Towards Sustainable Process Industries: The Role of Control and Optimisation

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SPIRE
Sustainable Process Industry through Resource and Energy Efficiency

Contents

- **Overview on the SPIRE PPP**
- The Role of Process Control & Optimisation
- Needs for Improvement
- New Information and Communication Technologies (ICT)
- Conclusions

Our Societal Challenges
as summarized by the European Commission for Horizon 2020

- **Health, demographic change and wellbeing**
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the **bio economy**
- Secure, clean and efficient **energy**
- Smart, green and integrated transport
- Climate action, environment, **resource efficiency** and raw materials
- Europe in a changing world – inclusive, **innovative** and reflective societies
- Secure societies – protecting freedom and security of Europe and its citizens

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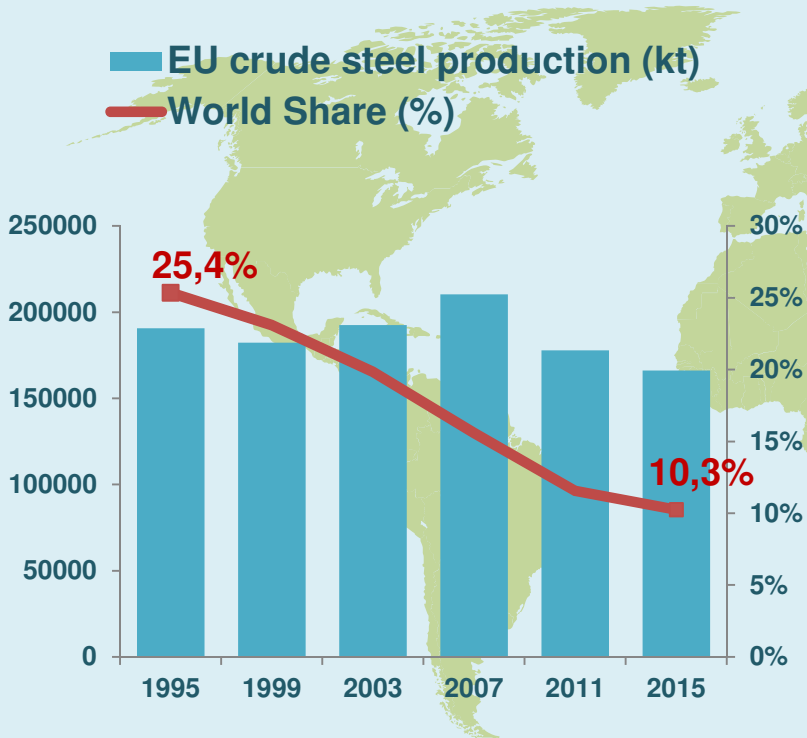
The European Process Industry Situation

A strong contributor to growth and jobs, but competition is growing

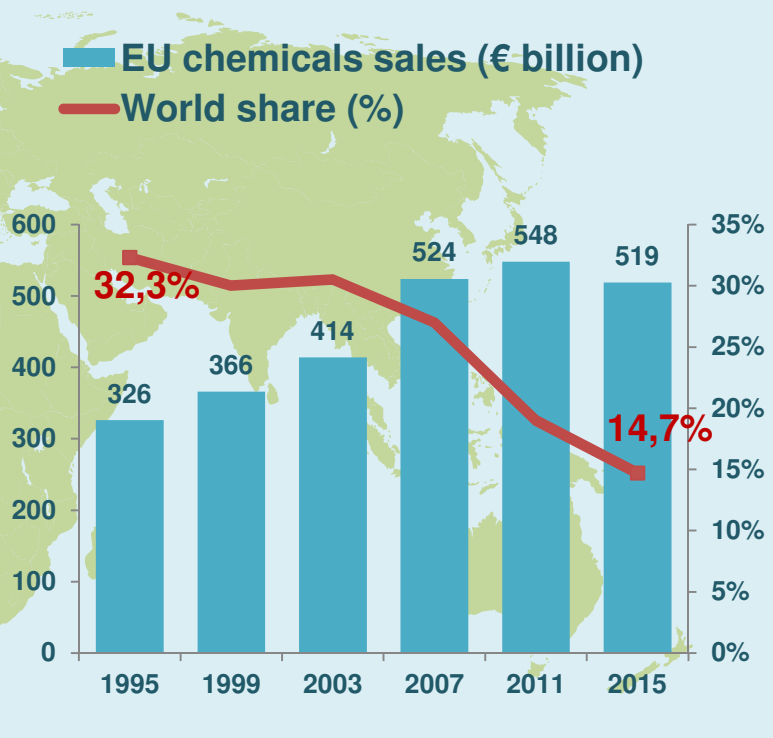
Access to competitive Raw Materials and Energy is more and more an issue

EU crude steel production reduced over last 20 years



Source: Steel Statistical Yearbook 2005 & 2015

EU chemicals sales increased in 20 years, while it's world market share halves



Source: Cefic Chemdata International 2016

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SPIRE PPP

Sustainable Process Industry through Resource and Energy Efficiency

First-ever Public Private Partnership (PPP) for process industries

Comprises 8 sectors
(6.8 million jobs, 450,000 enterprises, over €1,600 billion/year turnover)

Projects planned for ca. 2 billion € (over 7 years)

> 50 currently running projects

145 industry and research members

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Cerame-Unie The European Ceramic Industry Association
IMA Europe
EUROMETAUX EUROPEAN ASSOCIATION OF METALS
Elken A Bluestar Compar
AXELERA
cefic
CLIB 2021
EUROPEAN ALUMINIUM
alfran
VIOKERAL
TERREAL TERRE CUITE
LKAB
HYDRO
fimecc Finnish Metals and Engineering Competence Cluster
iris
DECHEMA
GREEN CHEMISTRY CAMPUS
repic
CEMBUREAU
LafargeHolcim
EUROFER The European Steel Association
ThyssenKrupp
DOW
BASF We create chemistry
BAYER
HEIDELBERGCEMENT
GERDAU
TATA TATA STEEL
suez environnement
INEOS THE WORD FOR CHEMICALS
P&G
CEMEX Building the future
voestalpine EINEN SCHRITT VORAUS.
Tenaris
ArcelorMittal
Tüpraş
REPSOL
DSM BRIGHT SCIENCE. BRIGHTER LIVING.
Solutex
EUnited. European Engineering Industries Association
PARAGON S.A.
cmi
Danske Commodities
EVONIK INDUSTRIES
LANXESS
AkzoNobel Tomorrow's Answers Today
The European Water Platform
IK4 Research Alliance
Britest
CLARIANT
SOLVAY asking more from chemistry®
exergy
econic technologies Polymers from CO2
ITENE
UNIVERSITY of GREENWICH
mrm Materials Resource Management
SUPREN Sustainable Process Engineering
Perstorp WINNING FORMULAS
ARKEMA
fives
eurecat Centre Tecnològic de Catalunya
idener
HYGEAR ENGINEERING FOR SUSTAINABLE GROWTH
CRIT
innobasque
LEITAT Technological Center
EU-VRi
cea
TU/e Technische Universiteit Eindhoven University of Technology
ADItech
UNIVERSITÀ DEGLI STUDI DI PADOVA
jtc
CARTIF
Scuola Superiore Sant'Anna
ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA
ICIQ Institut Català d'Investigació Química
Centro Sviluppo Materiali S.p.A. Research & Development for your competitiveness
AIT TOMORROW TODAY
CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS
circe
ispt
cpi ...the future inspired
KIT Karlsruhe Institute of Technology
BFI
KAПE CRES
MÄLARDALEN UNIVERSITY SWEDEN
LULEÅ TEKNISKA UNIVERSITET
ERIC European Research Institute of Catalysis
The University of Nottingham UNITED KINGDOM · CHINA · MALAYSIA
SP
tecnalia Corporación Tecnológica
UNIVERSITY of OULU OULUN YLIOPISTO
VTT
ASTER
tel-tek
RWTH AACHEN UNIVERSITY
LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST
CTMNC Terre et Pierre Expertise et Innovation
CRM GROUP CRM
The University of Nottingham UNITED KINGDOM · CHINA · MALAYSIA
zhaw
vito
IAT Innovation and Technology
UNIVERSITAT POLITÈCNICA DE VALÈNCIA
JERNKONTORET
ECN
Institut "Jožef Stefan" Ljubljana, Slovenija
TU Delft Delft University of Technology
Newcastle University
UNIVERSITY of LIMERICK
ENSCI
IVL Swedish Environmental Research Institute
MANCHESTER 1824 The University of Manchester
Fraunhofer
LABORATÓRIO ASSOCIADO LSRE
EPSRC Centre for Innovative Manufacturing
JIESIA
ENEA
TNO
swerea MEFOS
Technische Universität Braunschweig
SINTEF
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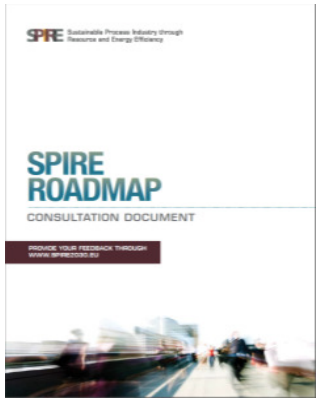
Why a PPP and why SPIRE?

- To facilitate **prioritisation** of R&I in line with the **Europe2020** objectives and industry needs of **8 sectors**
- To **leverage** research and innovation results in industry
- To strongly commit industry to **joint objectives**
- To solve problems **together**
- To provide **impactful results**
- To find **synergies** across sectors
- To create the basis for **uptake in industry**
- To strengthen European industrial **competitiveness**



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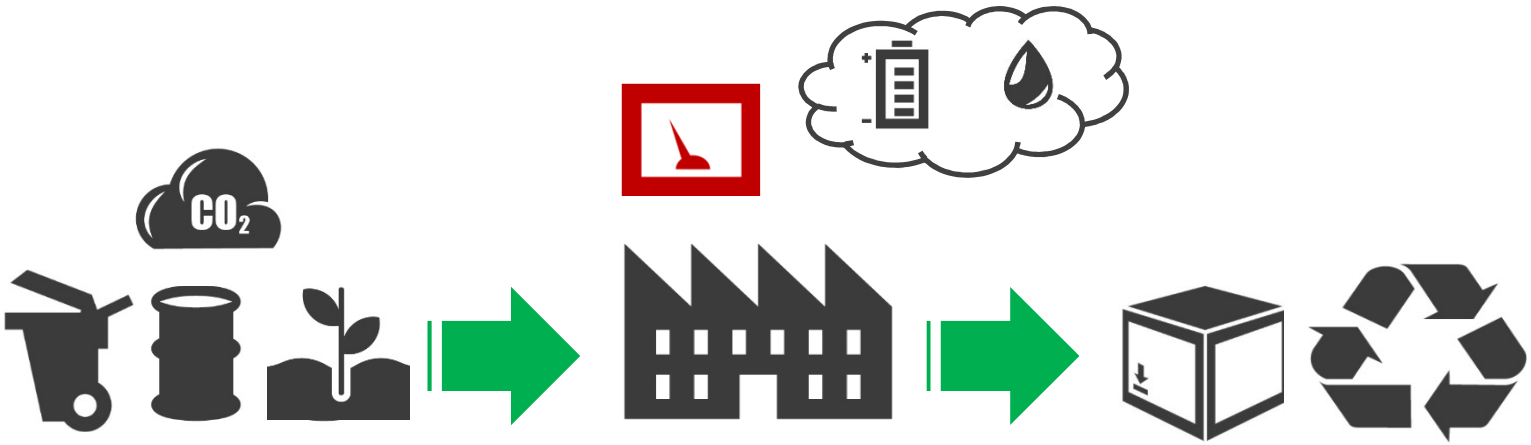
SPIRE Vision & Roadmap

Towards Tomorrow's Scenario:



- **(Re)invent** feedstock (waste, bio, CO_2)
- **Reduce** emissions; **(re)invent** energy & resource management concepts, incl. industrial symbiosis
- **Introduce digital devices for better monitoring and control**
- **(Re)invent** materials for optimised processes
- **(Re)invent** processes & materials with a significantly increased impact on resource & energy efficiency down the value chain: transport, housing
- **Reduce** waste & **(re)invent** technologies for valorisation of waste streams within and across sectors

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SPIRE Calls & Projects on Process Control

Integrated Process Control
(SPIRE-01-2014, projects started January 2015)

- … improved capabilities for **valid, reliable and real-time measurement** of the properties and **quality of process streams** and final products for existing and for more **flexible process operation** concepts.
- … better process operations with respect to **resource and energy efficiency**

consens INTEGRATED CONTROL AND SENSING
DiSIRE
iCspec
PROPAT INTEGRATED PROCESS CONTROL
RECOBA

Plant-wide Monitoring and Control of Data-Intensive Processes (SPIRE-02-2016 , projects started end of 2016)

- … **integration of local control** […]**into an overarching real-time optimisation and scheduling system** controlling and monitoring the operations of the whole plant
- … ensuring a **robust real-time optimisation of the plant's operations**

COCOP
COPRO COORDINATED PRODUCTION FOR BETTER RESOURCE EFFICIENCY
FUDIPO
MONSOON

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Why Process Control?

Every process is affected by variation and disturbances:

- Quality of raw materials
- Environmental conditions (humidity, temperature, etc.)
- Aging (catalyst, equipment)
- Fouling
- Delays in batch operation
- Manual interventions
- Load changes

Stable product quality

Efficient operation

Means to cope with variance:

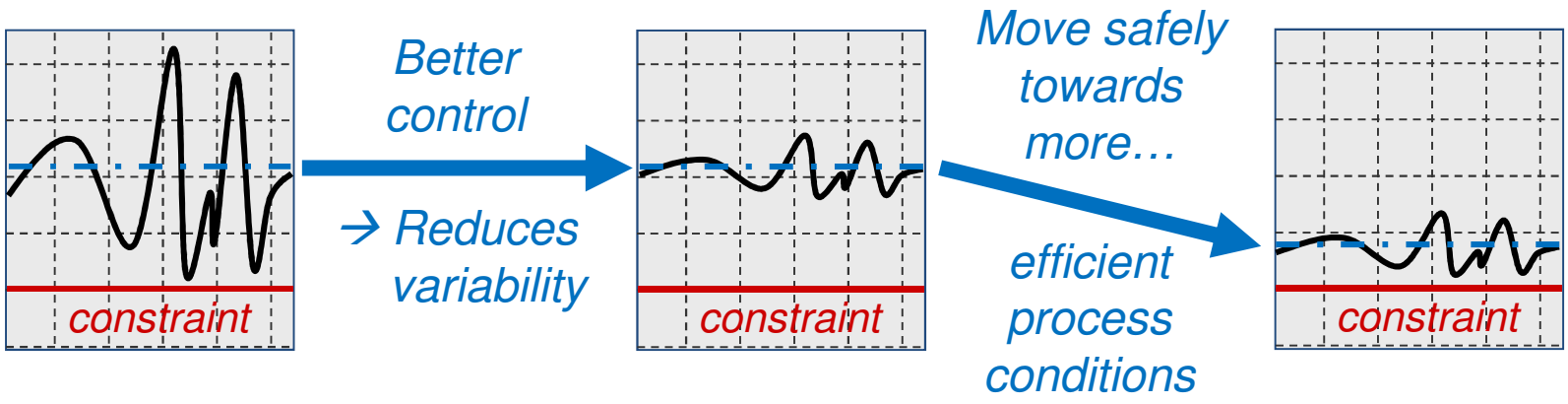
- **Online sensors**
- **Monitoring**
- **Process control**
- **Online optimisation**
- **Modelling and simulation**

Efficiency through Process Control

The most efficient process conditions are often limited by *operational limits,* e.g. purity or safety limits

Process fluctuations require to keep a certain distance from constraints

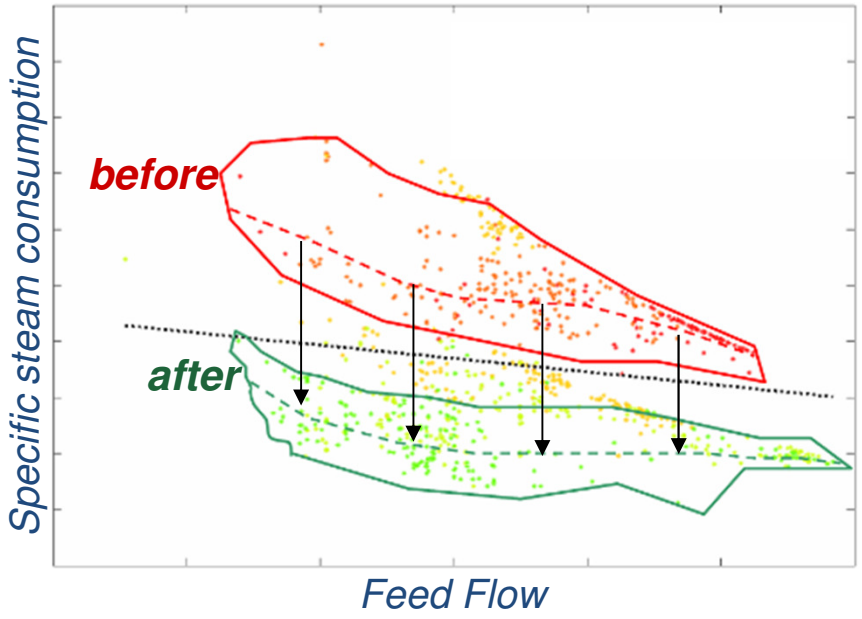
➔ **Reduction of process variation enables more efficient operation**:

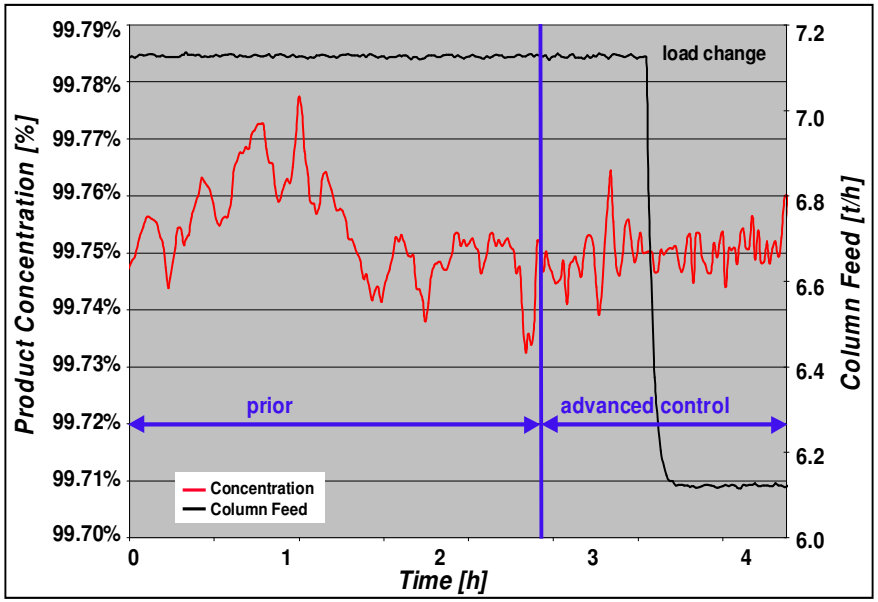


Example: Control of a Continuous Distillation

- Online PAT-sensors placed at right stages of distillation column
- Advanced Process Control (APC)

Result on real plant:





➔ Significantly reduced steam consumption

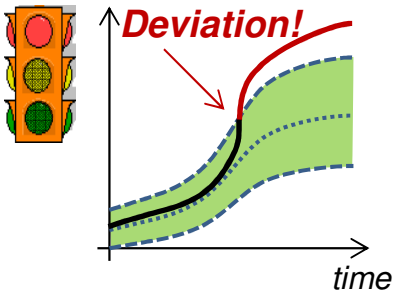
➔ Higher throughput can be achieved

➔ Quality level was significantly increased (much less variation)

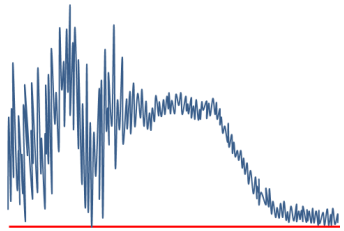
Elements of Process Control

(PAT-) Sensors provide valuable data on:
- Process and plant condition
- Product quality

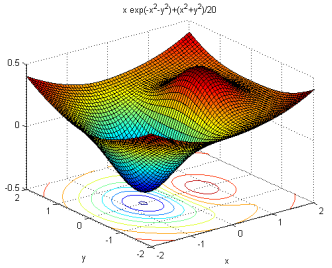
Online Monitoring provides additional insights about:
- Process performance
- Maintenance needs
- Process deviations



Advanced Process Control realizes:
- Compensation of variation & disturbances
- Efficient grade and load changes (continuous plants)
- Transient processes (e.g., start-up, batch)



Online Optimization and **Scheduling** strive for:
- Economic optimum of operation
- Adherence to process constraints



http://www.mathworks.com

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Levers for Ecological & Economic *Sustainability* of Process Industries

Raw Materials & Energy	• Energy and resource efficiency • Waste reduction • Circular economy & industrial symbiosis
Innovative Products	• High-value & high-quality products • *Mass customization, flexibility* • *Shorter innovation cycles* and time to market
Agility & Productivity	• *Fast response* to volatile market demand • *Seamless integration* along value chain • High degree of capacity utilization, low working capital
Training & Education	• *Highly skilled personnel* • Capable of taming ever-growing complexity

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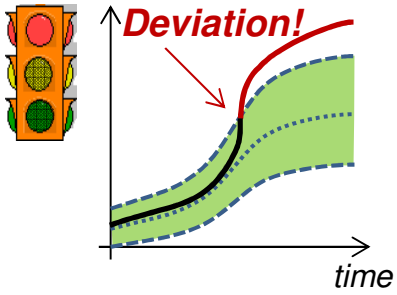
Specific Needs for Improvement 1/2

(PAT-) Sensors:

- Lower detection limits, better precision
- Cover “blind spots” with *new sensing technology*
- Inline real-time sensors, miniaturization, *disposable*
- Decrease costs and *maintenance effort*

Online Monitoring:

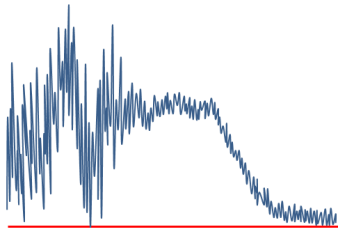
- Fusion of *more data* from different sources (e.g., process, engineering, maintenance, etc.)
- *Self-learning* capabilities
- Fast adaption to new products



Specific Needs for Improvement 2/2

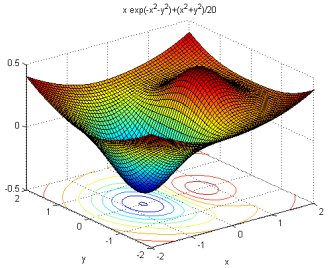
Advanced Process Control:

- *Fast and economic development* of control applications
- *Fast and flexible adaptation* to new products
- Easy reconfiguration (e.g., for modular plants)



Online Optimization and Scheduling:

- Enable vertical *integration* by using real-time feedback from lower levels (e.g., reactive scheduling)
- Enable horizontal integration by using real-time data from logistics (agile planning and scheduling)
- Platform for integration
- *Standardisation* of interfaces for communication



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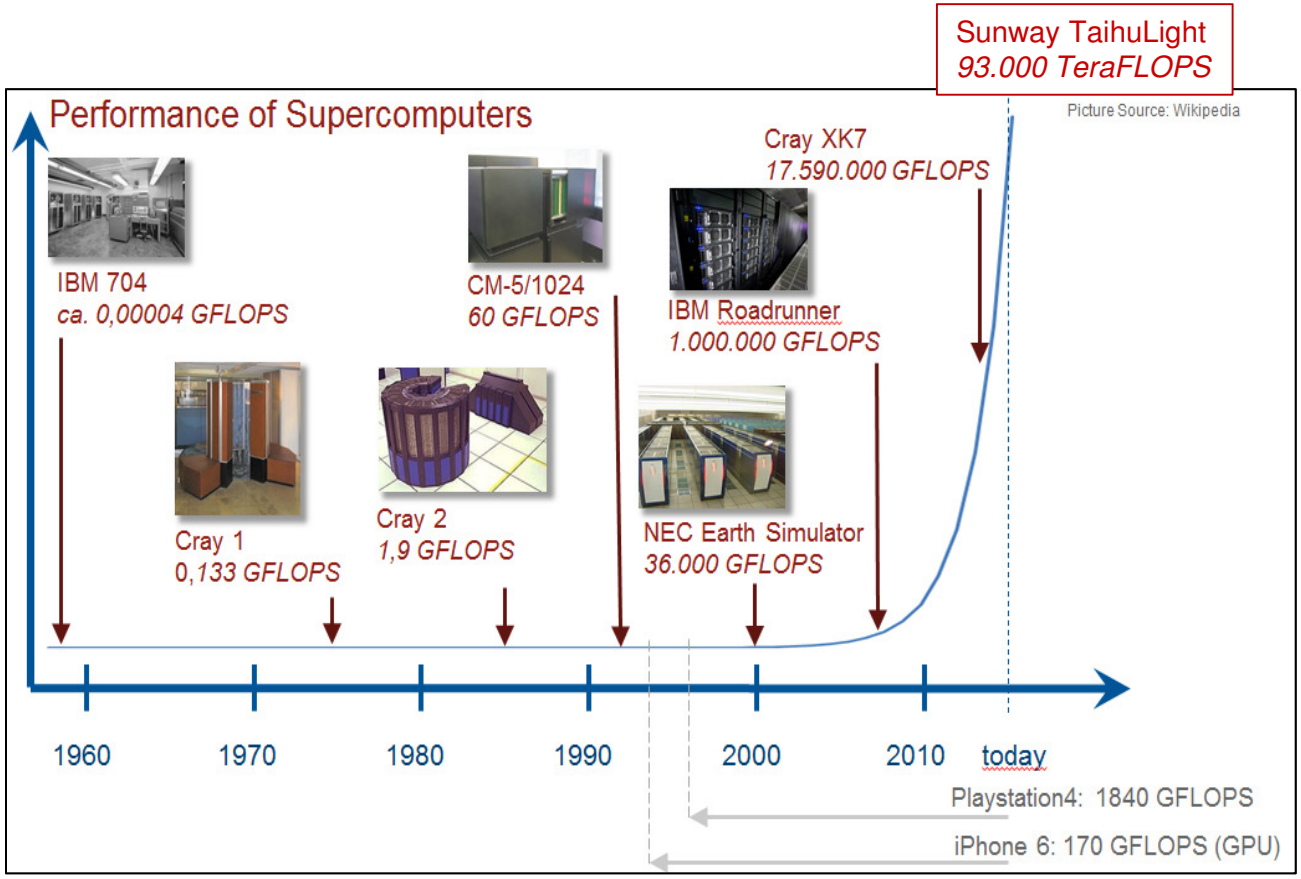
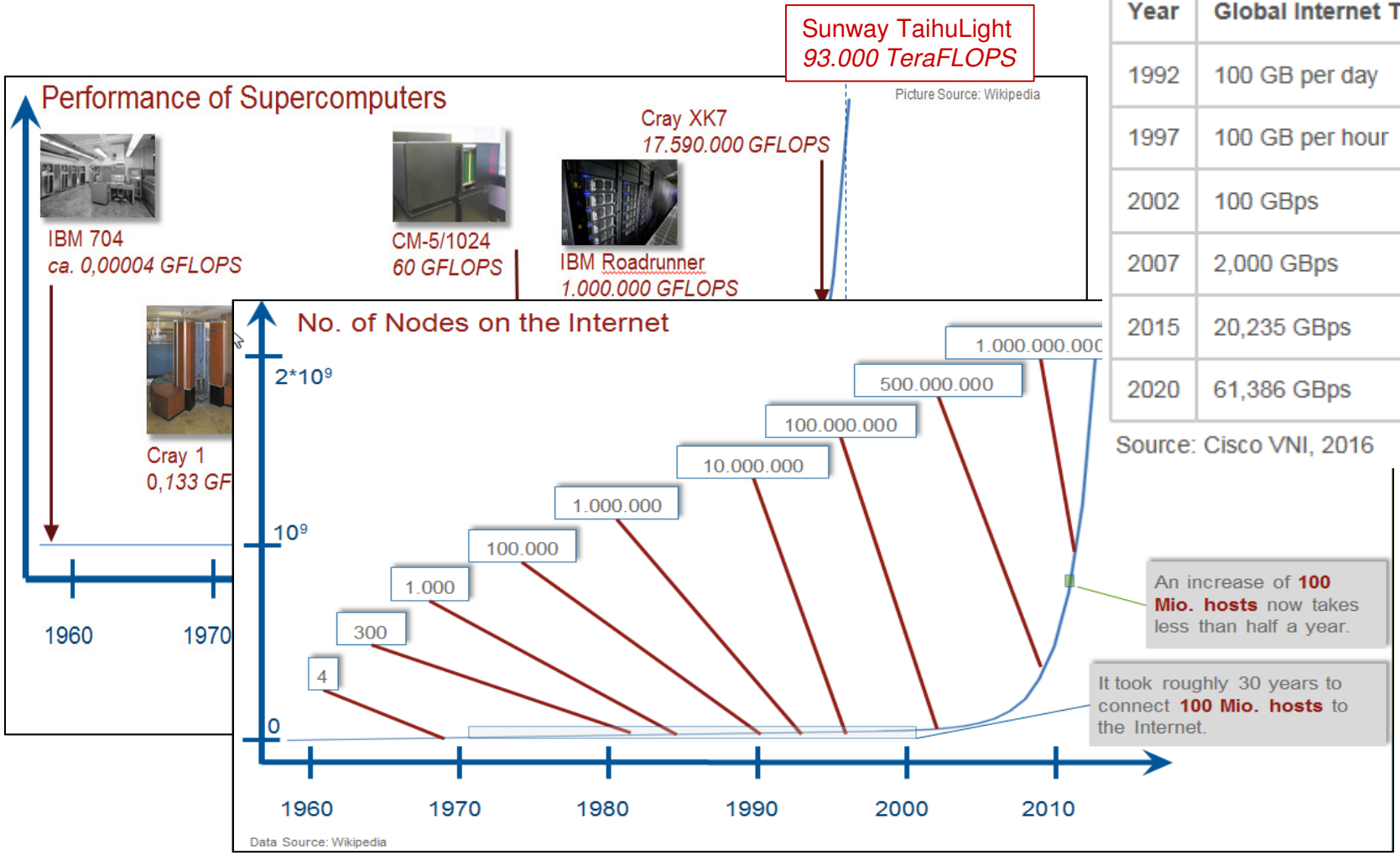
As a Result of Exponential Growth **Digitalization is transforming** life, **business** and the global economy



As a Result of Exponential Growth **Digitalization is transforming** life, **business** and the global economy



Year	Global Internet Traffic
1992	100 GB per day
1997	100 GB per hour
2002	100 GBps
2007	2,000 GBps
2015	20,235 GBps
2020	61,386 GBps

Source: Cisco VNI, 2016

As a Result of Exponential Growth **Digitalization is transforming** life, **business** and the global economy

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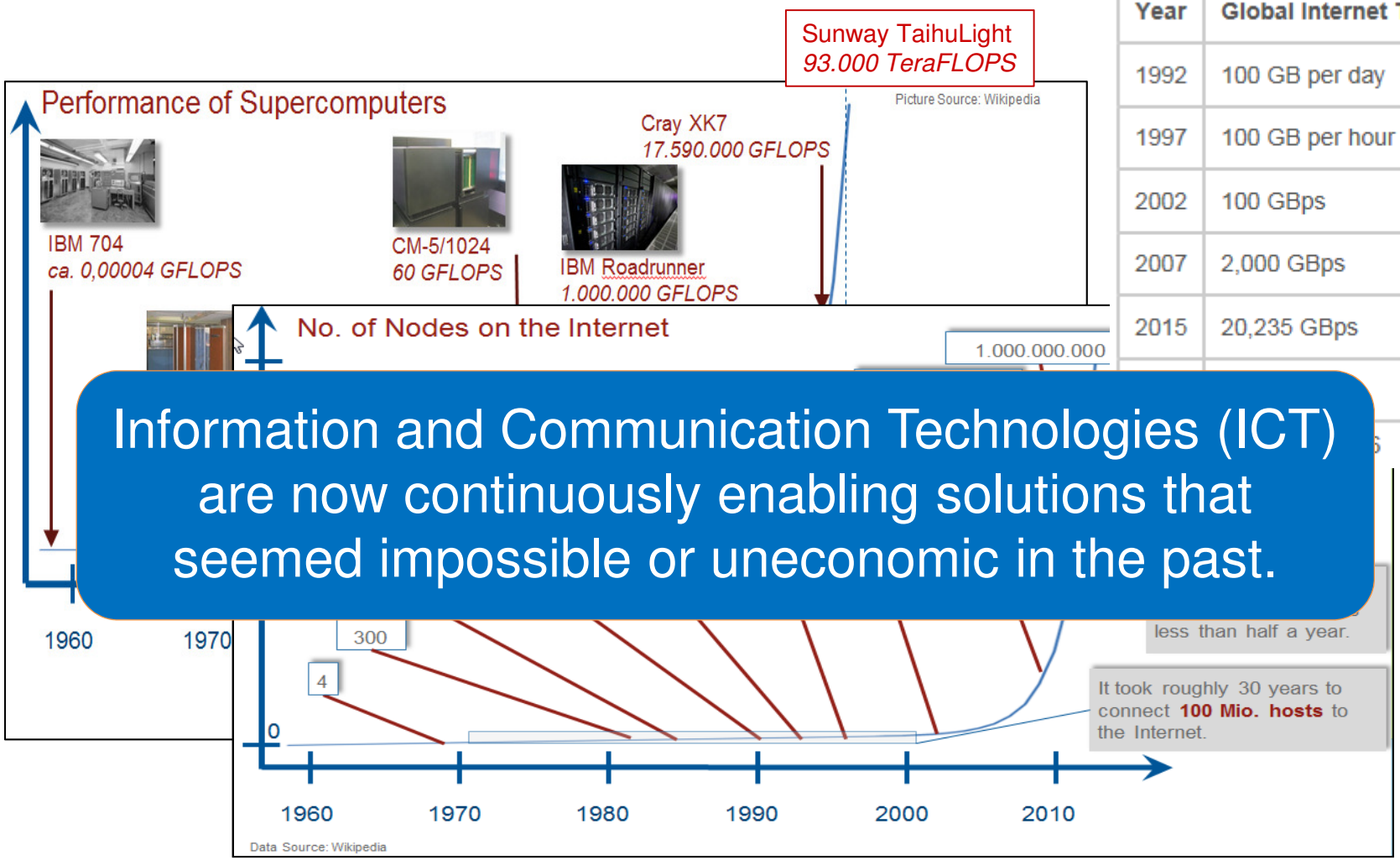
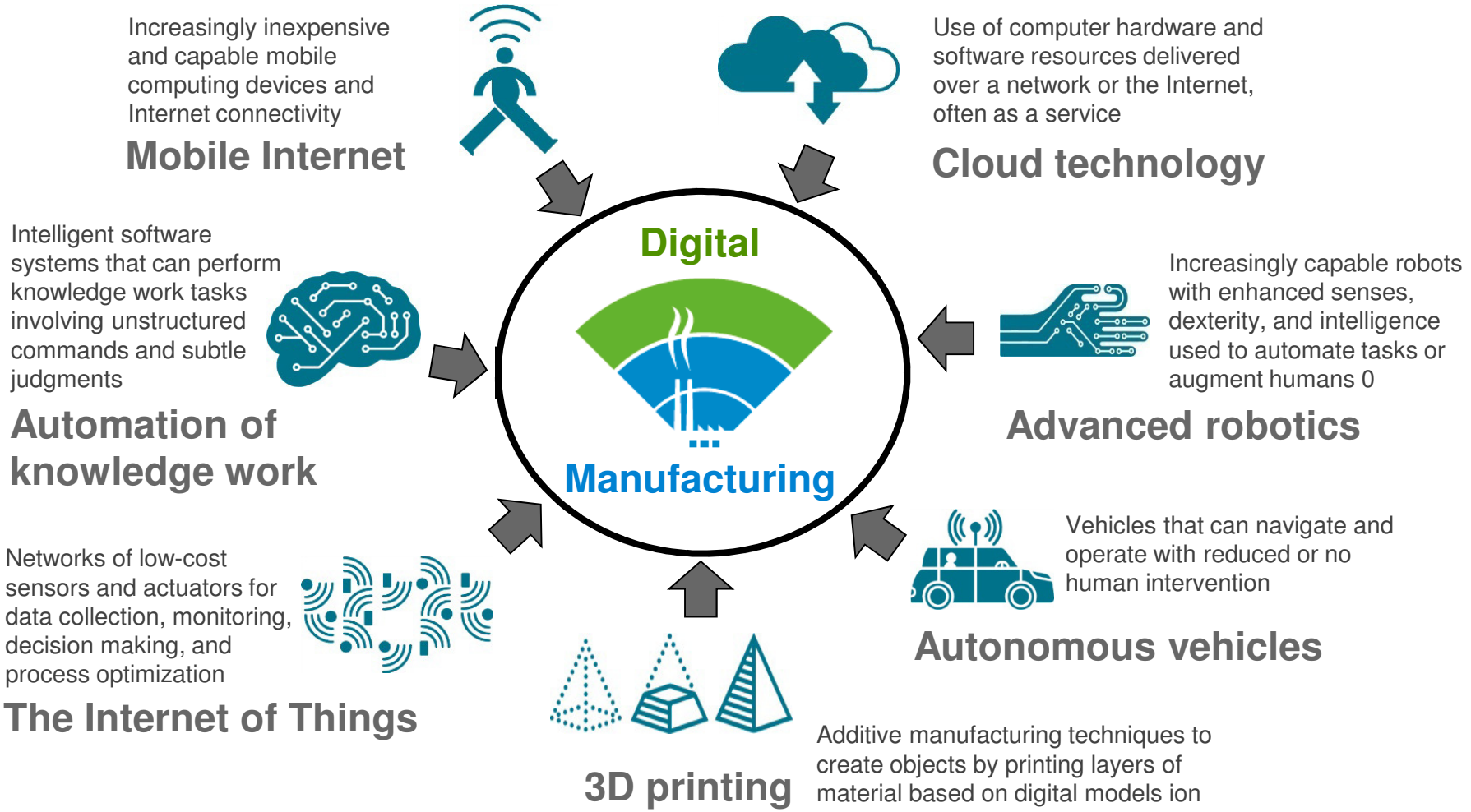


Information and Communication Technologies (ICT) are now continuously enabling solutions that seemed impossible or uneconomic in the past.

The importance of ICT is further increasing

Technologies that matter



Increasingly inexpensive and capable mobile computing devices and Internet connectivity

Mobile Internet

Use of computer hardware and software resources delivered over a network or the Internet, often as a service

Cloud technology

Intelligent software systems that can perform knowledge work tasks involving unstructured commands and subtle judgments

Automation of knowledge work

Increasingly capable robots with enhanced senses, dexterity, and intelligence used to automate tasks or augment humans 0

Advanced robotics

Networks of low-cost sensors and actuators for data collection, monitoring, decision making, and process optimization

The Internet of Things

Vehicles that can navigate and operate with reduced or no human intervention

Autonomous vehicles

Additive manufacturing techniques to create objects by printing layers of material based on digital models ion

3D printing

Source: McKinsey: Disruptive Technologies modified

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Combining Novel ICT with Sensing, Monitoring, Control, and Optimisation Creates Significant Advantages

Adaptability and flexibility

- Integration and interoperability of production-related IT and automation
- Flexible reconfiguration of control systems (e.g., for modular plants)
- Adaptive, self-configuring, autonomous, flexible production units

Real-time communication

- Fast provision of the correct information to authorized users
- Mobile human machine interfaces tailored to specific roles
- Integration of control level with enterprise level and logistics (vertical & horizontal)

Digital engineering and simulation

- Fast and reliable design of assets and control technologies for high performance
- Digital twin of asset provides a basis for automated diagnosis and optimisation

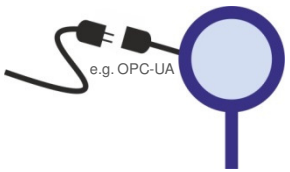
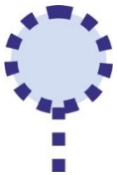
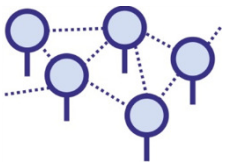
➔ Agile and economic engineering, operation, and maintenance

➔ Integration into the overall value chain

Technology Roadmap “Process Sensors 4.0”

„Smart“ sensors will provide services within networks and use information out of the network:

NAMUR

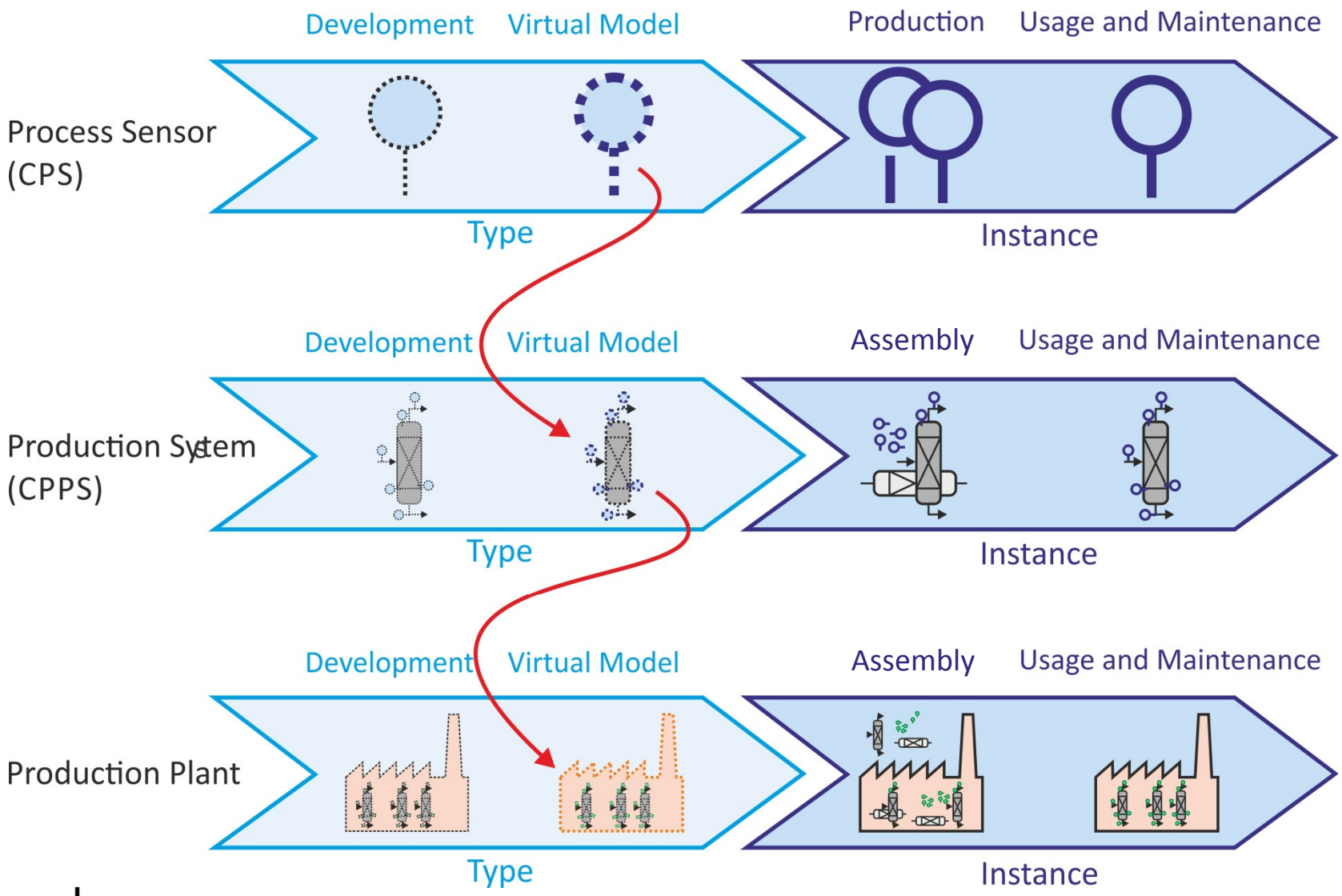
Connectivity and Communication	Maintenance and Internal Functions	Traceability and Compliance	Virtual Model	Ability to Interact
				
• Bidirectional communication • User interface to standard hardware (e.g., smart phone, smart pad, etc.)	• Interactive assistance • Self calibration • Automated order of spare parts • …	• Validity of calibration & validation • e.g., GMP compliance • …	• Digital planning and simulation • Sensor server for new calibration models/ patches • …	• Mutual check of plausibility • Better accuracy (interferences) • …

➔ Simplified integration (“plug & play”)

➔ Predictive maintenance by online-access to self-diagnosis data

➔ Basis for self-organizing cyber-physical production systems (CPPS)

“Process Sensors 4.0” – Digital Engineering



NAMUR

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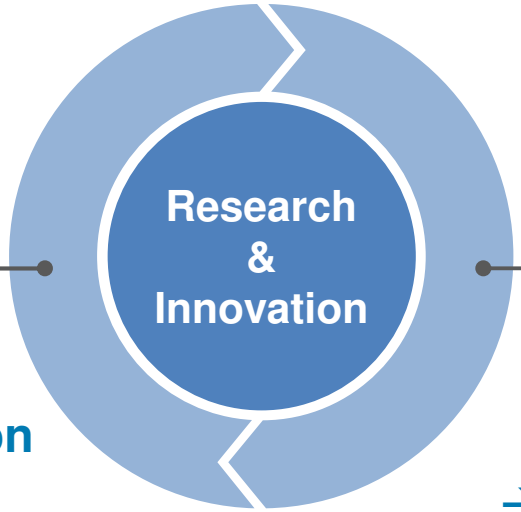
Technology Developers: Exploit Opportunities of Novel ICT!

Sensing, Monitoring, Control, and Online Optimization



New Information and Communication Technologies (ICT)

- → Processes resilient to disturbances & variation
- → Optimal process operation
- → Manufacturing of new excellent products

- → Integration into the overall value chain
- → Adaptability & flexibility
- → Agile and economic engineering, operation, maintenance and logistics

➔ **Sustainable and competitive process industries**

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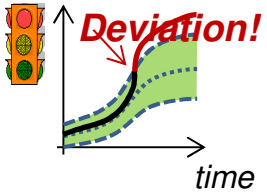
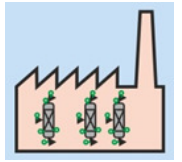
Conclusions

- Novel sensing, monitoring, control and optimization technologies are **essential** to achieve **sustainable** and **competitive** process industries in Europe
- The running SPIRE projects will provide substantial progress
- **Industrial implementation** of results is most crucial!
- Unlock the opportunities of novel ICT for sensing, monitoring, control and optimization!





I wish you all much success !

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