PICASSO IoT/CPS Expert Group

Towards EU-US Collaboration on the Internet of Things (IoT) and Cyber-physical Systems (CPS)

Interactive Webinar

Thursday, Feb. 2, 2017

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

- **How to Participate – An Overview of the Adobe Connect System**
  Margot Bezzi, APRE, Italy
  Project Manager

- **Welcome, PICASSO Overview, and Webinar Objectives**
  Sebastian Engell, Professor of Process Dynamics and Operations, Technische Universität Dortmund, Germany
  Expert Group Chair

- **Towards EU-US Collaboration on IoT/CPS – Drivers, Needs, and R&I Priorities**
  Christian Sonntag, Process Dynamics and Operations Group, Technische Universität Dortmund, Germany
  Expert Group Manager

- **Discussion and Feedback**
  Moderated by Sebastian Engell

How to Participate

An Overview of the Adobe Connect System

Margot Bezzi

APRE, Italy

Project Manager

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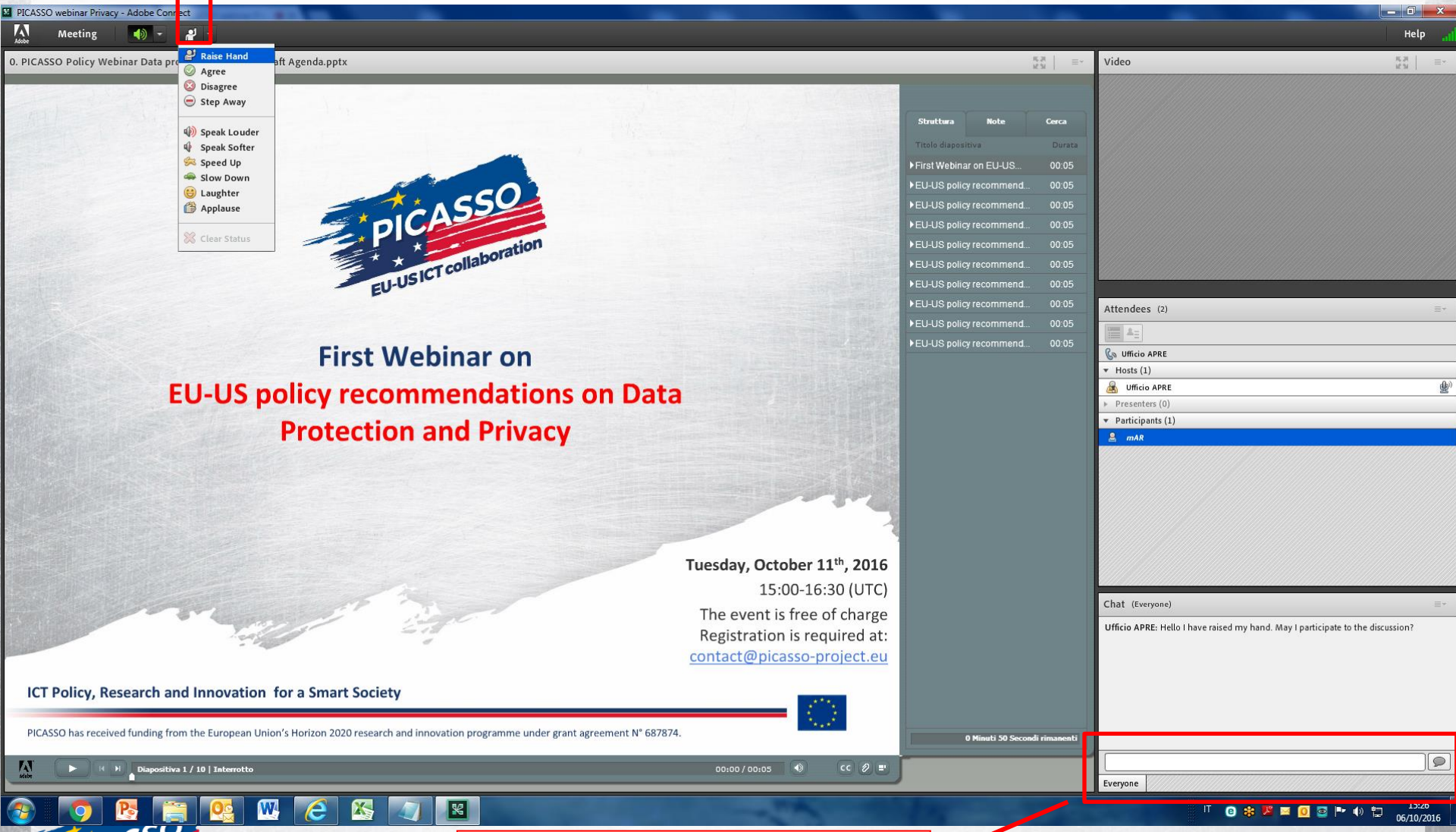
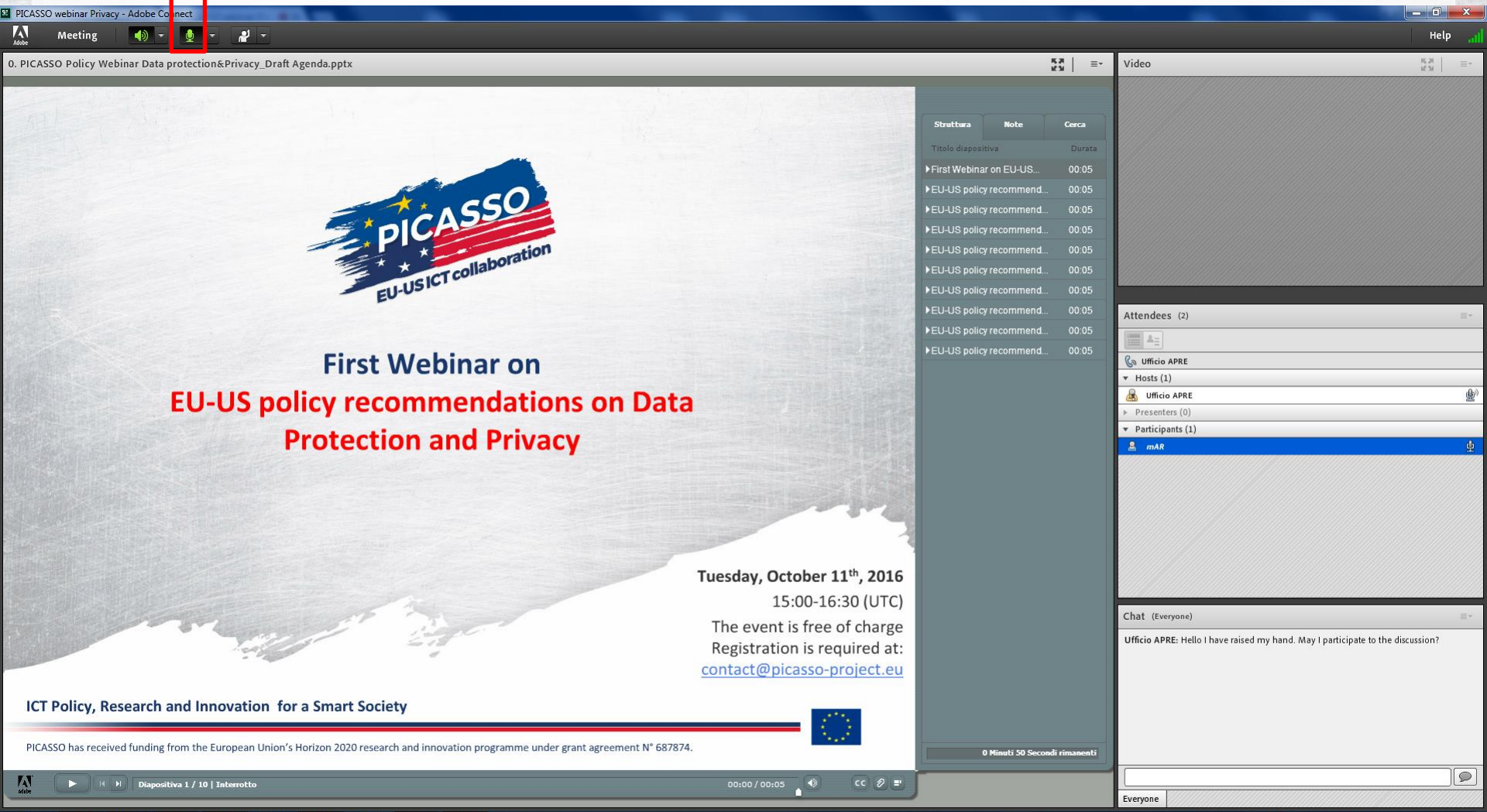
By raising your hand, you will be able to contribute to the discussion. The Host will receive your kind request and allow you to talk.



You will be able also to contribute to the discussion via Chat.

After be enabled to talk by the Host, make sure your microphone is enabled (in green). If needed, adjust the microphone's volume.



PICASSO
EU-US ICT collaboration

Welcome,
PICASSO Overview, and
Webinar Objectives

Prof. Sebastian Engell

Technische Universität Dortmund, Germany

Expert Group Chair

ICT Policy, Research and Innovation for a Smart Society

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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 "CROSSROADS"

> 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

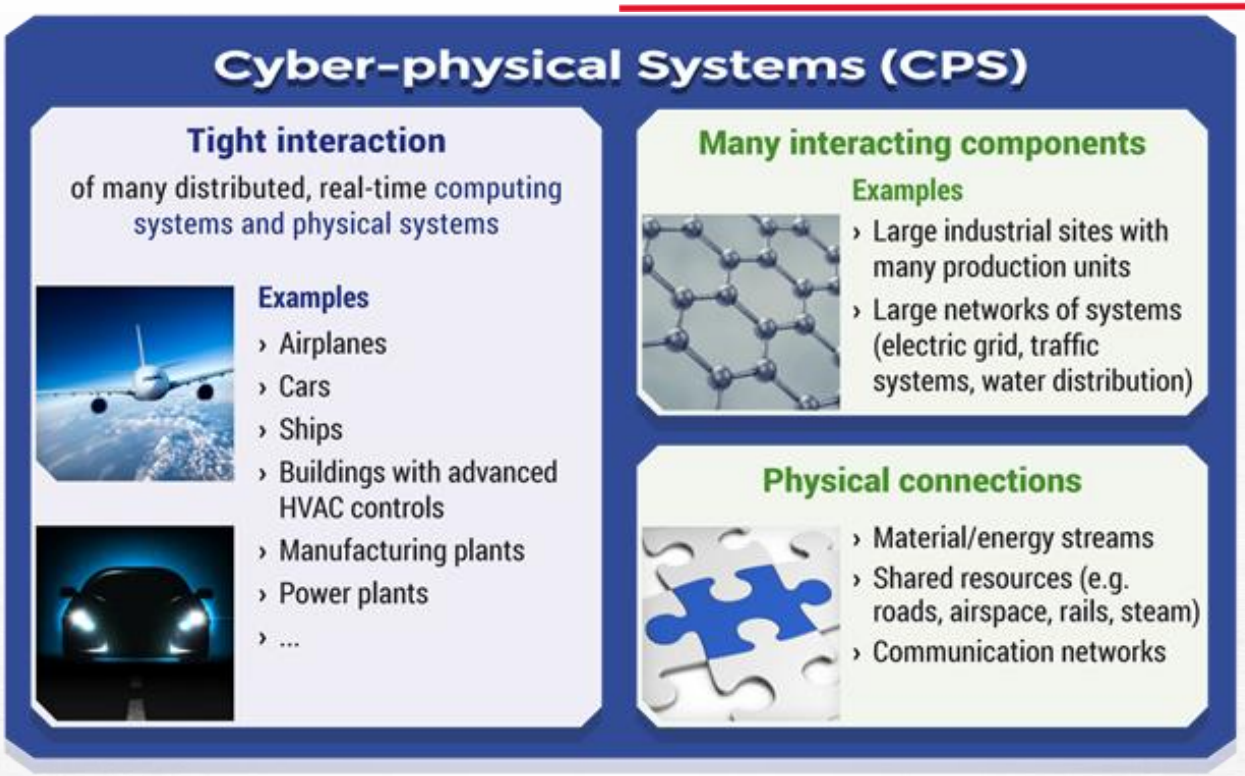
Policy issues:
Privacy and data protection | Cyber-security | Standards and interoperability | Ethics …

25+ Experts in total across all groups

The Internet of Things (IoT)

- **The Internet of Things (IoT)** – A paradigm based on the convergence of:
  - Low-cost sensing and computation
  - Ubiquitous connectivity and mobile apps
  - Cloud analytics and big data
- IoT annual global economic potential: Between **$1.4 trillion** to **$14.4 trillion** by 2020
- IoT initiatives, alliances, and clusters
  - **US:** Several alliances with international membership
  - **European IoT Research and Innovation Cluster** with over 40 European projects
  - **Alliance for Internet of Things Innovation (AIOTI**)

Cyber-physical Systems (CPS)



- **An area of European strength**
  - € 410 billion market
  - 4 million jobs worldwide, of which one quarter are in Europe

Convergence of IoT and CPS

Sebastian Engell, TU Dortmund

- **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**

- **Cyber-physical systems are often embedded in large systems consisting of many coupled components with partial autonomy**
  → **Cyber-physical Systems of Systems (CPSoS)**

See also www.cpsos.eu

The PICASSO IoT/CPS Expert Group

Sebastian Engell, TU Dortmund

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

- **Scope of the Expert Group: The intersection of IoT and CPS**
- **IoT related to applications that involve physical systems**
  - Smart Cities
  - Smart Energy
  - Smart Transport
  - Smart Production
- **Beyond connectivity**
  - How can the data be transformed into useful knowledge and actions?
  - Large scale systems (CPSoS) with multiple / multiscale feedback loops, local autonomy
  - Strong involvement of humans
  - But also strong need for support of humans (“Cognitive Systems”)

The Importance of Merging IoT and CPS

Sebastian Engell, TU Dortmund

EU

ARTEMIS Industry Association
SRA 2016

"The connectivity provided by the Internet of Things will become an enabling technology for Cyber-Physical Systems of Systems that close the loop from sensor information to actions performed by physical systems in transportation, energy systems, production plants, logistics, smart buildings, etc."

"How will the developments of Cyber-Physical Systems within the Internet of Things environment drive the digital transformation?"

AIOTI

"Getting billions of objects duly connected and managing these to create a reliable monitoring/actuating substrate only partially caters for the challenges ahead. **These challenges cannot be complete without considering how to handle the huge amount of data produced and how to transform it into useful and actionable knowledge.** This is indeed **the most difficult of the macro-challenges ahead** given it is related to intelligent reasoning over the data IoT will produce. ""

US

"**Companies need to close the loop across associated processes.** Asset maintenance insights need to be communicated proactively and traceably to multiple parties, while being integrated into the workflows that are implemented to ensure operationally effectiveness. For example, spare and underutilized equipment and spare service parts can be made more readily available through greater sharing of information in near real-time. …"

industrial internet CONSORTIUM

Samsung see the **CPS draft framework by NIST as an important prerequisite for the future of IoT**

SAMSUNG NIST

Several research projects funded by the NSF cover the idea of "**using the IoT as an enabler for CPS**" (e.g. *Action Webs*)

NSF

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
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

Sebastian Engell, TU Dortmund

Objectives of the IoT/CPS Expert Group

- 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

- **Basis: Draft IoT/CPS Opportunity Report for EU-US Collaboration**

  Available at: http://www.picasso-project.eu/outreach/project-reports

  - **Analysis and comparison of research and innovation (R&I) priorities** in the EU and the US
  - Analysis of **drivers and needs in application sectors**
  - Overviews of **barriers** and **potential collaboration mechanisms**
  - Five **R&I themes for EU-US collaboration**
  - **Public consultation under way until Feb. 20, 2017**

    See http://www.picasso-project.eu → News

- **Webinar Objectives**

  - **Discuss, validate, and refine our findings**
  - **Collect and generate ideas for EU-US R&I collaboration**

Invitation

Trans-Atlantic Symposium on ICT Technology and Policy

5G Networks, Big Data, Internet of Things and Cyber Physical Systems for a smart society

Minneapolis, Minnesota, U.S.A.

June 19-20, 2017

- **Objective: Promote trans-Atlantic discussions, exchanges, and collaborations on new developments in ICT**
- **Topics include:**
  - The **landscape of relevant ICT projects and programs** in the US and EU
  - **Project and activity highlights** in 5G networks, Big Data, and IoT/CPS
  - Applications for a **smart society** (smart cities, smart energy, smart production, smart transportation, ...)
  - Facilitating **academia-industry collaboration**, **technology transfer**, **commercialization**, and **global impact**
  - **Policy aspects** of ICT
- **Call for sessions is currently open -> contact Tariq Samad or us**

More information: www.picasso-project.eu → Project Events

Towards EU-US Collaboration on IoT/CPS – Drivers, Needs, and R&I Priorities

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

IoT/CPS Opportunity Report: Sources

Discussions within the Expert Group

1st Joint PICASSO Expert Group Meeting, May 2016, Washington D.C.

Strategic documents and roadmaps

CPS (EU)

CPS (US)

IoT (EU)

IoT (US)

PICASSO data collection and analysis efforts

- Report **Analysis of Industrial Drivers and Societal Needs - Towards New Avenues in EU-US ICT collaboration**
  - Based on interviews with > 100 experts
- Report **Panorama of the ICT Landscape in the EU and US: ICT, Policies, Regulations, Programmes, and Networks in the EU and US**
- Report **Overview on ICT-related Access Opportunities in the EU and US**

Freely available at
http://www.picasso-project.eu/outreach/

Funded IoT and CPS projects

- **EU** funding programmes *FP7*, *H2020*, *EUREKA/ITEA*, *ECSEL*, *ARTEMIS*
  - 46 CPS projects
  - 32 IoT projects
- **US** funding agencies *NSF*, *NIST*, *DoE*
  - 23 CPS projects
  - 23 IoT projects

Cross-domain Drivers and Needs

- **Combatting global climate change, reducing greenhouse gas emissions**
  - Customer demand is developing, companies see an opportunity and are seeking to satisfy needs with both products and services
- **Clean, renewable energy**
- **Globalization and urbanization**
- **Increases in connectivity and autonomy in all domains**
  - The advent of smart and connected devices
- **Vulnerability, trust, privacy, (cyber-)security, safety**
  - Stronger focus in the US than in the EU
- **Systems-of-systems integration applied in industrial environments - the Industrial Internet of Things**

Enabling Technologies

- **Information technology and high-performance computing**
  - Cloud computing, (mobile) edge and fog computing
  - Move toward distributed systems and more heterogeneity
  - Advances in data and signal processing
- **Communication and network technologies (e.g. broadband, 5G)**
- **Advances in data analytics, cognitive technologies, AI**
- **Connecting and powering the "hyper-connected society", e.g.**
  - Ubiquitous connectivity schemes, M2M communication
  - Reliable electricity to power the billions of IoT devices, energy harvesting
- **The "Tactile Internet" (covered by 5G Expert Group)**
- **Pervasive sensing and sensor technologies**

Cyber-physical Systems in the EU

- **Pillar of major European initiatives and programs**
  - European *Digital Single Market* strategy
  - *Digitising European Industry* initiative
  - Innovation programme *Smart Anything Everywhere*
  - *H2020*, *EUREKA/ITEA*, *ECSEL* Joint Undertaking, *ARTEMIS* Industry Association
- **Numerous projects funded in EU programmes**
  - Large-scale lighthouse projects, e.g. *CRYSTAL*, *CESAR*, and *EMC2*
  - Lots of smaller CPS-related projects
- **Complemented by national initiatives, e.g.**
  - *Industrie 4.0* (Germany)
  - *Produktion der Zukunft* (Austria)
- **CPS competence centres and related public-private partnerships (PPPs)**
  - E.g. *Factories of the Future (FoF)*, *Cyber-security*, *Robotics*

Cyber-physical Systems in the US

- **CPS is often seen as an extension of embedded systems**
  - EU definitions usually separate the two concepts more clearly
- **Enormous potential of CPS technologies**
- ***Networking and Information Technology Research and Development* (*NITRD*) Program coordinates programs, budgets, and policy recommendations for CPS research and development**
- **Major driver form CPS-related work: The Cyber-Physical Systems programme of the National Science Foundation (NSF)**
  - Over 350 CPS projects funded
  - CPS Virtual Organization (CPS-VO)
- **Independent efforts by other agencies, e.g. NIST, DARPA, DoE, DHS**

R&I Priorities for Cyber-physical Systems: Documents

Analyzed documents / roadmaps (EU)

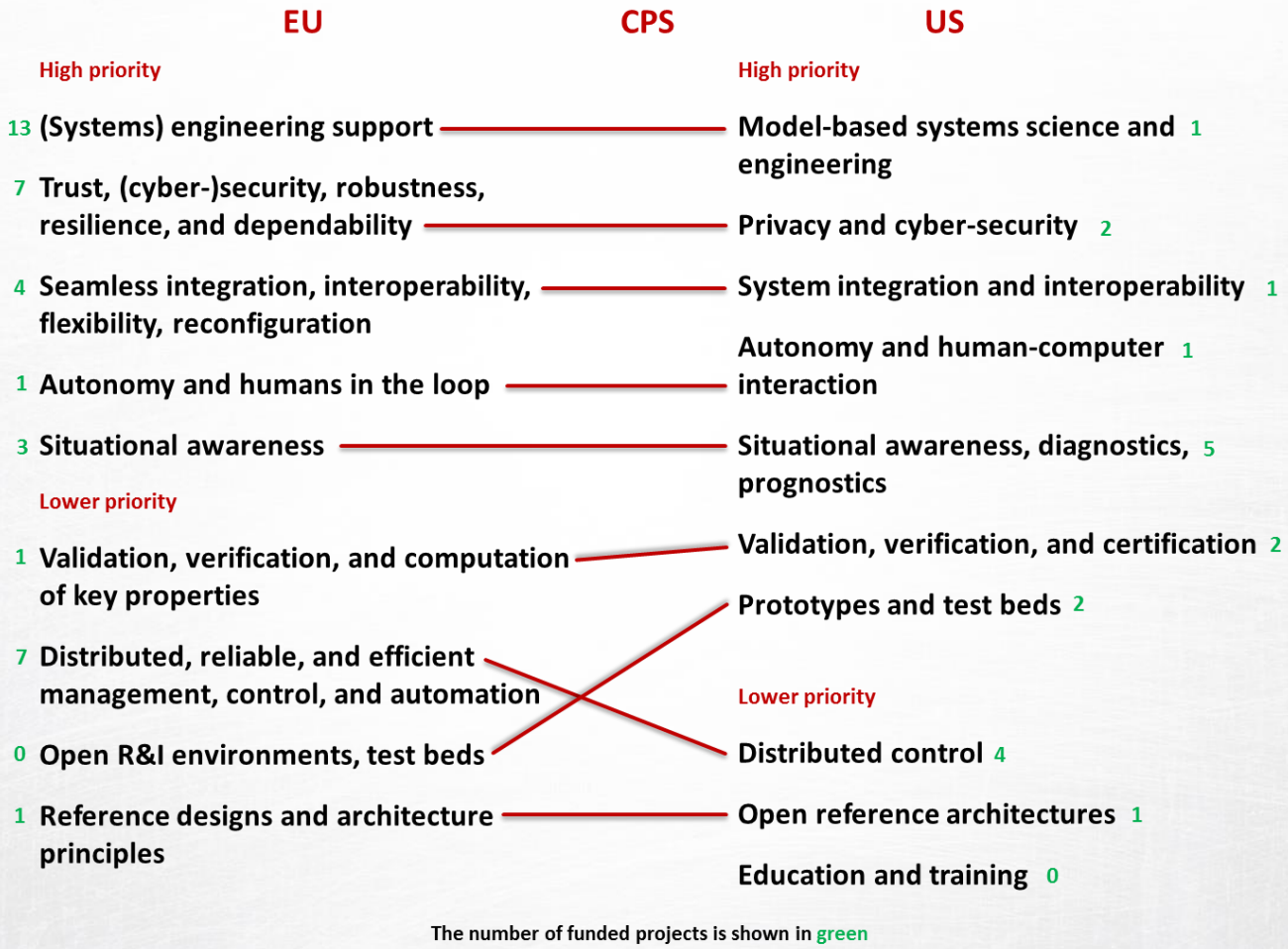
- ARTEMIS Strategic Research Agenda (SRA), 2016
- European Roadmap for Industrial Process Automation, 2013
- Proposal of a European Research and Innovation Agenda on Cyber-physical Systems of Systems, 2016-2025
- Road2CPS documents and workshop reports

Analyzed documents / roadmaps (US)

- NIRTD CPS Vision Statement, 2015
- NIST: Opportunities for 21st Century CPS, 2013
- White House PCAST: Designing a Digital Future, 2013
- White House: Multi-Agency Science and Technology Priorities for 2017
- NSF CPS Call, 2016
- CPS Summit Action Plan
- Report on US-German Workshop on IoT/CPS, 2016

Comparison of EU and US R&I Priorities for CPS

Significant overlap between the EU and the US



The number of funded projects is shown in green

The Internet of Things in the EU

- **Pillar of major European initiatives and programs (like CPS)**
  - European *Digital Single Market* strategy
  - *Digitising European Industry* initiative
  - Innovation programme *Smart Anything Everywhere*
- ***Alliance for the Internet of Things* (*AIOTI*)**
  - Objectives
    - ★ Develop and support the dialogue and interaction among the various IoT actors
    - ★ Facilitate the creation of a European IoT ecosystem
  - 40 IoT projects funded
- **IoT open architecture efforts such as *FIWARE* or *UniversAAL***
- **16 cross-sectoral *Future Internet Accelerators***
- **Complemented by national initiatives, e.g. in the UK, Germany, France, Spain**

The Internet of Things in the US

- **Largely driven by companies instead of R&I programmes or federal agencies**
  - Major players are e.g. *Google*, *Cisco*, and *Samsung*
- **Uptake driven by various industry-driven consortia and alliances**
  - *Industrial Internet Consortium* (*IIC*)
    - ★ Development and promotion of the Industrial Internet
  - *Allseen Alliance*
    - ★ Provision of providing an open environment for the Internet of Things
  - *Open Connectivity Foundation* (*OCF*)
    - ★ Development of a single standard for IoT by major companies
- **The IoT is promoted in federal efforts, e.g.**
  - *Digital Economy Agenda* of the *Department of Commerce* (*DoC*)
  - *National Telecommunications and Information Administration*

R&I Priorities for the Internet of Things: Documents

Analyzed documents / roadmaps (EU)

Vermesan, Friess: Digitizing the Industry, 2016

European Roadmap for Industrial Process Automation, 2013

EU-China Joint White Paper on the Internet of Things

Analyzed documents / roadmaps (US)

Industrial Internet Consortium (IIC)

- Whitepapers (Beyond digitization etc.)
- Journal of Innovation, 2016

Internet of Things: Transforming the future, 2016 (Samsung Framework Paper)

White House: Multi-Agency Science and Technology Priorities for 2017

Dept. of Commerce - Digital Economy Agenda, 2016

US Senate bill: Ensure appropriate spectrum planning and interagency coordination to support the Internet of Things, 2015

Comparison of EU and US R&I Priorities for the IoT

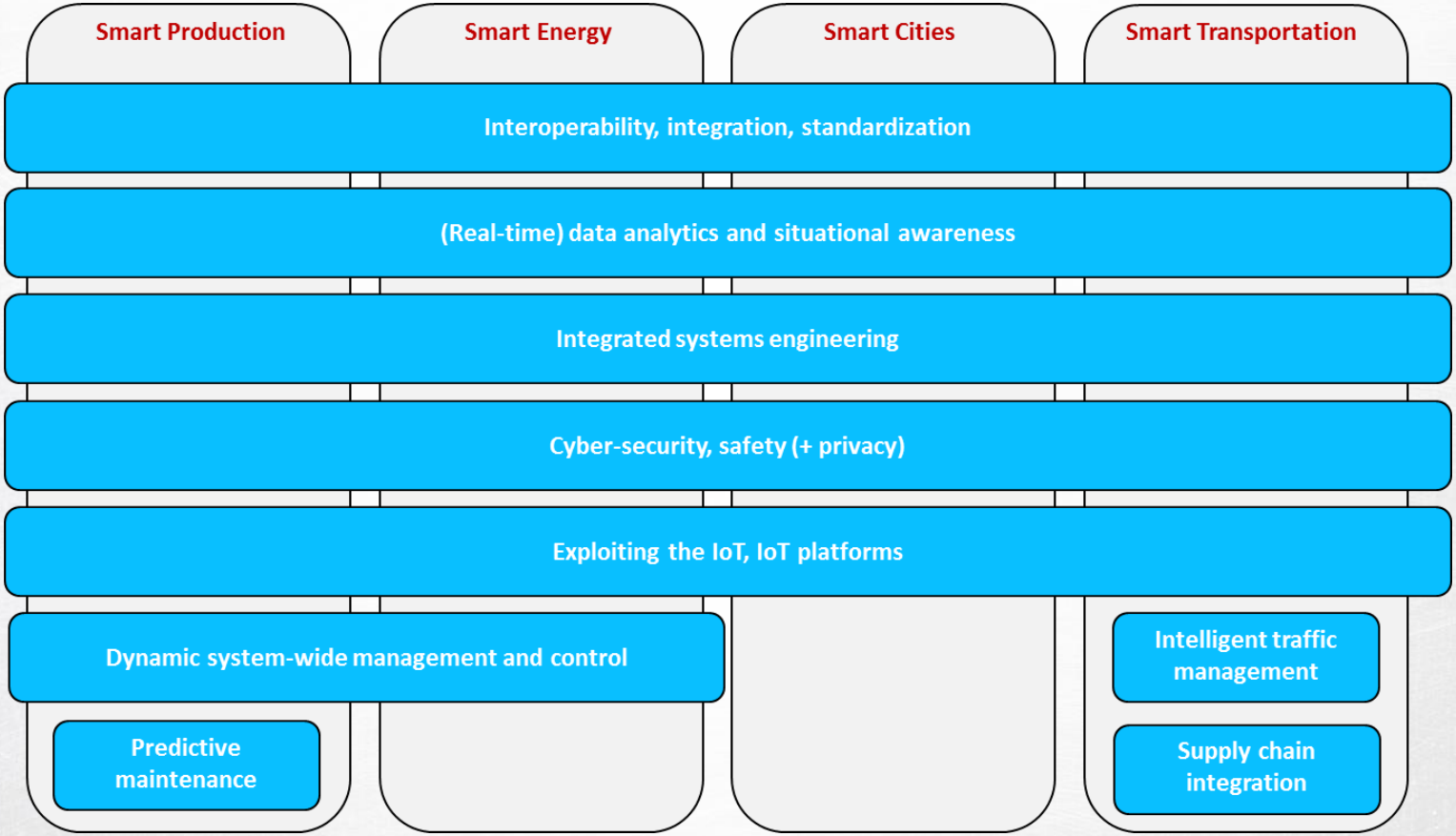
Significant overlap between the EU and the US

EU		IoT	US	
	High priority		High priority	
4	Semantic interoperability and integration	→	Open architectures, platforms, interoperability	7
2	Open architectures, platforms, and innovation ecosystems	→		
	Lower priority			
1	Closing the loop - creating a reliable monitoring/actuating IoT substrate	→	Closing the loop: IoT as an enabler for future CPS	0
1	Security, trust, dependability, and privacy	→	(Cyber-)security, privacy, resilience to faults/attacks, trust	5
			Lower priority	
5	Test beds and pilots		Human-centered IoT systems	0
0	Autonomous IoT devices		Skill-building initiatives	0
1	Smart M2M networks			

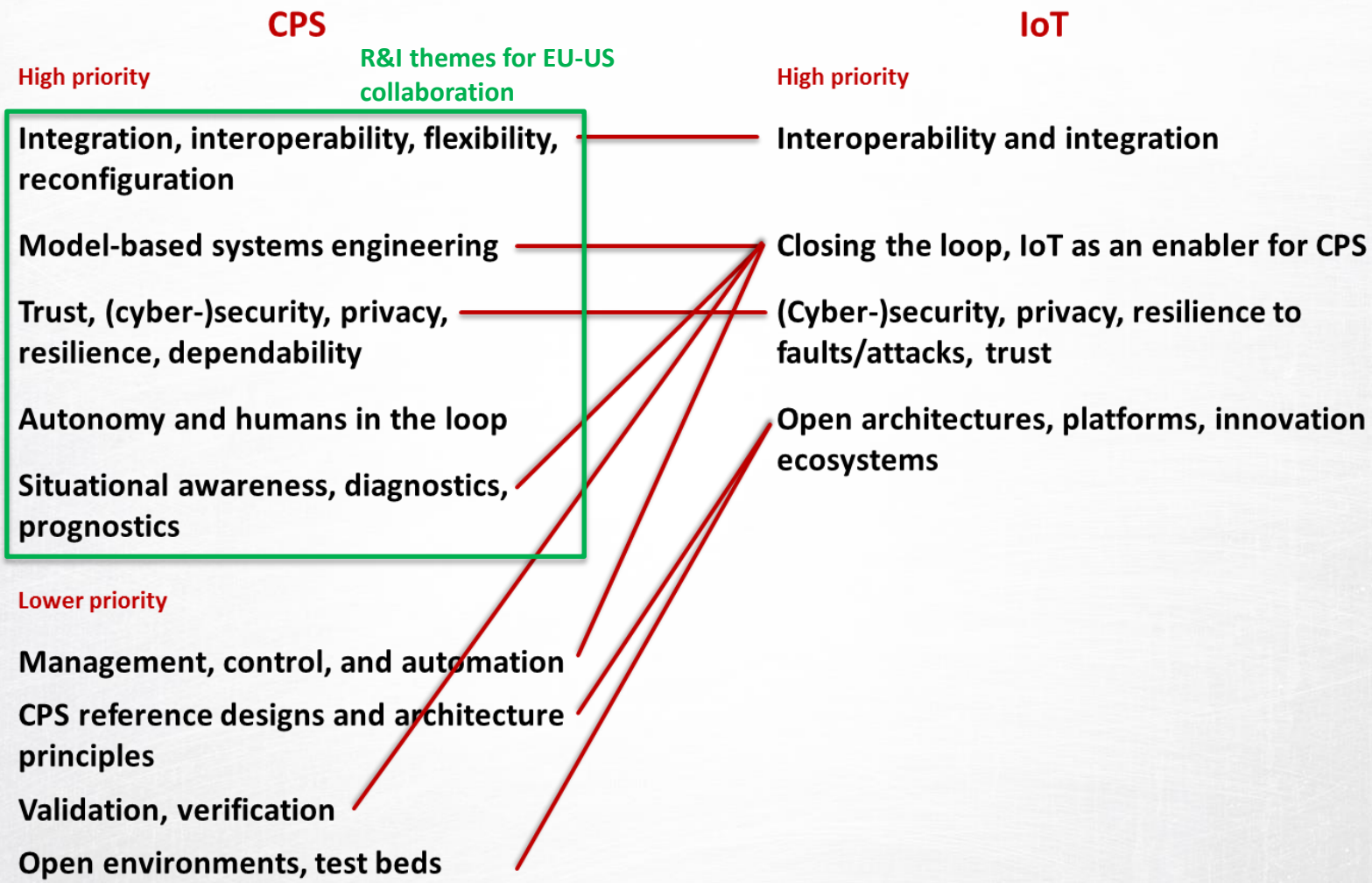
The number of funded projects is shown in green

Application Sectors: Drivers and Needs

All application sectors will profit from IoT/CPS advances and collaborations



Relating CPS and IoT Priorities



Christian Sonntag, TU Dortmund

Integration, Interoperability, Flexibility, and Reconfiguration

Potential R&I topics

- Semantic interoperability and semantic models
- Pushing openness and open standards, harmonization of standards
- Automatic configuration, reconfiguration, and plug-and-play integration of IoT and CPS components
- Joint testbeds and large-scale pilots for CPS and IoT systems, shared access
  - ★ Joint test beds are important tools to achieve interoperability
  - ★ Identified as promising in other projects
- IoT and CPS architectures and cross-domain infrastructures

Why EU-US Collaboration?

- Major challenges are similar, in particular on semantic interoperability and the need for open standards

Model-based Systems Engineering

Christian Sonntag, TU Dortmund

Potential R&I topics

- Integrated, virtual, full-life-cycle engineering, system-wide design
- High-confidence CPS, validation, verification, risk analysis and risk management
- System-wide management and coordination
- Models of heterogeneous large-scale systems
  - ★ Stochastic models
  - ★ Open simulation and model integration platforms
  - ★ Model adaptation, maintenance, and validation
  - ★ Data-based and grey-box modeling

Why EU-US Collaboration?

- New integrated model-based engineering methodologies are essential for future IoT-driven CPS
- US has more theoretical view, EU more practical view
- Major challenges are similar

Christian Sonntag, TU Dortmund

Trust, (Cyber-)security, Robustness, Resilience, and Dependability

- **Potential R&I topics**
  - Exception handling, fault detection and mitigation
  - Intrusion detection and prevention, resilience to cyber attacks
  - Trust in technical systems
  - Secure real-time and mixed-criticality systems
- **Why EU-US Collaboration?**
  - Cyber-security currently one of the dominant topics in the US
    - ★ Seen as important in the EU as well
  - Large overlap between major challenges in the EU and the US
  - **Restriction:** Collaboration on data-sensitive or privacy-related topics is most likely not feasible

    But: Collaborations on technology-oriented topics may be feasible

Autonomy and Humans in the Loop

Christian Sonntag, TU Dortmund

Potential R&I topics

- Autonomy in large-scale, complex, open systems
  - ★ Taking into account that such systems are not domain/knowledge-"contained"
- Models of autonomous CPS systems and humans
- Socio-technical aspects of IoT-driven CPS
  - ★ Humans in the loop and collaborative decision making
  - ★ Analysis of user behavior and detection of needs and anomalies
  - ★ Novel approaches for analysis, visualization, and decision support

Why EU-US Collaboration?

- Modern large-scale CPS are socio-technical in nature, autonomy and human interactions are seen as essential in the EU and the US

Christian Sonntag, TU Dortmund

Situational Awareness, Diagnostics, and Prognostics

Potential R&I topics

- Large-scale real-time data analytics and data management
- Data-based operation
- Machine learning, learning methodologies, adaptive behavior
- Predictive condition monitoring and maintenance
- Self-diagnosis tools

Why EU-US Collaboration?

- Increasing pervasiveness of affordable sensing devices in future IoT-enabled CPS will make the use of data crucial
- Seen as a major challenge in both, the EU and the US

Potential Barriers for Collaboration

- Collaborations that are based on **joint funding** will be difficult to implement
- Collaboration may be difficult on topics of **high near-term commercial importance**
  - Focusing on basic, low-TRL R&I is more promising
- Topics touching **export control issues**, **sensitive or classified data / information**, or **privacy issues** should be avoided
- A **lack of interoperability and (device) standards** can be a barrier to collaboration
- A **lack of awareness and knowledge of EU and US funders and experts of the other side** is detrimental to collaboration
- **Bureaucratic hurdles** are seen as a major barrier to collaboration
  - The need for US organizations **to sign grant and consortium agreements** when participating in EU projects was recently removed

Potential Collaboration Mechanisms

1. **Establishment of high-level bilateral agreements**
   - E.g. 14th EU-US Information Society Dialogue, 2016 Implementing Arrangement between the EU and the US
2. **Thematic, targeted funding programmes**
   - E.g. joint EC-NIH programme (health)
3. **Joint calls, twinning of research projects**
4. **Facilitating US participation in mainstream H2020 projects**
   - E.g. FP7 IP DANSE tried to involve US partner, but EC wouldn't fund them, high admin burdens
5. **Funding of joint workshops, conferences or series of seminars**
6. **Active support of the mobility of researchers, staff exchange, fellowships to students, trans-Atlantic training and education**
7. **Access to research infrastructure, sharing of equipment**
8. **Enhancing the visibility of EU/US programmes**
   - Examples: PICASSO, DISCOVERY, BILAT 2.0/4.0,
9. **Support to technology transfer, sharing of knowledge and application-oriented cooperation**
10. **Enhancing framework conditions for trans-Atlantic collaboration**

Discussion and Feedback

Moderated by

Prof. Sebastian Engell

Technische Universität Dortmund, Germany

Expert Group Chair

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

Discussion Points

1. Comments, recommendations, additions for the proposed R&I themes
   - Model-based Systems Engineering
   - Trust, (Cyber-)security, Robustness, Resilience, and Dependability
   - Integration, Interoperability, Flexibility, and Reconfiguration
   - Autonomy and Humans in the Loop
   - Situational Awareness, Diagnostics, and Prognostics

2. Most promising options for concrete EU-US collaboration mechanisms
   - Chances / opportunities for joint / coordinated projects