PICASSO IoT/CPS Expert Group

Challenges & Opportunities in Autonomous Cyber-physical Systems

Interactive Webinar

Wednesday, May 16, 2018

www.picasso-project.eu

ICT Policy, Research and Innovation for a Smart Society

PICASSO has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 687874.

Agenda

- **Welcome, PICASSO Overview, and Webinar Objectives**

  Sebastian Engell, Professor of Process Dynamics and Operations, Technische Universität Dortmund, Germany

  Expert Group Chair

- **Challenges & Opportunities for EU-US Collaboration in Autonomous Cyber-physical Systems**
- *Christian Sonntag, Process Dynamics and Operations Group, Technische Universität Dortmund, Germany*

  Expert Group Manager

- **Discussion and Feedback**

  Moderated by Sebastian Engell

Welcome, PICASSO Overview, and Webinar Objectives

Prof. Sebastian Engell

Technische Universität Dortmund, Germany

Expert Group Chair

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PICASSO: Objectives and Activities

Sebastian Engell, TU Dortmund

Enhancing Cooperation focusing on pre-competitive R&I

> Analyse industrial drivers, societal needs and barriers to exploitation

> Promote funding opportunities and develop the "ICT Industry Toolkit"

> Develop and promote success stories/ good practices of cooperation in ICT

> Outline and promote collaboration opportunities, especially for the industrial sector.

Contribute the EU-US policy dialogue

> Discuss policy-gaps or overregulation targeting core policy issues: Standards; Privacy; Cyber Security.

> Prepare Policy Briefs and propose ways forward

> Analyse the areas with the highest potential for EU-US ICT collaboration

> Propose mechanisms for ICT collaboration

Outline new avenues and develop strategic initiatives

> Put forward and promote strategic initiatives for EU-US ICT collaboration

> Start the implementation of selected strategic initiatives, e.g. on regulation /de-regulation needs, standardization...

> Propose and promote topics for EU-US collaboration under joint or coordinated schemes and in the field of ICT technological areas and societal challenges

The PICASSO Expert Groups

Sebastian Engell, TU Dortmund

Synergies between policy and technology groups

3 Technology Groups
On strategic ICT technology areas in relation to societal challenges

5G Networks

Big Data

IoT/CPS

1 Horizontal Group
On ICT Policy

Policy issues:
Privacy and data protection | Cyber-security | Standards and interoperability | Ethics …

25+ Experts in total across all groups

Convergence of IoT and CPS

- **Focus of current research and development in IoT**
  - Low-cost sensors / computing
  - Provision of connectivity, middleware
  - Enormous amounts of data can be collected
- **How to make use of the data is sometimes not clear**
  - What benefits can be gained from the data
  - **Challenge: From sensing to actuation, closing the loop**

→ **IoT is an enabling technology for CPS, especially for large-scale SoS**

→ **IoT-enabled Cyber-physical Systems / Cyber-physical Systems of Systems**

Cyber-physical Systems of Systems

www.cpsos.eu

What are Cyber-Physical Systems of Systems (CPSoS)?

Large, complex, often spatially distributed Cyber-physical Systems (CPS) that exhibit the features of Systems of Systems (SoS)

www.cpsos.eu

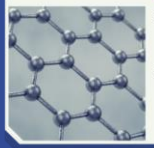
Cyber-physical Systems (CPS)

Tight interaction
of many distributed, real-time computing systems and physical systems

Examples
- Airplanes
- Cars
- Ships
- Buildings with advanced HVAC controls
- Manufacturing plants
- Power plants
- ...

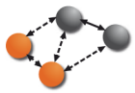
Systems of Systems (SoS)

Many interacting components



Examples
- Large industrial sites with many production units
- Large networks of systems (electric grid, traffic systems, water distribution)

Dynamic reconfiguration



Components may...
- be switched on and off (as in living cells)
- enter or leave (as in air traffic control)

Physical connections

- Material/energy streams
- Shared resources (e.g. roads, airspace, rails, steam)
- Communication networks

Continuous evolution

Continuous addition, removal, and modification of hardware and software over the complete life cycle (often many years)

Examples of Cyber-physical Systems of Systems

Integrated large production complexes
- Major source of employment and income in Europe
- Major consumer of energy and raw materials
- Many interconnected production plants that are operated mostly autonomously with distributed management structures

Transportation networks (road, rail, air, maritime, ...)
- Vital to the mobility of EU citizens and the movement of goods
- Large integrated infrastructures with complex interactions, also across national borders
- Involve multiple organizational and political structures

Many more examples, e.g. smart (energy, water, gas, ...) networks, supply chains, or manufacturing

Emerging behavior

The overall SoS shows behaviours that do not result from simple interactions of subsystems

Usually not desired in technical systems, may lead to reduced performance or shut-downs

Examples
- Power oscillations in the European power grid
- Oscillations in supply chains

Partial autonomy

Local actors with local authority and priorities

Autonomous systems ...
- cannot be fully controlled on the SoS level
- need incentives towards global SoS goals

Examples
- Local energy generation companies
- Process units of a large chemical site

Expert Group Members

Sebastian Engell, TU Dortmund

http://www.picasso-project.eu/iotcps-expert-group/

Name	Organization Position	Background
Sebastian Engell (Chair) 	**TU Dortmund, Germany** Professor	Automation and Control / Systems Management / CPS
Tariq Samad (Co-chair) 	**TLI, University of Minnesota, US** Professor	Industrial Automation
Massoud Amin 	**TLI, University of Minnesota, US** Director / Professor	Infrastructures / Smart Grid
Chris Greer 	**NIST, US** Program Office Director and National Coordinator	CPS / Smart Grid
Amit B. Kulkarni 	**Honeywell, US** Global R&D Leader for Wireless and IoT	Wireless, Internet of Things
Paul Nielsen 	**Software Engineering Institute, CMU, US** Director / CEO	Software development / CPS / Cyber-security
Martin Serrano 	**Insight Centre for Data Analytics, Ireland** Principal Investigator and Data Scientist	Internet of Things
Haydn Thompson 	**THHINK, UK** Director	Wireless sensors / Transportation / Manufacturing / Smart Cities
O. Sinan Tumer 	**SAP Co-Innovation Lab, US** Senior Director	Co-Innovation / Research Commercialization
Hubertus Tummescheit 	**Modelon Inc., US / Modelon AB, Sweden** CEO / Co-founder	Modeling / Simulation
Ovidiu Vermesan 	**SINTEF ICT, Norway** Chief Scientist, Chair WG01 AIOTI	Internet of Things

Objectives of the IoT/CPS Expert Group

Sebastian Engell, TU Dortmund

- Identify **gaps, (technical and societal) needs, drivers, and opportunities** in research, innovation, and policy at the intersection of IoT and CPS
- Analyze the **potential and the challenges for EU-US collaboration** in IoT/CPS research, innovation, and policies
- **Propose new avenues for EU-US ICT collaboration** and **pave the way** to strategic initiatives and actions in the domain of IoT/CPS
- **Support links** between EU and US networks (PPPs, ETPs, H2020 projects, associations) and contribute to PICASSO **outreach**
- **Distribute information on cross-Atlantic funding opportunities**

Webinar Objectives

Sebastian Engell, TU Dortmund

PICASSO opportunity report

Available here: www.picasso-project.eu → News / Reports

- Comprehensive analysis of
  - ★ Drivers and needs (general and for different application sectors)
  - ★ Research and innovation priorities in the EU and the US
  - ★ Collaboration barriers and opportunities

  in the domains of Big Data, 5G, IoT/CPS, and policy
- **Key technology theme: Autonomy in IoT-enabled cyber-physical systems**

Webinar objectives

- **Discuss the current challenges in autonomy**
- **Collect and generate ideas for EU-US R&I collaboration**

2nd Annual Transatlantic Symposium on ICT and Policy

Leveraging People, Technology, and Information for a Smart and Connected Society

Woodrow Wilson International Center for Scholars, Washington, DC, USA

June 18-19, 2018

- **Bring together leaders in government, academia, and industry to explore and discuss**
  - Key ICT topics (Cybersecurity, Big Data, Cyber-physical Systems and Internet of Things (IoT), Artificial Intelligence (AI), and 5G)
  - Cross-cutting issues (policy, open science, STEM workforce)
- **Promote trans-Atlantic discussions, exchanges, and collaborations on new developments in ICT**
- **More information: www.picasso-project.eu → Project Events**

Challenges & Opportunities for EU-US Collaboration in Autonomous Cyber-physical Systems

Christian Sonntag

Technische Universität Dortmund, Germany

Expert Group Manager

ICT Policy, Research and Innovation for a Smart Society

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Christian Sonntag, TU Dortmund

Key Technology Themes for EU-US Collaboration

- **Closing the Loop in IoT-enabled Cyber-physical Systems**
  - System-wide control via IoT-connected devices
  - Data-based operation
  - Control architectures for IoT-enabled CPS
  - Performance and stability in the face of unpredictability (outages etc.)
- **Integration, Interoperability, Flexibility, and Reconfiguration**
  - Semantic interoperability and semantic models
  - Openness and open standards, harmonization
  - Automatic (re-)configuration and plug-and-play
  - Shared infrastructure, large-scale pilots
  - Architectures and cross-domain infrastructures
- **Model-based Systems Engineering**
  - Integrated, virtual, full-life-cycle engineering
  - High-confidence CPS, validation, verification, risk analysis and risk management
  - Models of heterogeneous large-scale systems
- **Trust, (Cyber-)security, Robustness, Resilience, and Dependability**
  - Fault detection and mitigation
  - Trustworthyness of technical systems
  - Behavior-based methodologies for trust
  - New engineering perspectives
  - Secure real-time and mixed-criticality systems
- **Autonomy and Humans in the Loop**
  - Autonomy in open systems that are not domain/knowledge-“contained”
  - Models of autonomous systems and humans
  - Humans in the loop / collab. decision making
  - Analysis of user behavior
  - Analysis, visualization, and decision support
- **Situational Awareness, Diagnostics, Prognostics**
  - Large-scale data analytics, management
  - Machine learning, adaptive behavior
  - Predictive maintenance
  - Self-diagnosis tools

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Technology Challenges in Autonomy and Humans in the Loop

- Autonomy in large-scale, complex, open systems that are not domain/knowledge-“contained”
- Trust in / security of autonomous IoT-enabled CPS
- Human interactions with autonomous IoT-enabled CPS
- Collaborative decision making of humans and autonomous IoT-enabled CPS
- New engineering methods and tools for autonomous IoT-enabled CPS
- Models of autonomous IoT-enabled CPS systems and human actors
- Optimal coordination of (partially) autonomous IoT-enabled CPS
- Novel approaches for analysis, visualization, and decision support in autonomous IoT-enabled CPS

Barriers for Collaboration

- **Current political climate makes it very difficult to establish collaborations**
- **Structural differences in funding environments**
  - Centralized EU funding vs. decentralized US funding, different spans of TRLs targeted, long time between application and funding can be problematic for companies, implementation time differences between EU and US funding initiatives
- **Administrative overhead and legal barriers**
  - Heavyweight mechanisms not promising, too much overhead and political resistance
  - Legal requirements (e.g. signing of CA, GA) problematic, lightweight MoU/contracts needed (new *Implementing Arrangement* seen as positive)
- **Lack of clarity of the benefits of EU-US collaboration**
- **Restrictions due to Intellectual Property protection**
  - Collaboration difficult on topics of high near-term commercial importance
- **Lack of joint EU-US funding mechanisms and policies**
- **Export control and privacy restrictions**
- **Lack of awareness and knowledge**

Proposals for Strategic Initiatives (1)

- **Short-term: Joint EU-US Knowledge Exchange Initiative**
  - **Drivers**
    - ★ A **regular exchange on technological topics** is of crucial importance for
      - The establishment of a common understanding of EU and US experts, and
      - The determination of the concrete benefits and synergies that EU-US collaboration actions
    - ★ A **comprehensive education of the future workforce in the IoT and CPS domains** relies on international exchanges and collaborations
  - **Services provided by the initiative**
    - ★ **Funding and facilitation mechanisms** for regular EU-US knowledge exchange events
    - ★ **Fellowship and student exchange program** between EU and US research institutions
  - **Mechanism**
    - ★ Options: **Temporary mechanism** (successor CSA to PICASSO) or **permanent facilitation organization** (example: IMS)

Proposals for Strategic Initiatives (2)

- **Joint EU-US Knowledge Exchange Initiative (ctd.)**
  - **Multilateral vs. bilateral funding**
    - ⋆ Co-funding by the EC and the NSF or NIST
    - ⋆ Co-funding by a bilateral program between a single EU member state and NSF / NIST
  - **Additionally: EU-US cross-funding (e.g. by industry associations or suitable national agencies)**
- **Longer term (FP9): Joint NSF-EC Programme on Autonomous IoT-enabled Cyber-physical Systems**
  - **Co-funded by the EC and the NSF**
  - Provides **coordinated calls for low-TRL research & innovation** projects to advance the state of the art in **autonomy**
  - Fed by the short-term **knowledge exchange initiative**

Discussion and Feedback

Moderated by

Prof. Sebastian Engell

Technische Universität Dortmund, Germany

Expert Group Chair

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Discussion Points

1. Comments, recommendations, additions for the proposed technological challenges in autonomy and humans in the loop?
2. Comments, recommendations, additions for the EU-US collaboration barriers
3. Comments, recommendations, additions for the strategic initiative proposals?