T A

Č R

Výzkum užitečný pro společnost

Konference ANNO

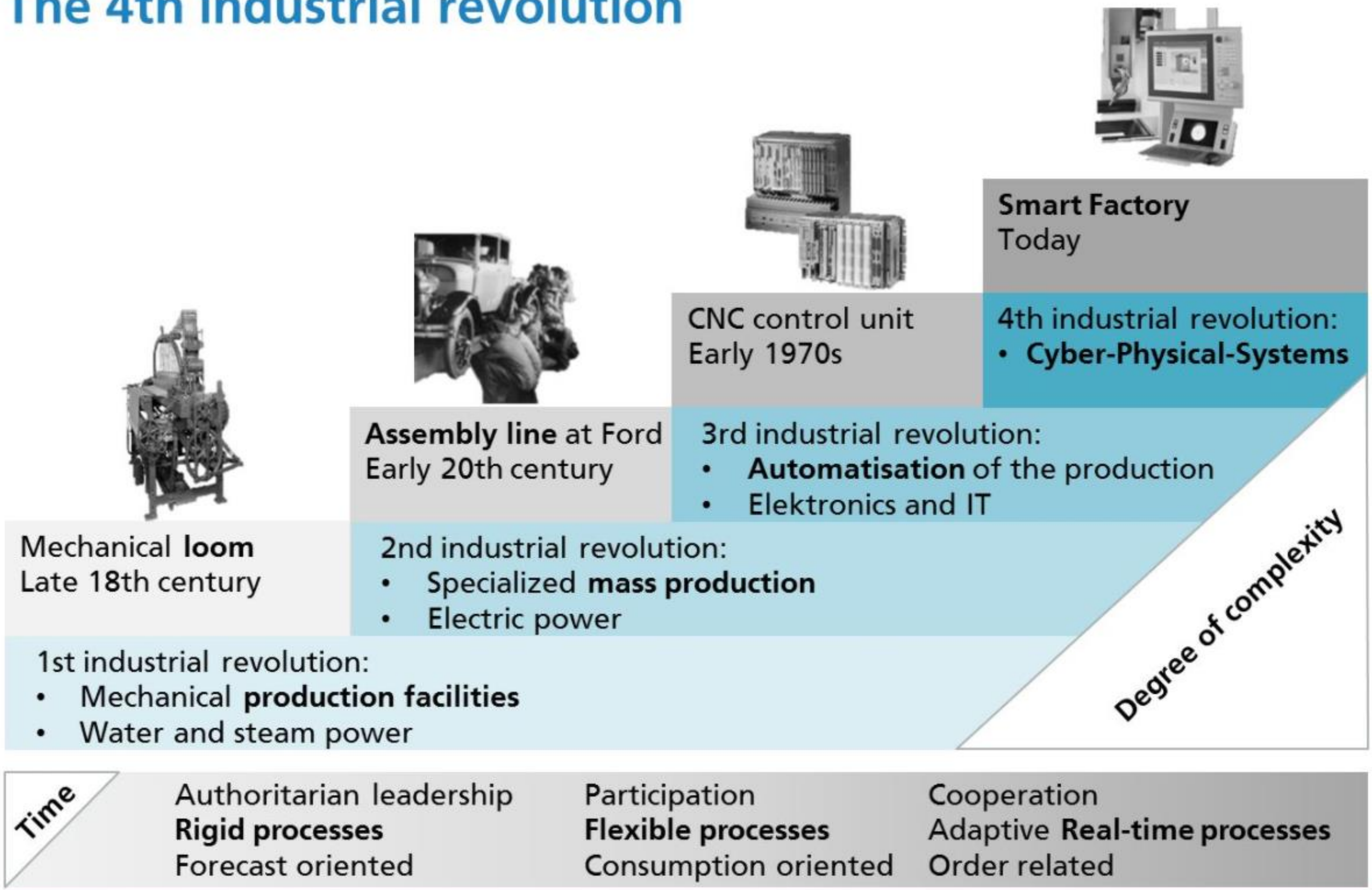
Sociální podnikání – Jiný úhel pohledu?

Společnost 4.0 jako reflexe průmyslu 4.0

Doc. Dr. Ing. Vladimír Kebo, Technologická agentura České republiky

Impact HUB Ostrava, Sokolská třída 1263/24, Moravská Ostrava a Přívoz

The 4th industrial revolution



Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Challenges in Industrie 4.0 technologies

Health and Environment

e.g. Human-Machine-**Interaction**/Cooperation

Production and Supply of Services

e.g. **Cyber Physical Systems**, predictive maintenance, customized and adaptive production ...

Communication and Knowledge

e.g. data **security** and safety, data rate and **latency**, deep **learning** ...

Energy and Resources

e.g. closed-loop production, **energy self-sufficiency**, intelligent grids

Mobility and Transport

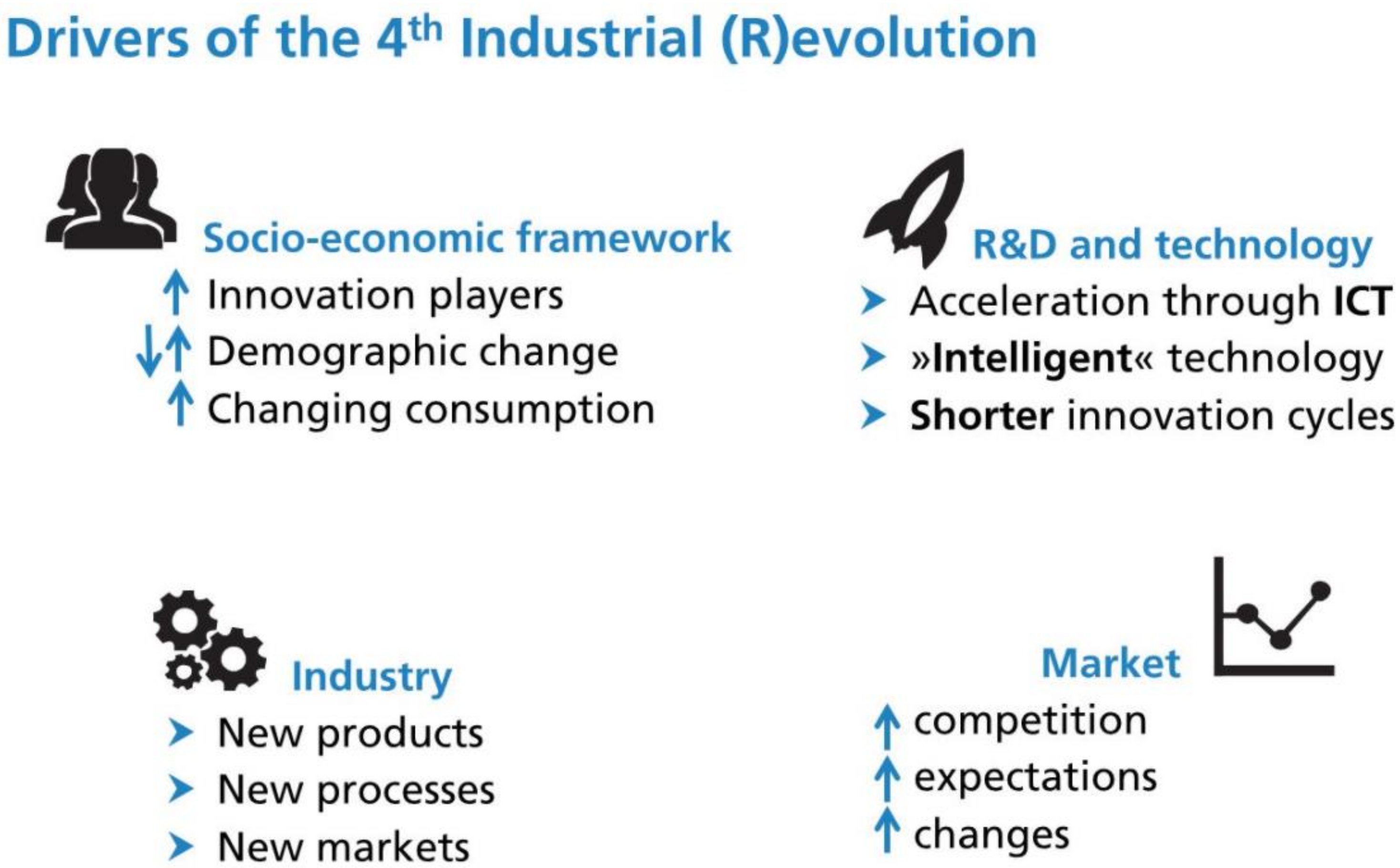
e.g. autonomous vehicles, **decentralized multi-agent logistics** ...

Security and Protection

e.g. cyber security, trusted data exchange, **resilient systems** ...

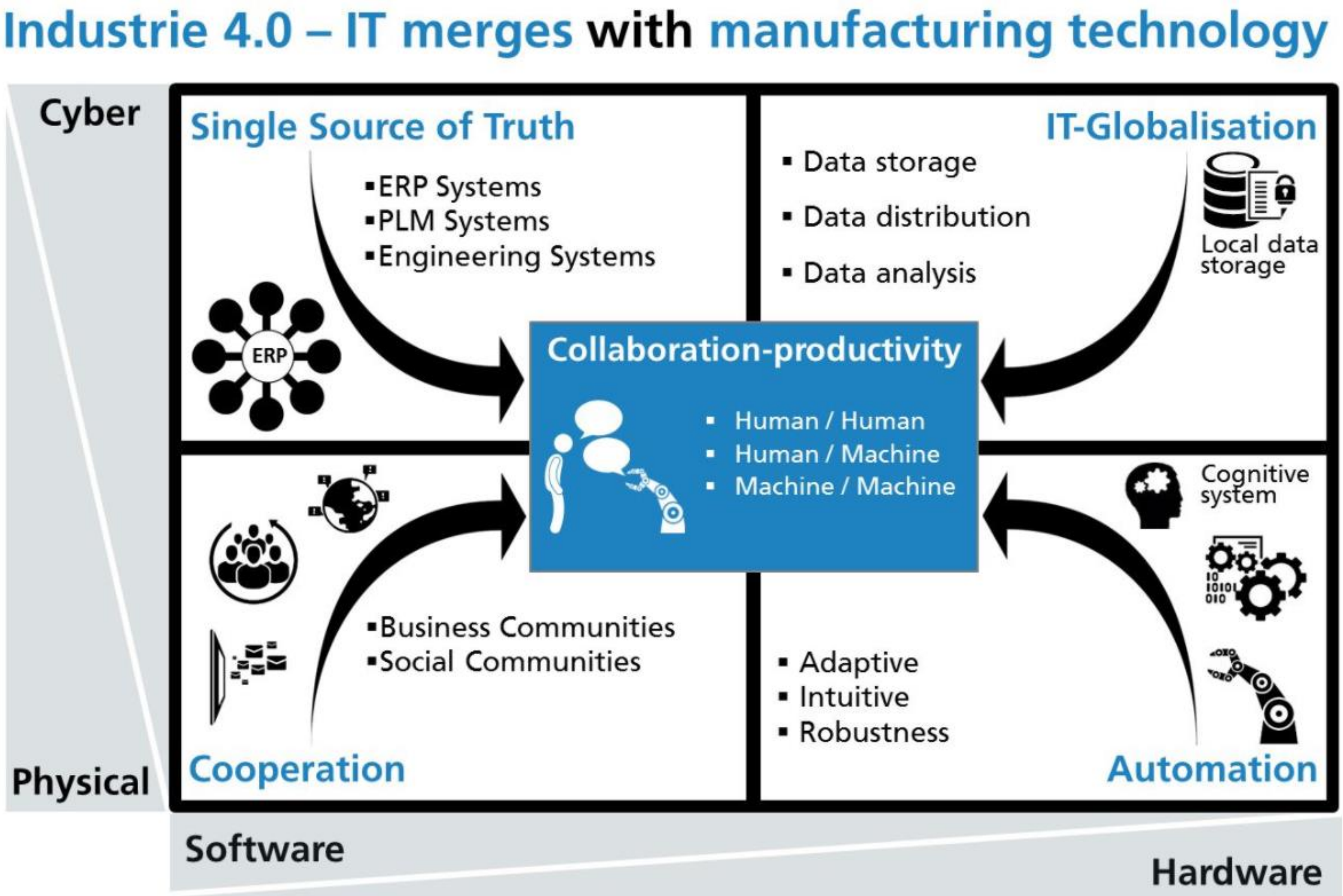
Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Frame conditions



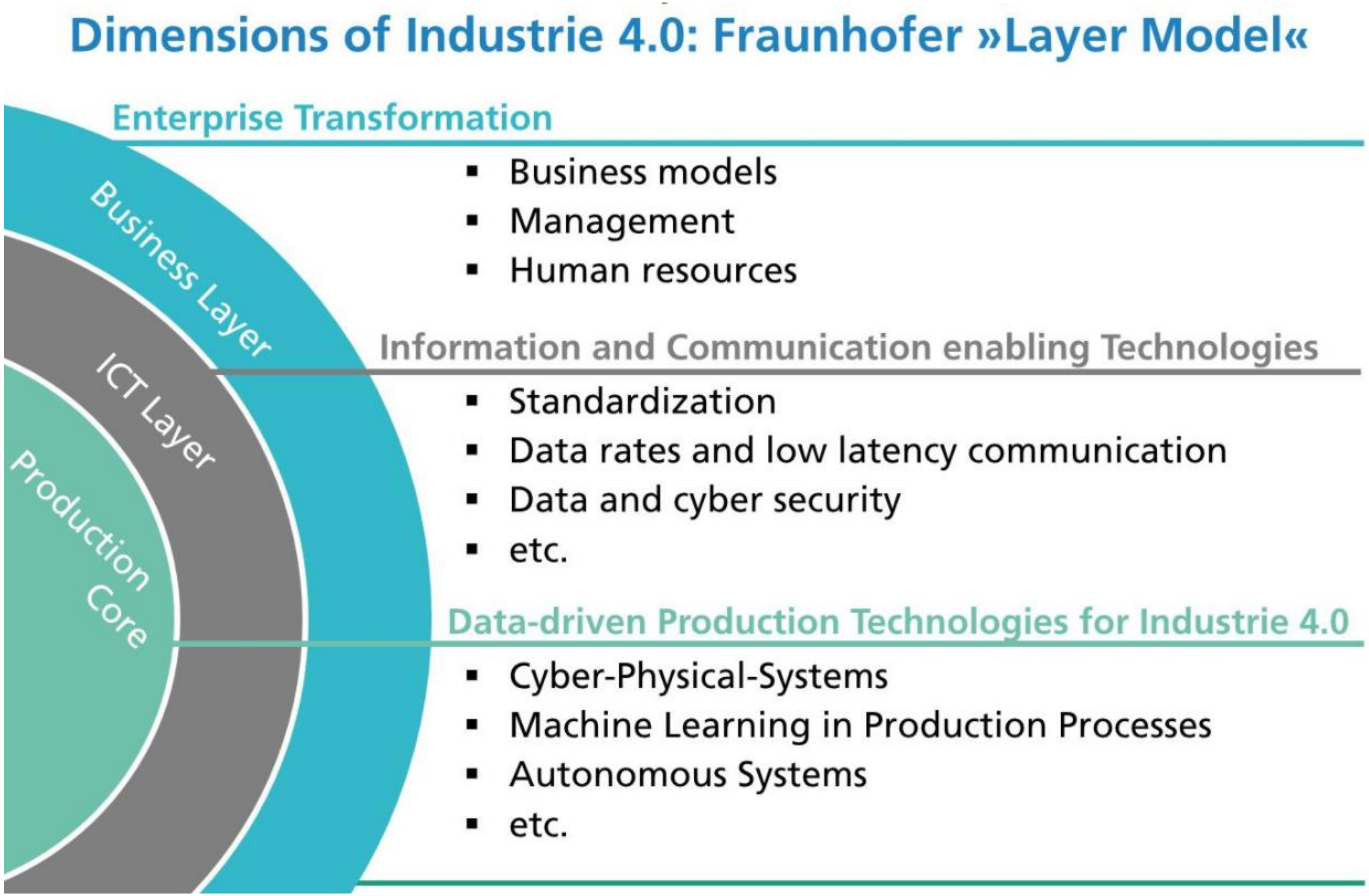
Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Frame conditions



Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

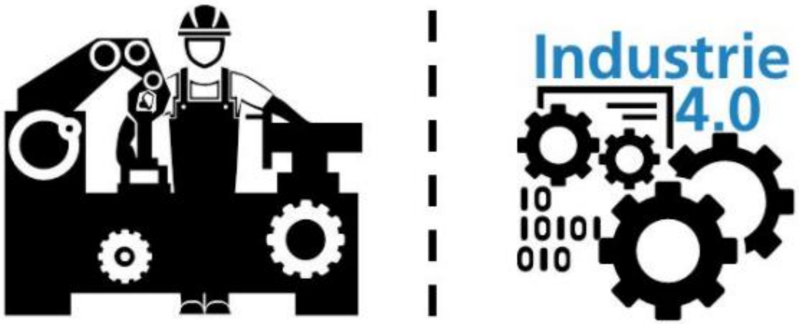
Fraunhofer „Layer Model"



Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Potentials and Challenges

German economic potential of Industrie 4.0



Forecast until 2025:

- Up to **430,000 new jobs**, but simultaneous **elimination** of **490,000 low-skilled jobs***
- **GDP growth** of about **30 billion EURO** **
- **Total investment** of about **250 billion EURO** **

Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Potentials and Challenges

Global economic potential of the Internet of Things

Nine settings where added value is expected	Size in 2025, $ trillion[1] (Low estimate – High estimate)
Factories – eg., operations management, predictive maintenance	1.2 - 3.7
Cities – eg., public safety and health, traffic control	0.9 - 1.7
Human – eg., monitoring and managing illness, improving wellness	0.2 - 1.6
Retail – eg., self-checkout, smart customer-relationship	0.4 - 1.2
Logistics – eg., logistics routing, autonomous vehicles, navigation	0.6 - 0.9
Work sites – eg., operations management, equipment maintenance	0.2 - 0.9
Vehicles – eg., condition-based maintenance, reduced insurance	0.2 - 0.7
Homes – eg., energy management, safety and security	0.2 - 0.3
Offices – eg., augmented reality for training	0.1 - 0.2

Total $ 4 trillion - $ 11 trillion

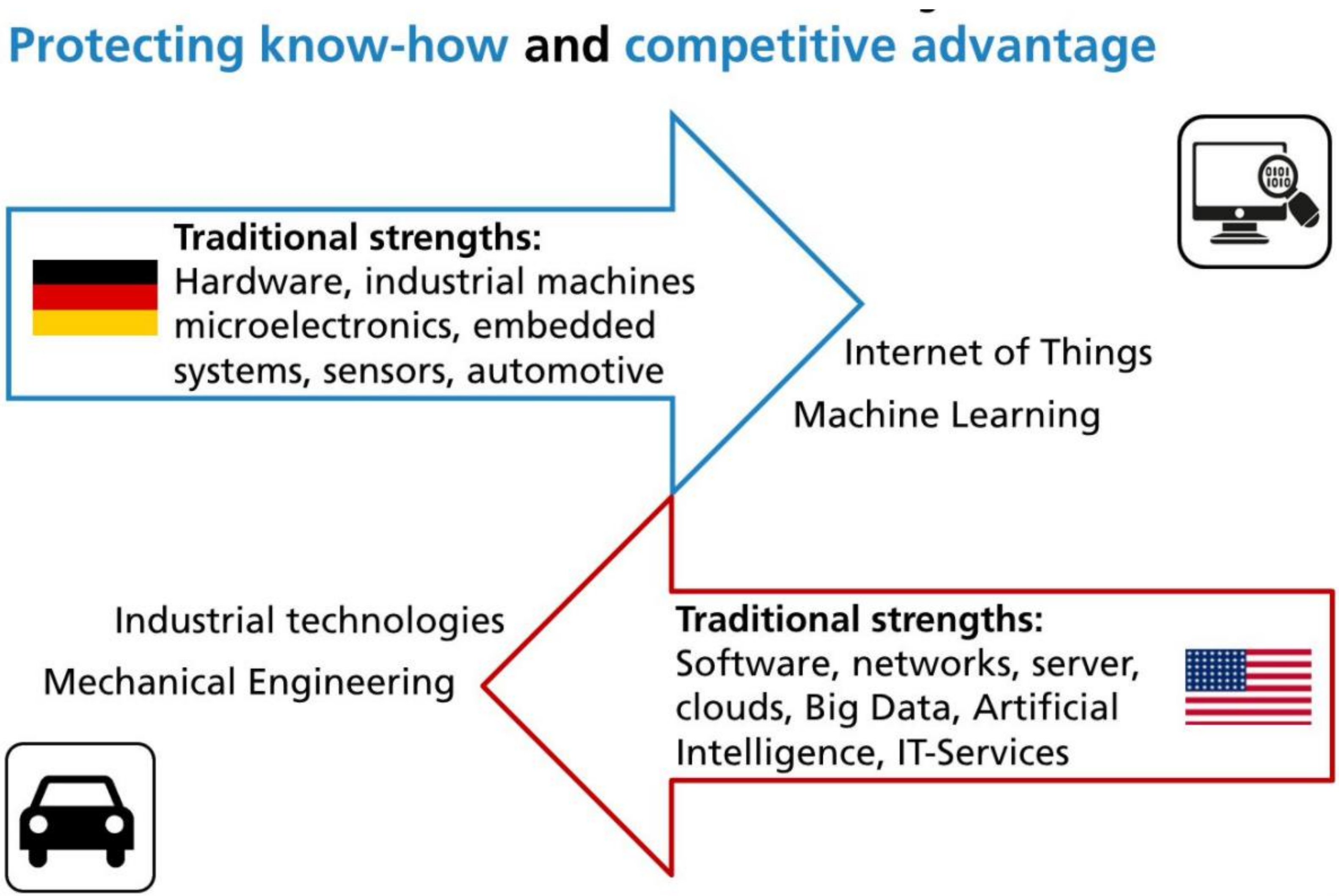
[1]Adjusted to 2015 dollars, for sized applications only; includes consumer surplus. Numbers do not sum to total, because of rounding

trillion | 1 000 000 000 000 (= 10^{12}) | bilion

Source: McKinsey Global Institute analysis, June 2015

Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Potentials and Challenges



Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Potentials and Challenges

Directions for the future of manufacturing

	Player	Situation	Goals	Means
Industrie 4.0 	Germany	Growing competition	Leadership in Cyber-Physical-Systems	Integrating ICT into manufacturing
Industrial Internet 	USA, UK	Service-centred economy	Re-industrialization	Adding manufacturing to ICT
Full Automation 	East Asia	Labour shortage, rising labour costs	Cheaper, faster, less labour	Using robots for manufacturing

Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Potentials and Challenges

New types of jobs emerge

»The spread of computers and the Internet will put jobs in two categories. People who tell computers what to do, and people who are told by computers what to do«

Marc Andreessen
(*1971 USA) Founder of Netscape Communications and
Developer of Mosaic, one of the first successful international web browser

Challenges

- Machines will perform tasks with repetitive character and low complexity
- Hard- and software will perform planning tasks autonomously
- Knowledge workers with medium qualification will be supervised and monitored by computers »Human Automation«

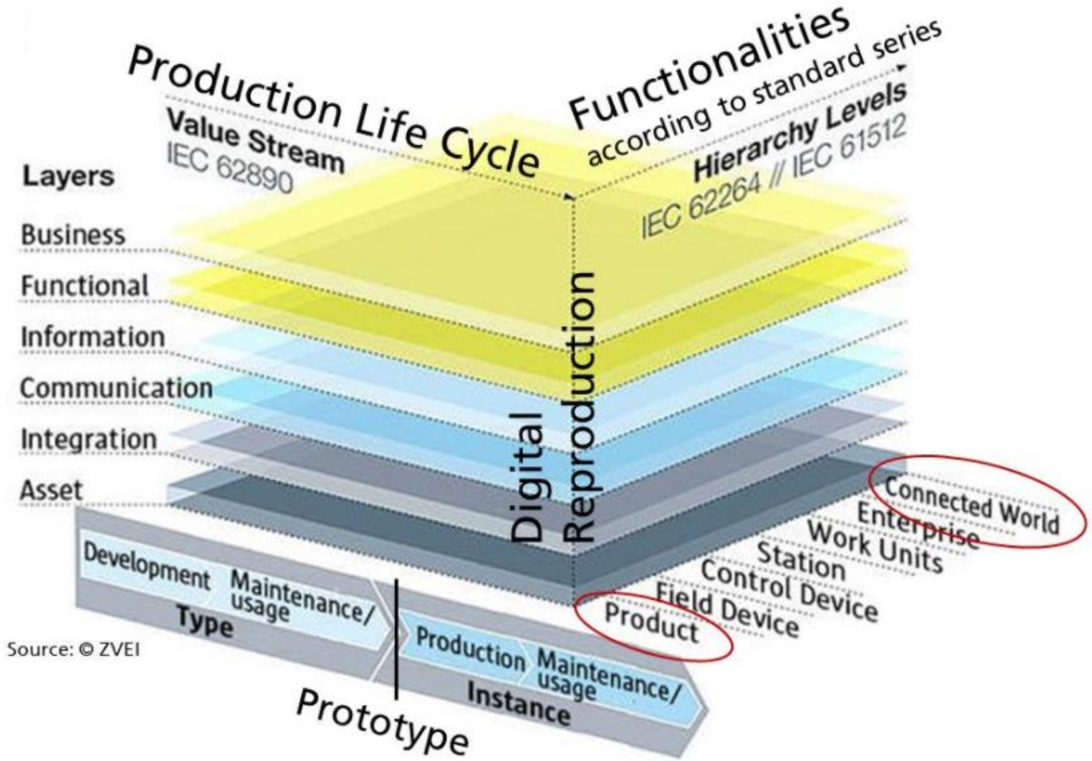
Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Requirments for Data Driven Production

Requirement: Standardization

Reference-Architecture-Model Industrie 4.0
(RAMI 4.0)

- Three-tier system
- Joint development by: Bitkom, VDMA, ZVEI, Plattform Industrie 4.0



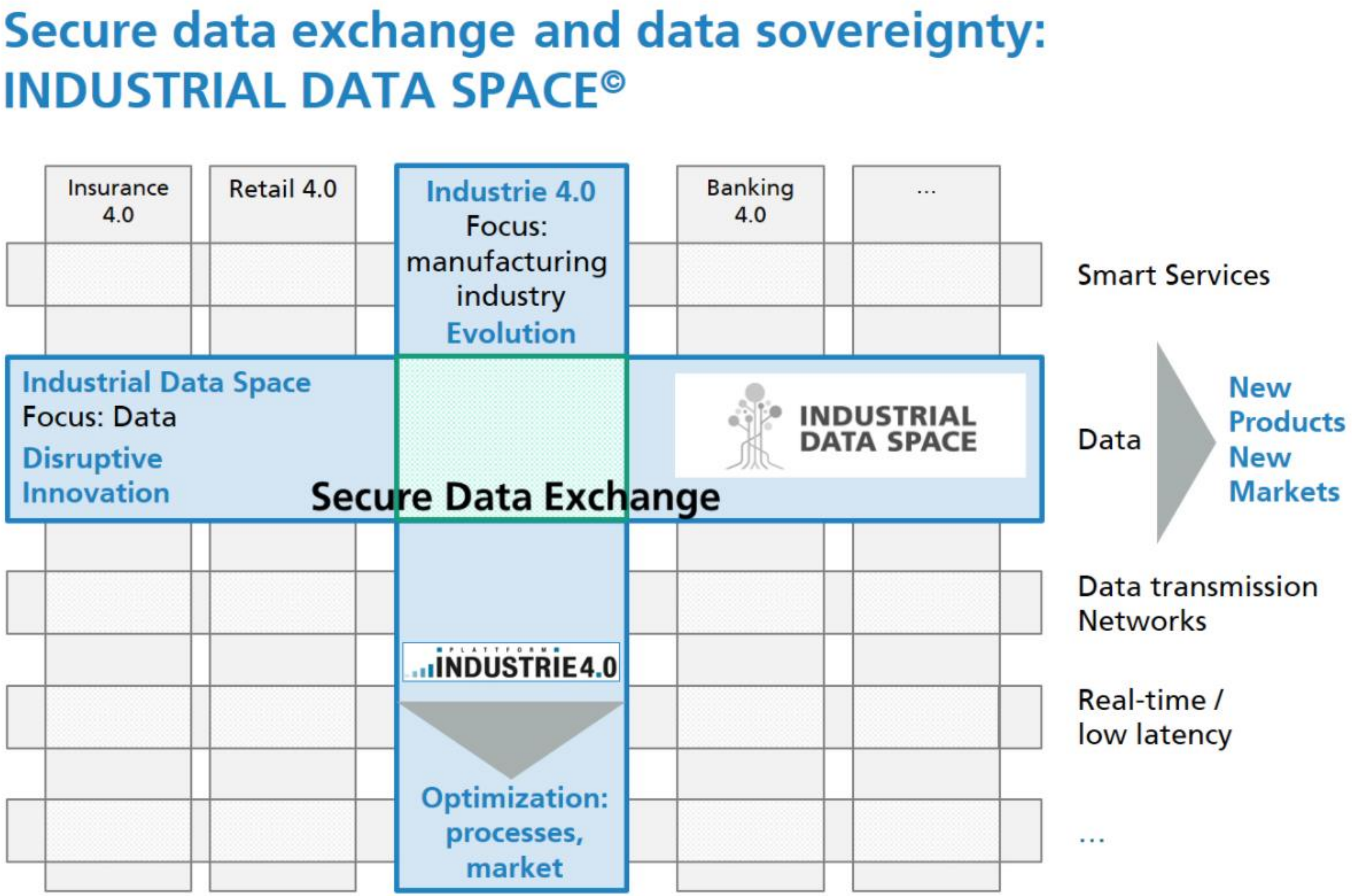
Standardization goals I4.0:

- **Identification** (location of participants)
- **Semantics** (communication)
- **Quality of service** (low latency, reliability)

→ compatibility and interoperability

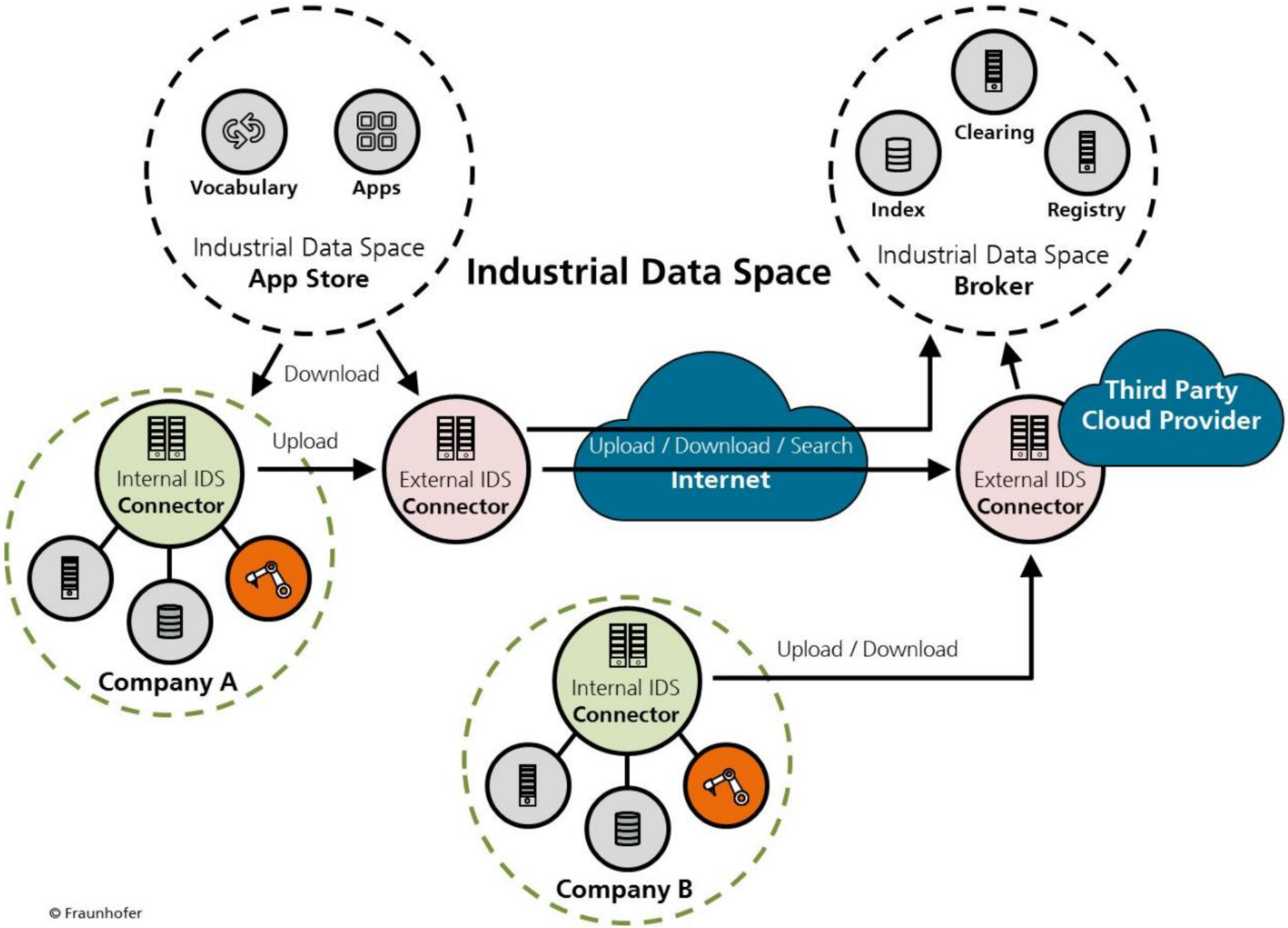
Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Requirments for Data Driven Production



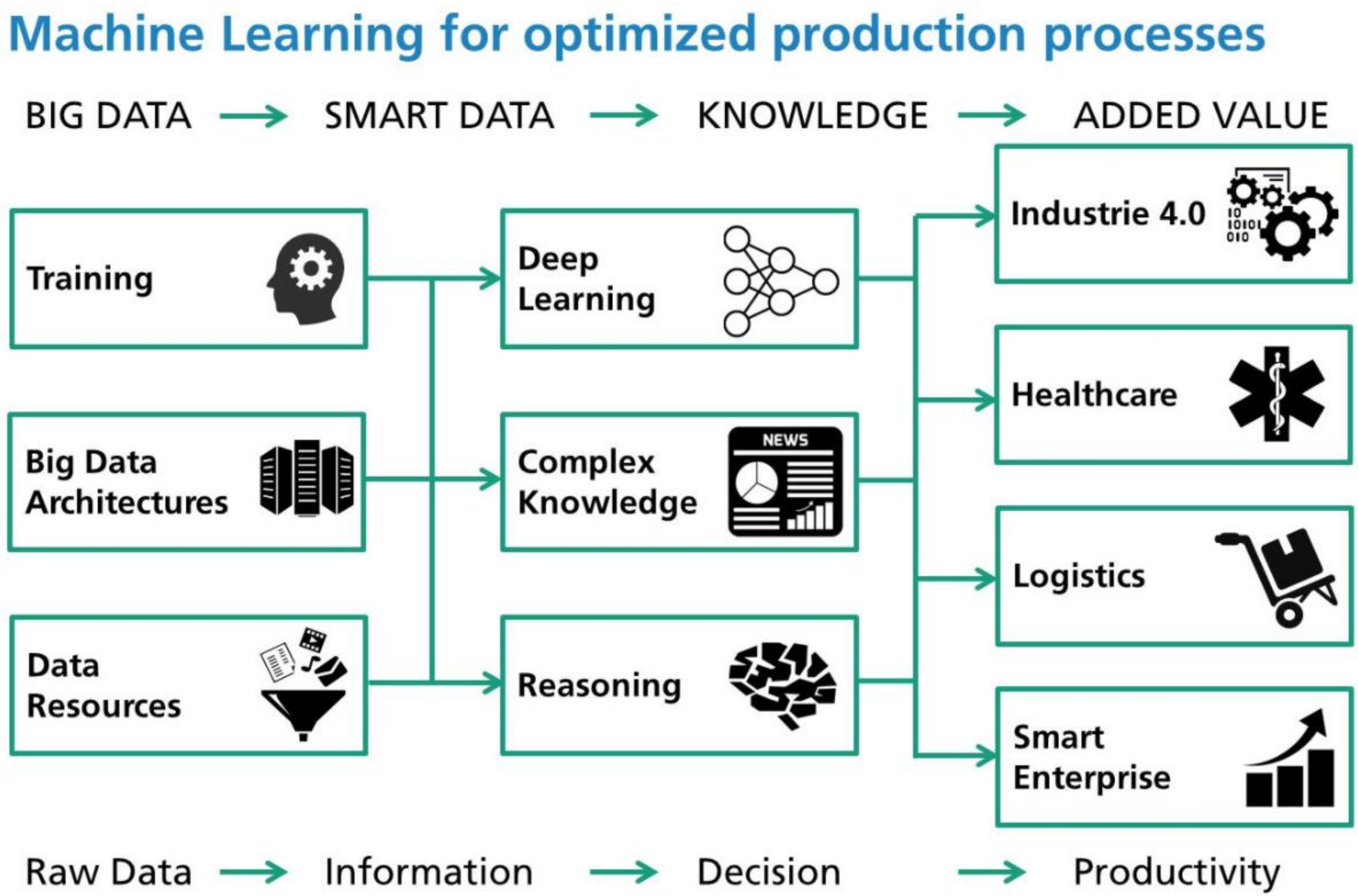
Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Industrial Data Space



Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Machine learning



Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Machine learning

»Machine Learning« leading to »Cognitive Machines«

Machine Learning (ML): »procedures of **Artificial Intelligence** that enable **machines** to **learn** from (data)examples in order to optimize their (decision) processes **without being explicitly programmed**.«

ML as enabler for »Cognitive Machines«

- Flexibility, versatility
- Interactivity, communication skills
- Iterativity, memory
- Contextual analysis, adaptability

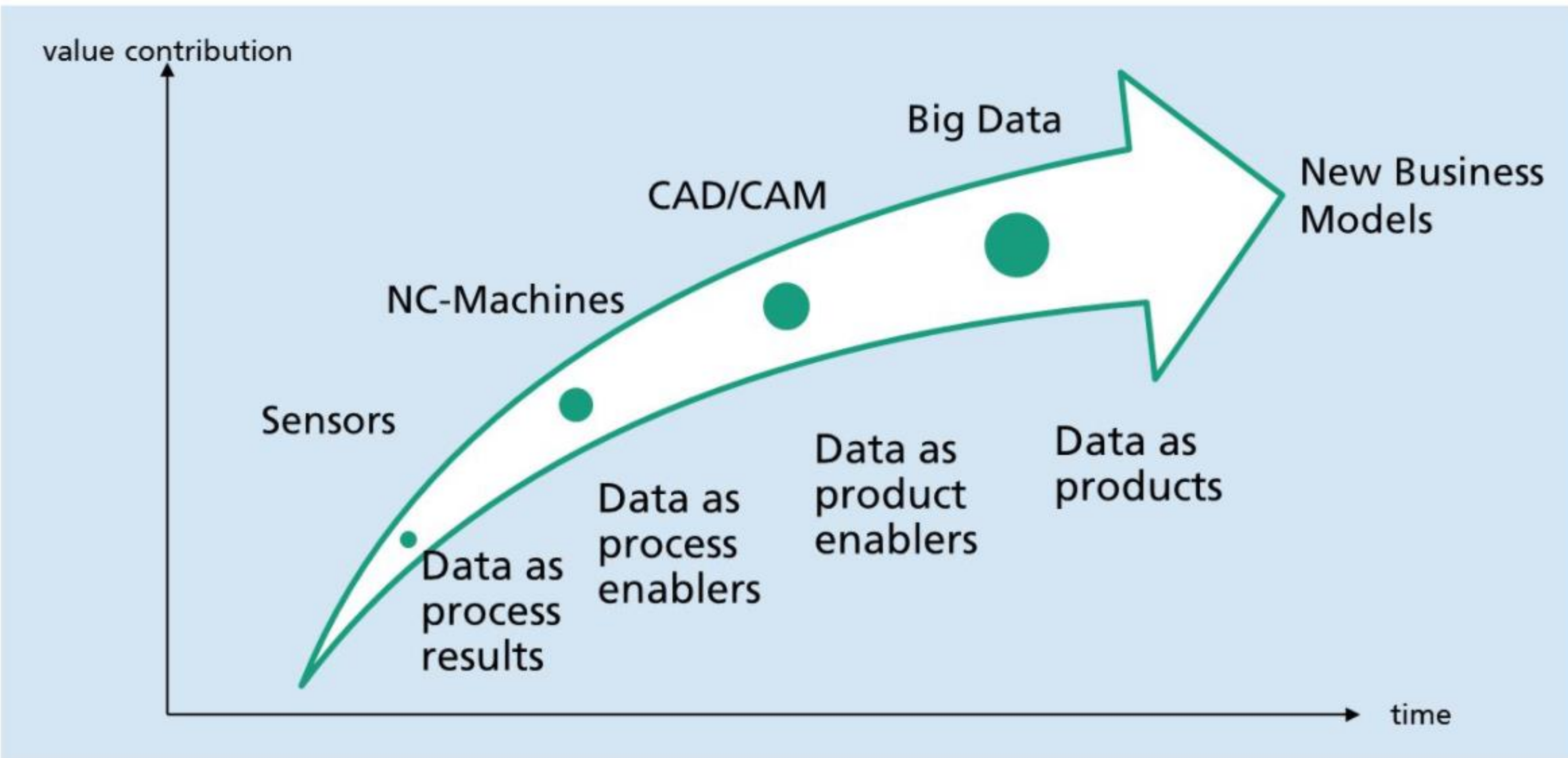
Progress through »Moore's Law«:

- processing speed
- data storage
- »clouds«
- »big data
- fast internet
- miniaturization

Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Data Driven Production

Data as a Strategic Resource



Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Data Driven Production

Digitization as driver and enabler of innovative business models

Pharma

- »Real-Life Evidence«
- More effective and efficient therapy
- Personalized medicine

product innovation

Automotive

- traffic management 2.0
- Dynamic routing
- »Connected Drive Services«

service innovation

Commerce

- Autonomous transparency along the supply chain
- Consumer-centric supply chain

process innovation

Production

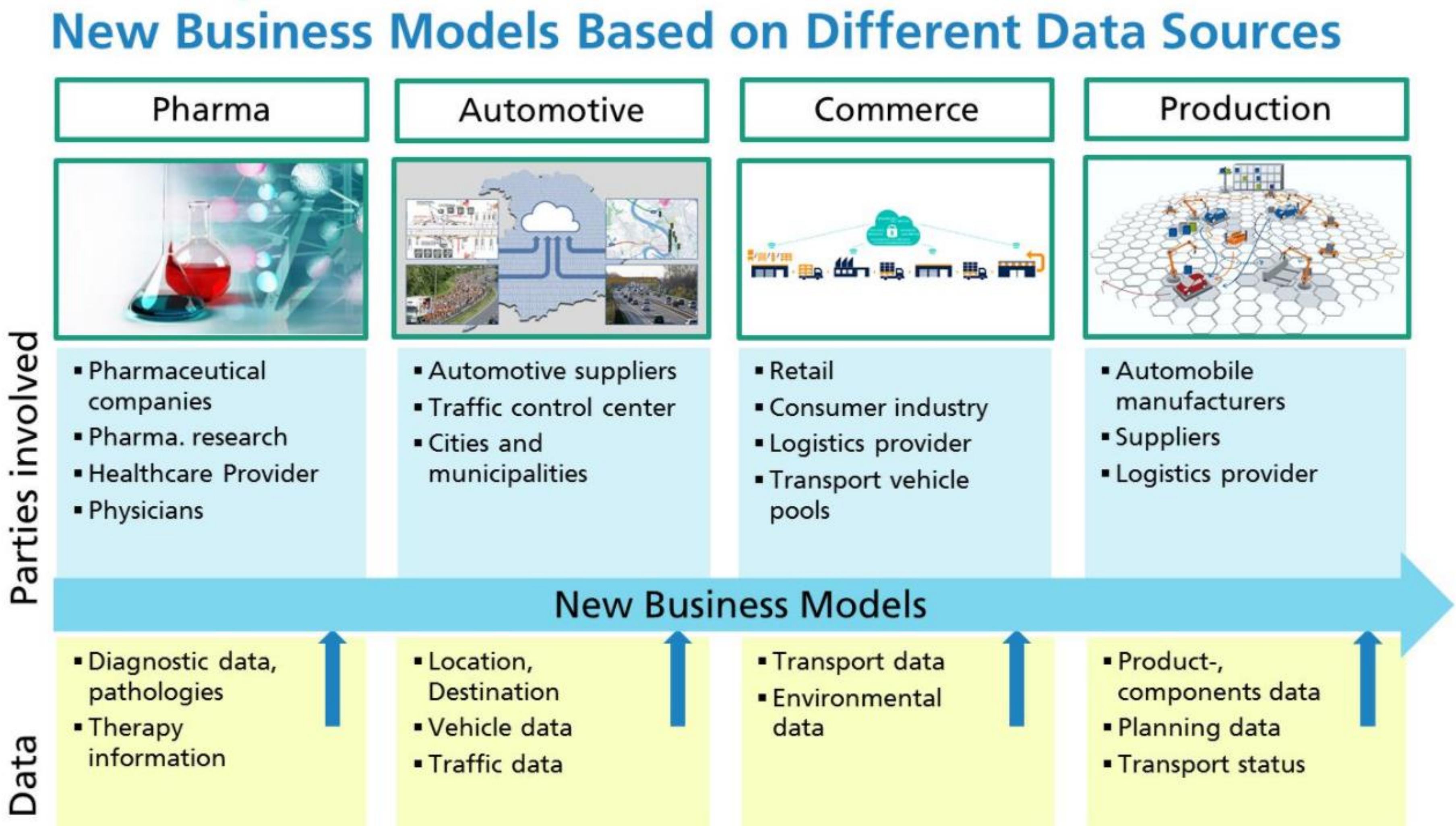
- Intelligent manufacturing concepts for small series
- Self-controlled manufacturing

organizational innovation

Asset

Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Economy 4.0



Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Human Integration

Developing Industrie 4.0 competencies

Challenges:
Utilization of Industrie 4.0 applications for competence development and real-life learning environments

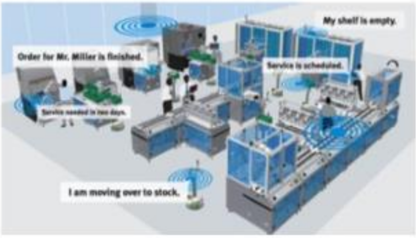
Requirements

- **Process understanding**, integration and **real-time synchronization** of **processes** throughout the product lifecycle
- **Transversal skills development** and training (IT, electronics, mechanics etc.)
- **Generic competences** about organization, communication and cooperation
- **High flexibility** and **decision-making** capability

Solutions for competence development: Fraunhofer »FUTURE WORK LAB«

Project work, simulations

Learning factories 4.0



Participation ramp-up

Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Intelligent IT-Assistence for everyday life

- Iris-Scan
  - replaces access card (ATM, hotel, appartment)
  - ergonomic adjustment (hotel, workplace, …)
- Interactive, collaborative Virtual Reality Conference
- Smart Energy Control
- Synchronization of private media library with external media systems





Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Fraunhofer: Hacker protection for Smart Homes

Challenges: A growing number of household functions can be controlled via internet and are therefore exposed to cyber attacks and hacking

Fraunhofer solution:
Software protection between internet and IT of the building

- »Firewall« blocks harming communication flow
- Useable for all kinds of building IT technologies
- No hardware exchange necessary

Source: Fraunhofer FKIE

Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

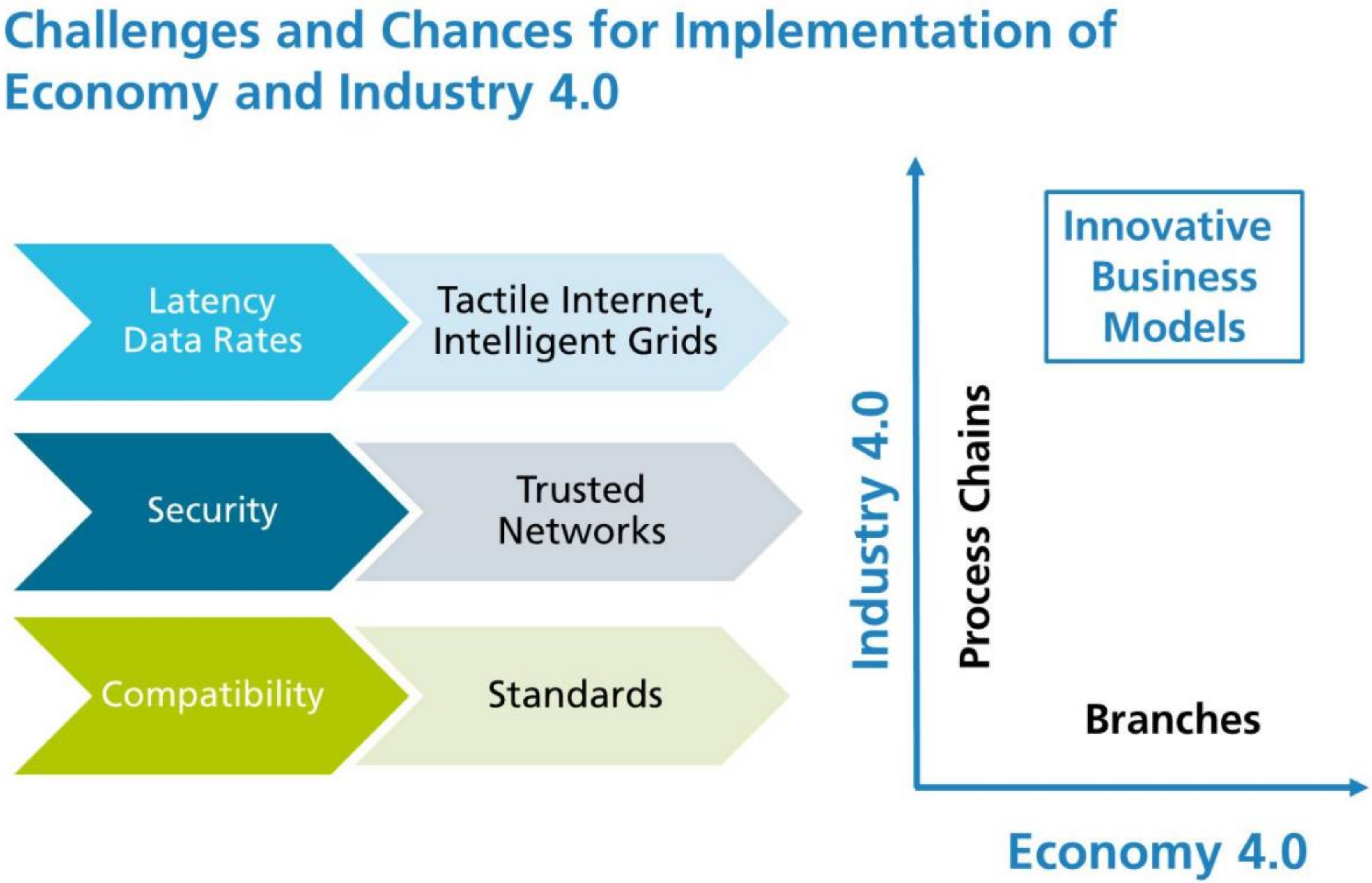
Human-Machine-Collaboration

- Safety
- Highly developed sensors/actors
- Intuitive communication
- Situational awareness
- Adaptability
- Learning ability

Care-O-Bot4 © Fraunhofer IPA

Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

Society 4.0 Outlook

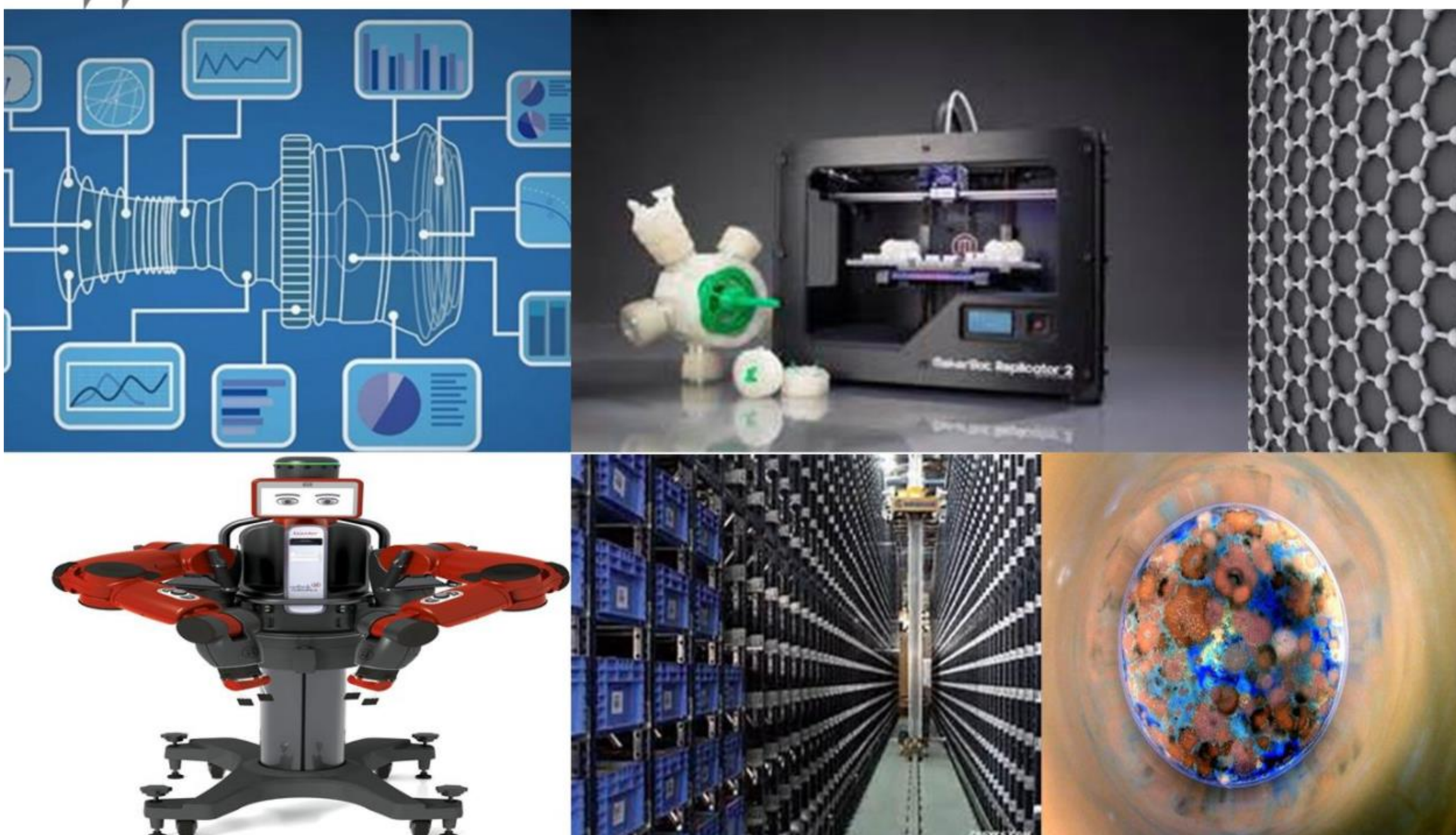


Source: Ralf Wehrspohn, Fraunhofer Institute, Praha, Den Technologické agentury ČR, 20. 10. 2016

OECD - NPR - New Production Revolution

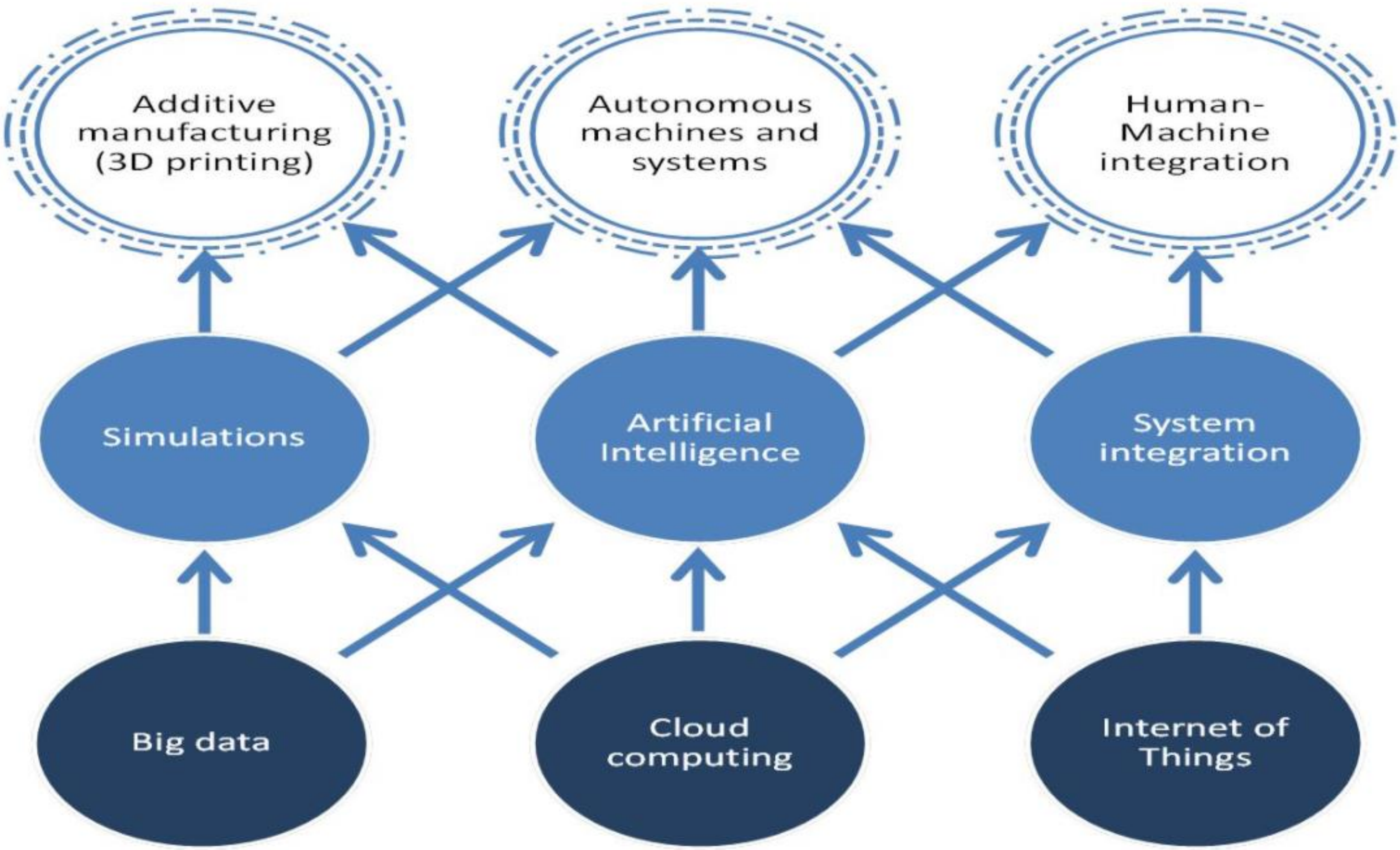
Andrew W. Wyckoff - Director for Science, Technology and Innovation at OECD

The NPR will be a confluence of new technologies…..



Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

….underpinned by digital technologies.



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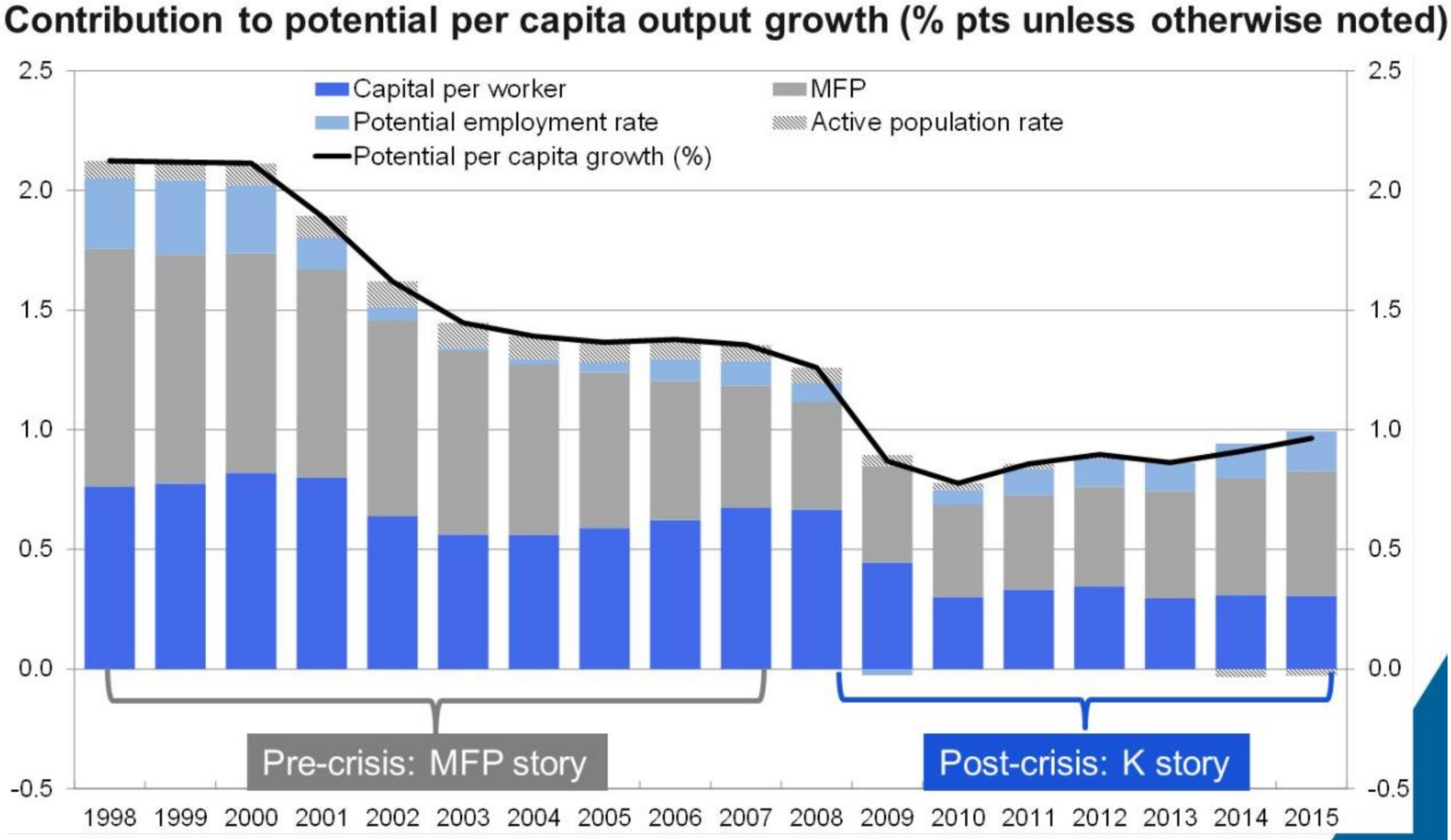
The possible productivity benefits of digital technologies are urgently needed.



Source: OECD Economic Outlook 2016, Volume 1.

Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

The possible productivity benefits of digital technologies are urgently needed.

-Output and productivity in US firms that adopt data-driven decision making are 5% to 6% higher than expected given those firms' other investments in ICTs

- (Brynjolfsson, Hitt and Kim, 2011).

-The Internet of Things reduces costs among industrial adopters by 18% on average.

- (Vodatafone, 2015).

-Autonomous mine haulage trucks could increase output by 15-20%, lower fuel consumption by 10-15% and reduce maintenance costs by 8%.

- (Citigroup-Oxford Martin School, 2015).

Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

Selected themes – digital technologies

Additive manufacturing (3D printing)

Autonomous machines and systems

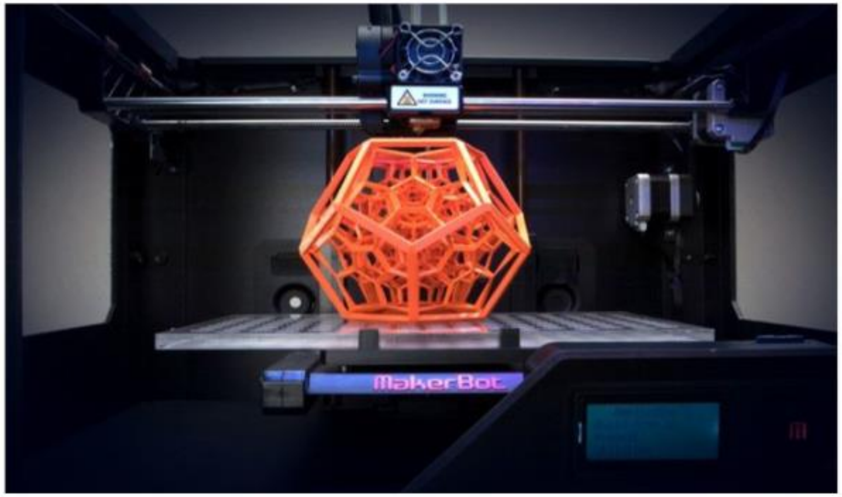
Human-Machine integration

Policy challenges include

- **Broadening access to critical ICT infrastructures.**
- **Reducing barriers to diffusion, increasing interoperability.**
- **Resolving issues of liability, transparency and ownership.**
- **Managing digital security and privacy.**

Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

Selected Themes - 3D printing



Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

3D printing

Could have positive environmental effects

E.g. It permits many materials to be shaped in ways previously possible only with plastics.

E.g. 3D-printed parts can also lower the environmental impacts of some products (3D-printed nozzles in jet engines lower fuel consumption).

But how widespread will 3D-printing be in manufacturing ?

Much machining work is now replaced by 3D-printing : Boeing has replaced hundreds of parts.

But machining is a small part of manufacturing (+/- 5% by value).

Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

Bio-based products are becoming widespread and familiar

Automotive
- Tyres
- Bioplastics, interior paneling
- Textiles
- biobased surfactants and lubricants

Consumer Goods
- Enzymes in Detergents
- Biobased Cosmetics
- Biological Dental Care

- Biobased Packaging
- Biobased Sweeteners
- Enzymes as Additives

Health, Medical Tech.
- Biological Coatings
- Implants
- Diagnostics

Building Industry
- Biological Insulating Materials
- Biobased Building Material
- Biobased Construction Chemicals

Nutrition
- Food Security
- Healthy Diets and Additives
- Biobased Flavourings

Medicine
- Biopharmaceuticals
- Antibiotics
- Tissue Replacement

Energy
- Biofuels
- Bioenergy

Source: Courtesy of BIOCOM AG, Germany

-Screening processes for manufacture and sale of synthetic DNA (avoid dubious customers);
-Public-private investments in bio-refineries;
-Improve regulation, e.g.
- -Boost the use of standards to reduce barriers to trade in bio-based products.
- -Improve waste regulation.

Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

Sound science and R&D policies are essential

…but many countries have reduced public spending on R&D…

Public R&D budgets 2008-2015 : G7,Korea and Czech Republic, Index 2008 = 100

Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

NPR may need changes to labour market policies

Complex aspects of the work of software engineers can be performed by algorithms (Hoos, 2012).

A version of IBM's *Watson* can act as a customer service agent (Rotman, 2013).

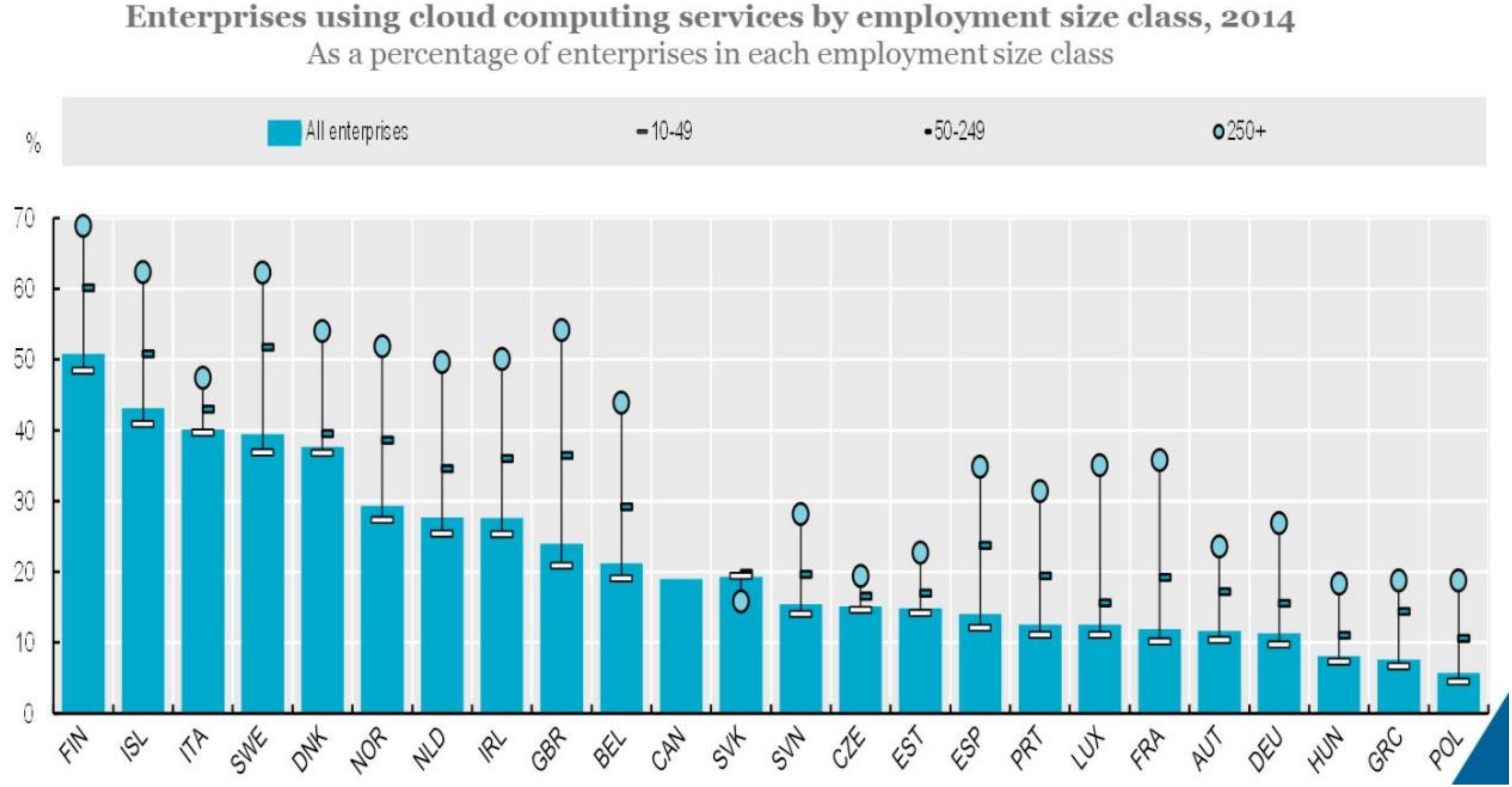
Computer-based managers are being trialled. These allocate work and schedules (Lorentz *et al*, 2015).

The *Quill* programme writes analytic reports and *Automated Insights* can draft text from spreadsheets.

Recent softwares interpret some human emotion better than humans (Khatchadourian, 2015).

Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

Well designed institutions needed for technology diffusion and adoption

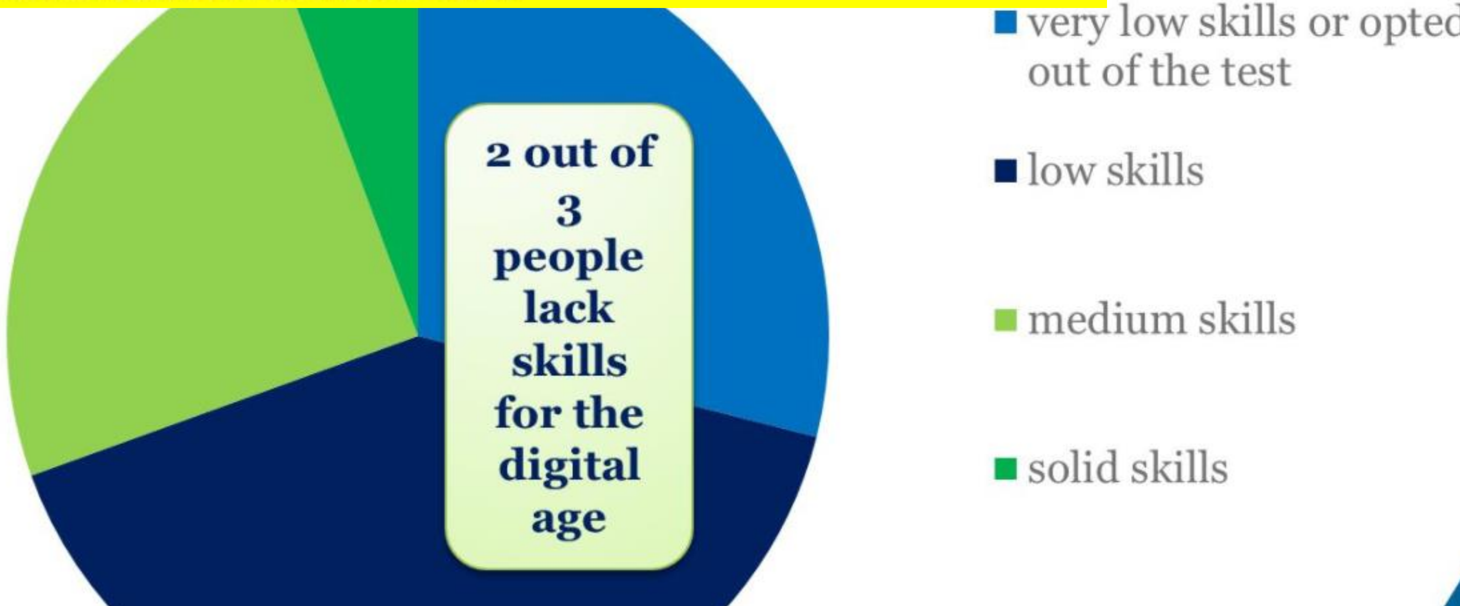


Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

Education and training systems needs constant attention

Two thirds of people surveyed lack the skills to succeed in technology-rich environments

-Increasing importance of inter-disciplinary education and research?



-But it is not only about balancing skills supply and demand.

-More interaction with industry as the knowledge content of production rises?

Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

Other cross-cutting issues

Policy also needs long-term thinking.

This has challenges, of course:

Robert Metcalfe, inventor of Ethernet, in 1995:

"I predict the Internet will soon go spectacularly supernova and in 1996 catastrophically collapse"

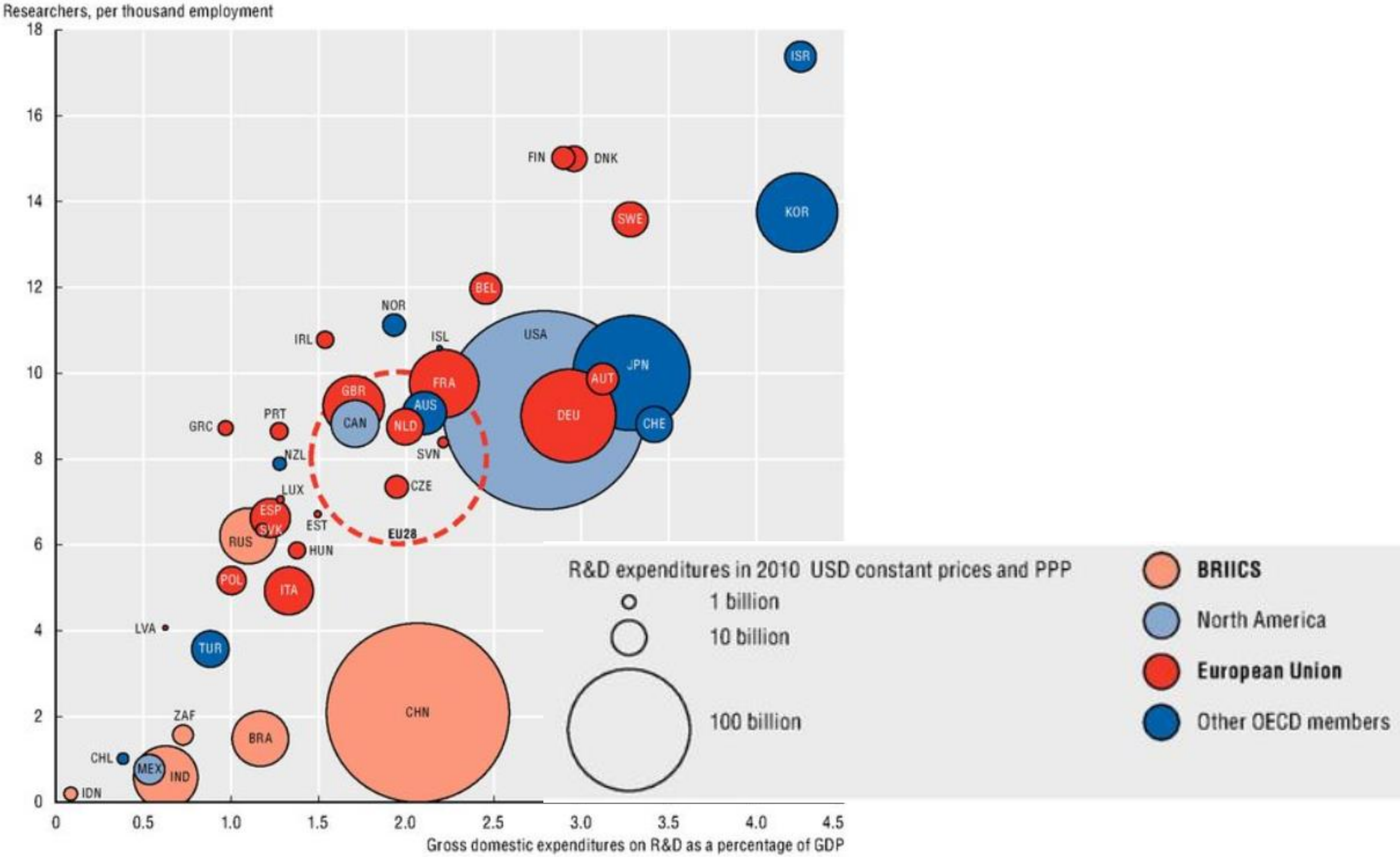
Public acceptance might also be important.

Public attitudes have shaped regulation of new technologies in the recent past

Source: Andrew W. Wyckoff, Director for Science, Technology and Innovation at OECD, Praha, Den Technologické agentury ČR, 20. 10. 2016

World R&D performance -

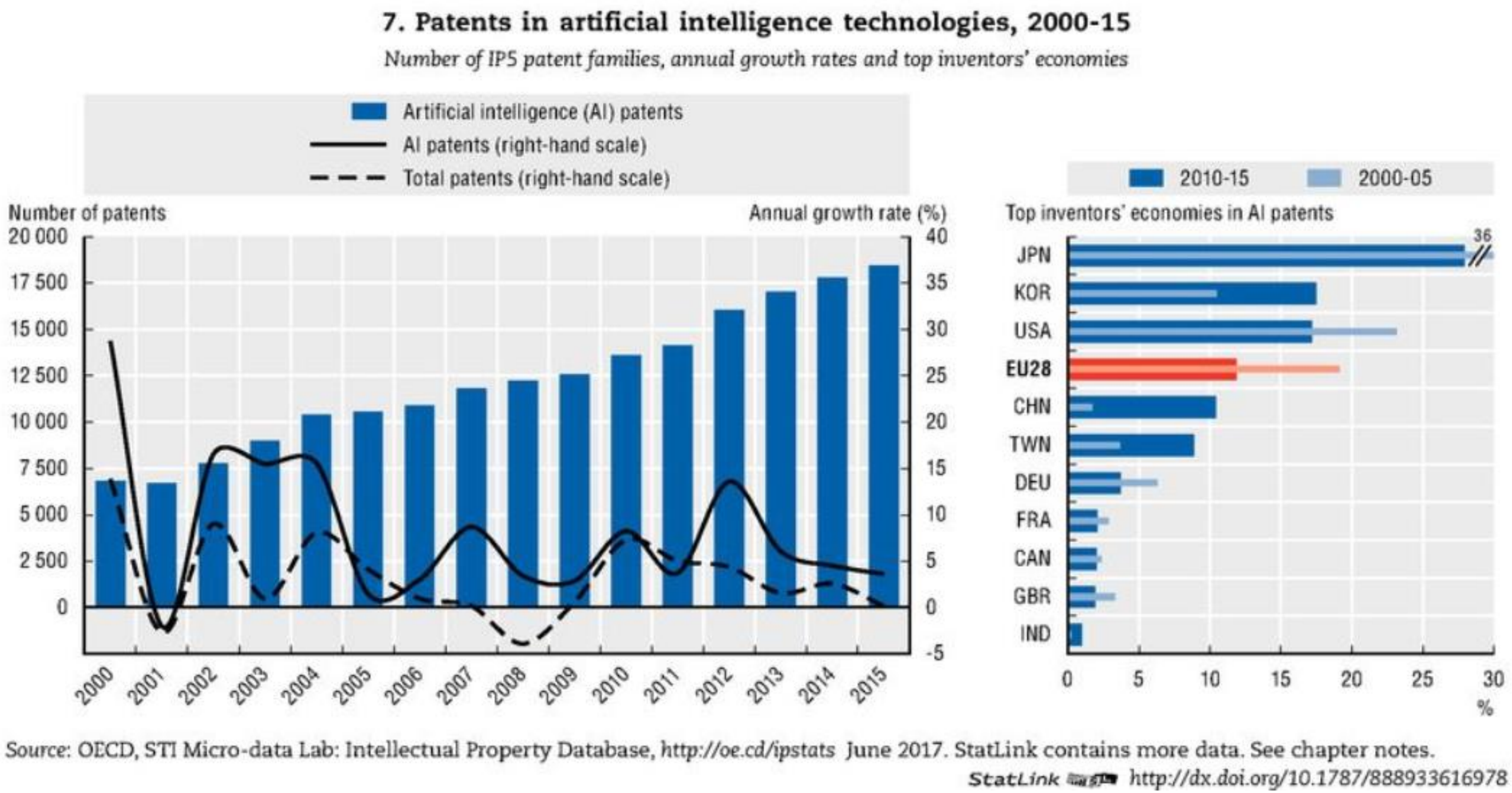
OECD Science, Technology and Industry Scoreboard 2017



Source: https://www.keepeek.com//Digital-Asset-Management/oecd/science-and-technology/oecd-science-technology-and-industry-scoreboard-2017_9789264268821-en#.Wq-pwOjOXb0#page23

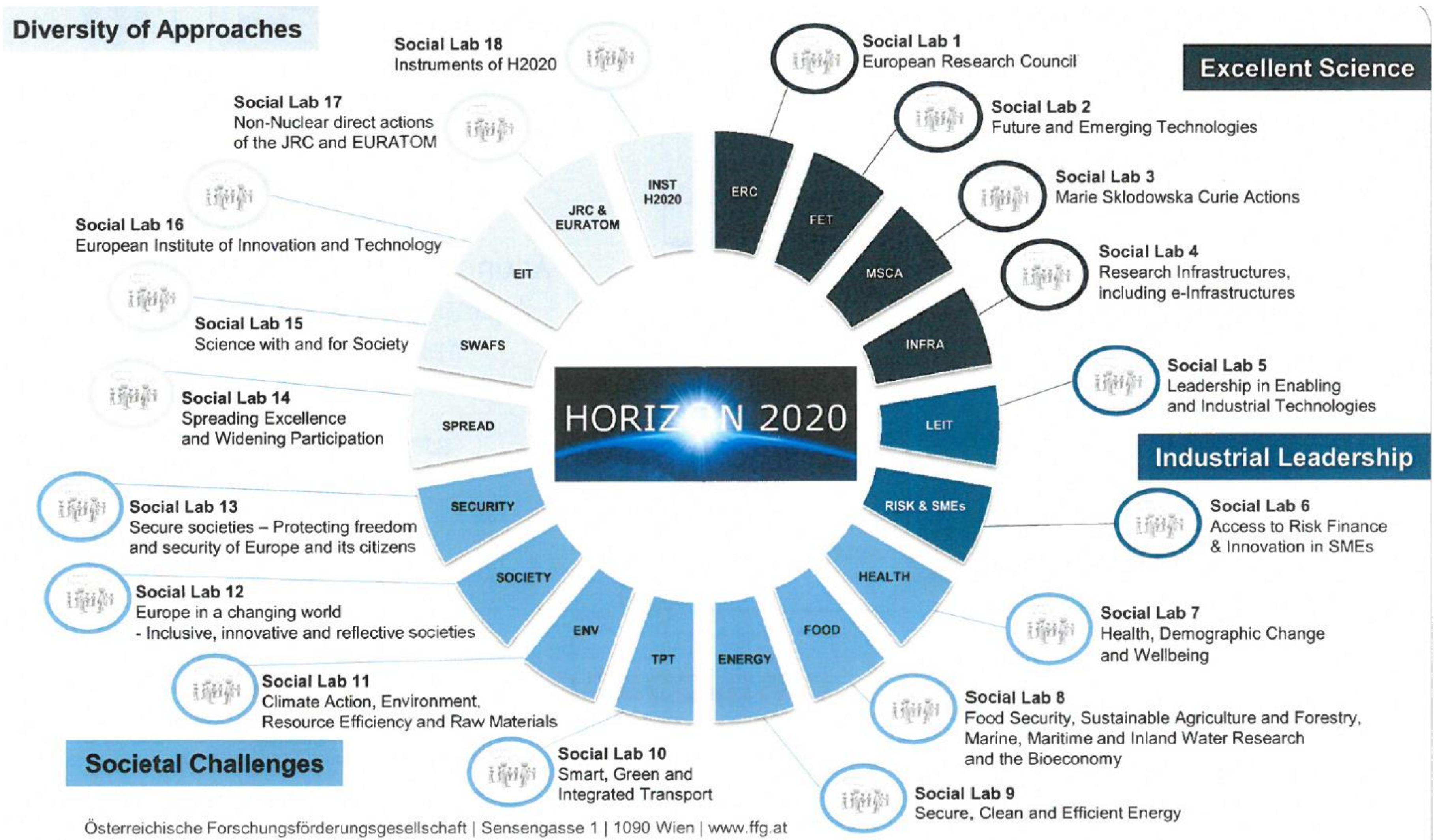
Artificial Intelligence –

OECD Science, Technology and Industry Scoreboard 2017



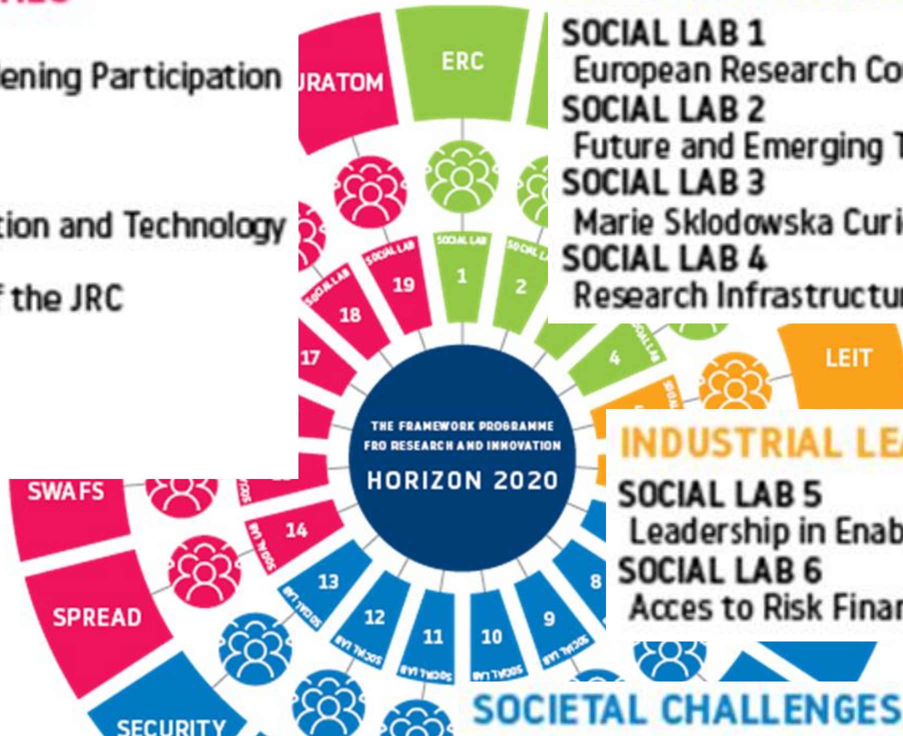
Source: https://www.keepeek.com//Digital-Asset-Management/oecd/science-and-technology/oecd-science-technology-and-industry-scoreboard-2017_9789264268821-en#.Wq-pwOjOXb0#page23

Horizon 2020 - Structure



NEW HORRIZON

Implementing 19 social Labs to analyse the FP



DIVERSITY OF APPROACHES

SOCIAL LAB 14
Spreading Excellence and Widening Participation
SOCIAL LAB 15
Science with and for Society
SOCIAL LAB 16
European Institute of Innovation and Technology
SOCIAL LAB 17
Non-Nuclear direct actions of the JRC
SOCIAL LAB 18
Instruments of H2020
SOCIAL LAB 19
EURATOM

EXCELLENT SCIENCE

SOCIAL LAB 1
European Research Council
SOCIAL LAB 2
Future and Emerging Technologies
SOCIAL LAB 3
Marie Sklodowska Curie Actions
SOCIAL LAB 4
Research Infrastructures, including e-Infrastructures

INDUSTRIAL LEADERSHIP

SOCIAL LAB 5
Leadership in Enabling Industrial Technologies
SOCIAL LAB 6
Acces to Risk Finance & Innovation in SMEs

SOCIAL LAB 11
Climate Action, Environment, Resource Efficiency and Raw Materials
SOCIAL LAB 12
Europe in a changing world - Inclusive, innovative and reflective societies
SOCIAL LAB 13
Secure societies – Protecting freedom and security of Europe and its citizens

SOCIETAL CHALLENGES

SOCIAL LAB 7
Health, Demographic Change and Wellbeing
SOCIAL LAB 8
Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and Bioeconomy
SOCIAL LAB 9
Secure, Clean and Efficient Energy
SOCIAL LAB 10
Smart, Green and Intergrated Transport

Responsible Research and Innovation

Why does the European Commission fund RRI?

The EC is convinced that the performance of the European innovation systems can be enhanced by a stronger integration of RRI.

What‘s the idea? How can performance be enhanced? - RRI can help to realize a higher efficiency and accuracy of public investment!

- RRI can generate **additional potential** to secure sustainable growth and prosperity
- RRI can help to reduce the number of **stranded innovations** and R&I investments
- There ist strong evidence that the purely technical solution of a socio-technical problem **aggravates the problem** it is designed to solve. - RRI can change that.

How does RRI intend to generate these potentials?

RRI aims at increasing the capacities to anticipate, include, reflect and respond to needs, expectations and values at project and system level.

Responsible Research and Innovation

Engagement: It implies that societal challenges should be framed on the basis of widely representative social, economic and ethical concerns and common principles on the strength of joint participation of all societal actors - researchers, industry, policymakers and civil society.

Gender Equality: Addresses the underrepresentation of women, indicating that human resources management must be modernized and that the gender dimension should be integrated in the research and innovation content.

Science Education: Faces the challenge to better equip future researchers and other societal actors with the necessary knowledge and tools to fully participate and take responsibility in the research and innovation process.

Open Access: States that RRI must be both transparent and accessible. Free online access should be given to the results of publicly funded research (publications and data).

Ethics: Requires that research and innovation respects fundamental rights and the highest ethical standards in order to ensure increased societal relevance and acceptability of research and innovation outcomes.

Governance: Addresses the responsibility of policymakers to prevent harmful or unethical developments in research and innovation. The latter is a fundamental basis for the development of the rest of the dimensions" (European Union 2012)

Responsible Research and Innovation

Excellence in science and innovation for Europe by adopting the concept of Responsible Research and Innovation

Key objectives of NewHoRRIzon

stronger integration of RRI

to work out the conceptual and operational basis for a stronger integration of RRI into…

- ... HORIZON 2020 and the upcoming framework programme FP9
- ... national R&I funding

coordinated understanding of RRI

to contribute to developing a Europe-wide coordinated understanding amongst representatives from business, research & education, public administration and civil society about…

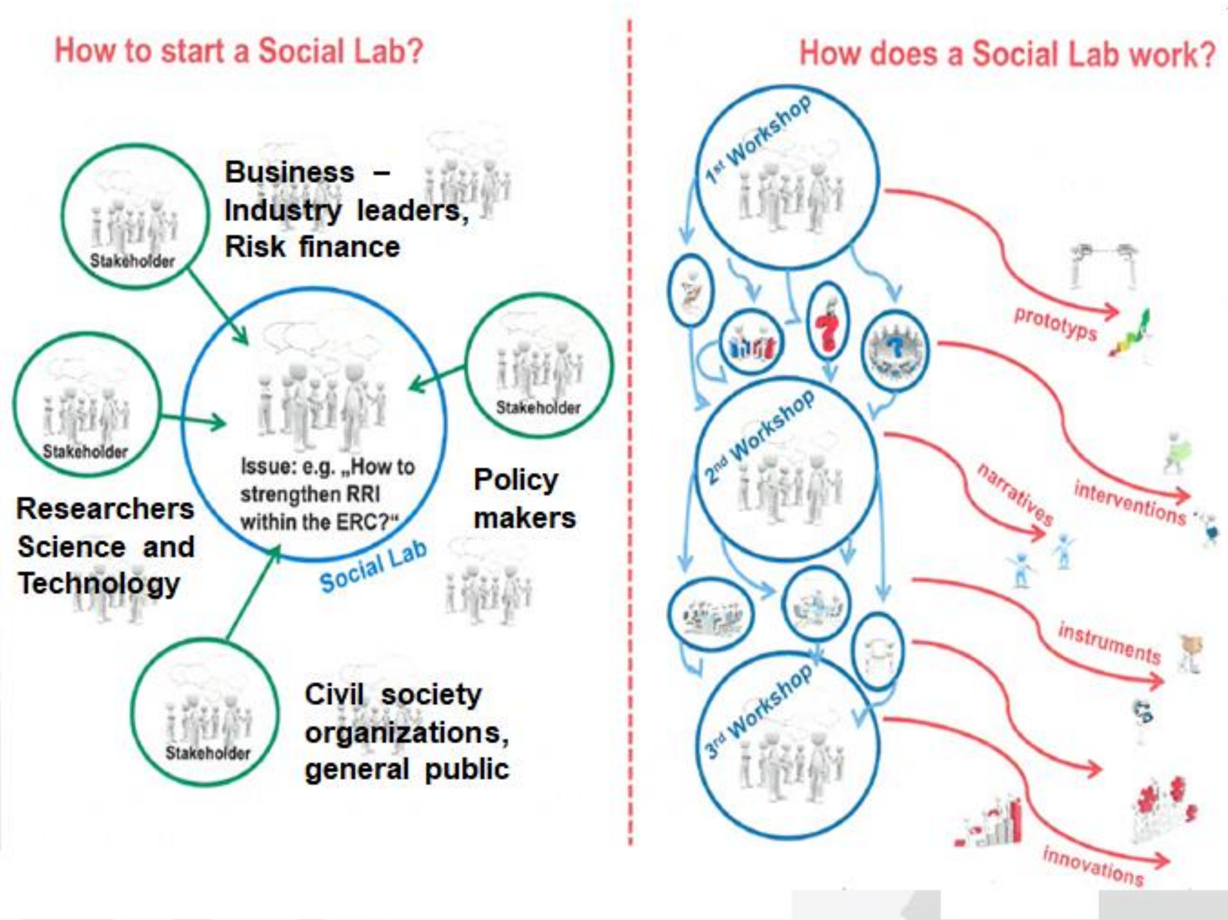
- … the concept of societal readiness of technology
- … the concept and practice of RRI
- … the socio-economic and socio-technical potential of RRI

Sociální Laboratoř

NEW HORRIZON

What's a Social Lab?

How to start it and how it works!



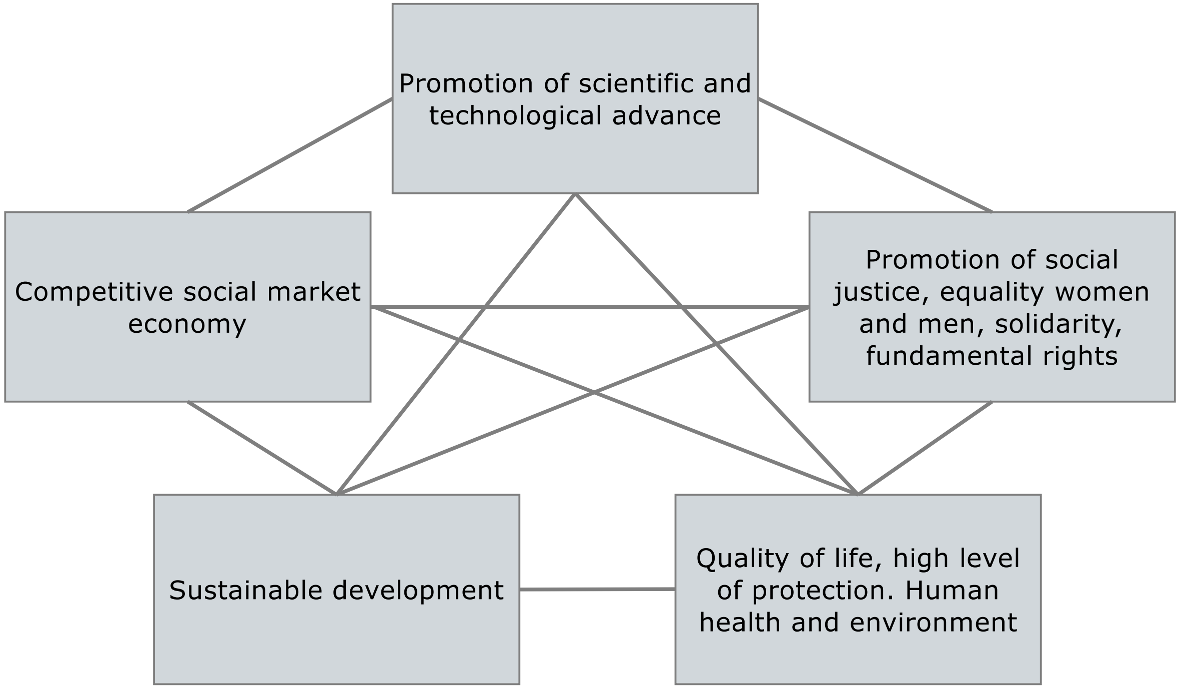
The Social Labs will involve a wide-ranging group of R&I stakeholders who will co-create tailor-made pilot actions to stimulate an increased use and acceptance of Responsible Research and Innovation (RRI) across H2020 and each of its parts.

Each Social Lab will involve 15 to 25 participants and will have a lifetime of 32 months (November 2017 to May 2020). There will be a total of three consecutive RRI stakeholder workshops in European capitals.

Monitoring the Evolution and Benefits of Responsible Research and Innovation - MoRRI

IMPACTS:

- Democratic: impact of RRI on the democratic and political system of society
- Societal: various forms of impact of RRI on society in a broader sense
- Economic
- Science and Research: on the science and research system itself



Source: Erich Griessler and the MoRRI Consortium - Impacts of Responsible Research and Innovation – Findings form Case Study Program,

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Public Engagement

Democratic	**Societal**	Scientific	**Economic**
Involvement and participation contributes to citizen empowerment and more qualified decision-making (Smith, 2005; CS01, CS02, CS03, CS11, CS13). Including citizen knowledge into policy-making strengthens the democratic system (CS01, CS02, CS13; Newton and Geissel, 2012). However, unreflective public engagement (…) can close down vital debates in contentious areas (Stilgoe et al., 2014, p. 11).	**Public gains knowledge and competences, which again can lead to higher awareness and more openness towards certain topics (CS01, CS02, CS11, CS13, CS14).** **Debate/communication between actor groups leads to new actor coalitions, new networks and increased trust building – especially between powerful and marginalised groups (CS01, CS02, CS11, CS13, CS14).**	Addressing societal needs and RRI aspects leads to new and different research questions and outcomes (CS11, CS13). Participatory methods help to access previously unavailable data (e.g. Citizen Science) (CS02, CS13). Public engagement methods help researchers to acquire new skills (CS13). Improves higher education curricula (CS11, CS13). Inclusion of public into science and agenda setting (CS02, CS11, CS13). Public engagement increases sciences' direct and indirect contribution to and exchange with society (Vargiu, 2014; CS13).	**Stakeholder involvement leads to cost-effective new outcomes and procedures (CS01, CS11, CS13, CS14).** **Public engagement mobilises additional research funding (CS02, CS11).** **Collective data collection and data usage generate cost savings (CS02, CS11).** **Knowledge can be generated about previously inaccessible areas (CS11).**

Source: Erich Griessler and the MoRRI Consortium - Impacts of Responsible Research and Innovation – Findings form Case Study Program,

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Gender Equality

Democratic	**Societal**	Scientific	**Economic**
Including gender sensitive research could contribute to better policy making, but can be curtailed by lack of funding (CS19).	**To increase the share of female researchers and female researchers in leading positions in R&I is an intrinsic societal benefit (CS04, CS06, CS17, CS18).** **Society benefits from better targeted and diverse research and products for all of the population which has positive effects on different fields of society, e.g. in health (EC, 2013; CS17, CS19).**	Addressing gender aspects in research leads to new and different research questions and outcomes (CS19). Diverse and inclusive scientific workforce is a benefit itself (Gilmer et al., 2014; CS04, CS06, CS17, CS18). Inclusion and diversity of researchers, teams, organisations, topics, and analysis lead to higher research quality and excellence (EC, 2013; Lipinsky, 2014; CS06, CS17, CS19). New gender-aware curricula are developed (CS19).	**Involving different perspectives increases the quality of R&I and therefore improves products and company performance (EC, 2013; Catalyst, 2014; CS03, CS15, CS17, CS19).** **Products (e.g. medicinal products) that match better with every part of society save costs and create new markets (CS17, CS19).** **Includes untapped human resources and creates a more diverse workforce (Gilmer et al., 2014; CS06).**

Source: Erich Griessler and the MoRRI Consortium - Impacts of Responsible Research and Innovation – Findings form Case Study Program,

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Science Literacy & Scientific Education

Democratic	**Societal**	Scientific	**Economic**
Scientifically literate policy makers can make better-informed decisions and are able to assess risks and benefits of research and innovation (CS10, CS13).	**Measures, promoting science literacy (information, training and participation) help society to better understand and participate in science (Miller, 1983; CS04, CS10, CS13).** **Both low and high ability students benefited from teaching, which contributes to an equal society in terms of chances for education (CS04).**	Science literacy and science education raise awareness for societal impact of science and technology (Miller, 1983). Better information improves the image of science in society and makes public debates on science more informed (CS10). Science literacy and science education increases the numbers of competent students and researchers qualified to conduct science (CS04)	**Science literacy and science education increase the number of a highly competent labour force (CS04).**

Source: Erich Griessler and the MoRRI Consortium - Impacts of Responsible Research and Innovation – Findings form Case Study Program,

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Ethics and Governance

Democratic	**Societal**	Scientific	**Economic**
Existing democratic institutions are strengthened or new ones are established (CS01). Instalment of new and transparent institutional practices contribute to trustworthy science as one basis for policy making (CS05).	**Trust-building and facilitation of communication between different actor groups (scientists, policy makers, stakeholders) through ethics activities (CS01).** **Safer and more sustainable research and development that reduces negative externalities, e.g. by reducing negative effects on society and negative impacts on the environment (CS15, CS16).**	Reputational gain and increase in trust in science and research (CS05, CS08, CS10). Increased funding chances because of improved reputation of scientific institutions and new funding opportunities (CS07, CS08). Change in scientific culture and new institutional processes (RIO; REC; CS07, CS08). Early-career researchers benefit from more open and transparent scientific culture (CS09).	**Litigation costs are saved because research misconduct is prevented and conflicts mediated early (CS08).** **Economic success also depends on fulfilling clients' demands related to RRI. Compliance avoids potential business losses (CS15).** **RRI and ethics is perceived as inherent to the business purpose (e.g. products which use less energy and are sustainable)and has not to be justified by numbers (CS16)** **Addressing RRI issues and forming for that purpose new and broader networks can result in new clients/contracts (CS14).** **Development of new business cases and ideas (CS14).** **Saved costs because of risk assessments or sustainability assessment (CS14, CS15, CS16).**

Source: Erich Griessler and the MoRRI Consortium - Impacts of Responsible Research and Innovation – Findings form Case Study Program,

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Open Access

Democratic	**Societal**	Scientific	**Economic**
Not mentioned in the sample: It can be assumed that OA increases availability for data for policy debate and decision making.	**Not mentioned in the sample: Societal benefit of OA "a general media advantage with OA (…) which can be used as a proxy or pathway to indicated greater societal impact (Tennant et al. 2016: 11).**	Sharing results, data, and knowledge can advance research and innovation (Costas, 2013; Dallmeier-Tiessen et al., 2011; Davies, 2013). Higher visibility and recognition of scientists as authors and new publication opportunities (Dallmeier-Tiessen et al., 2011; CS20). New patents (CS20). Open Access to data and knowledge benefits early-career researchers and young scientists (CS09).	**Sharing results, data, and knowledge can stimulate innovation and increase transparency (Dallmeier-Tiessen et al., 2011; Costas, 2013; Davies, 2013; CS20).** **New patents (C20).** **New funding opportunities (CS16).** **Time savings from use of existing open data (greater efficiency) (CS20).**

Source: Erich Griessler and the MoRRI Consortium - Impacts of Responsible Research and Innovation – Findings form Case Study Program,

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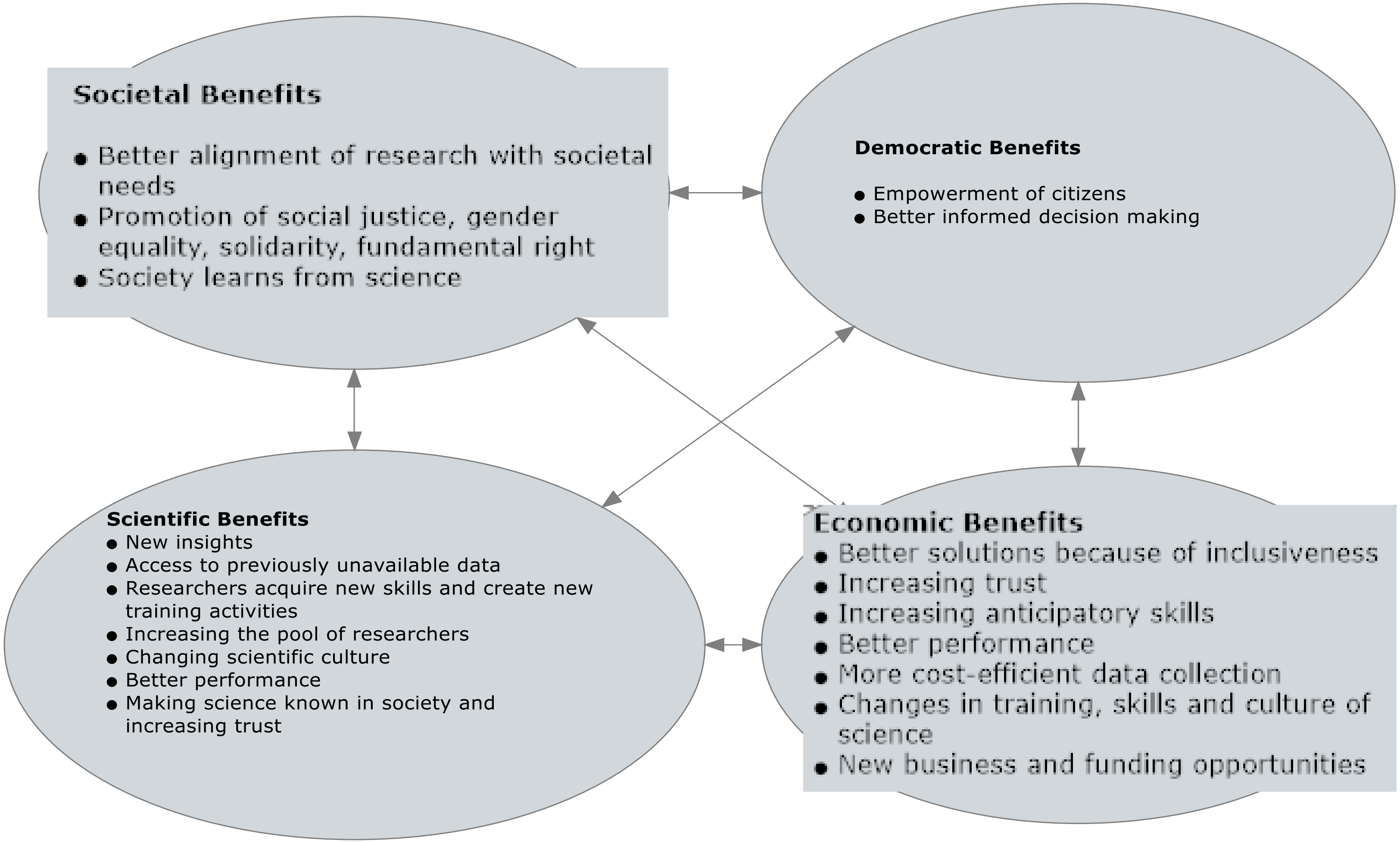


Source: Erich Griessler and the MoRRI Consortium - Impacts of Responsible Research and Innovation – Findings form Case Study Program,

Responsible Research and Innovation – according EC

-**EC ambition in science technology and innovation policy practices**

-**addressing societal challenges**

-**generating smart, inclusive and sustainable economic growth for Europe**

-**Societal objectives and values,** associated with

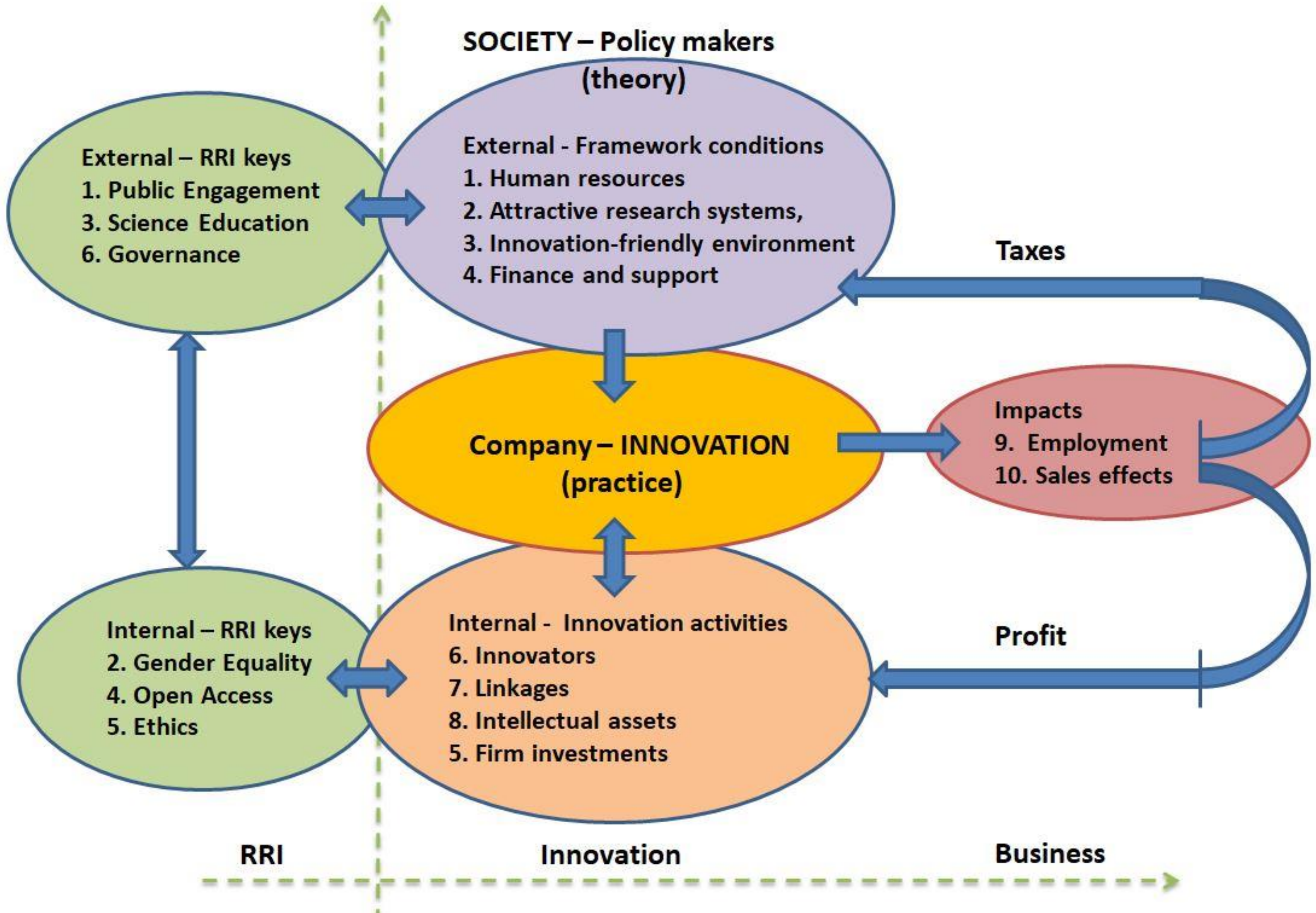
-high potential of **societal benefit but also**

-**risk, conflict and societal transformation**

Emerging STI policy paradigm increasingly seeks to **complement traditional goals of economic competitiveness and innovation capacity with** an ambition of addressing the so-called "**Grand Challenges**" such as health, sustainability and well-being.

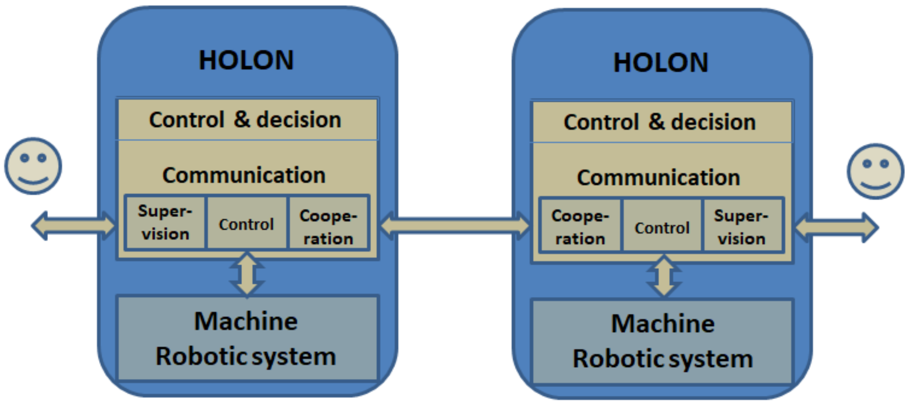
All societal actors - researchers, citizens, policy makers, business, civil society organizations - must work together during the whole R&I process aligning the R&I outcomes to the values, needs and expectations of European society.

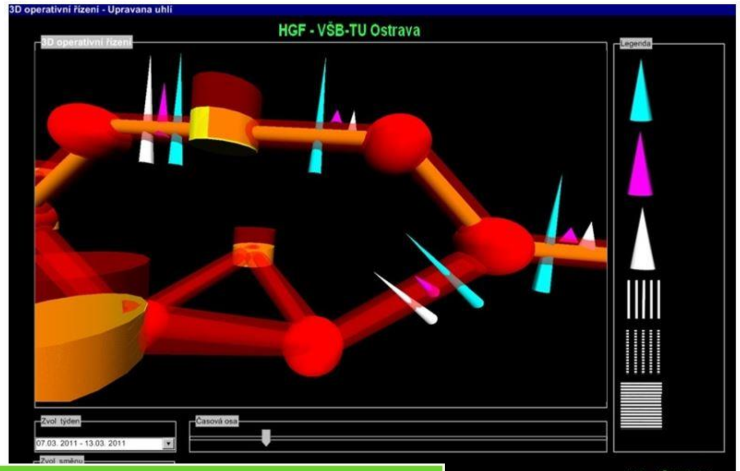
The landscape of RRI and Innovation

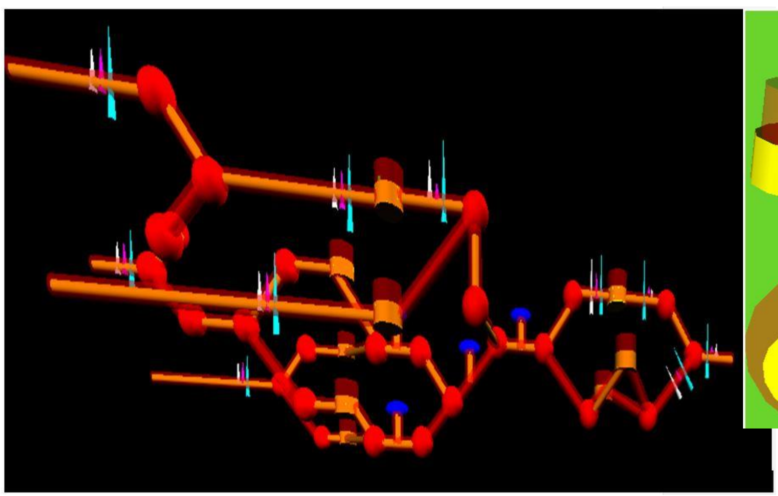


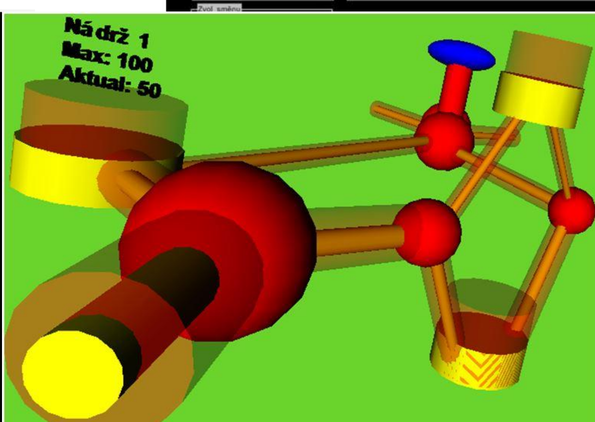
Holons in IoT

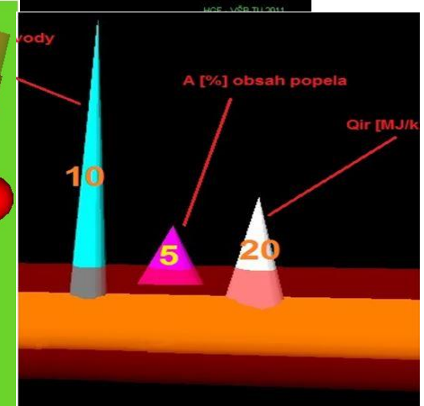
- CPS – cybernetics physical systems, digital twins
- Communication of holons, agents straight connected to machinery – goal orientation





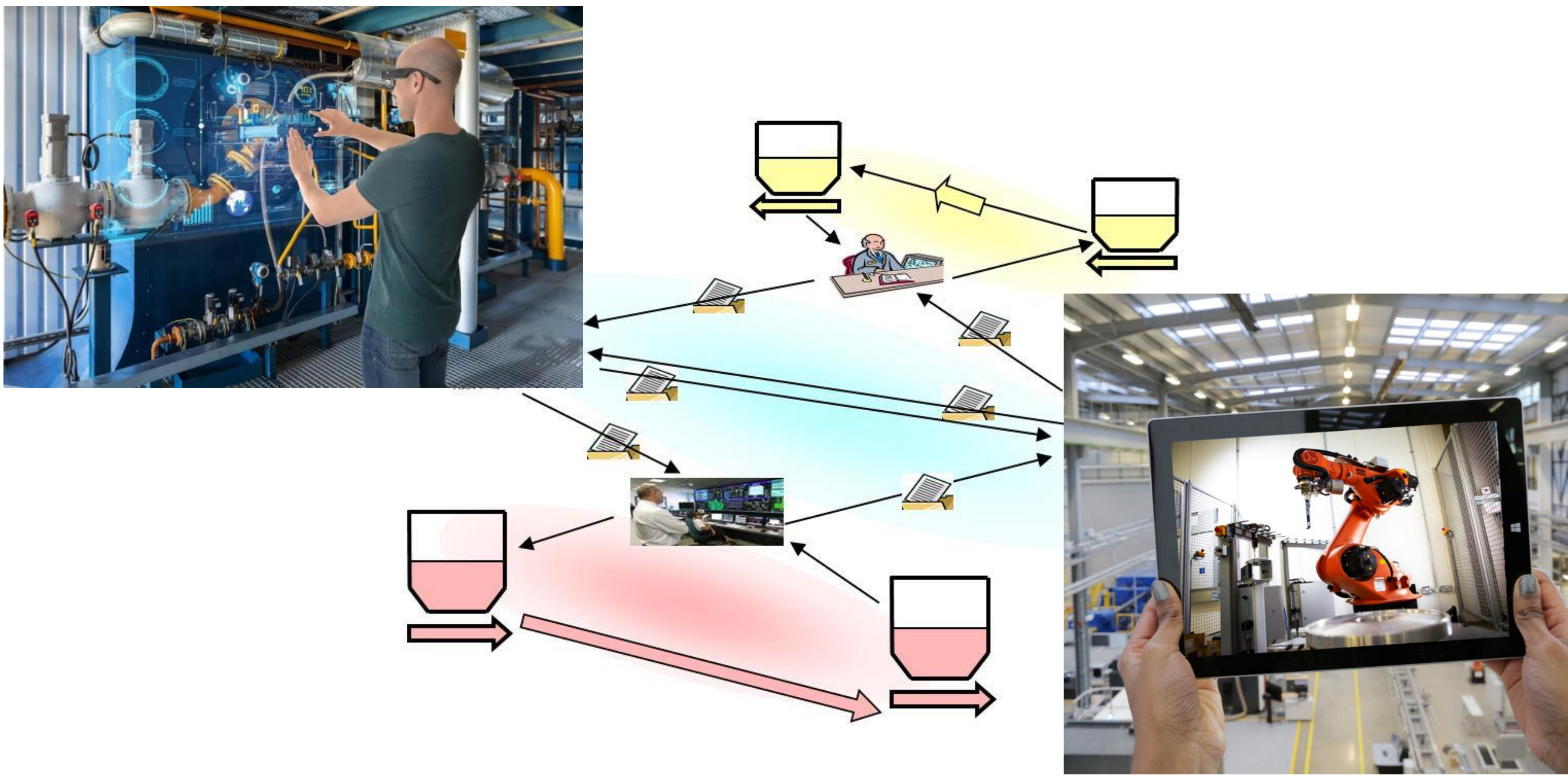






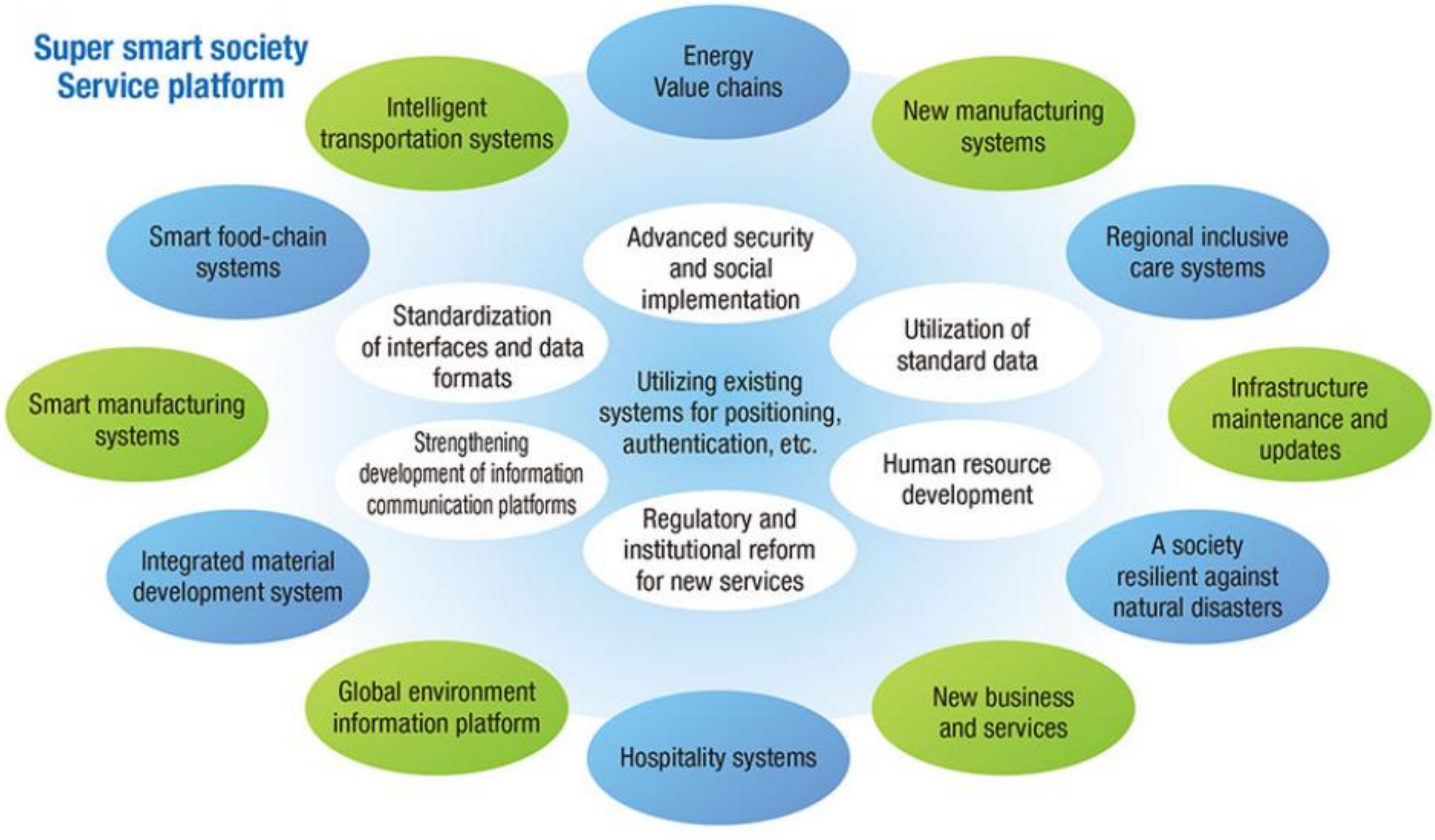
Virtual and Augmented reality

- CPS – visual models of digital twins
- Communication of agents - straight connected multilevel agents systems – vizualisation



New societal challenges – **Japan** production revolution – **Society 5.0**

Strongly promoted by Council for Science, Technology and Innovation; Cabinet Office, Government of Japan



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