tec-connection

Future Opportunities

A European Perspective

Patrick Courtney

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abstract

- Abstract: “Robotics are developing rapidly while the laboratory is often semi-automated at best. The creation of the European working group on analytical laboratory robotics is raising visibility with funders, academia and industry: end users and suppliers. Priorities such as Industry 4.0, the internet of things and autonomous systems are opening the door to new technological possibilities such as the smart connected laboratory as well as new opportunities for collaboration and funding.”

- Biog: **Dr Patrick Courtney** has 20 years industrial experience in technology development. He worked as Director for global firms such as PerkinElmer, as well as at Sartorius and Cap Gemini, as well as with spinouts, SMEs and clients in sectors such as life science, pharmaceuticals and healthcare. He has a long involvement in EU and national RTD programmes and leads a European working group on analytical laboratory robotics. He is on the board of directors of the non-profit organisation SiLA: standards in laboratory automation

Outline

- Take a step back and see the lab as a whole
  - Robotics and Automation: “analytical robotics”
  - for chemistry, life science, material science
  - Three things we can’t do

- Leverage other technology developments
  - Digitisation and industry “Industry 4.0”
  - German smart lab initiative
  - Research and advances in robotics and AI
- A commercial imperative

- Funding schemes: euRobotics and healthcare robotics

Typology of end-user analytical laboratory

Life sciences

Physical sciences

…missing chemical synthesis

Commercial robots today




The garden, the house, the factory, the street and the operating theatre



Images: wikipedia, Cmglee, iRobot, ABB, Tecan, Rethink, Google

Already 20 & 10 years ago - so why now?

The Automation Partnership: from Cellmate to Compact SelecT

TU München, University of Bielefeld / Bayer (2004)

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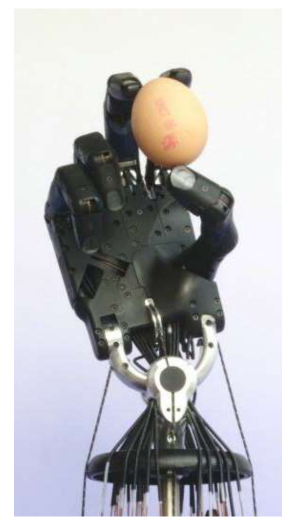
Technology **Science** **Political will**

EU robotics programme: 2005…2020


New application domains, new robotic forms and novel software capability

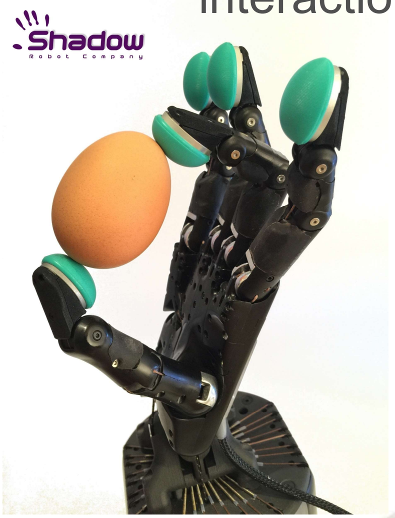


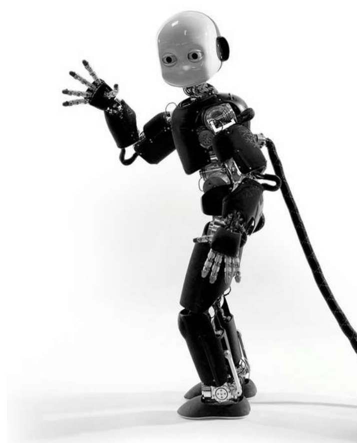



Images: CYBERLEGS, CloPeMa, VALERI, AEROARMS, Fraunhofer IFF, iCub/IIT italy, OCrobotics, Kuka/DLR, Shadow robot

New technological possibilities

interaction and collaboration





logistics and manipulation

What we can and can't yet do
Towards "analytical robotics"

New trends in intelligent robotics in the laboratory

Dr. Patrick Courtney
tec-connection

While robotics systems have been useful tools in the laboratory for many years, most notably in the area of liquid handling, many tasks are still only automated to a small extent. At the same time a new wave of robotic devices is reaching the market – from robot lawn mowers to driverless cars, as well as smarter robots in manufacturing. These benefit from the latest advances in mechatronics, sensors and artificial intelligence algorithms. Many of these advances are taking place in Europe thanks to ambitious public funding programmes. This article highlights some of the latest advances in robotics, which have the potential to take laboratory automation, and the science it enables, to the next level.

Robotics has been successfully introduced into several specific areas, including high-throughput screening for drug discovery, where throughput requirements, and the economic case for them, can be clearly made. Other successful areas have been in the management of large compound stores and, more recently, genomic analyses, forming isolated islands of automation. Up-coming technical advances open the door to much more widespread use. Since the role of the scientific laboratory is to obtain information and insight into the samples presented, analytical instruments lie at its heart. The robotics systems supporting these instruments could therefore be termed 'analytical robotics'.

Background trends and opportunity

The daily news is full of the latest developments in self-driving cars and programmes that can play 'go' better than humans, while our smartphones are stuffed with clever applications from speech to recommender systems. But what does this mean for the laboratory and how could these advances be applied to improve the productivity

36 European Pharmaceutical Review VOLUME 21 ISSUE 2 2016

- Good at liquid handling but still missing:

- Interaction and collaboration: new tasks & new capabilities
  "How to get the most out of my highly skilled scientists?"
  Learning on the job and from examples
  Collaborative robotics: combining strengths

- New robots for existing tasks: logistics and manipulation
  For those hard to automate steps: beyond the microplate

- Getting smarter in the lab:
  "Why can't I use my smartphone in the lab like I can at home?"
  Other side of the Internet of things: eye/ears – arms/legs
  Cloud chemistry models

What we can and can’t yet do
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Background trends and opportunity

- Good at liquid handling but still missing:

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  Collaborative robotics: combining strengths

Be safe and effective

- New robots for existing tasks: logistics and manipulation
  For those hard to automate steps: beyond the microplate

Avoid material handling, clogging

- Getting smarter in the lab:
  “Why can’t I use my smartphone in the lab like I can at home?”
  Other side of the Internet of things: eye/ears – arms/legs
  Cloud chemistry models

Log ALL the data

Smartlab at LabVolution Hannover, May 2017

SMARTLAB
INNOVATIONSNETZWERK

Ein Kompetenznetzwerk von EurA Innovation·finance·technology

Gefördert durch: Bundesministerium für Wirtschaft und Technologie aufgrund eines Beschlusses des Deutschen Bundestages

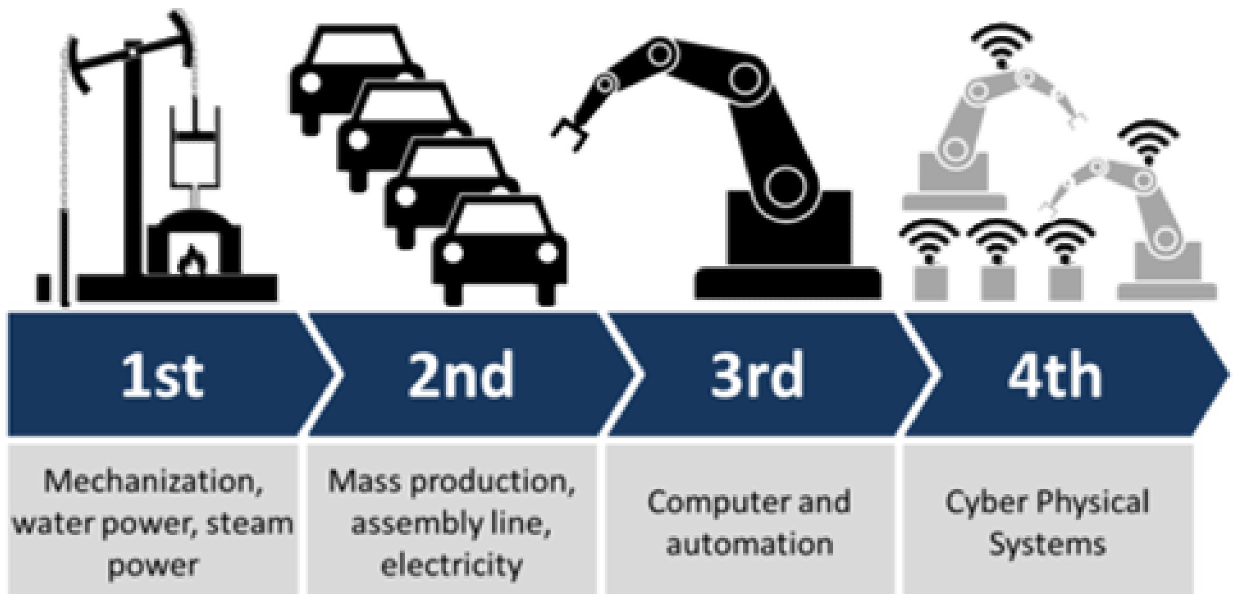
ZIM Zentrales Innovationsprogramm Mittelstand

DIE PARTNER

LAB VOLUTION · Venneos · zühlke empowering ideas · FH Aachen University of Applied Sciences · Deutsche Messe · iLIMS · HTibioX · antibodies-online.com · Herr M · Fraunhofer IPA · PreSens Precision Sensing · Köttermann · iuta · SLabS smart lab systems INT GROUP · TCI · cubuslab · Leibniz Universität Hannover · BERGHOF · nevoLAB.de lab data management · labfolder connecting laboratories · hiperscan

Smart Lab initiative: Industry 4.0

- The digital twin
  - Analytics
  - Visualisation
  - Modelling
  - Simulation
  - Optimisation



Watt Ford IBM

- Steps to Lab 4.0

As resources/services
+ materials/products
+ processes

Smart lab as an information factory

- Workflow
  - from Sample
  - Separation
  - Measurement
  - to Data

- Sample logistics
  - from solid to liquid

from the Information factory

to the Idea factory

SiLA Workshop@ELRIG-Drug Discovery 2017

The Way to the Next Gerneration Lab of the Future - What, Why, How?

From laborious data transfer and incorrect user settings, to poor utilization and uptime, the lab today can be a frustrating place to work!

The future promises to be bright, but what will the lab look like? **Can our labs benefit from the revolution of the Internet of Things and concepts from Industry 4.0?**

This innovative workshop held during the ELRIG event will bring together users and suppliers for a fresh discussion on trends and ideas that could influence the lab of the future and make it a more pleasant, safe and productive place to work. In this workshop, we will explore the how labs could evolve from user and automation perspectives and the

Workshop:

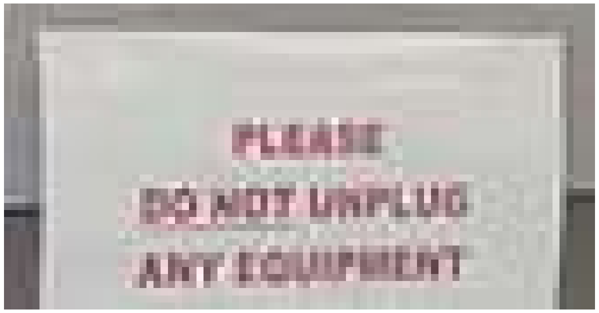
Join us for **4 highly-interactive linked sessions** over a morning, each **led by industry leaders**, taking us on the journey to the lab of the future.

Each session will propose a vision of what is cutting edge in each area and attendees will debate that vision and how best to prepare for it in a fun and interactive way.

Date: Oct 4, 2017
Time: 09:00am - 13:15pm
Location: Liverpool Conference Centre

Please, please!

what the connected lab really looks like today



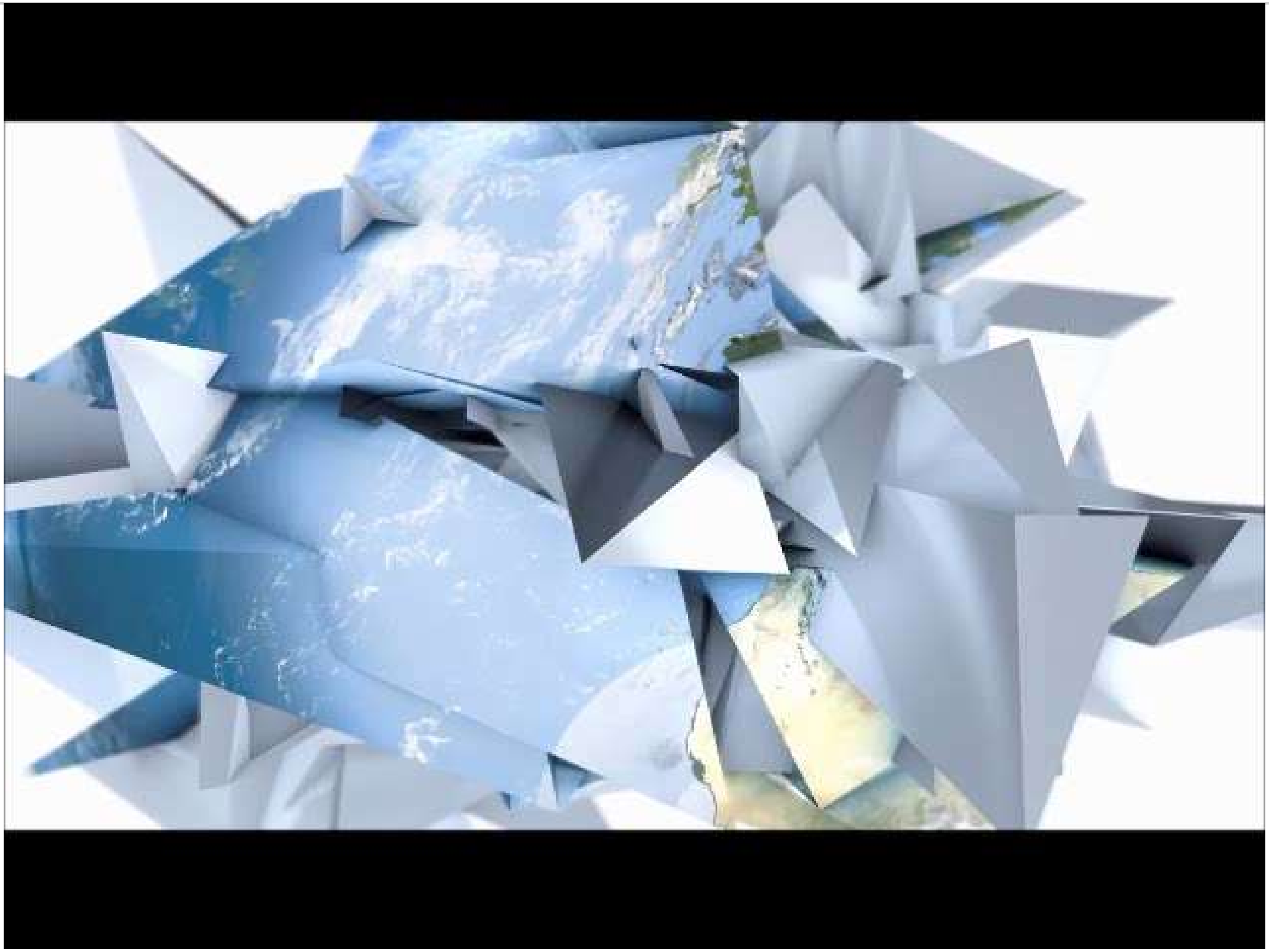
Towards “analytical robotics”

- Interaction and collaboration: new tasks & new capabilities
  “How to get the most out of my highly skilled scientists?”
  Learning on the job and from examples
  Collaborative robotics: combining strengths

- New robots for existing tasks: logistics and manipulation
  For those hard to automate steps: beyond the microplate

- Getting smarter in the lab:
  “Why can’t I use my smartphone in the lab like I can at home?”
  Other side of the Internet of things: eye/ears – arms/legs
  Cloud chemistry models

Learning by example

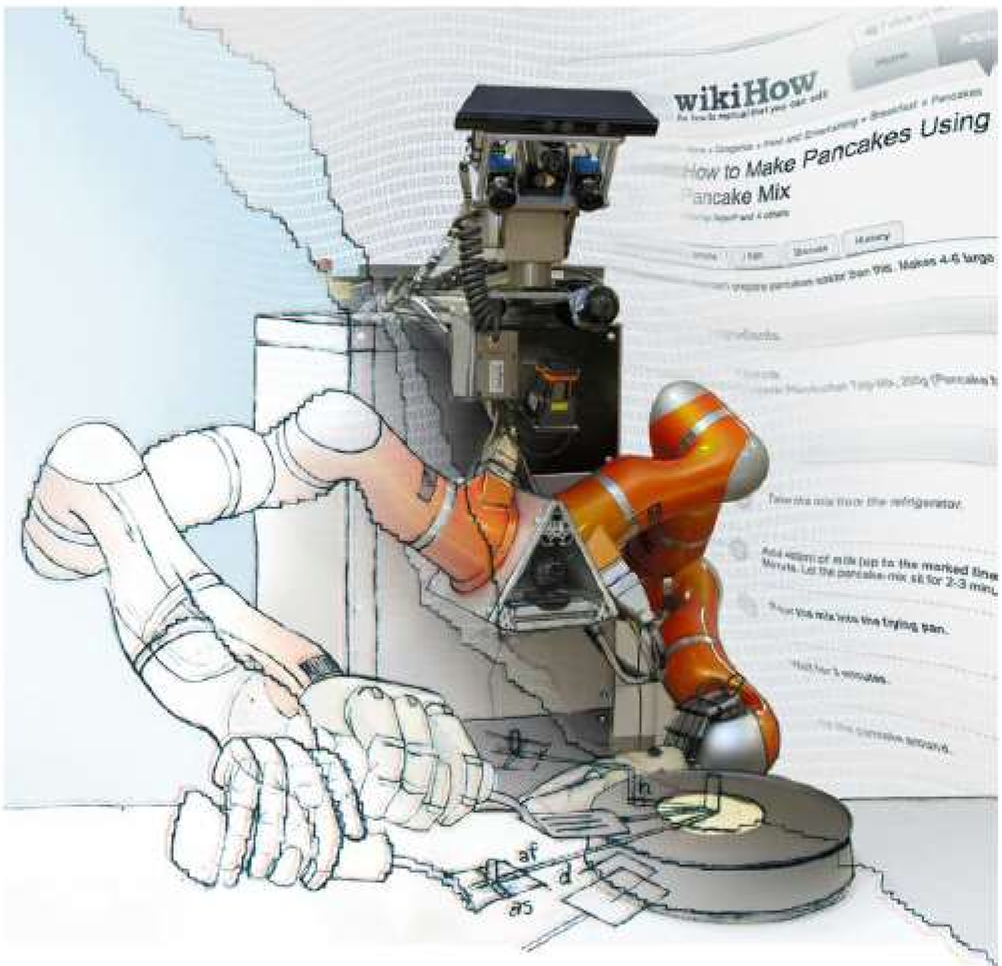


3:10

Performing everyday tasks

3:00

The RoboHow Vision



realize autonomous robots that can

- read instructions,
- observe the activities of others, and
- generate actionable plans from this information

;

Entry Point Pancake Demo

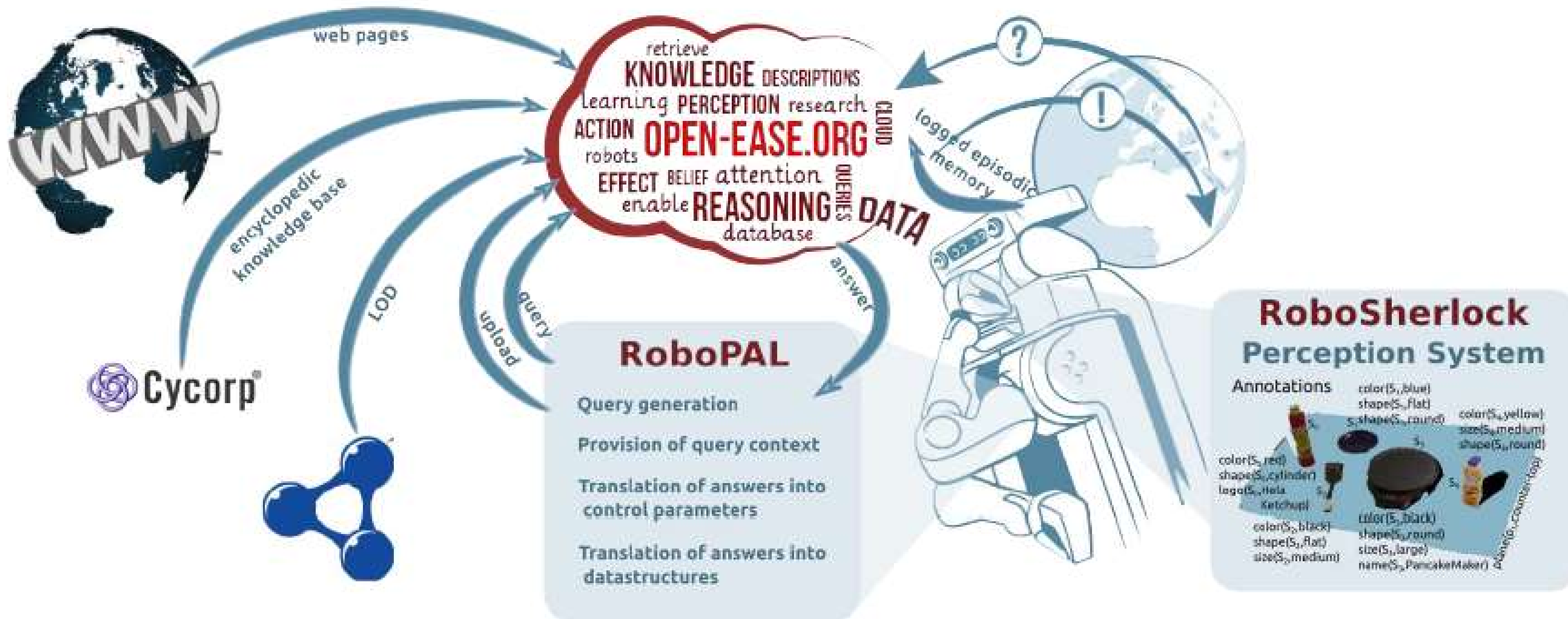
Drew McDermott: "If you know the solution before you have understood the problem you can be sure to be wrong"

insights:

- the amount,
- the breadth, and
- the depth

of the knowledge needed to perform seemingly simple everyday manipulation tasks

Step Change 1: Representation and Reasoning
Step Change 2: Perception
Step Change 3: Semantic Manipulation



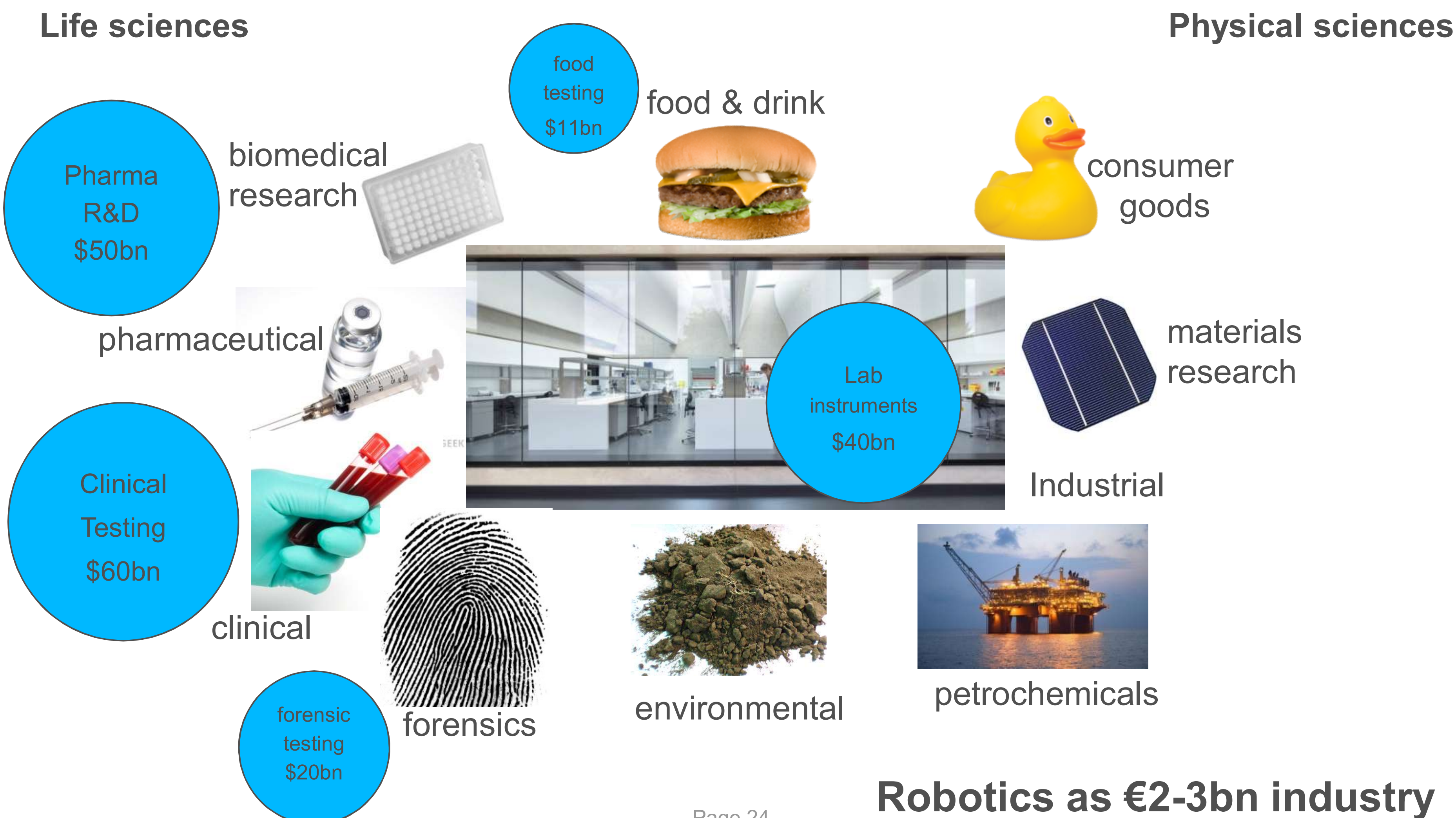
Insights: amount, breadth & depth of knowledge needed to perform “simple” tasks

Laboratory automation market
A commercial imperative

A supplier perspective

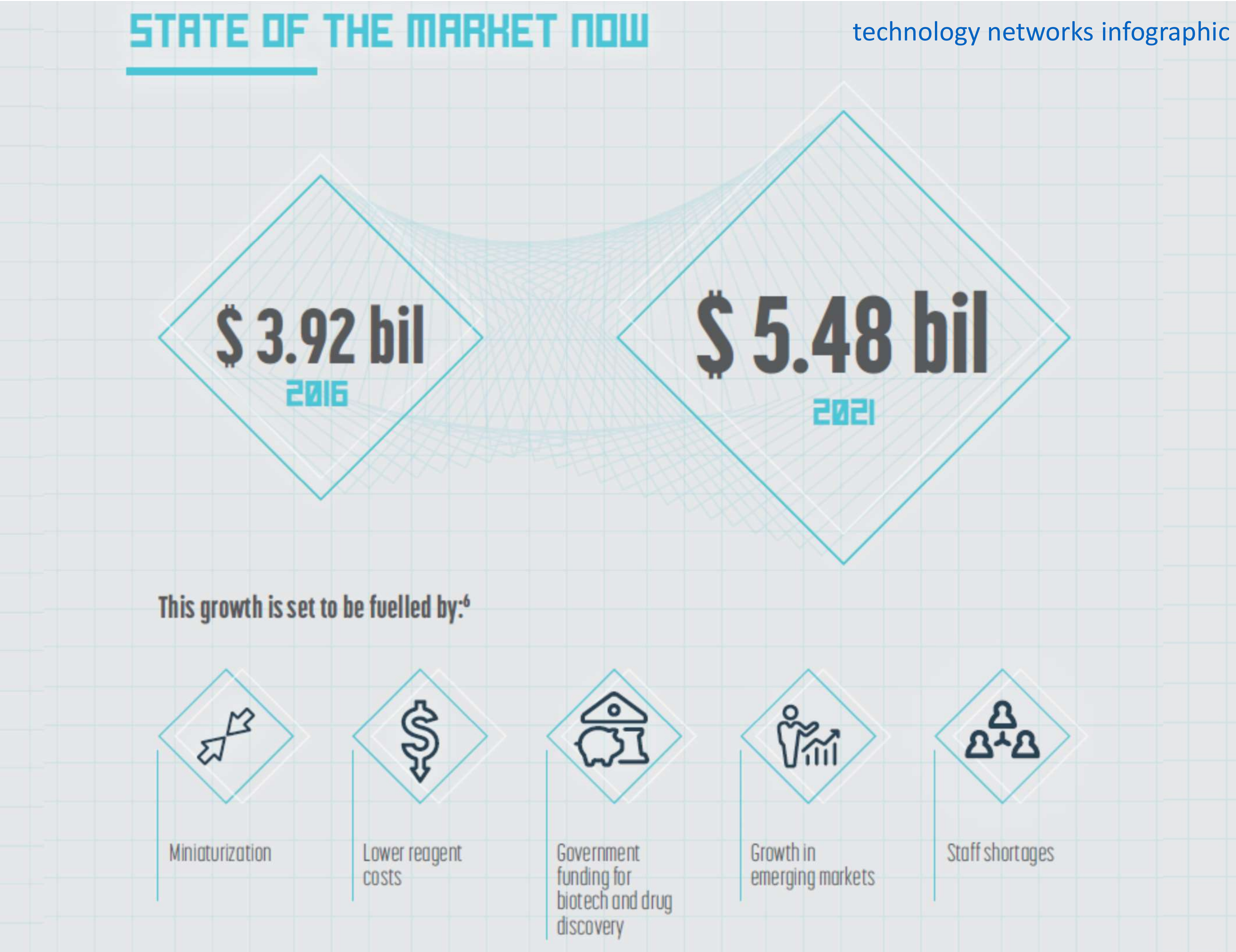
Opportunity and threat

Typology of end-user laboratory



Robotics as €2-3bn industry
and mostly in Europe

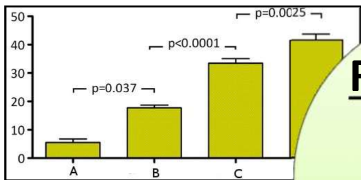
technology networks infographic



Benefits

Create sufficient data to demonstrate <u>significance</u>

Driver: Replication concerns



<u>Replication</u> repeat and extend previous work

<u>Collaborate</u> sharable robot/lab protocols

Driver: Open Innovation

Benefits for new robotic technology

<u>Speed</u>: try out new ideas fast and respond to literature

Driver: Time to market

Better **<u>safety</u>** and compliance, less RSI

Driver: Regulation

<u>Focus</u>: time to **plan experiments** and **analyse data**

Driver: Cost and asset utilisation

now quantify these…

THE BENEFITS

Whilst increasing productivity by as much as 75%

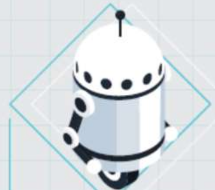
75%

Laboratory automation has been shown in peer-reviewed literature to reduce human errors by 50%

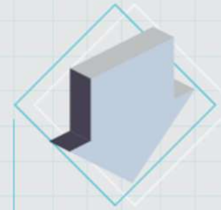
50%

As such, automation presents an attractive solution for hitting tight deadlines and getting the most out of overstretched teams.[7]

TURNAROUND TIME



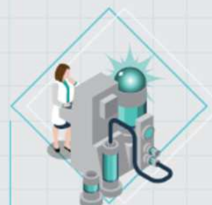
Implementing laboratory automation systems has shown to reduce the sample turnaround time of a clinical lab by up to **30%.**[8]



A genetic testing lab could see testing times reduced by **50%.**[9]

A drug discovery lab could reduce the process of designing, synthesizing and screening a compound from **weeks to days.**[10]

REDUCES COSTS



Reagent savings
One study showed that by automating tissue sample processing they could save 70% on reagents annually.[12]

Labour
They also found that they could reduce the amount of hands on time by 50%.[12]

This represents a combined saving of over **$250,000** per year.[12]

REDUCES REPETITIVE INJURIES

90% of people that pipette in continuous sessions of 1 hour or more report hand pain.[11]

Studies show that women that pipette

300 hours a year

which is only 75 minutes per working day, are at **much higher risk of hand and shoulder ailments.**[11]

ELIMINATE HUMAN ERROR

A study from Hofstra University revealed that the average cost of a lost sample was **$584** and that sample tracking errors over a 4-month period totalled **$20,000 in losses.**[13]

Differences in pipetting between operators has been shown to be up to **11.8%** when handling 10 µL. Whilst an automated pipetting system can keep errors below **2%**, right down to 1 µL.[14,15]

technology networks infographic

Emeryville, CA, USA

Emerald Cloud Lab

“big data + robots = all problems solved”

5 NOVEMBER 2015 | VOL 527 | NATURE

Tech investors bet on synthetic biology

Once hesitant, Silicon Valley venture capitalists are warming to the idea of engineered cells.

MONEY FOR MICROBES

Investments in synthetic-biology start-ups have increased dramatically in the past three years. Much of the funding comes from prominent technology investors.

COMPANY	YEAR FOUNDED	BUSINESS	TOTAL FUNDS (US$)	NOTABLE INVESTORS
Twist Bioscience	2013	DNA synthesis	$82.11 million	Yuri Milner (Internet-company investor)
Zymergen	2013	Microbial-strain optimization	~~$44 million~~ $133M	Obvious Ventures; Eric Schmidt (Alphabet executive chairman)
Ginkgo Bioworks	2008	Microbial engineering	$54.12 million	Matt Ocko (Facebook and Zynga investor)
Bolt Threads	2009	High-performance fibres	$40 million	Peter Thiel and Max Levchin (PayPal co-founders)
Transcriptic	2012	Robotics for biology labs	$14.37 million	Jerry Yang (Yahoo co-founder)
Riffyn	2014	Software	$1.8 million	O'Reilly AlphaTech Ventures
Emerald Therapeutics	2010	Technology platforms	$34 million	Peter Thiel and Max Levchin

EU opportunities: initiatives, resources & funding

Industrial leadership

HORIZON 2020

Robotics unit
Public Private Partnership
Flagships

accmet

imi innovative medicines initiative

FP9

chist-era

Long-term Challenges in Information and Communication Sciences & Technologies ERA-NET

SC1 Societal Challenge 1
aging society

autostem

Adalab

Excellent science

Societal Challenges

EU opportunities: initiatives, resources & funding

chist-era

Long-term Challenges in Information and Communication Sciences & Technologies ERA-NET

Adalab

AdaLAB Adaptive Automated Scientific Laboratory

- The robot scientist

- knowledge representation
- ontology engineering
- semantic technologies
- machine learning
- bioinformatics

→ automated experimentation

- A biological process from yeast
- Partners: Manchester, Brunel, Paris, Leuven

EU opportunities: initiatives, resources & funding

2018 call robotics smart factory
Publishes June
Opens October

chist-era

Long-term Challenges in Information and Communication Sciences & Technologies ERA-NET

1. Object recognition and manipulation by robots: Data sharing and experiment reproducibility

The ability of recognising objects and manipulating them is central to robotics. Robots should for example be able to recognise objects mentioned by a user and fetch them or to visually determine if and how an object can be safely grasped. However, despite decades of research, such abilities remain limited in practice. Limiting factors are the lack of large data sets for training robust models for the tasks under study and of objective evaluation protocols to test these models in a reproducible way. A new approach going beyond the organisation of robotics competitions is needed, whereby robotic perceptions about the surrounding environment and internal states are recorded, annotated with reference information usable to evaluate models, and shared across researchers working on the same task.

Application sectors: Industrial and service robotics

Keywords: Robotics, object recognition, image recognition, artificial vision, visual servoing, grasping, object manipulation, perception through interaction, embodied cognition, machine learning, benchmarking, performance evaluation, experiment reproducibility

2. Industrial big data and process modelling for smart factories

Industry and its production plants are increasingly digitized and the production processes generate increasing amounts of heterogeneous data, from simple sensor data to complex 3D video streams. This opens the way for new intelligent, flexible, network-centric production approaches where parts, products and machines are interconnected across plants, companies and value chains. This evolution is often referred to as the fourth industrial revolution. Most industrial sectors are concerned, including aeronautics, energy, chemical industry, dairy farming and 3D industry, among others.
The goal is to enable production at higher yield, higher quality, lower costs, lower environmental footprint and increased flexibility. For that purpose, intelligent context-aware automation systems should be developed. Such systems should be generic enough to be reusable in various settings. One of the research challenges is to combine a priori knowledge about the processes with learning from data.

Application sectors: Industry, manufacturing, maintenance.

Keywords: Smart industry, cognitive plants, advanced manufacturing, predictive maintenance, process modelling, big data, machine learning

EU opportunities: initiatives, resources & funding

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Societal Challenges

FP7 Accmet Accelerated Metallurgy

The European Research Roadmap, Metallurgy Europe

- to lay the **technical foundation** for the design and discovery of next-generation alloys, compounds and composites that can be processed into higher- performance metallic components for industrial end-users
- to establish new high-tech **start-ups** and **pilot-scale** factories in Europe
- to develop a **talent pipeline** of well-trained post-docs, PhDs, masters students, apprentices and school children, who will eventually be part of the much- needed metallurgy workforce of Europe
- to **create 100,000 jobs** within a decade, comprising both manufacturing and adjacent service jobs
- to develop **1000 patents** in order to secure European independence in metallurgy, as well as the protection of crucial intellectual property for new materials and processes;
- to make a positive contribution to Europe's GDP and societal wellbeing.

This Roadmap has evolved into a partnership between 260 companies and research organisations throughout Europe which is now established as an EUREKA Network. This program aims to raise up to a 1 billion Euro of funding for metallurgy research throughout Europe over the next 7 years and has been through its first round of applications for setting up projects within the three key areas of: Material discovery, Novel design, metal processing and optimisation, Fundamental understanding of metallurgy

Metallurgy Europe is a seven-year EUREKA Cluster Programme (Σ!9169) started in 2014 [15 member states including: Norway, Turkey, CH]

EU opportunities: initiatives, resources & funding

Public Private Partnerships

Flagships

Horizon2020: from PPP to Flagship

- Public Private Partnership: for robotics as “euRobotics”

- Other relevant PPPs:
  - EFFRA European Factories of the Future Research association
  - SPIRE: Sustainable Process Industries through Resource & Energy Efficiency
  - Others (Green vehicles, photonics, green buildings, HPC, 5G…)

- Emerging PPPs: Big Data, Personalised Medicine
  - A filtering process will be applied!

Horizon2020: convergence in euRobotics

- Produce a Multi-annual roadmap
  - Feeds into the work-programme

- Topic groups: technology and market sector
  - Medical
  - Analytical Laboratory Robots
  - Miniaturised Robots

- The Healthcare Lighthouse

TOPIC GROUPS, COORDINATORS

23 July 2014

euRobotics aisbl

Topic group	Coordinator
Aerial Robots	Anibal Ollero
Agricultural Robots	Thilo Steckel Stefan Stiene
Autonomous Navigation	Jesús-Pablo Gonzalez
Benchmarking and Competitions	Fabio Bonsignorio
Bio-Inspired Robots	Manuel Armada
Civil Robots	Francesco Fedi
AI and Cognition in Robotics	Alessandro Saffiotti Markus Vincze
Robot Companions for Assisted Living	Paolo Dario
Field/Service Robots in unstructured Environments	Roland Siegwart Prof. Jonas Buchli
Healthcare	Christophe Leroux Paolo Fiorini Birgit Graf Thierry Keller
Industrial Robotics	Björn Matthias Elisabeth Schärtl
Maintenance and Inspection	Ekki Zwicker
Marine Robotics	Massimo Caccia
Mechatronics and Materials	Markus Grebenstein Michael Suppa
Miniaturised Robots	Nicolas Andreff
Natural Interaction with Social Robots	Kerstin Dautenhahn M. Chetouani

The Healthcare Lighthouse vision



Laboratory




Surgery

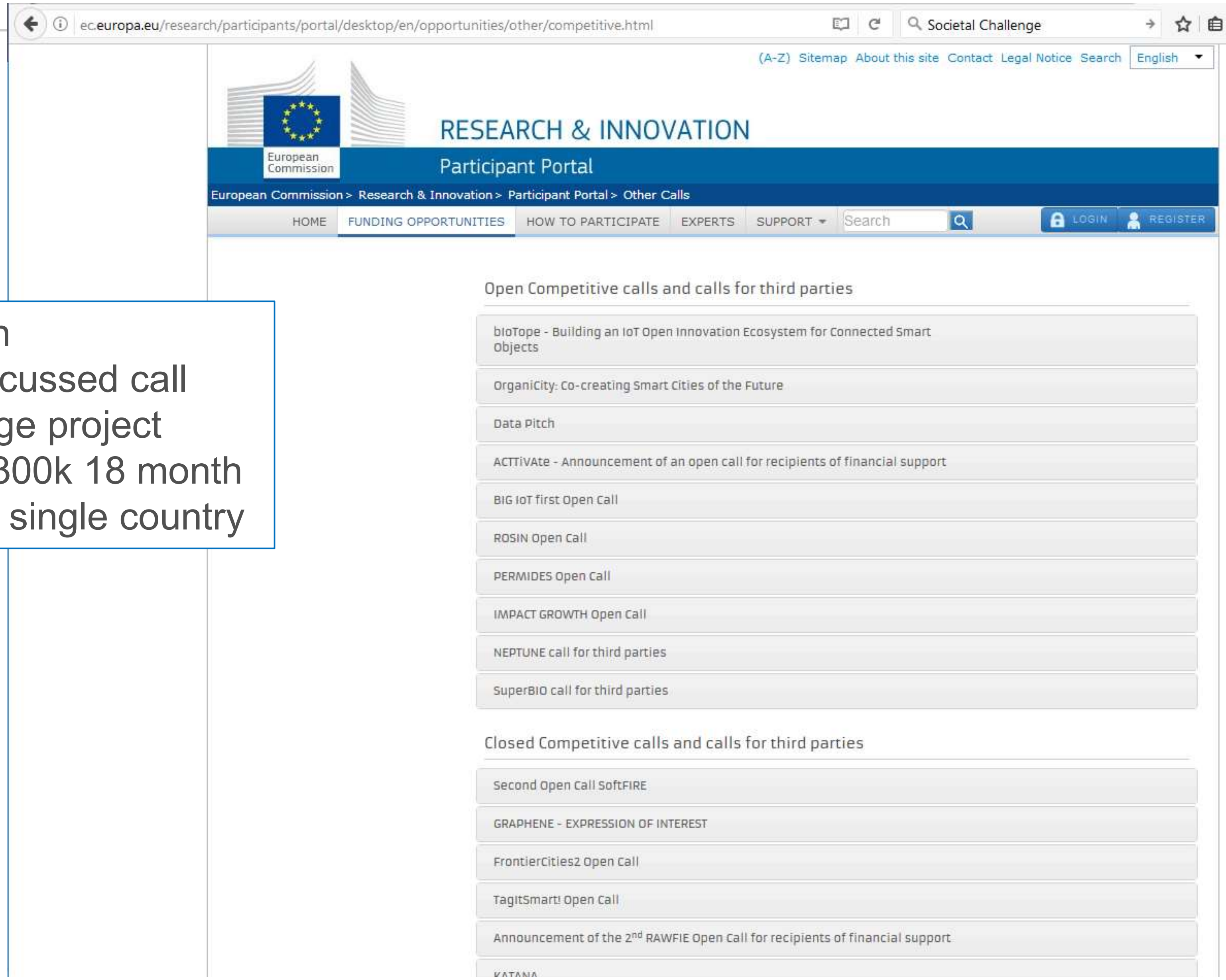
Care




Rehabilitation

Delegation: Cascade funding projects

Low burden
Part of a focussed call within a large project
Typically €300k 18 month
1-2 partner single country



Horizon2020: from PPP to Flagship

- Flagships €1bn over 10 years
  - 2013: Human Brain, Graphene
  - 2016: Quantum technologies

- Another round is in preparation to compete

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Summary

- Dial-a-Molecule touches on some existing initiatives
  - Laboratory robotics TG, Smartlab, Industry 4.0
- There are commercial imperatives
- There are opportunities to engage with EC
  - PPP: new or existing, cascade funding
  - Societal challenges, flagship…FP9
  - with and without Brexit
- Thank you for listening

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Thanks to input from 100+ organisations

- Associations: ELRIG, SiLA, Allotrope foundation; MMIP, EVA, Biolago, Toolpoint, euRobotics Topic Groups in Healthcare Robotics and Miniaturised Robotics
- End users: GSK, AstraZeneca, Boehringer, Curie Inst, QUT, Actelion, Novartis, Synthace, Sellafield, Unilever, Johnson Matthey, Milan University Hospital, Lonza,, UCB, MIB, EMBL, Inst. Pasteur, NHM, Biontech; Aachen, QEHospital Gateshead, Bayer, Grünenthal, Roche
- Suppliers: Roche, Agilent, TTP Labtech, Hamilton, Cytomate, Cognex, Bosch, SMC, Tecan, BEE robotics, Shadow Robot, Festo, Sartorius, Waco automation, LGC, bioMérieux, Titian Software, Telerobot, Renishaw, Chemspeed, Labman, Analytik Jena, ABB, Kuka, Brechbuehler, Liconic, HiRes, Eppendorf, Qiagen, Bionic Robotics, Bertin, Singer Inst., Mitsubishi, Precise, UniversalRobots, Schunk, Aseptium, Adept, PAA, Integra, Helbling, Kiestra; Hackscience, Roboratory AndrewAlliance Miltenyi Kötterman Primadiag Altran Zühlke Nevolab Vetter PerkinElmer Precise
- RTOs: Fraunhofer IFF/IPA IPT, CSEM, VTT, IIT, Catapult (CGT, MedDisc, HVM)
- Academics groups: University of Manchester, University of Bielefeld, Brunel, Birmingham, Bristol, Bremen, TCI Hannover, Dresden, Rostock, Liverpool, TU Munchen, FH Buchs, HSR Rapperswil, Imperial, Kings college, Copenhagen, Strathclyde, Aachen, TUT, TUWien, ETH-BSSL, ETH-FGZ, Uni Konstanz, NTA-Isny,