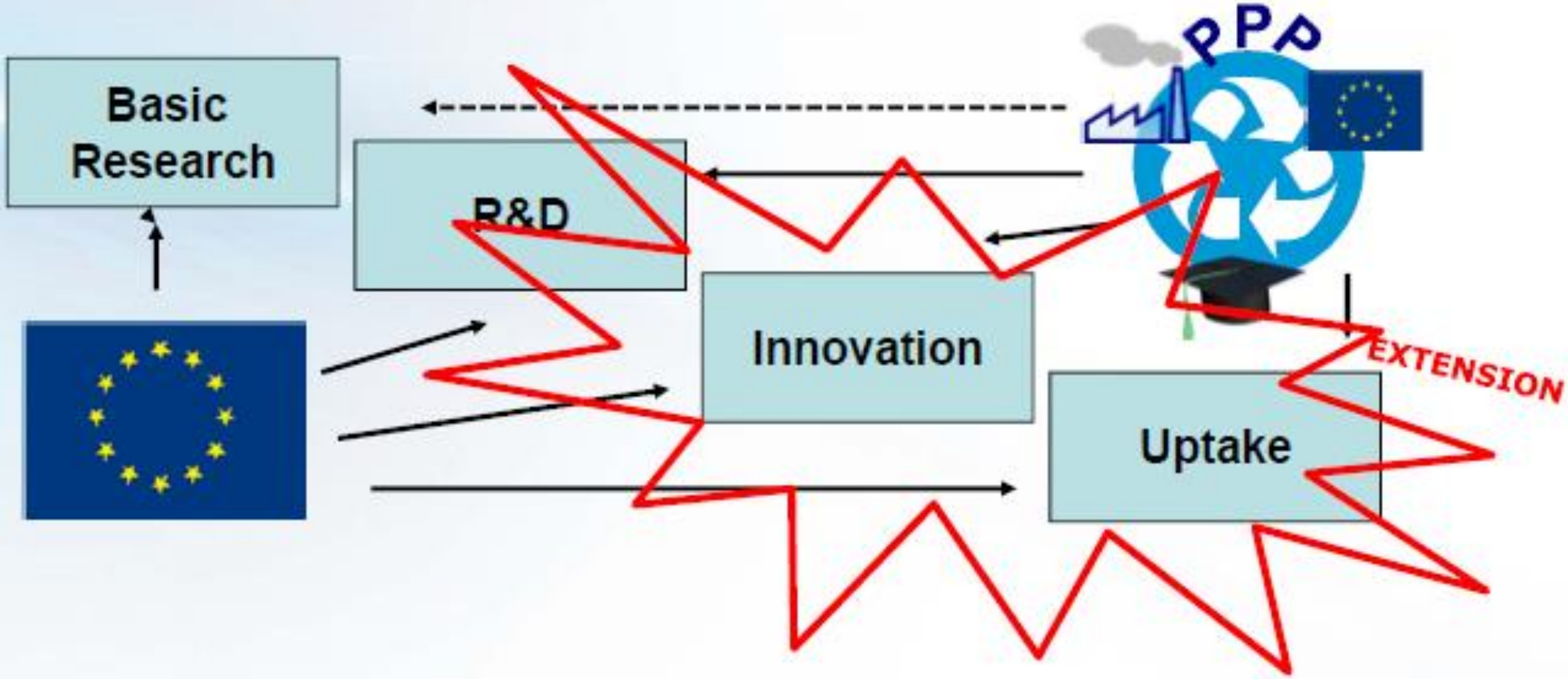
Goals

- **Growth, Jobs & Competitiveness**
- **Better articulation of research and innovation**
- **Seamless funding from idea to market**

What's new:

More innovation, *from research to market, all forms of innovation -> NOT SHIFT BUT EXTENSION*

Towards Horizon 2020:
Public-Private Partnership (PPP) in robotics



What is a PPP?

European Robotics PPP

Private Partner - euRobotics aisbl		Public Partner
• Development of research & development & innovation agenda • Suggesting call topics, priorities, funding profile	*Regular meetings* *structured dialogue*	• Implementation of R&D&I agenda

CLEAR SEPARATION OF ROLES

Private Partner => Strategy

Public Partner => Implementation

The private part is not involved in the selection of proposals

SPARC

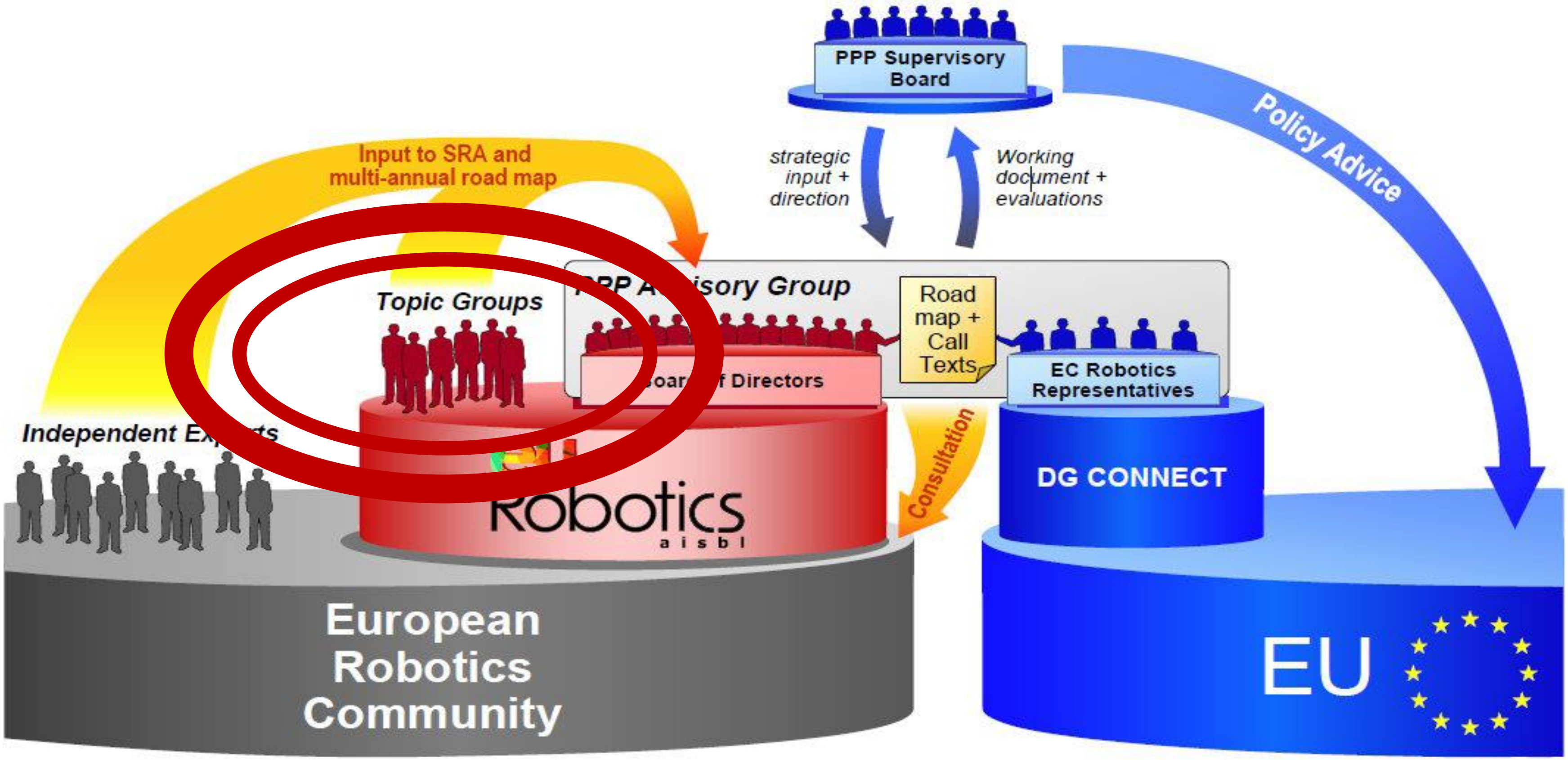
(slides at the end of the document)

Topic Groups (TGs)

- "Readers of the MAR are encouraged to engage with this process (described above) and to contribute your knowledge to the content of the document."
- Reflect and sustain a live discourse on the current state of robotics technology
- Do this by joining euRobotics and then contributing to the Wiki and the associated Topic Groups

Why Topic Groups?

- Recall: H2020 is ”road-map driven research”



[Courtesy Rainer Bischoff and Herman Bruyninckx]

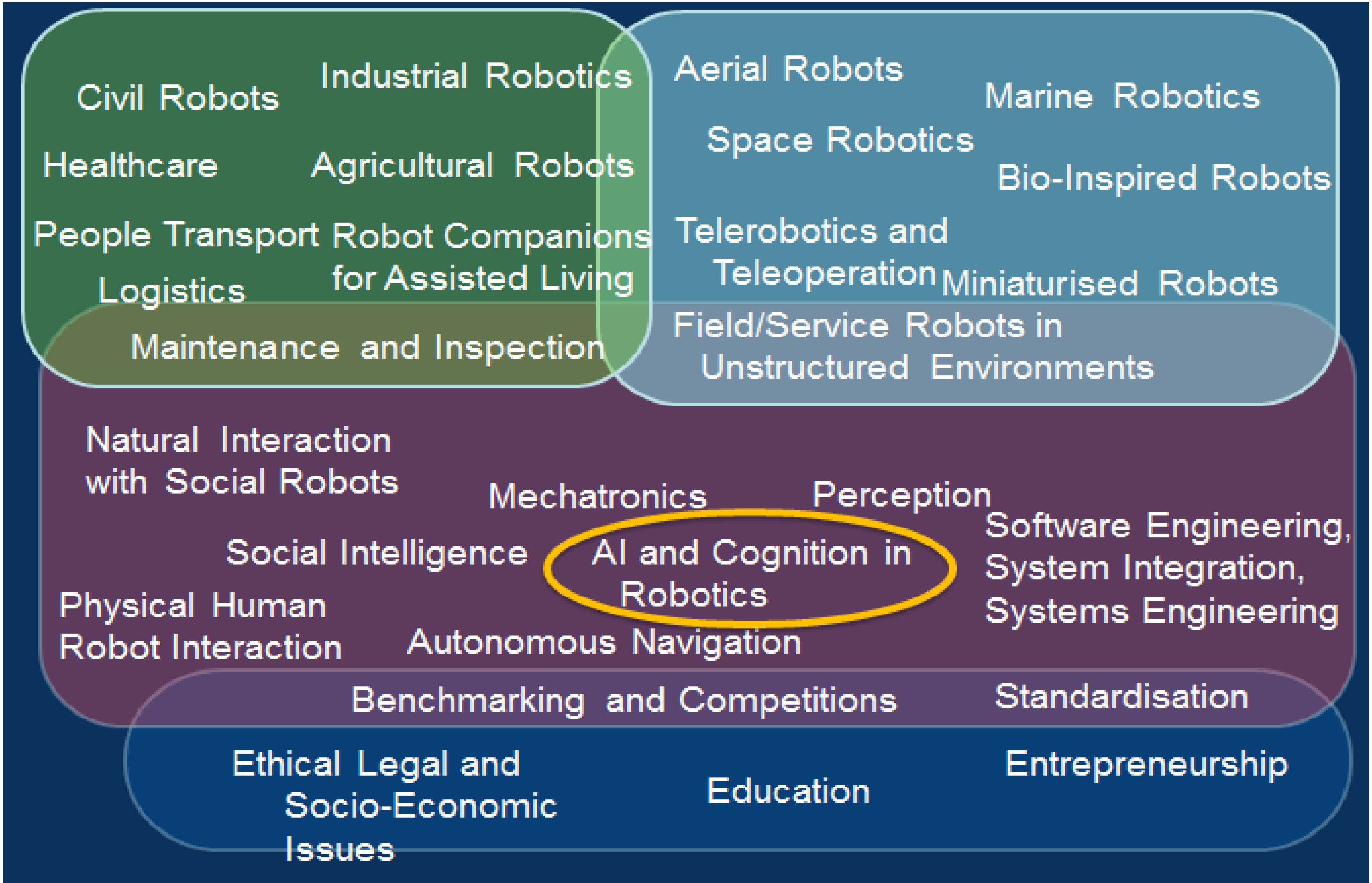
Topic Group ``Terms of Reference´´

- Topic Group Function:
  - Each TG represents a sub-section of EU robotics community.
  - TGs must be able to trace their impact in terms of sections in the Strategic Research Agenda (SRA) and Multi-Annual Roadmap (MAR).
- Topic Group Membership:
  - TGs are open to euRobotics aisbl members and non-members
- A Topic Group should:
  - Provide input to each MAR Cycle.
  - Identify gaps in MAR and propose ways to overcome such gaps
  - Collect and communicate Key Performance Indicators
  - Be aware of any advances in the state of the art and communicate changes during the MAR Cycle to ensure that the MAR is timely and relevant.
  - Identify synergies and overlaps to other TGs

Why are TGs important?

- Annually update the MAR
- Provide input to Calls: Orientation Document
  - SOD (Strategic Orientation Document)

Topic Groups



History of the AICoR Topic Group

- 2012: The Conception
  - Some people from AI who work with robots ...

    ... and some people from Robotics who use AI techniques ...

    ... joined together, and created a series of ”AI meets Robotics” events

- The “Lucia Event” (Örebro, Sweden, 2012)
- AAAI Spring Symposia (2012, 2013)
- European Robotic Forum 2013 (Lyon, France)
- Workshop at AAAI (Bellevue, WA, USA, 2013)
- Workshop at IROS (Tokyo, JP, 2013)
- The ”Lucia 2013” Winter School (Örebro, Sweden, 2013)

IEEE

icaps

December 13th

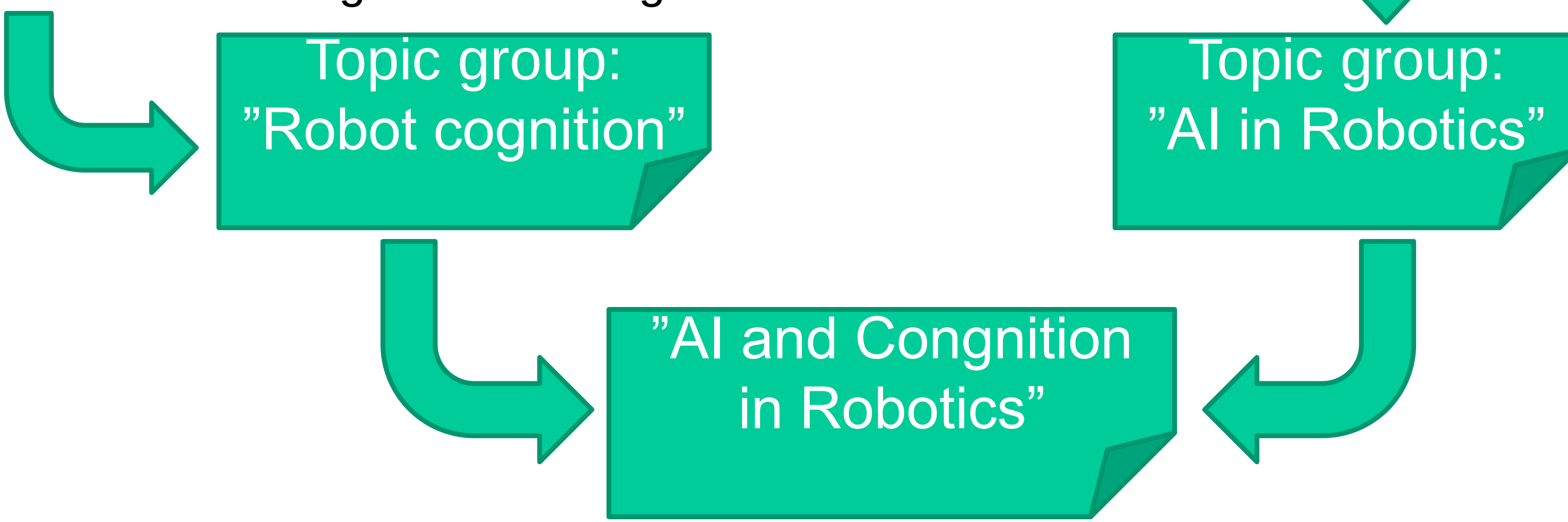
The Return of the Light

Örebro Winter School on
Artificial Intelligence
and Robotics

Örebro University, Sweden, Dec 9-13, 2013

History of the AICoR Topic Group

- A story of two souls
  - Some people from AI who work with robots ...
    ... and some people from Robotics who use AI techniques ...
    ... created a series of ”AI meets Robotics” events
  - Some people from Cognitive Systems who work with robots
    created the euCognition / euCog networks



AICoR: first balance

- Meta-result
  - Proof that AI community and Cognitive System community can cooperate in the framework of robotics
- ”Cognition” entry in the SRA
  - began to identify AI & Cognition techniques for robotics
- AI and Cognition pervasively present in current MAR
  - albeit still in a rather chaotic form
- Extensive membership and growing
  - 63 members in the mailing list so far
- Stated interest by euRobotics and by the EC

History of the AICoR Topic Group

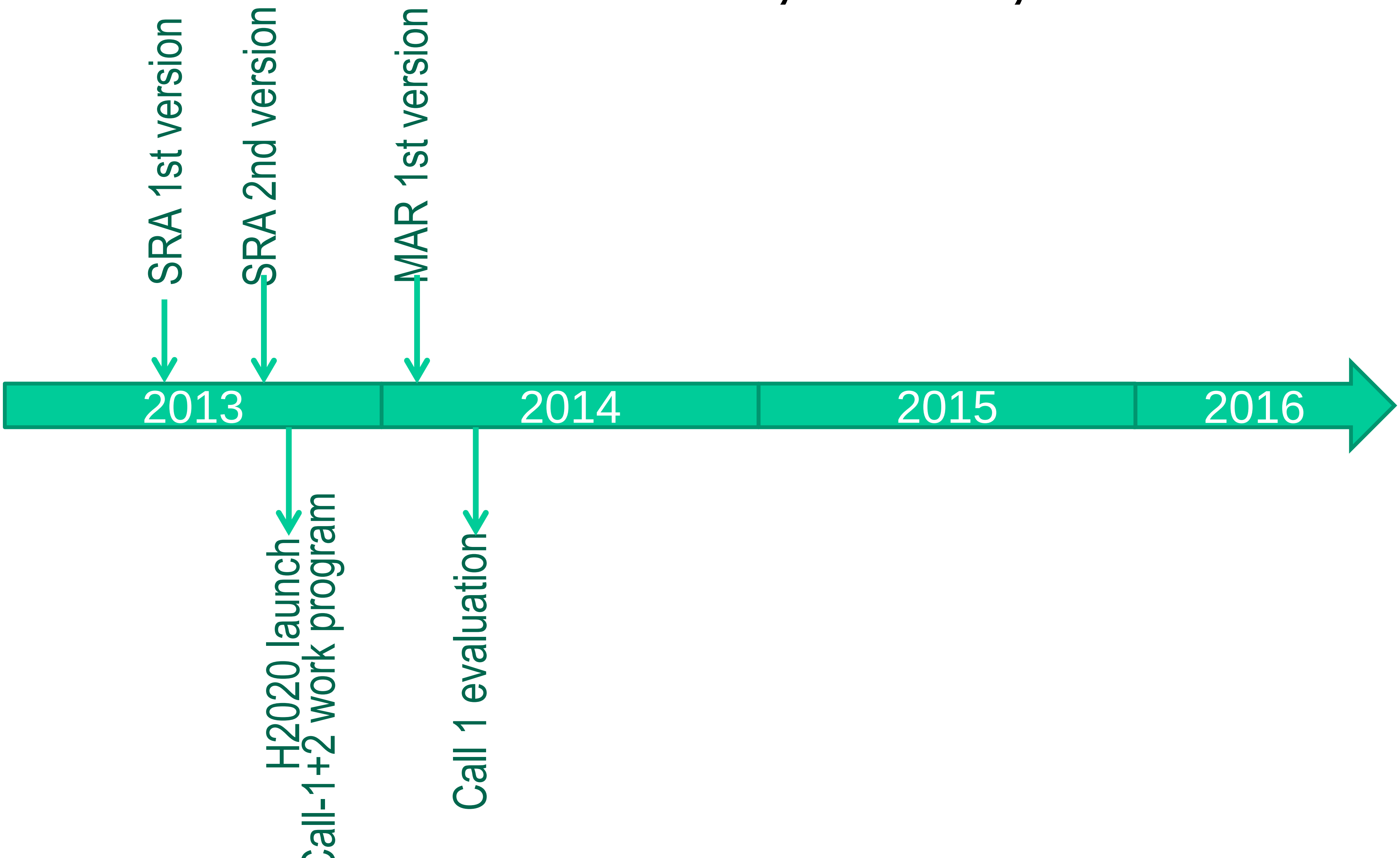
- June 2013 – July 2014
  - Jun 2013: created mailing list (93 members today)
  - Jul-Aug: participated in euRobotics MAR workshops
  - Aug-Sep: collective work on 2nd version of SRA
  - Aug-Sep: collective work on 1st version of MAR
  - Sep: submitted official proposal for Topic Group
  - Dec: first Winter school on AI (and cognition) in Robotics
  - Mar 2014: AICoR approved at a euRobotics Topic Group
  - Mar 2014: first AICoR workshop (at ERF-2014)
  - Apr 2014: created AICoR wiki
  - Jul 2014: AICoR organizational meeting (online)
- Documents and minutes available in the AICoR wiki

  http://aicor.wikispaces.com/

TG AICoR

- Contributions coordinated by
  - Alessandro Saffiotti
  - Markus Vincze
- Great thanks to David Vernon for comprehensive contributions
- Contact: asaffio@aass.oru.se

Timeline of SRA, MAR, SOD



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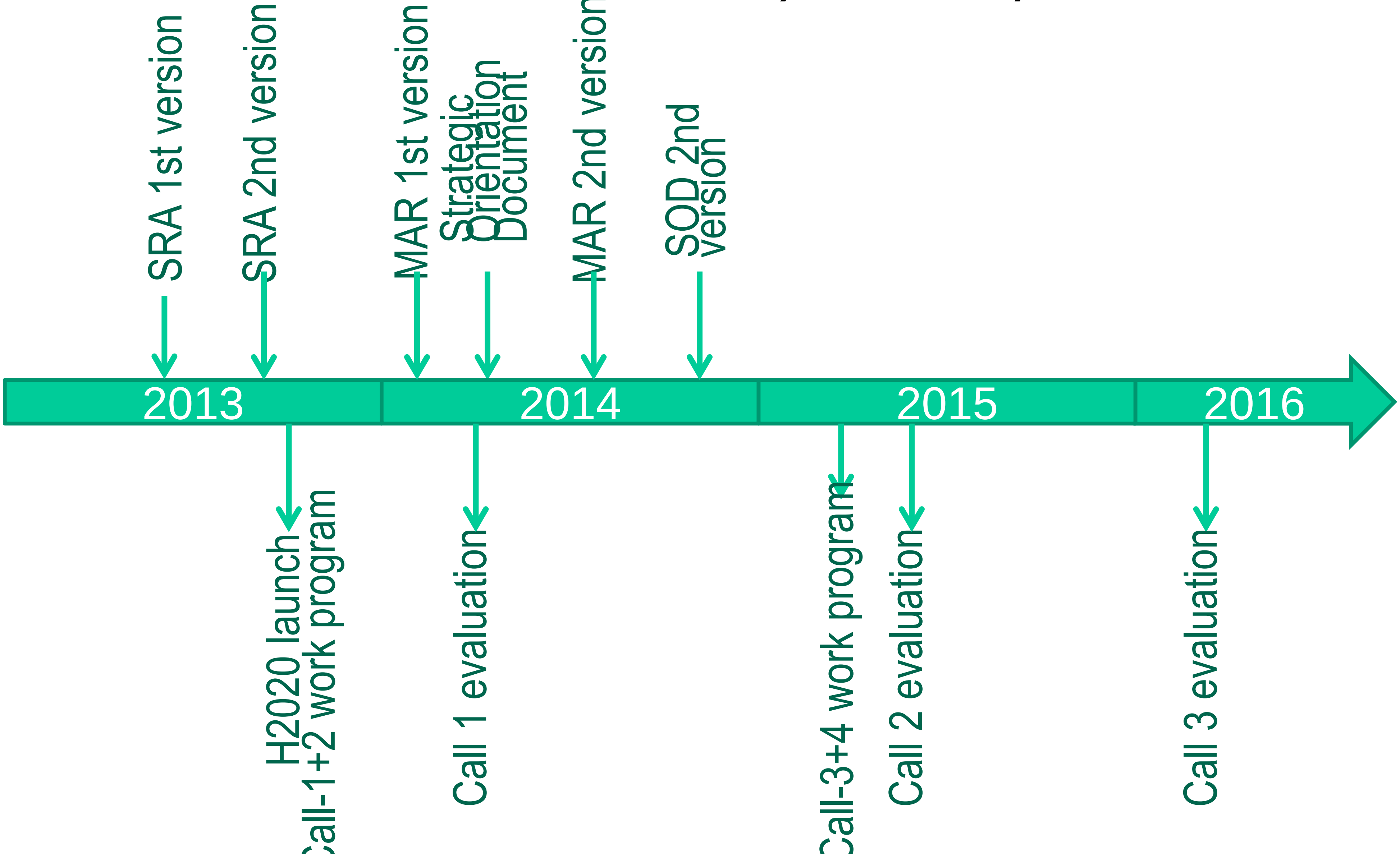
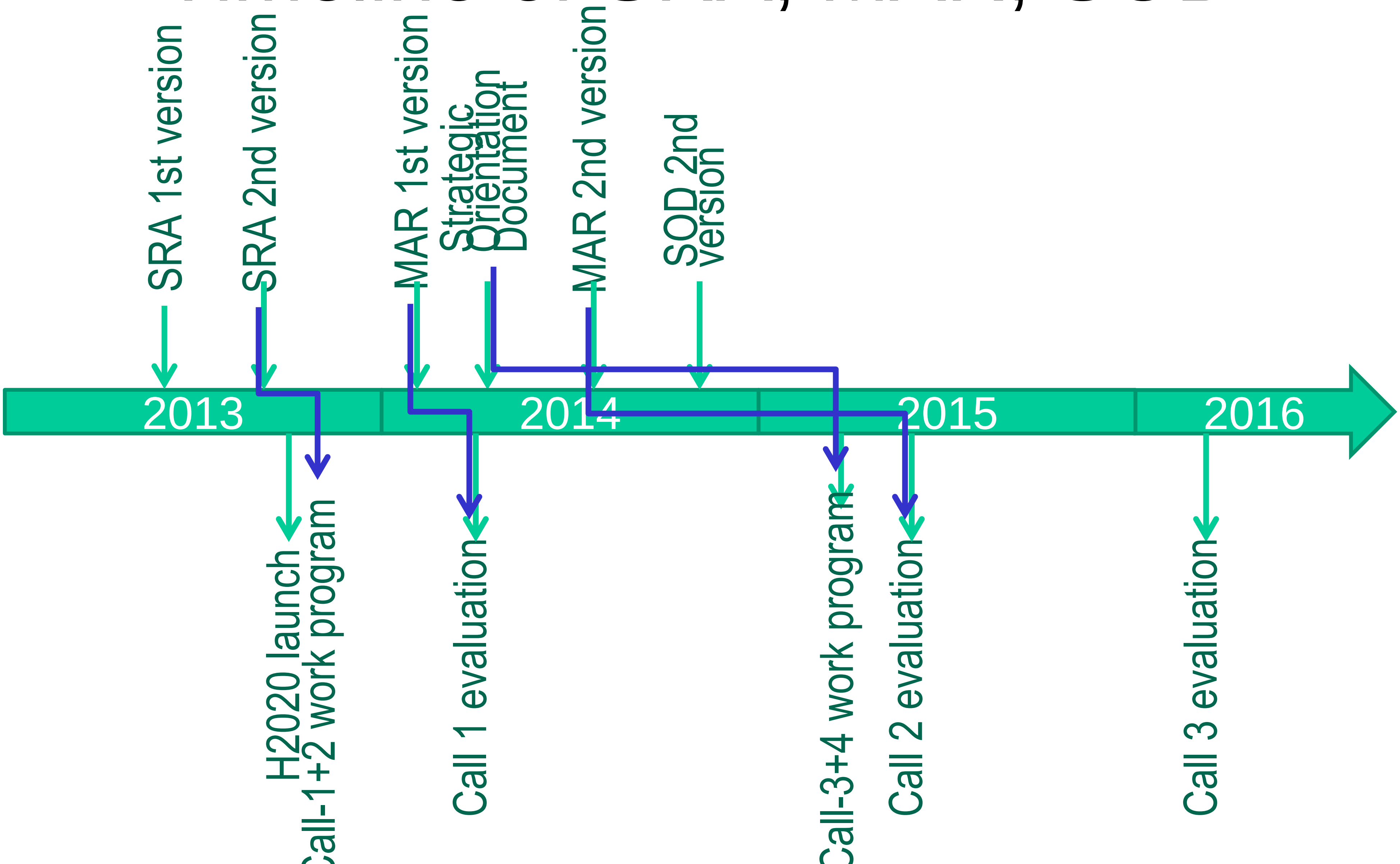
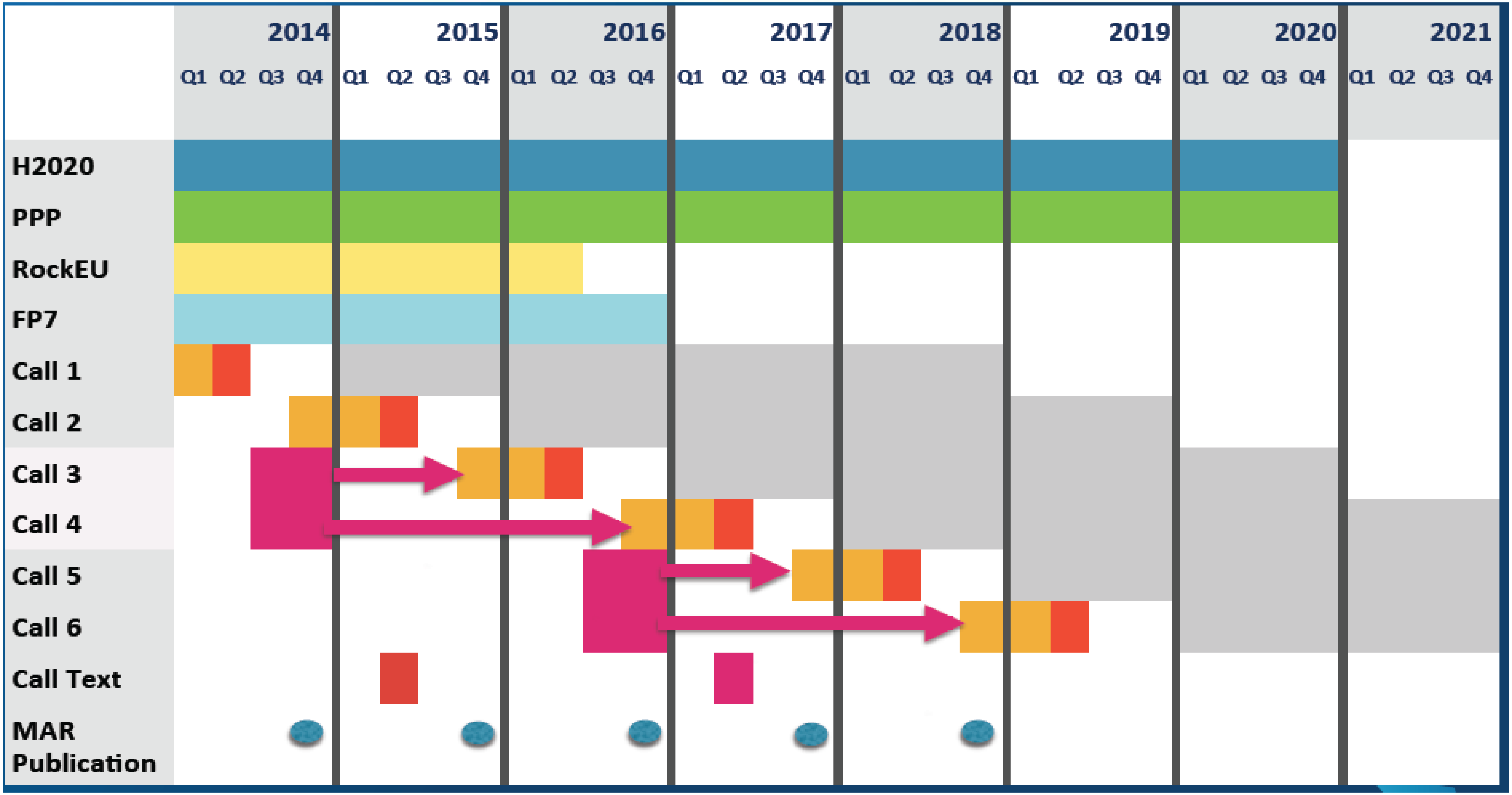


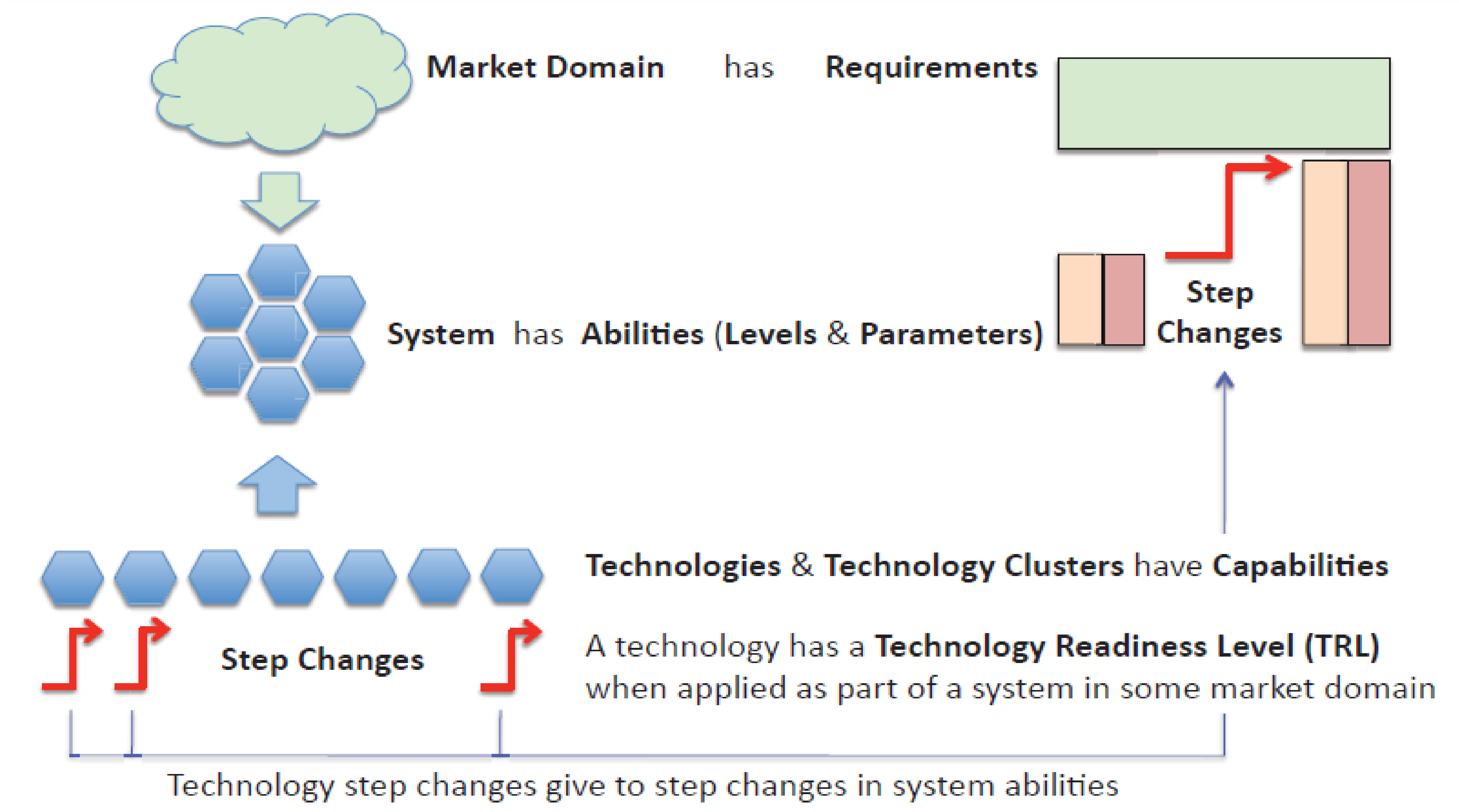
Timeline of SRA, MAR, SOD



H2020 Schedule Overview



The euRobotics MAR model



[Courtesy of David Vernon]

The SOD – overview

- Strategic justifications for investment
- Identify expected achievements
- EU Added value, Socio-economic impact
- Identify SWOT for Robotics
- Set out R&D&I objectives
- Identify cross cutting links

[Courtesy of David Bisset]

The SOD – versus call text

- Orientation sets out high level strategy and focus
  - It defines the targets and potential focii.
  - It is common between the two calls within the work programme.

- The Call text specifies the detailed priorities per call
  - It details the targets
  - It details the specific focus for each target.

The SOD – versus MAR

- Roadmap addresses multiple pillars
  - Science (FET), Societal Challenges and LEIT
  - Details technical progression

- Orientation addresses LEIT objectives
  - Includes Societal Challenges where relevant.
  - Addresses collaboration, infrastructure and community.
  - Sets out priorities.

[Courtesy of David Bisset]

The SOD – Timeline

- July: First draft to Commission
- July-September: Refinement with Commission
- Oct/Nov: Final draft to Commission
- Q1/2 2015 Workprogramme development
- Q3/4 2015 Publication

[Courtesy of David Bisset]

The SOD – RDI strategy (1)

- Need to stimulate well focused proposals.
  - Maximises market impact
  - Ensures excellence
- Orientation, Call text and MAR drive this process
- Reduce oversubscription
- Goal is a smaller number of well constructed, focused proposals.
  - well focused targets in the Call.
  - With appropriate short and long term time scales

[Courtesy of David Bisset]

The SOD – RDI strategy (2)

- Focus on what the domains need.
  - Specified as “technical competencies”
- Prioritise
  - Common cross sector needs
  - High market Impact
  - LEIT Objectives
- Match to what technology can deliver
- Identify related infrastructure actions
- Identify related support actions

[Courtesy of David Bisset]

The SOD – Technical competences

- Relates to
  - Combined sets of Abilites
  - Technology combinations
- Independent of Domain or Application
- Descriptions need to be specific:
  - "Ability to grasp soft objects in unknown environments with a success rate of 75% at first attempt."
  - "Ability to navigate accurately to within 1cm in a complex indoor environment with dynamic objects"
  - …

[Courtesy of David Bisset]

The SOD – Input from TG's

Topic Groups need to identify:

- Domain needs
- Technical capability
- Infrastructure support needed
- Support actions needed

[Courtesy of David Bisset]

The SOD – Input from AICoR

- What “technical competency” can you provide by 2020 at TRL 6/7?
  - Identify three to five areas of competency
  - Independent of domain or application.
  - Prioritise in terms of technical risk.
- Consider technical dependencies.
- Consider TRL progression.
  - What is the current TRL of the competency?
  - Based on TRL3/4 today can this get to TRL6/7 by 2020?
- How can technical progress be demonstrated to Domain users?
- What are the main barriers to progressing the TRL of your three areas of competency?

[Courtesy of David Bisset]

Status

- Call 2 (closing 21 April 2015)
  - MAR updated, draft approved by euRobotics board
  - Draft sent to Commission
  - (Call text is already fixed)
- Calls 3 & 4
  - SOD approved by euRobotics (board of directors)
  - Final sent to Commission (Oct. 2014)
  - MAR will be updated
- Iterated for Calls 5 & 6

Result: SOD Contents

- Strategic justification for investment
- Expected achievements
- EU Added value, socio-economic impact
- SWOT for Robotics in Europe
- Work Programme **Objectives**
- Measuring Success

SOD Objectives

- Objective 1: Roadmap based research and innovation
- Objective 2: Pulling systems and technologies closer to market
- Objective 3: Building a European robotics infrastructure
- Objective 4: Coordination Actions
- Objective 5: engage with investors and sources of funding for innovators
- Objective 6: Link to other programmes (IOT, big data, ..)

AICoR Input

- Objective 1: Roadmap based research and innovation

Ability Levels

- \- **Knowledge services**: enable robots to build, maintain, and use knowledge services; to ground that knowledge into physical perception and action; to use knowledge to improve understanding and deliberation; to exchange knowledge and use remote knowledge services.
- \- **Real-world cognitive perception for robotic systems**: including scalable robotic object and place recognition in natural scenes and active view selection. (This topic is also of interest to the following TGs: Socially Intelligent Robots, Systems and software, Perception).
- \- **Long-term adaptation**: performance improvement based on long-term experience of task environments, success rates, action timings

Transferable Modular Systems

\- **Explicit knowledge representation**: representation of the knowledge and data available in each module, that can be used for reasoning <u>within</u> the module and <u>about</u> that module.

AICoR Input

- Objective 1: Roadmap based research and innovation

Wide area long term autonomy

- **Persistent autonomy**: task planning, plan execution and learning must be tightly coupled with perception to cope with dynamic environment and to enable, long-term autonomy.

Integrated tool chains

- **Formal specification and synthesis of control systems**: Tools like temporal logics and description logics can be used to prove formal properties on the behaviour of a cognitive robotic system.

- **Simulation for long-term autonomy**: tools to simulate robot performance in challenging environments over long periods faster than real-time to test the full range of autonomous capabilities.

- **Evaluation of cognitive robots**: development of testbeds, benchmarks, criteria and standards for performance access for knowledge-based robotic systems

AICoR Input

- Objective 2: Pulling systems and technologies closer to market

End user driven full system demonstrators

- **Planning and reasoning**: grounded knowledge representation and reasoning and action planning are needed in any cognitively enabled full robotic system.

High TRL technology gaps In applications with significant impact

- **Reasoning under uncertainty**: in most applications, existing cognition technologies need to be extended to allow a realistic and tractable treatment of the uncertainty, incomplete knowledge and conflicting information which are inherent to the robotic domain.

AICoR Input

- Objective 3: Building a European robotics infrastructure

Software and design repository

- How should this be organised?

Investigation and deployment of industrial strength, open cloud-based software services for perception and knowledge-based reasoning to provide low-cost robots, such as autonomous vacuum cleaners or the Pepper robot with intelligent control capabilities to cope with open environments

AICoR Input

- Objective 4: Coordination Actions

Cohesion activities

- **Cross-disciplinary education**: enabling the use of cognitive technologies in robotics systems requires to train students and researches in disciplines beyond standard robotics, including artificial intelligence and cognitive science.

- **Standardization of knowledge-based systems**: Standardisation is perceived as one of the key enablers for breakthroughs in intelligent knowledge systems (in the commercial as well as in the academic world, cf. [NSF2013]). Research on standardized representation and ontologies for robot applications is expected to achieve similar breakthroughs in the broad application of knowledge and reasoning in intelligent robotic applications

Summary

- SPARC as the connection between private and public side
  - Private: euRobotics – The Europen Robotics Network
  - Public: European Commission
- TGs provide input for targetted Calls in robotics
- Many opportunities for cognitive techniques
- Become active, TGs are open!
- Call 2: MAR is an important supporting document
  - You should read it and refer to it
  - Reviewers will be primed

Upcoming Events

- October, November : Finalisation of MAR for Call 2
- January (TBC) : Possible Info Day for H2020-ICT-2015 ICT24a-e (Call 2).
- March 11th - 13th: Vienna - ERF 2015.
- April 21st : H2020-ICT-2015 (Call 2) Closes

?

TRL – Technology Readiness Level

TRL 1 – basic principles observed

TRL 2 – technology concept formulated

TRL 3 – experimental proof of concept

TRL 4 – technology validated in lab

TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 7 – system prototype demonstration in operational environment

TRL 8 – system complete and qualified□

TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

ICT Presentation
9^{th}-10^{th} October 2014

Thanks to
Dr. Uwe L. Haass,
Secretary-General

SPARC
The Partnership for
Robotics in Europe

What is SPARC?

SPARC is...

- A Public Private Partnership (PPP)
  - Between the European Robotics Association (euRobotics AISBL)
  - and the European Commission

SPARC outputs…

- From the private side:
  - Development of research & development & innovation agenda
  - Suggesting call topics, priorities, funding profile
- From the public side
  - Implementation of R&D&I agenda through Horizon 2020.
- Joint dialogue

SPARC is now…

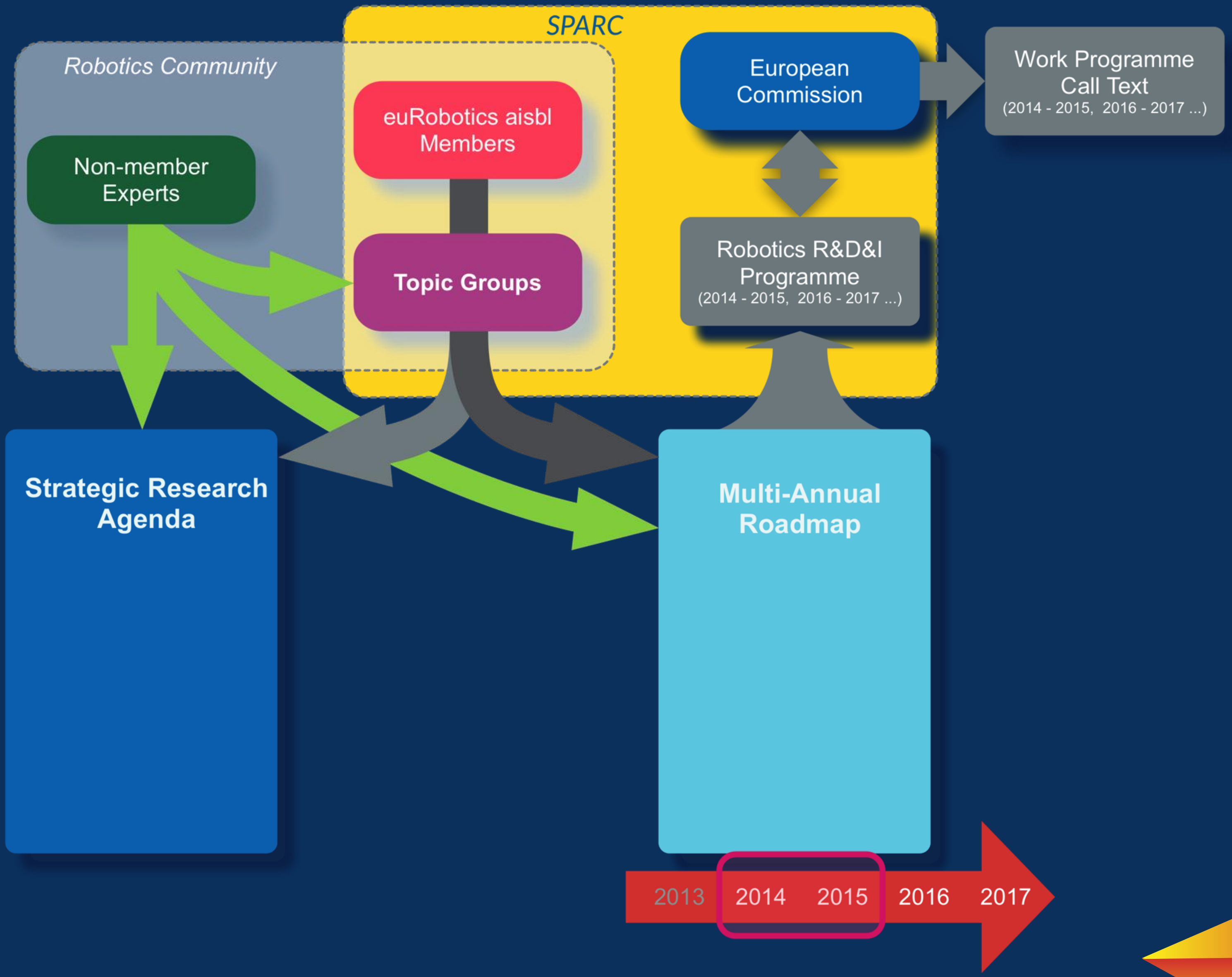
Launched on 3 June 2014 during Opening Session of Automatica

- 700 M EUR from EC
- 2.1 B EUR from EU Industry
- Largest civilian robotics programme in the world
- Europe should stay No. 1 in robotics
- Robotics will have a very positive impact on European economy and society

http://europa.eu/rapid/press-release_SPEECH-14-421_en.htm

What does SPARC deliver?

SPARC Organisation



SPARC Documents

SRA: High level document

- Wide readership
- Strategy and targets
- Framework of description

MAR: Technical detail

- Updated each year
- Context and detail
- Will be available from…

www.eu-robotics.net

Topic Groups