Smart Cyber-Physical Systems Concertation Event

Haydn Thompson
# Overview of Day

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<td>9:00</td>
<td>Registration</td>
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<td>9:30</td>
<td>Welcome and Introduction</td>
<td>Meike Reimann (Steinbeis)</td>
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<td>9:40</td>
<td>EC - Strategy and Vision</td>
<td>Werner Steinhögl (EC - DG Connect)</td>
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<td>10:00</td>
<td>Road2CPS final results</td>
<td>Meike Reimann (Steinbeis)</td>
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<td>10:30</td>
<td>TAM54CPS final results</td>
<td>Michael Henshaw (Loughborough Uni)</td>
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<td>Networking coffee / Poster Session</td>
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<td>11:15</td>
<td>sCorPlouS final results</td>
<td>Marco Taisch (Politecnico di Milano)</td>
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<td>HIPEAC Vision</td>
<td>Marc Duranton (CEA)</td>
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<td>CPS Innovation Actions 2014 + RIA 2014</td>
<td>Matthais Althoff (University Munich)</td>
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<td>- UnCoVerCPS (RIA)</td>
<td>Holger Pfeifer (fortiss)</td>
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<td>- CPSELabs</td>
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<td>Olivier Thomas (CEA)</td>
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<td>14:00</td>
<td>Industry Key-note</td>
<td>Roland Rosen (Siemens AG)</td>
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<td>14:30</td>
<td>CPS Research and Innovation Actions 2104</td>
<td>Paolo Gal (Evidence S.R.L.)</td>
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<td>- AXIOM</td>
<td>Andreas Brokalakis (Synelixis)</td>
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<td>Ken Pierce (Newcastle University)</td>
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<td>- INTO-CPS</td>
<td>Christian Prehofer (fortiss)</td>
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<td>Shaukat Ali (Simula Research Lab)</td>
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<td>15:10</td>
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<td>ARTEMIS Vision and Intro to Association</td>
<td>ARTEMIS-IA</td>
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<td>CPS Research and Innovation Actions 2016</td>
<td>Oscar Deniz Suarez (UCLM)</td>
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<td>- BONSEYES</td>
<td>Francesca Palumbo (Uni Sassari)</td>
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<td>- CPSWARM</td>
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<td>16:30</td>
<td>CPS Coordination and Support Actions</td>
<td>Charles Robinson (Thales)</td>
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<td>- Platforms4CPS</td>
<td>Harald Rueß (fortiss)</td>
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<td>- CPSSummit</td>
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<td>16:50</td>
<td>Short Rapport &amp; Synergy Session</td>
<td>Rapporteur / Panelists</td>
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<td>End of the day</td>
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Digitising European Industry

- Leadership in digital value chains
- From vertical markets to mainstream
- Access to latest technology (SMEs, Midcaps, non tech.)
- Skilling our workforce for digital change
- Adapting the legislation

Actions
- Public Private Partnerships - ECSEL
- European Leadership in Platforms (and technology gateways) – opportunity and already active area
- Large scale pilots and test beds
- Innovation Hubs – SMEs

In partnership, industry, member states and regions

Autonomous Driving, Smart Factory, Healthy Aging
Road2CPS

Road2CPS was a 24-month coordination and support action in the area of Smart Cyber-Physical Systems. The project aimed to carry out strategic action for future CPS through **roadmaps, impact multiplications and constituency building** by:

- identifying the gaps of current research (**72 projects**) and bridging the efforts (**useful tool developed to do this**),
- analysing future research priorities and business opportunities
- bringing the relevant stakeholders together to facilitate mutually beneficial collaborations between them

The project aimed to **build a constituency united by the commonly faced challenges** and also a joint action plan for the future development of CPSs.
- **Lot of synergy with Digitising European Industry**
- **Less technology creation** – move to promoting innovation and raising awareness
TAMS4CPS

TAMS4CPS has a mission to develop a strategic research and collaboration agenda to foster **Trans-Atlantic research in Modelling and Simulation (M&S) for Cyber-Physical Systems (CPS).**

**TAMS4CPS Mission**
- Lay the foundations for concrete EU-US collaboration in modelling and simulation for CPS
- Define the scope of CPS for US and Europe and, based on this, an agreed scope for collaboration
- Identify priority research and development needs for modelling and simulation for CPS
- Create a **strategic research agenda** for collaboration in modelling and simulation for CPS, which is endorsed by European and US industry and academia
- Provide key enablers for Trans-Atlantic collaboration in modelling and simulation for CPS
- Disseminate the findings of the project widely and freely

**Key Findings**
- Identified 7 themes but biggest problem is **verification** – need to think differently for the future
- Need additional access to joint test beds for CPS – particularly for SMEs
- Human factors need to be considered in modelling for situation awareness
- Problem is structural barriers to collaboration
- Identified 4 test cases where collaboration may be possible
Driven by worldwide economic downturn Western companies need to cut costs and enhance performance to maintain European leadership and excellence in manufacturing

- European businesses cannot compete on workforce costs with Eastern countries
- Manufacturers have to leverage on more sustainable and efficient production systems
- ICT is the crucial enabler for competitiveness and innovation in manufacturing

**sCorPiuS**

- Define role of CPS in manufacturing performance – **120 interviews**
- Create a roadmap of most important technological trends
  - 6 clusters (data for new business models/improved products, closed loop manufacturing, plug and produce, efficiency, digital ergonomics)
- Create consensus and build a community - Vision Product and Factory Dimension – Digital Twin
- Plan Research - **14 Priorities Identified in White Paper**
HiPEAC

Drivers
- Cyberphysical entanglement - Computers are disappearing from view – blurring between cyber and physical worlds - computers now embedded in cars, smart meters, wearable, etc.
- Centaur Era – cobots, brain computer interface, intelligent personal assistant – more natural interaction with users, e.g. sound and images

Challenges
- Security, privacy and safety for Mixed Criticality - Humans need to trust machines and the information that they keep about us – Internet of Threats
- Guarantee safety - need to ensure that functional and non-functional properties are met (e.g. timing, reliability)
- New design techniques - that allow the building of reliable systems from unreliable parts
- Transforming Data into Information as soon as possible
  - Need cloud and supercomputers (HPC) for processing - connectivity is crucial – not good for cars
  - Local processing - becoming increasingly important (also for privacy monitoring elderly)
- Need hardware and software together
- Energy efficiency - major challenge for coming years
- AI needed by human designers to help master complexity
- Need to re-invent computing
UnCoVerCPS

The Unifying Control and Verification of Cyber-Physical Systems (UnCoVerCPS) will develop new methods for de-verticalisation of the development processes by a generic and holistic approach towards reliable cyber-physical systems development with **formal guarantees with the aim to synthesise and verify controllers on-the-fly during system execution**. Completely new methods will be developed, which are integrated in tools for modelling, control design, verification, and code generation that will leverage the development towards reliable and at the same time open cyber-physical systems.

Objectives

- Develop novel on-the-fly control and verification concepts
- Develop methods for unifying control and verification to quickly react to changing environments
- Provide seamless integration of modelling and conformance testing
- Develop a unique tool chain to integrate modelling, control design, formal verification, and automatic code generation
- Applications include **automated vehicles and human-robot collaborative manufacturing, wind turbines and smart grids**
- Automated driving example – reachability set – how fast human arm can move – can prove safety
CPSE Labs

- Cyber-Physical Systems Engineering Labs (CPSE Labs) is an initiative designed to provide technical support and funding for European technology businesses to develop **trustworthy CPS**

- **CPSE Labs funds industrial experiments.** Businesses (and other organisations) could submit experiment proposals

- Provide a **number of platforms** across a number of domains

- Experiments focused and fast-track with explicit objectives that improve a business's ability to innovate

- **Over 100 proposals**

- Platforms being used in Autonomous Vehicles, Aerospace and Maritime projects, Smart Cities
EuroCPS

- EuroCPS gathers several design centres in order to boost and initiate synergies between innovative companies, major CPS-platforms and CPS-competency providers.
- **Provides 8 Technology Platforms across 9 countries to SMEs for experiments**
- The aim is to enable companies making new CPS products to get access to leading edge technology platforms from large companies and support from competency partners.
- A second goal is to link user and supplier across value-chains and region within the help of the competence partners (coaching, development plan definition, service providers).
- Support, management and monitoring are provided by the cascade funding partners coming from RTOs and technology transfer-oriented university institutes.
- EuroCPS is supporting projects considering their excellence, their impact on the ecosystem and their industrialization implementation possibility and prospects.
- **3 open calls - 118 proposals 34 selected in a mixture of Smart topics**
CP-SETIS

• A common, European wide open Interoperability Specification for the development of critical Cyber-Physical Systems – 100’s-1000’s of software tools needed for complex systems, e.g. aerospace
• Achieve cross-sectorial reusability of Embedded Systems devices and architecture platforms (for example, for interoperable software components for automotive, railways, aerospace and manufacturing)

Objectives
• Build-up a consensus across key stakeholders (i.e., end-users organisations, tool providers, research organisations) and projects (CESAR, MBAT, CRSTAL, HOLIDES) on a common IOS Standardisation Strategy
• Define a concrete model for sustainable IOS Standardisation Activities
• Support implementation of Sustainable IOS Standardisation Activities within sustainable structures, that have a far longer lifespan than a single project
• Get commitment from key stakeholders for supporting common IOS Standardisation Strategy and its implementation – problem not easily mapped to a single standardisation body
• Have created a standardisation database which is open to all stakeholders – IOS Coordination Forum
Eyes of Things EoT

• To be “smart everywhere” we will need to have “eyes everywhere” e.g. wearable applications, augmented reality, surveillance, ambient-assisted living, etc.

• Vision is our richest sensor, allows mining big data from reality

• Vision is the most demanding sensor in terms of power consumption and required processing power

Objective

• Build a power-size-cost-programmability optimized core vision platform that can be embedded into all types of artefacts

• Maximize inferred information per milliwatt

• Adapt the quality of inferred results to each particular application

• Applications – doll to recognise emotions, peephole camera, lifelogging, museum audio guide
Customer Benefits by Cyber Physical Systems
Roland Rosen (Siemens AG)

Megatrends
- Digitalization – by 2020 44 zettabytes, 50 billion devices linked online
- **Business models change** – e.g. eBook, Music Streaming
- Physical to virtual prototypes, connectivity monitoring and access, digital twin, plug and operate
- Technologies – communication and connectivity, etc.

Manufacturing Industry
- Modularity, Connectivity, Autonomy and Digital Twin
- Moving to mass customisation - lot size one
- Need to customise for regions

Industrie 4.0
- Customer benefits first
- Build on core strengths
- Use case based approach
- Value Chains – need to consider supply chain
- Have defined application scenarios, e.g. The Adaptable Factory

Have set up Plattform Industrie 4.0 – cooperation, standardisation

Changing from **Automated Systems to Autonomous Systems**

4 Siemens Core Technology Initiatives - Deep Artificial Intelligence, Digital Twin Unleashed, Autonomous Systems Revolution and Simulation

Safety, security and human as part of the system is important
AXIOM

The AXIOM project (Agile, eXtensible, fast I/O Module) aims at researching new software/hardware architectures for CPSs considering:

- Objects and people will become nodes of the same digital network
- Rapid and close interaction: system-system, human-system, system-human.
- Smart systems will improve and simplify human behaviour

- Designing small board (Xilinx Zynq) that can be connected in a cluster using DMA for communications
- Video and Audio applications
- Easy programmability via OmpSs
- Releasing software stack
The COSSIM ("Novel, Comprehensible, Ultra-Fast, Security-Aware CPS Simulator") project is developing a novel simulator framework which is being integrated with a novel network simulator – nothing currently exists!

- Seamlessly simulate, in an integrated way, both the networking (OMNET++) and the processing parts (GEM5) of the CPS
- Provide much more accurate results especially in terms of power consumption
- Hooks available for connecting power consumption (McPAT) and security (in-house) measurement tools
- Hardware acceleration using parallelisation and distributed hardware and also field programmable gate arrays (FPGAs)
- Perform simulations significantly faster
- Setting up a spin-off to support the tool
INTO-CPS

The aim of the INTO-CPS project is to create an integrated “tool chain” for comprehensive Model-Based Design (MBD) of Cyber-Physical Systems (CPSs). The tool chain will support the multidisciplinary, collaborative modelling of CPSs from requirements, through design, down to realisation in hardware and software. This will enable traceability at all stages of the development.

Objectives
Build an open, well-founded tool chain for multidisciplinary model-based design of CPS that covers the full development life cycle of CPS. The tool chain will support multiple modelling paradigms and will cover multiple development activities, including requirements modelling, analysis, simulation, validation, verification, and traceability

• Provide a sound semantic basis for the tool chain. This will include semantics for FMI co-simulation, as well as SysML, discrete-event and continuous-time paradigms.
• Provide practical methods in the form of guidelines and patterns that support the tool chain.
• Demonstrate in industrial applications (automotive, agricultural, railways and building automation)
• Formed an Industrial Follower Group with 71 members
SAFURE - Safety And Security By Design For Interconnected Mixed-Critical Cyber-Physical Systems targets the design of cyber-physical systems by implementing a methodology that ensures safety and security "by construction". The goals of the SAFURE project are:

• to implement a holistic approach to safety and security of embedded dependable systems, preventing and detecting potential attacks,
• to empower designers and developers with analysis methods, development tools and execution capabilities that jointly consider security and safety,
• to set the ground for the development of SAFURE-compliant mixed-critical embedded products.
• It will produce a framework with the capability to detect, prevent and protect from security threats on safety with the the ability to monitor system integrity from application level down to the hardware level including time, energy, temperature and data integrity
• 3 industrial use cases in automotive and telecommunications – mixed critical time scheduling, time sensitive networking, smart phones, body area network, multicore ECU and network with TTEthernet
The main goal TAPPS (Trusted Apps for open CPS) project is to extend and customize CPS devices with new **3rd party services and features in an Apps platform in an efficient, secure and trusted way.** TAPPS is based on a dedicated execution environment for distributed, safety-critical CPS applications offering multiple layers of security and a holistic, open end-to-end tool chain for developing and deploying CPS Apps.

The project will:

• Design, implement and validate a separate, dedicated, real-time **Trusted Execution Environment (TEE) for highly-trusted CPS Apps.** The TEE is located inside the system control units and uses TAPPS’ processor- and network-centric security mechanisms and a hypervisor for virtualization

• Provide and validate an end-to-end solution for development and deployment of trusted Apps

• Validate the multi-level trusted Apps platform and tool chain in several application domains using industrial, realistic use cases: electric motorbike and smart trolley for medicine – also Industrie 4.0

• **ARM multicore with normal and secure regions**
U-Test

The U-Test (Testing Cyber Physical Systems under Uncertainty) project aims at ensuring that CPSs are **tested adequately under uncertainty** using systematic and automated techniques such as model and search-based testing to guarantee their correct operation in real environment.

**Overall Aim and Concept**

- U-Test will improve dependability of CPSs by defining extensible MBT frameworks supporting holistic testing of the systems under uncertainty in a cost-effective manner by:
  - Providing a comprehensive and extensible taxonomy of uncertainties, classifying uncertainties, their properties, and their relationships.
  - Creating an Uncertainty Modelling Framework (UMF) to support modelling uncertainties at various levels (relying on exiting modelling/testing standards).
  - Developing the **Uncertainty Testing Framework (UTF)** that can smartly discover unknown uncertainties and generate cost-effective test cases to test CPSs under known and unknown uncertainties.
- Developed two tool chains
- Using multiobjective search for testing
- Two case studies: Logistics Handling Systems and GeoSports
ARTEMIS-IA

- ARTEMIS Industry Association is the association covering Embedded & Cyber-Physical Systems with more than **170 members** and associates from all over Europe.
- The multidisciplinary nature of the membership provides an excellent network for the exchange of technology ideas, **cross-domain fertilisation, as well as for large innovation initiatives, e.g. mobility**.
- ARTEMIS-IA promotes the R&I interests of its members to the European Commission and the Public Authorities of the participating states.
- Continues the work of the European Technology Platform ARTEMIS and is responsible for the ARTEMIS Strategic Research Agenda (SRA) on Embedded & Cyber-Physical Systems.
The Bonseyes project aims to develop a platform consisting of a **Data Marketplace, Deep Learning Toolbox, and Developer Reference Platforms** for organizations wanting to adopt Artificial Intelligence in low power IoT devices (“edge computing”), embedded computing systems, or data centre servers (“cloud computing”). An Open software architecture will be used (aligned with the European FI-PPP activities and FIWARE)

- Targets shifting balance between edge computing and cloud computing – more processing at edge devices shifts – **moving from the connected device paradigm to the intelligent device paradigm**

The project will:
- Bring about orders of magnitude improvements in efficiency performance, reliability, security, and productivity in the design and programming of Systems of Artificial Intelligence
- Solve a chicken-egg problem for organisations who lack access to Data and Models

CERBERO

The Cross-layer modEl-based fRamework for multi-oBjective dEsign of Reconfigurable systems in unceRtain hybRid envirOnments (CERBERO) project aims at developing a design environment for CPS based of two pillars: a cross-layer model based approach to describe, optimize, and analyse the system and all its different views concurrently; an advanced adaptivity support based on a multi-layer autonomous engine.

Target

Design speed up (one order of magnitude), increased performance (30% less energy) and reduced costs of deployment (by rapid prototyping and system in the loop incremental design) and maintenance (by runtime verification and adaptivity) of CPSoS are expected.

CERBERO will provide:

- Libraries of generic Key Performance Indicators for reconfigurable CPSs in hybrid/uncertain environments
- Novel formal and simulation-based methods
- Automated multi-objective decisions to meet requirements and correct/optimized–by–construction designs
- A continuous design environment guaranteeing early-stage analysis and optimization of functional and non-functional requirements, including energy, reliability and security.

CERBERO effectiveness will be assessed in diverse industrial scenarios:

- An embedded CPS with self-healing capabilities for planetary explorations
- An ocean monitoring CPSoS
- Smart Travelling CPSoS for an Electric Vehicle
CPSWARM

CPSwarm proposes a new science of system integration and tools to support engineering of CPS swarms. CPSwarm tools will ease development and integration of complex herds of heterogeneous CPS that collaborate based on local policies and that exhibit a collective behaviour capable of solving complex, industrial-driven, real-world problems. Model-centric design and predictive engineering are the pillars of the project, enabling definition, composition, verification and simulation of collaborative, autonomous CPS while accounting for various dynamics, constraints and for safety, performance and cost efficiency issues.

Challenges

• A single consistent science of system integration for CPS has not yet been consolidated
• CPS development remains a complex and error-prone task, often requiring a collection of separate tools
• Interactions can become an advantage if explicitly managed rather than being an unwanted byproduct

Approach

The project will define a complete toolchain that enables the designer to:

• set-up collaborative autonomous CPSs
• test the swarm performance with respect to the design goal
• massively deploy solutions towards “reconfigurable” CPS devices

Tested in 3 real-world use cases: swarms of Unmanned Aerial Vehicles and Rovers for safety and security purposes; autonomous driving for freight vehicles; and swarm logistics
Platforms4CPS

Market analysis and ecosystem
- Promoting platform building
- Bring together leading CPS experts from academia and industry to collaborate on future CPS architectures and platforms
- Pre-normative activities
  - Pre-normative activities (creating a repository of CPS technology bibles)

“Vision and Strategy”

“Building the Ecosystem”
Constituency Building and Collaboration
- Structuring of constituencies
- Cooperating with other European programmes ARTEMIS, ECSEL and ITEA
- on the foundations of CPS engineering
  - Consensus-building on societal and legal issues related to the deployment of CPS

Roadmapping and Recommendations
- Strategically updating and validating CPS roadmaps

Dissemination, Exploitation and Communication
- Management
CPS Summit

The Transatlantic CPS Summit was an 18-month support action with the goal of facilitating and creating an enduring and sustainable collaboration campaign on CPS research and development between Europe and the US. The support action achieved its overall aim by means of a series of CPS Summit Workshops to:

• Identify and evaluate possible R&D co-operations between Europe and the US
• Investigate and promote implementation of opportunities for cooperation
• Prepare a roadmap for R&D cooperation on CPS engineering between the EU and US together with recommendations for action
• Present final results to interested stakeholders (e.g. public bodies, industry, academic researchers) on both sides of the Atlantic
Outreach to SMES
- EuroCPS several design centres
- CPSE Labs several design centres

EU-US Collaboration
- CPS Summit collaboration on CPS research and development between Europe and the US
- TAMS4CPS strategic research and collaboration agenda to foster Trans-Atlantic research in Modelling and Simulation (M&S) for Cyber-Physical Systems (CPS).

Tool Chains
- INTO-CPS integrated “tool chain” for comprehensive Model-Based Design (MBD) of Cyber-Physical Systems
- CERBERO Multi-object Design of Reconfigurable Systems

Development and Integration
V&V
- Unifying Control and Verification of Cyber-Physical Systems (UnCoVerCPS)
- U-TEST Testing Cyber Physical Systems under Uncertainty

Interoperability
- CP-SETIS European wide open Interoperability Specification for the development of critical Cyber-Physical Systems

Safety & Security
- SAFURE - Safety And Security By Design For Interconnected Mixed-Critical Cyber-Physical Systems
- TAPPS (Trusted Apps for open CPS)

Hardware/Software
- AXIOM (Agile, eXtensible, fast I/O Module) aims at researching new software/hardware architectures for CPSs

Simulators
- COSSIM Novel, Comprehensible, Ultra-Fast, Security-Aware CPS Simulator

Sensing
- EoT “eyes everywhere”

Data
- BONSEYES – Deep Learning, AI for Data Marketplace

Autonomy
- CPS-SWARM Collaborative Autonomous CPS

Safety
-Siemens AG Customer Benefits from CPS Industrie 4.0
- Digital Twin Unleashed
- Autonomous Systems Revolution
- Simulation
Also Important - Safety, security and human interactions

Simulation

Engaging with Community
Roadmaps
- Road2CPS The project aims to carry out strategic action for future CPS through roadmaps, impact multiplications and constituency building
- sCorPiuS CPS in manufacturing, research roadmap and raise awareness
- Platforms4CPS Updating roadmaps, platform building and constituency building
- HiPEAC Embedded Systems Vision Artificial Intelligence

Engaging with US

EU-US Collaboration
- CPS Summit collaboration on CPS research and development between Europe and the US
- TAMS4CPS strategic research and collaboration agenda to foster Trans-Atlantic research in Modelling and Simulation (M&S) for Cyber-Physical Systems (CPS).

Industry Engagement
ARTEMIS Industry Association Strategic Research Agenda

Safety/Security

Hardward/Software

Interoperability
- CP-SETIS European wide open Interoperability Specification for the development of critical Cyber-Physical Systems

Roadmaps
- Road2CPS The project aims to carry out strategic action for future CPS through roadmaps, impact multiplications and constituency building
- sCorPiuS CPS in manufacturing, research roadmap and raise awareness
- Platforms4CPS Updating roadmaps, platform building and constituency building
- HiPEAC Embedded Systems Vision Artificial Intelligence
Concluding Remarks

• Digitisation – Fragmentation across Europe, skills
• Number of roadmaps – some overlap, some sector specific
• Industry views
• Areas not addressed today – scalability?

• Challenges
  • Interoperability – Federation of platforms
  • Coordinating development efforts
  • Demonstrations at scale
  • Connecting with SMEs at regional level – access to technology
  • Skilling workforce for digital transformation
  • Supporting legislation
Key Questions

• Have we got every research priority covered? Number of Roadmaps (6) with Recommendations!
  • Are there any key gaps, e.g. cognitive systems, sociotechnical issues?

• Are there any ideas for co-operation across projects and programme?
  • How do the activities of your project link to digital platforms and digital innovation hubs?

• What are the barriers for industry? What can EC do to help?
  • Sociotechnical, e.g. developing trust, raising awareness with public?
  • Need for regulation, safety, privacy, legal (SLAs, liability)?
  • Standards for interoperability?