Towards value creation from CPS

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Road2CPS Strategy Roadmap Workshop
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Goal: Create added-value via cross-layer collaboration

**Internet of “Brains”**
- People
- Insight
- Decisions

**Internet of Businesses Process**
- Business applications
- Process automation
- End-to-end process integration

**Internet of Services**

**Internet of Things**
- Smart Items
- Execution
- Edge Processing
Data acquisition & analysis as game changer → new business models

Virtual World: Enterprise Systems
Global Business Networks

Implicit Data
Generation
Automated Capturing &
selected sync
Sync @ (msec)

Cost Gap for Data Entry
Punch card  Keyboard  Barcode

Human Assisted Monitoring

Machine (automated) Monitoring & Control

IoT/CPS-Technologies

Real World
Real-World Processes

S. Karnouskos
CPS/IoT for a data-driven business

source: https://www.youtube.com/watch?v=KCADMSkSZhk
An IoT/CPS focus area view

Next Generation Knowledge-Driven

Game Changer: Analytics on IoT/CPS Big Data + Creation of Actionable Knowledge

Maturing Area & Expansion to Large Scale

Apps, Services, Tools, Systems

Visualization

Decision Support

Simulation

Data Analytics

Data Management

Data Acquisition

Device Integration

Provision of tools, algorithms, models, methodologies etc.

Take advantage of modern technologies and realize new approaches e.g. not possible 5 years ago.

Empower non-experts to take advantage of data analytics derived actionable knowledge
Example: From sensor to insight to outcome

Source: http://go.sap.com/documents/2016/10/8ec7f23f-917c-0010-82c7-eda71af511fa.html
How to benefit from CPS?

Think differently … acquire new insights & make these insights available to non-experts.
# ICPS – Where and When to invest in Research, Innovation, Business?

<table>
<thead>
<tr>
<th>Area</th>
<th>Key Challenges</th>
<th>Difficulty</th>
<th>Priority</th>
<th>Maturity in</th>
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</thead>
<tbody>
<tr>
<td>CPS Capabilities</td>
<td>Real-time control of CPS systems</td>
<td>high</td>
<td>high</td>
<td>4-7 years</td>
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<tr>
<td></td>
<td>Real-time CPS SoS</td>
<td>high</td>
<td>medium</td>
<td>3-5 years</td>
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<td></td>
<td>Optimization in CPS and their application</td>
<td>high</td>
<td>medium</td>
<td>4-7 years</td>
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<td></td>
<td>On-CPS advanced analytics</td>
<td>medium</td>
<td>high</td>
<td>3-5 years</td>
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<tr>
<td></td>
<td>Modularization and servification of CPS</td>
<td>low</td>
<td>high</td>
<td>3-5 years</td>
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<td></td>
<td>Energy Efficient CPS</td>
<td>medium</td>
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<td>3-5 years</td>
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<tr>
<td>Lifecycle Management</td>
<td>Lifecycle Management of CPS</td>
<td>medium</td>
<td>medium</td>
<td>5-8 years</td>
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<tr>
<td></td>
<td>Management of (very) large scale CPS and CPS-SoS</td>
<td>high</td>
<td>high</td>
<td>5-8 years</td>
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<td>Security and Trust Management for heterogeneous CPS</td>
<td>high</td>
<td>high</td>
<td>5-8 years</td>
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<tr>
<td>CPS Engineering</td>
<td>Safe programming and Validation of CPS SoS</td>
<td>high</td>
<td>high</td>
<td>5-10+ years</td>
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<td>Resilient risk-mitigating CPS</td>
<td>high</td>
<td>high</td>
<td>5-10+ years</td>
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<td>Methods and tools for CPS lifecycle support</td>
<td>high</td>
<td>high</td>
<td>3-7 years</td>
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<td></td>
<td>New operating systems and programming languages for CPS and CPS SoS</td>
<td>medium</td>
<td>low</td>
<td>3-6 years</td>
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<tr>
<td></td>
<td>Simulation of CPS and of CPS-SoS</td>
<td>medium</td>
<td>high</td>
<td>3-6 years</td>
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<tr>
<td>CPS Infrastructures</td>
<td>Interoperable CPS services</td>
<td>medium</td>
<td>high</td>
<td>2-5 years</td>
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<td></td>
<td>Migration solutions to emerging CPS infrastructures</td>
<td>medium</td>
<td>high</td>
<td>3-6 years</td>
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<td></td>
<td>Integration of heterogeneous/mobile hardware and software technologies in CPS</td>
<td>low</td>
<td>medium</td>
<td>2-4 years</td>
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<td>Provision of ubiquitous CPS services</td>
<td>medium</td>
<td>medium</td>
<td>3-5 years</td>
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<tr>
<td></td>
<td>Economic impact of CPS Infrastructure</td>
<td>high</td>
<td>high</td>
<td>3-6 years</td>
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<td>CPS Ecosystems</td>
<td>Autonomic and self-* CPS</td>
<td>high</td>
<td>medium</td>
<td>7-10+ years</td>
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<td>Emergent behaviour of CPS</td>
<td>high</td>
<td>medium</td>
<td>7-10+ years</td>
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<td>CPS with Humans in the Loop</td>
<td>high</td>
<td>high</td>
<td>2-5 years</td>
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<td>Collaborative CPS</td>
<td>medium</td>
<td>medium</td>
<td>5-8 years</td>
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<tr>
<td>CPS Information Systems</td>
<td>Artificial Intelligence in CPS</td>
<td>high</td>
<td>high</td>
<td>7-10+ years</td>
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<td>Cross-Domain large-scale information integration to CPS Infrastructures</td>
<td>medium</td>
<td>low</td>
<td>6-9 years</td>
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<td>Transformation of CPS data and information analytics to actionable knowledge</td>
<td>high</td>
<td>high</td>
<td>4-8 years</td>
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<td>Knowledge-driven Decision Making/Management</td>
<td>high</td>
<td>medium</td>
<td>6-10+ years</td>
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Source: [http://dx.doi.org/10.1016/j.compind.2015.08.004](http://dx.doi.org/10.1016/j.compind.2015.08.004)
Considerations (1/2)

- Consider waves of innovation in conjunction with tangible business benefits: enable high-impact efforts (economy, society etc.)
- Rethink of business models and business processes based on intrinsic qualities e.g. smart grid
- Understand the system-wide economic and social impacts
- Socio-technical aspects incl. safety, security, privacy, trust
- Focus on value-added services, networks and business models (from products to services)
- Create conditions for multi-angled education/training for the stakeholders
- Adjust/Harmonize EU-wide CPS affected legislations.
- Focus on human-CPS cooperation & symbiosis in a future CPS-society
- CPS Ethics, Law, Society: need to be discussed and understood
Considerations (2/2)

- Create open, extensible, interoperable CPS digital platforms (baseline)
- Focus on co-habitation of CPS solutions and reuse of infrastructure & data across domains, technologies and areas (e.g., Future Factory within a Smart City ...)
- Focus on KPI (quantitatively measured) efforts that reduce complexity, developing time, cost, easy onboarding etc.
- Reinforce incremental innovation of funded projects (coupled with open access to results)
- Attempt to streamline EC – national efforts towards strong ecosystem
- Focus on added value and high impact
- Make benefits tangible and visible to business & society
Thanks for attending!

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