"Innovative Smart Enterprise - Case study of Croatia"

Prof. Ivica Veža

Faculty of Electrical Engineering, Mechnical Engineering and Naval Architecture – FESB, University of Split, Croatia

João Pessoa, October 4th 2016

hrzz
Hrvatska zaklada za znanost

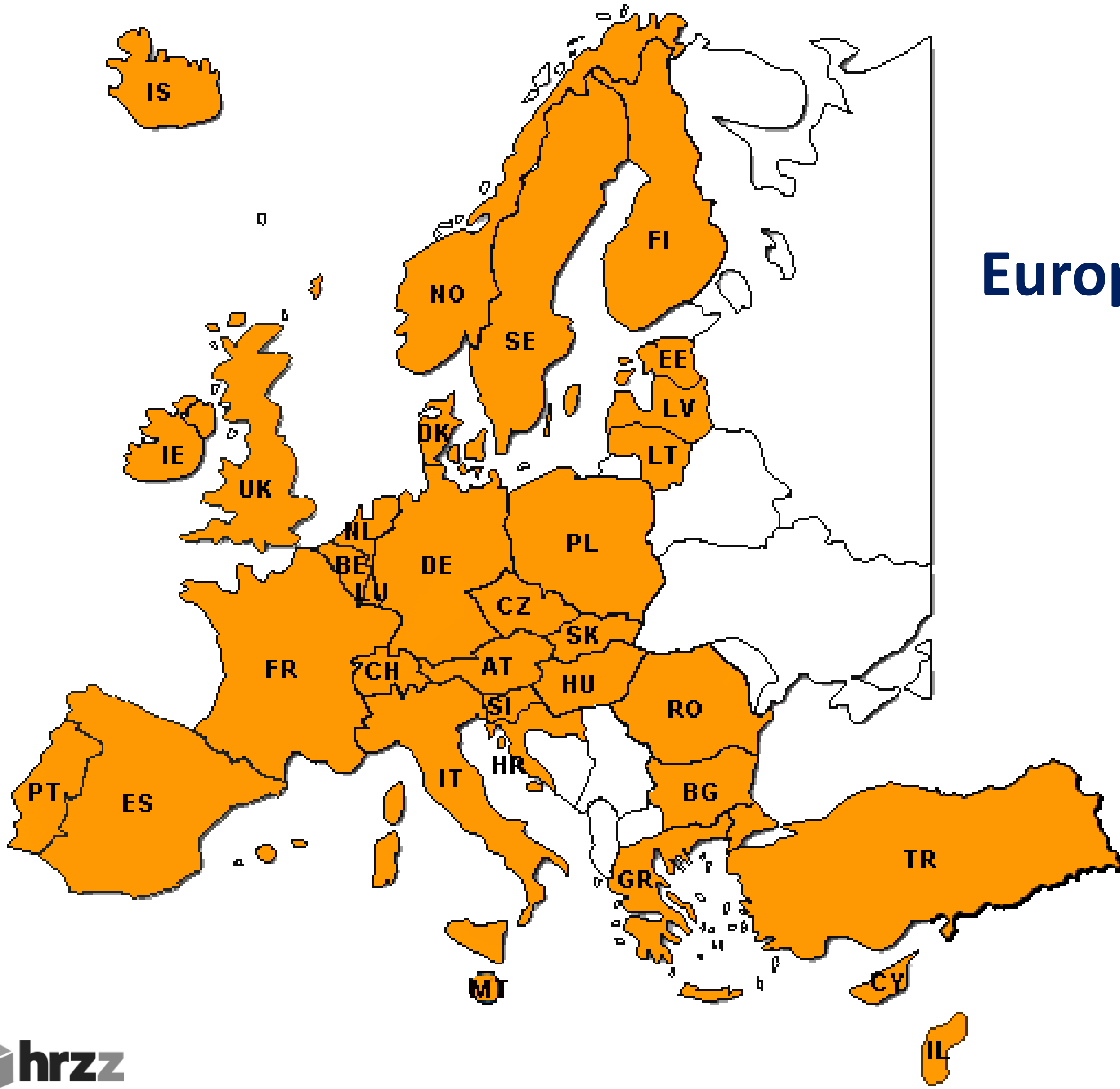
Agenda

1. Introduction
2. Industry 4.0
3. Project Innovative Smart Factory INSENT
4. Lean Learning Factory
5. Conclusion

Agenda

1. Introduction
2. Industry 4.0
3. Project Innovative Smart Factory INSENT
4. Lean Learning Factory
5. Conclusion

hrzz
Hrvatska zaklada za znanost



Europa – Croatia?

hrzz
Hrvatska zaklada za znanost

hrzz
Hrvatska zaklada za znanost

OUR ROLE IN CROATIA

- Largest Croatian county with surface area of 14,045 km2 (mainland 4,572 km2)
- Highest number of inhabitants among Croatian counties (464 thousand)
- Total 55 local self-government units, out of that 16 cities and 39 municipalities
- Natural diversity (hinterland, coastland, islands) and attractions (Natural Park Biokovo, Cetina River, Zlatni Rat beach, Blue Cave…)
- Rich cultural heritage: UNESCO (Old Town Split with Diocletian's Palace, Old Town Trogir), archaeological findings (Salona, Pharos, Issa), events (Split Summer Festival, Harmony-Singing Festival Sinjska Alka chivalrous tournament)…
- BDP in 2006 approximately EUR 6.000 per capita (approx. 80% Croatian average)
- Approx. 142 thousand of employees total

ECONOMY DEVELOPMENT - ACTIVITIES OF COUNTY ECONOMIC DEVELOPMENT DEPARTMENT

- *The successfully society does not miss development chances; it undertakes steps in order to they would create it.*

ECONOMIC RESTRUCTURING PROGRAM

CLUSTER DEVELOPMENT

SMALL AND MEDIUM SIZE ENTERPRISE INCENTIVE PROGRAM

DEVELOPMENT FUNDS

ENTREPRENEURSHIP ZONE ESTABLISHING PROGRAM

MASTER PLAN OF TOURISM

AGRICULTURE AND AGROTOURISM DEVELOPMENT PROGRAM

SCIENCE-TECHNOLOGY PARK

ENERGY DEVELOPMENT PROGRAM

Split is the cultural and economic hub of Central Dalmatia.

It grew out of the Palace of the Roman Emperor Diocletian, built around AD 300 and now a place where ancient times live on along side the urban rhythm of the twentieth century. Its 1700 years of living history is protected by the UNESCO and will always fire the interest of visitors and travellers.

Split

Diocletian’s palace 305-2005

hrzz
Hrvatska zaklada za znanost

CITY PROFILE

SPLIT – CITY OF KNOWLEDGE

UNIVERSITY OF SPLIT

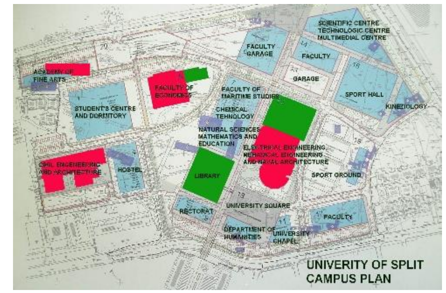
- The largest university in Dalmatia
- 11 faculties
- 3 university centers for studies
- University library
- Approximately one thousand professors and assistants
- Approximately 25 thousand students

OTHER INSTITUTIONS OF EDUCATION AND KNOWLEDGE

- 28 elementary schools
- 26 high schools
- Mediterranean Institute for Life Sciences

DEVELOPMENT PROJECTS

UNIVERSITY CAMPUS

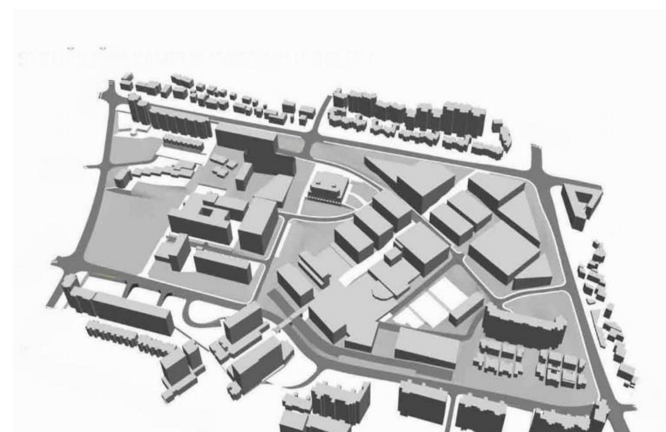


SURFACE
- 20,16 hectares

CONCEPT

Development of university campus with the following facilities:
- New buildings of several faculties
- Scientific center, technology center, and multimedia center
- University library
- Sports hall and sports courts
- Student center, student housing, and hostel
- Administrative and supporting facilities

INVEST.
- Approximately 180 million euros

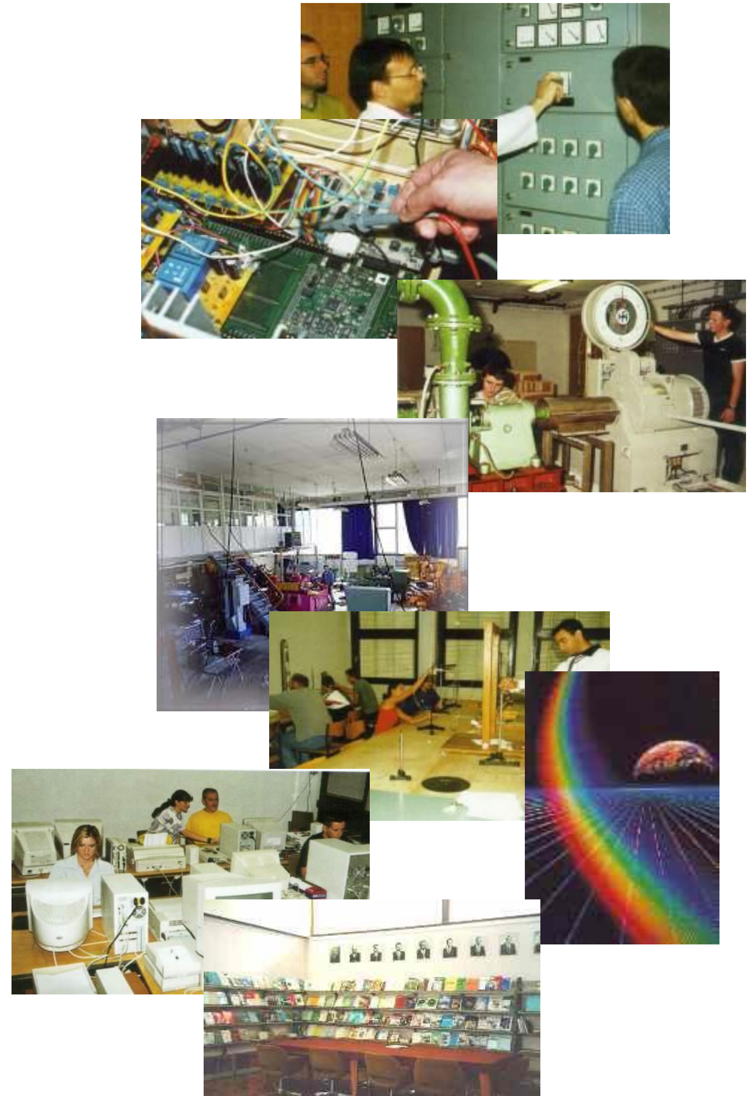


UNIVERSITY OF SPLIT
CAMPUS PLAN - 3D SIMULATION

hrzz
Hrvatska zaklada za znanost

Organisation

- Department of
  - Power engineering
  - Electronics
  - Mechanical engineering and naval architecture
  - Mechanical technology
  - Mathematics and physics
  - Centre for common courses
- Computing centre
- Library
- Office of the Dean
- 250 employees
  - 170 lecturers and researchers



Some statistics

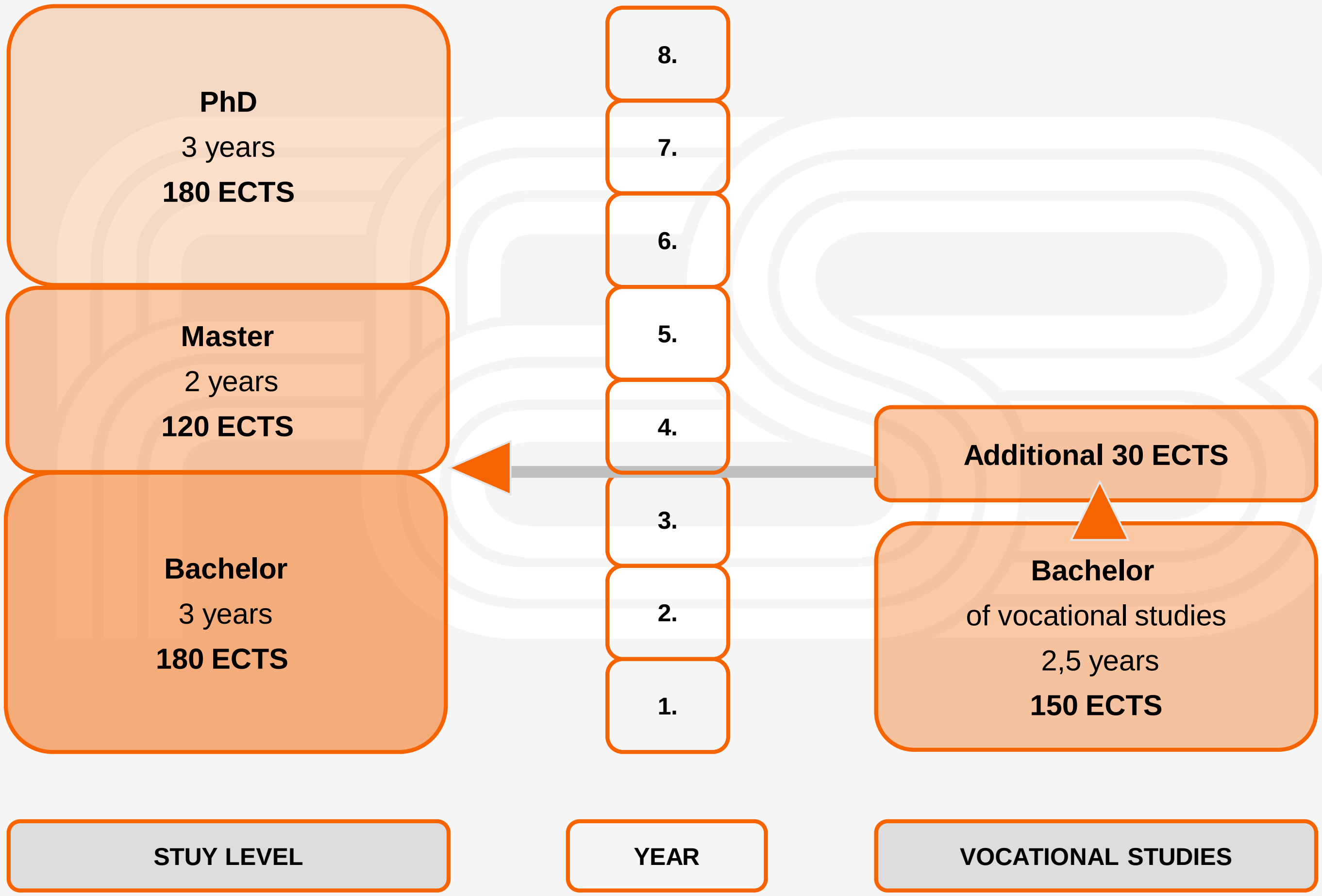
Students:

Bachelor/Master	Vocational studies
Current number of students	
1700	650
Enrolled in 2014./2015.	
450	200
Graduated	
3800	1500
Master of science	**PhD**
75	40

Teaching stuff:

Full professors	26
Associated professors	17
Assistant professors	16
Assistants and lecturers	54
Technical support	18

Bologna process @ FESB



Electrical Engineering and Information Technology

- Freshmen per year: 200 (40 paying fees)

- **Bachelor of**
  - ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY

- **Master of**
  - AUTOMATICS AND SYSTEMS
  - ELECTRONICS AND COMPUTING ENGINEERING
  - ELECTRICAL ENGINEERING
  - COMMUNICATION AND INFORMATION TECHNOLOGY

Computing

- **Bachelor of**
  - COMPUTING
    - First year: general knowledge and basic programming
    - Second year: databases, algorithms, OOP, discrete systems …
    - Third year: networks, software engineering, distributed systems, business systems …

- Freshmen per year: 80 (50 paying fees)

- **Master of**
  - COMPUTING
    - Advanced programming
    - Advanced distributed systems
      - e.g. research in GRID
    - Advanced architectures
    - Multimedia systems …
    - Diploma thesis – whole semester

Mechanical Engineering

- **Bachelor of**
  - **MECHANICAL ENGINEERING**
    - Freshmen per year: 90

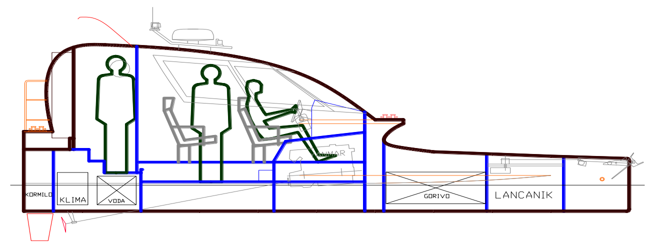
- **Master of**
  - **MECHANICAL ENGINEERING**
  - **Specialisations in:**
    - **ENGINEERING DESIGN**
    - **PRODUCTION ENGINEERING**
    - **COMPUTER AIDED DESIGN AND ENGINEERING**

Naval Architecture

- **Bachelor of**
  - **NAVAL ARHITECTURE**
    - Freshmen per year: 40

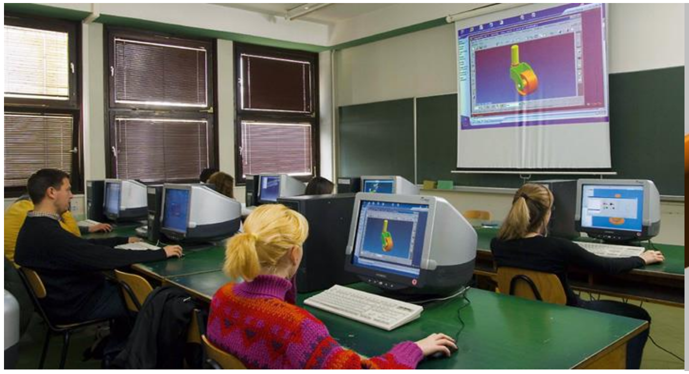


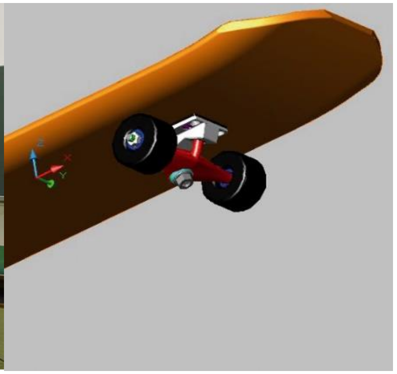

- **Master studies in Zagreb or Rijeka**



Industrial Engineering

- **Bachelor of**
  - **INDUSTRIAL ENGINEERING**
    - Freshmen per year: 80 (30 paying fees)





- **Master of**
  - **INDUSTRIAL ENGINEERING**

- **Joint study with Faculty of Economics in Split**

Research

Our researchers are

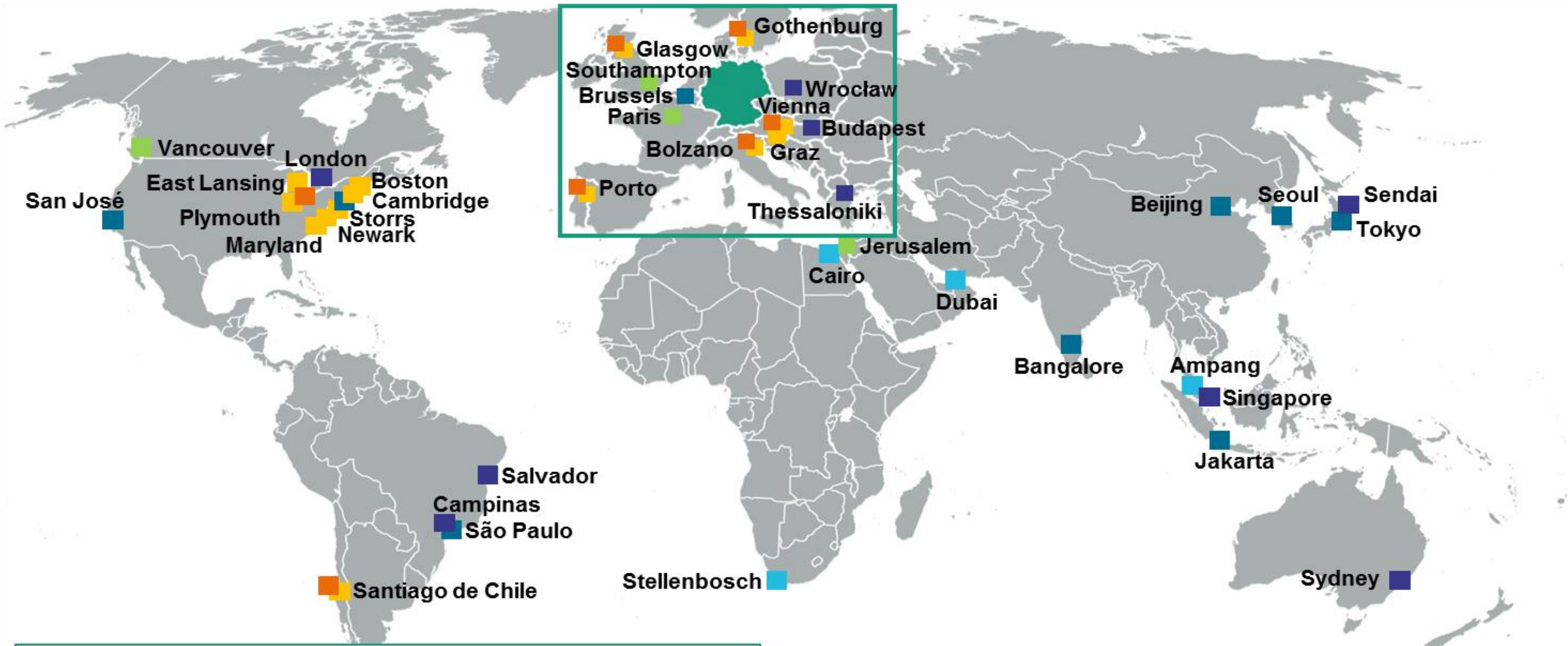
- Leaders of more than 60 scientific/technological/information technology projects sponsored by Ministry of science, education and sports
- ***Participating in international projects:***
  - Croatian-Slovenian cooperation program
  - COST (Electromagnetic Compatibility in Distributed and Complex Systems)
  - CEEPUS
  - TEMPUS
  - CERN (ALICE - A Large Ion Collider Experiment, CMS - Compact Muon Solenoid)
  - CROATEA (CRoatian Observatory At The Eastern Adriatic)
  - FP6 i FP 7, HORIZON 2020 projects
- ***Guest professors and guest scientists*** at many universities and labs
  - University of Berkeley, University Stuttgart, Technical University Berlin, Fraunhofer Institut fiir Betriebsfestigkeit, Columbia University, Imperial College of Science, University of Texas, Stanford University, Max Planck Institute, Universite Libre de Bruxelles, King's College London, University of Viena, University of Wales, Emory University Atlanta, Paul Scherrer Institute, Ecole Polytechnique, UNIDU ...

Ivica Veža: Curriculum vitae

- Professor in fields of Production Management, Production Systems, Plant Layout and Logistic,
- Specialization at Fraunhofer Institutes - IPA Stuttgart, IPK Berlin, RTWH Aachen – 3 years
- Published 10 books, 30 papers in journal and over 150 articles on domestic and foreign symposiums,
- Worked 3 years in Shipyard Split and development director in Jugoplastika Footwear Split
- Visiting professor: Nagoya University, Japan; Technical University Vienna, Austria; Malta College of Arts, Science and Technology – MCAST, Malta; University of Maribor, Slovenia
- Secretary of Mechanical Engineering and Naval Architecture department of Croatian Academy of Engineering
- Counselor of the president of Split-Dalmatian County for economy
- Member of the European Academy for Industrial Management AIM
- Head of the Technology Platform of Croatia www.manufuture.org
- Head of the Shipbuilding cluster of the Split-Dalmatian County

Fraunhofer-Gesellschaft

The leading organisation for applied research in Europe



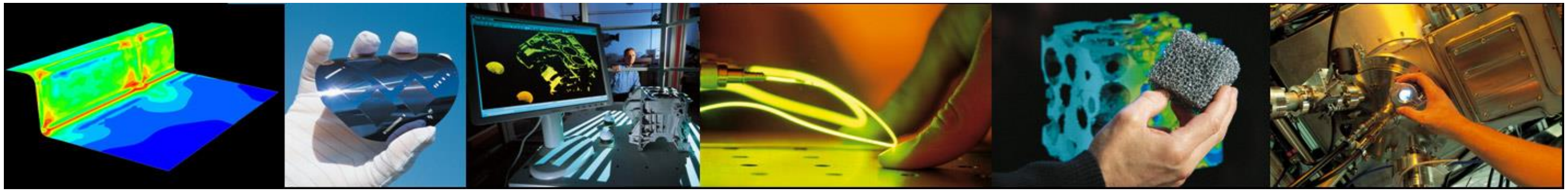
66 institutes, 80 research facilities
22 000 employees
€ 1.9 bn EUR research budget
2/3 of Project Turnover from Industry-Projects
1/3 of Project Turnover from Public Research-Projects

Subsidiary
Center
Project Center
ICON / Strategic Cooperation
Representative / Marketing Office
Senior Advisor

Fraunhofer Profile

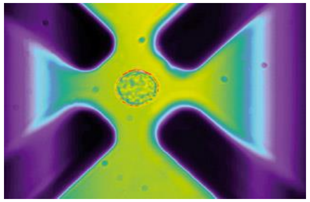
7 Alliances:

- Microelectronics
- Production
- Information and Communication Technology
- Materials and Components
- Life Sciences
- Surface Technology and Photonics
- Defense and Security



Fraunhofer Product Highlights

Exhibition guide
personalized information and navigation system



Cell lab
cells can be carefully sorted and characterized in an electro-magnetic field

Transparent ceramics

Tower 24
automatic storage and collection system for on-line purchases

Intelligent functional clothes
with integrated electronics, e.g. for bicycle couriers

Fuel cells
for mobile electronic devices

Kyoto

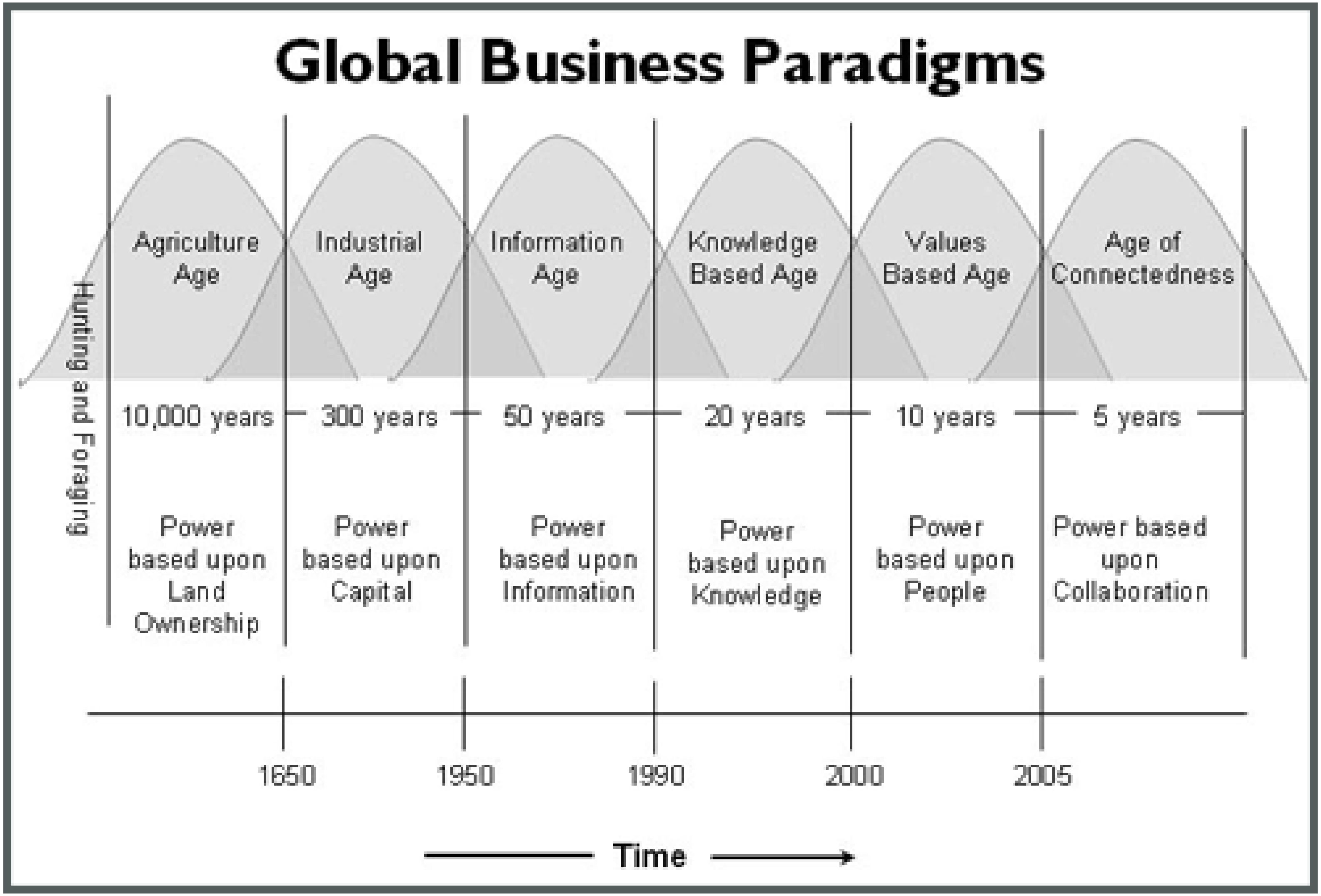
Tokyo

Nagoya


豊橋造船
300T

Agenda

1. Introduction
2. Industry 4.0
3. Project Innovative Smart Factory INSENT
4. Lean Learning Factory
5. Conclusion



Source: Guillory W. A, Harding C, Guillory D: "The FuturePerfect Organization - Driven by Quantum Leadership", 2004

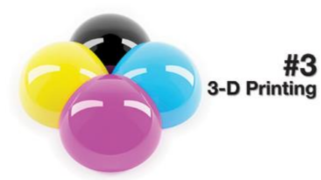
Megatrends - overview

Source: Abele & Reinhart, 2011; Credit Suisse, 2009; Credit Suisse, 2010; Geisberger & Broy, 2012; Z_punkt & BDI, 2011

hrzz Hrvatska zaklada za znanost

Technology trends

Merging Real and Virtual World

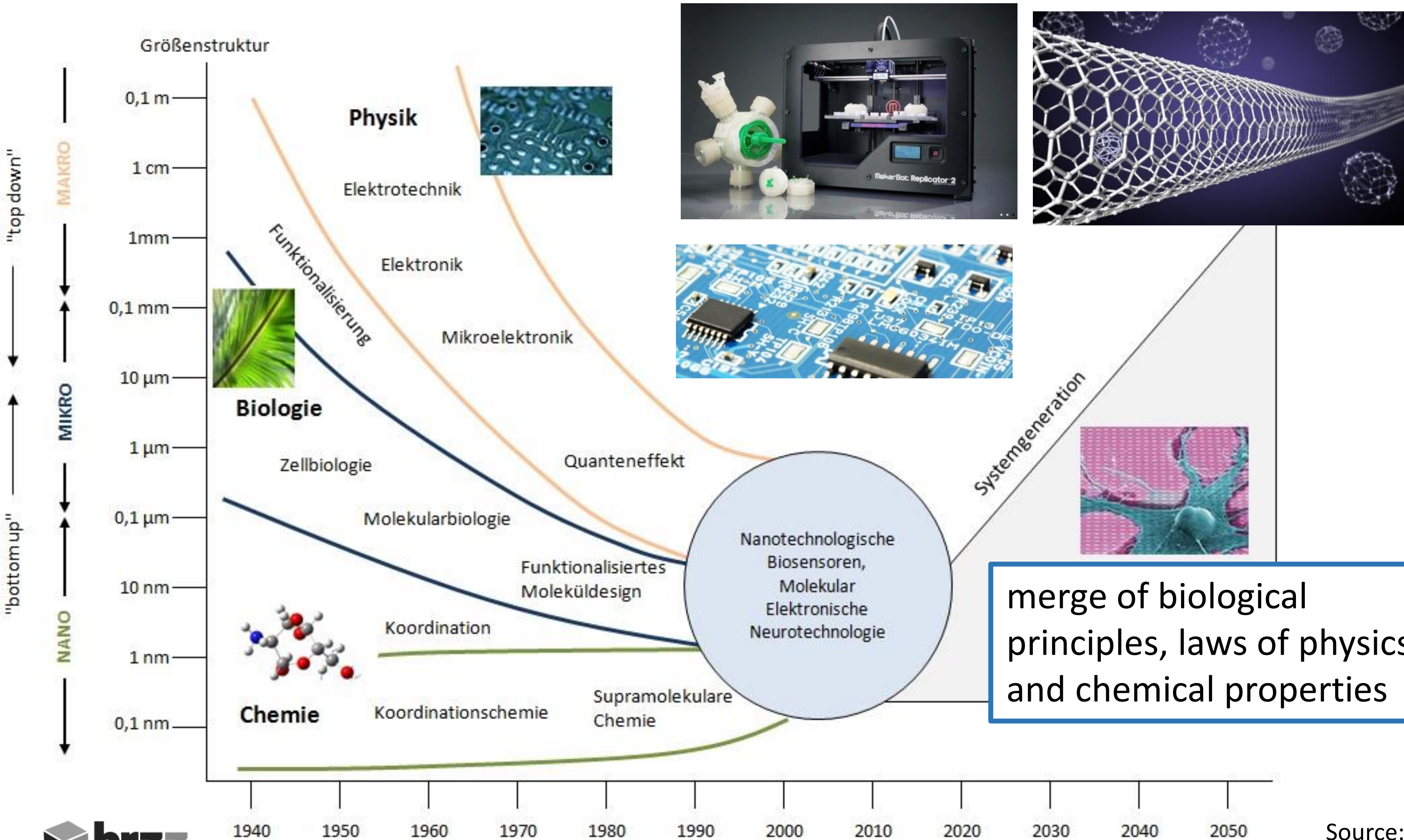


Intelligence everywhere

New IT Reality

Source: Gartner | information-management.com

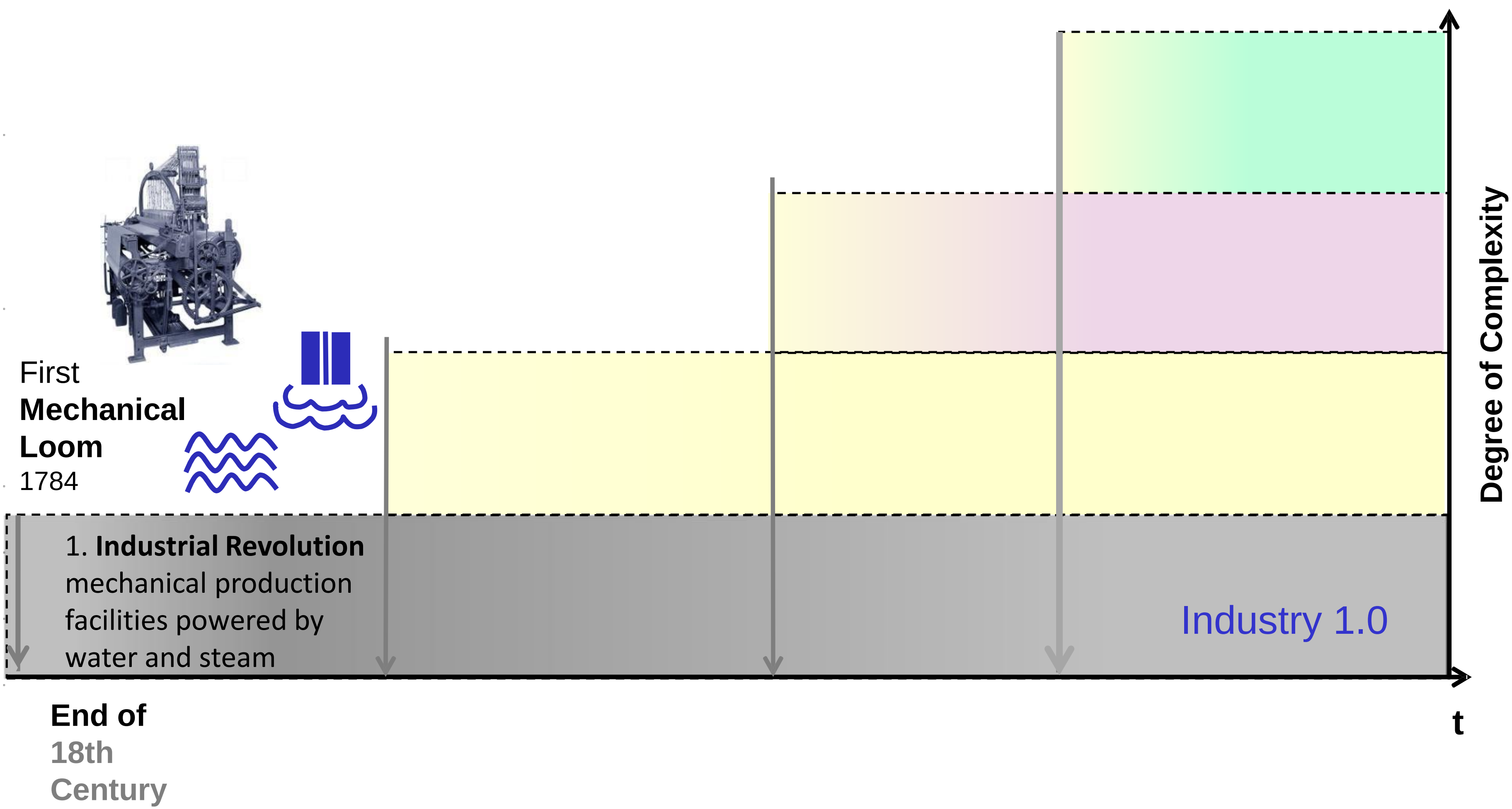
New materials and technologies



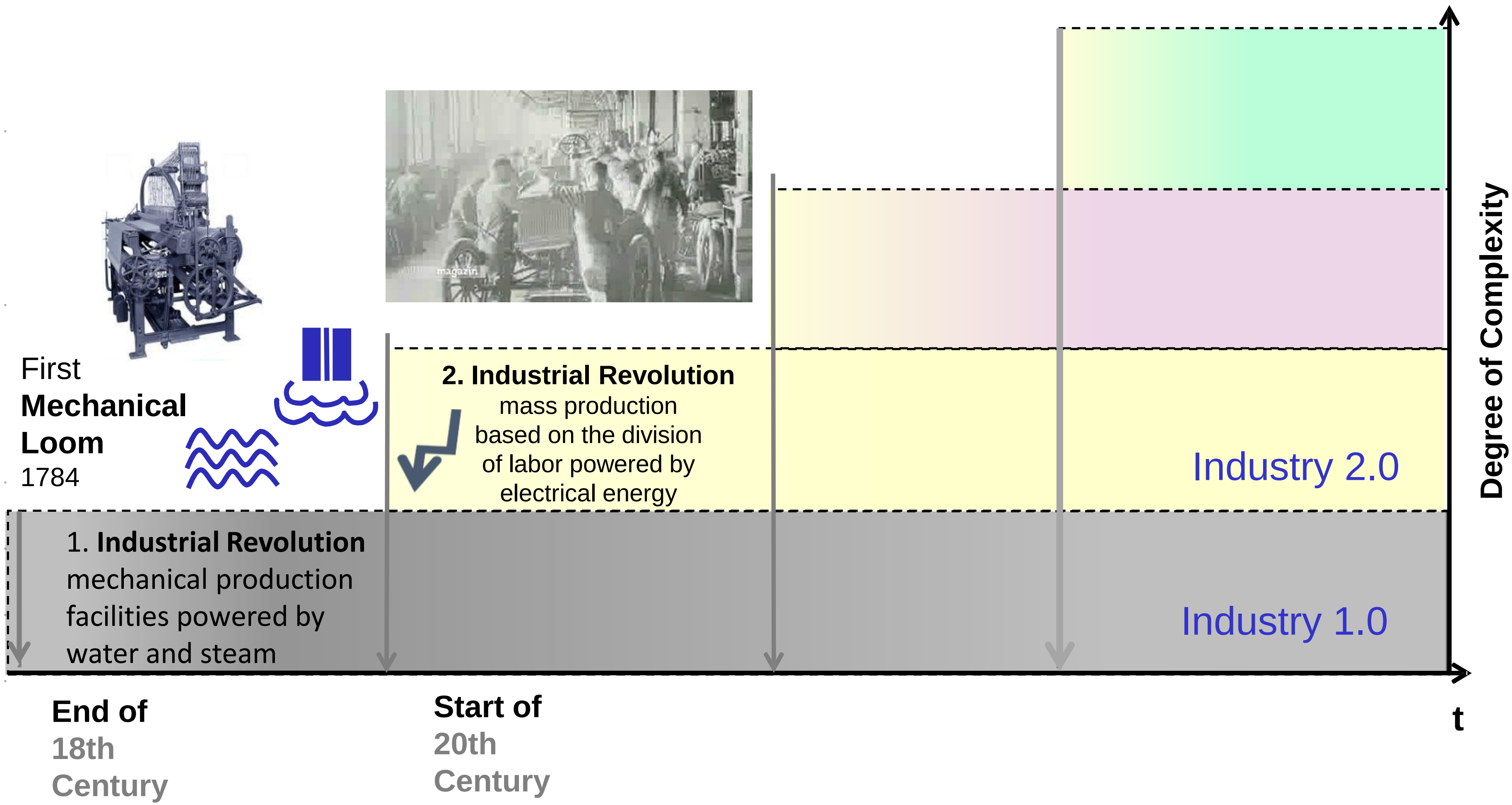
merge of biological principles, laws of physics and chemical properties

Source: H.-J. Bullinger 2009

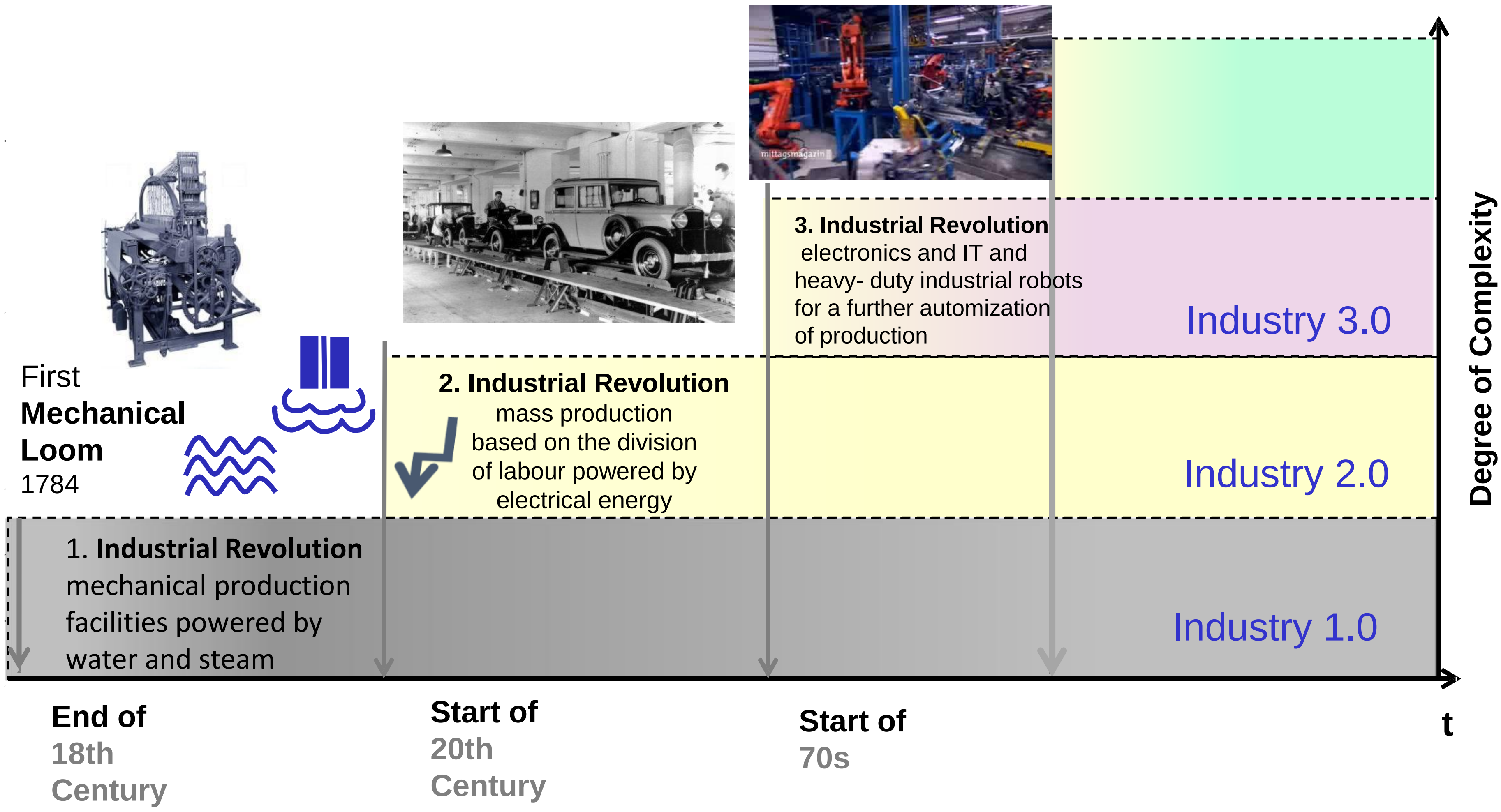
From Industry 1.0 to Industry 4.0: Towards the 4th Industrial Revolution



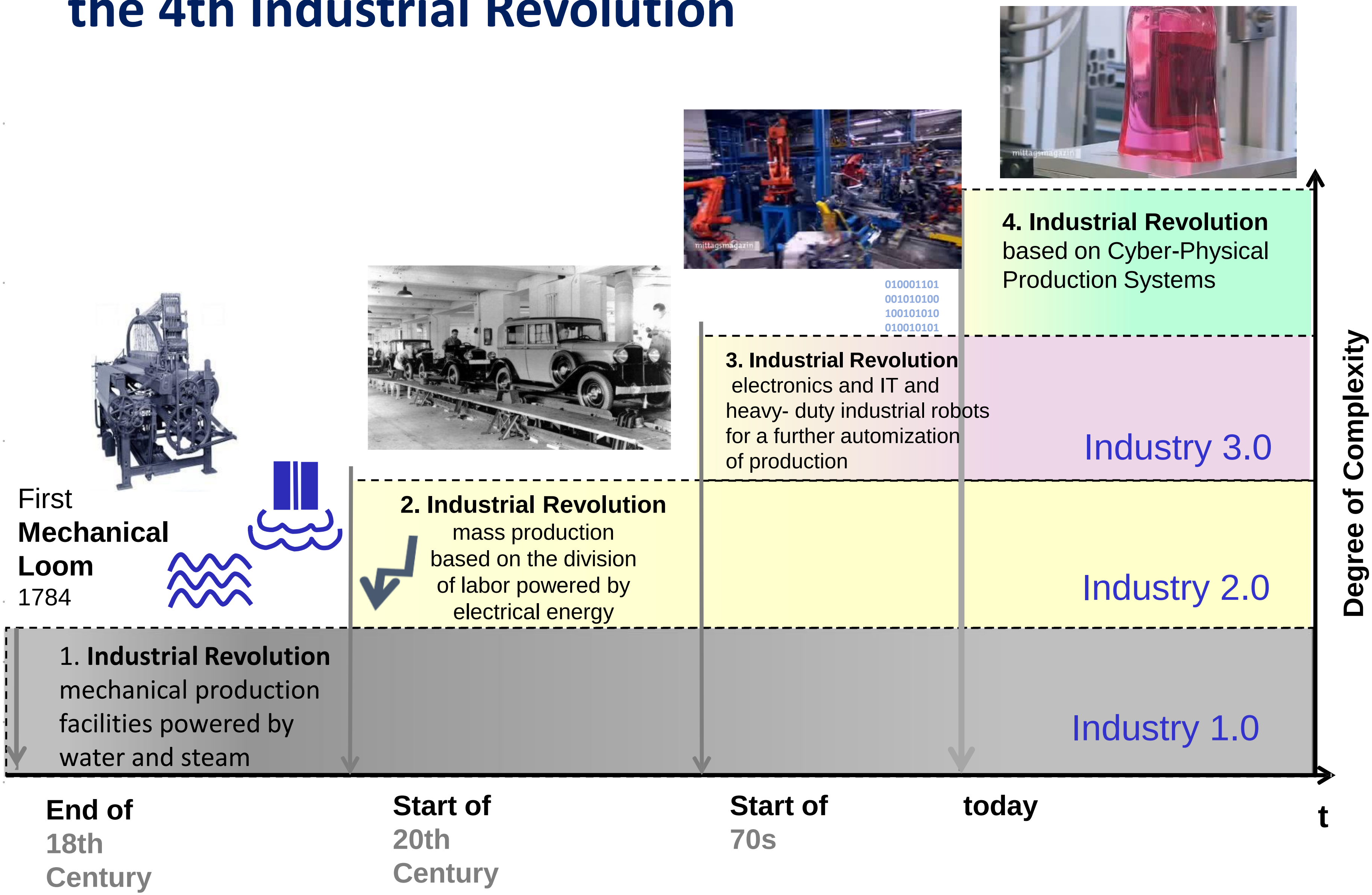
From Industry 1.0 to Industry 4.0: Towards the 4th Industrial Revolution



From Industry 1.0 to Industry 4.0: Towards the 4th Industrial Revolution



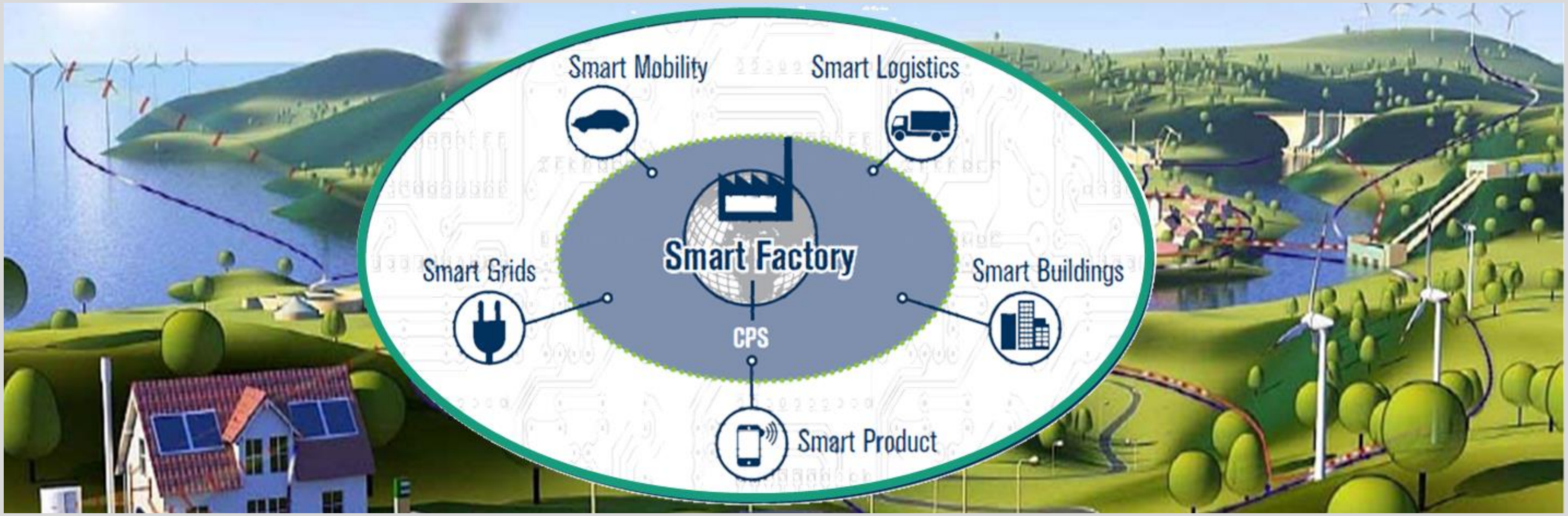
From Industry 1.0 to Industry 4.0: Towards the 4th Industrial Revolution

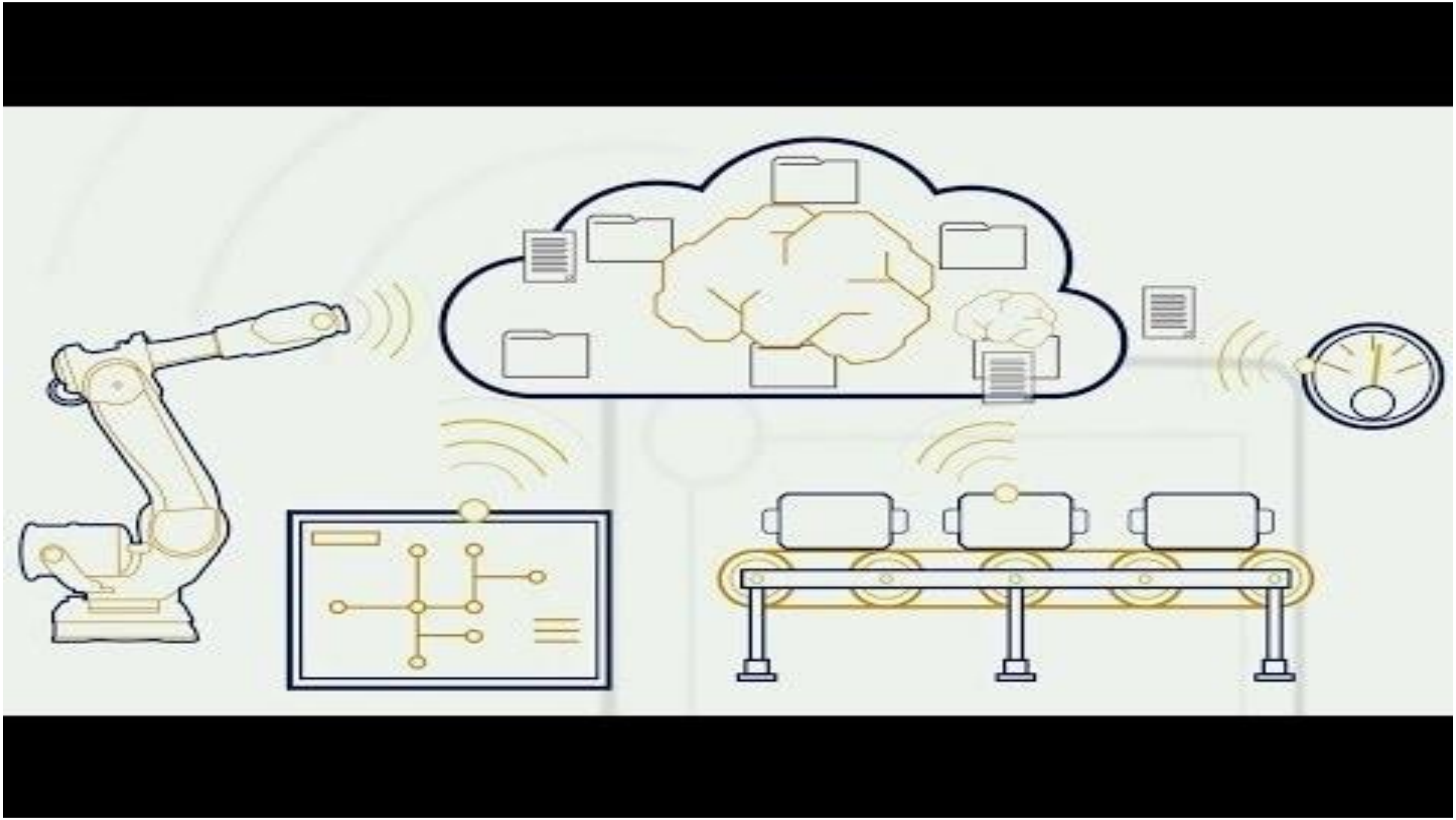


Industry 4.0 – What is it about?

Definition Industry 4.0

- “Industry 4.0“ encompasses the **integration of state-of-the-art information- and communication technology (ICT) with conventional physical production and processes,** which enables the **development of new markets and business models**.
- “Industry 4.0” thereby targets the question of **how this integration can generate a customer-individual benefit,** for which the client is willing to pay.





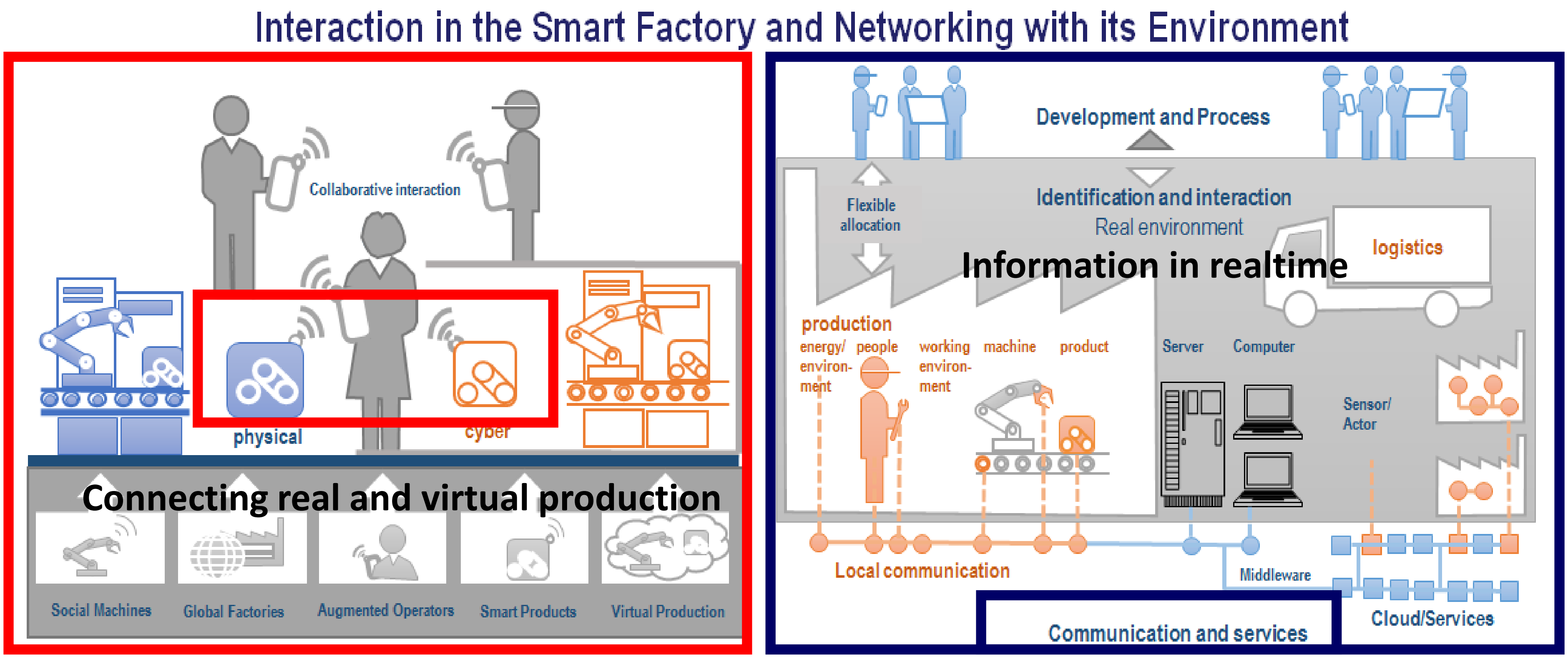
hrzz
Hrvatska zaklada za znanost

Cyber-Physical Systems

- „physical and virtual, local and global, horizontally and vertically networked systems, dynamic system boundaries, partial or complete autonomy, active real-time control, cooperation and comprehensive cooperation between human and system“
- “cyber-physical systems”, “internet of things”, “smart factory” and “industry 4.0” belong together

Source: E. Geisberger, E. and M. Broy, M., agendaCPS – Integrierte Forschungsagenda Cyber-Physical Systems (acatech STUDIE), Springer, 2012.
J. Jasperneite: “Industrie 4.0 - Alter Wein in neuen Schläuchen? ”, Computer & AUTOMATION, Vol.12, pp.24-28, 2012

Industry 4.0 and Cyber-Physical (Production-) Systems



- The concept of the smart factory is based on flexible and consistent networking of the data sources on the basis of a services model.
- This enables (partly) autonomous and self-organized processes, which lead to increased efficiency and flexibility..

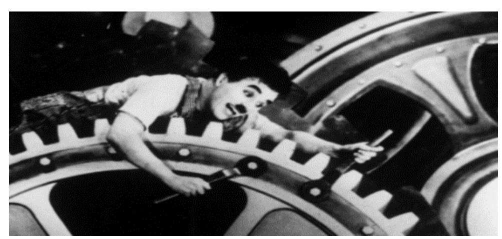
Source: Abschlussbericht des Arbeitskreises Industrie 4.0, Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0, (2012).

Industry 4.0 - What should we pay attention?

Design aspects of Cyber-Physical Production Systems

Focus: Organiszation

Focus: Human



Focus: Technology

Implementation of the design aspects in Cyber-Physical Production Systems

Industry 4.0 – Robot meets Human

Increasing degree of automation

High level-reasoning (e.g. complex mathematical calculations) requires very little computation

Lower level human skills (e.g. walking) are carried out unconsciously by humans while they require enormous computational resources if carried out by robots

→ Moracev - Paradoxon

The development of co-operating, socio-technological systems results in an increasing degree of automation and is one of the main enablers of Industry 4.0

Source: www.fashini.net; Daimler – Dr. Stefan Kienzle

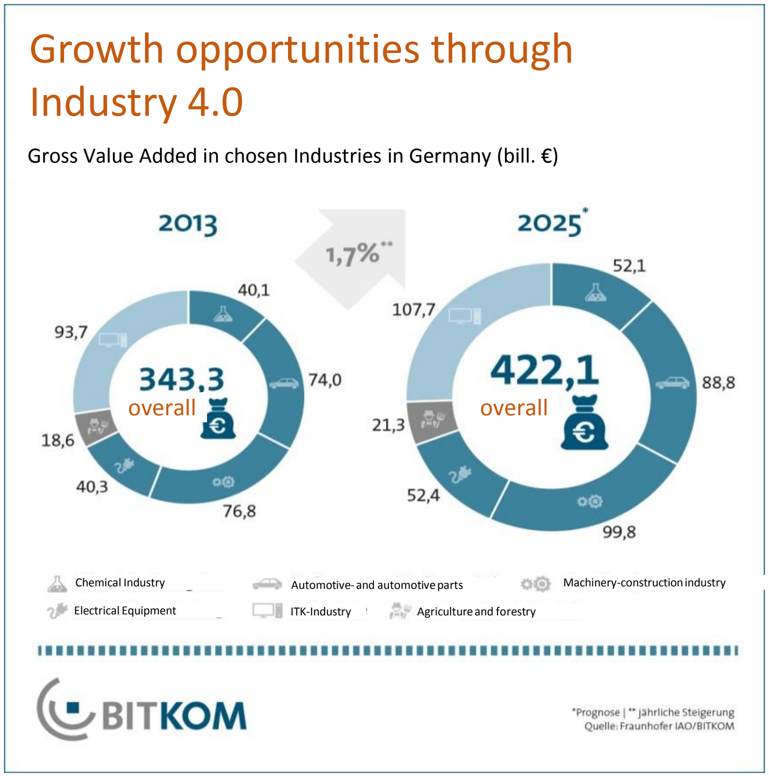
Industry 4.0 – Linking the World

…happens already

Source: next.pwc.at

Industry 4.0 – What are the Economic Potentials?

1,7% additional growth caused by Industry 4.0 - Germany



- The average growth of 1,7% per year and Industry is created through **innovative Products, new Services** & **Business Models** as well as **more efficient** operational **Processes**.
- The study investigated the potentials of 14 per cent of Germany‘s Gross Domestic Product (GDP)
  - Overall-effect are far reaching
  - Not all effects of interactional and systematic interconnections of different applications are assessable at the present

The application of Industry 4.0 regards to the whole value creation chain:

Distribution/Sales → Product development → Production → Logistics

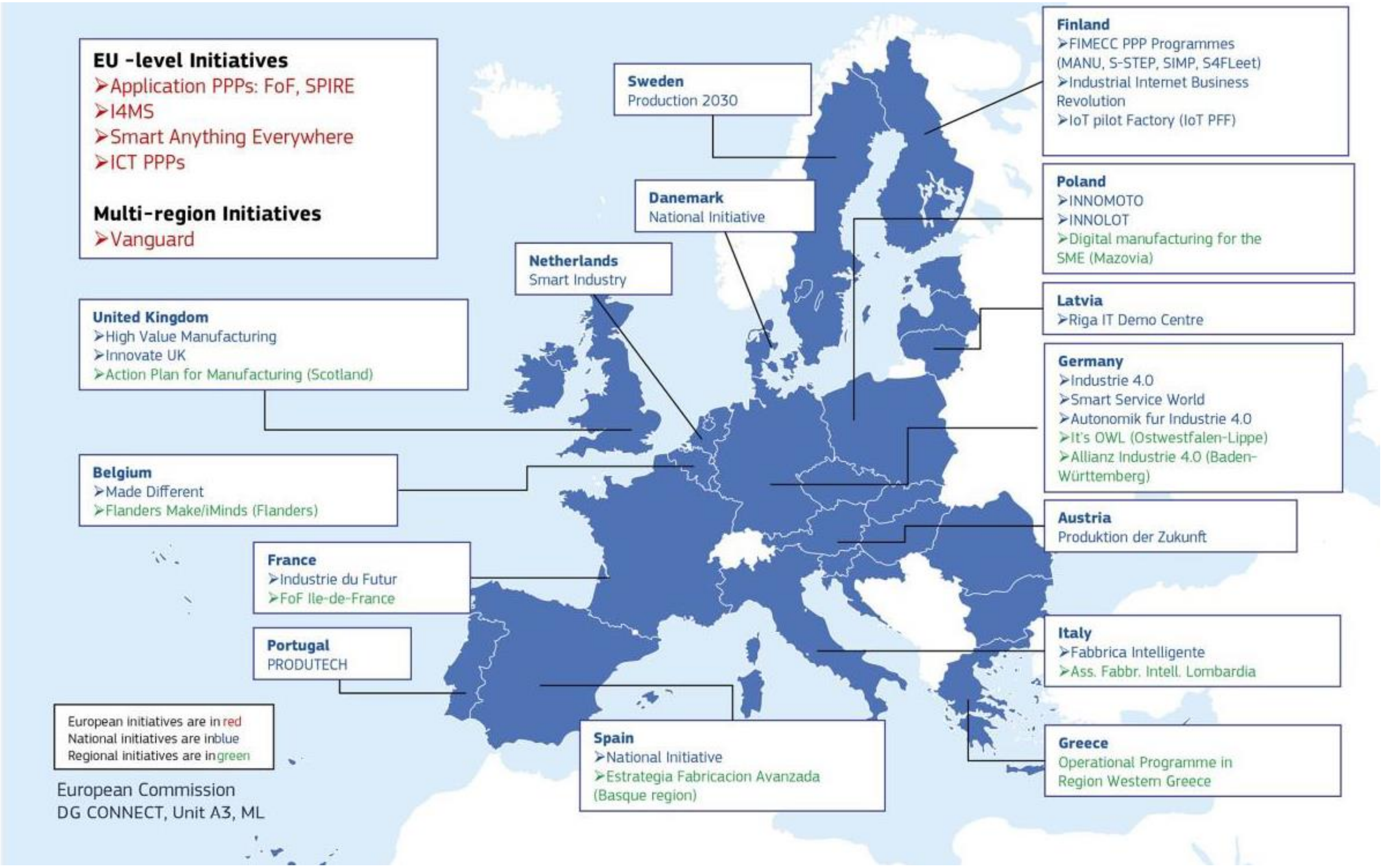
Source: BITKOM, Fraunhofer IAO

Initiatives around the world are accelerating the 4th industrial revolution

Source: World Manufacturing Forum, Barcelona 2016

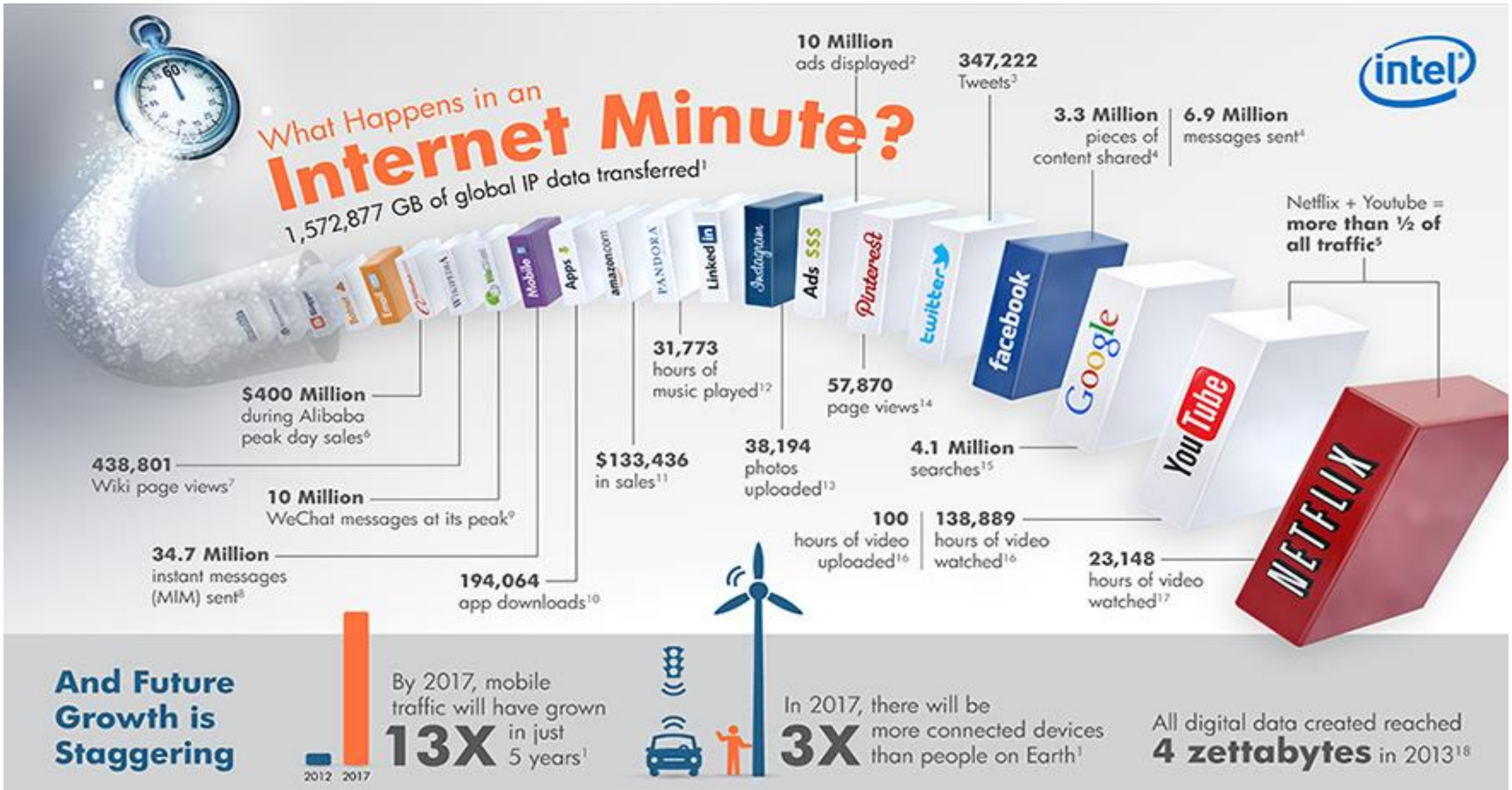
Industry 4.0

Overview of Digital Manufacturing Initiatives across Europe



Industry 4.0 – Linking the World

...happens already



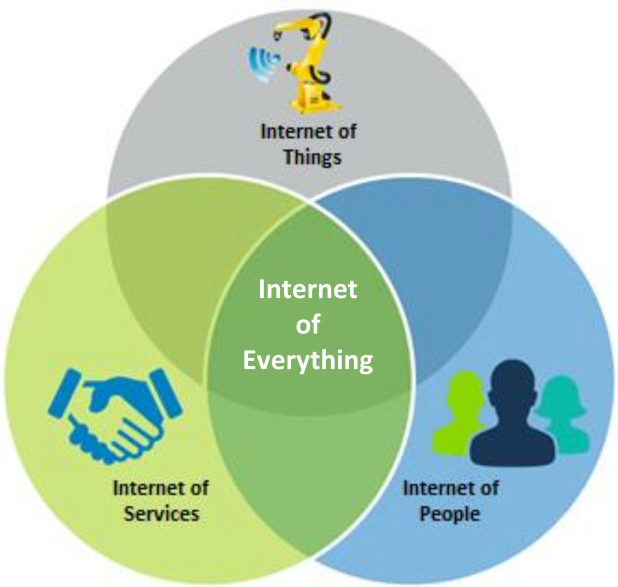
Source: http://www.intel.de

Industry 4.0

Internet of Everything (IoE)

- Linking **Things**, **Processes**, **Data**, **Services** and **People** on the Internet

- “**Internet of Everything**” as the ”**Intersection**“ of:
  - **Internet of Things (IoT)**
  - **Intern**
  - **Intern**

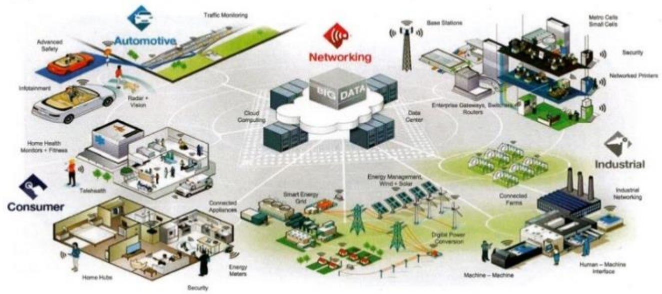


Source: http://www.tweaktown.com

Industry 4.0

Internet of Everything (IoE)

- Internet of Things (IoT)
  - Linking objects and computer on the Internet
  - Objects as for example machines, robots, sensors, control units, etc.
  - **In 2008** the Internet connected things exceeded the number of people living on earth
  - 2015 **25 billion Things** & 2020 **50 billion Things** are connected to the Internet



The linking of objects on the Internet is basis for Industry 4.0

- Internet of Services (IoS)
  - **IoS** goes hand in hand with the concept "**Cloud Computing**"
  - Whole software applications as for example programming environment, database, administration tools, servers, memory capacity, computing power, etc.
  - Dynamic coupling and smooth integration of software applications
  - Indirect use of software applications on a platform – service offered from a service supplier

Service is available on platforms → Similar tradable like a product

- Internet of People (IoP)
  - People will be connected in a more relevant and valuable way with each other
  - Person-to-Person communication via social media (Facebook, Twitter, etc.)
  - People define, program and monitor processes
  - We will still have the decision making authority
  - **IoP** also includes "Smart Wearables": Smart Clothes, Smart Watches, Smart Glasses, etc.

People have a central role in the "Internet of Everything"

Source: http://www.theregister.co.uk, http://www.davranetworks.com, http://www.elinext.com

Principles and Concepts

Industry 4.0

„Smart solutions - customized, flexible, fast“

Principles

Internet of things and services

- Service orientation
  - Standardization
  - Decentralization
  - Real-time capability
- Intelligent networking
- Blended reality (continuous connection between virtual and real world)

Technologies

- Cyber-physical systems on the basis of embedded systems
- Machine-to-machine communication
- Big Data

Smart Factory

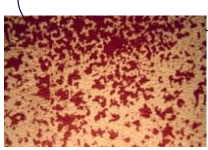
- Adaptability
- Continuous ergonomy
- Interoperabilität
- Resource efficiency
- Customer orientation

Smart Logistics

- Tracking
- Multi-agent systems

Smart Products

- Smart devices
- Gentelligent components

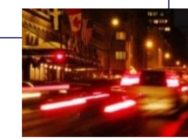


Smart Grid

- Micro-grid
- Virtual power plant
- Energy management

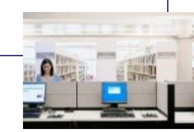
Smart Mobility

- Augmented Reality
- Traffic management
- Car2X communication



Smart Health

- Telemonitoring
- Medical network



Smart Home

- Smart meter
- Ambient Assisted Living (AAL)

Public-social level

Resource level

Industry level

hrzz Hrvatska zaklada za znanost

Industry 4.0

Internet of Everything using the example Microsoft HoloLens

- Microsoft HoloLens
  - Augmented-Reality-Glasses → Mixing reality and fiction
  - Allows the user to display interactive 3D-Projections as holograms in the direct environment

Source: https://www.microsoft.com/microsoft-hololens/en-us

Microsoft HoloLens

Industry 4.0

Internet of Everything using the example Microsoft HoloLens

- Internet of Things
  - Glasses are connected directly with the Internet
  - The glasses can also be connected with other devices and communicate with them

- Internet of Services
  - Software as a Service → Providing software-applications from various suppliers
    - Apps for private use (weather, games, tutorials, TV, etc.)
    - Software uses for professional use (CAD, meetings, assembly-instructions, etc.)
  - Infrastructure as a Service → providing of for example storage space
  - Interaction and dynamic-coupling of the various software-applications

- Internet of People
  - Person-to-Person communication (Social Media, Skype, etc.)
  - Person-to-Machine communication
  - Smart Wearables (combine the HoloLens with for example a Smart Watch)

Source https://www.microsoft.com/microsoft-hololens/en-us

Industry 4.0

Results and potentials through the „Internet of Everything“

- The “Internet of Everything” will create an economic potential of **12,6 Trillion Euro** from 2013 to 2023
    - **2,2 Trillion Euro** – Better use of existing infrastructure
    - **2,2 Trillion Euro** – Employee-productiveness and -effectiveness
    - **2,4 Trillion Euro** – Improved value chain and logistics while avoiding additional waste
    - **3,2 Trillion Euro** – Improved customer loyalty
    - **2,6 Trillion Euro** – Shorter times up to the product maturity

- Driver for new Business Models
    - Business Model Innovations caused by new Information Technologies
    - Business Models become digital → “Who does not digitalize now, leaves the added value to others“

- Driver for new Service Models
    - E.g.: Internet of Services, B2B-Web-Shop, better communication with customers, After-Sales-Services

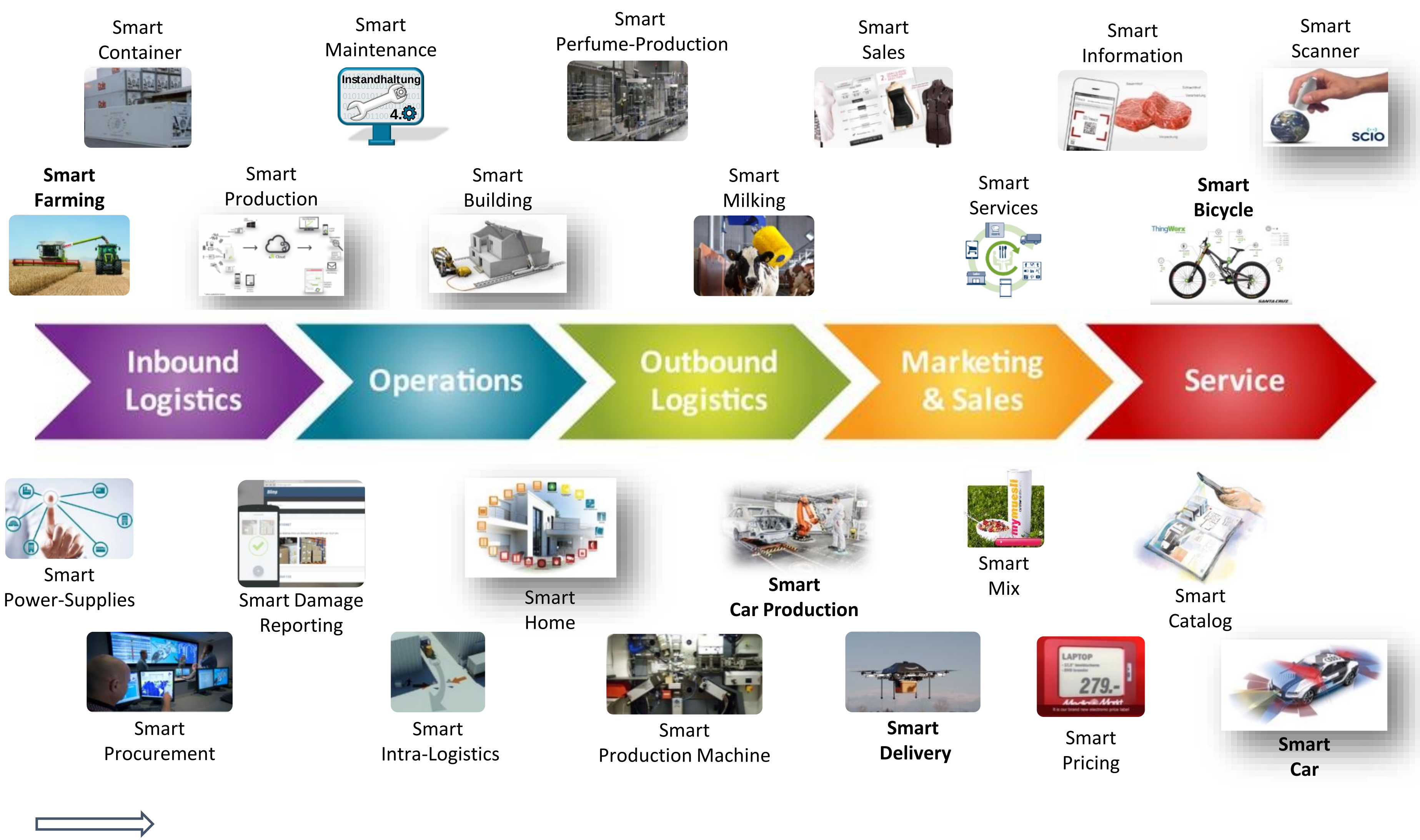
→ rising customer satisfaction → higher turnovers

- Driver for the Consumer Area
    - E.g.: Smart Wearables, Smart Sales, Smart Pricing, Smart Homes

Industry 4.0 takes place in all areas of our lives - not only in factories
It is driver for new Business Models and it shows new added value potentials.

Source http://www.cisco.com/web/about/ac79/docs/innov/IoE_Economy.pdf, www.accenture.com

Industry 4.0 | Along the entire value chain



Inbound Logistics › Operations › Outbound Logistics › Marketing & Sales › Service

Industry 4.0 – Smart Farming

Automated harvest-process

Deutsche Telekom

CLAAS INDUSTRIETECHNIK GMBH

Overview:

Description:

- Machine – to - Machine communication (LTE-Standard)
- Automatic measurement of the filling continuance in the harvester and the crop quality
- Independent driving to the harvester for unloading
- Data-supply via a tablet in the driver`s cab
- Automatic suggestion of the best harvest-strategy based on measurements (Big Data)

Benefits/Advantages:

- Shortening of the harvester-unloading times (approx. one full harvester every 10min.)
- Unloading tractor drives to the harvester only when required (reduction of the equipment needs)
- Optimal harvest strategy (based on weather, filling-level of the other vehicles, etc.)

hrzz Hrvatska zaklada za znanost

Source: www.ikt.nrw.de
Video source: http://www.autonomik.de/de/marion.php

Inbound Logistics | Operations | Outbound Logistics | Marketing & Sales | Service

Deutsche Telekom

CLAAS INDUSTRIETECHNIK GMBH

Industry 4.0 – Smart Farming

Automated harvest-process

Source: www.ikt.nrw.de
Video source: http://www.autonomik.de/de/marion.php

Inbound Logistics | Operations | Outbound Logistics | Marketing & Sales | Service

Industry 4.0 – Smart Car Production

The future of automotive engineering

Volkswagen

Overview:

Description:

- Traditional car production involving hundreds of identical vehicles lined up in a row now longer exists
- The options available to customers are now so vast that each car becomes a unique and individual object
- Digitalisation of all elements of production is essential for a new area in industrialization (everything is given a virtual likeness in the system world)→ The result is an "Internet of Things"
- 3D-Printer in tool making: Pressing tools are no longer shaped in a laborious manner→ Instead these tools can be made from steel granulate in a 3D-Printer
- Human-Robot cooperation: Employees and robots will work increasingly hand in hand → Robots take over monotonous and incriminating activities
- Big Data Monitor: Enables the rapid virtual processing of data from the suppliers

Benefits/Advantages:

- 3D-Printers open the door on completely new possibilities for design with a level of precision unknown until today
- Human-Robot cooperation contributes to more ergonomic working places in the production
- Big Data Monitor shows potential bottlenecks, greatest need for action and visualises this information in real time
- Efficient and cost-effective production as well as brand new opportunities for employees

hrzz
Hrvatska zaklada za znanost

Source: http://www. volkswagenag.com/

Inbound Logistics | Operations | Outbound Logistics | Marketing & Sales | Service

Industry 4.0 – Smart Car Production

The future of automotive engineering

Volkswagen

Source: https://www.youtube.com/watch?v=zPqHRGA5kx8/

Industry 4.0 – Smart Delivery

Package-delivery using civil drones

Overview:

Description:

- Carrying out the project “PrimeAir”, amazon is testing the package-delivery by small, autonomous drones
- First project-goal: to deliver packages with a weight up to 2,3kg within a 16km radius – in a delivery-time of less than 30min
- The weight of 2,3kg is sufficient as 86% of all the goods delivered by amazon weights less
- The allowance for testing the drones within the civil air space in the US has been given in March 2015
- The German DHL is also testing drone-deliveries using the so called “PackageCopter”

Benefits/Advantages:

- Environmentally-friendly and noise-reduced delivery of packages
- Delivery to remote areas such as mountains and fast emergency-deliveries (e.g. medicine)
- Inclusion of the customer into the company-activities as customer triggers automatic delivery-process

Source video: https://www.youtube.com/watch?v=dyT9FgSf1XI
Source: http://www.amazon.de/

Inbound Logistics | Operations | Outbound Logistics | Marketing & Sales | Service

Industry 4.0 – Smart Bicycle

The networked bike

Overview:

Description:

- Bicycle is equipped with 7 sensors
- Sensors measure for example: speed, acceleration, steering wheel angle, saddle height, pedal power, suspension, etc.
- The smartphone of the driver sends the data to the manufacturer
- The data is analyzed and a feedback will be displayed on the drivers smartphone – in real time
- Also possible to represent the measured variables in an augmented reality application

Benefits/Advantages:

- Real-time-representation of all information for the driver
- Adjusting the bicycle-configuration according to the manufacturer`s feedback (e.g. ideal saddle height depending on the ground)
- Use of the data for the manufacturer (optimization of the bicycles)
- Improved customer loyalty (After-Sales-Services)

Source: http://de.ptc.com

Inbound Logistics | Operations | Outbound Logistics | Marketing & Sales | Service

Industry 4.0 – Smart Bicycle

The networked bike

Source: http://de.ptc.com, https://www.youtube.com/watch?v=DRrX-nNnTKw

Industry 4.0 – Smart Car

Piloted driving

Audi
Vorsprung durch Technik

Overview:

Description:

- Piloted (self-driving) car
- Up to 12 ultrasonic sensors scan the close environment of the vehicle
- The front radar detects objects up t a distance of 250 meters ahead of the car
- The rear radar sensors monitor the traffic behind
- The top view camera works together with the ultrasonic sensors and recognises the lane markings as well as pedestrians and objects
- This technology is as small as a laptop and goes by the name of zFAS – all functions, one unit
- The car can easily be maneuvered into a garage or a tight parking space from the outside (smart phone)

Benefits/Advantages:

- Audi A7 550 mile piloted drive: from Silicon Valley to Las Vegas
- Hand over responsibility, together with the stress of everyday traffic, to a system that works perfectly
- System never gets tired, never gets distracted or bored and always makes exactly the right decision
- Enhances safety in road traffic and solves infrastructural transport problems
- Interlinked vehicles provide for fluent traffic → avoidance of traffic jam and less environmental impact

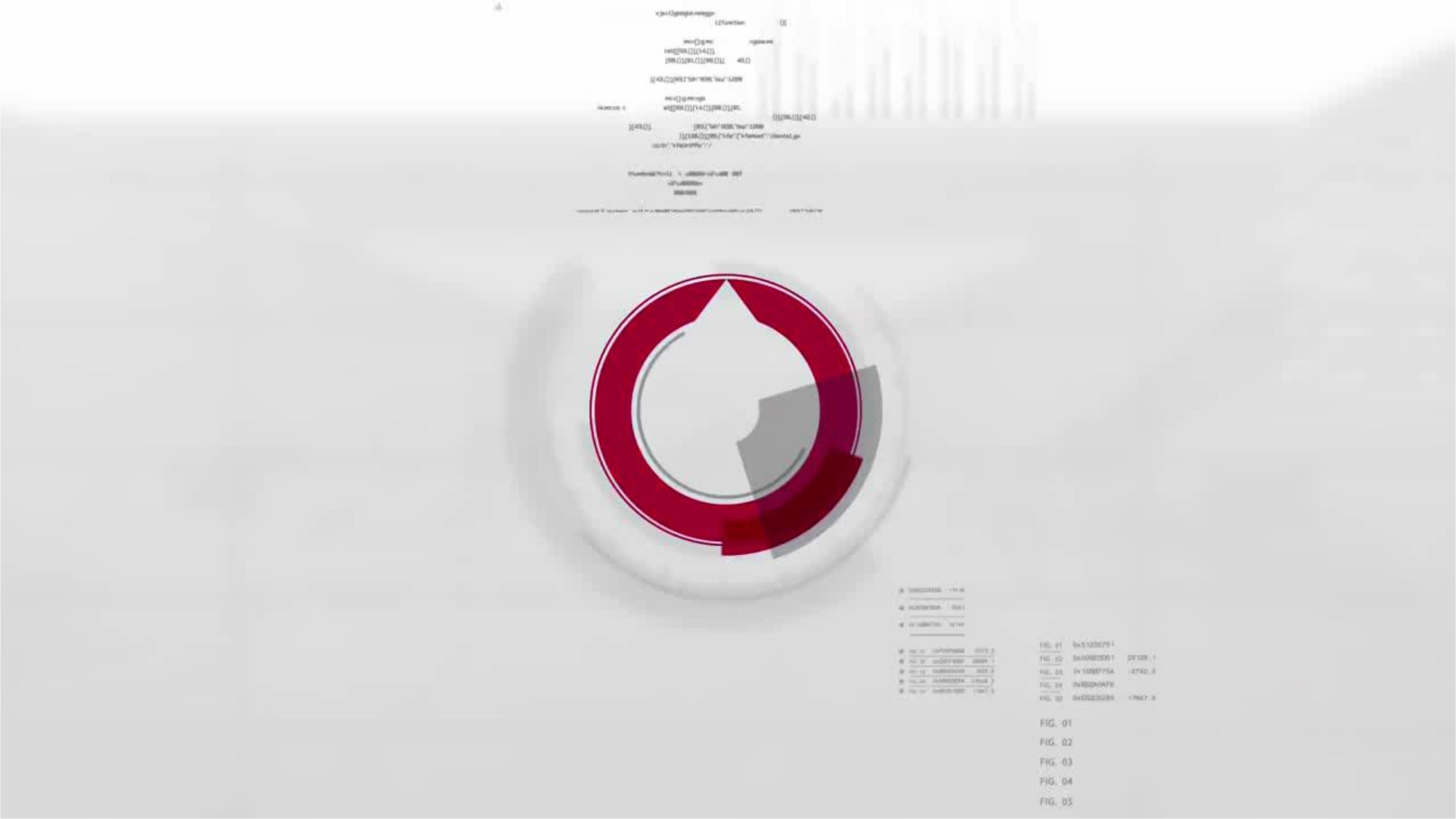
Source: www.audi.at

Inbound Logistics → Operations → Outbound Logistics → Marketing & Sales → Service

Industry 4.0 – Smart Car

Piloted driving

Audi
Vorsprung durch Technik



hrzz
Hrvatska zaklada za znanost

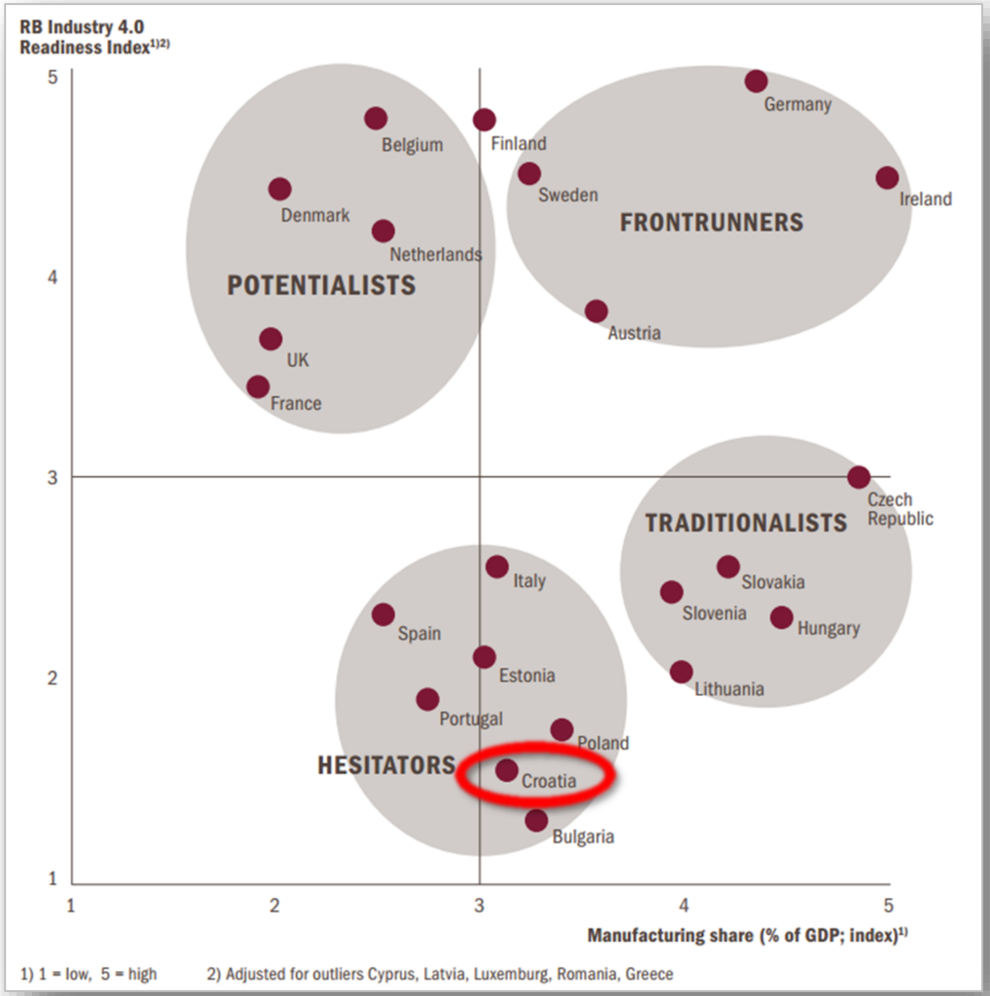
Source: www.audi.at

Agenda

1. Introduction
2. Industry 4.0
3. Project Innovative Smart Factory INSENT
4. Lean Learning Factory
5. Conclusion

Industry 4.0: Case study ‘Croatian industry’

- ‘Roland-Berger’ consultants calculated **1.6 as ‘Industry 4.0 Readiness index’ for Croatian industry** (index scale is from 1 to 5).
- It placed Croatia into group of ‘**Industry 4.0 hesitators’**.
- However, Croatia has a huge share of manufacturing in GDP: **index 3.2** (index scale is from 1 to 5).
- Therefore, industry should be important to Croatia!



hrzz
Hrvatska zaklada za znanost

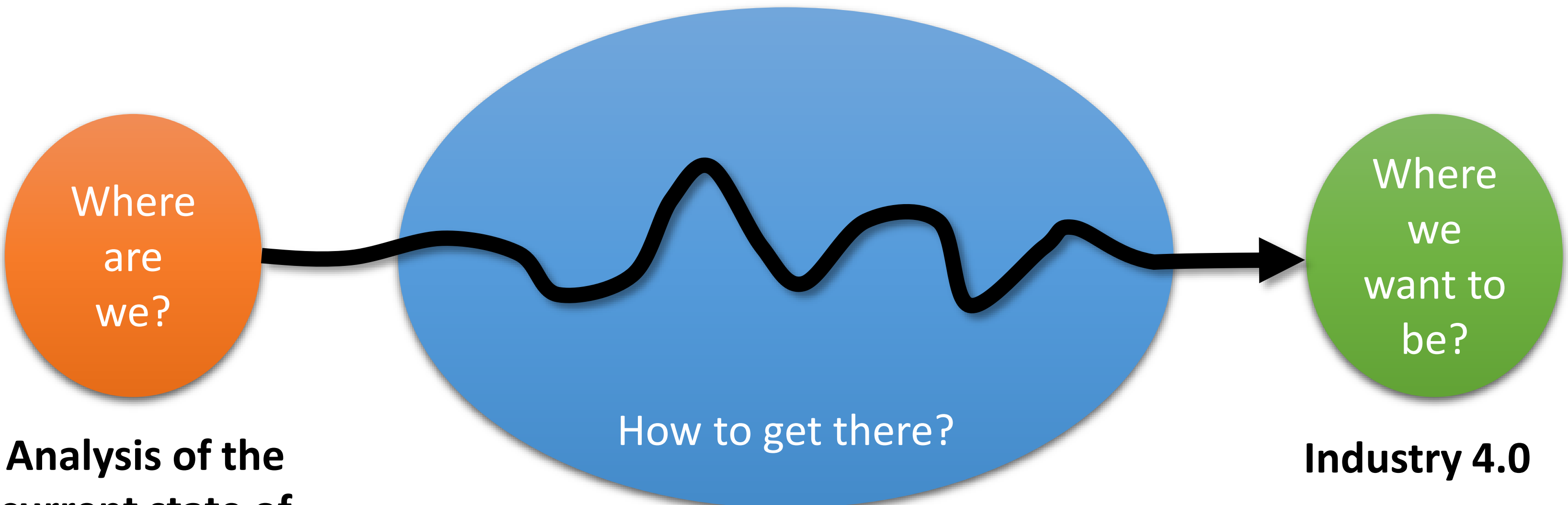
Project INSENT
Main aim

- 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

hrzz
Hrvatska zaklada za znanost

Project INSENT
Main aim



Analysis of the current state of Croatian manufacturing industry

Industry 4.0

Project Innovative Smart Enterprise (INSENT)

Objectives

- 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 it with specific regional way of thinking, manufacturing and organizational tradition, and specific education
- To achieve this, **three questions must be answered** through three objectives

hrzz
Hrvatska zaklada za znanost

Objective 1

- Objective is to answer the question: **“Where are we?”**
- It is important to perform profound research to **describe current state of Croatian manufacturing enterprise**
- It will be done by **questionnaires and interviews** with CEOs and/or technical directors of manufacturing enterprises in Croatia

hrzz
Hrvatska zaklada za znanost

Objective 2

- Objective is to answer the question: **“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)
- A special efforts will be made **to bridge the cultural and mentality gaps** between State-of-the-art models and current Croatian model

hrzz
Hrvatska zaklada za znanost

Objective 3

- Objective is to answer the question: **“How can we get there?”**
- A special learning environment will be established in one Laboratory as a **Learning Factory**
- Laboratory will be organized to **simulate factory based on HR-ISE model**
- It will be a place in which **transfer of developed HR-ISE model to the economy** subjects will be achieved

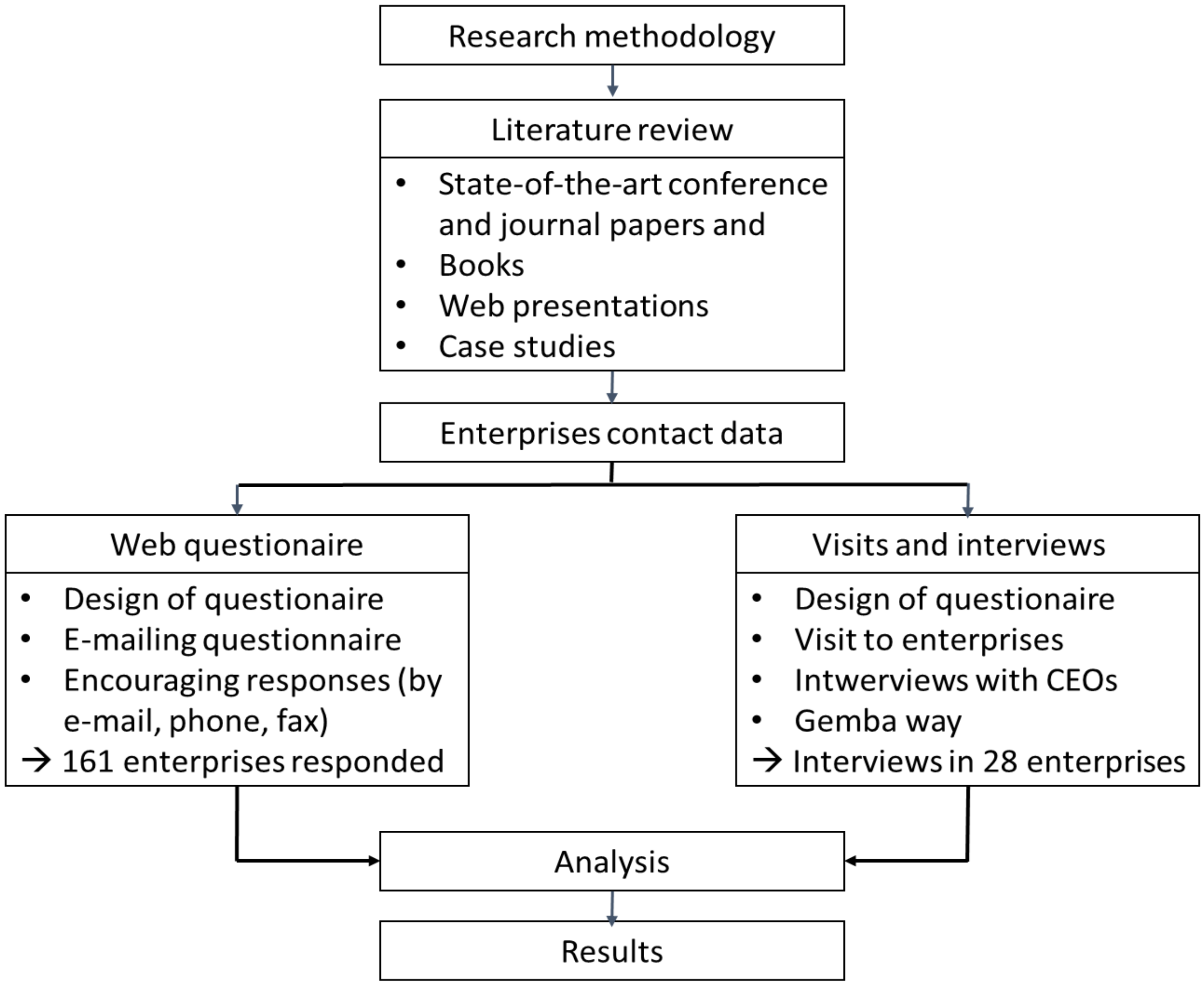
hrzz
Hrvatska zaklada za znanost

Work Packages

Objectives will be realized through **4 Work Packages** in the period of 4 years:

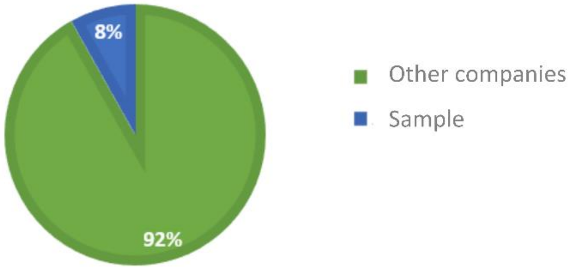
- **WP 1:** Analysis of current state of Croatian manufacturing enterprise
- **WP 2:** Development of Croatian model of Innovative Smart Enterprise – HR-ISE model
- **WP 3:** Experimental testing of HR-ISE model through Learning Factory
- **WP 4:** Project dissemination

Methodology for obtaining maturity level of Croatian industrial enterprises

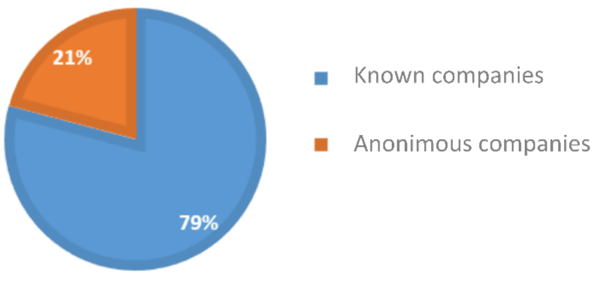


Where are we?

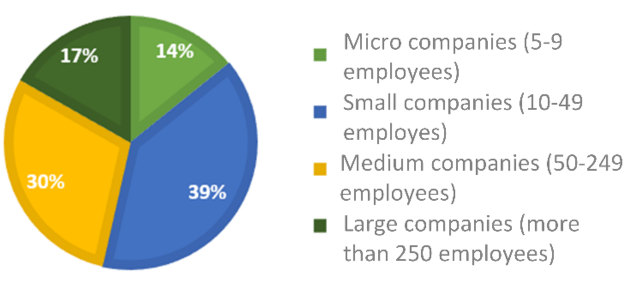
SAMPLE SIZE

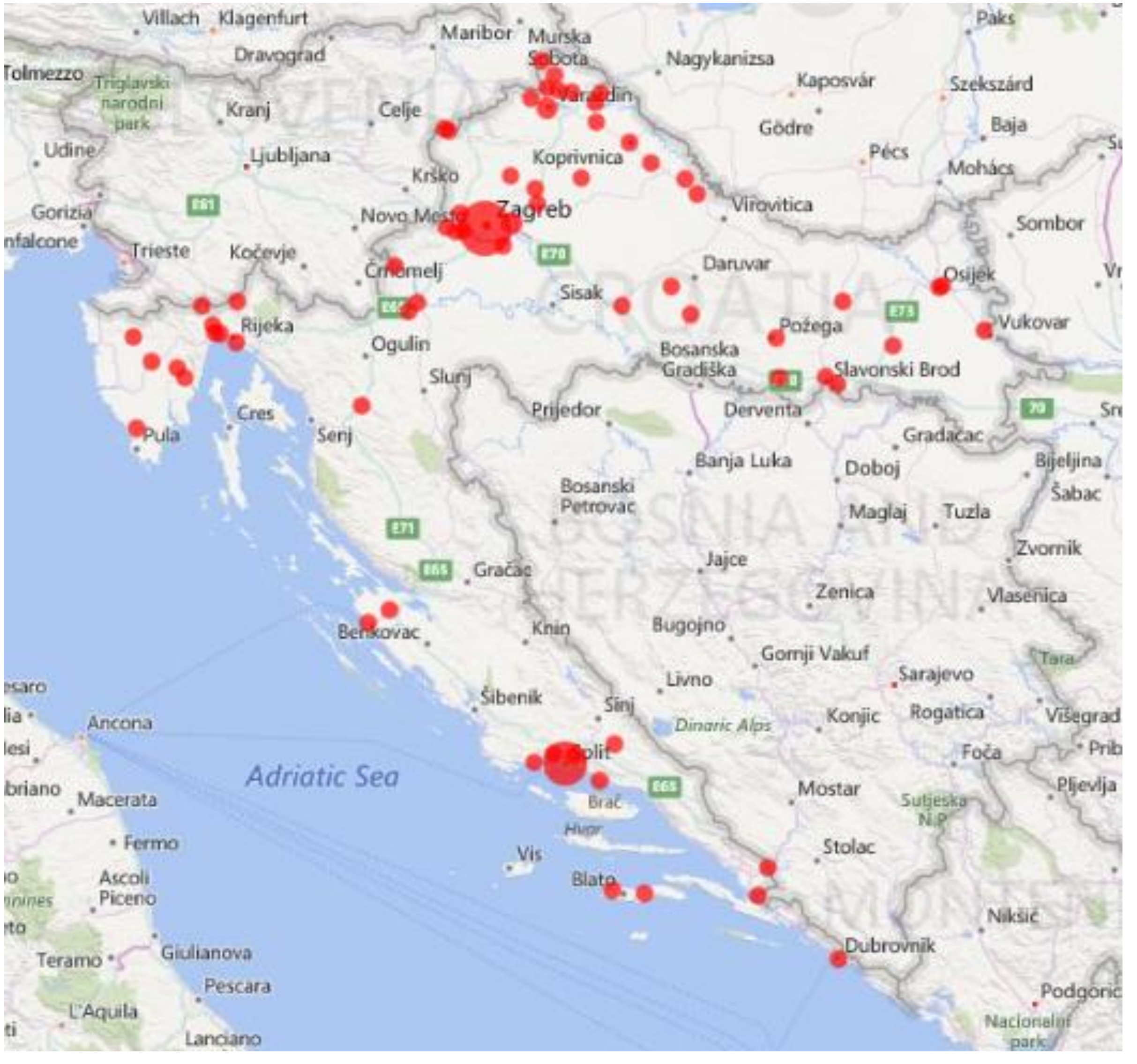


ANONYMITY OF RESPONSES



COMPANY SIZE

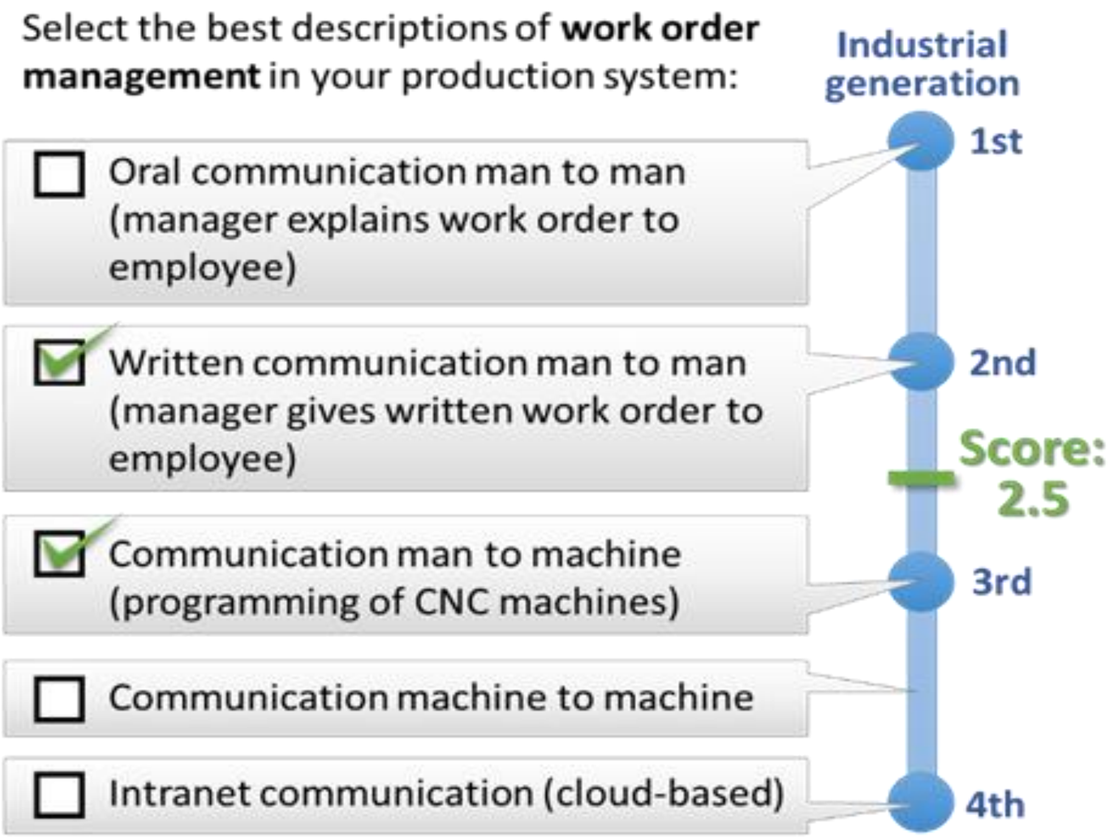




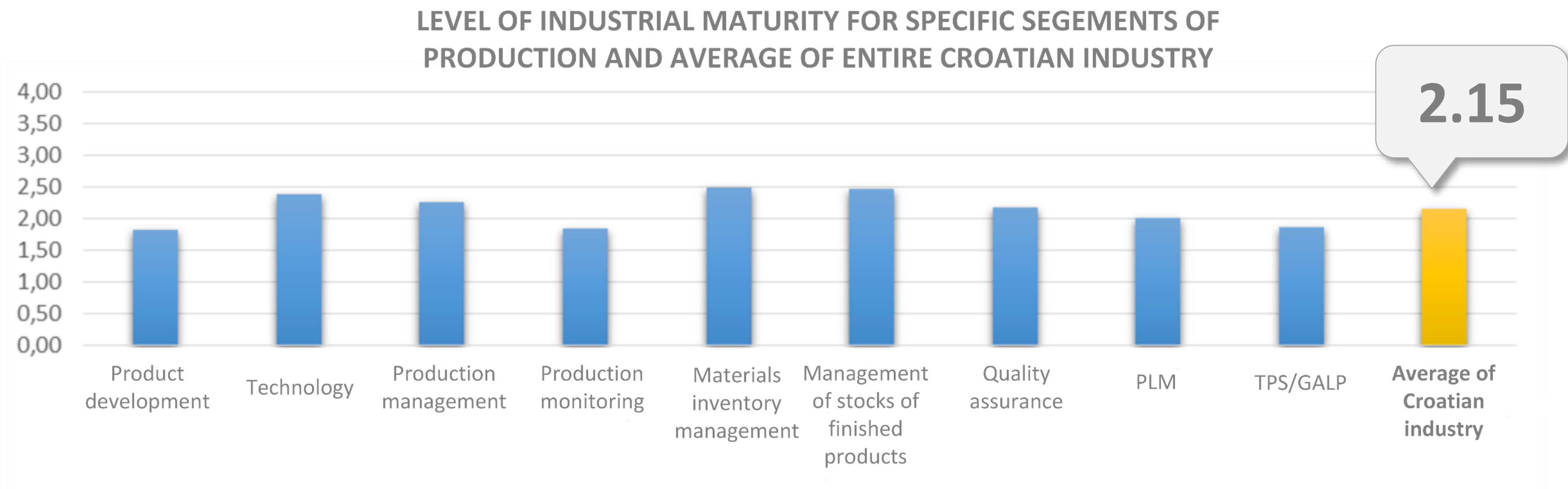
Set of nine questions for factories

1. Product development,
2. Technology,
3. Work orders management in your production system,
4. Monitoring of production traceability,
5. Materials inventory management,
6. Finished products stocks management,
7. Quality Assurance,
8. Product Lifecycle Management,
9. Application of Toyota Production System TPS and Green and Lean Production GALP concept.

The example of scoring model for one question

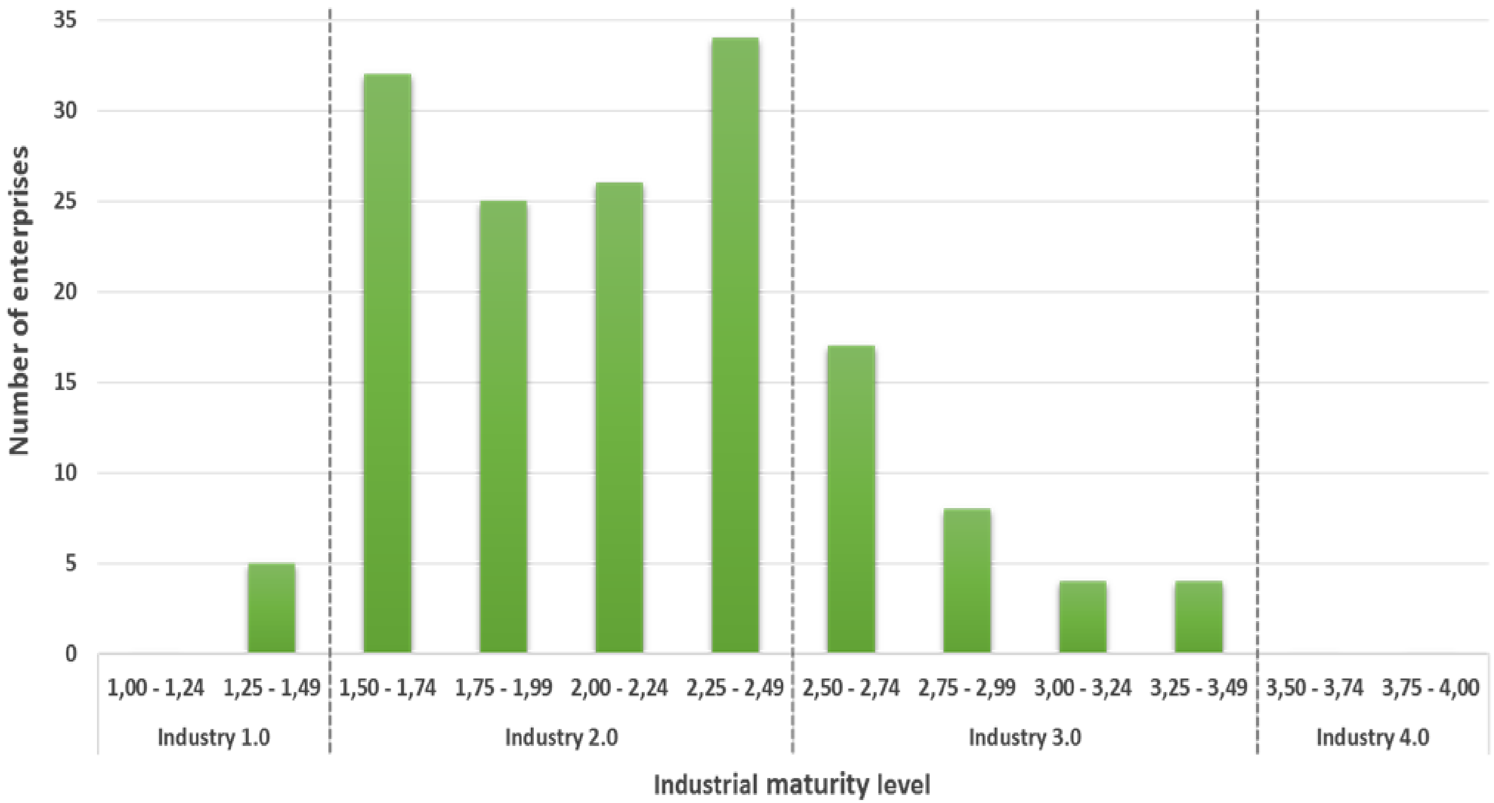


Results: Average level of Industrial maturity



hrzz
Hrvatska zaklada za znanost

Positioning enterprises according to their industrial maturity



hrzz
Hrvatska zaklada za znanost

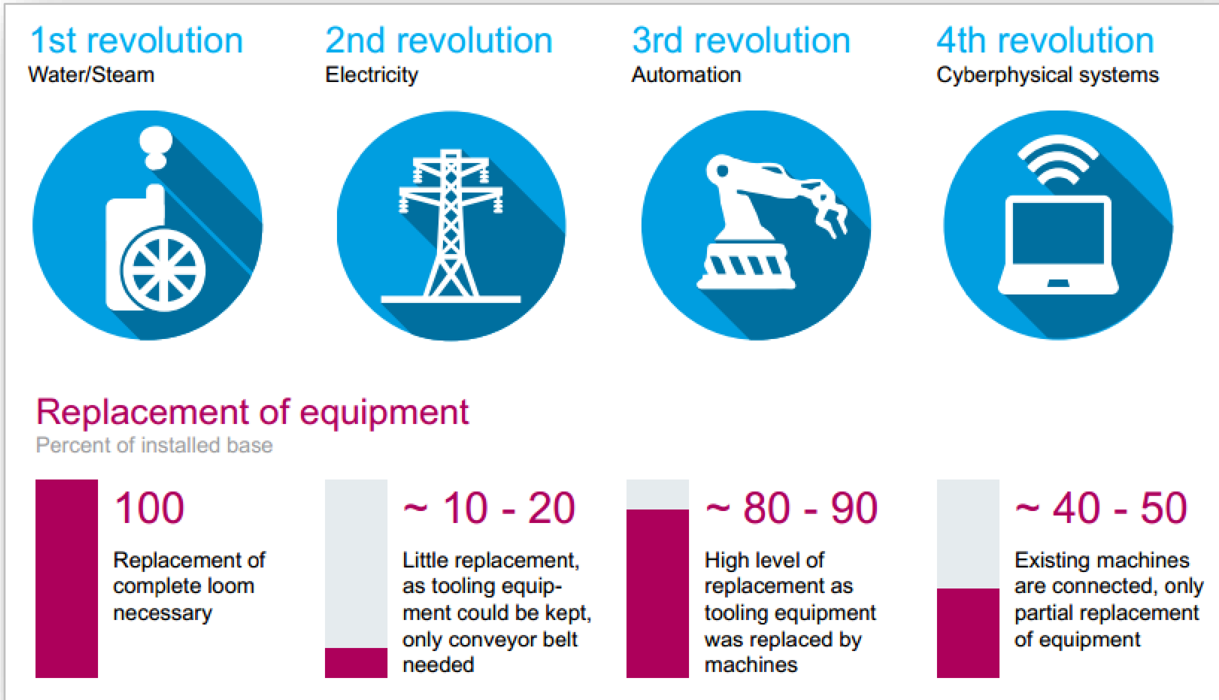
Range of Industrial Maturity Index in Croatia

To Industrial maturity index 3,4

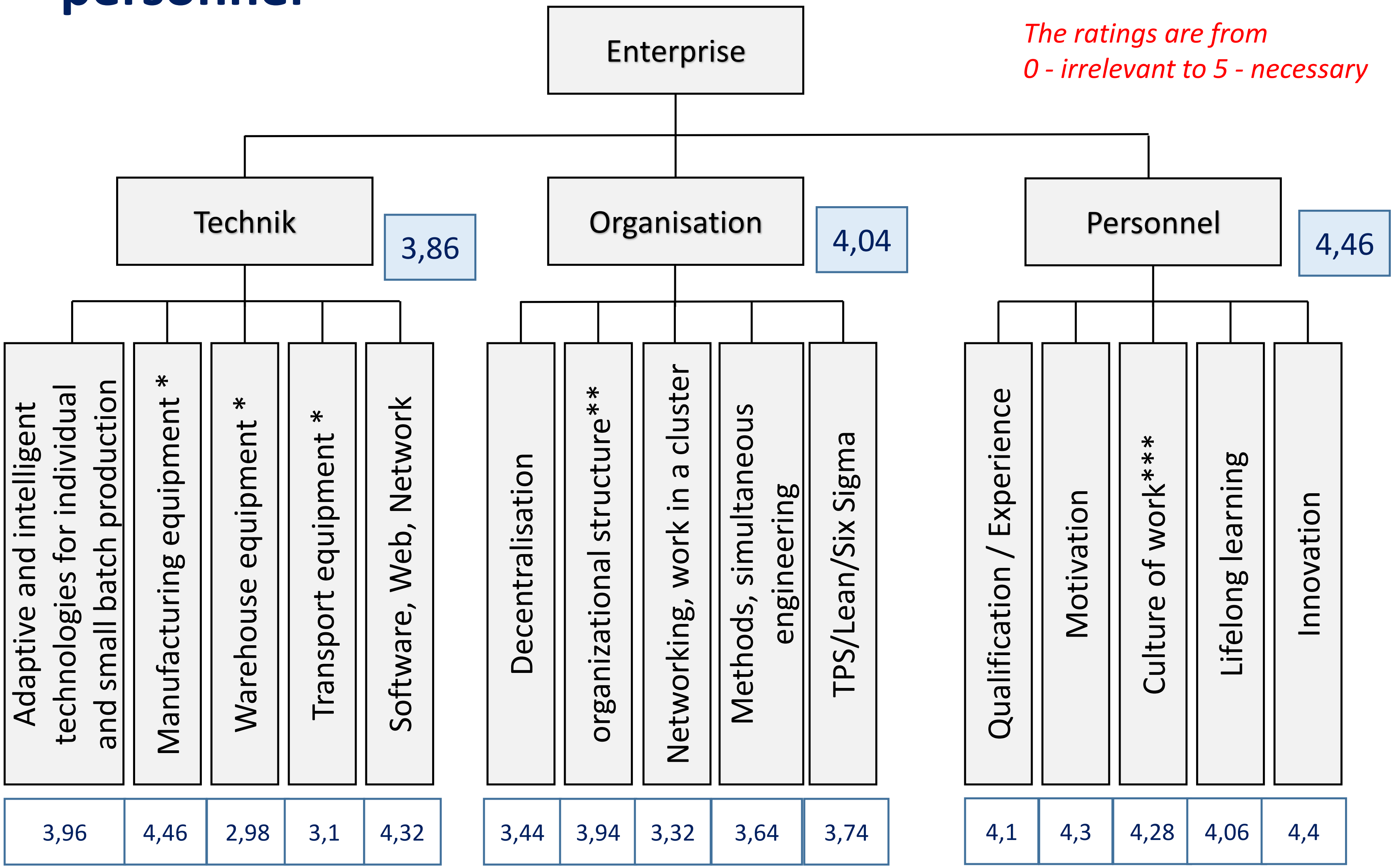
From Industrial maturity index 1,7

Industry 4.0: Case study ‘Croatian industry’

- According to ‘McKinsey’ consultants, the highest technology jump was from 2nd industrial generation to 3rd.
- Since 3rd industrial generation represents automated production lines, robots and CNC machines, it is clear why most of the enterprises in Croatia haven’t made that jump.
- The question is: **Is it possible to jump from 2nd industrial generation to 4th?** To jump over one whole industrial generation?



Evaluation results of techniques, organization and personnel

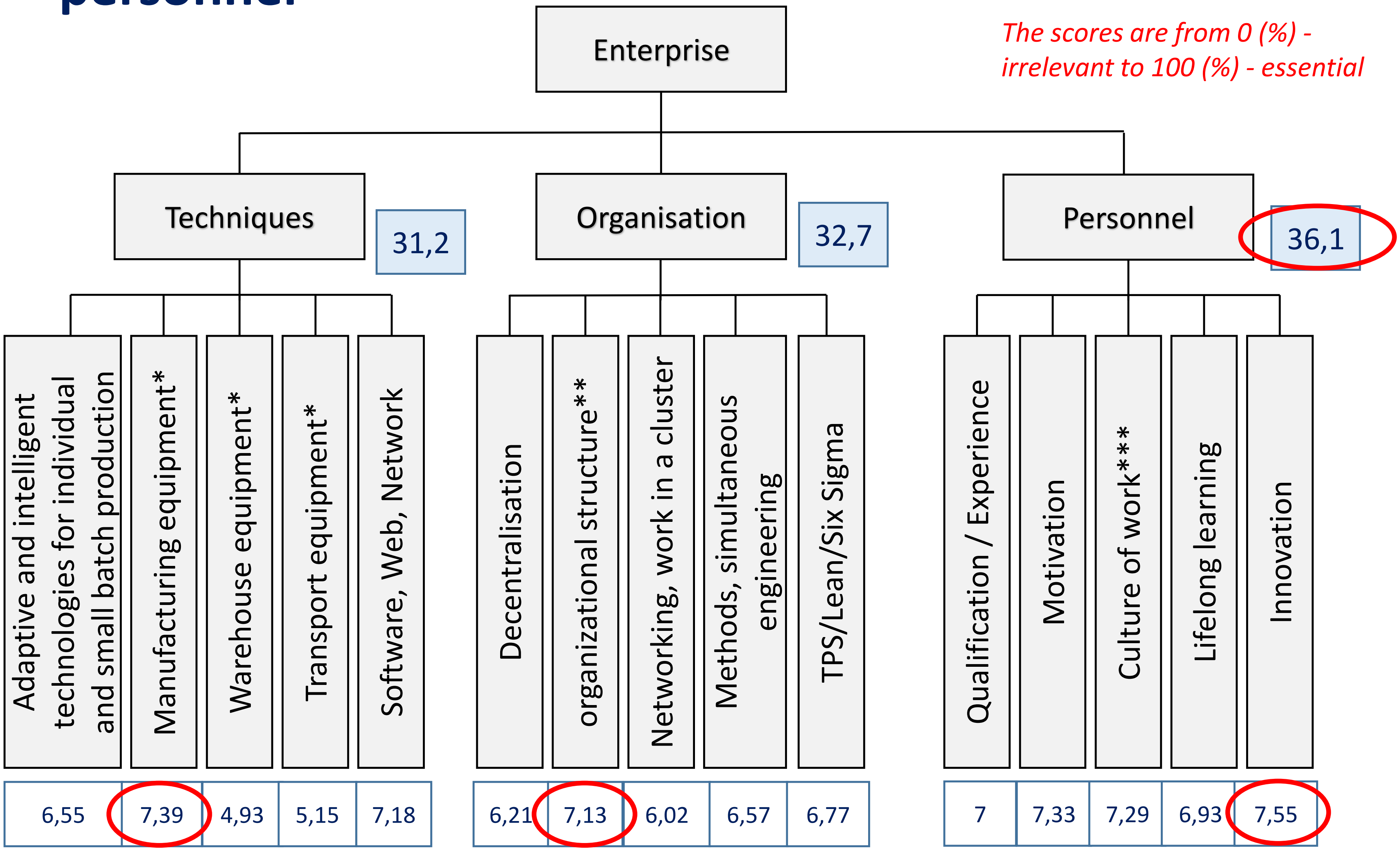


* The modularity, flexibility, intelligent components, automation

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

*** A holistic, interdisciplinary approach, teamwork

Evaluation results of techniques, organization and personnel



* The modularity, flexibility, intelligent components, automation

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

*** A holistic, interdisciplinary approach, teamwork

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**
   - 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.
   - 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.
   - 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.

“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.).

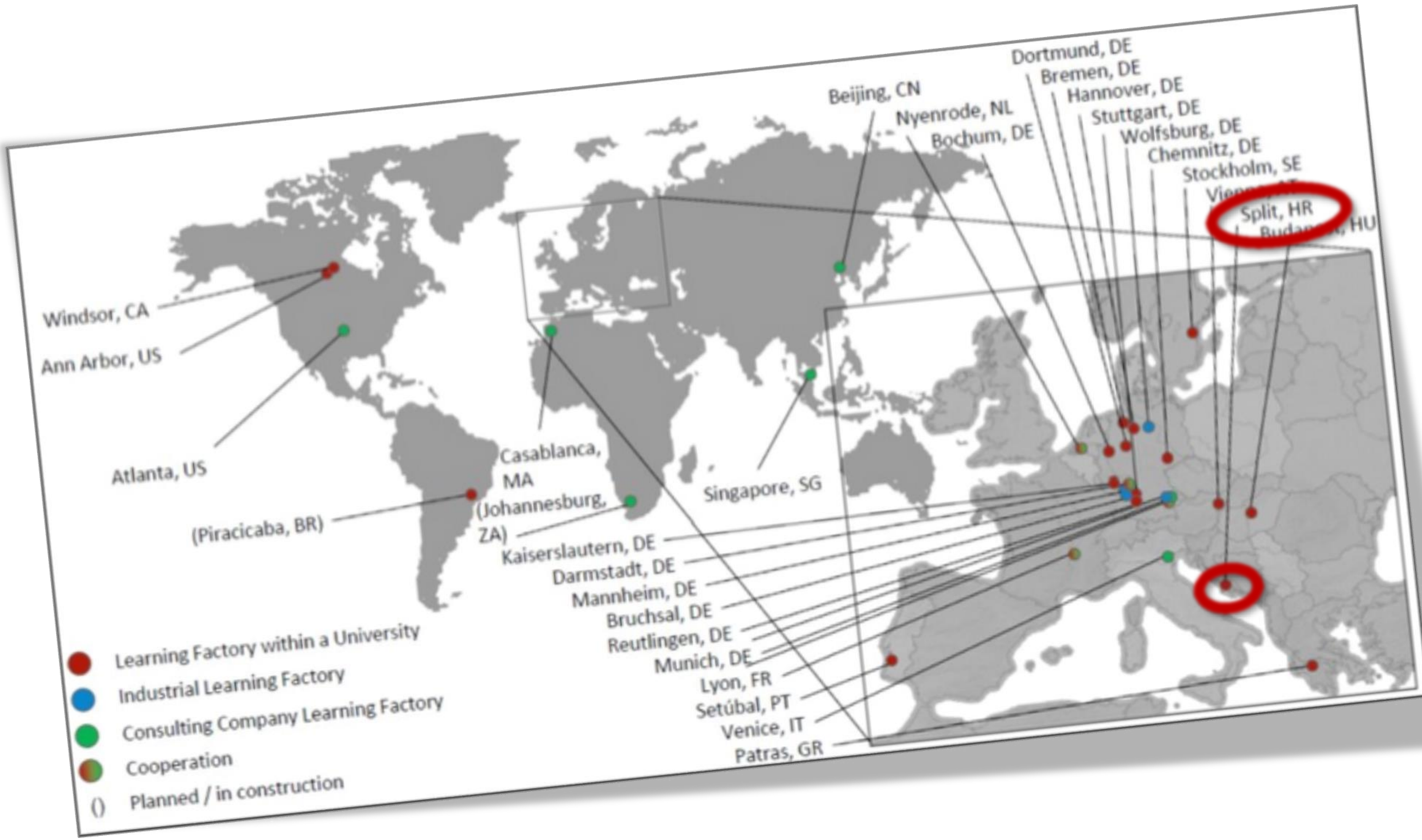
Laboratory will be organized to simulate factory based on HR-ISE model. Hence, Laboratory will be learning environment not just for students but for engineers from manufacturing enterprises. It will be a place in which transfer of developed HR-ISE model to the economy subjects will be achieved.

All supporting material and equipment for education will be provided.

Agenda

1. Introduction
2. Industry 4.0
3. Project Innovative Smart Factory INSENT
4. Lean Learning Factory
5. Conclusion

Learning Factories world-wide



Vision and Mission of Lean Learning Factory at FESB

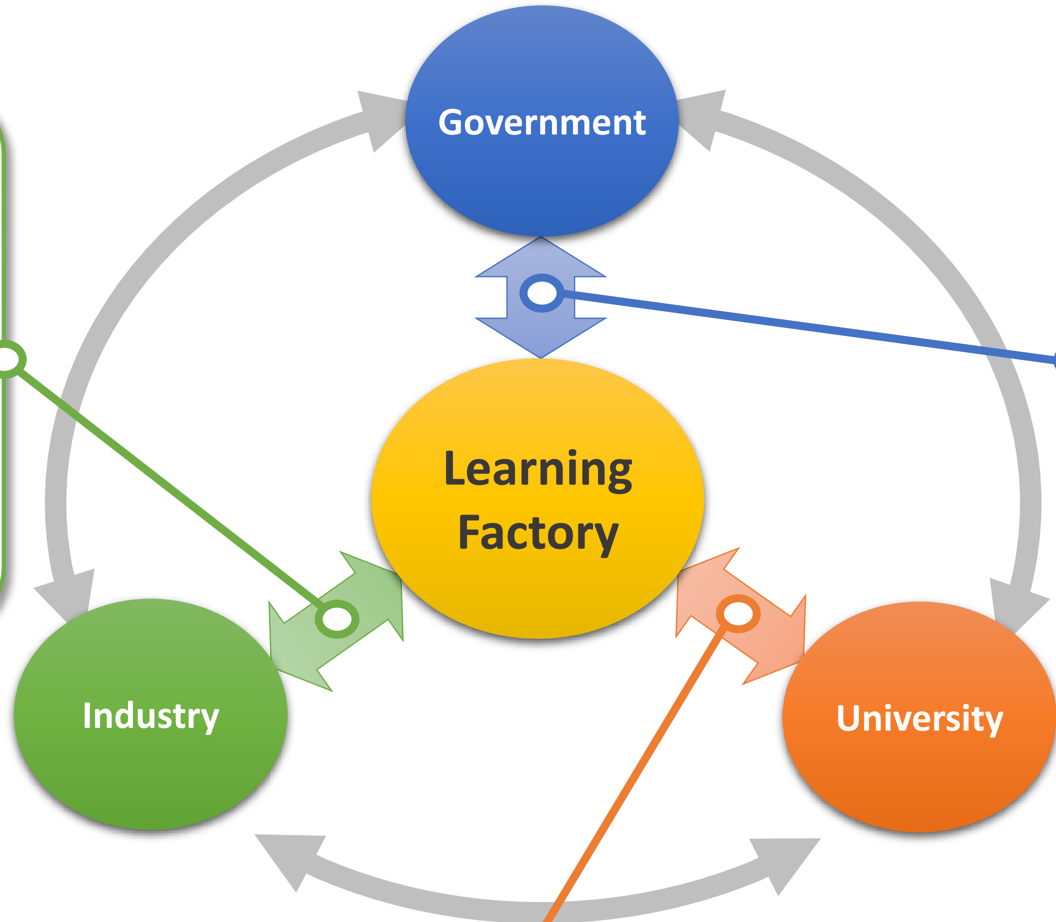
- Vision of Lean Learning Factory at FESB is to be a place where University, Industry and Government meet each other share needs and expectations, and work on collaborative projects.

- 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

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



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

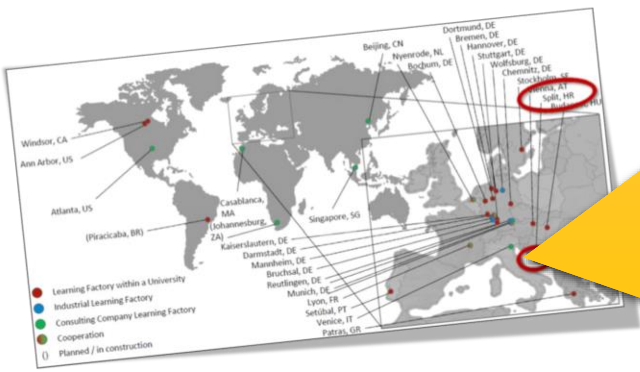
- Balance between engineering science and engineering practice
- New curriculums and study programs

Hrvatska zaklada za znanost

Lean Learning Factory @ FESB

- **Learning Factory concept** represents educational laboratory with realistic industry environment, so it must look like a **real factory**.
- Laboratory C417 at FESB, University of Split has transformed into **'Lean Learning Factory'** through different research projects (EU-TEMPUS MAS-PLM, DAAD NIL, EU-LDV LOPEC, HRZZ INSENT).
- **Two assembly lines** with **eight work-stations** for **two real industrial products** are dominating in the laboratory layout.

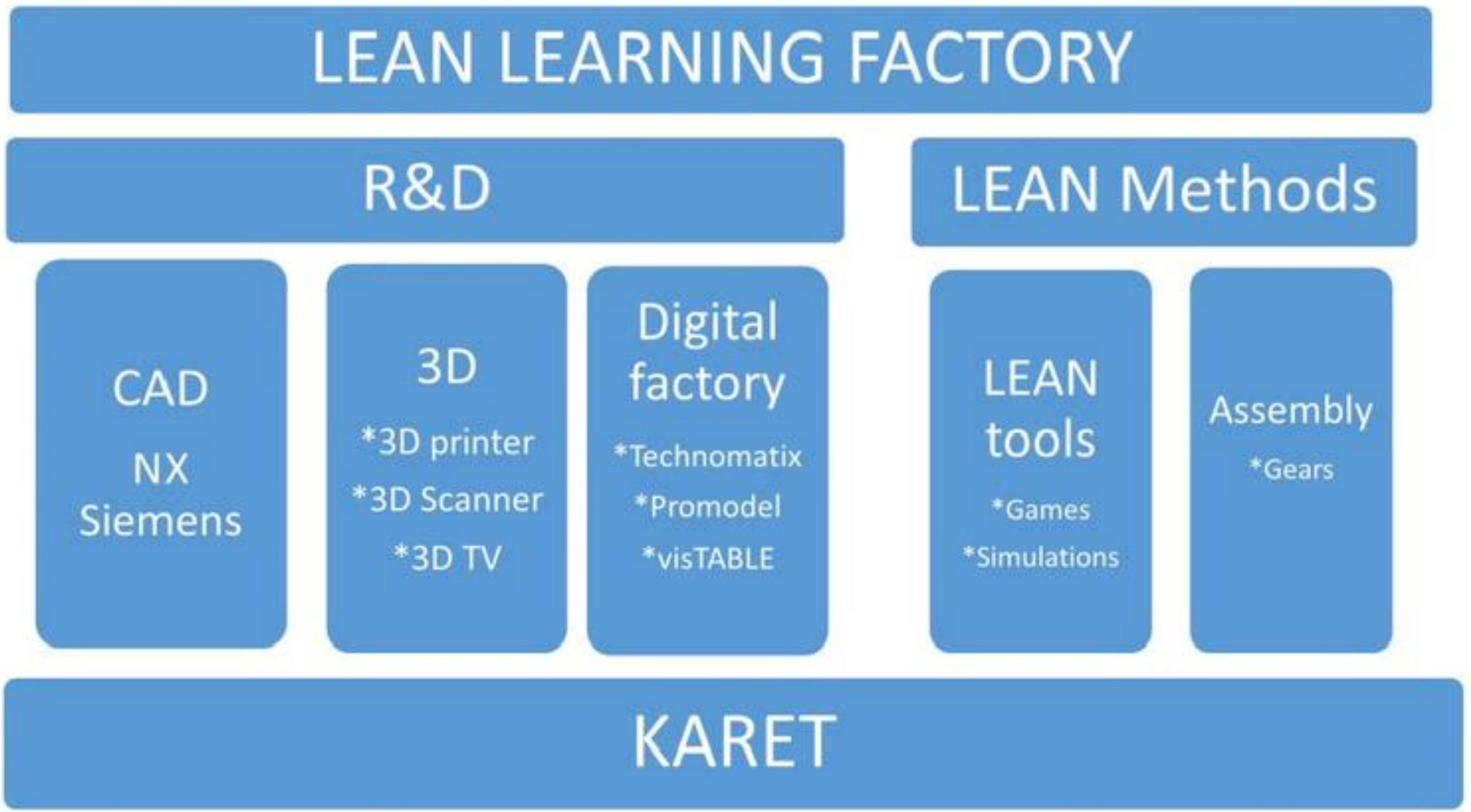
Typology of ‘Lean Learning Factory @ FESB’



Characteristic	Features					
Operating organization	industry	consulting	university	technical college	professional school	
Type of use	education / training	research	further industrial use			
Industrial target groups	operational staff	engineer	manager			
Academic target groups	students	research stuff / post graduated				
Other target groups	lean experts / lean specialist	other consultants				
Selected industries	machine building	automotive industry	chemical industry	electrical industry	insurance, banks, etc.	
Product	real products	imaginary (didactic) product				
Production process	machining	assembly	logistic	IT	indirect	production
Module content	process improvement	diagnosis	system design	quality control		
	quality	material flow	technology optimization	lean transfer		
Integrated departments	production	distribution	purchasing	ideas mgmt.	design / develop.	prod. plan. and control
Integrated teaching methods	presentation	demonstration	tutorial	web-based training	simulation game	
	discussion	case study	role play	experimental game	...	
Learning factory size	< 300 sqm	300 – 2000 sqm	2000 – 10000 sqm	> 10000 sqm		
Number of course participants	< 5	5 – 10	10 – 20	20 – 30	> 30	
Duration of module	< 2 h	2 – 5 h	5 – 10 h	10 – 20 h	> 20 h	

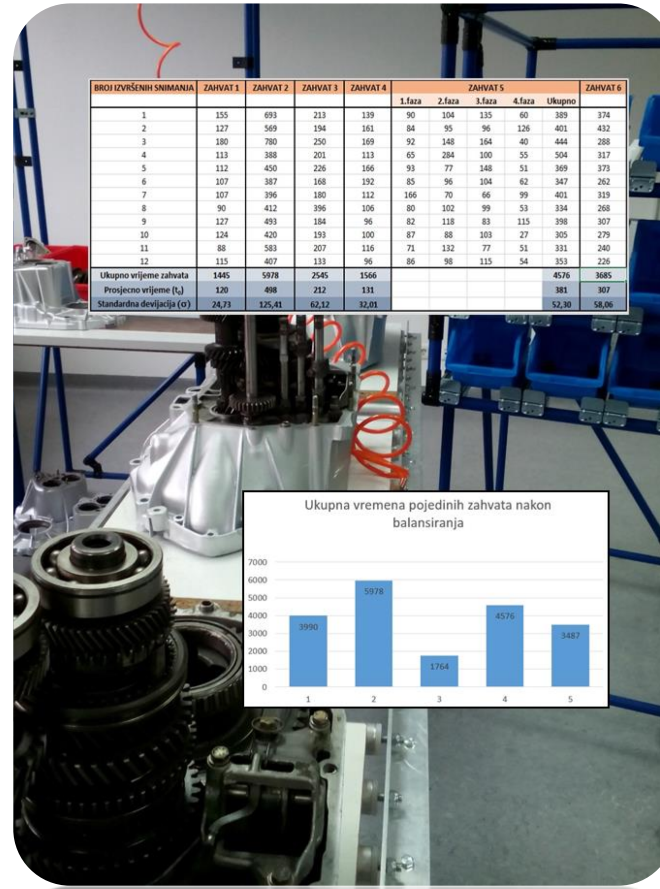
hrzz
Hrvatska zaklada za znanost

The content of Laboratory for Learning factory at FESB

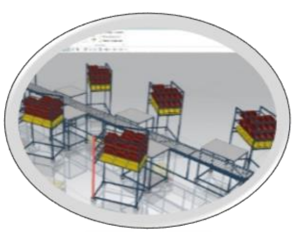


Process Improvement

- ‘Lean Learning Factory @ FESB’ offers **support, training and projects for process improvement**, based on simulation and optimization of production system, Lean management tools, etc.
- It offers set of **methods and tools from Lean management**, **simulation** software, software for **modelling** and **optimization of production systems**, **and didactic games**.



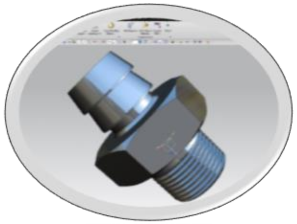
BROJ IZVRŠENIH SNIMANJA	ZAHVAT 1	ZAHVAT 2	ZAHVAT 3	ZAHVAT 4	ZAHVAT 5					ZAHVAT 6
					1.faza	2.faza	3.faza	4.faza	Ukupno	
1	155	693	213	139	90	104	135	60	389	374
2	127	569	194	161	84	95	96	126	401	432
3	180	780	250	169	92	148	164	40	444	288
4	113	388	201	113	65	284	100	55	504	317
5	112	450	226	166	93	77	148	51	369	373
6	107	387	168	192	85	96	104	62	347	262
7	107	396	180	112	166	70	66	99	401	319
8	90	412	396	106	80	102	99	53	334	268
9	127	493	184	96	82	118	83	115	398	307
10	124	420	193	100	87	88	103	27	305	279
11	88	583	207	116	71	132	77	51	331	240
12	115	407	133	96	86	98	115	54	353	226
Ukupno vrijeme zahvata	1445	5978	2545	1566					4576	3685
Prosjecno vrijeme (t_0)	120	498	212	131					381	307
Standardna devijacija (σ)	24,73	125,41	62,12	32,01					52,30	58,06

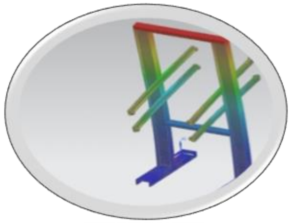


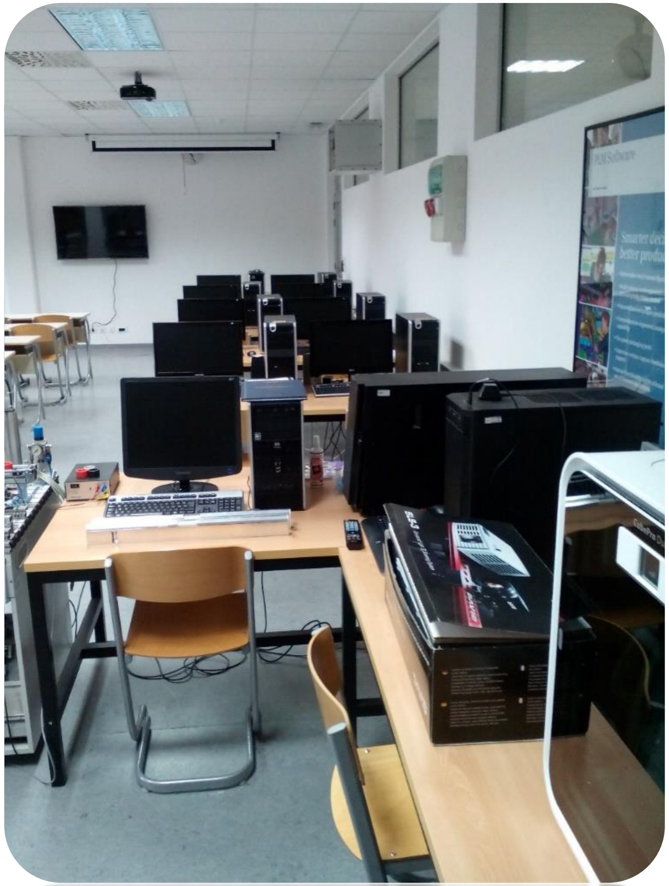
hrzz
Hrvatska zaklada za znanost

Rapid Prototyping

- ‘Lean Learning Factory @ FESB’ offers support in **research and development of a new product**, emphasizing **rapid prototyping**.
- It is equipped with all necessary software and hardware: **3D scanner**, **3D printer**, **CAD/CAM** software, **PLM** software, **simulation** software,, software for **modelling** and **optimization of production systems**, etc.







Activities in Lean Learning Factory at FESB

1. Education
2. Implementation of Lean and Green concept in economy
3. Scientific research activities

Education

- Undergraduate lectures: study of work and time, organization of production systems
- Bachelor thesis
- Graduate lectures: manufacturing technologies planning and optimization, plant layout
- Master thesis
- Postgraduate study lectures: Modeling and simulation, CIM, Logistics optimization
- Doctoral thesis
- Professional study lectures: production planning and control
- Professional study thesis

Lifelong Learning

- ‘Lean Learning Factory @ FESB’ **offers lifelong learning to people from industry**, in area of operations management, Lean management, project management, Six Sigma, etc.
- It also offers a project of **development and establishment of Learning Factory concept** on site of an industrial enterprise (so called Industrial Learning Factory).

hrzz
Hrvatska zaklada za znanost

Implementing and improving didactic games for learning purpose

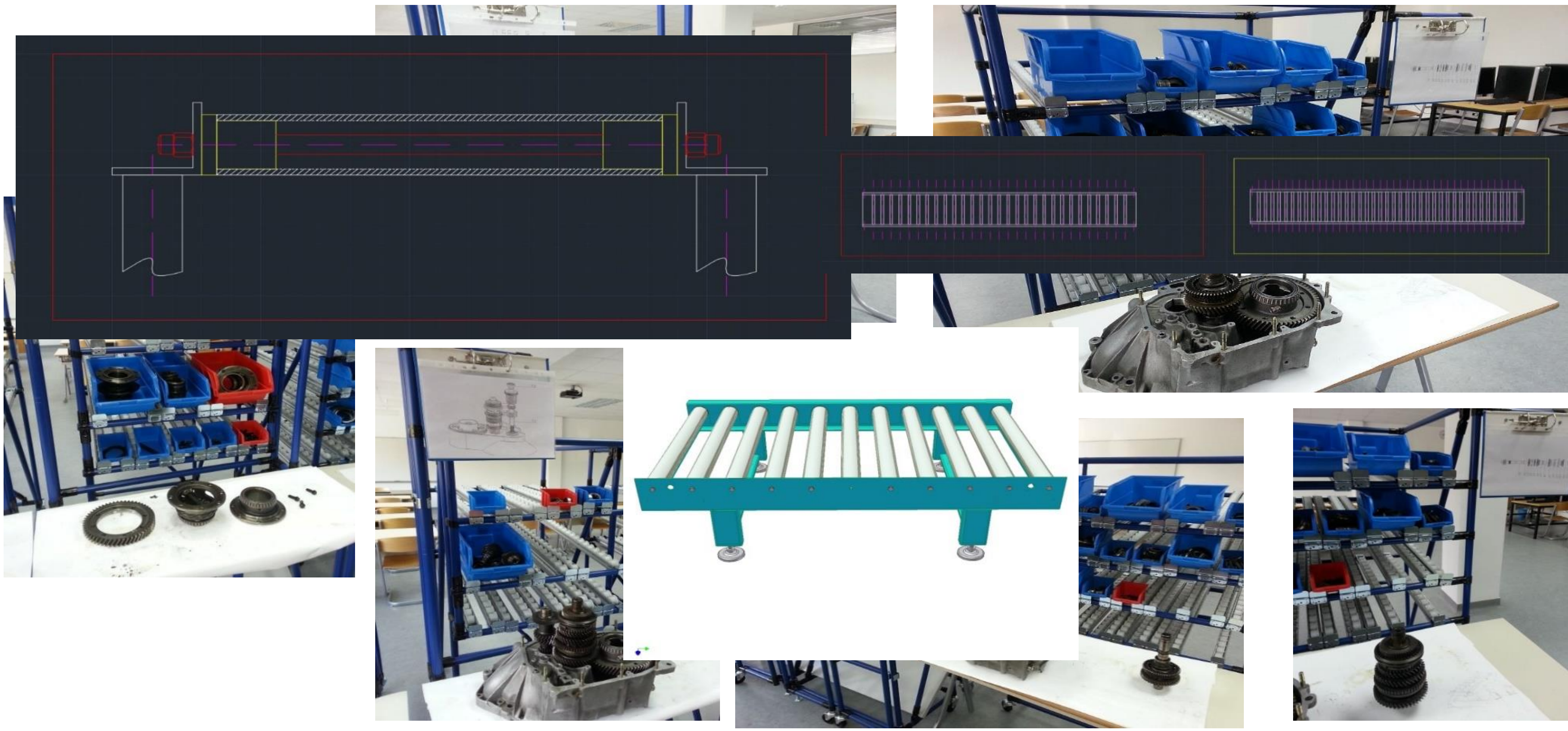
hrzz
Hrvatska zaklada za znanost

Development of assembly line model – real product: gear boxes




Hrvatska zaklada za znanost

Development of assembly process diagrams–study of time and work



hrzz
Hrvatska zaklada za znanost

Involving students for assembly line workload balancing

EU Leonardo da Vinci project LOPEC

- Lean management is a ‘homework’ that must be made before implementing Industry 4.0.
- At ‘Lean Learning Factory @ FESB’ we also see **Lean management as a prerequisite for any significant improvement**.
- ‘Lean Learning Factory @ FESB’ was a part of **EU Leonardo da Vinci project LOPEC**, which had Lean as its topic.

Logistics Personal Excellence by continuous Self-Assessment

LOPEC

– Hochschule Reutlingen, ESB Business School
http://www.esb-business-school.de/

– Universität Dortmund, Sozialforschungsstelle sfs
http://www.sfs-dortmund.de/v2/index.php

– Fraunhofer Austria Research GmbH, Wien
http://www.fraunhofer.at

– Universtiy of Split, FESB
http://www.fesb.unist.hr/

– Eurofortis SA
www.eurofortis.lv

IBK - Management Solutions GmbH, Wiesbaden
http://www.ibk.eu/de/

NIL Network innovative Learning Factories

http://www.esb-business-school.de/en/forschung/forschungsprojekte/nil-network-innovative-learning-factories.html

NIL

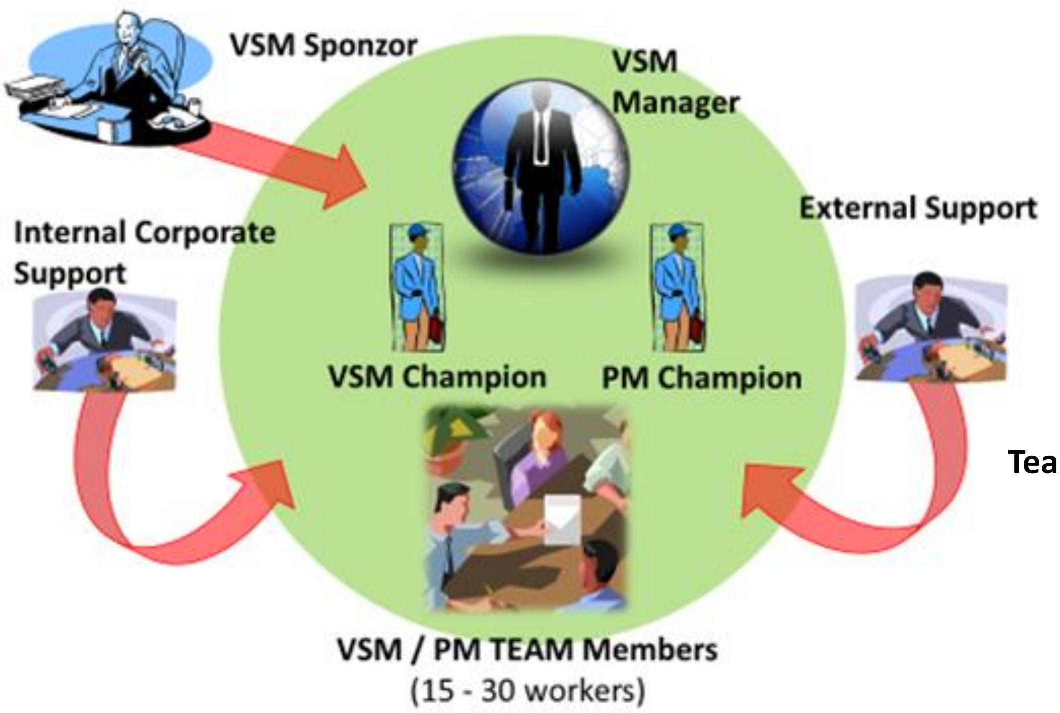
Netzwerk Innovativer Lernfabriken

hrzz

Hrvatska zaklada za znanost

Implementation of Lean and Green concept in economy

Scheme of team for implementation of Lean and Green concept



Team from Laboratory IE

hrzz
Hrvatska zaklada za znanost

Three steps of education of employees for successful implementation of Lean concept

Step 1: **Basics of Lean**	**Step 2:** **Elements of Lean**	**Step 3:** **Lean thinking**
• Toyota Production System • Lean principles • Standardization of work • 7+1 types of waste • Quality techniques • Didactic games (car production, beer game etc.)	• Just-in-Time • Heijunka (line balancing) • Push-Pull production • One piece flow • Quick change-over (SMED) • Tact time • Supermarket • Kanban • Kaizen • Value Stream Mapping	• Leadership for lean • Lean in other areas (administration, hospital, education, government etc.) • Kata for improvement • Visual management (Obeya)

Reference

- Siemens Končar Power Transformers, Ltd., Zagreb
- Feromont Novi, Donji Kraljevac
- FEAL, Široki Brijeg, BiH
- Jadranska banka, Šibenik,
- Clinical Hospital Centre, Zagreb
- County roads, Zagreb
- Potomac, Zagreb
- Standard, Prnjavor, BiH
- Dalekovod, Velika Gorica
- Water supply and drainage, Zagreb
- Shipyard Brodotrogir, Trogir
- otp Bank, Zadar

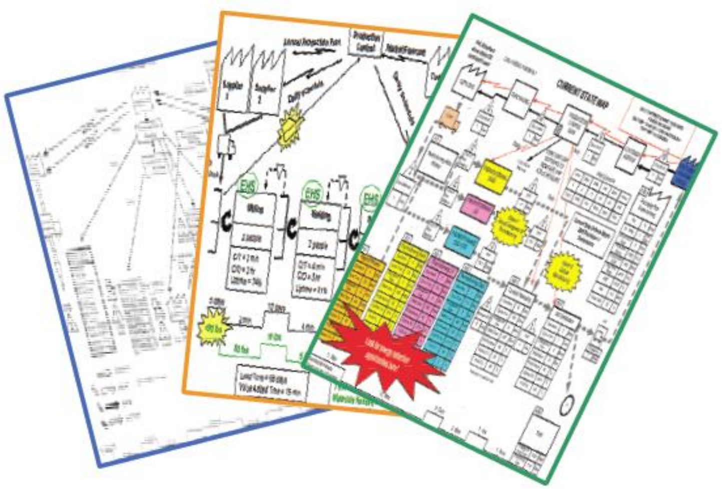
Sveučilište u Zagrebu
Fakultet strojarstva i brodogradnje

LEAN MENADŽMENT INICIJATIVA

Sveučilište u Splitu
Fakultet elektrotehnike, strojarstva i brodogradnje

Končar Power Transformers, Ltd.

Value Stream Mapping Workshop REPORT



Zagreb, May 2011

KPT – Value Stream Mapping

OBJECTIVES	RESULTS

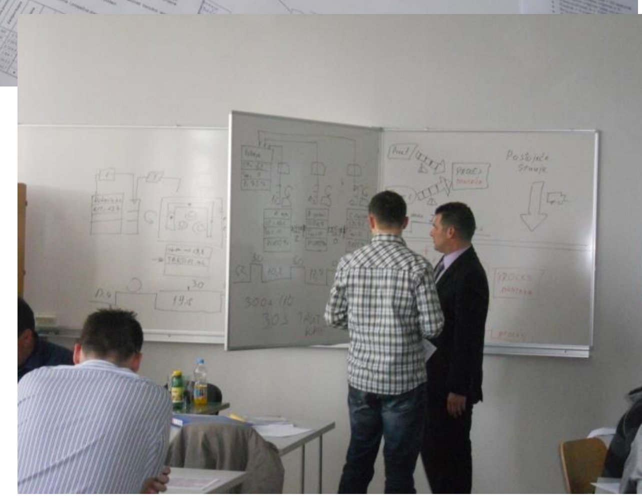
OBJECTIVES

- Education on VSM, Process Mapping and LEAN Management
- Skills adopting in process and VSM mapping
- Implementation of acquired knowledge on real example(KPT - CHEVIRE 100 MVA)
- Team approach to process improvement
- LEAN Improvements Team

RESULTS

- VSM Current State
- Spaghetti diagram
- Functional Process Map
- Identified opportunities for improvements
- Defined metrics
- Plan for future activities

KPT – VMS Workshop

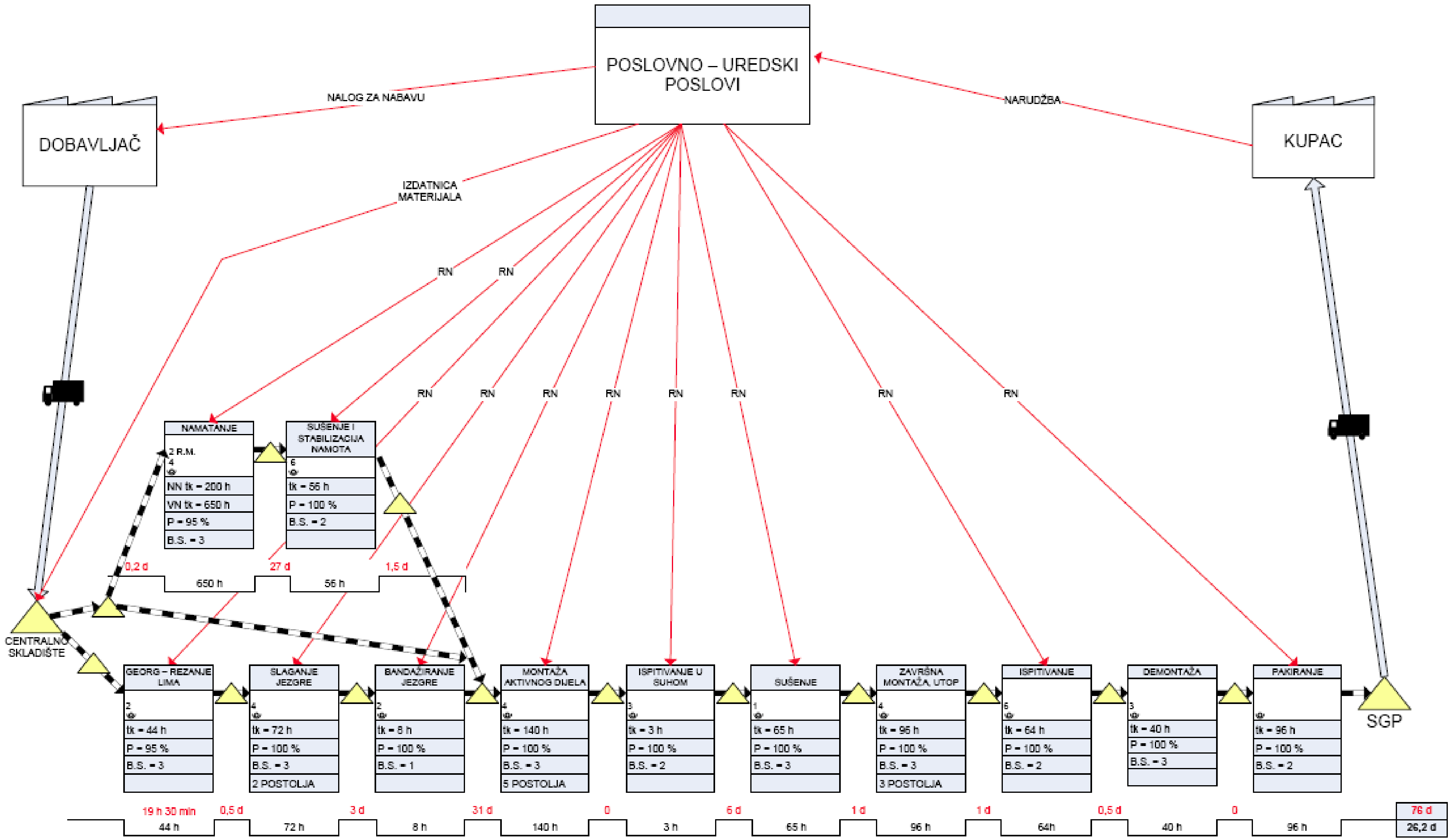


REPORT

KPT – VSM Workshop

REPORT

KPT – VSM Current State



KPT – VSM Current Analysis

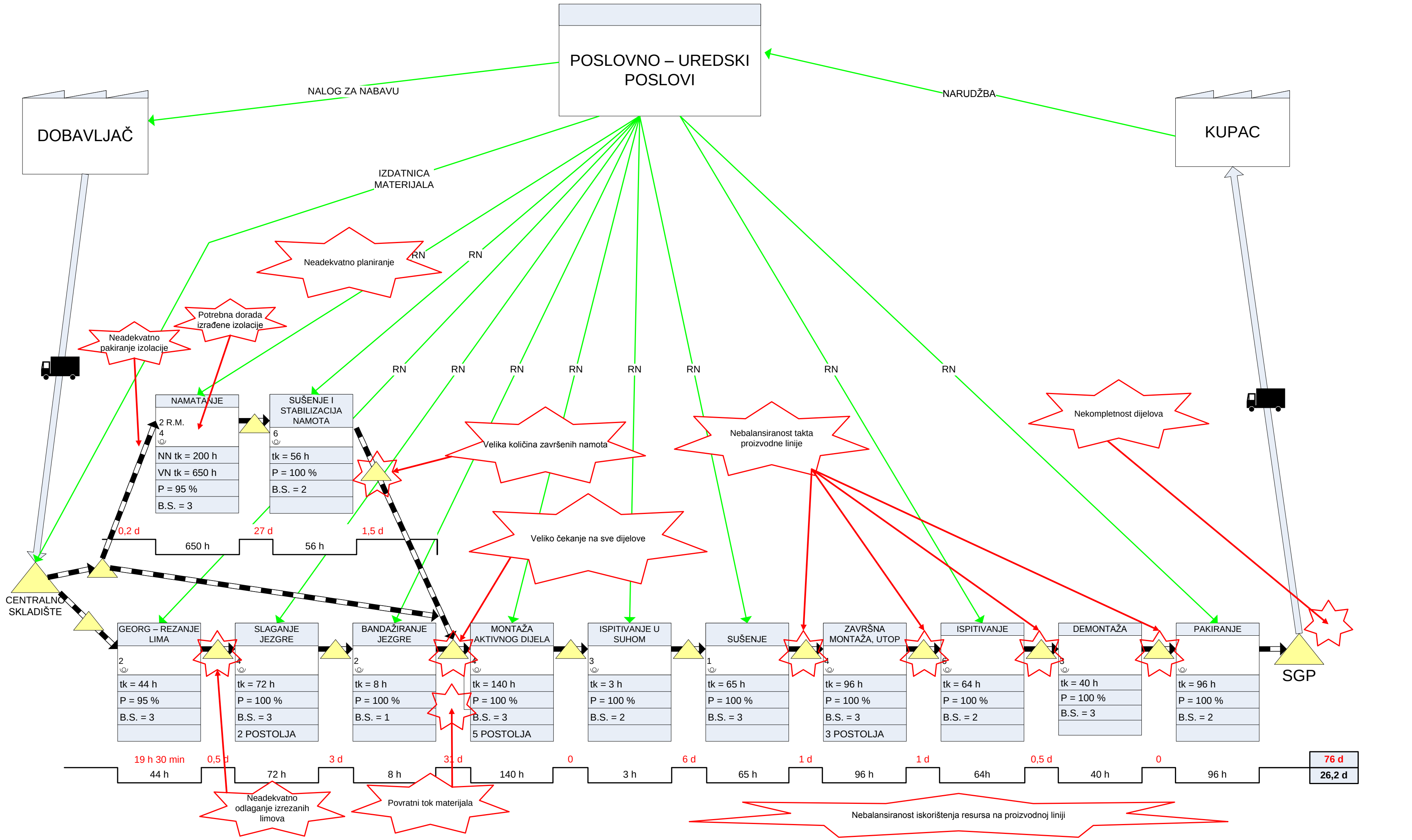
Improvements possibilities

- Space shortage for cut metal sheets
- Too often schedule change what affects efficiency of cutting
- Waiting of active parts assembly
- Production process efficiency 30,7 %
- Preparation of Isolation – finished 2 months before
- Defect isolation parts - rework
- Unsorted isolation material
- 3 – 4 days of inventory in assembly area

Metrics

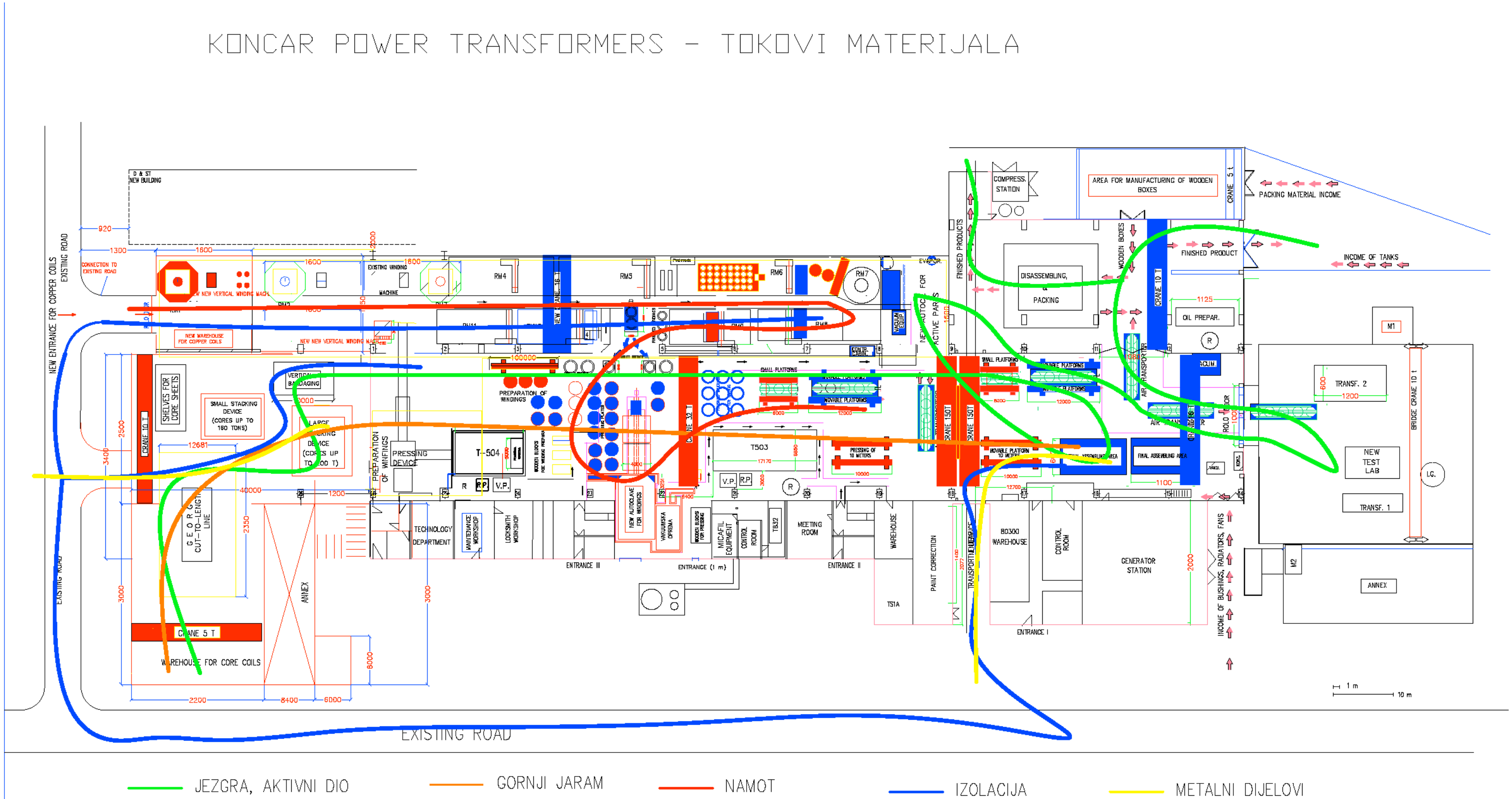
- Production Cycle Time [Days]
- Processing Time [h, days]
- Overtime Per Employee [h]
- Utilization of Resources [%]
- Work In Process
- Rework Rate [%]

KPT – VSM – KAIZEN Blitz



REPORT

KPT – Spaghetti diagram



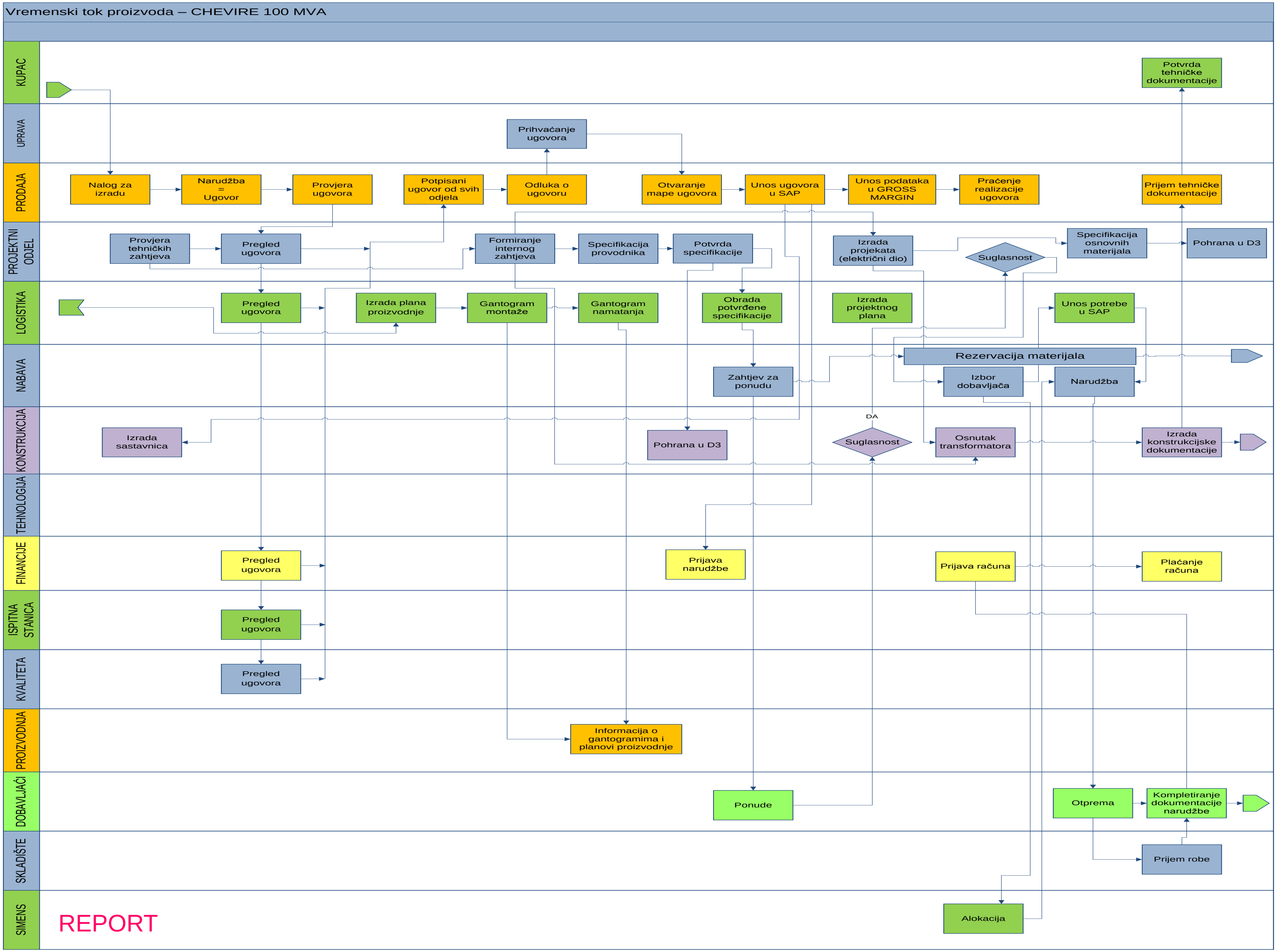
REPORT

KPT – Spaghetti diagram

Analysis	Metrics
• Reverse material flow • Unequal material flow in some departments (specially in assembly department) • Additional transport is needed what causes waiting and disturbance of production process	• Transportation routes lenght [m] • Availability and interdependence of gantry cranes [%] • Buffer space [m^2]

REPORT

Current Process Map



Potential improvements

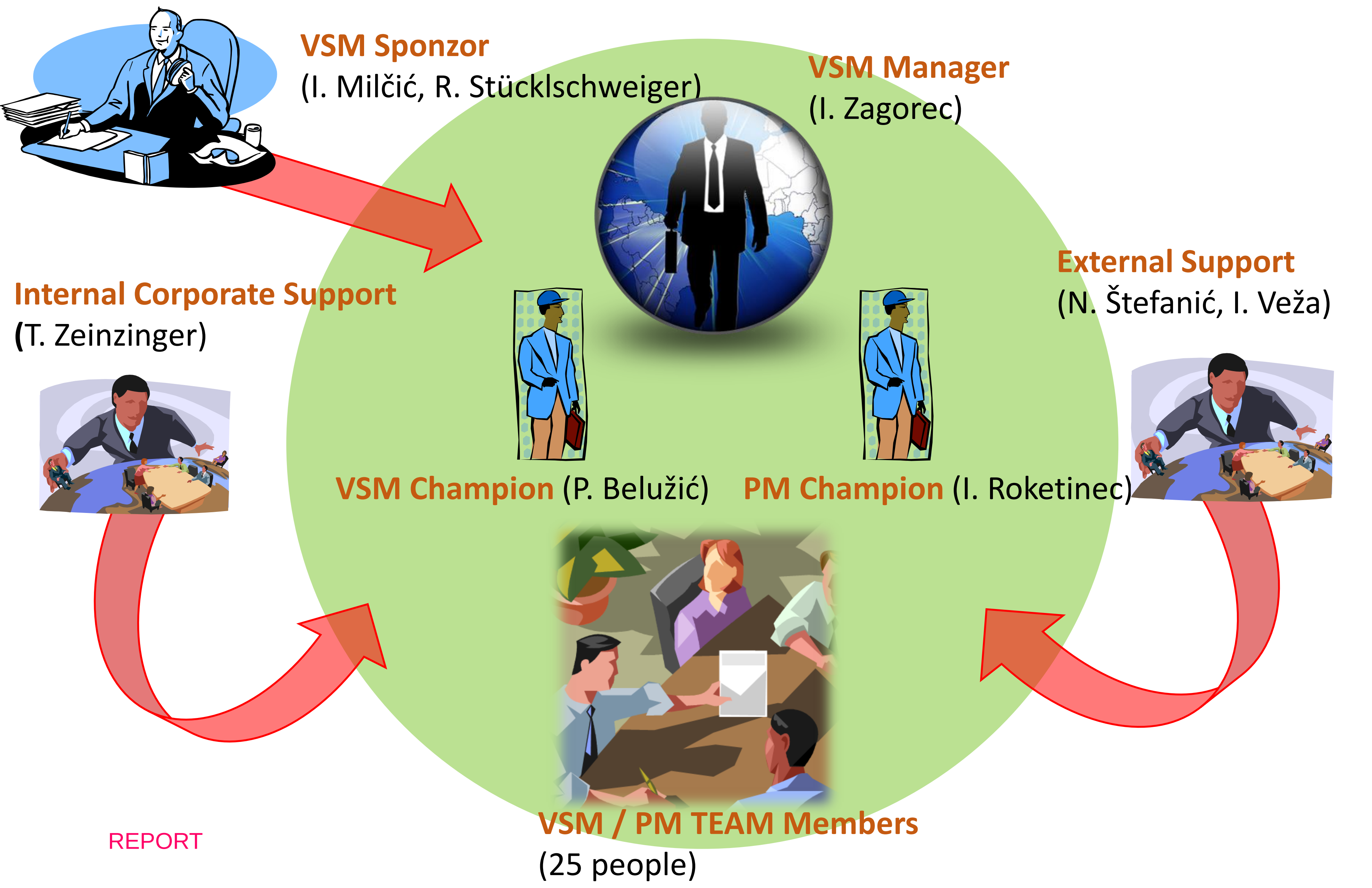
VSM

- Process planning (i.e. Cutting department)
- Work procedures and reporting about defects and disturbances
- Constrained inventory space for parts processed on GEORG)
- Reverse material flow after core bandaging
- Packing of isolation material for wiring department and rework of isolations
- Waiting for assembling active parts
- Assembly line balancing

Process Mapping

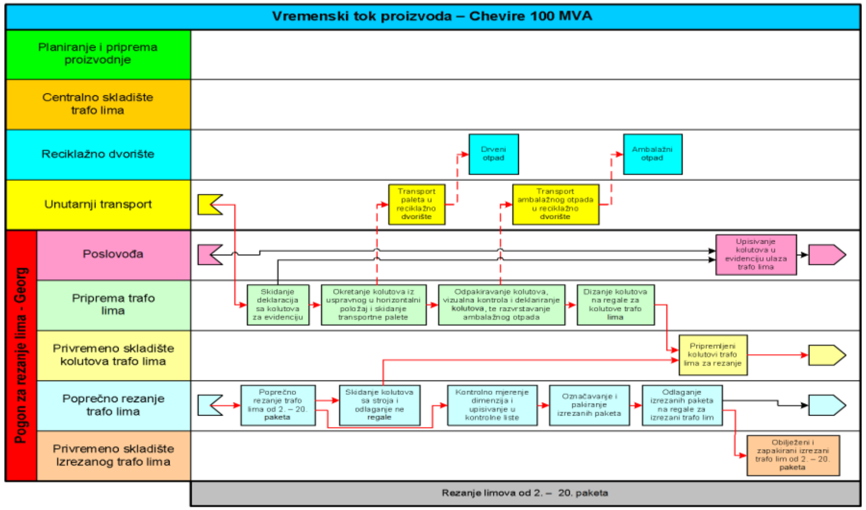
- Multiplied data input in the system
- Not enough defined demands at the beginning
- Correct and timeliness data input in SAP
- Standardization of Plates marking process
- Managing of direct improvement proposal
- Improvement of design process
- Business process optimization
- Departments communication

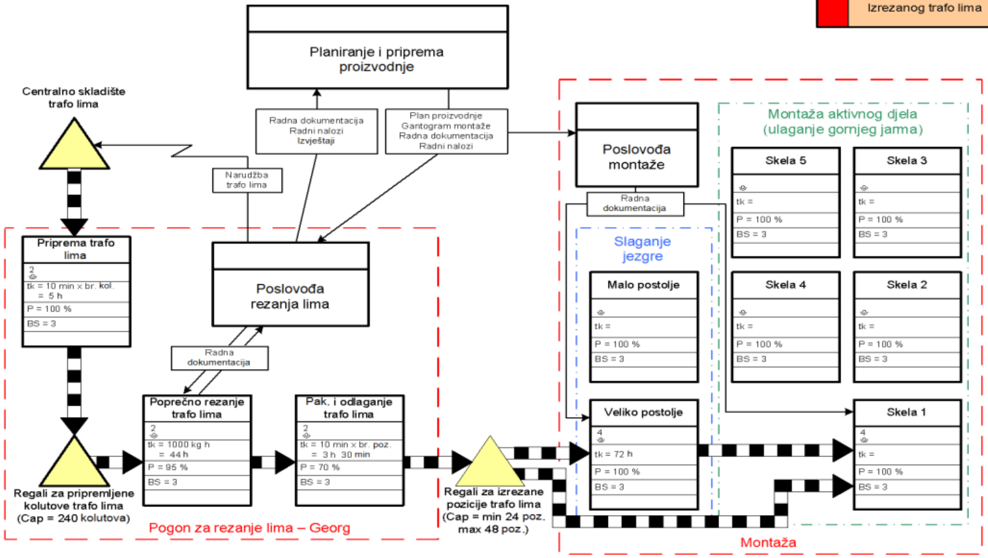
ImprovementsTeam



VSM champion – Predrag Belužić

Nabava i transport trafo lima	1.	Narudžba lima prema dnevnom planu rezanja	1 h	1 (poslovođa)
	2.	Čekanje zbog zauzetosti skladištara	1 h	
	3.	Označavanje lima u skladištu, te skidanje sa liste zaliha	1 h	1 (skladištar)
	4.	Čekanje zbog zauzetosti viljuškara	2 h	
	5.	Vađenje lima iz skladišta i transport u predprostor hale za rezanje lima	2 h	1 (vozač)/1(viljuškar)
	6.	Čekanje zbog zauzetosti prostora u hali	1 h	
	7.	Transport iz predprostora u halu za rezanje lima	1 h	1 (vozač)/1(viljuškar)



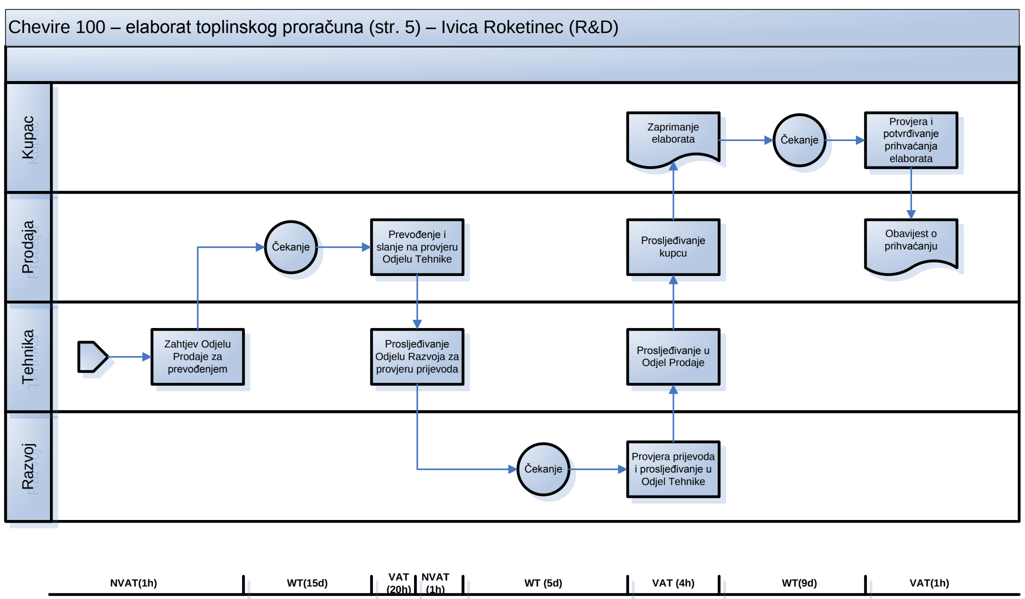


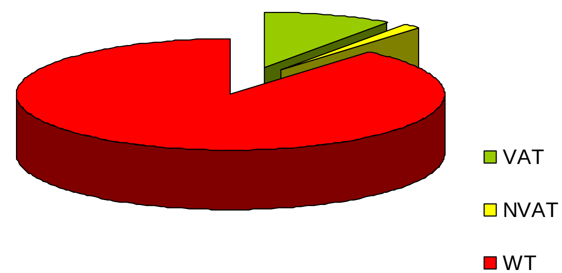
VAT	44 h
NVAT	31h 33 min
WAT	14d 19h 30 min

REPORT

PM champion – Ivica Roketinec

Chevire 100 – Aktivnosti u izradi elaborata dodatnog toplinskog proračuna			
Red. broj	**Aktivnost**	**Vrijeme**	**Mjesto realizacije**
1	**Zahtjev za dodatnim proračunom**	**-**	**Kupac**
2	**Proučavanje zahtjeva i prosljeđivanje Odjelu Tehnike**	**4h**	**Prodaja**
3	**Primitak zahtjeva**	**-**	**Tehnika**
4	**Čekanje**	**5d**	**Tehnika**
5	**Analiza zahtjeva**	**8h**	**Tehnika**
6	**Konzultacije s Odjelom Razvoja**	**2h**	**Razvoj**
7	**Izrada usporednog proračuna (Turska 125 – Cheviré 100)**	**8h**	**Tehnika**





VAT	NVAT	WT	Eff-Cycle
15.875	**2.75**	**147**	**10.6%**

REPORT

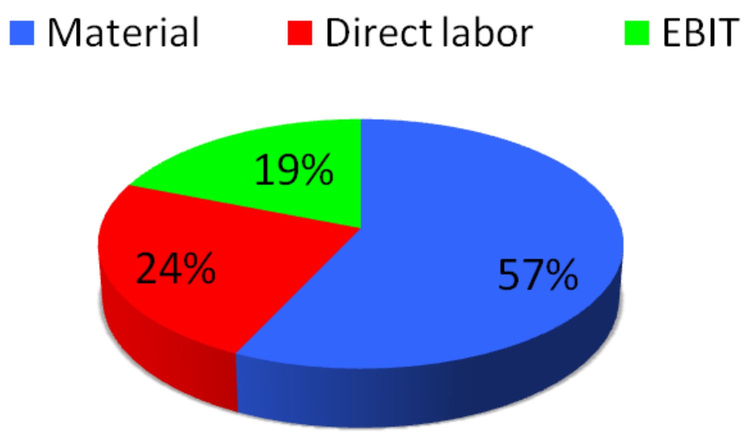
Possible savings calculation

Savings after VSM analysis(world expirience)

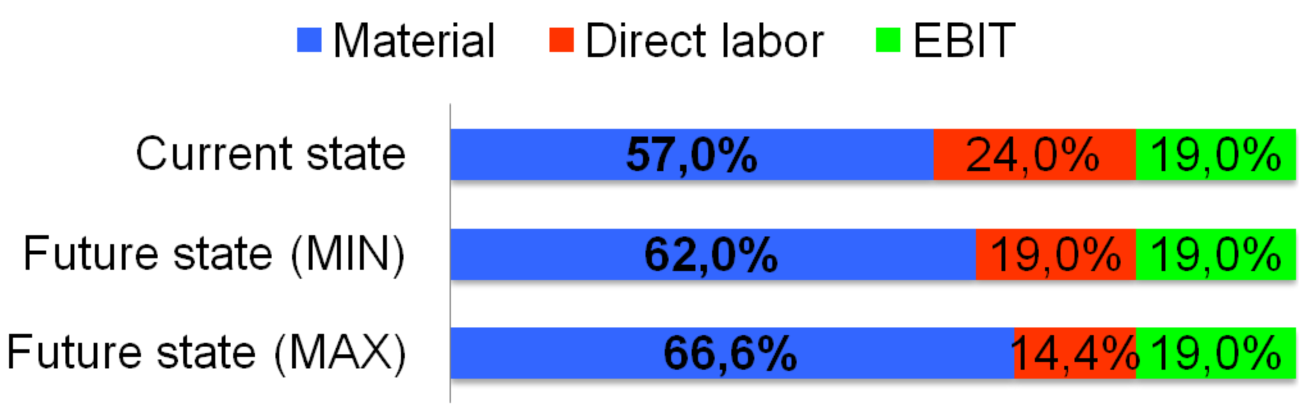
PCT [days] ↘ 25 % - 40 %

DCT [h] ↘ 25 % - 40 %

Sales



Improvements



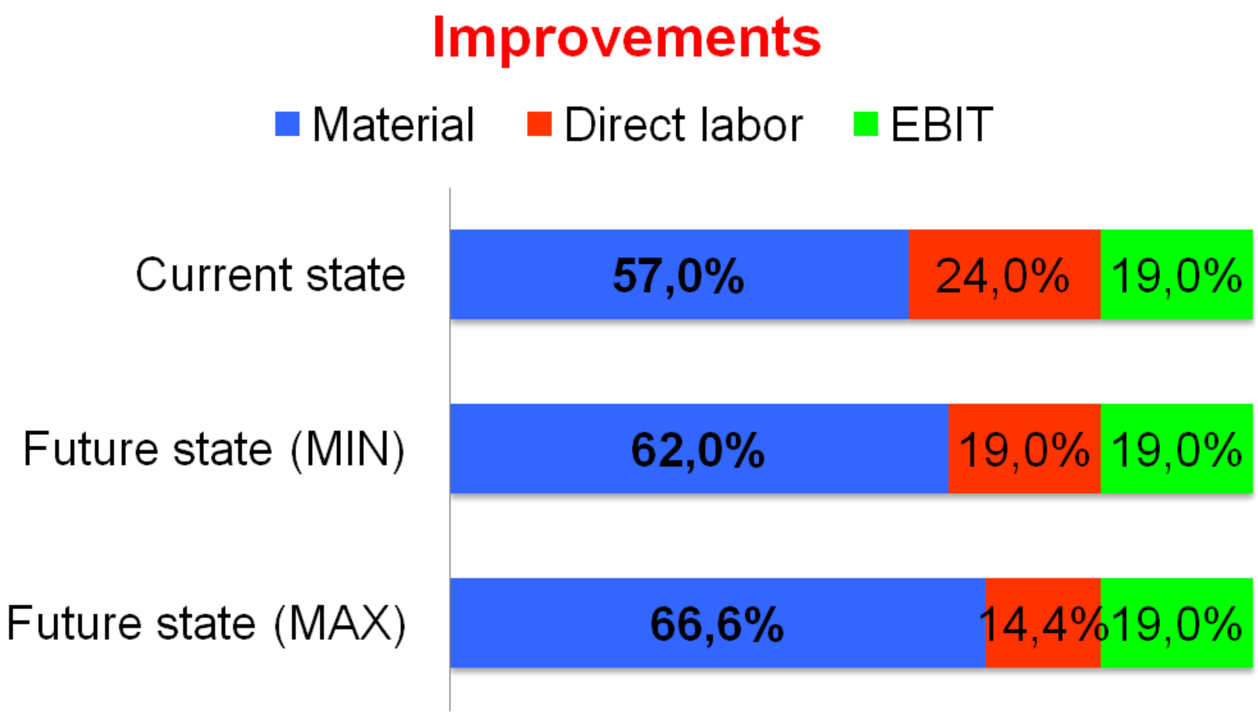
Savings:

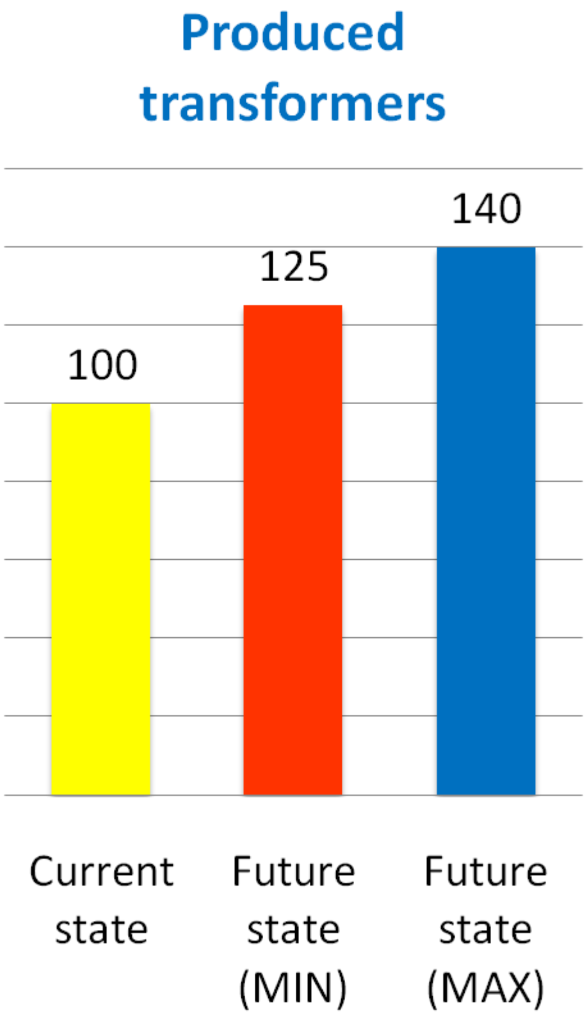
10.2 mill €

16.32 mill €

REPORT

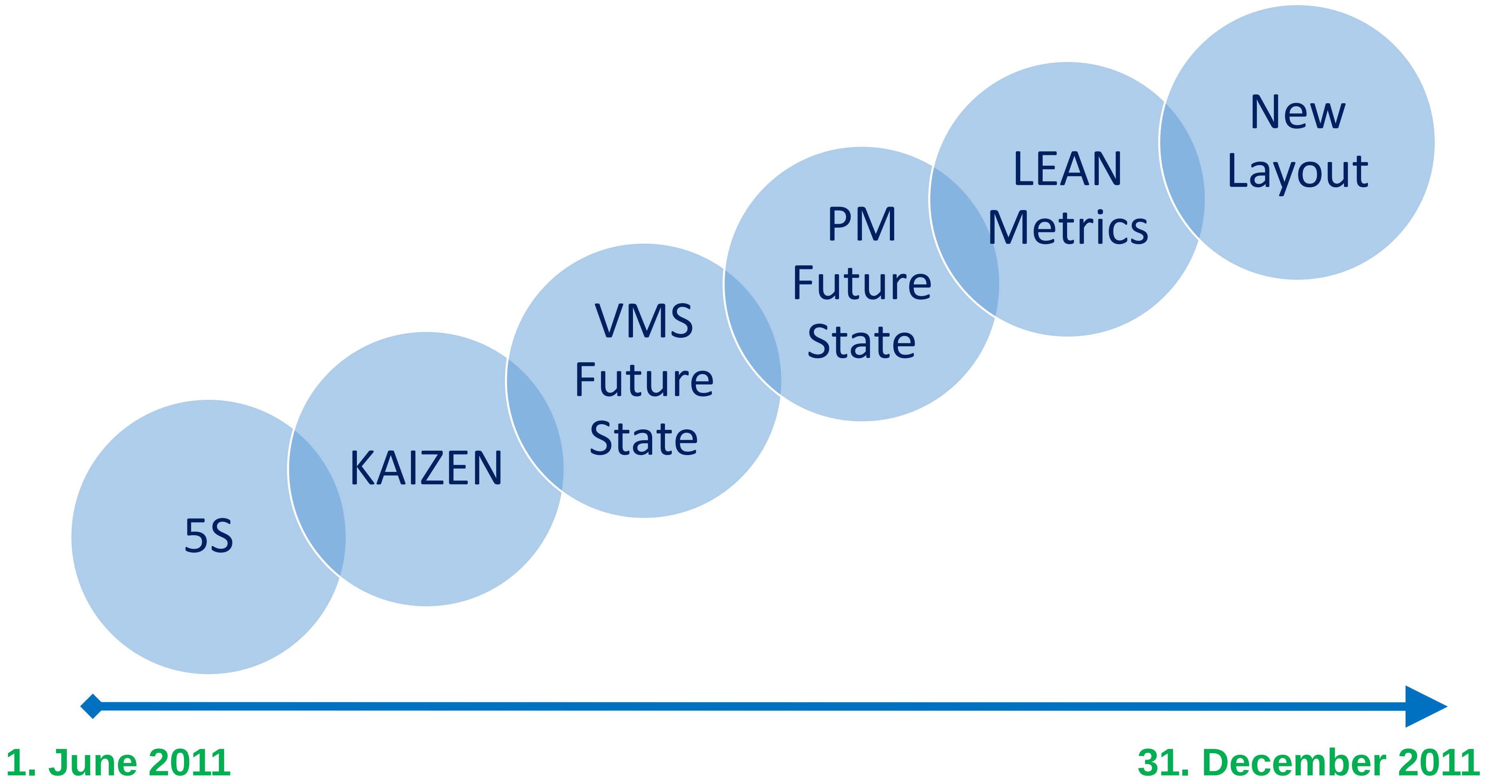
Possible savings calculation





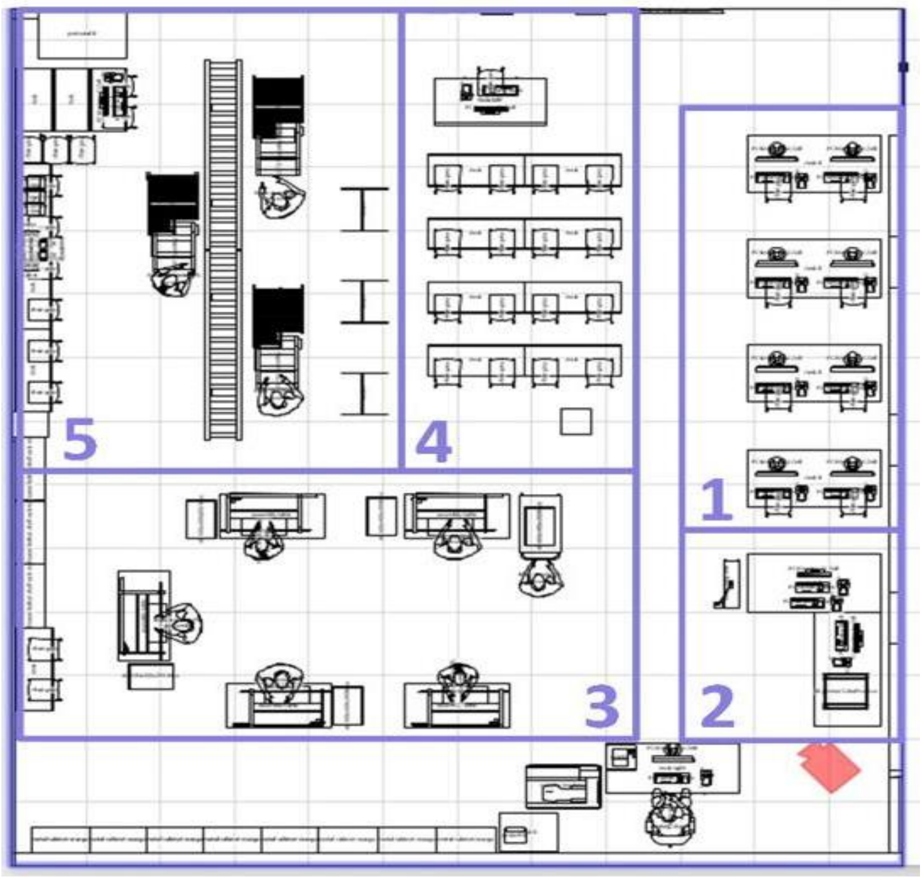
REPORT

Future Activities



REPORT

Learning Factory - Layout

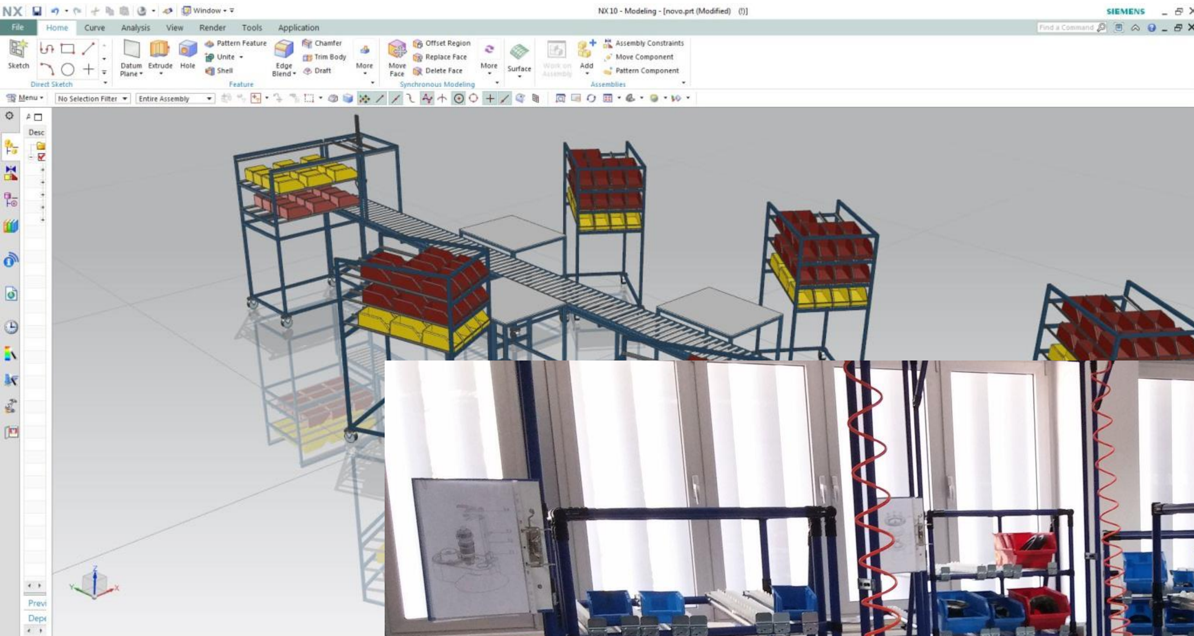


Explanation :

1. Server with 8 PC and Siemens PLM
2. 3D scanner and 3D printer
3. Assembly line of karet
4. Classroom with lean tools and simulations
5. Assembly line of gearbox

3D model of laboratories in VisTable

Planed reconfigurable assembly line in Learning Factory



hrzz
Hrvatska zaklada za znanost

The development of new products, specific to the City of Split

Karet - vehicle without drive, braking and safety elements; generations favorite street toy on downhill of Split.

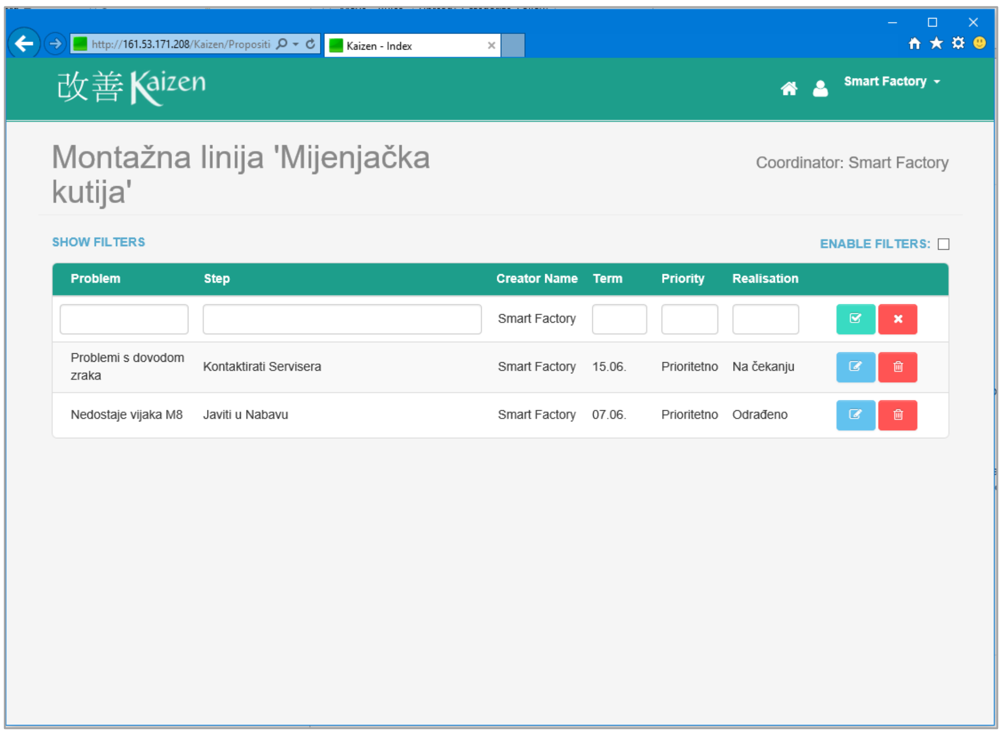
Version of the original karet

Improved karet by the FESB

Integrating Smart Factory elements into Learning Factory

Windows tablets will be installed on 4 work-stations.

At the moment, Kaizen web application has been developed.

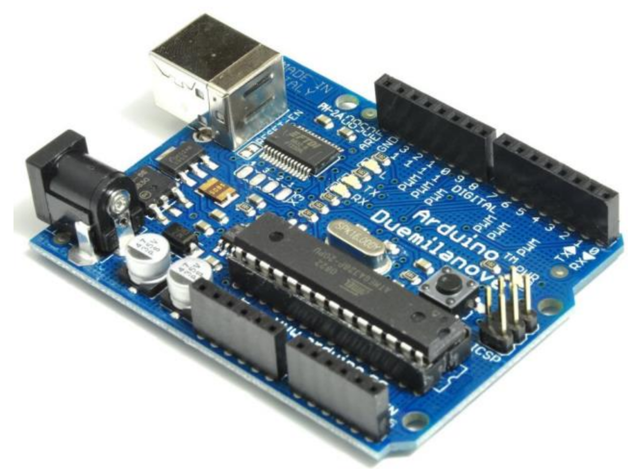


hrzz
Hrvatska zaklada za znanost

Integrating Smart Factory elements into Learning Factory

Lucas-Nuelle RFID system with 2 antennas will be installed.

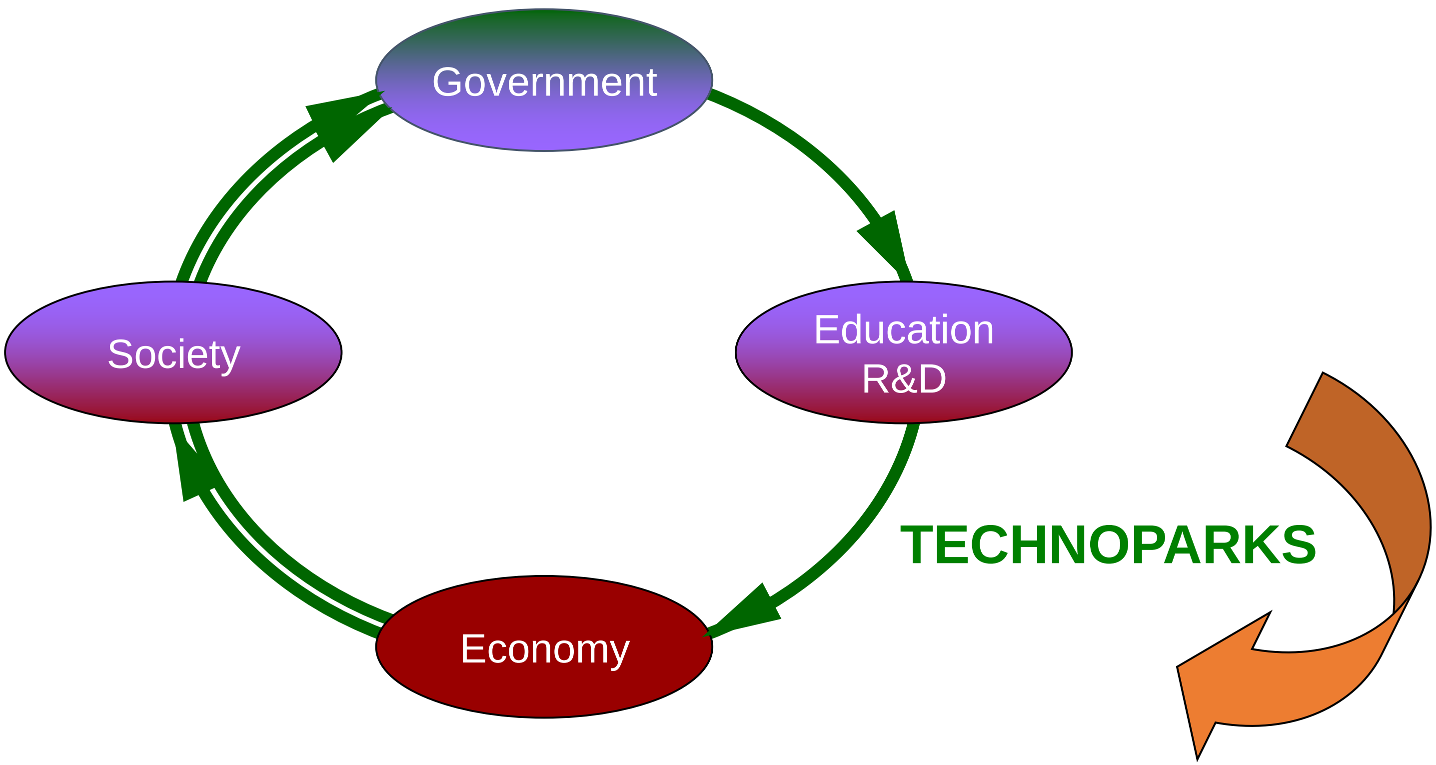
Additionally, customized solutions for assembly line and manipulator (based on PLC unit and Arduino micro-controllers) will be developed.



Agenda

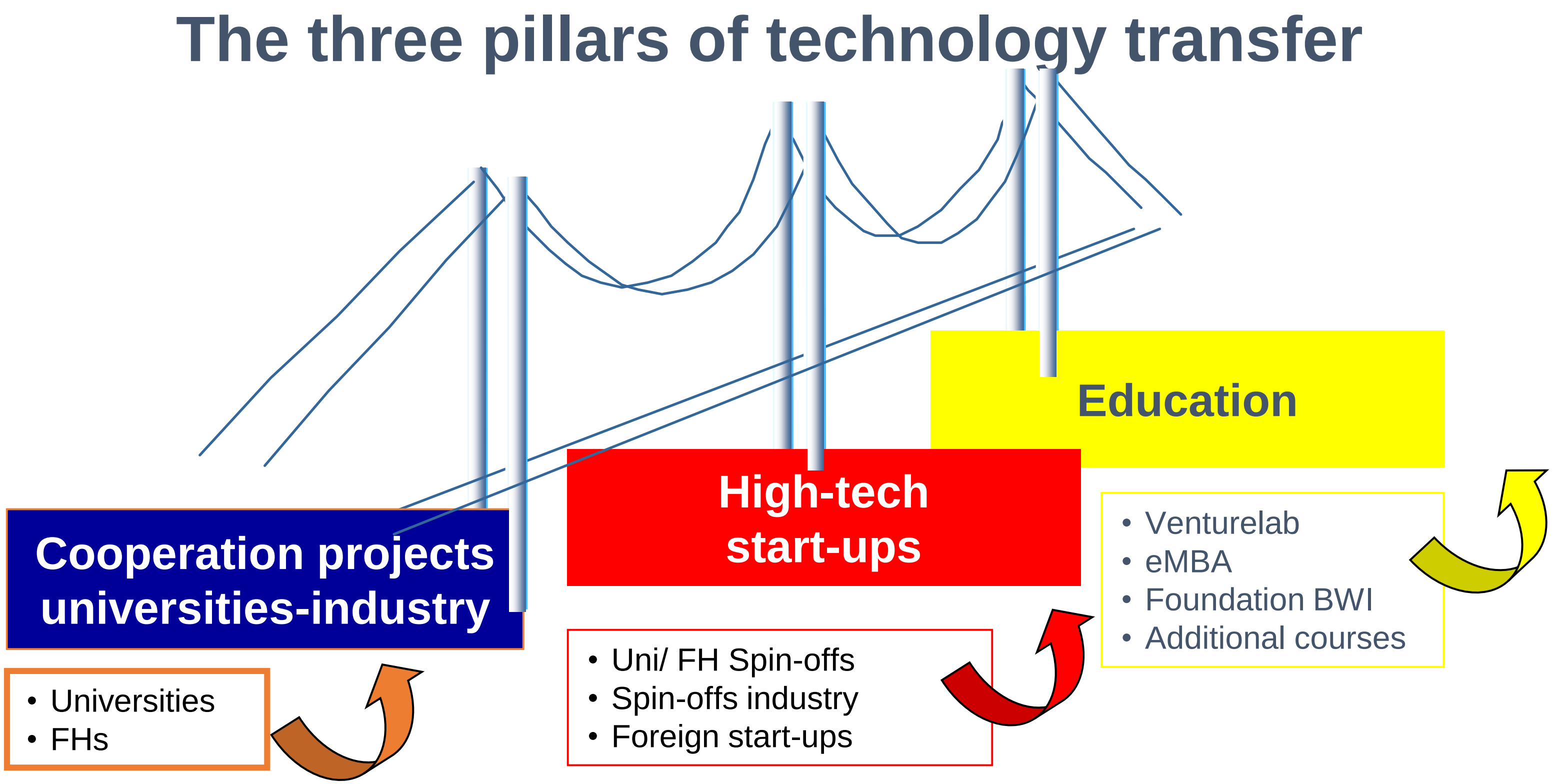
1. Introduction
2. Industry 4.0
3. Project Innovative Smart Factory INSENT
4. Lean Learning Factory
5. Conclusion

Closing the economic cycle: Creating new jobs through the transfer of technologies



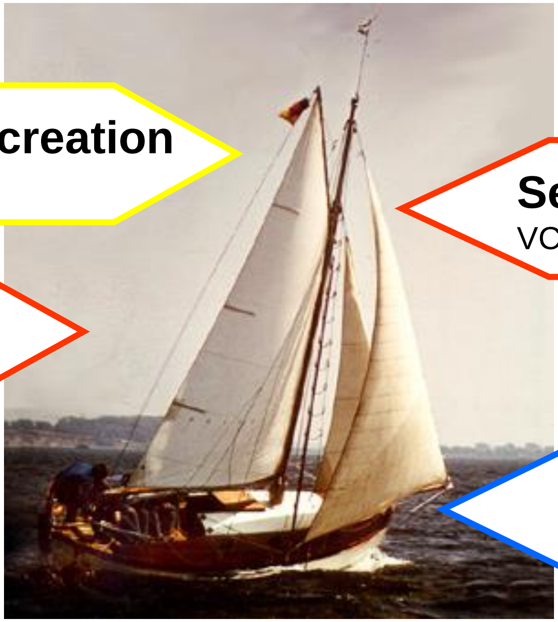
S. Bonaccio, Head of ETH transfer, ETH Zurich, 2008

Transfer of knowledge and know-how



S. Bonaccio, Head of ETH transfer, ETH Zurich, 2008

We cordially invite you for a fruitful cooperation!



Knowledge creation
Universities/ FH

Seed/ growth capital
VCs, BAs, foundations, banks

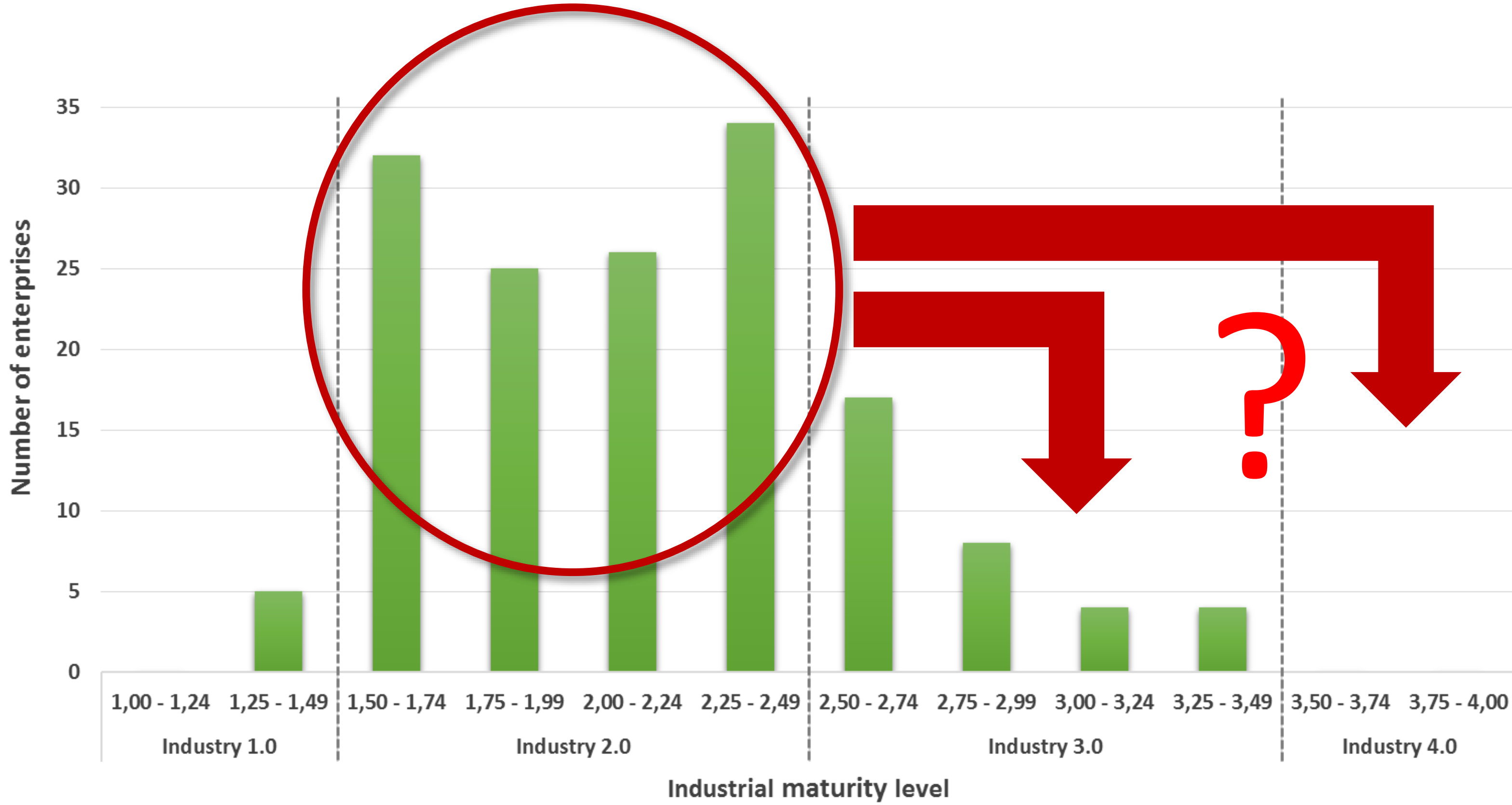
Gov. programs
CTI Start-up, Venturelab

Value chain
SMEs, large companies

➔ **Consolidate efforts, „flagship“ function**

S. Bonaccio, Head of ETH transfer, ETH Zurich, 2008

Move toward Industry 3.0 or Industry 4.0 ???



Replacement of equipment

Percent of installed base

100
Replacement of complete loom necessary

~ 10 - 20
Little replacement, as tooling equip-ment could be kept, only conveyor belt needed

~ 80 - 90
High level of replacement as tooling equipment was replaced by machines

~ 40 - 50
Existing machines are connected, only partial replacement of equipment

INSENT findings

Most of the Croatian manufacturing enterprises **have less than 100 employees** and they are **producing single products or small lots for other enterprises (suppliers!).**

They have less interest in Industry 4.0!

Micro enterprises and SME

Single item / Small lots production

Medium and Large-sized enterprises

Serial / Large lots production

INSENT Hypothesis for Croatia: There are Industry 4.0 Providers and Industry 4.0 Users

HSTec
HIGH SPEED TECHNIQUE

SINEL
d.o.o. - Labin - Croatia

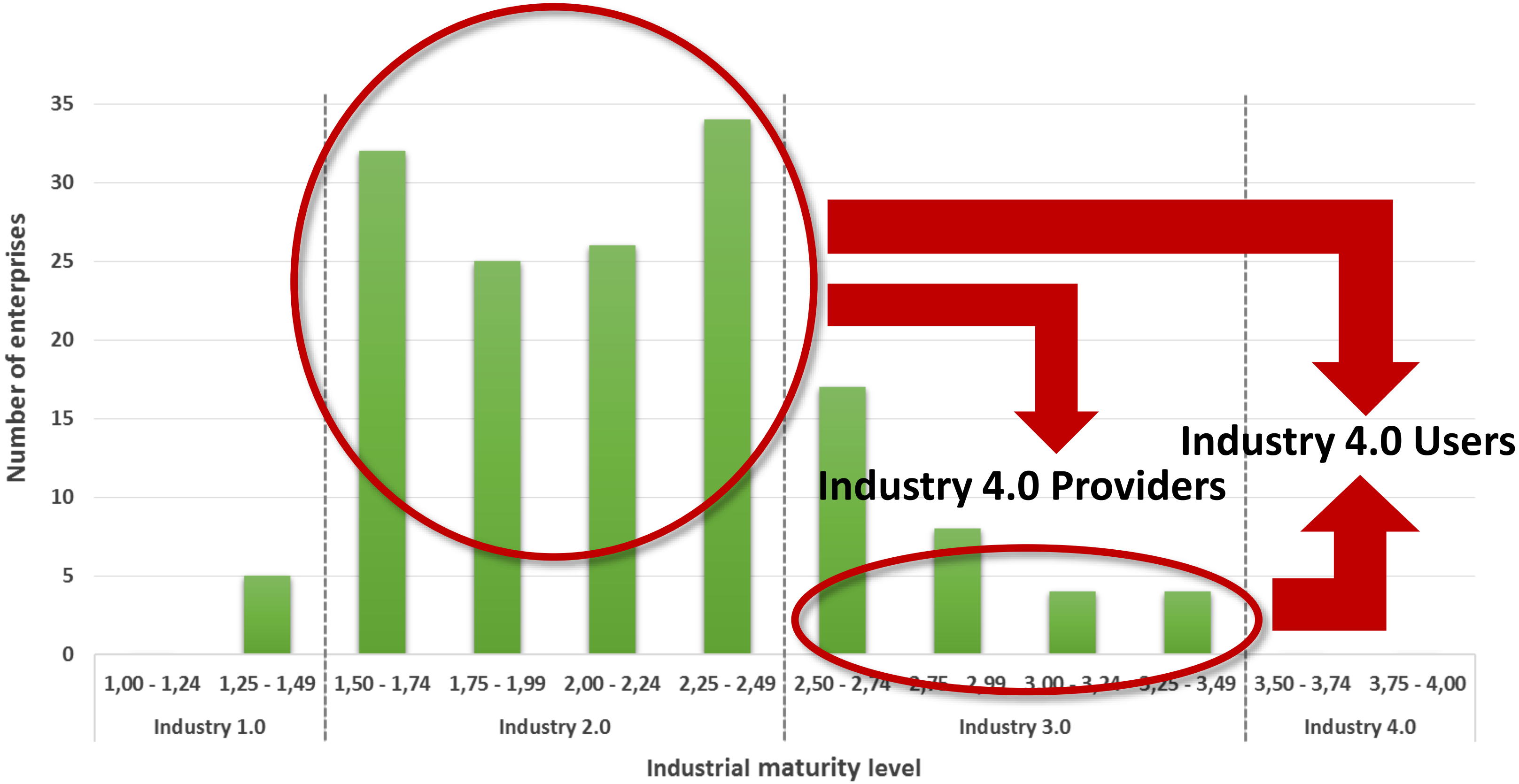
Industry 4.0 Provider		Industry 4.0 User
XS, S, M	**Enterprise size**	M, L
Single item / Small lots	**Production type**	Serial / Large lots
3.0	**Industrial maturity level**	4.0
Product	**Integration of I4.0 into**	Process
Personalized product	**Production networks integration**	Manufacturing-as-a-Service
Developers	**I4.0 software and IT interfaces**	End-users

OMCO

Jajce Alloy Wheels

Hypothesis for Croatian manufacturing industry

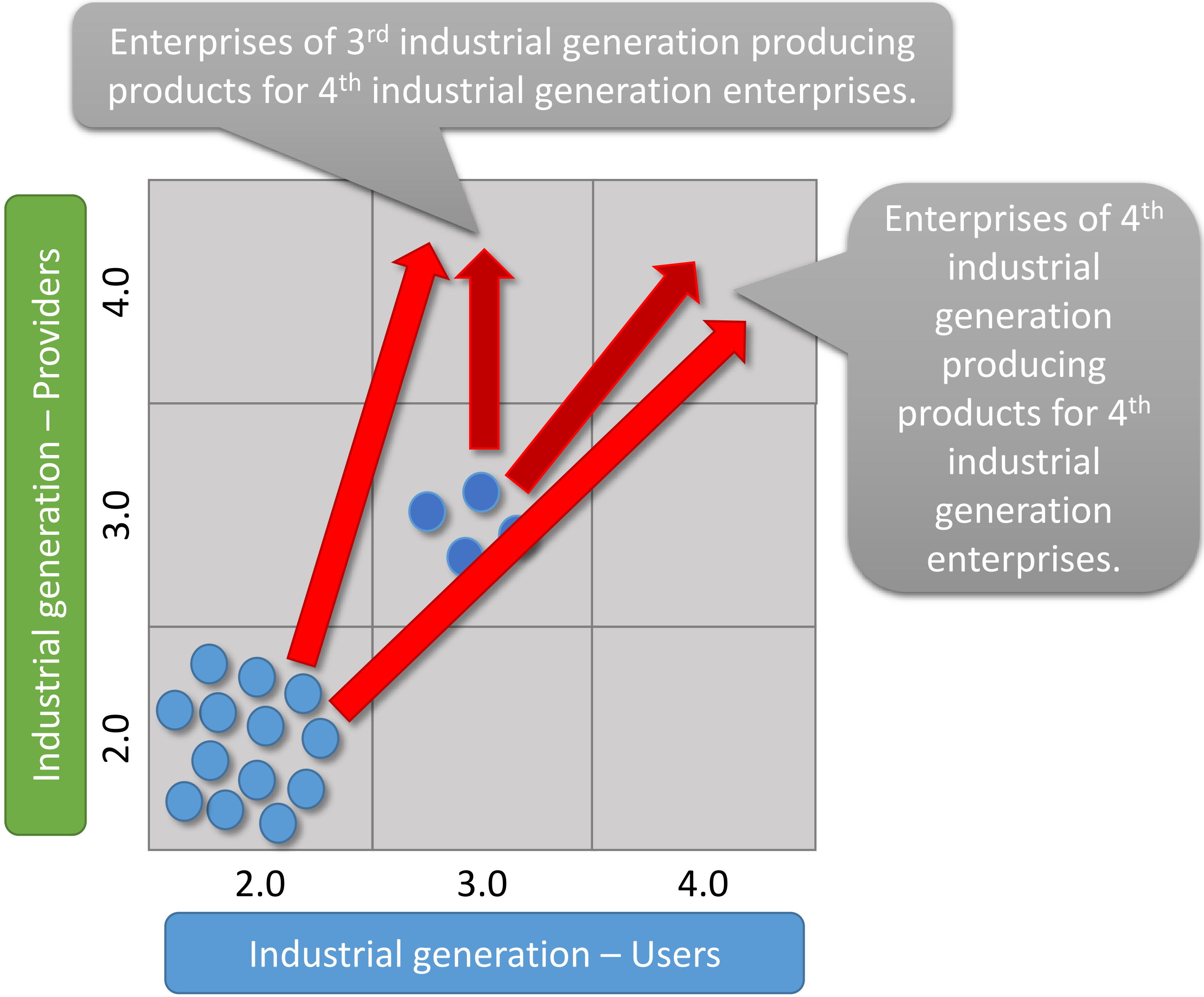
Move toward Industry 3.0 or Industry 4.0? Both!



hrzz
Hrvatska zaklada za znanost

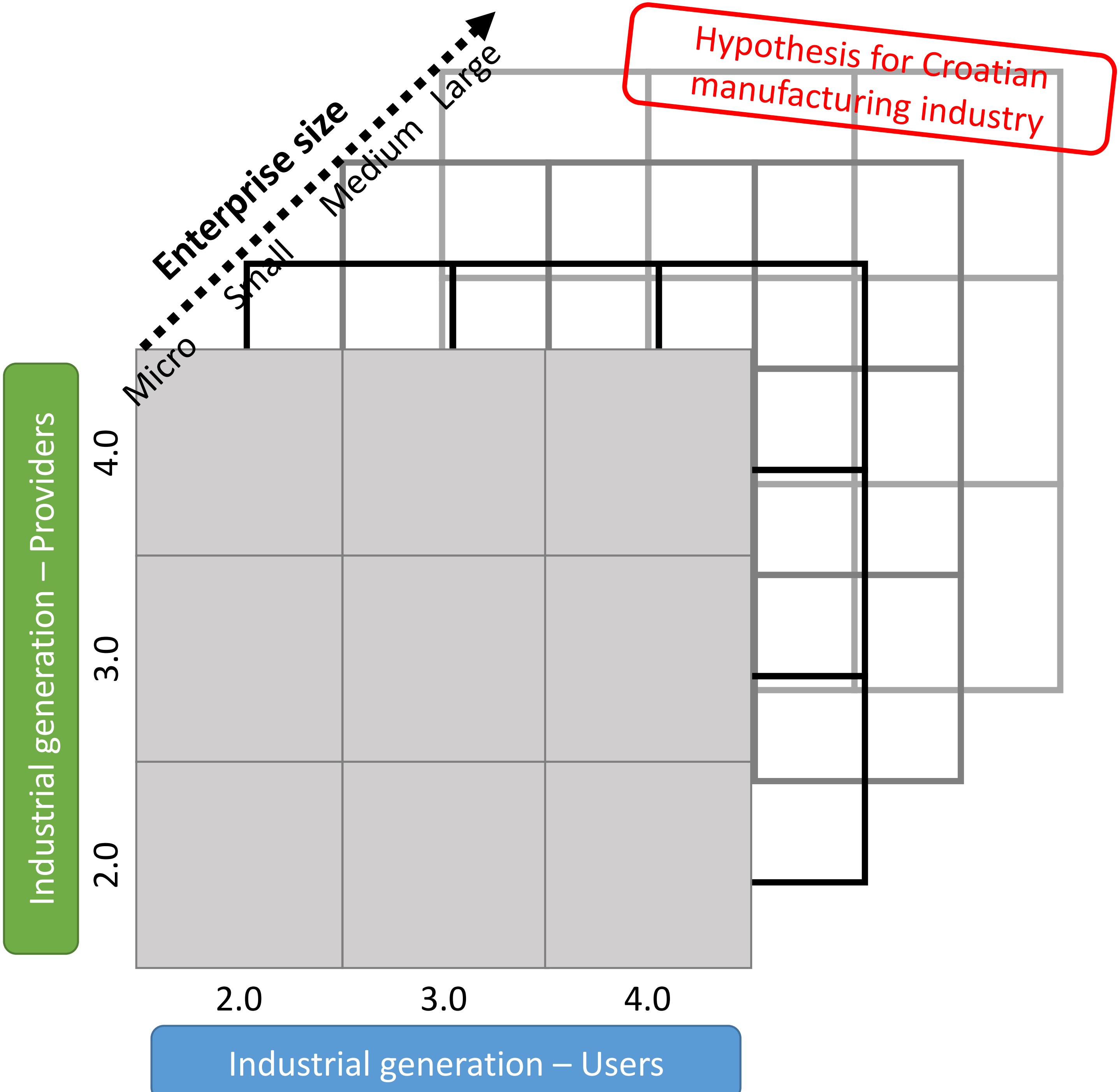
Industry 4.0 Providers vs Industry 4.0 Users

Hypothesis for Croatian manufacturing industry



hrzz Hrvatska zaklada za znanost

Different approaches for different enterprise size?



hrzz
Hrvatska zaklada za znanost

Conditio sine qua non

- **Defining the strategy of the Republic of Croatia,** one of the priorities is research and development and lifelong learning→ from the current allocation of approximately 0.7% of GDP per min. 3% of GDP, with the trend of further growth
- **Defining of Croatian production platform** according to the Strategic Research Agenda for Europe
→ new tehnologies → new studies of new technologies (not for pushing the students to the Bureau of employment)
- **Positioning of quality people on the functions relevant to the implementation of the strategy,** rather than according to political party eligibility
- **Change management** → positioning people, instead of profit, in the center of the system
- **The awareness that only industrial development and industrialization can drive us out of the crisis → Push out the importers lobby!**

hrzz
Hrvatska zaklada za znanost

If everything is under control you are just not driving fast enough.

Stirling Moss
(Rennfahrer, geb. 1929)

Croatian Science Foundation
Innovative Smart Enterprise
INSENT (1353)

Thank you for your attention

F E S B   S p l i t

Contact:

Prof. Ivica Veža

University of Split
Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture

ivica.veza@fesb.hr

http://**insent.fesb.hr**

This work has been fully supported by the Croatian Science Foundation under the project Innovative Smart Enterprise – INSENT (1353).