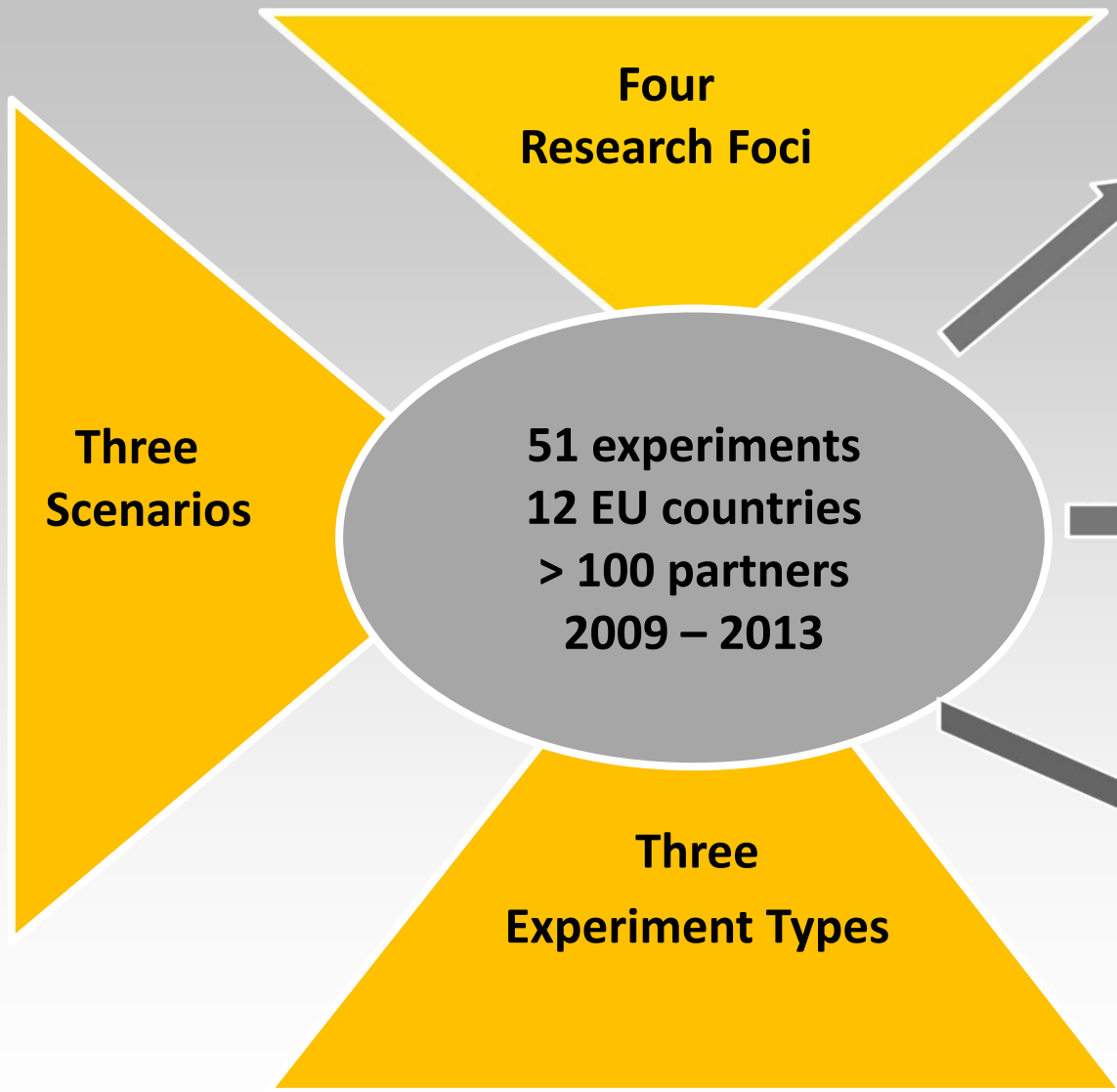
Definition of *Step Changes*

„Technological step changes create applications and markets“

Set-up based on then SRA (2006/7)



Technology Advancement

→ Strongest focus in ECHORD experiments

Cost Reduction

→ Side effect in some ECHORD experiments

Reduction in resource requirement

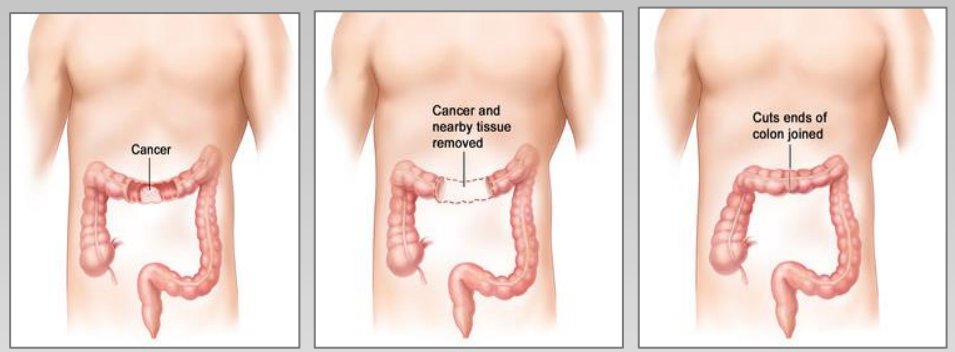
→ focus of some ECHORD experiments

Characterisation of experiments

The experiments flagged by the independent experts during the final review:

Flag	Experiments flagged
Success stories	11
Media attractive experiment	14
RTD breakthrough	5
Knowledge transfer from academia to industry	11
Bringing results of previous experiments to a higher level	8

Step changes: a closer look at examples



Development of a robotic manipulator of human tubular tissues for suture and support in anastomosis surgery interventions

INSEWING:

- Technology offers advantage over rival technologies
- A surgical procedure gets more efficient and safe
- One patent filed and accepted
- Three competing applicants for commercialization (two in the US, 1 in EU) to commercialize directly

Develop intraoperative ultrasound based non-invasive real-time bone tracking schemes
Integrate Robot-assisted navigation through surgeon-robot co-manipulation - KUKA LWR arm

HipRob

- Benefit patients: more reliable long term results for the prosthesis
- Benefit surgeons: simpler, more accurate, surgical procedure.
- Creation of a spin-off ongoing

Step changes: a closer look at examples

A human worker and an industrial robot assemble airplane components in a classic human-robot-co-worker cooperation.

JILAS:

- Increased safety features for manipulators in common workspace with humans
- Work can be done with one human that required two human workers before
- First system of its kind with a large potential for generalization

Development of an application in which a robotic co-worker supports a KANBAN production process by taking care of the flow of materials.

KANMAN

- Increased safety features for manipulators in common workspaces with humans: Powerball manipulator
- Low-cost sensor module for the magnetic field
- Mobile manipulator for production plants, succesful quick system integration

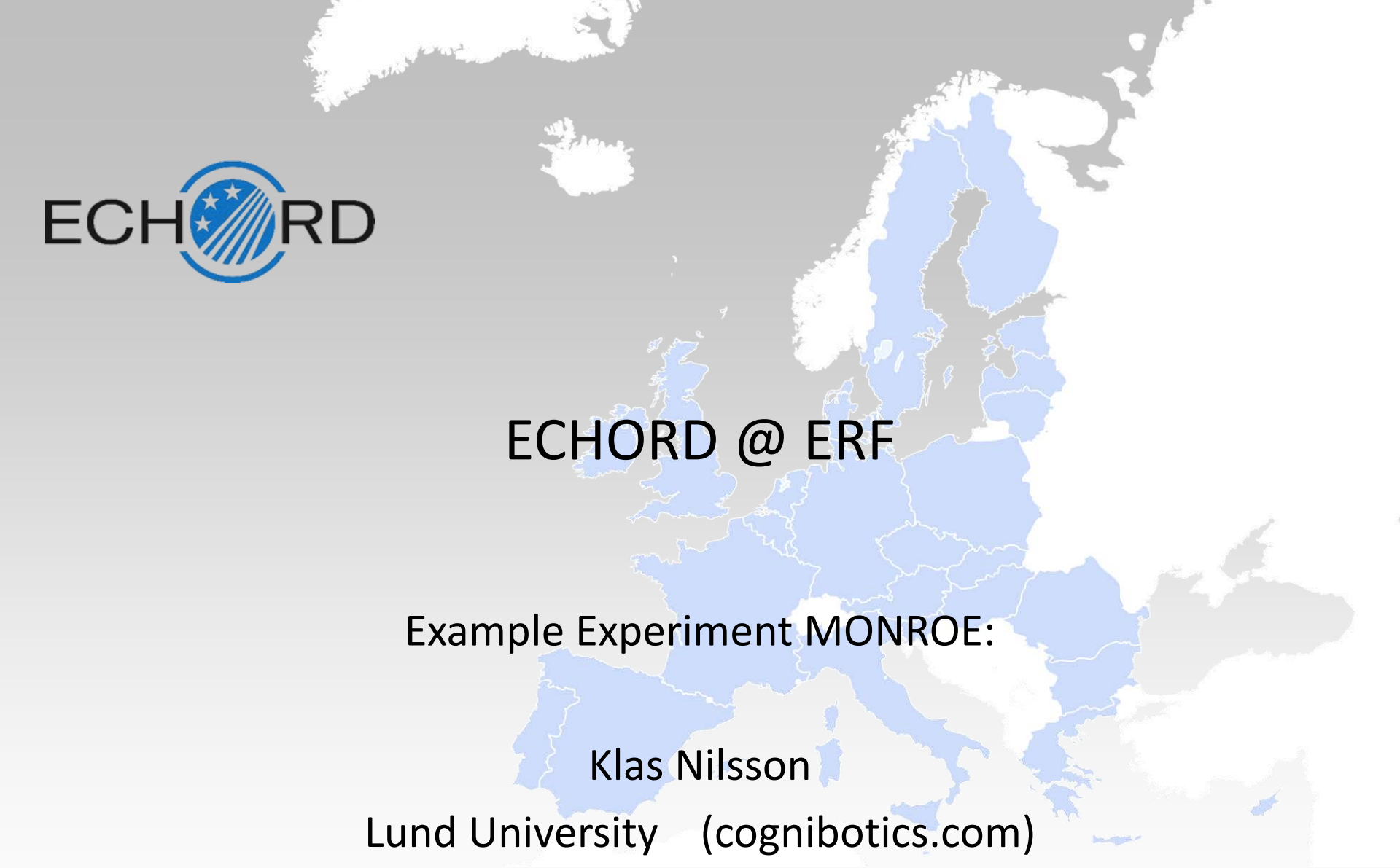
What can we learn for the future …?

- In order to identify the benefit of the project, applicants will be asked for a **clear description of their starting point** (input from other projects – national funding or European funding) and the **targeted situation at the end** of a successful experiment

- If a link with Multi-Annual Roadmap MAR is sensible, then **the expected technology step changes** should be clearly outlined by proposers – this will help all the parties involved

- **Performance indicators are important**, which reflect the step change definition of the MAR.

- We should all make a strong effort to also attract experts **with an industrial background** to our robotics projects

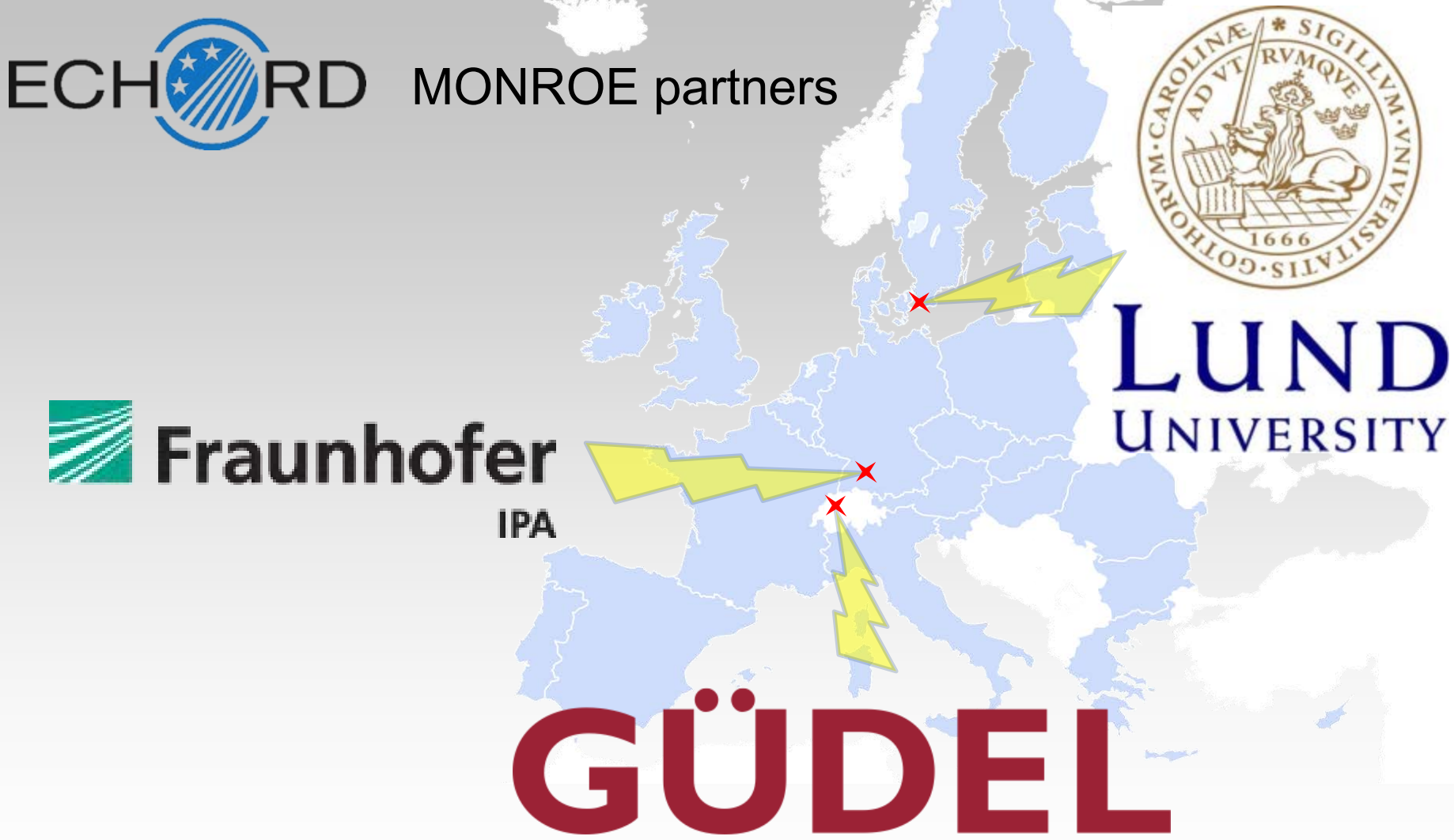


ECHORD @ ERF

Example Experiment MONROE:

Klas Nilsson
Lund University (cognibotics.com)

Hyper-Modular Open Networked RObot systems with Excellent performance



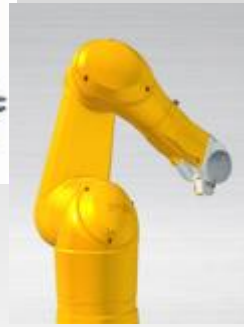
S&T Objectives of the experiment

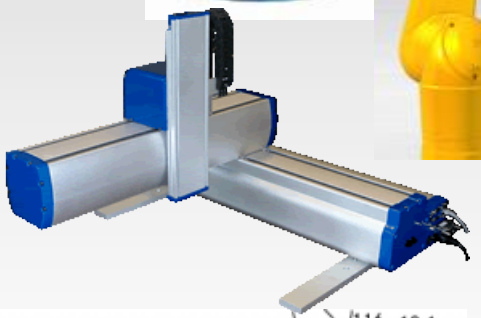
Robots do not behave properly ☹ due to trade-offs:

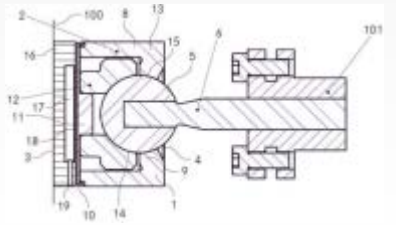
1. Stiff **robots are heavy** (in terms of moving mass), and thereby **slow and/or too expensive**.
2. **Parallel robots** providing stiffness and high forces **have small and closed workspace**.
3. Precise robots are **expensive**, slow, and/or **lack stiffness** w.r.t. process forces.
4. **Modular robots have low performance** due to lack of mechatronic optimization.

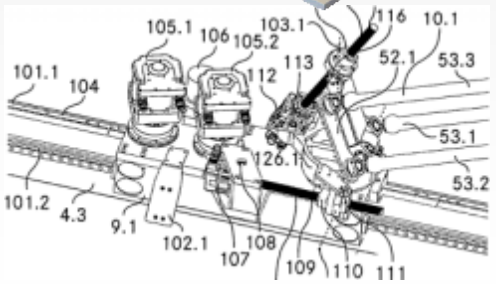
Overall objective: Overcome all four trade-offs!

We did it ☺ for parallel robots; enablers created for all robots.





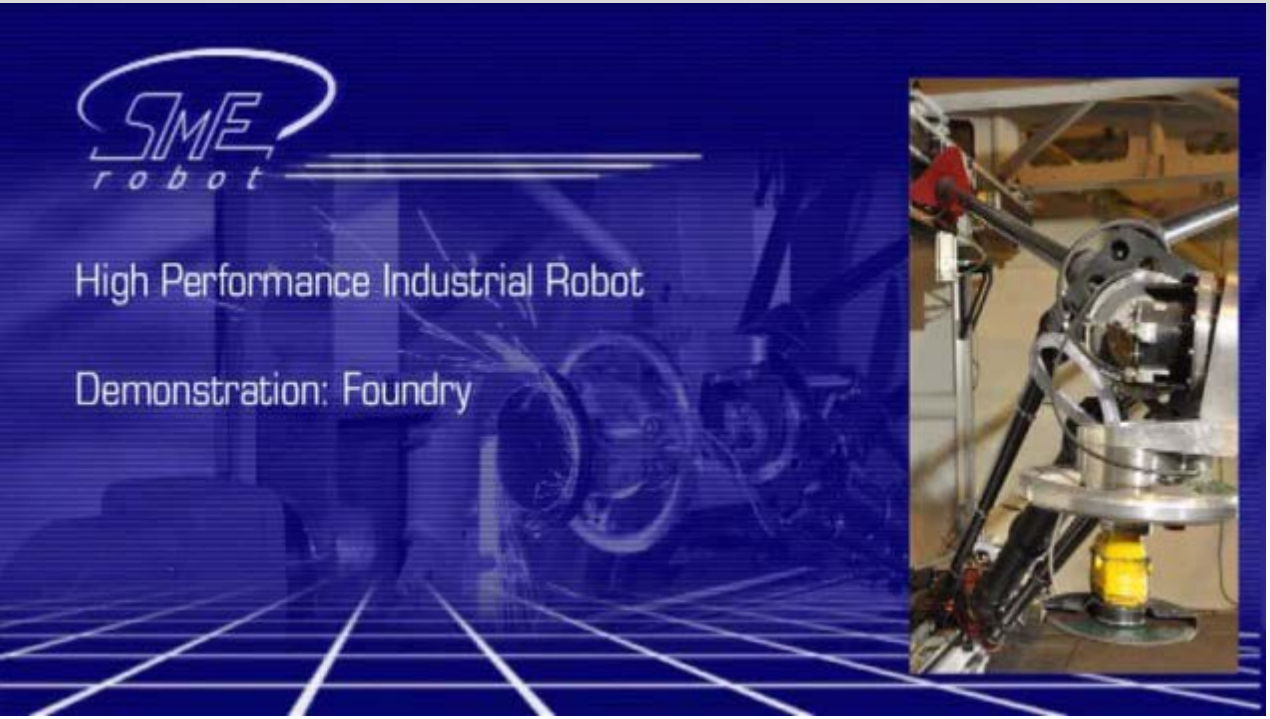


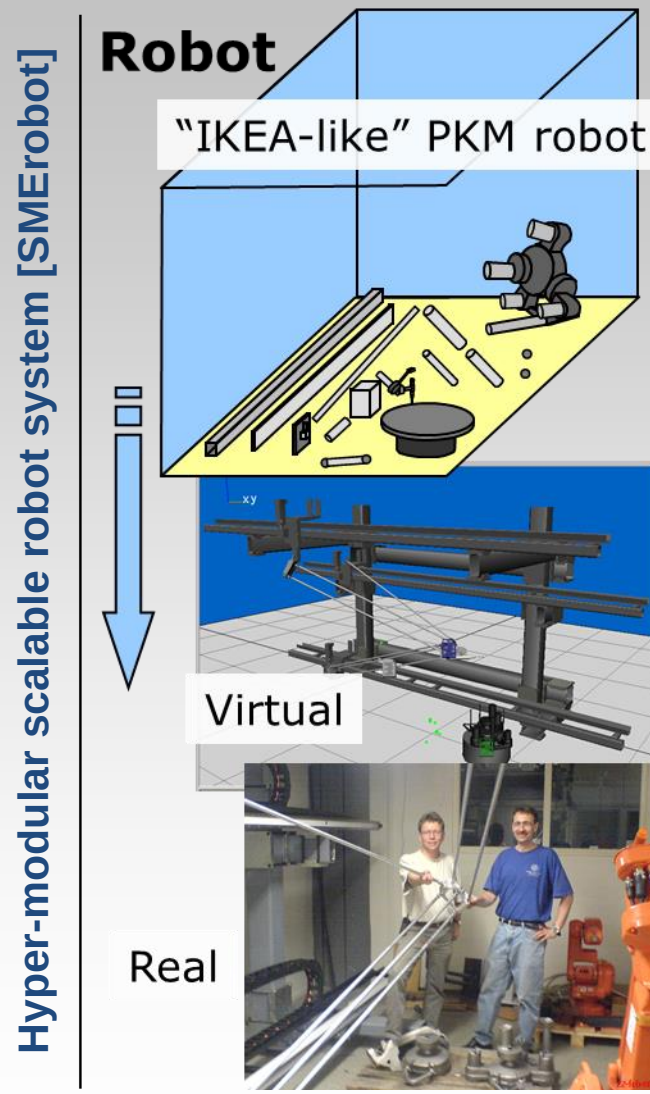


Background; why an Echord experiment?

Echord/MONROE motivation:

- SMErobot: Proven benefits of novel kinematics (GantryTau); not used…
- Exploit modularity (HW&SW)
- Complement articulated robots
- Enable product/market





Impact objectives and motivation for the experiment

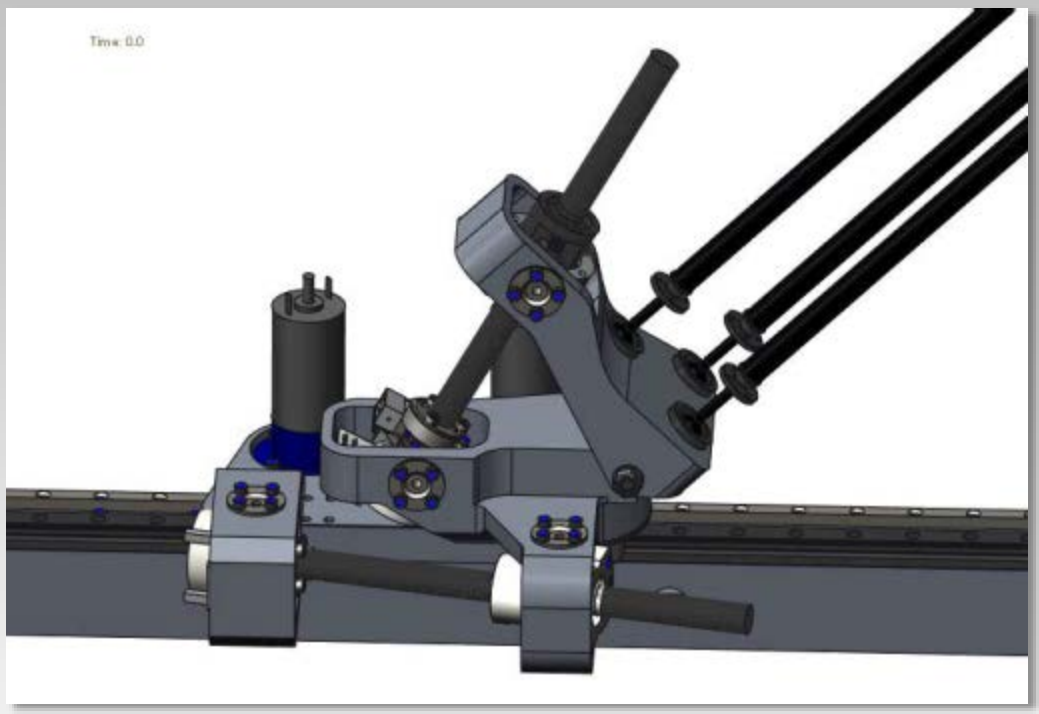
Impact objectives [for the experiment]

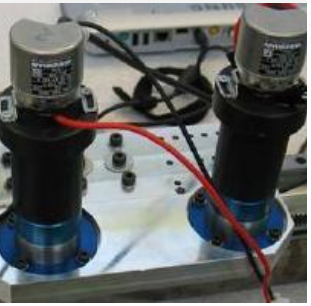
- Make **hyper-flexible modular robots** widely applicable, and improve their network communication and programming.
- Bring the **new high-performance robots and the components closer to the market**.

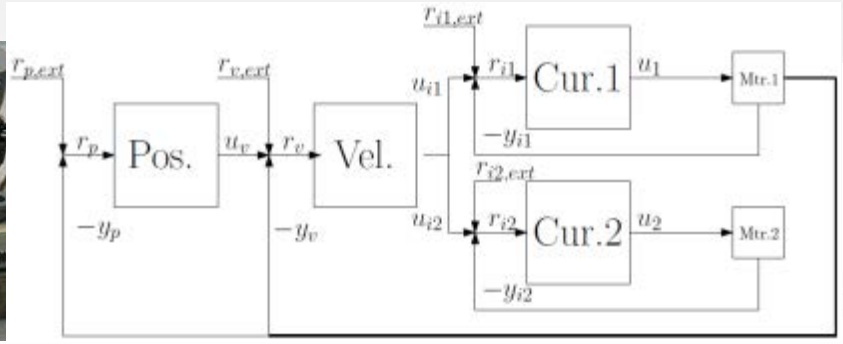
Why accuracy?

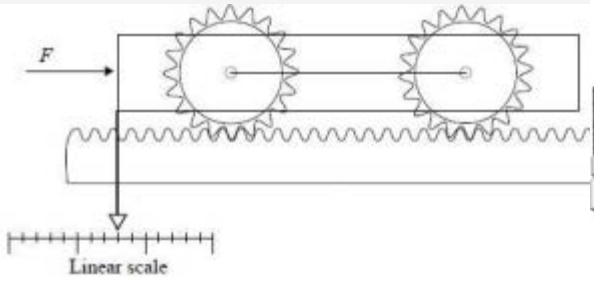
1. **Expand high-end industrial applications.**
2. **Productive cognition by managed uncertainty!**
3. **Enable lower-cost robots!!**

Example result: New kinematics and dual-motor control





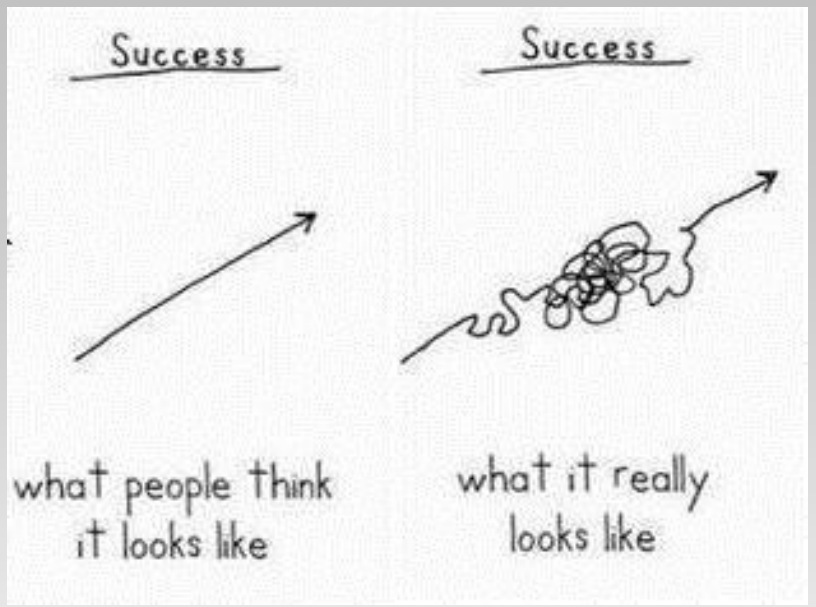




Repeatability 1 micron

☹ : Struggles with component difficulties

Both electronics and mechanics was much harder than expected



Resulting Intellectual Property

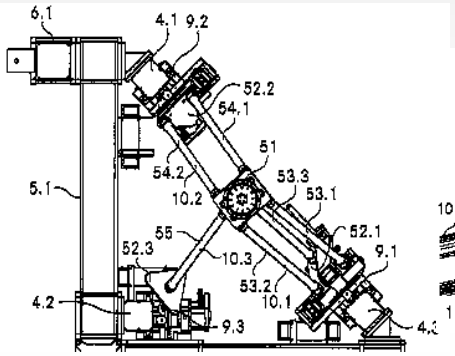
2 patents from the parallel COMET project (FoF):

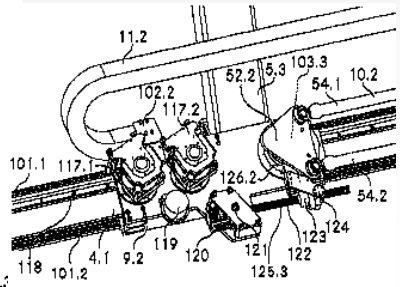
Title [number] granted/WO-date		**Status**	**year**
Method and system for determination of at least one property of a joint [PCT/SE2013/051224]	2012-10-23	SE-OK PCT	2012
Method and system … manipulator [SE 1350981-5]	2013-08-27	SE-PP	2013

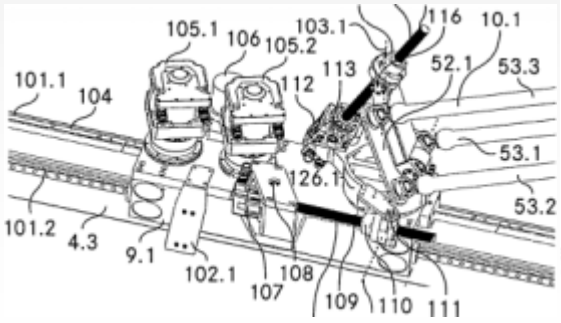
+

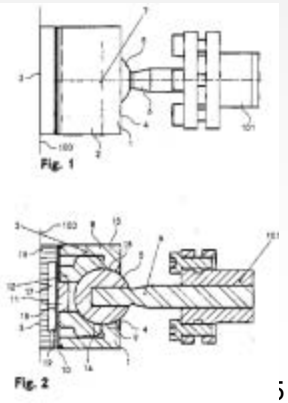
2 patents from the Echord experiment (ICT):

Title [number] granted/WO-date		**Status**	**year**
Parallel kinematic wrist [EP2574428 +other countries]	2013-04-03	EP-A	2011
Ball joint [PCT/CH 2012/000115: WO2013173931]	2013-11-28	WO-A1	2012



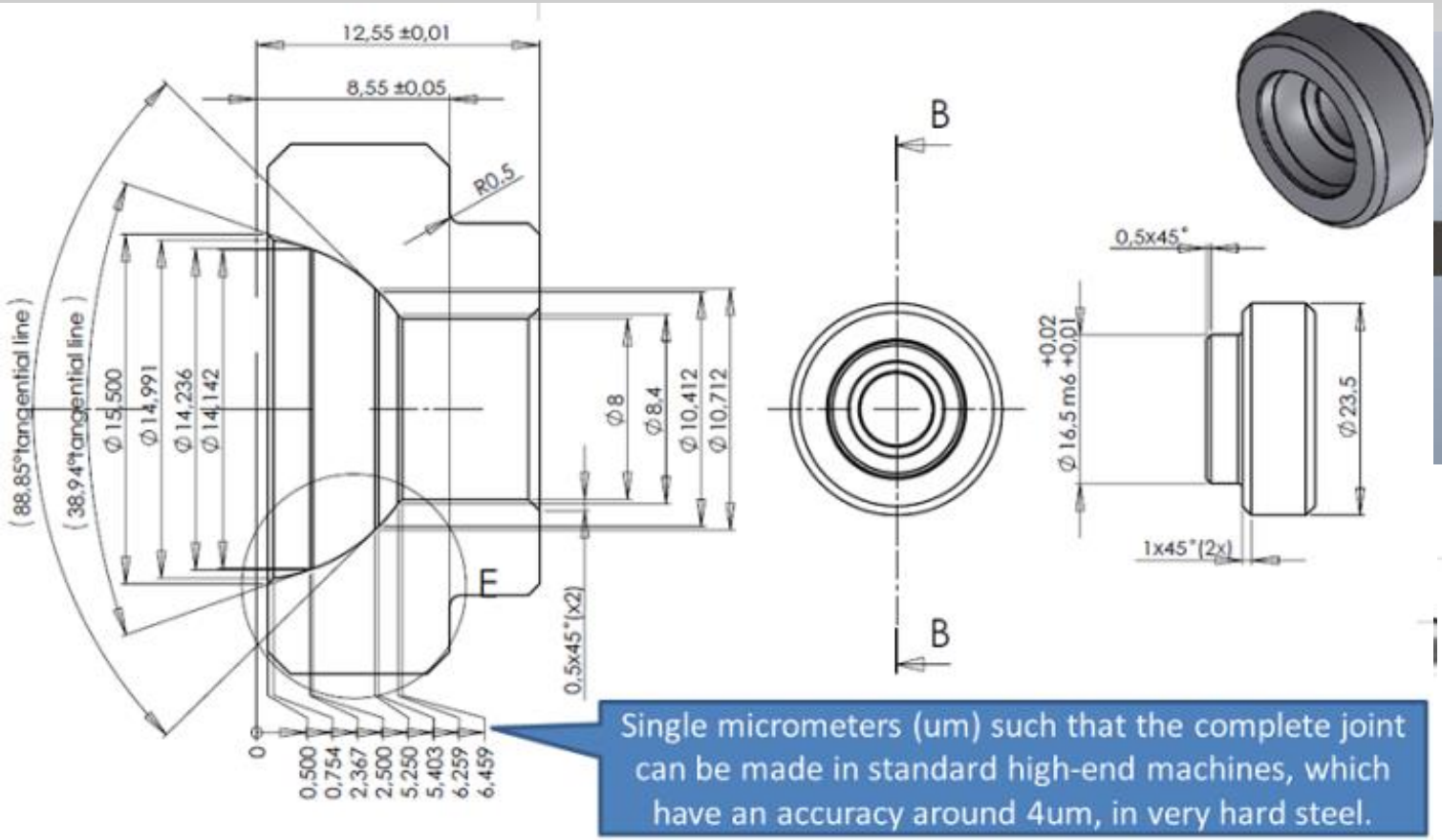


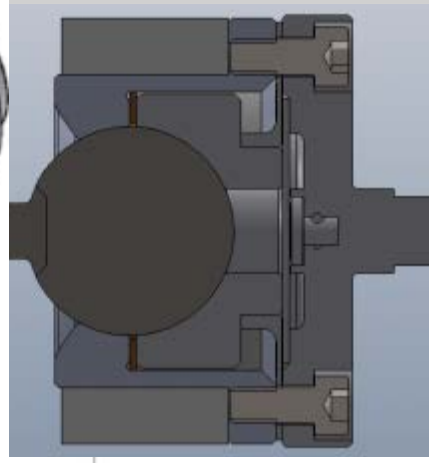


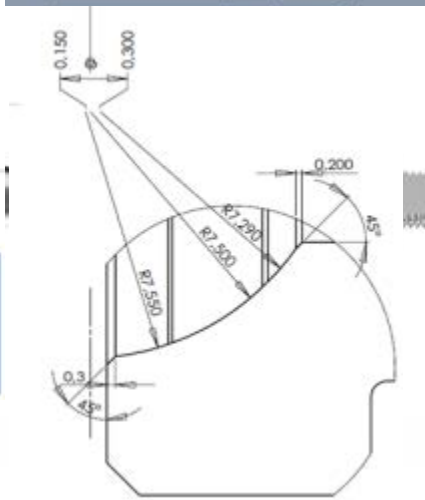


Exploitation 1: Products @ Gudel.com

Title	year
Parallel Kinematic Machines (PKM) / Robots, within Güdel AG	2014--
Components for PKM Systems, within Güdel AG	2012--







Exploitation 2: Corebon.com

Title	year
Less parts, lower weight & lower cost: R-Idea -> Corebon AB	2013

From skis to robot parts:

year 2013

Title Determination and compensation of robot properties: Cognibotics AB

Exploitation 3: Cognibotics.com

http://www.cognibotics.com/ — Cognibotics

About

Cognibotics specializes in methods and services for high-performing and cost-effective determination of robot properties such as backlash, friction, and non-linear compliance.

By knowing joint and link properties, robots can:

- move with higher accuracy
- better compensate for deflections due to process forces
- be more predictable by simulating the effect of the determined properties
- be monitored to predict upcoming errors due to robot wear

Cognibotics offers low-cost solutions for determining joint properties, thereby enabling robots to work in application areas where existing calibration techniques and current robot solutions are not tractable.

Acknowledgement

The COMET FP7 project and EC FP7 programme for providing the research opportunity that resulted in the foundation of this company.
LUIS for helping in forming a business out of research results.
The ProFlexa project and SSF/ProViking for complementary national research funding.
Modelon for providing office space.

Cognibotics

Founders of Cognibotics

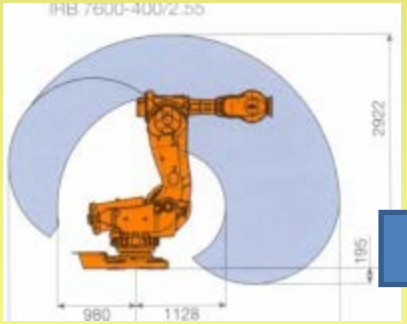
Lower costs

Monitor wear

Be precise

Complementary (non-overlapping) research actions

+



=

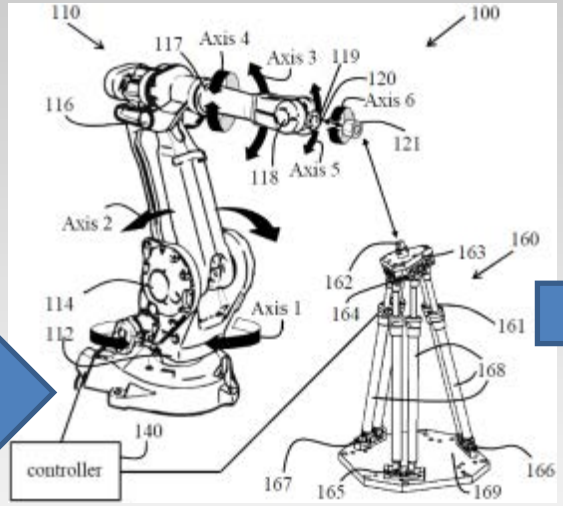
SME robotics

ABB

PRACE

Industrial applicability:
Cognition + Manufacturing = TRUE

Grant agreement no.: 258769
COMET



COGNI BOTICS

ECHORD

GÜDEL

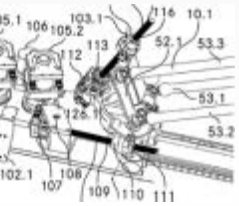
Superior Carbon Fiber Composite Technology Solutions Provider

COREBON

Summary / Conclusions

- Mechatronic solutions that enable future robots to behave.
- Enhanced modularity (mechanics, networks, software,..).
- Connecting research results to product developments.
- Cognitive topics in further EU projects (SMErobotics, ..)
- **New/extended products and businesses created.**
- **Could (in practice) only be done in Europe** [GM, et.al.].
- **Based on European cross-fertilization (credit: EC).**
- Targeted effort less suitable for ‘ordinary’ projects.
- **Echord (ICT) and COMET (FoF) together enabled innovations:**

http://gudel.com



GÜDEL

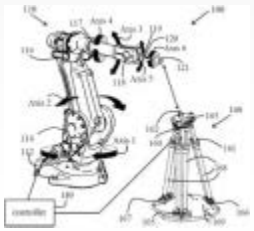
http://corebon.com

Superior Carbon Fiber Composite Technology Solutions Provider

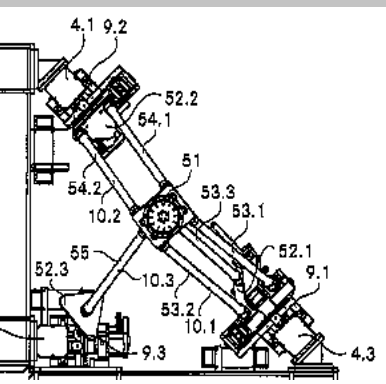
COREBON

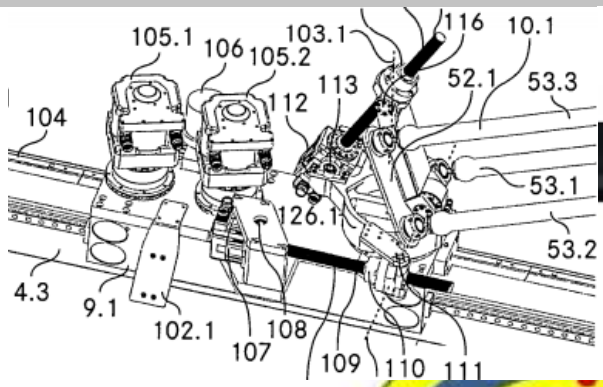
http://cognibotics.com

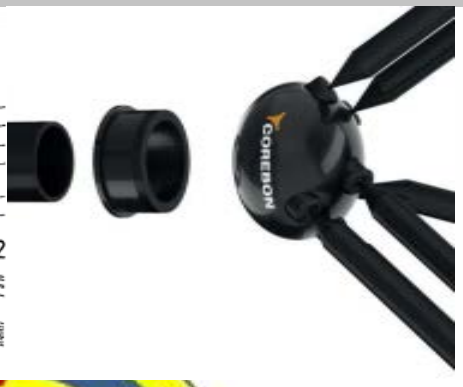
COGNI BOTICS

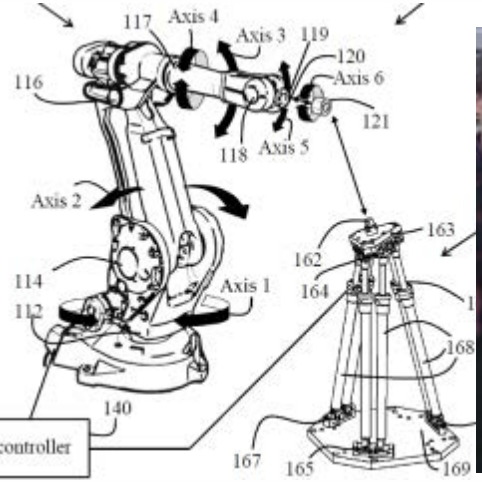


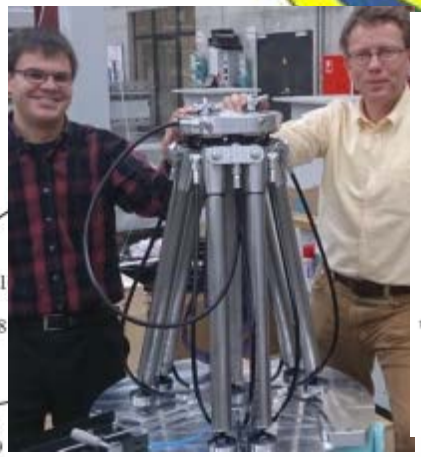
Managing robot uncertainties / Thank you!

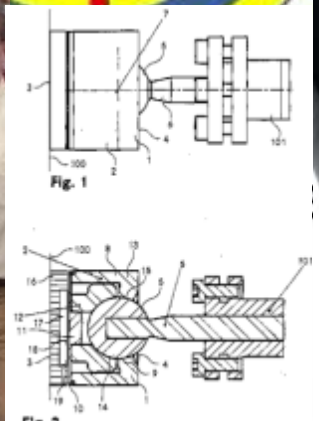












ECHORD++

European Clearing House for Open Robotics Development Plus Plus

ECHORD++ Project

Paolo Dario

The BioRobotics Institute

Scuola Superiore Sant'Anna

Pisa, Italy

12th March 2014

ECHORD++

Main Instruments

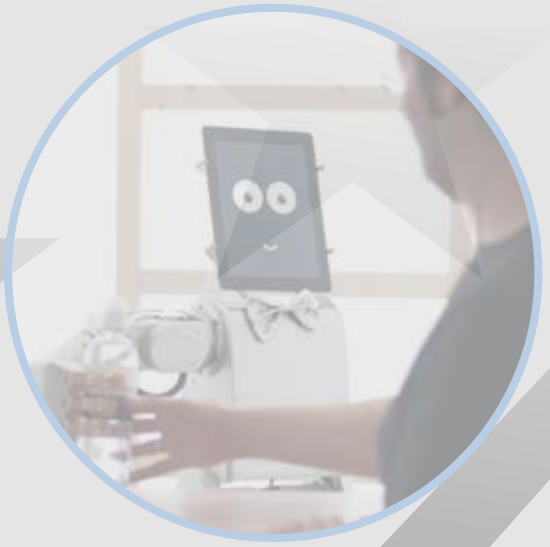
Experiments

Robotics Innovation Facilities (RIF)

Pre-Commercial Procurement Pilots (PCP Pilots)

ECHORD++

Main Instruments



Experiments

Robotics Innovation Facilities (RIF)

Pre-Commercial Procurement Pilots (PCP Pilots)

ECHORD++

Robotics Innovation Facilities (RIF)

RIFs are facilities for **bringing researchers and industry in direct contact** with current and new users of **robotics technology**!

RIFs will attract **new user groups** and help to build an **innovation ecology**.

ECHORD++

Robotics Innovation Facilities (RIFs) as Key Indicators of Step Changes

- Infrastructure in which Experiments will be **tested, standardized** and **validated**
- Real and realistic Environment that will host Experiments and External Users **testing actual step changes in Robotics**
- **Single capabilities** in Robotics will be developed in order to provide improved skills

RIF France: Medical & Health Robotics

In Paris at CEA (Commission for Atomic Energy and Alternative Energies) Institute for Smart Digital Systems

RIF in GB: Cognitive Workers

In Bristol at the Bristol Robotics Lab (BRL)

RIF in ITALY: Indoor & Outdoor, Logistic, Agricultural, Medical Robotics

In Italy at BioRobotics Institute in Peccioli

MAR→Experiments

MAR Application Domains

- Manufacturing
- Healthcare
- Agriculture
- Civil
- Commercial
- Transport & Logistics
- Consumer
- Military

E++ Experiment Scenarios

- Cognitive Tools and Workers for Cognitive Factories
- General Purpose Robotic Co-workers
- Cognitive Logistics Robots for Industry
- Medical Robotics
- Agricultural and Food Robotics

Experimental Robotics Innovation Facilities

MAR Application Domains

- Manufacturing
- Healthcare
- Agriculture
- Civil
- Commercial
- Transport & Logistics
- Consumer
- Military

E++ Scenarios

Research Scenarios	RIF
1.Cognitive Tools and Workers for Cognitive Factories	Bristol (UK), Pisa (IT), Paris (FR)
2.General Purpose Robotic Co-Workers	Bristol (UK), Pisa (IT), Paris (FR)
3.Cognitive Logistics Robots for Industry	Bristol (UK), Pisa (IT)
4.Medical Robotics	Paris (FR), Pisa (IT)
5.Agricultural and Food Robotics	Bristol(UK), Pisa (IT)

MAR→RIFs

RIF will provide support on HW&SW and Marketing

MAR Ability Targets

- Configurability
- Adaptability
- Interaction
- Dependability
- Motion
- Manipulation
- Perception
- Decisional Autonomy
- Cognitive

E++ Experiment Foci

- Key Issues in Practical Machine Cognition
- Advanced Perception and Action Capabilities
- Multiple Cooperating Mobile Manipulators
- System Architectures, Systems and Software Engineering Processes and Tools

ECHORD++

European Clearing House for Open Robotics Development Plus Plus

THANK YOU!