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Road2CPS

Priorities and Recommendations for Research and Innovation in Cyber-Physical Systems

Meike Reimann, Carsten Rückriegel (Lead authors)
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Executive Summary

This document summarises the findings of the Road2CPS project, co-financed by the European Commission under the H2020 Research and Innovation Programme, to develop a roadmap and recommendations for strategic action required for future deployment of Cyber-Physical Systems (CPS).

The term *Cyber-Physical System* describes hardware-software systems, which tightly **couple the physical world and the virtual world**. They are established from networked embedded systems that are connected with the outside world through sensors and actuators and have the capability to collaborate, adapt, and evolve. In the ARTEMIS Strategic Research Agenda 2016, CPS are described as ‘**Embedded Intelligent ICT Systems**’ that make products smarter, more interconnected, interdependent, collaborative, and autonomous. In the future world of CPS, a huge number of **devices connected to the physical world** will be able to **exchange data** with each other, access web services, and **interact with people**. Moreover, information systems will **sense, monitor and even control** the physical world via Cyber-Physical Systems and the Internet of Things (HiPEAC Vision 2015).

Cyber-Physical Systems find their application in many highly relevant areas to our society: **multi-modal transport, health, smart factories, smart grids and smart cities** amongst others. The deployment of Cyber-Physical Systems (CPS) is expected to increase substantially over the next decades, holding great **potential for novel applications and innovative product development**. Digital technologies have already pervaded day-to-day life massively, affecting all kinds of interactions between humans and their environment. However, the inherent complexity of CPSs, as well as the need to meet optimised performance and comply with essential requirements like safety, privacy, security, raises many questions that are currently being explored by the research community. Road2CPS aims at accelerating uptake and implementation of these efforts.

The **Road2CPS project** identifying and analysing the relevant **technology fields** and related **research priorities** to fuel the development of trustworthy CPS, as well as the specific technologies, needs and barriers for a successful implementation in different **application domains** and to derive recommendations for strategic action.

The document at hand was established through an interactive, community-based approach, involving over 300 experts from academia, industry and policy making through a series of workshops and consultations. **Visions and priorities** of recently produced **roadmaps** in the area of CPS, IoT (Internet of Things), SoS (System-of-Systems) and FoF (Factories of the Future) were discussed, complemented by sharing views and perspectives on CPS implementation in **application domains**, evolving multi-sided eco-systems as well as business and policy related **barriers, enablers and success factors**. From the workshops and accompanying activities **recommendations for future research and innovation activities** were derived and topics and timelines for their implementation proposed.

Amongst the **technological topics**, and related future research priorities ‘**integration, interoperability, standards**’ ranged highest in all workshops. The topic is connected to digital platforms and reference architectures, which have already become a key priority theme for the EC and their Digitisation Strategy as well as the work on the right standards to help successful implementation of CPSs. Other themes of very high technology/research relevance revealed to be ‘**modelling and simulation**’, ‘**safety and dependability**’, ‘**security and privacy**’, ‘**big data and real-time analysis**’, ‘**ubiquitous autonomy and forecasting**’ as well as ‘**HMI/human machine awareness**’. Next to this, themes emerged including ‘decision making and support’, ‘CPS engineering (requirements, design)’, ‘CPS life-cycle management’, ‘System-of-Systems’, ‘distributed management’, ‘cognitive CPS’, ‘emergence, complexity, adaptability and flexibility’ and work on the foundations of CPS and ‘cross-disciplinary research / CPS Science’.