“Human Centered Production in Cyber-Physical Production Systems”

Case study Croatia

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Vienna, September 19, 2015

European Academy on Industrial Management

www.europe-aim.de

Agenda

1. Cyber-Physical Systems
2. Analysis of the current state of Croatian manufacturing industry
3. Lean Learning Factory
4. Conclusion

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Computing Evolution

ÅMainframe computing (60’s-70’s)**
- Å Large computers to execute big data processing application

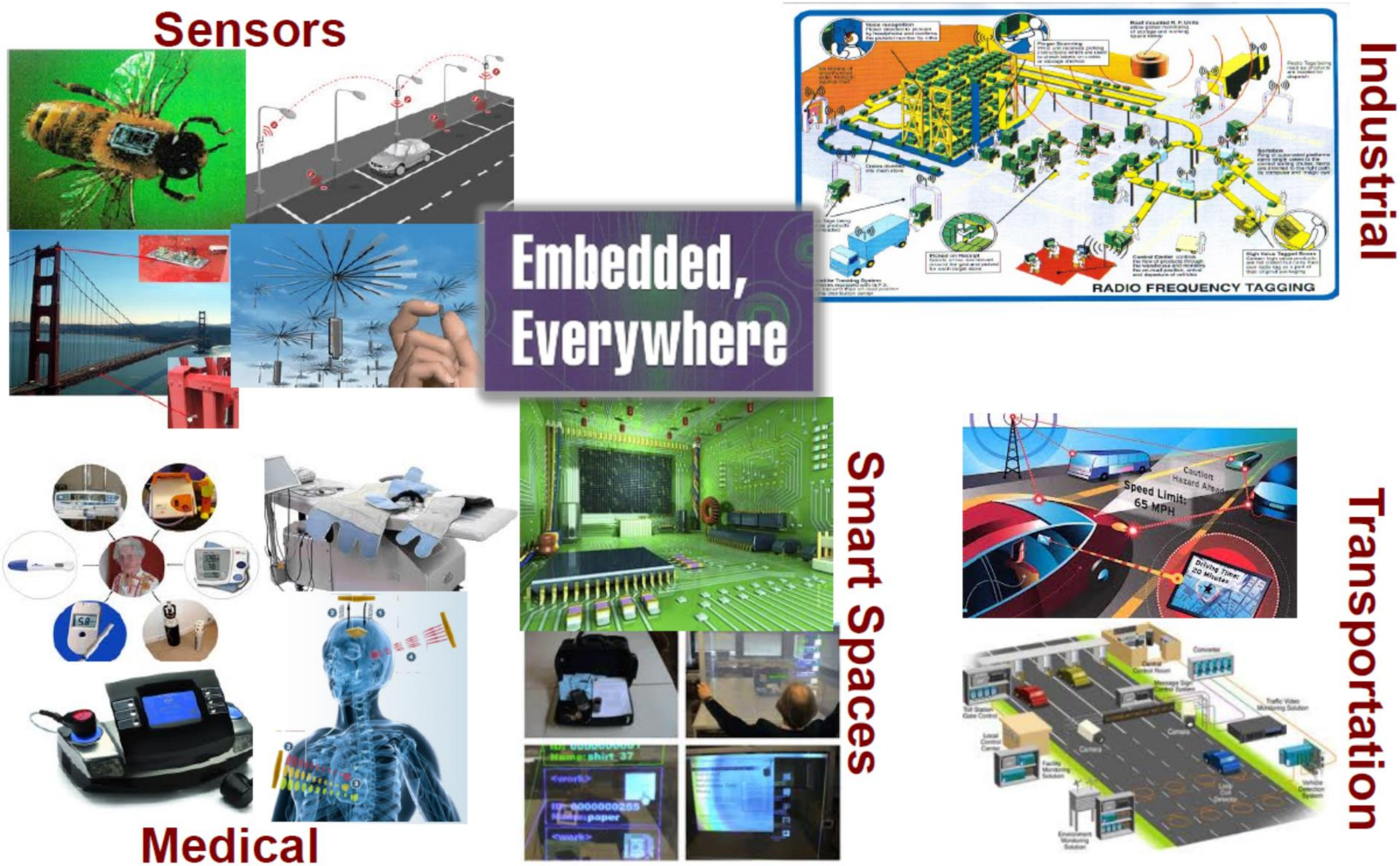
Å**Desktop computing & Internet (80’s-90’s)**
- Å One computer at every desk to do business/personal activities

Å**Ubiquitous computing (00’s)**
- Å Numerous computing devices in every place/person
- Å „Invisible” part of the environment
- Å Millions fo desktops vs. Billions for embedded processors

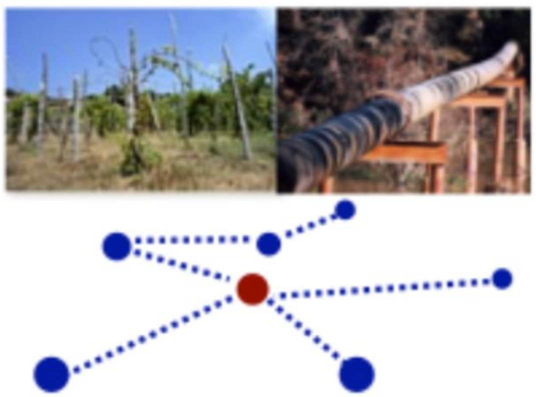
Å**Cyber Physical Systems (10’s)**

Source: Tamer Nadeem: Cyber Physical Systems, Old Dominion, 2013

Trend 1: Data/Device Proliferation (By Moore's Law)

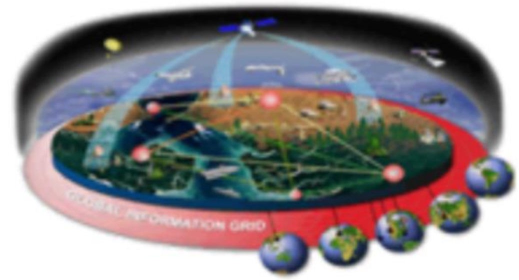


Trend 2: Integration at Scale (Isolation has cost!)



World Wide Sensor Web

Smart Building Environment



Future Combat System

Low End ⟷ High End

Ubiquitous embedded devices

Å Large-scale networked embedded systems

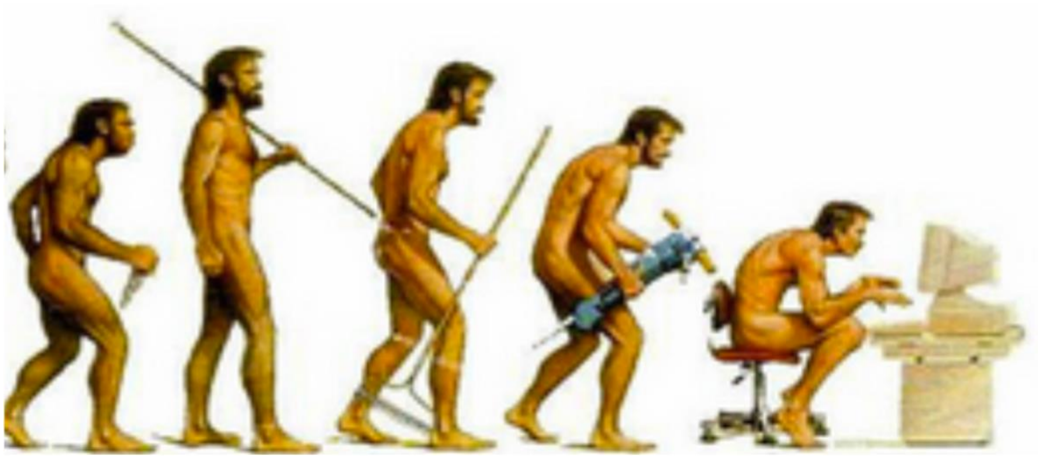
Å Seamless integration with a physical environment

Integration & Scaling Challenges

Complex systems with global integration

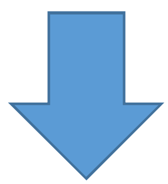
Å Global Integration Grid

Trend 3: Biological Evolution



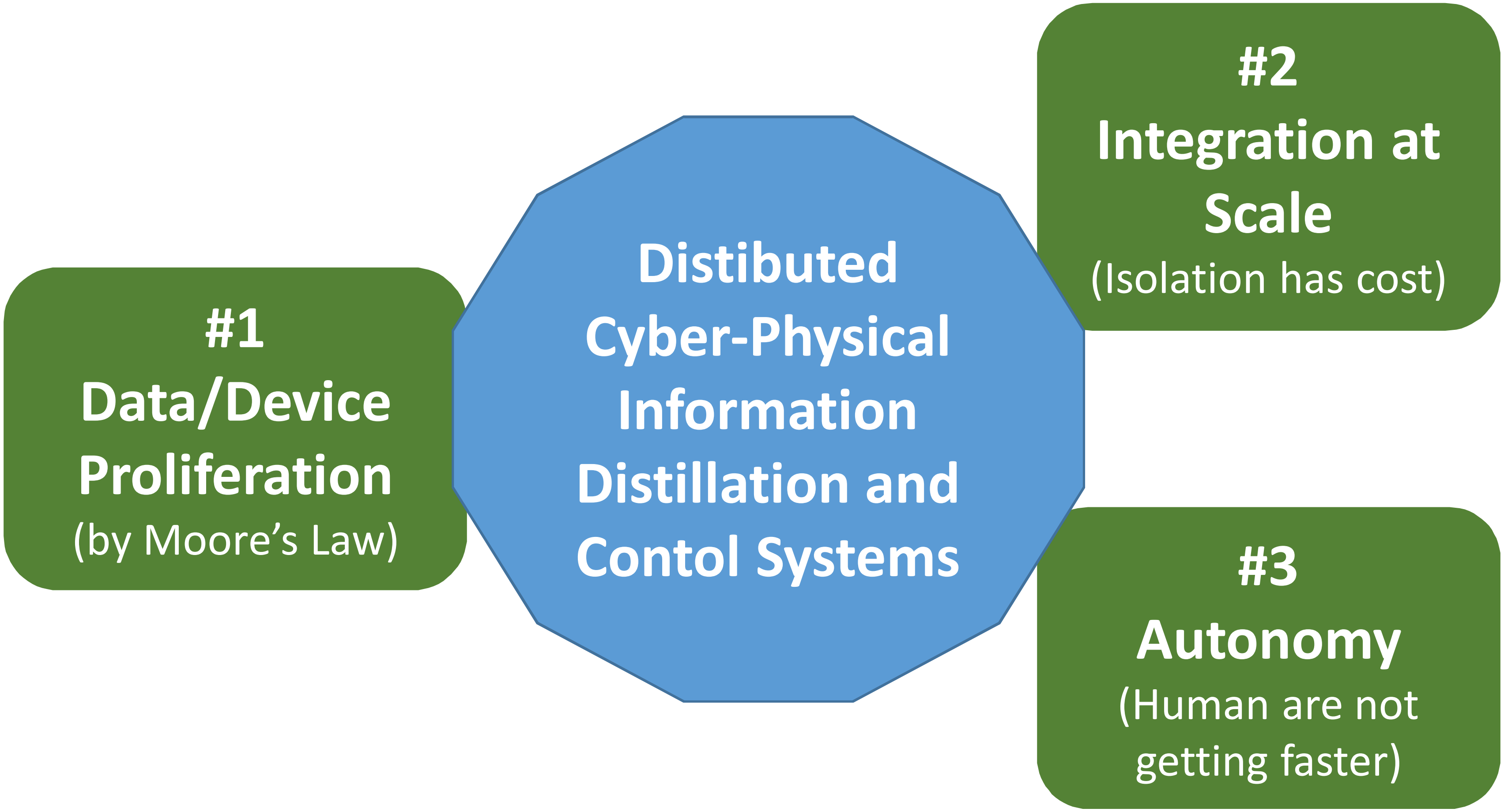
TOO SLOW!

The exponential proliferation of embedded device (afforded by Moore's Law) is ***not*** matched by a corresponding increase in human ability to consume information!



Increasing autonomy (human out of the loop)

Confluence of Trends



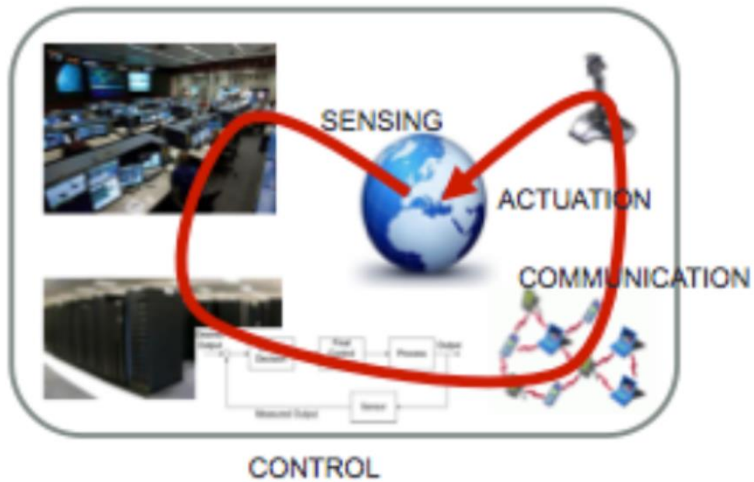
What are Cyber-Physical Systems?

- Cyber – computation, communication, and control that are discrete, logical, and switched
- Physical – natural and human-made systems governed by the laws of physics and operating in continuous time
- Cyber-Physical Systems – systems in which the cyber and physical systems are tightly intergrated at all scales and levels

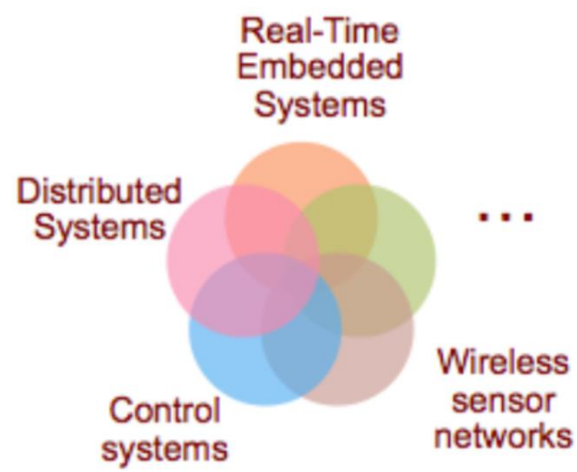
„CPS will transform how we interact with the physical world just like the Interent transformed how we interact with one another."

What are Cyber-Physical Systems?

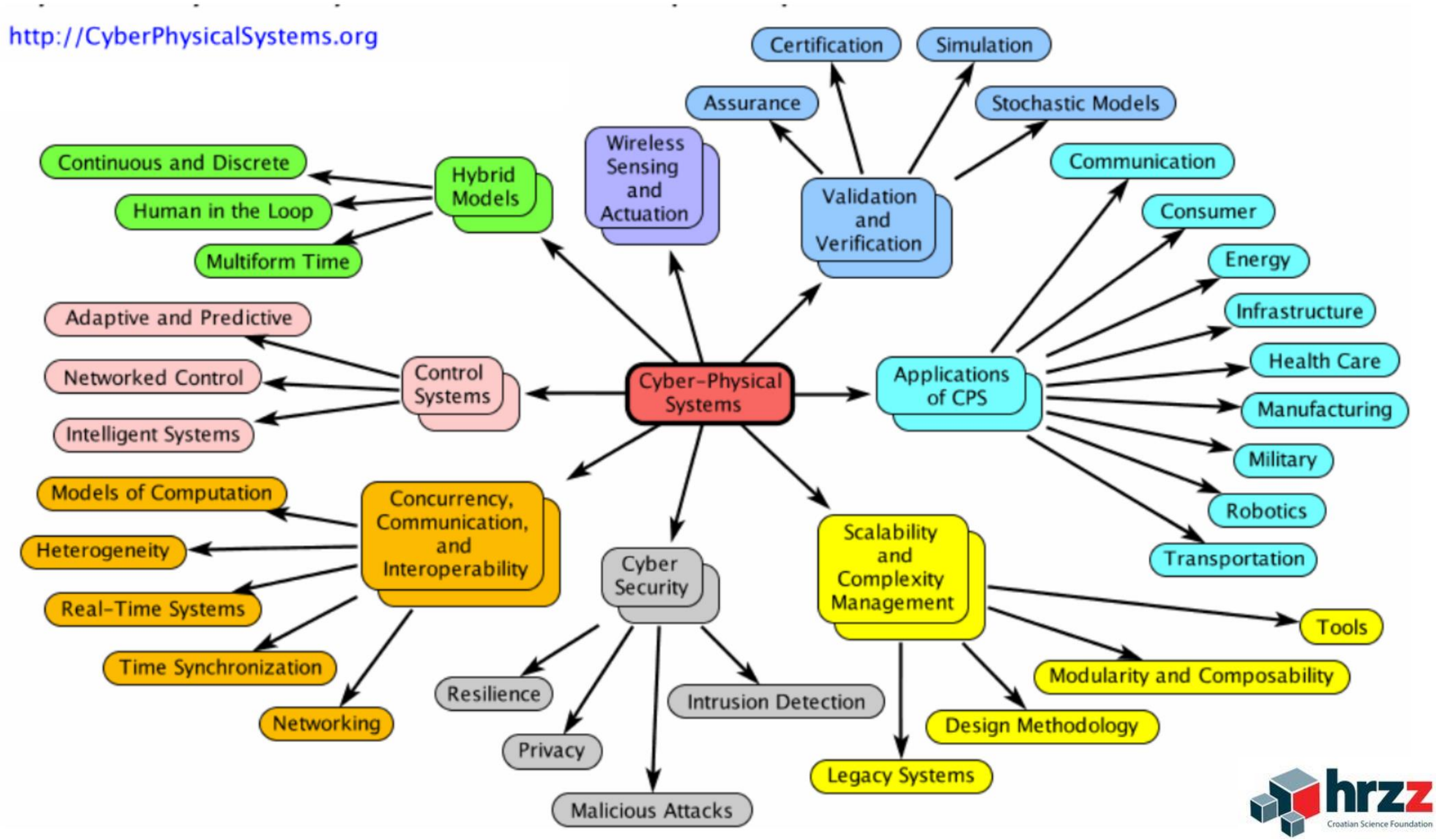
- Cyber-physical systems (CPSs) are physical and engineered systems whose operations are monitored, coordinated, controlled und integrated by a computing and communication core



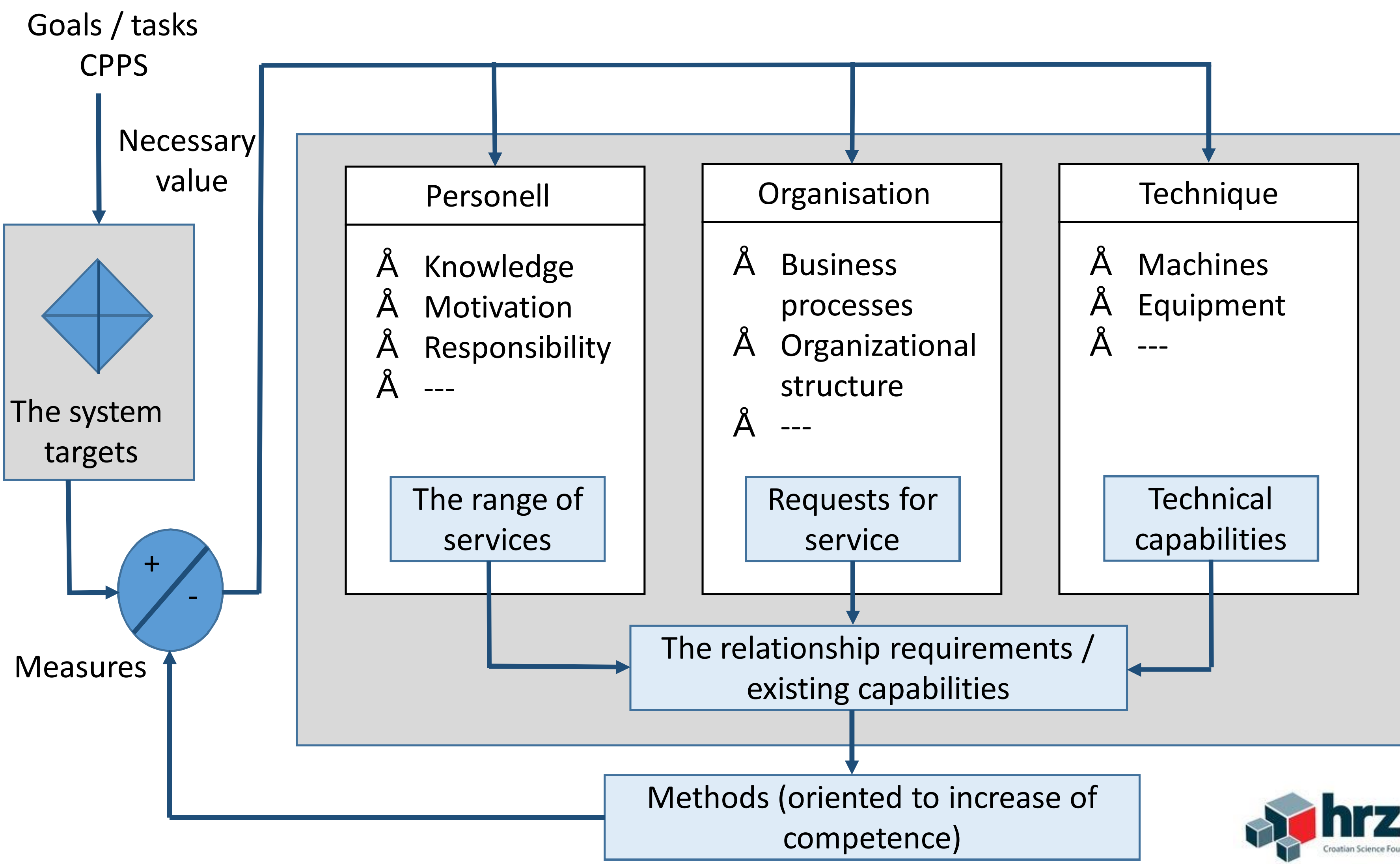
- Convergence of computation, communication, information, and control



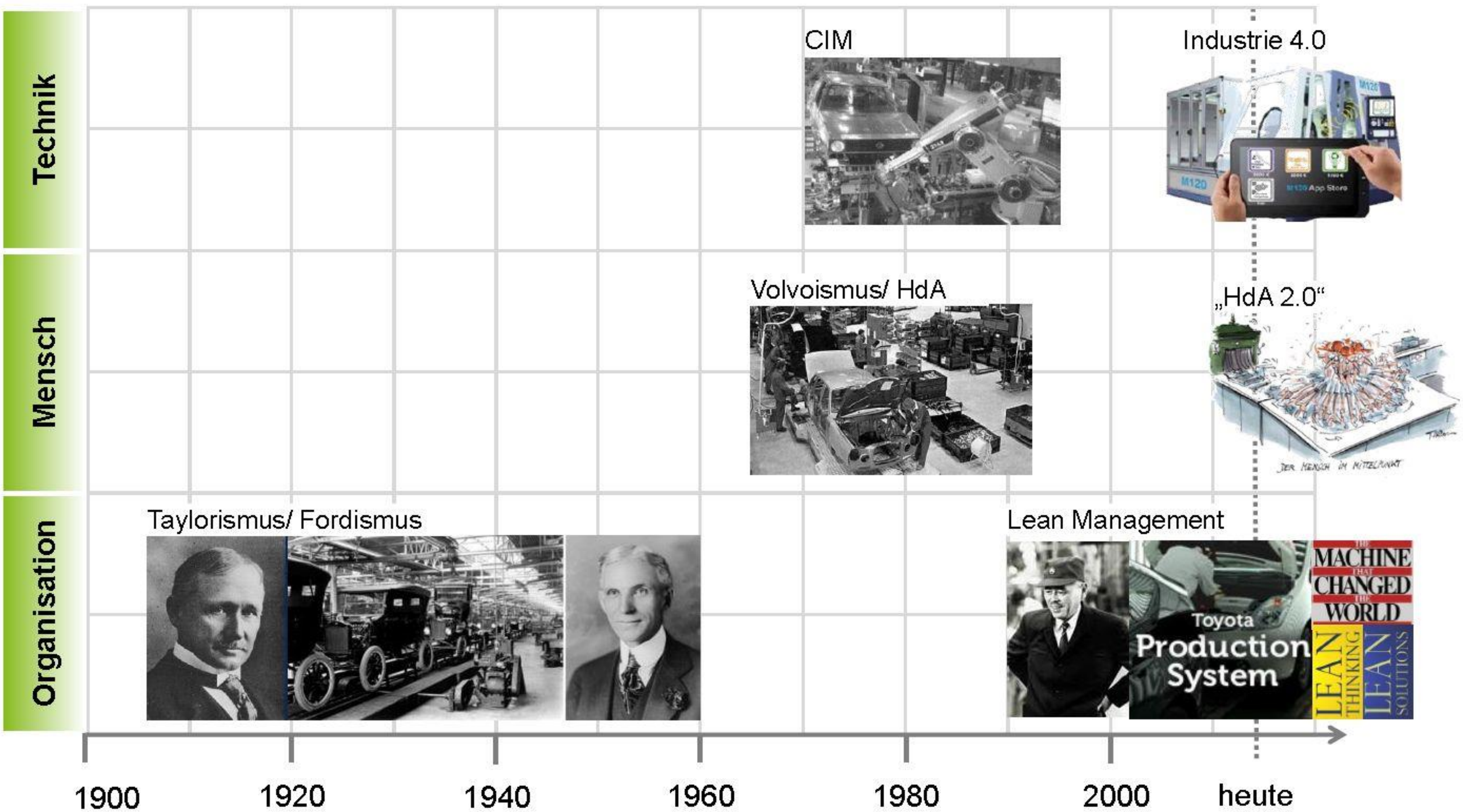
CPS – Concept Map



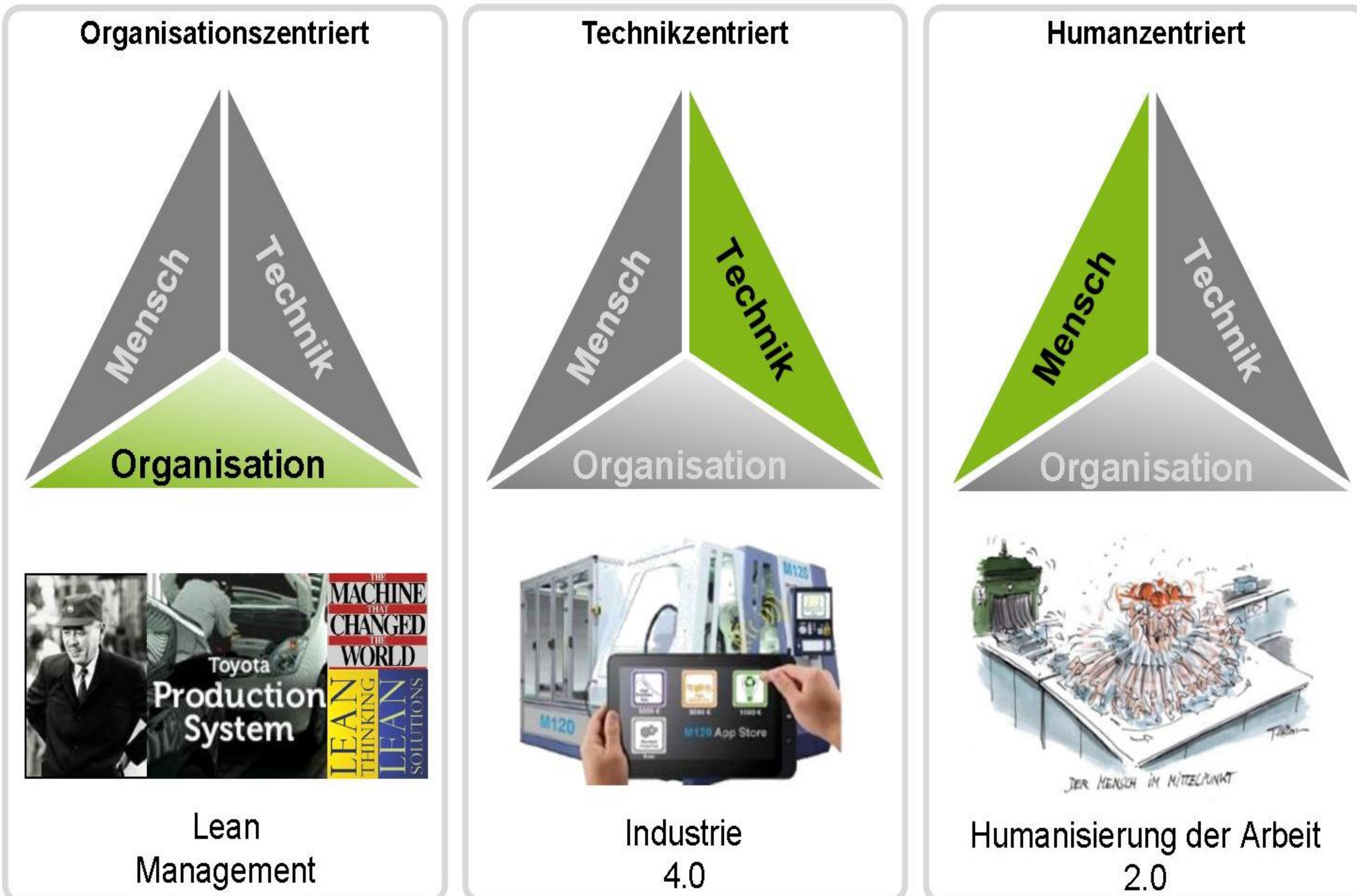
Control of Cyber-physical production system (CPPS)



Paradigms of production systems design



Paradigms of production systems design



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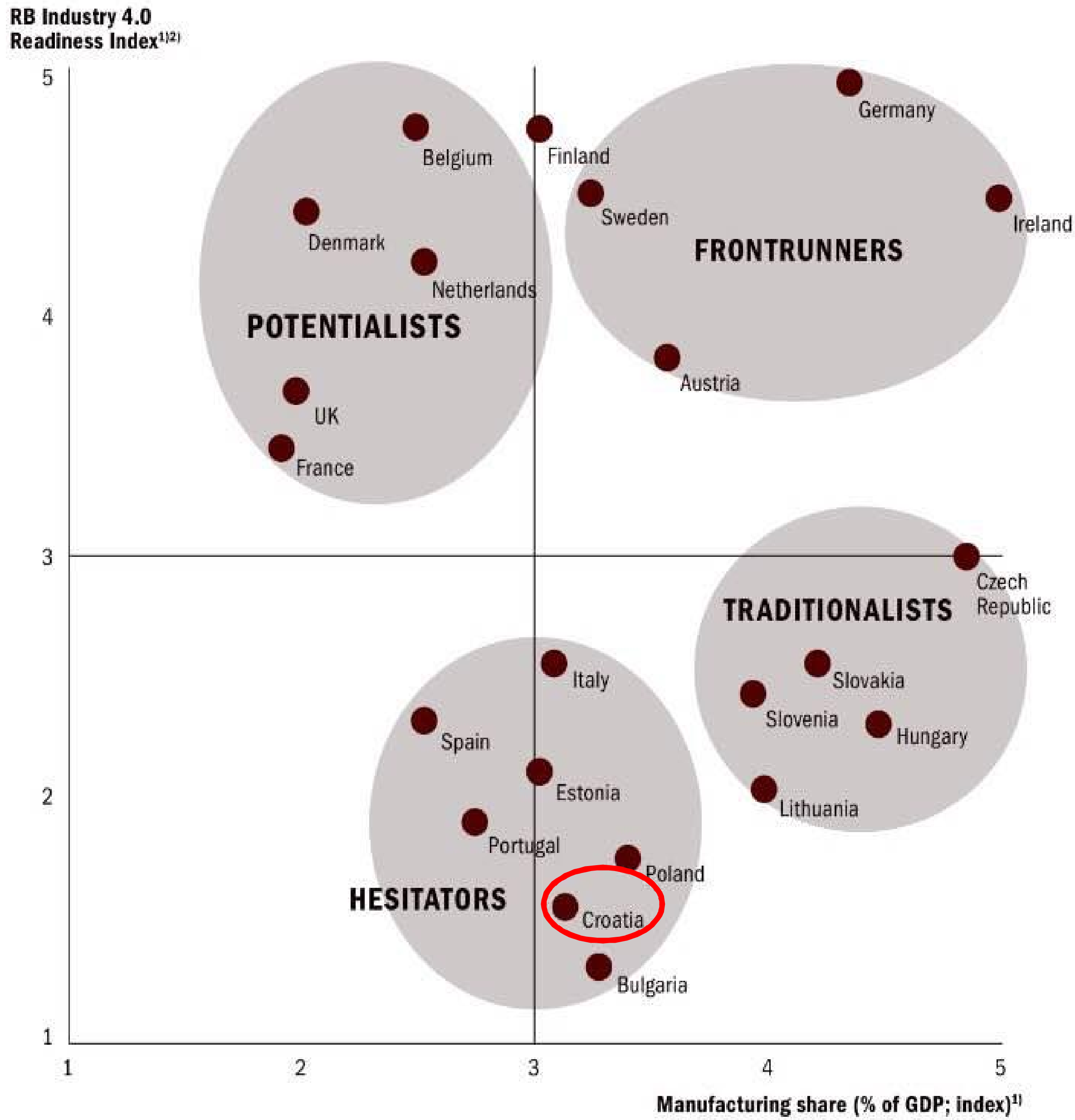
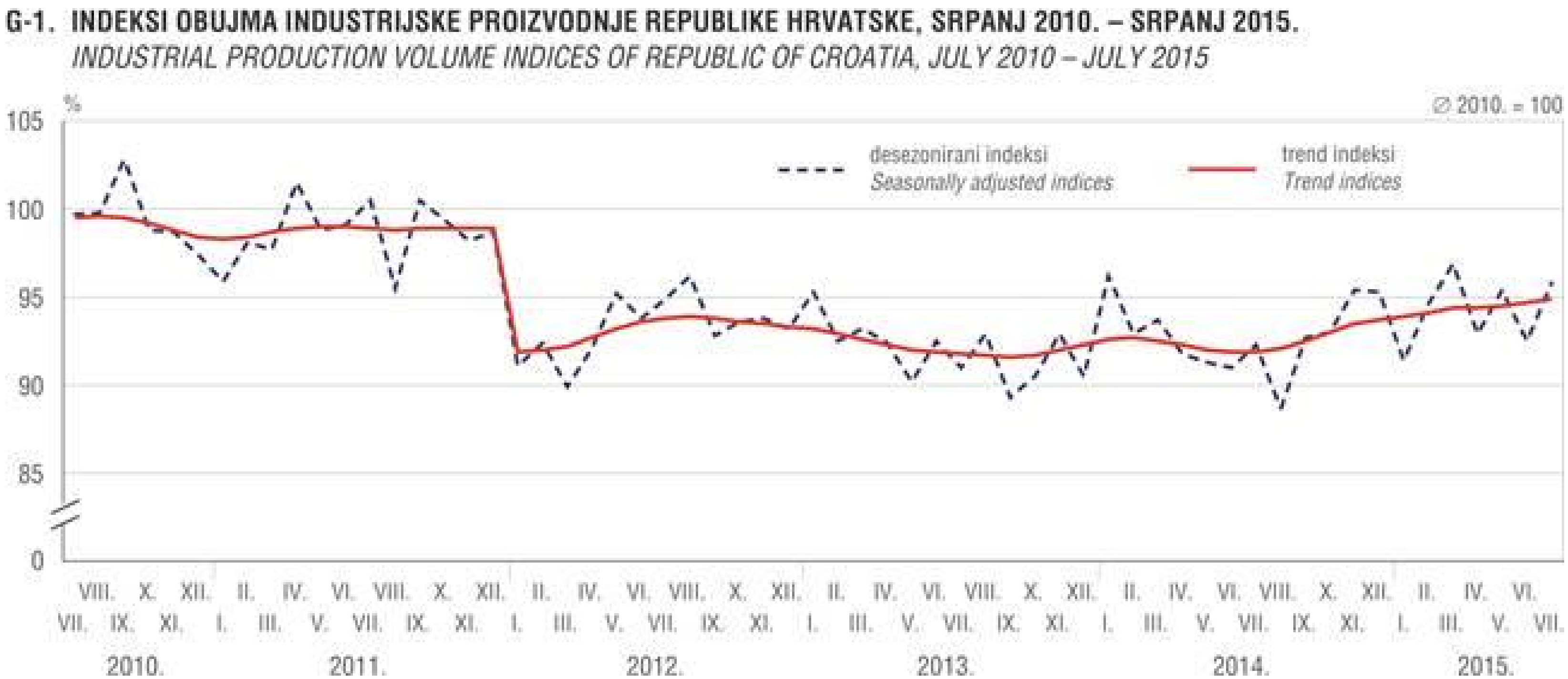


1) 1 = low, 5 = high 2) Adjusted for outliers Cyprus, Latvia, Luxemburg, Romania, Greece

Industrial Production Volume Indices



Source: *the Croatian Bureau of Statistics, September 2015.*

The total seasonally adjusted industrial production in July 2015 (as compared to June 2015) - **increased by 3.5%**.

The industrial production in July 2015 (as compared to July 2014) - **increased by 3.9%** (working-day adjusted).

Manufacturing Volume Indices

According to NKD 2007. sections and divisions*

G-2. INDEKSI OBUJMA PRERAĐIVAČKE INDUSTRIJE REPUBLIKE HRVATSKE, SRPANJ 2010. – SRPANJ 2015.
MANUFACTURING VOLUME INDICES OF REPUBLIC OF CROATIA, JULY 2010 – JULY 2015

Source: *the Croatian Bureau of Statistics, September 2015.*

The total seasonally adjusted industrial production in Manufacturing in July 2015 (as compared to June 2015) - **increased by 3.0%**.

The industrial production in Manufacturing in July 2015 (as compared to July 2014) - **increased by 4.6%** (working-day adjusted).

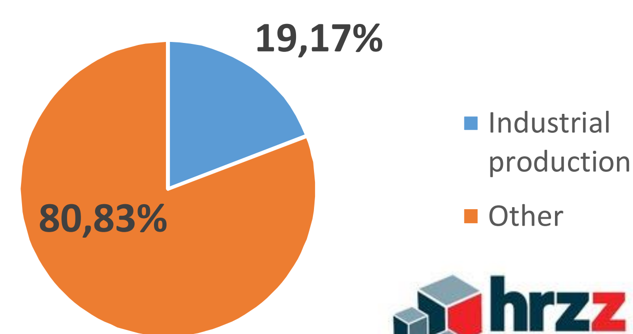
Number of persons employeed in Industrial production

*In July 2015, the number of persons in paid employment in legal entities in the Republic of Croatia amounted to **1.129.638**, out of which there were **532.370** women.*

NKD 2007	Category	Total	Women
B	Mining and quarrying	4.885	613
C	Manufacturing	197.186	68.786
D	Electricity, gas, steam and air conditioning supply	14.490	3.110
	Total for industrial production	**216.561**	**72.509**

Source: *the Croatian Bureau of Statistics, September 2015.*

Persons in paid employment in legal entities in RH (July 2015)

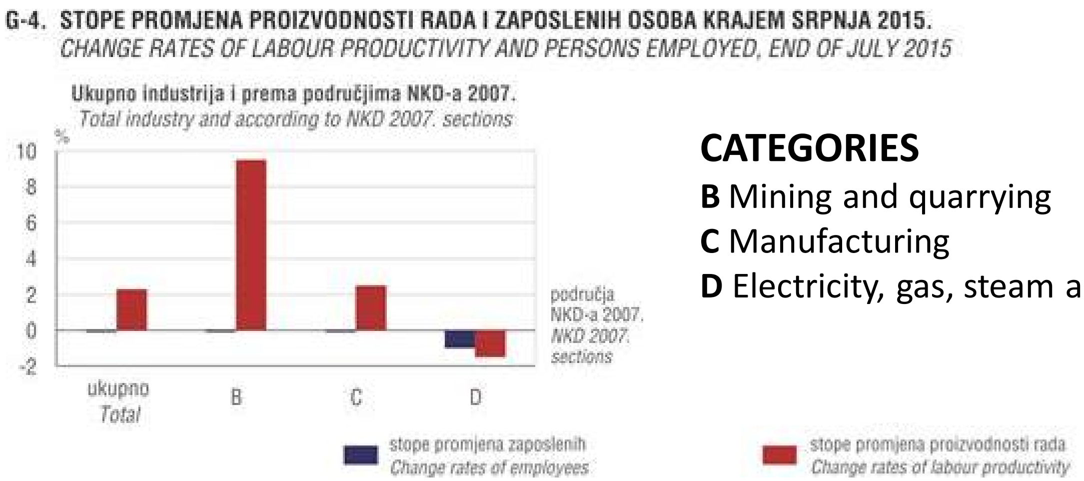


Industrial production (According to NKD 2007.* sections and divisions):
B Mining and quarrying
C Manufacturing
D Electricity, gas, steam and air conditioning supply

Change rates of Labour Productivity and Persons Employed

According to NKD 2007. sections and divisions*

*The total number of persons employed in industry in July 2015 was by **0.1%** lower than in June 2015 and by **1.4%** lower than in July 2014.*



CATEGORIES

B Mining and quarrying

C Manufacturing

D Electricity, gas, steam and air conditioning supply

Source: *the Croatian Bureau of Statistics, September 2015.*

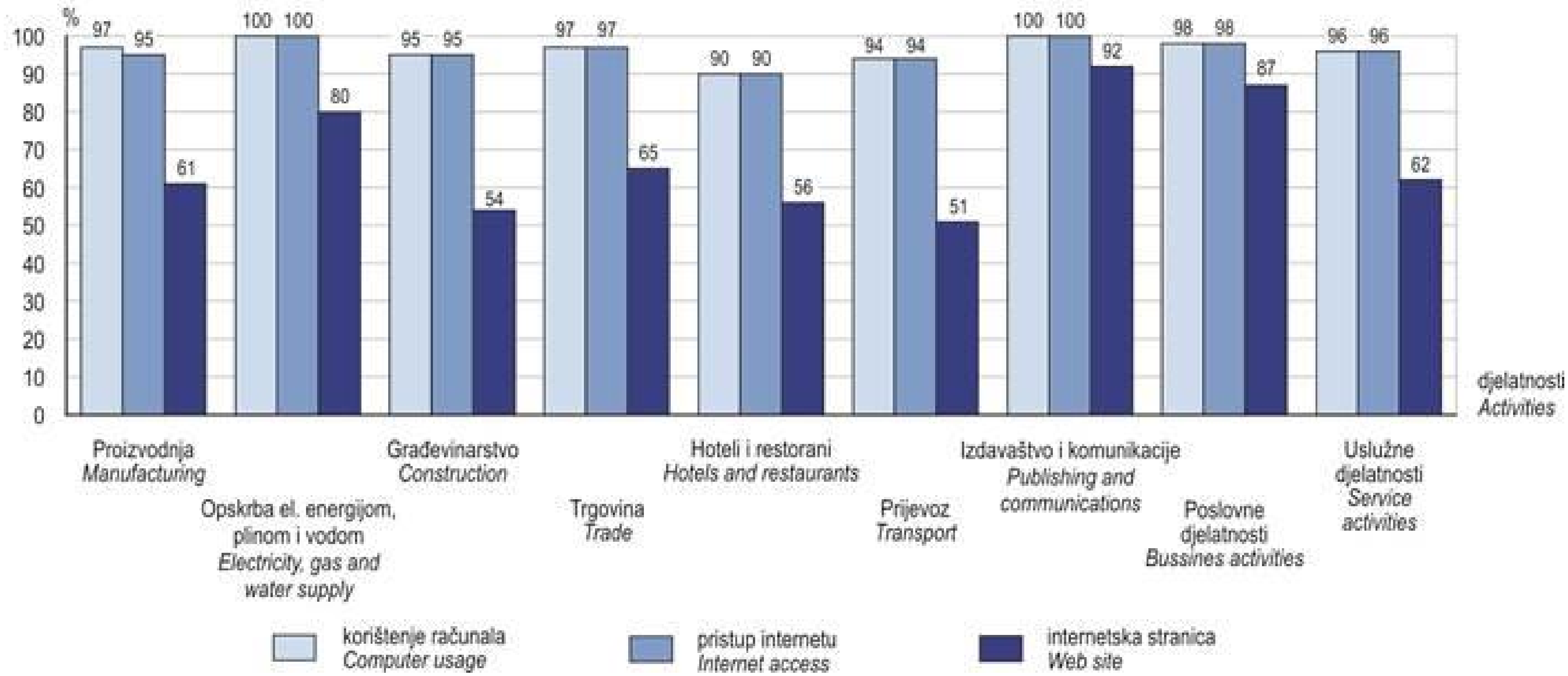
In July 2015, as compared to June 2015, the number of persons employed was **by 0,1% lower** in Manufacturing (C).

The number of persons employed in in Manufacturing in July 2015 compared with the number for July 2014 was **by 1,2% lower**.

Usage of Information and Communication Technologies (ICT) in Enterprises, 2014

*High level of ICT integration in business conduct; **96%** of enterprises used computers; **96%** had the internet access; **66%** of enterprises owned a web site*

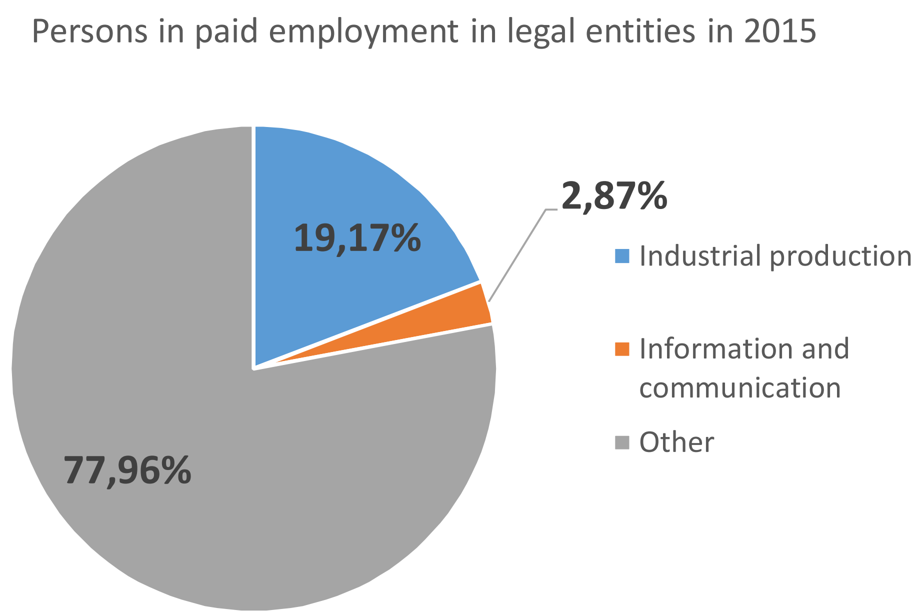
G-1. UPORABA IKT-A U PODUZEĆIMA PO DJELATNOSTIMA U 2014.
USAGE OF ICT IN ENTERPRISES, BY ACTIVITIES, 2014



Source: *the Croatian Bureau of Statistics, September 2015.*

Usage of Information and Communication Technologies (ICT) in Enterprises, 2014

*In July 2015, the number of persons in paid employment in legal entities in the Republic of Croatia amounted to **<u>1.129.638</u>**, out of this number, **32.434** persons worked in ICT, or **2,87%***



Source: *the Croatian Bureau of Statistics, September 2015.*

Project INSENT
Main aim

- The main objective of this project is to develop **Croatian model of Innovative Smart Enterprise (HR-ISE model)**.
- The aim is to perform **model's regional fit**, i.e. to harmonize Innovative Smart Enterprise model with specific regional way of thinking, manufacturing and organizational tradition, specific education, and especially to **help Croatian enterprises to bridge the gap** between their competencies and EU enterprises' competencies and capabilities.

http://insent.fesb.hr

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Project INSENT
Main aim

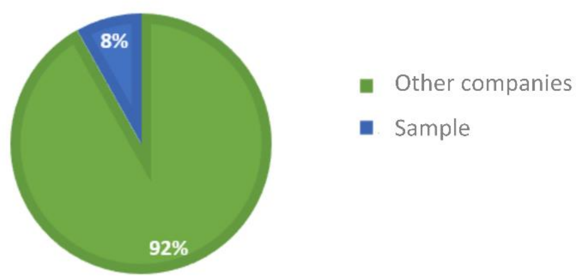
Analysis of the current state of Croatian manufacturing industry

Project Innovative Smart Enterprise (INSENT)

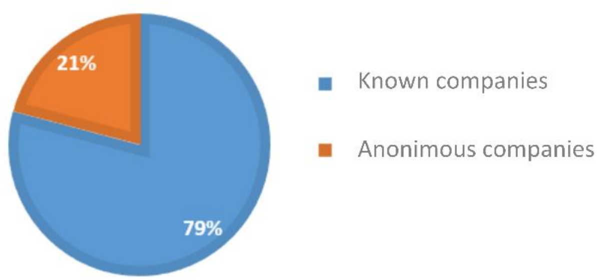
Industry 4.0

Where are we?

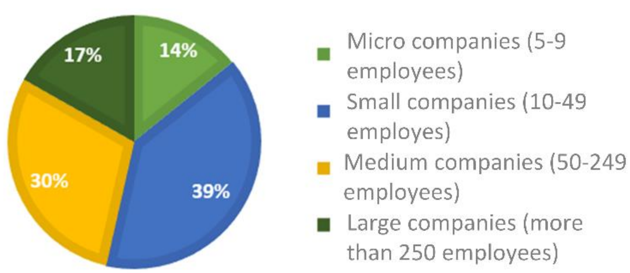
SAMPLE SIZE

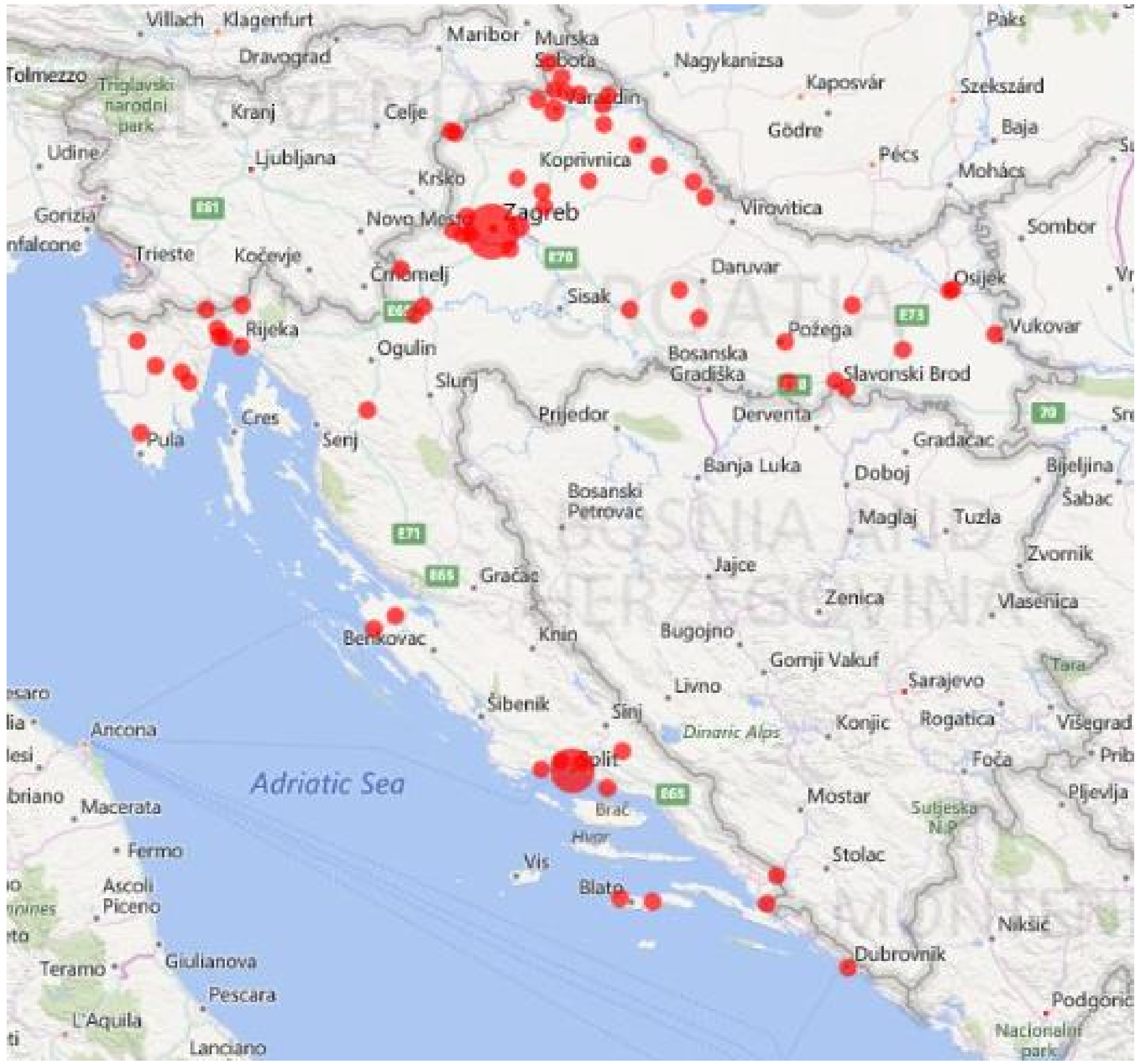


ANONYMITY OF RESPONSES

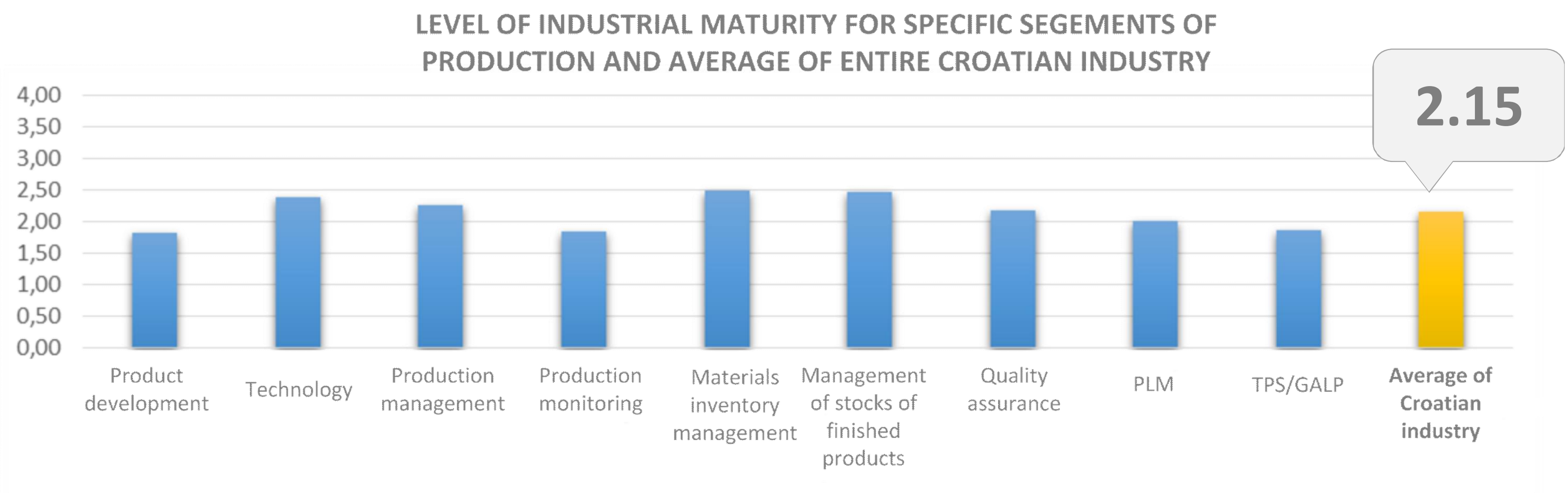


COMPANY SIZE





Results: Average level of Industrial maturity

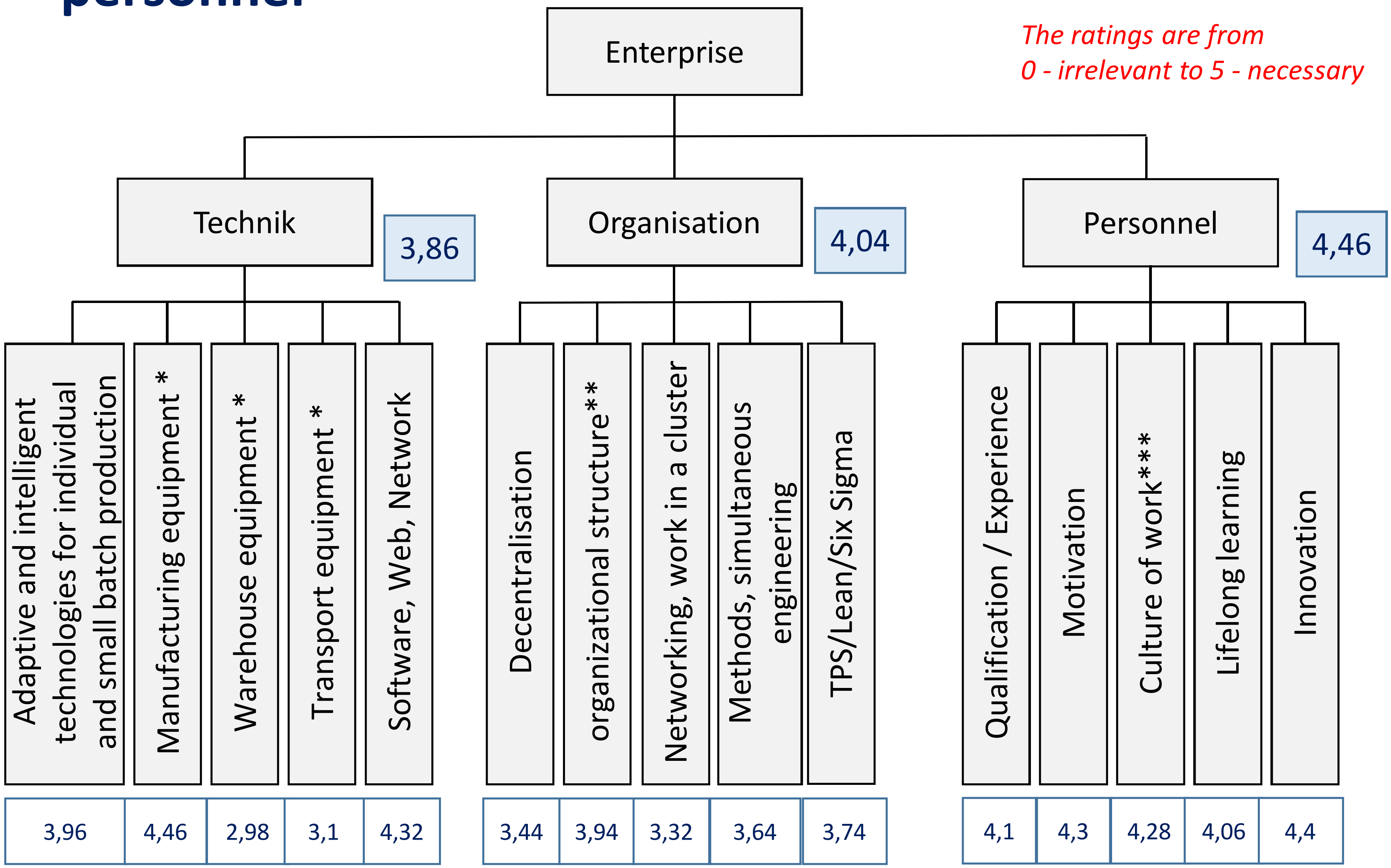


Range of Industrial Maturity Index in Croatia

To Industrial maturity index 3,4

From Industrial maturity index 1,7

Evaluation results of techniques, organization and personnel

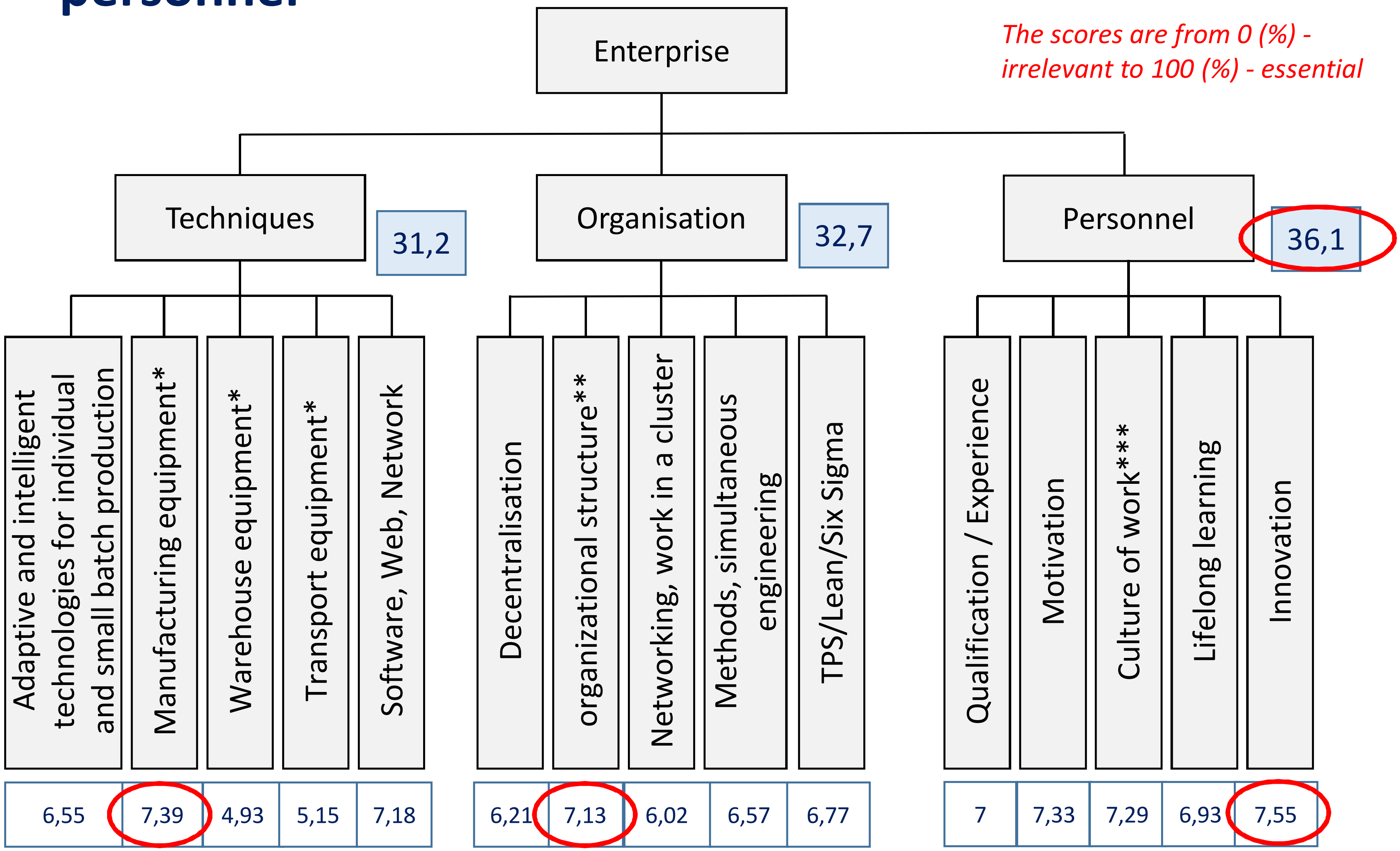


* The modularity, flexibility, intelligent components, automation

** Functional vs. process, project, fractals, profit centers

*** A holistic, interdisciplinary approach, teamwork

Evaluation results of techniques, organization and personnel



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** Functional vs. process, project, fractals, profit centers

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Analysis of personnel

1. **The age structure** (dominated by older workers with extensive experience and knowledge with an average 50 to 60 years).
2. **Level of the qualification**
   - Å From 5-10% of workers employed in the company has university degree, master's degree or a doctorate (in companies with more than 100 employees). A large percentage of companies have no research and development department.
   - Å Enterprises also complain about the lack of specific knowledge and competencies at all levels: industrial practice finished students, knowledge of a foreign language, computer application in product development and manufacturing, numerical control machine tools, basic knowledge in the field of mechanical engineering, naval architecture and mechatronics etc.
   - Å Only the rare enterprises give scholarships to students during high school and university.

Analysis of personnel

3. **Motivation.** Enterprises often do not offer any type of motivation to its employees. Some companies believe that is sufficient motivation and wages alone, which is regular. In practice, the most common form of employee motivation is financial incentives to reward.
4. **Innovation.** Enterprises generally do not have developed system of monitoring employee innovation. Exceptions are those companies that have a service that tracks innovation and suggestions for improvements by employees and such proposals rewards and recognized. They are mostly companies that largely cooperating with foreign companies and a high proportion of their production is exported.
5. **Life-Long Learning.** Other important factors include the following areas: **foreign language skills, knowledge of legislation, management skills, knowledge of ISO norms and standards of quality assurance products, computer aided design and manufacturing, design, knowledge of specific computer programs and tools, knowledge of new technologies, handling equipment and machinery, etc.** There are rare enterprises whose employees spend more than 5 days per year on training. Also 95% of the enterprises has been solved retraining of employees.

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“Where we want to be?”

A synthesis of analysis of Croatian manufacturing enterprises will be done through development of Croatian model of Innovative Smart Enterprise (HR-ISE model).

HR-ISE model will be based not just on State-of-the-art theoretical models but also on State-of-the-art practical models like Lean Management philosophy from Toyota Production System.

A special efforts will be made to bridge the cultural and mentality gaps between State-of-the-art models and current Croatian model.

“How can we get there?”

A special learning environment will be established in one Laboratory. It will be a Learning Factory, i.e. simulation of a real factory through specialized equipment (virtual reality gadgets, specialized assembly tables, real products, automatic assembly station, etc.).

Laboratory will be organized to simulate factory based on HR-ISE model. Hence, Laboratory will be learning environment not just for students but for engineers from manufacturing enterprises. It will be a place in which transfer of developed HR-ISE model to the economy subjects will be achieved.

All supporting material and equipment for education will be provided.

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Vision and Mission of Lean Learning Factory at FESB

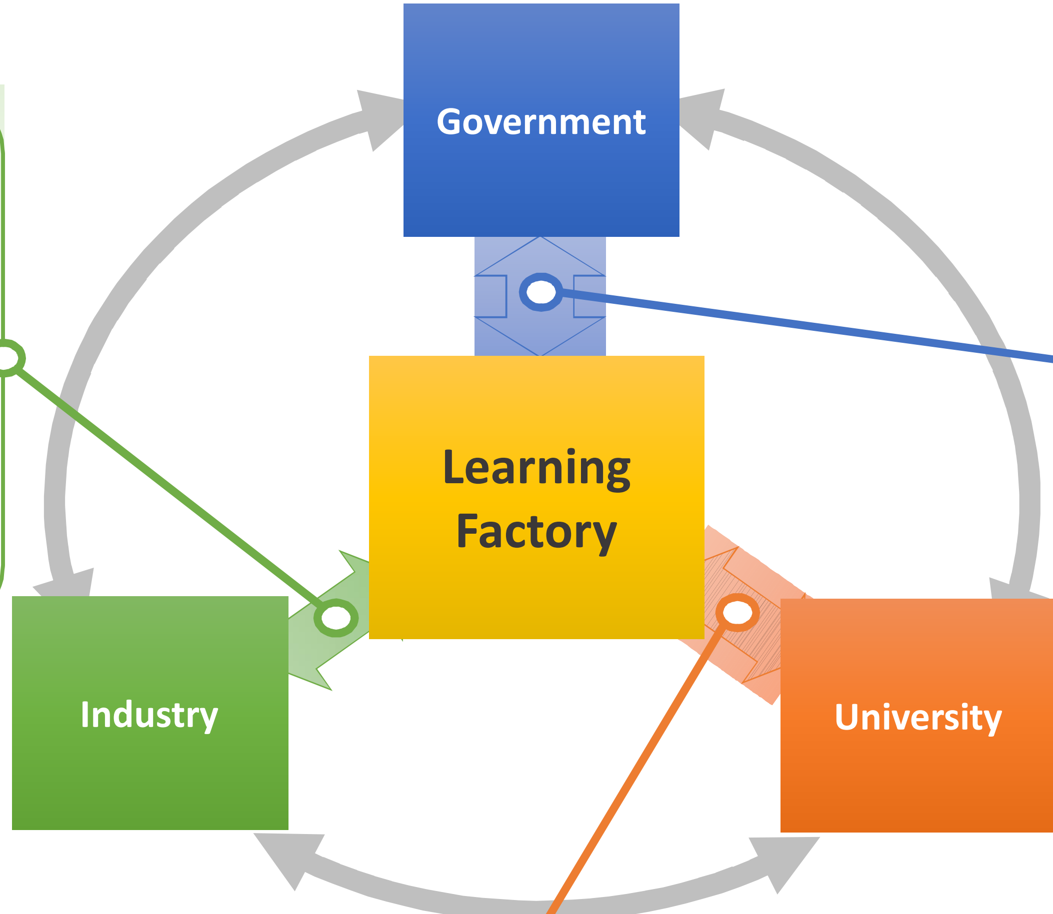
- Vision of Lean Learning Factory at FESB is to be a place where University, Industry and Government meet each other share needs and expectations, and work on collaborative projects.

- Mission of Lean Learning Factory at FESB is to help bring the real-world into the classroom by providing practical experience for engineering students, to help transfer latest scientific research to industry through collaborative projects and LLL, and to help government identify needs of industrial enterprises.

- “Living lab” will be based on Learning Factory concept, and aims will be achieved through projects: **NIL (DAAD project)** and **INSENT (CSF project)**.

Learning Factory as a missing link in Triple helix model

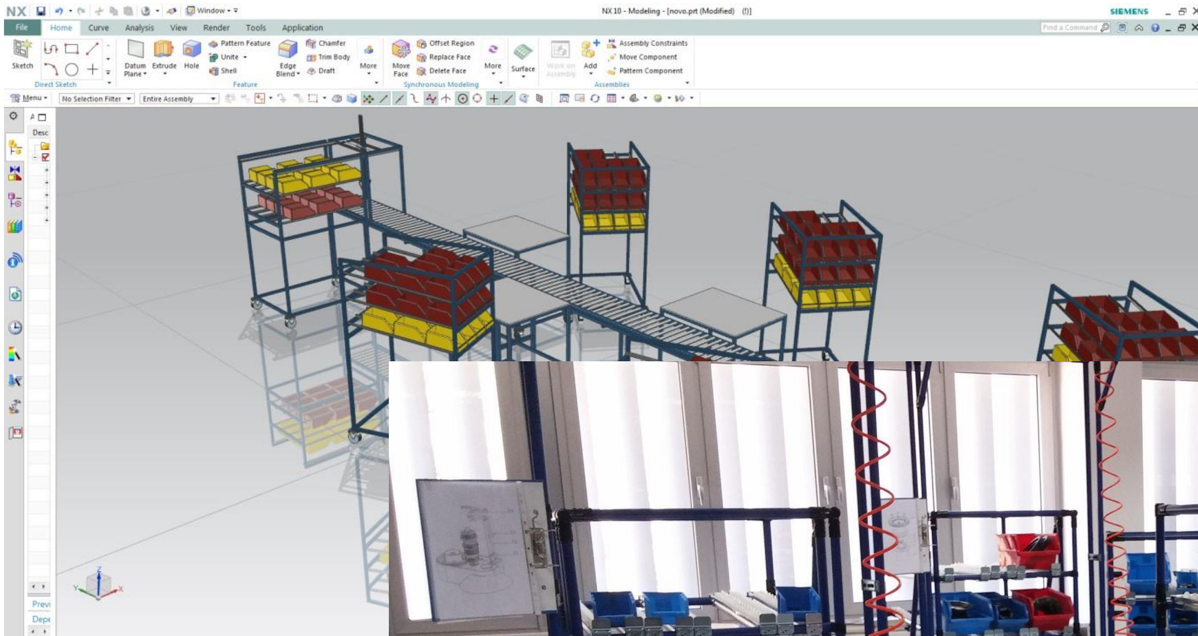
Å Collaboration with industry
Å Real life projects
Å Life-Long Learning
Å Transfer of latest scientific research to industry



Å Identification of industrial needs
Å Defining of industrial strategy
Å Spin-off and Start-up enterprises

Å Balance between engineering science and engineering practice
Å New curriculums and study programs

Planed reconfigurable assembly line in Learning Factory



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Competency Model for Industry 4.0

Traditional industry					Industry 4.0
Personal	Academic	Workplace	Industry		
Motivation Accountability Soft skills Integrity Interpersonal skills	Mathematics Computer science Critical and analytic thinking	Management Planning Marketing Problem solving Decision making Tools & technology Sustainability Continuous improvement	Manufacturing Production Maintenance Supply chain logistics Quality Sustainability Health and safety	+	Data mining Internet of things Virtual reality Continuous improvement RFID Customer oriented Sensors

Industrial engineers are the most suitable to fill the gap

Needs for new competencies will affect:

Elementary and high school education

University education

Life long learning

Special human abilities

Å Feeling, emotion, sensation
Å Experience, process memory
Å Solution competence
Å Ability to judge, decision-making ability
Å Combination ability
Å Fantasy
Å Flexibility
Å Rapid adaption to different environmental conditions
Å Intention ability and will power
Å Communication ability

Technology can support these abilities, but not substitute them.

It is a main task of a human centered work design to foster these abilities!

Source: H.-J. Bullinger, 23. International Conference for Production Research ICPR, Manila 2015

Special technology abilities

Sensors, IT, Cloud Data, networking

Å Processing Big Data
Å Objectivity, impartiality
Å Clear reaction pattern, predefined activity
Å Detection of well defined signals / actions with high reliability
Å Measuring and counting of physical values
Å Reliable reaction on clear input signals
Å Output signals without fatigue
Å Multitasking ability
Å No disposition
Å Rapid linking of constraints
Å Linking of value added processes, business models

Technology is in this case superior to human beings.

In a human centered work design technology can complement the needed ability!

Thank you for your attention

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