Agribots – robotické systémy a Zemědělství 4.0

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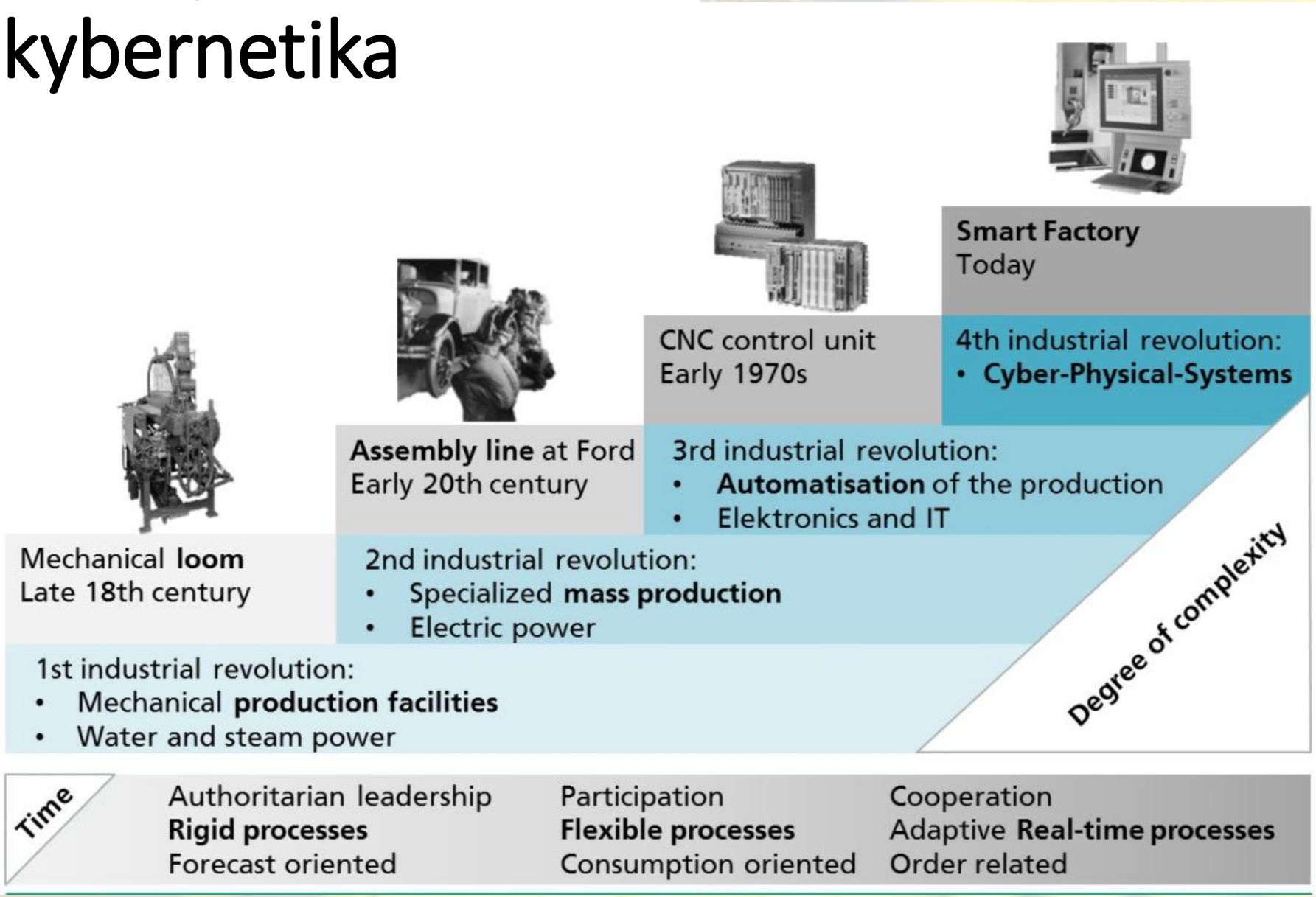
Agronomická fakulta

Ústav zemědělské, potravinářské a environmentální techniky

Od Průmyslu 4.0 k Zemědělství 4.0

- **Plán pro Průmysl 4.0**
- **Pohled do světa**
- **Podpora v navigaci – GSA**
- **Kolaborativní robotika**
- **Decentralizace zdrojů**
- **Zemědělství 4.0 – Swarms of Agribots?**

Průmyslové revoluce a kybernetika

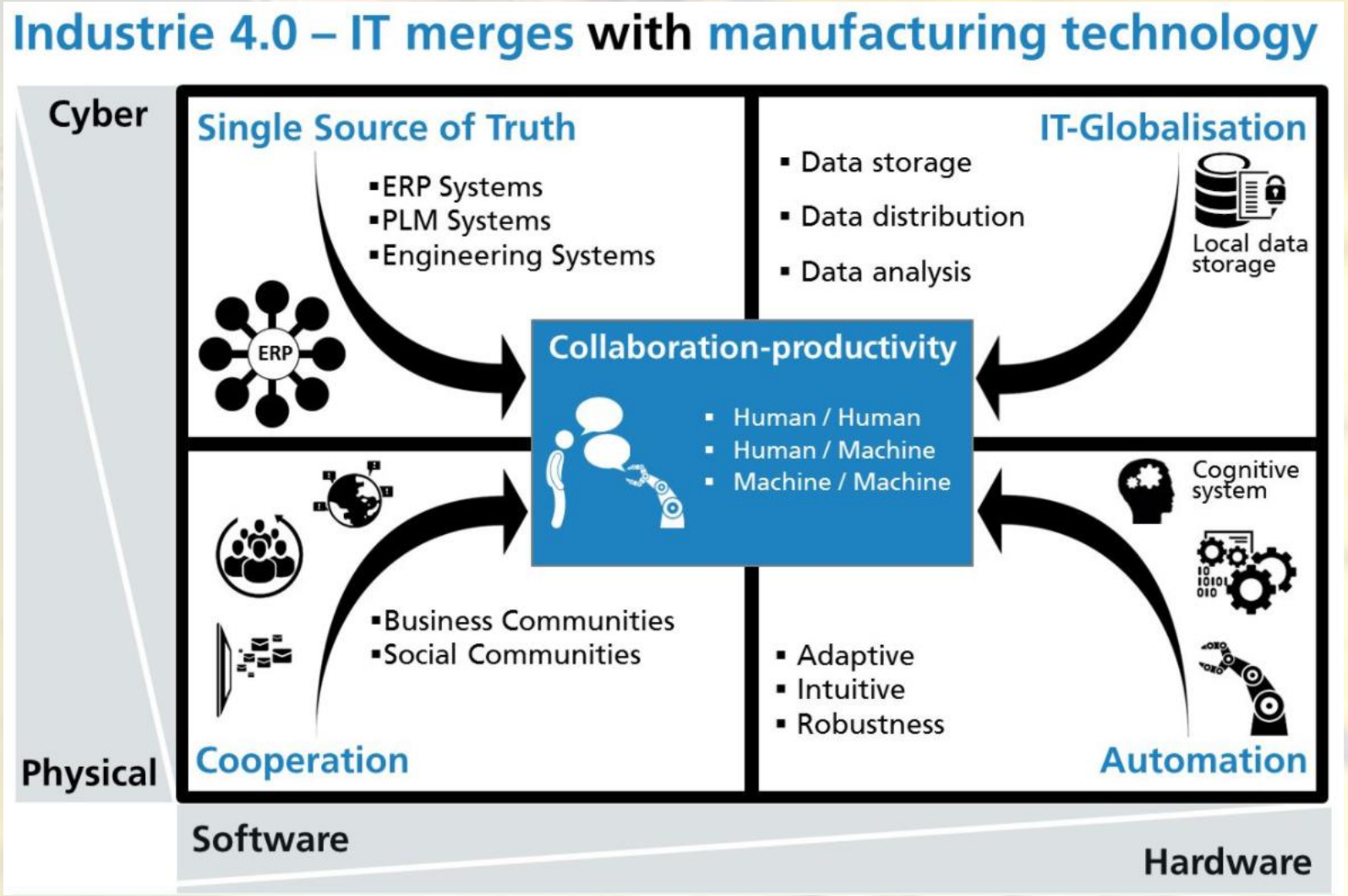


Source: Ralf Wehrspohn, Fraunhofer Institute

Úroveň ZV

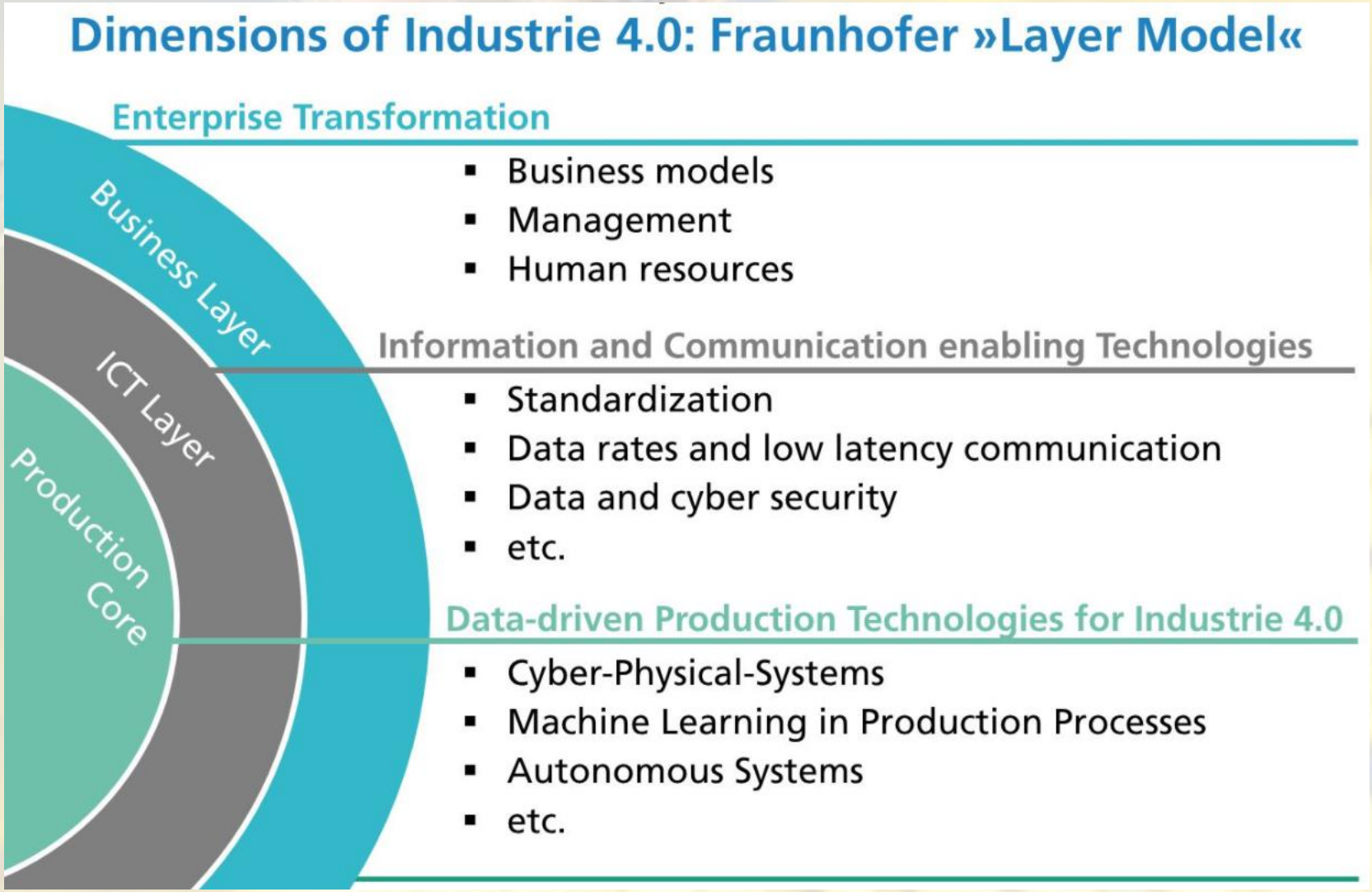
- **Sociální ZV**
- **Symbolická ZV**
- **Programová ZV**
- **Operační ZV**
- **Stabilizace**

4. Průmyslová revoluce



Source: Ralf Wehrspohn, Fraunhofer Institute

Fraunhofer - „Layer Model“



Source: Ralf Wehrspohn, Fraunhofer Institute

Potenciál a výzvy nových technologií

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

Potenciál a výzvy nových technologií

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

Požadavky na výrobu řízenou daty

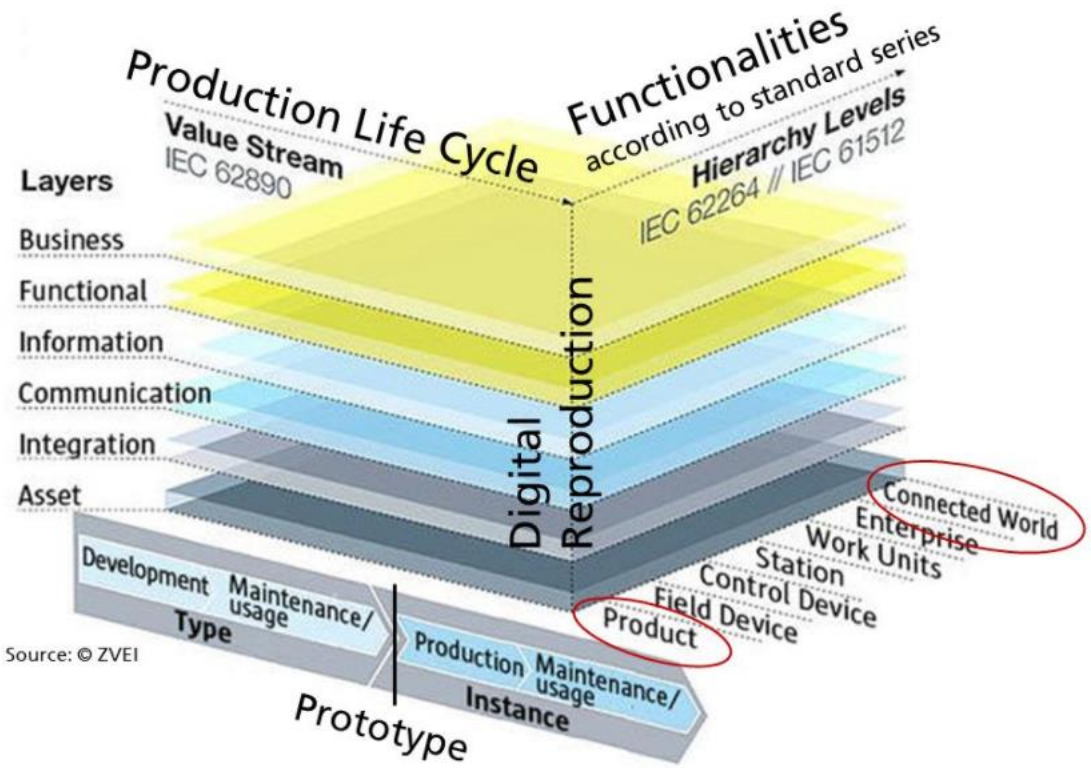
Requirement: Standardization

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:

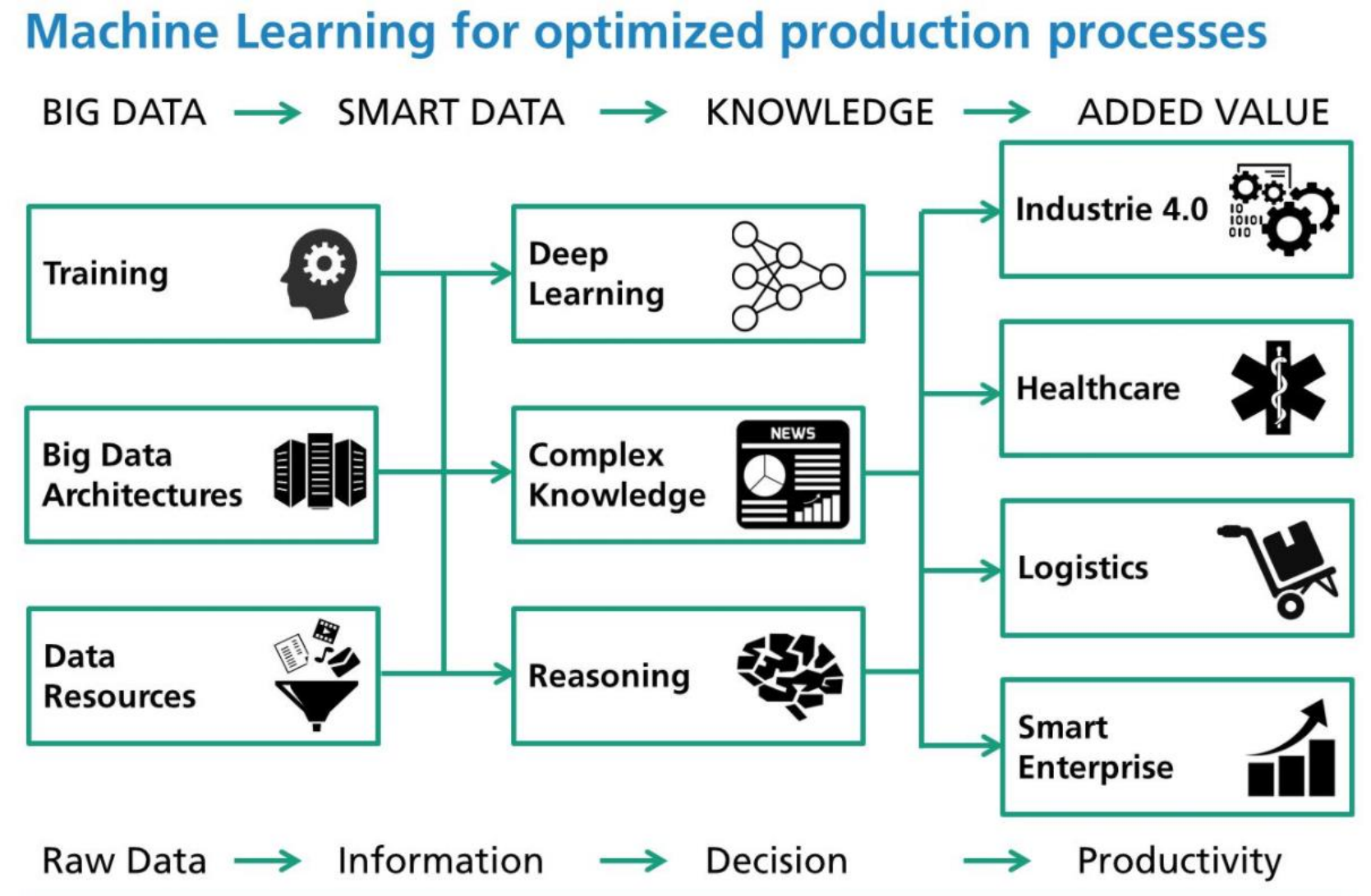
- **Identification** (location of participants)
- **Semantics** (communication)
- **Quality of service** (low latency, reliability)



→ compatibility and interoperability

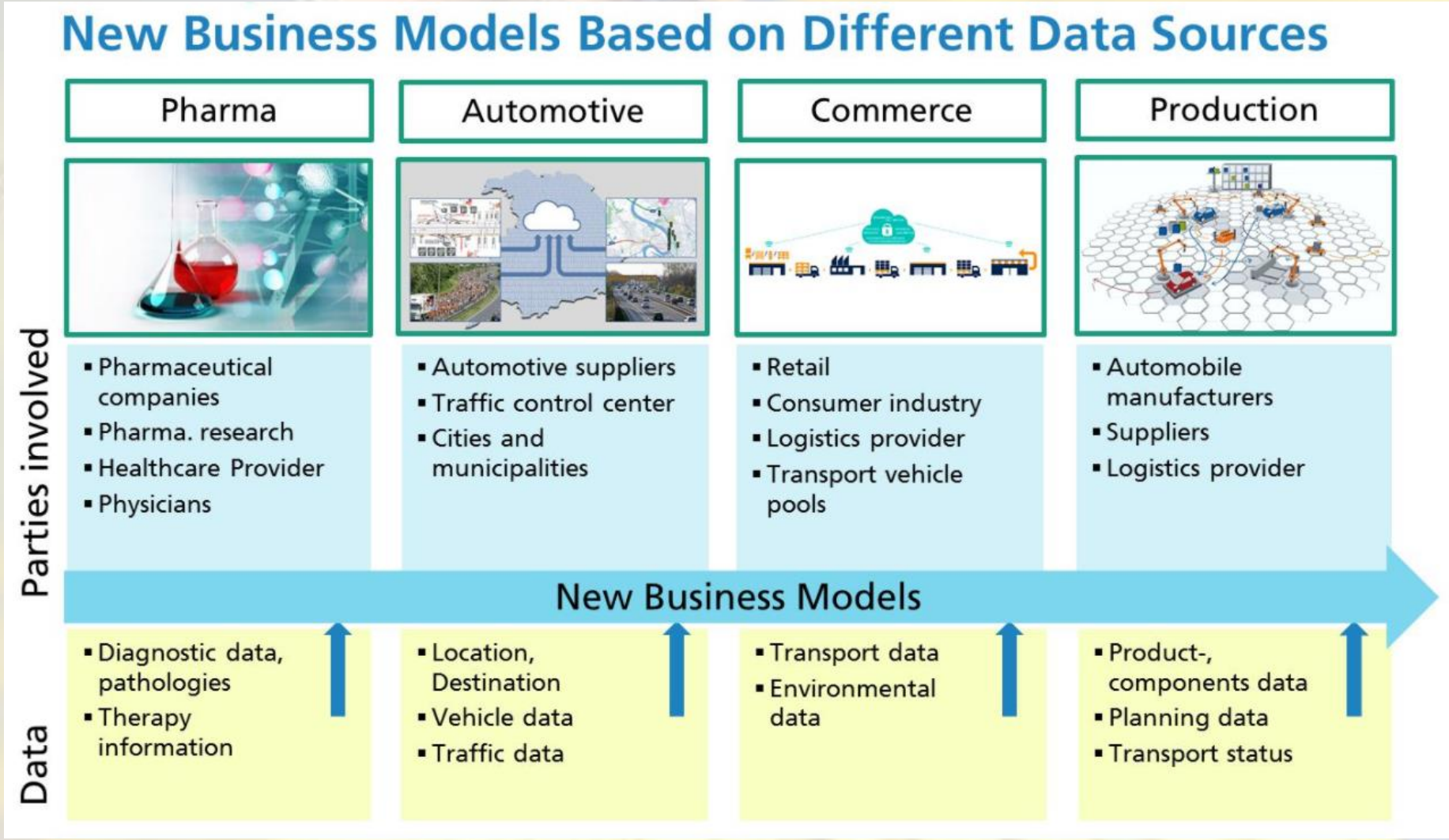
Source: Ralf Wehrspohn, Fraunhofer Institute

Potenciál strojového učení



Source: Ralf Wehrspohn, Fraunhofer Institute

Ekonomika 4.0



Source: Ralf Wehrspohn, Fraunhofer Institute

Integrace lidí a strojů

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«

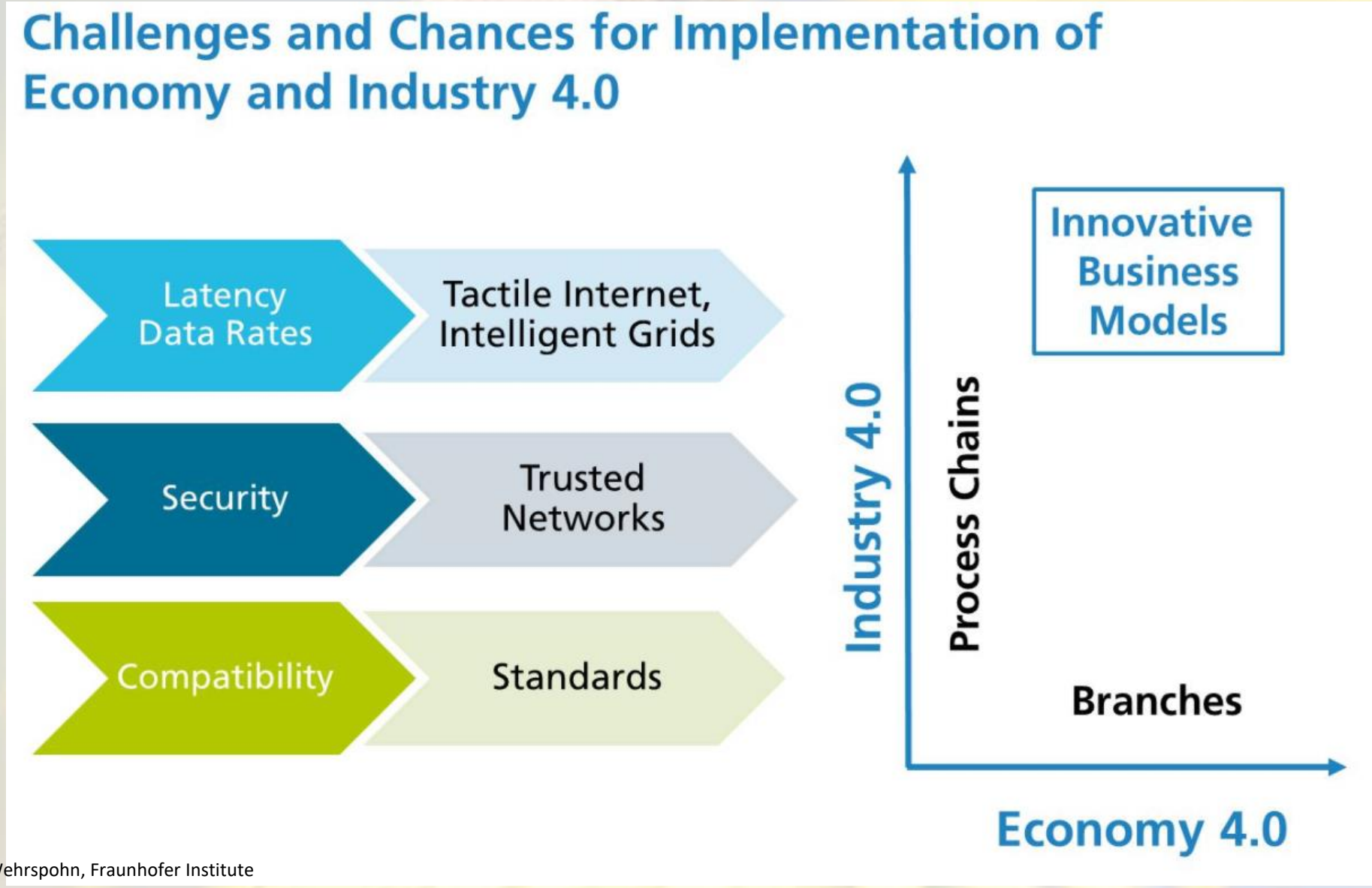
Project work, simulations

Learning factories 4.0

Participation ramp-up

Source: Ralf Wehrspohn, Fraunhofer Institute

Společnost 4.0 - budoucnost

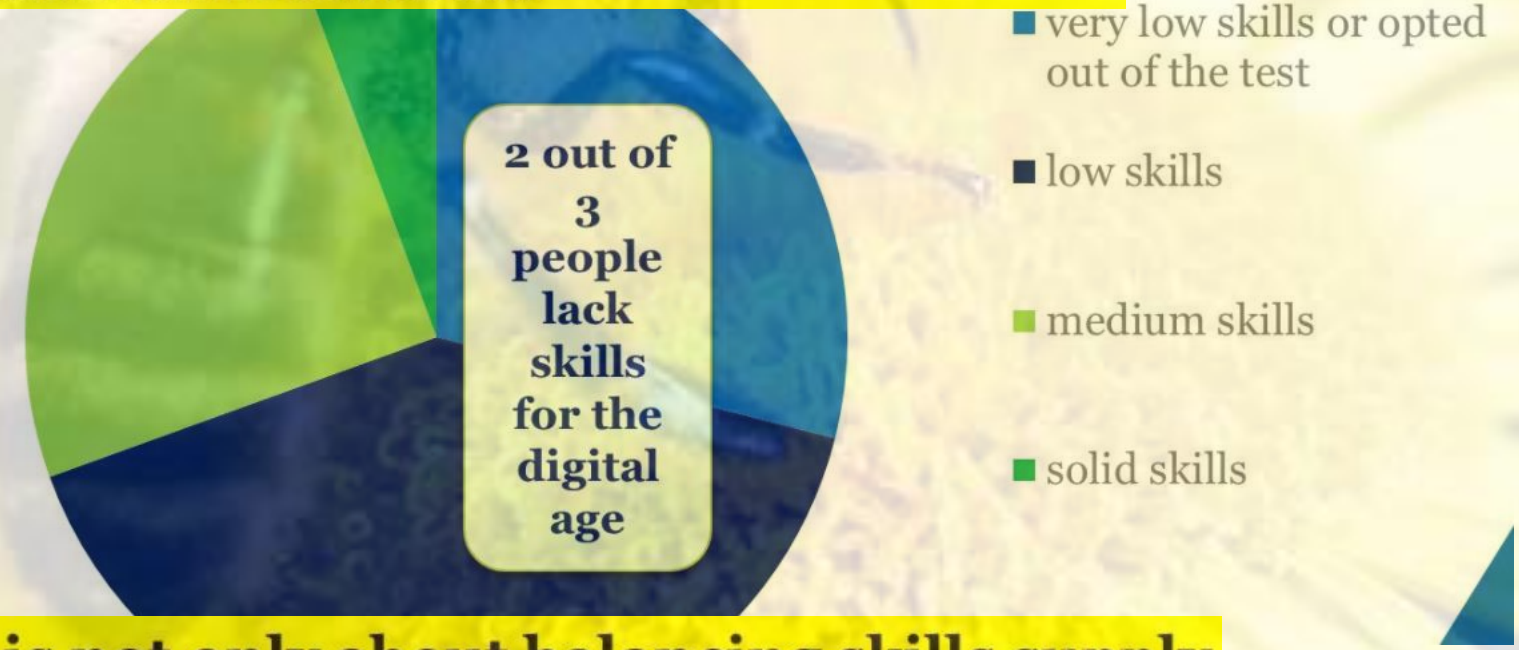


Source: Ralf Wehrspohn, Fraunhofer Institute

Nutnost celoživotního vzdělávání lidí

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

-Increasing importance of inter-disciplinary education and research?



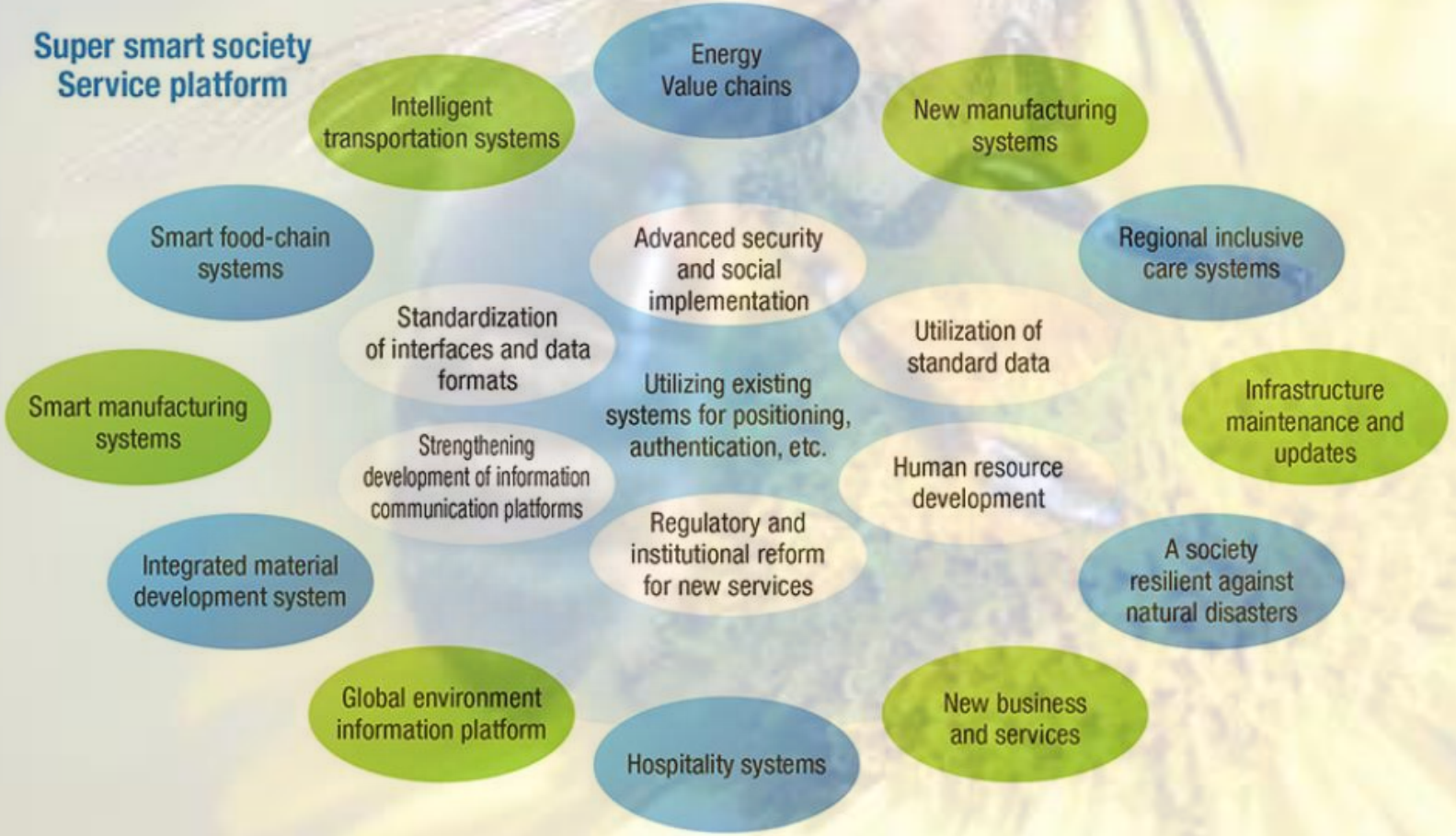
-But it is not only about balancing skills supply and demand.

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

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

Sociální výzvy – Japonská vize společnosti 5.0

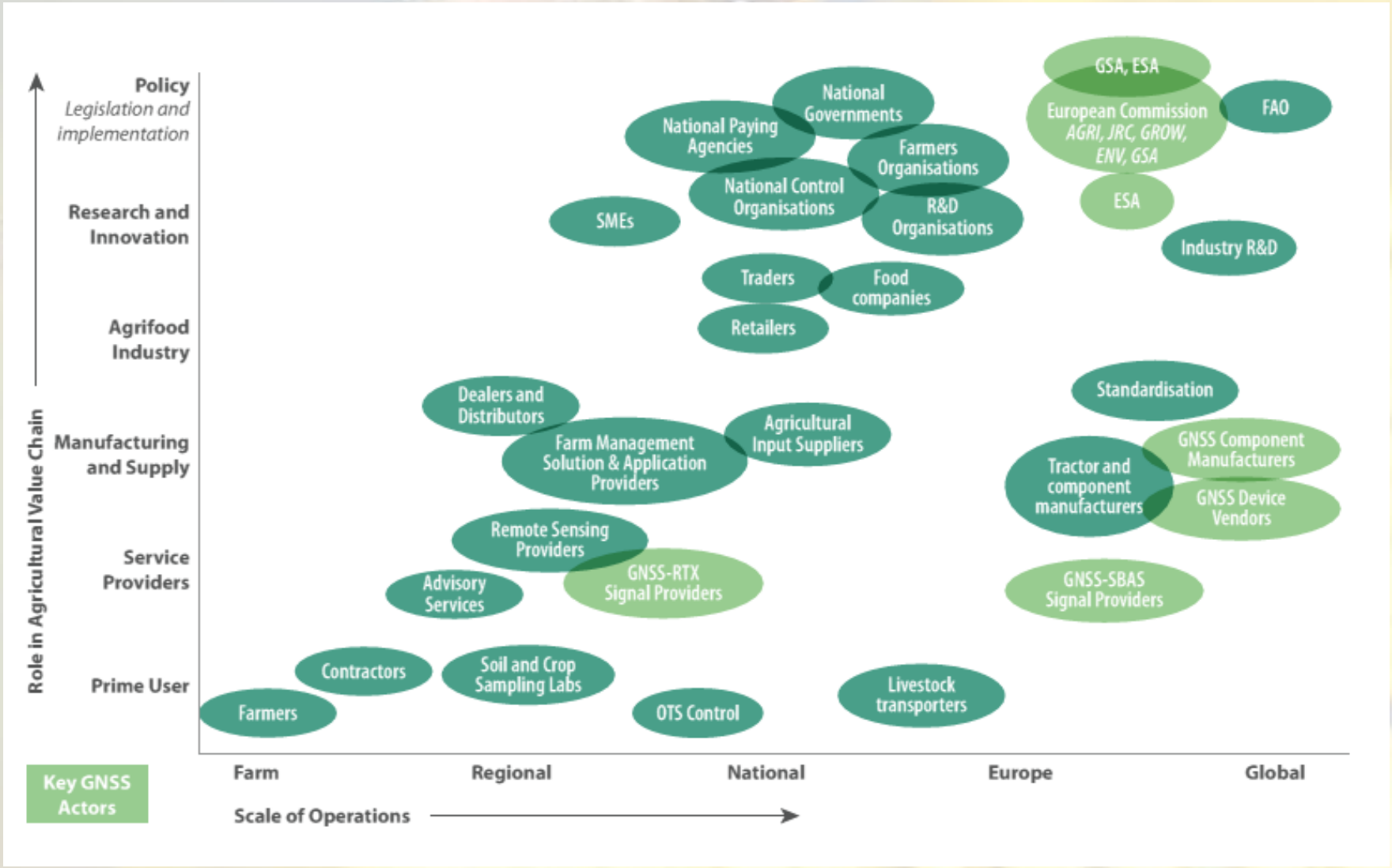
Strongly promoted by Council for Science, Technology and Innovation; Cabinet Office, Government of Japan



The 5 walls to 'break through' in moving to Society 5.0

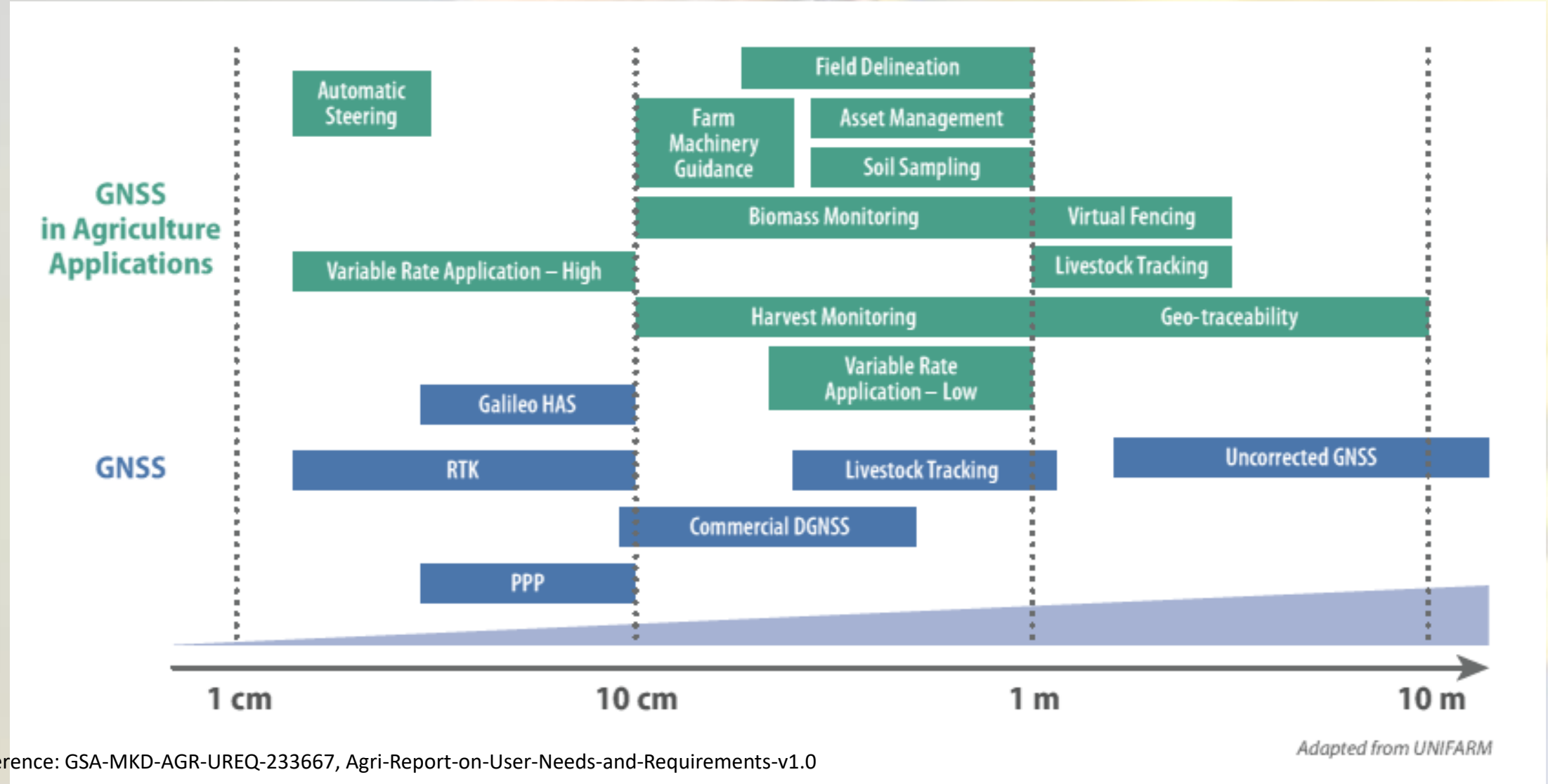
- **Ministries and Agencies**
- **Legal system**
- **Technologies**
- **Human resources**
- **Social acceptance**

Role navigace v hodnotovém Agro-řetězci



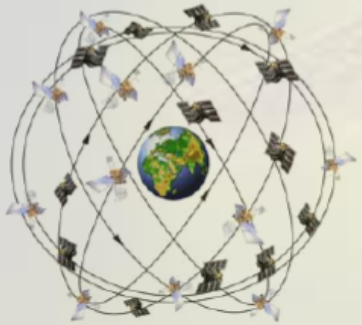
Reference: GSA-MKD-AGR-UREQ-233667, Agri-Report-on-User-Needs-and-Requirements-v1.0

Požadavky na přesnost GNSS - aplikace a technol.



Reference: GSA-MKD-AGR-UREQ-233667, Agri-Report-on-User-Needs-and-Requirements-v1.0

Porovnání satelitních navigačních systémů



GPS

35 Satellites / 31 Set Healthy

SISE(*) **0.52m** (RMS)
(18 Aug 2019 – 15 Aug 2020)

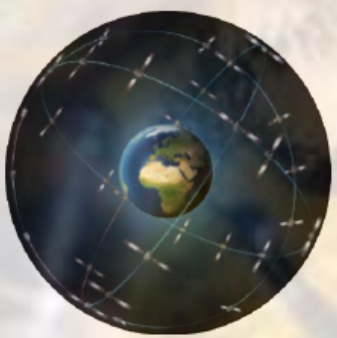
Latest Performance Standard (5th Edition) published in April 2020

GLONASS

27 Satellites / 23 Set Healthy

SISE **1.15m** (RMS)
(best week 28/01/2020-05/02/2020)

Latest Performance Standard (Edition 2.2) published in June 2020

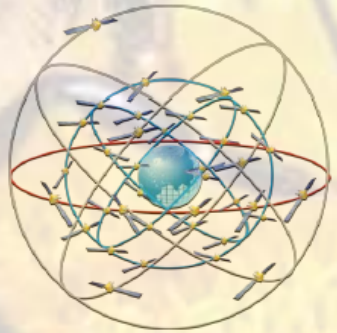


GALILEO

26 Satellites / 22 Set Healthy, all broadcasting in 3 frequency bands

SISE **0.15m** (RMS)
(0.25m 95%, August 2020)
→ BEST ACCURACY
→ 2-5 times better than other GNSS

Galileo Service Definition Document v1.1 issued in May 2019.



BeiDou

BDS-2, 15 Set Healthy
BDS-3, 27 Set Healthy

SISE (B1C/B2a) ~**0.25m** (RMS)
(August 2020)

BeiDou OS Performance Standard version 2.0, December 2018

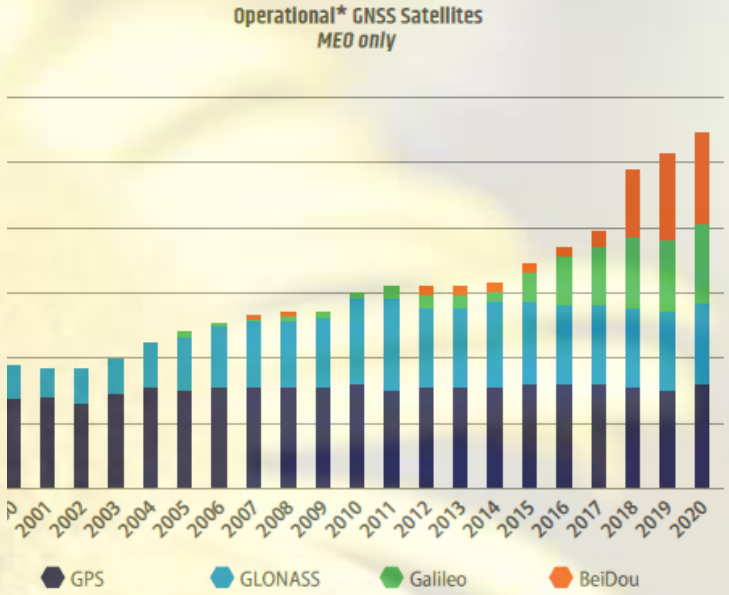
BDS-3 formally commissioned on 31/07/2020

QZSS

1GEO satellite
3 QZO satellites (IGSO)

SISE **0.55-0.85m** (RMS)
(01/09/2018-18/08/2020)

QZSS Performance Standard rev. 002, August 2020



(*) **SISE** Signal In Space Ranging Error

(ref. ION GNSS+ Sept 2020)

Reference: GSA-MKD-AGR-UREQ-233667, Agri-Report-on-User-Needs-and-Requirements-v1.0

Mendelova univerzita v Brně
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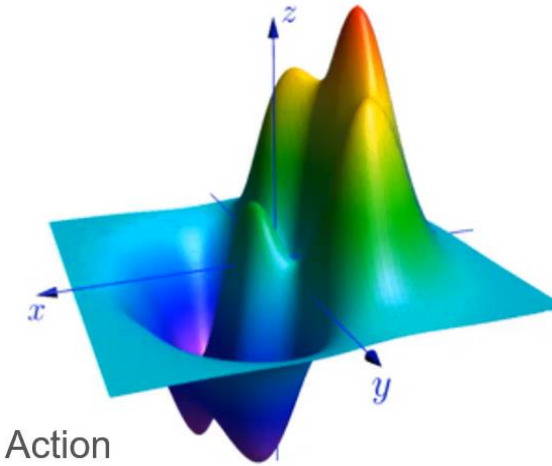
Swarms of CPS x Large Harvesting machinery

FieldBee
efarmer

Precizní zemědělství z pohledu strojírenství

Mendelova univerzita v Brně
Agronomická fakulta

THE BIG PICTURE

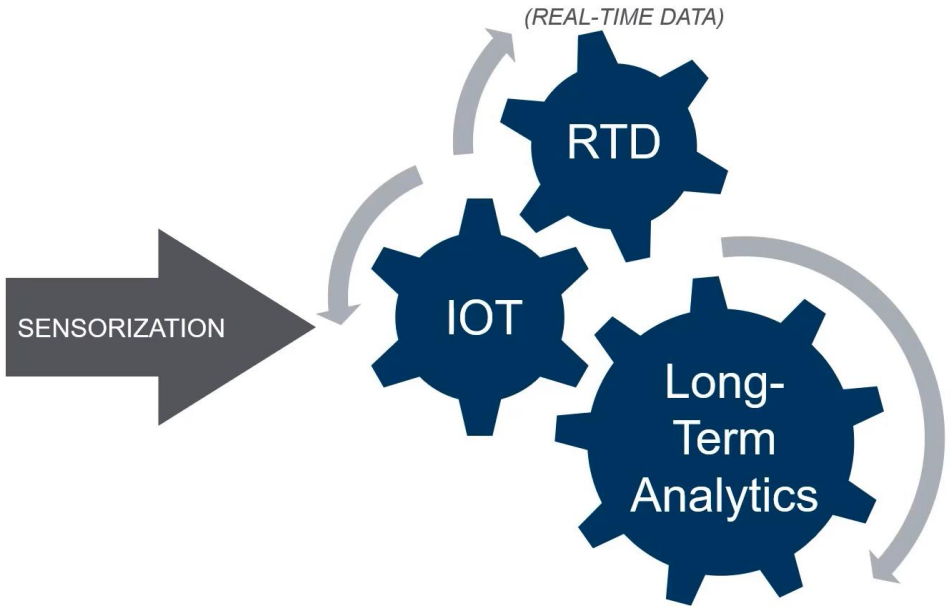


Precision Ag
- Environmental Variation
- Analyze & Compensate

Automation
- Repetitive Action
- Flexible Response to Variation
- Sensor-Driven

Reliability
- No baby-sitting
- Repair can be costly
- Time sensitivity

WHAT COMES NEXT?



Reference: Machine Design Webinars, Tips to Enhance Motion System Reliability in Precision Agriculture, Bishop-Wisecarver

Precizní zemědělství z pohledu strojírenství

WHERE IS GUIDED MOTION IN AGRICULTURE?

Single Axis (Example: Probing)

One axis of actuation to control the depth of the auger for an autonomous soil sampler.

Multiple Axes (Example: Picking)

Vertical and horizontal guided motion for the cutting tools on an asparagus harvesting robot operating continuously in the field.

Curvilinear (Example: Conveyance)

Straight + curved motion path for carrying product to indexed points in a multi-step operation (e.g. scanning, trimming, packaging).

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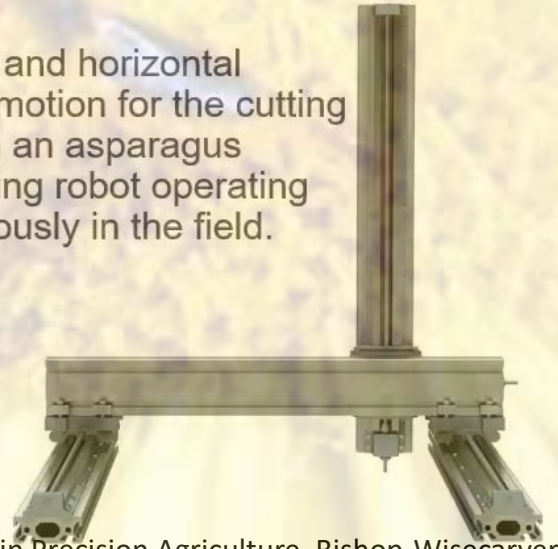

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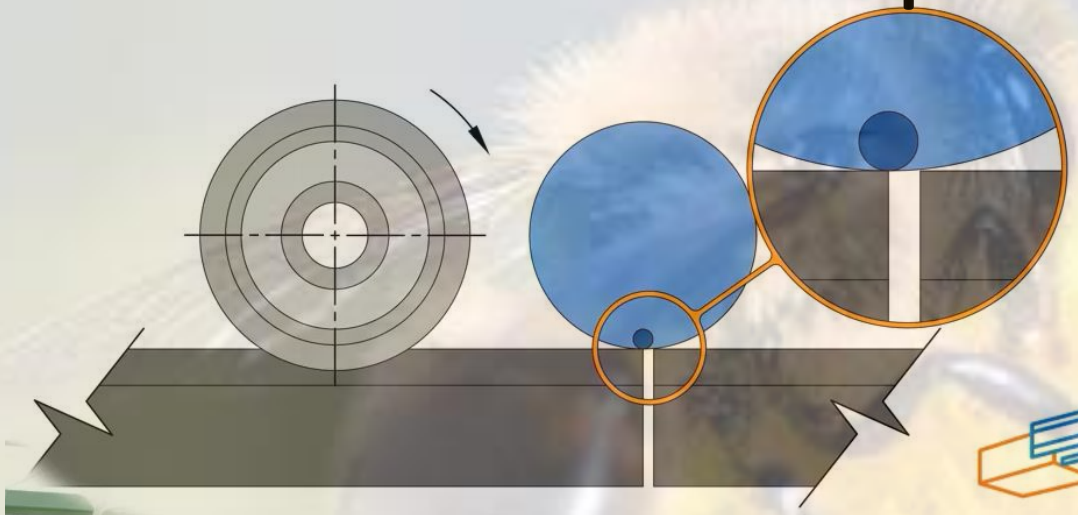
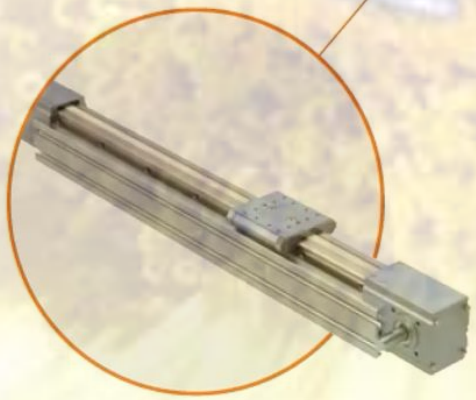
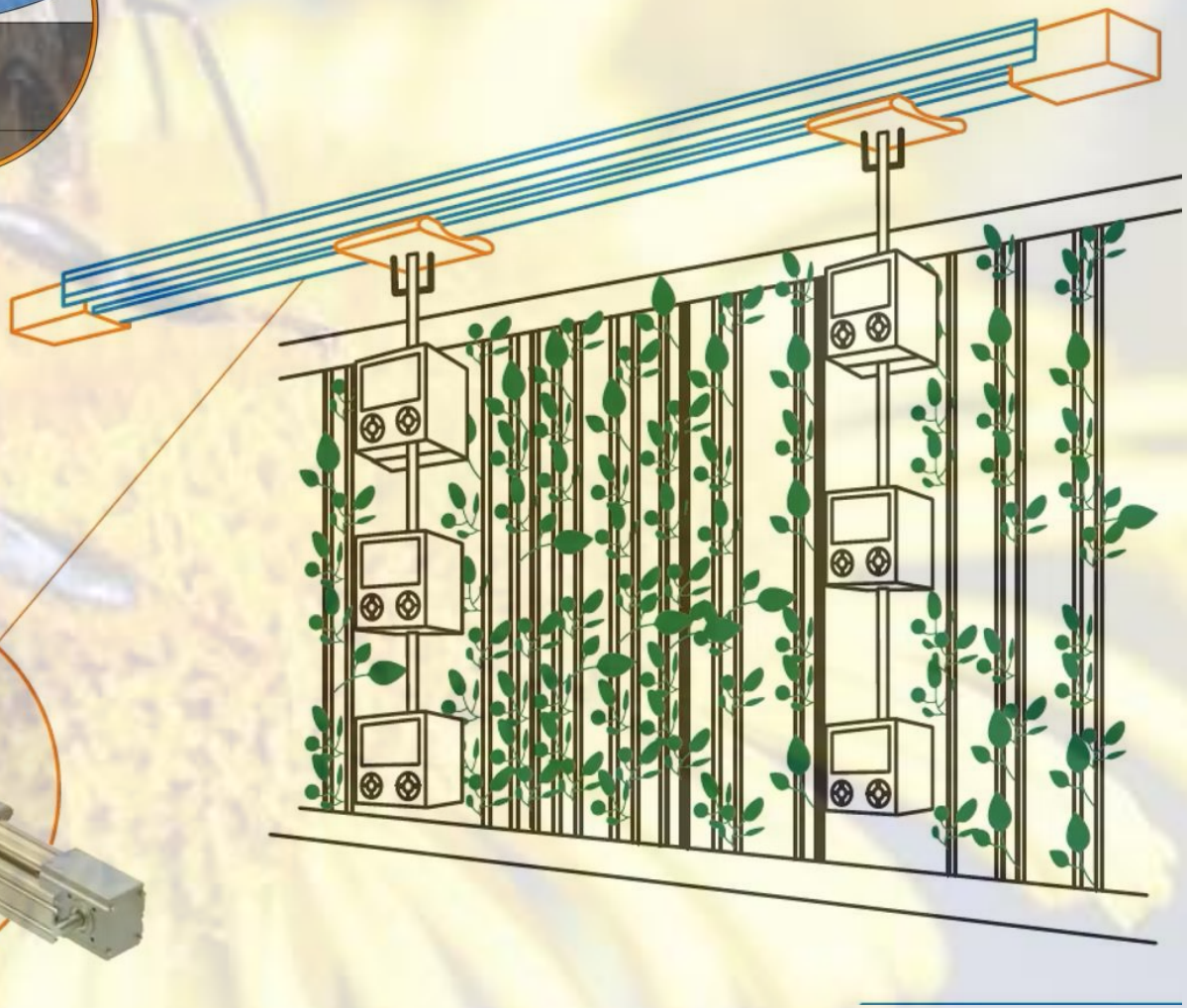


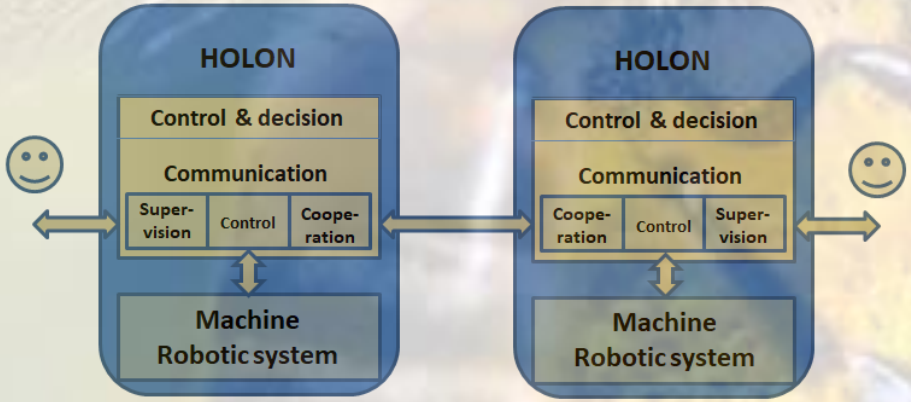


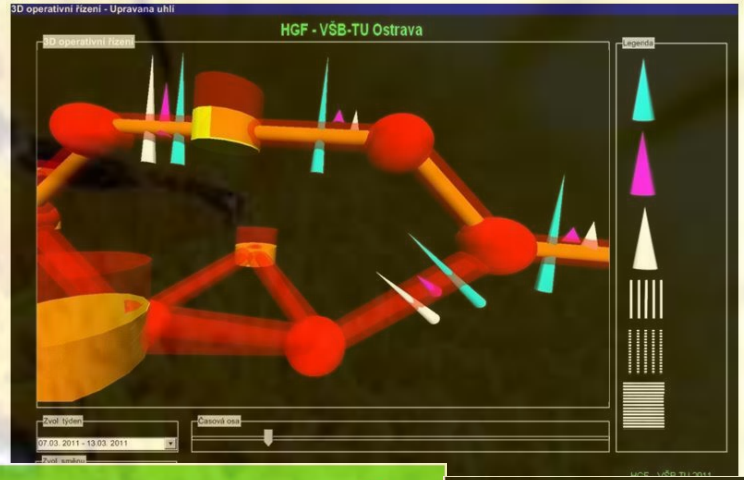


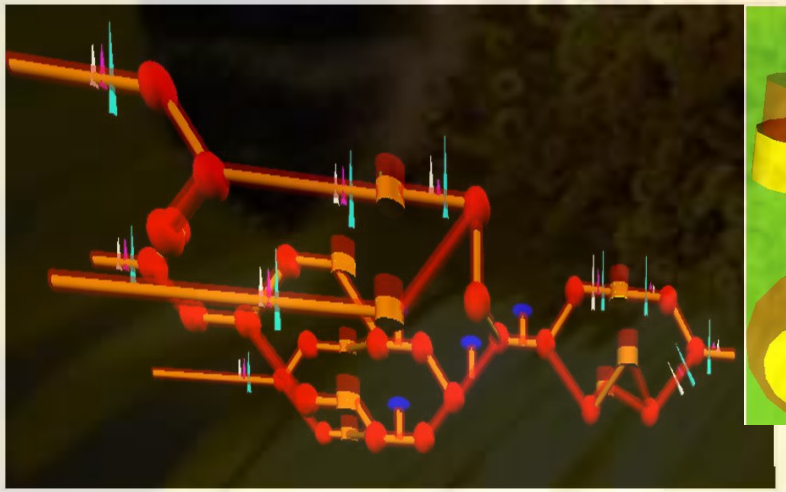
Reference: Machine Design Webinars, Tips to Enhance Motion System Reliability in Precision Agriculture, Bishop-Wisecarver

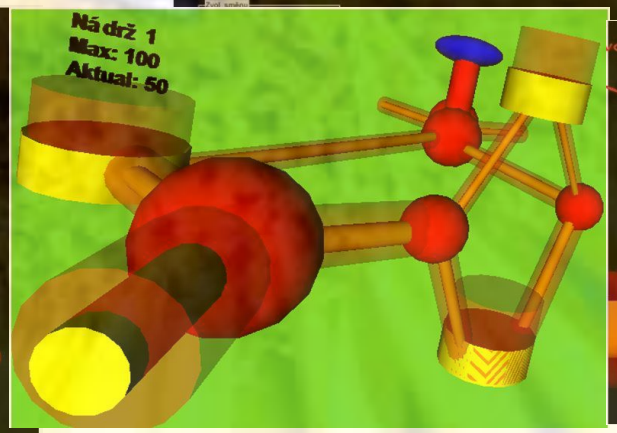
Holony a CPS - kyberneticko fyzikální systémy

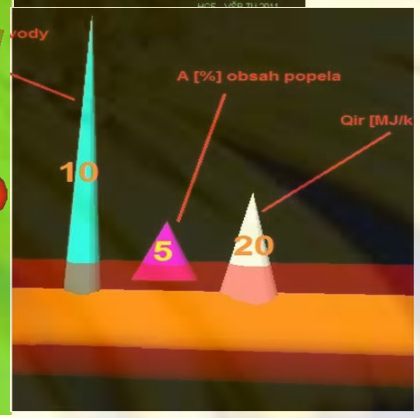
- CPS – cybernetics physical systems, digital twins
- Communication of holons, agents straight connected to machinery – goal orientation







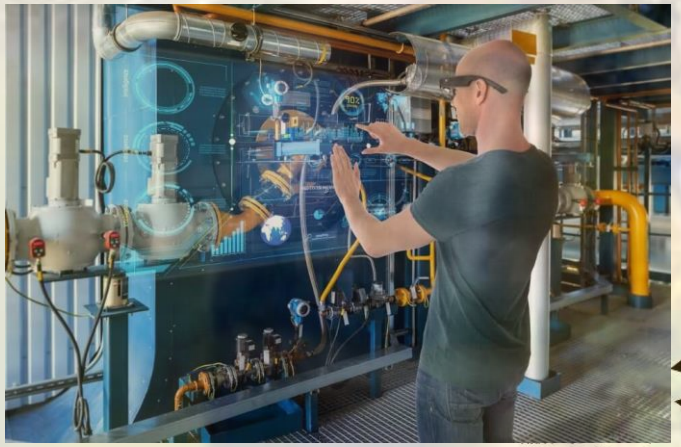


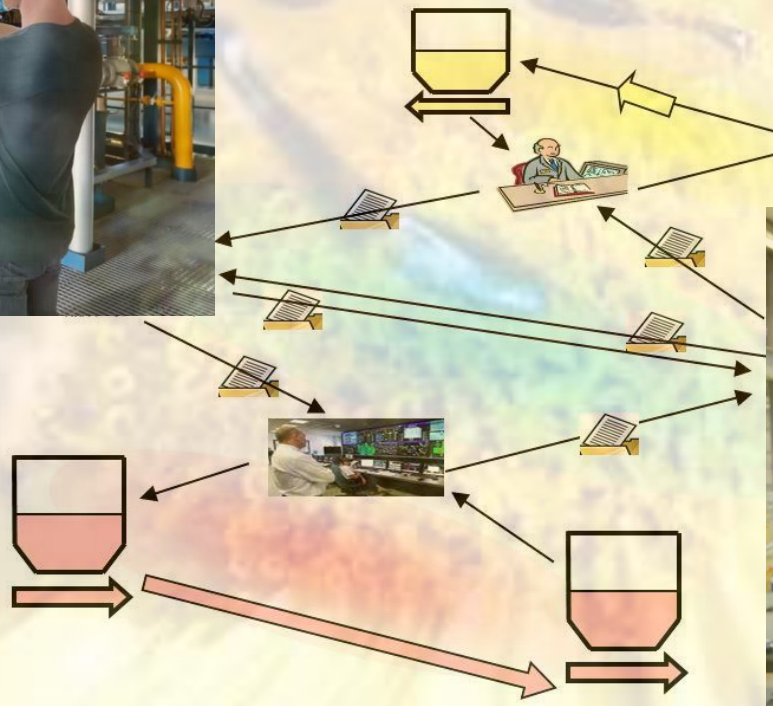


Source: RFID International laboratory and ENET Centre, VSB-Technical University of Ostrava

VR a AR - Virtuální a Rozšířená realita

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





Source: RFID International laboratory and ENET Centre, VSB-Technical University of Ostrava

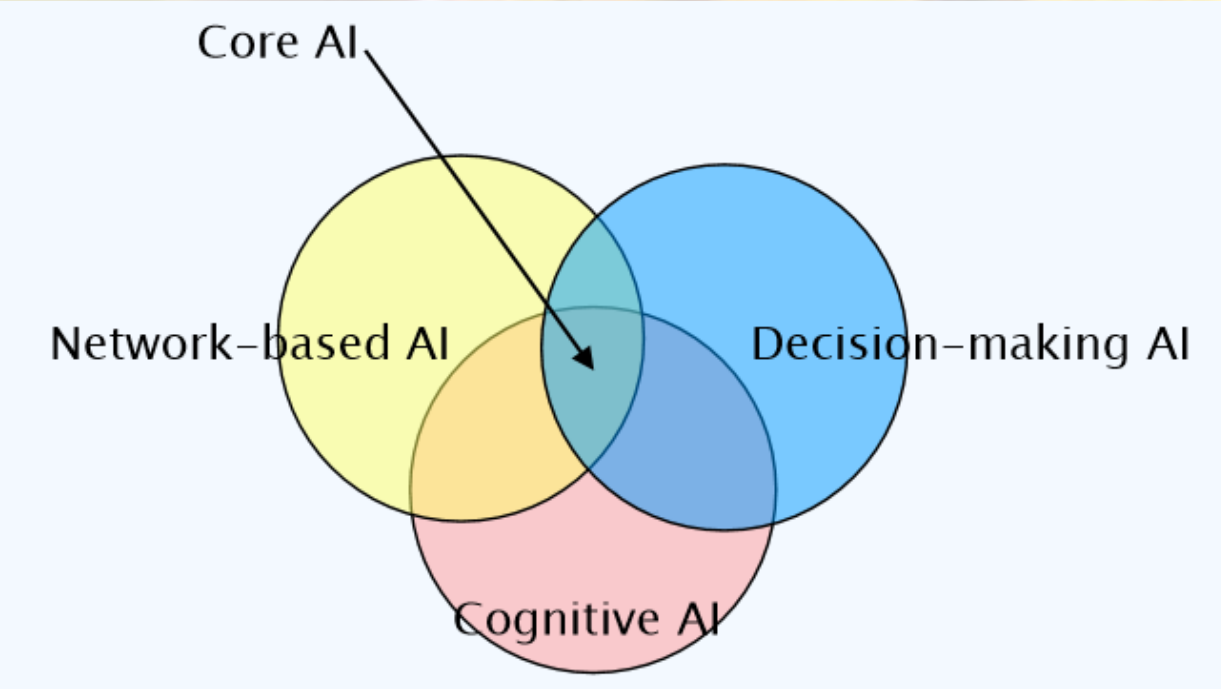
Výzvy I4.0 – Zemědělství 4.0

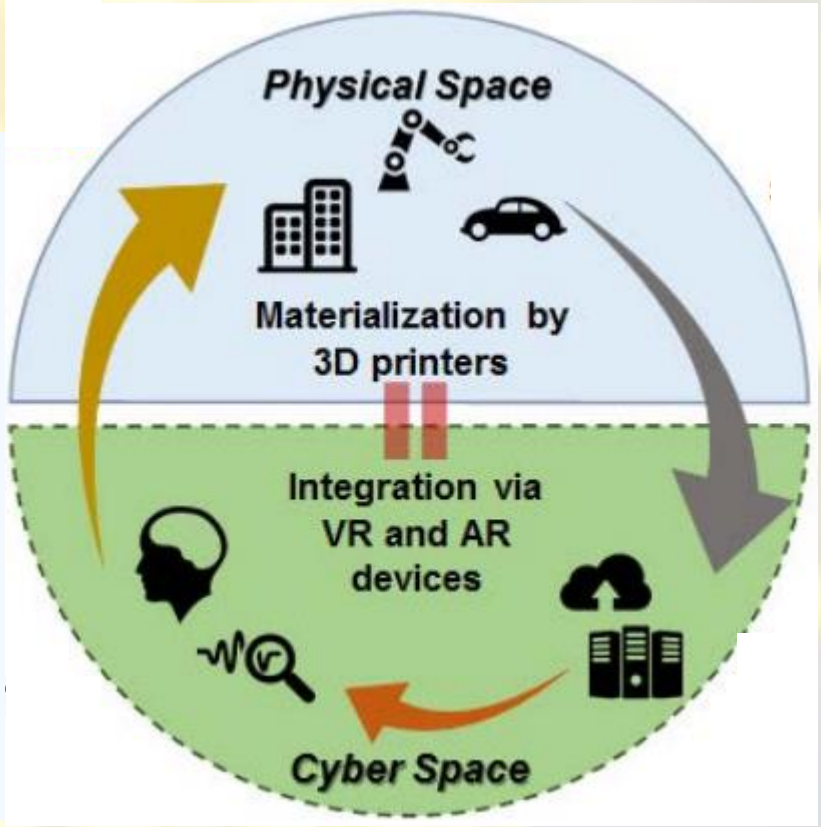
- Dynamic Agriculture 4.0 Control System – AI tools and principles in Resilient Integration
- New Areas of AI – bottom up process of estimation of needs from real industrial and business space and infrastructure
- The smart solutions are not complex – SMEs have provided partial solutions.
- AI systems are dynamic – depended on LEs
  - - knowledge quantity and quality
  - - computational technologies
  - - existing SW and HW platforms

Source: RFID International laboratory and ENET Centre, VSB-Technical University of Ostrava

Výzvy I4.0 – Zemědělství 4.0

- Dynamic Agriculture 4.0 Control System – AI tools and principles in Resilient Integration
  - Intelligent network of entities/CPS – autonomous and parallel activities, virtual twins
  - Cutting of the virtual - real border





Source: RFID International laboratory and ENET Centre, VSB-Technical University of Ostrava

Výzvy I4.0 – Zemědělství 4.0

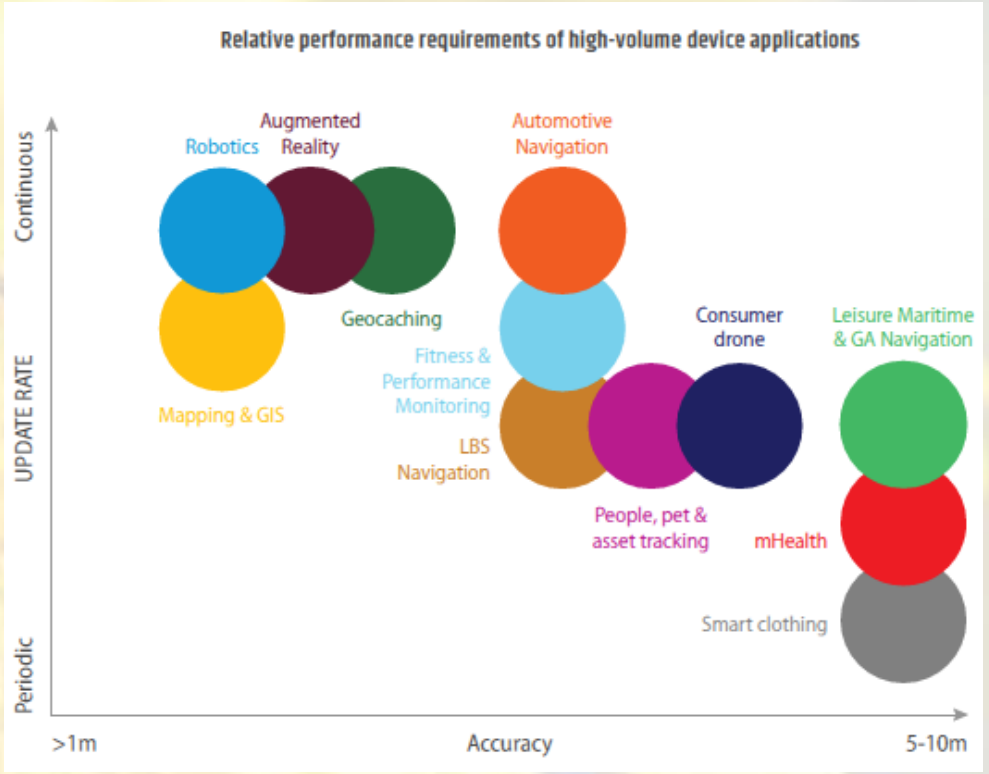
- Integration of tools and principles of Artificial Intelligence AI – Cyber Physical Systems – CPS

- New key feature – the CPS has the
  - ability of **learning** – knowledge processing
    - Local dimension – machine optimisation
    - Global dimension – distributed model of „World“
  - ability of communication
    - Knowledge Why? What?
    - Coordination of activities – swarm/hord
    - Negotiation to global goals

Source: RFID International laboratory and ENET Centre, VSB-Technical University of Ostrava

Výzvy I4.0 – Zemědělství 4.0

- New key feature – the CPS has the
  - Continuous development –
    - System „Is alive“ – new features
    - Sharing and creation of knowledge
  - Digital twin – creates the Virtual space
  - Use of external services
    - Total interconnection
    - IoT, IoS, IIoT, … IoEverything
  - Social dimension – cooperation with people

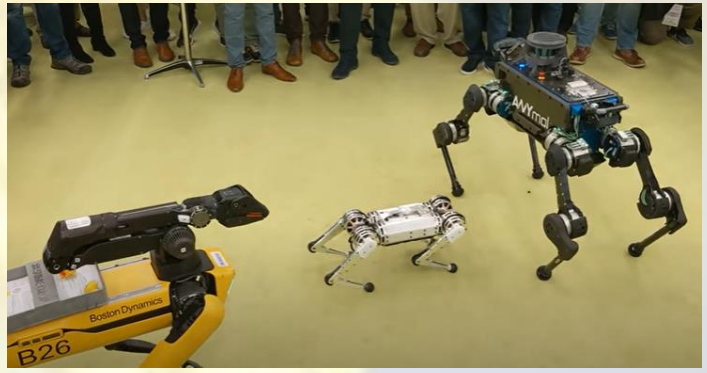


Výzvy I4.0 – Zemědělství 4.0

- New key feature – KNOWLEDGE INTEGRATION
  - Need of global digitalisation - networks
  - Virtualisation – integration or knowledge resources
  - Optimisation – knowledge learning – algorithms
  - Partial algorithms nested in knowledge systems
  - CPS – autonomous agent
    - Sharing of knowledge and goals
    - Thinking globally
    - Acting locally

Výzvy I4.0 – Zemědělství 4.0

- What need the Smart Farm?
  - Interdisciplinarity – wide platform of researchers, visions and partial solutions
  - Social digital transformation - creation of new ecosystem for AI
  - TestBed – new strategic element within the research and scientific space
  - AAAI: *"AI testbeds must strive to balance tractability and real - world relevance. Many researchers choose to study simplified tasks in closed domains, rather than open - ended real - world problems, because toy tasks are more tractable for today's methods."*



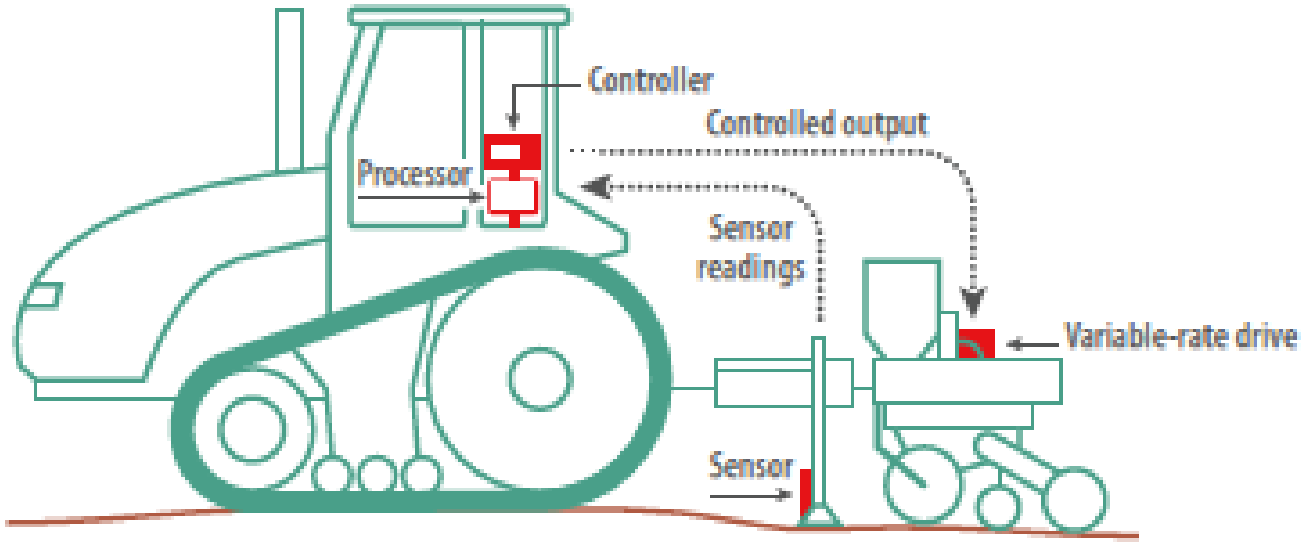
Výzvy I4.0 – Zemědělství 4.0

- What need the Smart Farm – Agriculture 4.0?
  - Resilient digital infrastructure and sustainability
  - Mindset to global visions - new economy models
  - Information and knowledge resources integration
  - Energy management 4.0 – the fundamental structure
  - Building of National centres – sharing of Research and Development - environment and infrastructure – „Green Deal“
  - Motivate the „Academic potential“ - push science to reality

Principy kolaborativní robotiky

- Sdílení společných cílů
- Koordinace a aktivní kooperace
- Flexibilní plánování
- Komunikace a principy vyjednávání
- Delegace úloh a podúlohy
- Sdílení znalostí – okolní svět a kooperující entita
- Uvažování v kontextu
- Redistribuce úloh a rolí

Agribot – autonomní traktor?



Reference: GSA-MKD-AGR-UREQ-233667, Agri-Report-on-User-Needs-and-Requirements-v1.0

Swarms of Agribots x Large Harvesting machinery

https://www.youtube.com/watch?v=xH9sXhYA3nE

FarmBot – stacionární portálový agribot

Reference: Laboratoř Ústavu zemědělské, potravinářské a environmentální techniky, Agronomická fakulta, Mendelova univerzita v Brně, https://docs.farm.bot/

Děkuji za pozornost.

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