Road2CPS

Smart Cyber-Physical Systems Clustering and Communication Event

14 April, 2016
Vienna

Speaker and Project Information

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CRYSTAL - Critical System Engineering Acceleration

Dr. Christian El Salloum (coordinator and speaker)

Short-CV

Dr. Christian El Salloum finished his PhD studies in Computer Science in 2008 with Prof. Hermann Kopetz at the Vienna University of Technology. At the Vienna University of Technology he worked as an assistant professor at the Real-Time Systems Group, participated in several national and international research projects and was the global coordinator of the ARTEMIS ACROSS project. In 2013 he joined AVL and took the position of the global strategic and technical coordinator of the ARTEMIS CRYSTAL project. At AVL, Christian works also as a technology scout for big data and cloud computing and leads the data management strategy of the AVL Integrated Open Development Platform (IODP).

Abstract of presentation

The processes of developing, deploying, governing, operating and maintaining modern safety-critical embedded systems is highly complex and requires specialized tools supporting different activities throughout the entire product life cycle. Therefore, OEMs and suppliers are typically operating a large set of tools from different vendors often complemented by custom in-house solutions. Tool integration is often done in an ad-hoc manner by creating proprietary bridges between each pair of tools. Such an approach does not scale, since the number of required bridges grows exponentially with the number of employed tools.

The project CRYSTAL (CRitical sYSTem engineering AcceLeration) has identified the need for a standardized and open integration approach and establishes an Interoperability Specification (IOS) as an open European standard for the development of safety-critical embedded systems in the automotive, aerospace, rail and health care domain. This standard allows loosely coupled tools to share and interlink their data based on standardized and open Web technologies that enable common interoperability among various life cycle domains. This reduces the complexity of the entire integration process significantly. OEMs will benefit from better supplier collaboration and reduced system design costs due to the improved and the smart integration of system analysis, safety analysis, and system exploration tools. In addition, the CRYSTAL IOS will increase the flexibility for all stakeholders and has the potential to deeply impact the market on a global level.

Partner in/ Coordinator of related projects (H2020-ICT-Programm – CPS/IoT or ECSEL/ITEA)
none

Project Information

Project Name: **CRITICAL SYSTEM ENGINEERING ACCELERATION**

Acronym: CRYSTAL/ Ref.nr.: 332830/ Duration: 01/2013-07/2016

Project Facts / Website: www.crystal-artemis.eu/

Funding: 13.47 M Euro (EU), 22.33 M Euro (National)
Funding Scheme: FP7
Topic(s): Enabling Seamless Life-Cycle Collaboration for Safety-Critical Systems Engineering
Call for Proposal: ARTEMIS-JU Call 2012
Related Projects: CESAR, SAFE, iFEST, MBAT
Coordinator: Dr. Christian El Salloum, Annemarie Hamedler / AVL List GmbH (Austria)
TRL: between 6 and 7 for 50% of the implemented tool chains.

Relevant Domains
- Aerospace
- Automotive
- Health Care

Rail

Consortium:
- AVL List GmbH
- Airbus Defence and Space GmbH
- Airbus Defence and Space GmbH – Airbus Group Innovations
- Airbus Group SAS
- Airbus Operations Ltd - AirbusGroup Innovations
- AirbusGroup Limited
- AleniaAermacchi SpA
- All4Tec
- Alstom Transport
- Ansaldo STS S.p.A.
- ArcCore AB
- Arcticus Systems AB
- Austrian Institute of Technology
- AVL Schrick GmbH
- AVL Software and Functions GmbH
- Barco N.V.
- Centro de Innovación y Soluciones Empresariales y Tecnológicas, S.L.
- Centro Ricerche Fiat SCPA
- Chalmers tekniska högskola
- Creative Intellect Consulting Ltd.
- Daimler AG
- ElektroBit
- Fondazione Bruno Kessler
- Fraunhofer
- FUNDACION TECNALIA RESEARCH & INNOVATION
- GMV, S.A.
- Honeywell International, s.r.o.
- IBM Nederland B.V.
- IBM United Kingdom LT
- Instituto Tecnológico de Informática
- ITK Engineering
- Kompetenzzentrum - Das virtuelle Fahrzeug, Forschungsgesellschaft mbH
- Masaryk University
- Mate Consulting
- Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek
- Volvo Technology AB
- Obeo
- OFFIS e. V.
- Orbital Aerospace
- Personal Space Technologies
- Philips Medical Systems Nederland B.V.
- Politecnico di Torino
- RGB Medical Devices
- Sagem Défense Sécurité
- Second University of Naples
- SIEMENS AKTIENGESELLSCHAFT
- SIEMENS INDUSTRY SOFTWARE GMBH & CO KG
- Soyatec
- Systemite AB
- Technical University Eindhoven
- Technische Universität Berlin
- Technische Universität Berlin
- Technische Universität Graz
- Test and verification and Solutions Ltd.
- Testing Technologies IST GmbH
- Thales Alenia Space
- THALES ALENIA SPACE ESPANA, SA
- Thales AT
- Thales Austria GmbH
- Thales Global Services
- Thales Research & Technology France
- TTTech Computertechnik AG
- Universidad Carlos III de Madrid
- University of Freiburg
- University of Genova
- University of Naples "Federico II"
- Valeo FR
- Volvo Technology AB

Main Objectives / Aims / Goals

CYRSTAL establishes and pushes forward an *Interoperability Specification (IOS)* as an open standard for the development of safety-critical embedded systems in the automotive, aerospace, rail and health care domain. This standard allows loosely coupled tools to share and interlink their data based on standardized and open web technologies that enable common interoperability among various life cycle domains. This reduces the complexity of the entire integration process significantly.

3 to 4 bullet points • CRYSTAL is an industry-driven application-/user-oriented project. • CRYSTAL implements – based on existing technologies (generic interoperable and federated technology bricks and services) – **ready-for-use integrated tool chains** that can be applied industrially in the partner's engineering environment.	• CRYSTAL will **drive forward cross-domain reusability, ontology, and interoperability** including an **interoperability specification (IOS)**.

Achievements/Highlights/Results/most striking achievements

CRYSTAL establishes an interoperability specification (IOS), a reference technology platform (RTP) and a platform builder for setting up a system engineering environment (SEE). The project develops tool chains ranging from requirement analysis up to post sales surveillance of safety critical systems.
Furthermore, generic engineering methods are developed which focus on simulation management, test coverage of requirements, safety risk management, certification management, and version control. Multiple use cases from four industrial domains (aerospace, automotive, train, health care) are used to drive the design towards interoperability between tools based on interfaces defined by the IOS.
The CRYSTAL IOS uses and promotes the industry-wide interoperability OSLC standard and has developed various extensions (e.g. for configuration management, for safety) which constitute a major value for the whole embedded systems industry.

3 to 4 bullet points • The awareness of OSLC as an open standard for life-cycle interoperability was dramatically increased by CRYSTAL. • Multiple tool vendors support OSLC interfaces out-of-the-box in the recent versions of their tools.	• Real-world industrial use cases • Impressive demonstrators in all four targeted industry domains (aerospace, automotive, train, health care)

Arrowhead - Local cloud automation based on IoT and SoS

Jerker Delsing (coordinator and speaker)

Short-CV

Prof. Jerker Delsing received the M.Sc. in Engineering Physics at Lund Institute of Technology, Sweden 1982. In 1988 he received the PhD. degree in Electrical Measurement at the Lund Univeristy. During 1985 - 1988 he worked part time at Alfa-Laval - SattControl (now ABB) with development of sensors and measurement technology. Early 1995 he was appointed full professor in Industrial Electronics at Lulea University of Technology where he currently is working as the scientific head of EISLAB, http://www.ltu.se/eislab. His present research profile involves automation system architectue ansd platforms based on IoT nad SoS. Currently he is the coordinator of the very large ARTEMIS proposal Arrowhead, with 78 partners and a budget of 68M€.

Abstract of presentation

Arrowhead Framework - Local cloud automation based on IoT and SoS

Automation solutions in local clouds having real time capabilities paired with strong security and ease of engineering is facilitated by the Arrowhead Framework. Within a local loud performance critical closed loop control can be executed with good protection from outside disturbances or attackers. A number of measurements gives that engineering of local cloud automation solutions is about five times as effective as current state of the art. Interoperability among IoT devices is facilitated at a service level using SOA protocols and SOA protocol translation. Scalability of local cloud automation solutions is facilitated by inter-cloud service exchange mechanisms thus meting the requirements on very large automation systems, milions of I/O's, foreseen.

Arrowhead Framework is the core result out of the Arrowhead project. The Framework is now made public as open source through Arrowhead Framework wiki site.

Partner in/ Coordinator of related projects:

Arrowhead coordinator, EMC2 partner, DISIRE, partner, OPTI partner, I2Mine partner

Project Information

Project Name: **ARROWHEAD**

Acronym: Arrowhead / Ref.nr.: 332987 / Duration: 2013-03-01 - 2017-02-28

Project Facts Website: www.arrowhead.eu

Funding: 68M€ Funding Scheme: ECSEL Topic(s): - Call for Proposal: Related Projects: EMC2, OPTI, DISIRE, I2MIne Coordinator: (country) Sweden TRL: 3-6	Consortium: 78 partners see see our web page	Relevant Domain: • Automation

Main Objectives / Aims / Goals

Vision: Enable collaborative automation by networked embedded devices.

Grand challenges:
Enabling the interoperability of services provided by almost any device.
Enabling the integrability of services provided by almost any device.

Achievements/Highlights/Results/most striking achievements

Arrowhead Framework as an open source platform enabling IoT and SoS based automation solutions.
Demonstrated the feasibility of Arrowhead Framework in more than 20 demos across several fields of application:

- Production automation
- Smart building automation
- Electro-mobility automation
- Energy - automation and optimisation

More than 10 new products
Two new companies (so far)
Adoption of Arrowhead Framework technology by more than 5 other larger EU projects.

Recommendations/ Work to be continued

Further project support to the Arrowhead Framework open platform community.
http://forge.soa4d.org/arrowhead-f

MANTIS - Cyber Physical System based Proactive Collaborative Maintenance

Dr Erkki Jantunen (coordinator and speaker)

Short-CV Dr Erkki Jantunen is principal scientist at VTT Technical Research Centre of Finland. Between 1978 and 1990 he worked in the shipbuilding industry in structural, vibration and hydrodynamic fields. Since 1990 he has been employed by VTT having various project responsibilities related to maintenance, condition monitoring and diagnosis of rotating machinery. He has been a member of the editorial board and acted as a reviewer of a number of scientific journals. He has been project manager of many research pro-jects. He is the author and coauthor of several books and more than 100 research papers in the field of condition monitoring, diagnosis and prognosis and e-maintenance. He has a position as a visiting professor at the University of Sunderland.
Abstract of presentation The overall concept of MANTIS is to provide a proactive maintenance service platform architecture based on Cyber Physical Systems that allow to estimate future performance, to predict, and prevent imminent failures, and to schedule proactive maintenance. Physical systems e.g. industrial ma-chines and vehicles and the environment they operate in, are monitored continuously by a broad and diverse range of intelligent sensors, resulting in massive amounts of data that characterize the usage history, operational condition, location, movement and other physical properties of those systems. MANTIS consists of distributed processing chains that efficiently transform raw data into knowledge while minimizing the need for bandwidth. Sophisticated distributed sensing and decision making functions are performed at different levels in a collaborative way. The research addressed in MANTIS will contribute to companies' assets availability, competiveness, growth, and sustainability.
Partner in/ Coordinator of related projects: VTT Technical Research Centre of Finland

Project Information

Project Name: **Cyber Physical System based Proactive Collaborative Maintenance**

Acronym: MANTIS/ Ref.nr.: 662189/ Duration: 36 Months

Project Facts / Website: http://www.mantis-project.eu/

Funding: 9,791,974.29 €
Funding Scheme: 32.49 % of total costs
Topic(s): ECSEL-01-2014 - ECSEL Key Applications and Essential Technologies (RIA)

Call for Proposal: ECSEL-2014-1
Related Projects: ARROWHEAD
Coordinator: Mondragon (ES)
TRL: 7

Relevant Domains
- Production asset maintenance
- Energy production asset management
- Vehicle maintenance management

Health equipment maintenance

Consortium:
- MGEP (Mondragon Goi Eskola Politeknikoa J.M.A. S.Coop.)
- MONDRAGON (Mondragon Corporacion Cooperativa S.Coop.)
- IKERLAN (Ikerlan S.Coop.)
- TEKNIKER (Fundacion Tekniker)
- FARR (Fagor Arrasate S.Coop.)
- KONIKER (Koniker S.Coop.)
- GOIZPER (Goizper S.Coop.)
- ACCIONA (Acciona Infraestructuras S.A.)
- MSI (Mondragon Sistemas De Informacion S.Coop.)
- VTT (Teknologian Tutkimuskeskus VTT Oy)
- LUAS (Lapin Ammattikorkeakoulu Oy)
- NOME (Nome Oy)
- FORTUM (Fortum Power And Heat Oy)
- MAINIOT (MainIoT Software Oy)
- WAPICE (Wapice Oy)
- AAU (Aalborg Universitet)
- DANFOSS (Danfoss A/S)
- DETH (Deth Logistiks Aps)
- HGE (Hg Electric A/S)
- VESTAS (Vestas Wind Systems A/S)
- SIRRIS (Sirris Het Collectief Centrum Van De Technologische Industrie)
- ILIAS (Ilias Solutions Nv)
- ATLAS (Atlas Copco Airpower Nv)
- 3E(3e Nv)
- PCL (Philips Consumer Lifestyle B.V.)
- PHC (Philips Medical Systems Nederland B.V.)
- PHILIPS (Philips Electronics Nederland B.V.)
- S&T (Science and Technology B.V.)
- TU/E (Technische Universiteit Eindhoven)
- RUG (Rijksuniversiteit Groningen)
- UNINOVA (UNINOVA - Instituto de Desenvolvimento de Novas Tecnologias)
- ISEP (Instituto Superior de Engenharia do Porto)
- INESC (Instituto de Engenharia de Sistemas e Computadores do Porto)
- ADIRA (ADIRA - Metal Forming Solutions S.A.)
- ASTS (Ansaldo STS S.p.A.)
- CINI (Consorzio Interuniversitario Nazionale per l'Informatica)
- AIT (Austrial Institute of Technology GmbH)
- HBM (Hottinger Baldwni Messtechnik GmbH)
- INNOTEC (Innovative Technology and Science Limited)
- AITIA (AITIA International Inc.)
- BME (Budaperst University of Technology and Economics)
- JSI (Josef Stefan Institute)
- XLAB (XLAB d.o.o.)
- FHG (Fraunhofer Institute for Experimental Software Engineering IESE)
- M2X (M2Xpert GmbH & Co KG)
- STILL (STILL GmbH)
- BOSCH (Robert Bosch GmbH)
- LIEBHERR (Liebherr-Hydraulikbagger GmbH)

Main Objectives / Aims / Goals

The main objective of MANTIS is to develop a Cyber Physical System based Proactive Maintenance Service Platform Architecture enabling Collaborative Maintenance Ecosystems. Such a Collaborative Maintenance Ecosystem will be able to estimate future performance, to predict and prevent imminent failures and to schedule proactive maintenance:

- Reduce the adverse impact of maintenance on productivity and costs
- Increase the availability of assets
- Reduce time required for maintenance tasks
- Improve the quality of the maintenance service and products
- Improve labor working conditions and maintenance performance
- Increase sustainability by preventing material loss (due to out-of-tolerance production)

3 to 4 bullet points • To define the overall service platform architecture of the MANTIS distributed system for proactive maintenance. • To develop the next generation framework for highly distributed sensing, including preprocessing, data acquisition and adaptive information processing maintenance, the MANTIS Framework.	• To conceive a distributed collaborative maintenance decision making system. • Provide user-friendly, ergonomic and intuitive context-aware human-machine interaction based on the MANTIS Maintenance Framework.

Achievements/Highlights/Results/most striking achievements

The MANTIS project started on May the 1st 2015 with duration of three years. At this first milestone after twelve months, the project has already detailed plans and organized the work between all 47 partners. All use case and technology requirements have been collected, the decisions towards the adoption of existing frameworks that support the reference architecture are about to be taken, and a first version of the MANTIS Reference Architecture already exists. This will definitely guide the development of the technical work throughout the rest of the project through developing the pieces of the architecture that will validate MANTIS in the different scenarios.

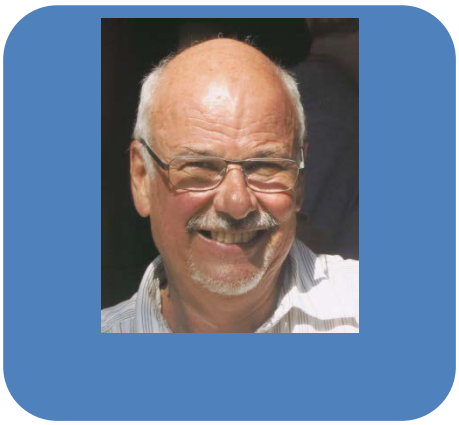
3 to 4 bullet points • Requirements & Specifications • Sensors to be used and developed for monitoring assets	• First version of the MANTIS reference architecture specification • Failure prediction prototypes

CPSoS - Towards a European Roadmap on Research and Innovation in Engineering and Management of Cyber-physical Systems of Systems

Christian Sonntag (speaker)

Short-CV

Christian Sonntag obtained a M.Sc. degree in information engineering from City University, London, UK, in 2000, and a Dipl.-Ing. degree in electrical engineering from TU Dortmund, Germany, in 2004. Since 2004, he has been with the Process Dynamics and Operations Group (DYN) at TU Dortmund, Germany, first as a research assistant, and later as a senior researcher. Since 2012, he is the Managing Director of the SME euTeXoo GmbH, Germany, that focuses on commercial exploitation strategies for novel academic research and innovation results. The research of Christian Sonntag spans several areas, including modeling and simulation, model-based tool integration, algorithmic model transformation, operational excellence, and logic control systems design, implementation, and verification. He was (and is) involved in several European projects, including HYCON, HYCON2, MULTIFORM, EMBOCON, CPSoS, and PICASSO within FP6, FP7, and H2020, and serves an invited expert for several strategic FP7 and H2020 coordination and support actions. In addition, Christian Sonntag has experience in professional software development and consulting with large IT companies (e.g. Hewlett Packard) and smaller IT providers, where he has worked on database analysis, interfacing, and design, software development for embedded systems, business management software, graphical software, software for data processing, analysis, and visualization, and scientific algorithm development.



Sebastian Engell (coordinator)

Short-CV

Sebastian Engell obtained the Dr.-Ing. degree and the venia legendi in Automatic Control from Universität Duisburg, Germany, in 1981 and 1987. 1986 - 1990 he was the head of an R&D group at the Fraunhofer Institute IITB in Karlsruhe, Germany. 1990 he was appointed to his present position as Full Professor of Process Dynamics and Operations in the Department of Biochemical and Chemical Engineering at TU Dortmund. 2008 he was a Visiting Professor at Carnegie Mellon University, Pittsburgh, USA. He was Department Chairman 1996-1999 and 2011-2014 and Vice-Rector for Research and International Relations of TU Dortmund 2002-2006. He has graduated more than 65 PhD students at TU Dortmund and published more than 130 journal papers. In 2012, Professor Engell was awarded a European Advanced Investigator Grant for the Project MOBOCON – Model-based optimizing control – from a vision to industrial reality. He has led and contributed to several EU projects, both in ICT (MULTIFORM, EMBOCON) and in NMP (F3 Factory, CAEC, CONSENS). Currently, he is leading the project DYMASOS (Dynamic Management of Physically Coupled Systems of Systems) and the Support Action CPSoS (Cyber-physical Systems of Systems) and is the scientific coordinator of the STREP MORE – Real-time Monitoring and Optimization of Resource Efficiency in Chemical Plants.
His research interests are in optimization and control of production processes, plant automation, production planning and scheduling, design and engineering and operation of cyber-physical systems of systems and optimization-based plant design.

Abstract of presentation

The next generation of energy systems, transportation networks, large industrial production systems and infrastructures large buildings will consist of many smart elements that are globally networked (Internet of Things), and highly integrated, responding to the challenges that the world faces today, reducing emissions, improving energy and resource efficiency, providing better services at a lower cost and in a sustainable manner. They are controlled by a large number of distributed and networked computing elements and by human users. Their features include partial autonomy of the subsystems, continuous evolution over their life-cycle, frequent and dynamic reconfiguration of the overall system, and the possibility of emerging behaviors. These systems are called Cyber-physical Systems of Systems (CPSoS).
This talk gives a brief overview of the European project CPSoS, as well as medium-term research and innovation priorities that were developed based on an extensive survey of ongoing research projects and challenges met by industry. These priorities are part of a proposal of a European research and innovation agenda that will soon be available for download here: **www.cpsos.eu/roadmap**.

Partner in/ Coordinator of related projects (H2020-ICT-Programm – CPS/IoT or ECSEL/ITEA)
The Process Dynamics and Operations Group (DYN) at TU Dortmund, Germany, is coordinator or partner in the FP7/H2020 projects DYMASOS, MORE, CONSENS, MOBOCON, CONNECT2SEA, PICASSO and in the ITNs oCPS and PRONTO.

Project Information

Project Name: **Towards a European Roadmap on Research and Innovation in Engineering and Management of Cyber-physical Systems of Systems**
Acronym: CPSoS / Ref.nr.: 611115 / Duration: 10/13-06/16 (33 months)

Project Facts / Website: www.cpsos.eu

Funding: 0.64 million € (EC contribution: 0.56 million €) Funding Scheme: - Topic(s): ICT-2013.3.4: Advanced computing, embedded and control systems Call for Proposal: FP7-ICT-2013-10 Related Projects: see above Coordinator: TU Dortmund, Germany TRL: -	Consortium: • TU Dortmund, Germany (coordinator) • Haydn Consulting Ltd., UK • TU Eindhoven, Netherlands • Inno TSD, France	Relevant Domains • Processing Industries • Manufacturing Industries • Transportation • Logistics • Energy generation and distribution • Engineering • Coordination, control, and operation

Main Objectives / Aims / Goals

CPSoS – Towards a European Roadmap on Research and Innovation in Engineering and Management of Cyber-physical Systems of Systems – is a 33-month Support Action supported by the European Commission under the FP7 programme. Its goals are to develop a European research and innovation agenda for cyber-physical systems of systems, and to provide a forum and an exchange platform for systems-of-systems-related communities and ongoing projects, focusing on the challenges posed by the engineering and the operation of technical systems in which computing and communication systems interact with large complex physical systems. Its approach is simultaneously integrative, aiming at bringing together knowledge from different communities, and applications-driven.

3 to 4 bullet points • Develop a European research and innovation agenda for the engineering and operation of cyber-physical systems of systems, in which computing and communication systems interact with large complex physical systems.	• Build up a network of key researchers and application domain experts in the area • Provide a forum and an exchange platform for systems-of-systems-related communities and ongoing projects

Achievements/Highlights/Results/most striking achievements

With the support of a large network of key researchers and application domain experts, CPSoS has developed a proposal for a European research and innovation agenda, which is disseminated widely, e.g. by means of public events, to stimulate the take-up by research, industry, and funding bodies. The agenda was developed based on a thorough identification of the industrial and societal needs, and of the state of the art of tools and theories, for cyber-physical systems of systems. In addition, CPSoS has organized several joint events for systems-of-systems-related communities, ongoing projects, and external researchers and practitioners, and has served as an information hub for SoS-related projects.

3 to 4 bullet points • European research and innovation agenda on the engineering and operation of cyber-physical systems of systems • Establishment of a large network of key researchers and application domain experts	• Identification of industrial & societal needs and of the state of the art of tools and theories for cyber-physical SoS • Organization of joint events for systems-of-systems-related communities, ongoing projects, and external researchers and practitioners

CP-SETIS - Towarda Cyber Physical Systems Engineering Tool Interoperability Standards

Jürgen Niehaus (coordinator)

Short-CV

Jürgen Niehaus studied Computer Science in Oldenburg, Germany. He started work as a researcher and project manager at the University of Oldenburg in the group of Prof. Werner Damm. In 2004, he became the Managing Director of the DFG funded Transregional Collaborative Research Center AVACS and shortly after the CEO of the International Research Center on Safety Critical Systems at the University of Oldenburg. Since 2006, he is the CEO of SafeTRANS, a German competence network comprising Large Industry, SMEs and Research Organisations in the area of development processes for safety-critical Embedded and Cyber-Physical Systems.

Abstract of presentation

This talk presents the intermediate results of the CP-SETIS project, a 24 month action aiming at the definition and implementation of a sustainable coordination and communication platform for all stakeholders concerned with open standards for data and tool interoperability for the development of CPS. We recall the rationale and motivation of one such major standard, the IOS (Interoperability Specification), which has been developed in various European projects, and explain the need for sustainable organisational structures furthering continuous development and formal standardisation of this specification. ICF (IOS Coordination Forum) is such an organisational structure proposed by CP-SETIS; we present its format, activities, operational rules, and status of implementation.

Partner in/ Coordinator of related projects (H2020-ICT-Programm – CPS/IoT or ECSEL/ITEA)

SafeTRANS participates in ENABLE-S3 (JU ECSEL)

Project Information

Project Name: **Toward Cyber-Physical Systems Engineering Tool Interoperability Standards**

Acronym: CP-SETIS / Ref.nr.: Grant-Agreement No. 645149 / Duration: 1.3.2015, 24 month

Project Facts / Website: http://www.cp-setis.eu/

Funding: - Funding Scheme: Horizon2020 Topic(s): CPS (Coordination) Platforms Call for Proposal: Horizon2020 ICT-1 Related Projects: iFEST, CESAR, MBAT, HOLIDES, CRYSTAL (all ARTEMIS), SAFE (ITEA), ENABLE-S3 (ECSEL),… Coordinator: SafeTRANS (Germany) TRL: not applicable	Consortium: • AIT Austrian Institute of Technology GmbH (A) • ARTEMIS-IA (NL) • AVL LIST GMBH (A) • KUNGLIGA TEKNISKA HOEGSKOLAN (KTH) (S) • OFFIS (D) • Siemens (D) • THALES GLOBAL SERVICES (F)	Relevant Domains • Embedded Systems • Cyber-Physical Systems • Standards for Engineering Tools

Main Objectives / Aims / Goals

CPS require multiple engineering competences across various engineering disciplines. The development of such systems is a huge challenge, also because of the heterogeneity of engineering tools involved in development platforms across the development lifecycle. In order to overcome this challenge, past and ongoing EU research projects have developed the basis for an International Open Standard for Development Tool Interoperability, the so called Interoperability Specification (IOS).

The main goal of CP-SETIS is to conceive and set up a sustainable organisational structure as a coordination platform joining all stakeholders, to coordinate all IOS-related activities, especially the formal standardisation and further extensions of the IOS.

CP-SETIS will ensure the support of all stakeholders for this structure, its operational rules, its implementation within existing structures and, most importantly, their commitment to coordinate all IOS-related activities within this structure.

3 to 4 bullet points • Goal 1: The **alignment of all IOS-related forces** within Europe to support a common IOS Standardisation Strategy, aiming at a formal standardisation process of the IOS. • The definition and implementation of **sustainable IOS Standardisation Activities** supporting both, formal standardisation as well as extensions of IOS, if possible within existing structures that survive the lifespan of single projects.	

Achievements/Highlights/Results/most striking achievements

CP-SETIS has developed a model for a sustainable organisational structure called **ICF (IOS Coordination Forum)** as a cooperation platform in which all IOS stakeholders – CPS development organisations, Tool Provider, Research Organisations, Standardisation bodies – can meet to synchronise and coordinate their IOS activities. Specifically, ICF will

(a) collect and make available the current baseline of the IOS, together with information about the concrete specifications, maturity level, status of formal standardisation, current versions, etc., and update this information according to results from projects, standardisation activities, etc.
(b) facilitate and give organisational support for stakeholders to coordinate their activities to extend

and further develop the IOS – for example by incubating new R&D projects,

(c) facilitate and give organisational support for stakeholders to synchronise their activities for formal standardisation of parts of the IOS, and

(d) support the building of an IOS community by collecting and proving all information related to IOS (from technical specifications and contacts to experts to workshop and event notifications) and organising workshops, coordination meetings, etc.

Currently, CP-SETIS is (i) coordinating and harmonising these activities with a large group of stakeholders and (ii) contacting various existing organisations to evaluate and find a potential host for ICF.

Impact/Successes

ICF will be an ideal means for meeting other stakeholders at eye level and coordinate IOS related activities amongst this large and diverse group. It will also allow these stakeholders to

- find allies and cooperation partners
- extend and shape those parts of the IOS that are relevant them
- push formal standardisation of IOS
- find experts for IOS related matters
- be able to guarantee sustainability and accessibility for their IOS related project results
- easily exchange and gather IOS related information, e.g., the current baseline, new extensions under development, standardisation activities, etc.

while at all times being able to focus on those parts of the IOS, that are actually of interest to them.

By these activities, formal standardisation and industrial take-up of the IOS as an open standard for development tool interoperability will be pushed, which will reduce the complexity and risk of increasingly complex software infrastructures (Engineering Environments), avoid costly and inefficient in-house-developments and vendor lock-ins, and enable Tool Providers to focus energy and resources on higher-value functionality and customisation, thus providing time and cost savings.

EoT – Eyes of Things

Noelia Vallez Enano (speaker)

Short-CV She is an assistant researcher and lecturer at University of Castilla-La Mancha. In 2009, she finished her studies in computer science at the University of Castilla-La Mancha, where she graduated with top honors. Since then, she has obtained a master's degree in physics and mathematics and a PhD in computer vision from the same University. She contributes to the VISILAB research group, her interests including computer vision, machine learning and medical image processing. She is author of 2 books on OpenCV. She has also served as visiting researcher at AstraZeneca (UK) and TissueGnostics (Austria). She is participating in two European projects, the FP7 AIDPATH and the H2020 EoT projects.
Abstract of presentation Vision is the most demanding sensor in terms of power consumption and required processing power and, in this respect, existing mass consumer mobile devices have problems such as power consumption or unused sensors for most vision-based applications. Our objective in this project is to build an optimized core vision platform that can work independently and also embedded into all types of artifacts. The envisioned open hardware must be combined with carefully designed APIs that maximize inferred information per milliwatt and adapt the quality of inferred results to each particular application. This will not only mean more hours of continuous operation, it will allow to create novel applications and services that go beyond what current vision systems can do, which are either personal/mobile or “always-on” but not both at the same time.
Partner in Eyes of Things (H2020-ICT-Programm)

Dr. Oscar Deniz Suarez (coordinator)

Short-CV

He is an Associate Professor at University of Castilla-La Mancha and has an MsC in computer science and a PhD in computer vision from the same University. He contributes to the VISILAB research group, his interests including computer vision and machine learning. He is the author of more than 50 refereed papers in journals and conferences. Oscar has received the runner-up award for the best PhD work on computer vision & pattern recognition by the Spanish Association on Pattern Recognition and the 'Image File & Reformatting Sofware' Challenge Award by Innocentive Inc. He has been national finalist of the 2009 Cor Baayen Award. He has led projects for more than 10 cutting-edge companies over the past 3 years, most of them for mobile vision application development. He has 2 patents. Oscar has also contributed to OpenCV, the well-known open source computer vision library. He is the author of 3 books on OpenCV and OpenCV programming for mobile devices. Oscar has also served as visiting researcher at Carnegie Mellon University (USA), Imperial College London (UK) and Leica Biosystems (Ireland). He is a Senior Member of IEEE and is affiliated with the AAAI, IAPR and The Computer Vision Foundation. He serves as an Academic Editor of Journal PLoS ONE. Currently, he is the Coordinator of EU Horizon 2020 "Eyes of Things" project and partner in FP7 AIDPATH Marie Curie Action. He serves as a reviewer/expert for EU programs such as Eurostars.

Project Information

Project Name: **Eyes of Things**

Acronym: EOT / Ref.nr.: H2020-643924-EoT / Duration: 3 years

Project Facts / Website: http://www.eyesofthings.eu

Funding: EC | H2020 Funding Scheme: IA - Innovation action Topic(s): ICT-01-2014 - Smart Cyber-Physical Systems Call for Proposal: H2020-ICT-2014-1 Related Projects: Coordinator: Oscar Deniz (Spain) TRL:	Consortium: • UCLM (Spain) • AWAIBA CONSULTADORIA, DESENVOLVIMENTO E COMERCIO DE COMPONENTES MICROELECTRONICOS, LDA. (Portuga) • CAMBA TV LIMITED (Ireland) • DEUTSCHES FORSCHUNGSZENTRUM FUER KUENSTLICHE INTELLIGENZ GMBH (Germany) • MOVIDIUS LTD (Ireland) • THALES COMMUNICATIONS & SECURITY SAS (France) • FLUXGUIDE AUSSTELLUNGSSYSTEME OG (Austria) • NVISO SA (Switzerland)	Relevant Domains • Computer Vision • Embedded CV • Wearable device • Always-on • Low-cost • Low-power • … • …

Main Objectives / Aims / Goals

Objective 1: Building an ultra-low power (10mW) and low-cost (approximately $12.50/unit) core vision system comprising of an image sensor, image processor and wireless connectivity intended to contribute to a paradigm of "eyes everywhere". The system is intended to be an "always-on" ubiquitous reference vision platform capable to function both standalone and embedded into more complex systems.
Objective 2: Developing the associated software architecture at two levels. First, an opensource operating system and computer vision (CV) APIs will be present in the device. Second, a middleware for major existing platforms (particularly mobile) will provide functionality for wireless data communication with the device.
Objective 3: Demonstrating and assessing the whole system in 4 end-user scenarios: Security, Augmented reality, Cloud processing and Perceptual computing.

3 to 4 bullet points • Embedded computer vision • Always-on device	• Low-cost • Opensource API

Achievements/Highlights/Results/most striking achievements

The EoT Project envisages a computer vision platform that can be used both standalone and embedded into more complex artifacts, particularly for wearable applications, robotics, home products, surveillance etc. The core hardware will be based on a SoC that has been designed for maximum performance of the always-demanding vision applications while keeping the lowest energy consumption. This will allow 'always on' and truly mobile vision processing. Software will be developed in parallel to this design, at both the low and middleware levels, and also for a number of demonstrators. The demonstrators span applications in surveillance, wearable configuration and embedded into a household item.

3 to 4 bullet points • Embedded computer vision	• Low-cost • Opensource API

• Always-on device	

Impact/Successes

- Reduction of development time for CPS by 30% as compared to the state-of-the-art in 2013 and significant reduction in maintenance costs.
- Stronger pan-European collaboration across value chains and technology levels from the components and hardware to higher systems level creating open innovation eco-systems and stimulating consensus building on open tools, platforms and standards.
- Development in Europe of a competitive offer for next generation core ICT platforms spanning from operating systems and middleware to application development and deployment tools with built-in security. This should translate into a significant increase of Europe's market share in this area and in higher added value generated from embedded ICT.
- Uplifting Europe's innovation capacity and competitiveness across all economic sectors with the wider adoption of networked embedded ICT, notably in SMEs.

3 to 4 bullet points • Products/Services • Patents • Spin-offs	• Standardisation aspects • Demonstrators/pilots • other

Gaps/Challenges

- Size – Wearable device
- Cost – The device should be cheap in order to be competitive
- Consumption – Always-on devices demand a low-power consumption
- Computer Vision capabilities – The device is designed to run computer vision applications

3 to 4 bullet points • Size • Cost	• Consumption • Computer Vision

CPSELabs – CPS Engineering Labs - expediting and accelerating the realization of cyber-physical systems

Holger Pfeifer (coordinator and speaker)

Short-CV

Holger Pfeifer is a Senior Scientist at the fortiss research institute in Munich, Germany. His research interests focus on methods and tools for the engineering of dependable systems. At fortiss he is coordinating the innovation project "CPS Engineering Labs", a European network of Design Centres with a mission to support small and medium-sized businesses engineering or operating dependable cyber-physical systems (CPS) in Europe.
Before joining fortiss, Holger Pfeifer was a staff researcher at the Chair for Software and Systems Engineering at Technische Universität München, where he led the activities on cyber-physical system in the European KIC project EIT ICT Labs (now EIT Digital). He studied Computer Science at Ulm University, Germany, and obtained his PhD on formal modelling and verification of distributed algorithms in 2003.

Abstract of presentation

Cyber-Physical Systems Engineering Labs (CPSE Labs) is a European Union-funded initiative designed to provide support for engineering and technology businesses in Europe.
CPSE Labs builds upon some of Europe's top cyber-physical systems research institutes - in Madrid, Munich, Oldenburg, Newcastle, Stockholm, and Toulouse - and turns these regional clusters into a network of excellent Design Centres for CPS Engineering.
CPSE Labs makes technical support and funding available to European technology businesses. We primarily support businesses by funding experiments. Businesses (and other organisations) working in a variety of technology and engineering domains can design and propose research experiments to us. CPSE Labs will review the proposed experiments and the best will receive funding. The process for submitting experiment proposals has been designed to be business-friendly. In addition to funding, experiments gain access to high quality world class expertise from our Design Centres, including support and advice from specialist research staff.
Experience gained from experiments, validation results, and best practices are developed by CPSE Labs into cross-cutting engineering principles for integrating software and hardware elements. This creates a body of knowledge that benefits participating experimenters.
In addition, CPSE Labs will develop a marketplace to provide an open forum for sharing platforms,

architectures, and software tools for engineering of dependable and trustworthy cyber-physical systems.

Partner in/ Coordinator of related projects (H2020-ICT-Programm – CPS/IoT or ECSEL/ITEA)

CPSE Labs coordinator

Project Information

Project Name: **Cyber-Physical Systems Engineering Labs**

Acronym: CPSELabs / Ref.nr.: 644400 / Duration: 36 months

Project Facts / Website: http://www.cpse-labs.eu/index.php

Funding: 7654030,00€ Funding Scheme: Horizon2020 Topic(s): Cyber-Physical Systems Call for Proposal: H2020-ICT-2014-1 Related Projects: Coordinator: (country) Germany TRL: -	Consortium: • Fortiss GmbH • Kungliga Tekniska Hoegskolan • Office National d'Etudes et de Recherches Aerospatiales • LAAS-CNRS • University of Newcastle • OFFIS EV • INDRA Sistemas S.A. • Steinbeis Innovation gGmbH • Universidad Politecnica de Madrid	Relevant Domains • Embedded Systems • Maritime, adaptive production, automotive, smart cities, urban sustainability, autonomous systems and robotics

Main Objectives / Aims / Goals

- Foster an open, pan-European network of design centres committed to transitioning science and technology for engineering trustworthy and dependable CPS into the marketplace.
- Identify, define, and execute focused and fast-track experiments with a specific innovation focus.
- Spread best CPS engineering practices and promote cross-regional and cross-sectoral learning among industry and academia.
- Establish a marketplace for CPS engineering assets.

• CPS Design Centres • CPS innovation experiments • CPS engineering best practices	• CPS Engineering professional training and learning

Achievements/Highlights/Results/most striking achievements (M12)

CPSE Labs carried out investigations to create a solid understanding of the innovation and engineering eco-systems surrounding the CPSE Labs Design Centres. Interviews of key stakeholders that work within, or are closely aligned to, the Design Centres have been conducted, which identified a number of challenges with respect to learning and sharing of best practices. Efforts were made to prepare for the creation of Market Place pilots, by eliciting areas where marketplaces and related open forums have already formed. After two round of Open Calls all 6 CPSE Labs Design Centres host innovation experiments on topics such as safety for autonomous robotic systems, modelling for traffic management systems, energy management in process technology, or efficient CPS tool chain integration.

• CPS innovation eco-systems • Collaborative innovation projects with SMEs	

Impact/Successes

Through its portfolio of innovative experiments CPSE Labs expects to facilitate lower cost and faster adoption of CPSs by increasing scalability of pre-competitive infrastructure deployment and de facto standardization of architectures and platforms. The network of Design Centres established by CPSE Labs stimulates stronger pan-European collaboration across value chains and technology levels, building an ecosystem around the Centres committed to transitioning CPS technology into the marketplace, and provides physical and virtual meeting

points for all relevant stakeholders for CPS innovations.	
• Products/Services • Patents • Spin-offs None so far.	• Standardisation aspects • Demonstrators/pilots • Other 6 Design Centres host experiments (April 2016)
Gaps/Challenges The exploitation of innovative ideas by students, researchers and industrialists with respect to the design of CPS is hindered by the lack of innovation ecosystems for CPS. There is only limited cross-disciplinary and cross-sectorial collaboration and limited spreading of best practices in engineering CPS. CPSE Labs addresses the bottlenecks in the innovation system and creates and strengthens synergies among relevant stakeholders and efforts, where industrial technology leaders and academic researchers play a complementary role for an efficient innovation and value creation process. SMEs and mid-caps, in particular, bring adaptability, reactivity and innovation, and academia bring long term and disruptive ideas for future innovations.	
• CPS engineering ecosystems • Cross-disciplinary and cross-sectorial collaboration	• Facilitating technology access for SMEs
Recommendations/ Work to be continued The new H2020 “cascading funding” mechanism that underlies CPSE Labs’ Open Calls proves an effective means to dynamically involve and cooperate with small enterprises and midcaps in small-scale innovation experiments.	

AXIOM – Agile, eXtensible, fast I/O Module for the cyber-physical era

Roberto Giorgi, Coordinator

Short-CV

Roberto Giorgi is an Associate Professor at Department of Information Engineering, University of Siena, Italy. He was Research Associate at the University of Alabama in Huntsville, USA. He received his PhD in Computer Engineering and his Master in Electronics Engineering, Summa cum Laude both from University of Pisa, Italy. He is the coordinator of the European Project AXIOM. He coordinated the TERAFLUX project in the area of Future and Emerging Technologies for Teradevice Computing. He is participating in the European projects HiPEAC (High Performance Embedded-system Architecture and Compiler), ERA (Embedded Reconfigurable Architectures). He contributed to SARC (Scalable ARChitectures), ChARM (performance evaluation of ARM-processor based embedded systems). His current interests include Computer Architecture themes such as Embedded Systems, Multiprocessors, Memory System Performance, Workload Characterization.

Abstract of presentation

We are entering the Cyber-Physical age, in which both objects and people will become nodes of the same digital network for exchanging information. Therefore, the general expectation is that “things” or systems will become somewhat smart as people, allowing a rapid and close interaction not only system-system, but also human-system, system-human. Moreover, through smart systems, the human behavior is improved and simplified. More scientifically, we expect that such Cyber-Physical Systems (CPS) will at least react in real-time, provide enough computational power for the assigned tasks, consume the least possible energy for such task (energy efficiency), scale up through modularity, allow for an easy programmability across performance scaling, and exploit at best existing standards at minimal costs. The whole set of these expectations impose scientific and technological challenges that need to be properly addressed.
The AXIOM project (Agile, eXtensible, fast I/O Module) aims at researching new software/hardware architectures for CPSs to meet the above expectations.

Coordinator of related projects (H2020-ICT-Programm – CPS): AXIOM (645496)

Project Information

Project Name: **Agile, eXtensible, fast I/O Module for the cyber-physical era**

Acronym: AXIOM / Ref.nr.:645496 / Duration: 36 months

Project Facts / Website: http://www.axiom-project.eu/

Funding:-	Consortium:	Relevant Domains
Funding Scheme: - Topic(s): - Call for Proposal: Related Projects: Coordinator:…ITALY (country) TRL: -	• The University of Siena • The Barcelona Supercomputing Center • Herta Security S. L. • Evidence Srl • FORTH-ICS • SECO Srl • VIMAR Srl	• Computer Architecture • Programming Models • Video surveillance • Operating System • Interconnects • Single Board Computers • Smart Home

Main Objectives / Aims / Goals

- Goal: European-designed and -manufactured single board computer: The heart of future smart applications
- Flexible, energy efficient and multi-board
  - Flexibility: FPGA, fast-and-cheap interconnects based on existing connectors like SATA
  - Energy efficiency: low-power ARM, FPGA
  - Modularity: board-to-board fast interconnects
- Easily Programmable FPGA
  - Programming model: Improved OmpSs
  - Runtime & OS: improved thread management
  - Compiler: BSC Mercurium, OS: Linux, Drivers: provided as open-source by partners
- Easy Interfacing with the Cyber-Physical Worlds
  - Platform: integrating also Arduino support for a plenty of pluggable board (so-called “shields”)
  - Platform: building on the UDOO experience from SECO

3 to 4 bullet points	
• Goal: European-designed and -manufactured single board computer: The heart of future smart applications • Flexible, energy efficient and multi-board	• Easily Programmable FPGA • Easy Interfacing with the Cyber-Physical Worlds

Achievements/Highlights/Results/most striking achievements

- Dataflow-based execution model that spawns threads across single and multiple boards
- OpenMP based programming model to both accelerate applications on FPGAs and on multiple boards

3 to 4 bullet points	
• Simulator based (open-source, full system) demonstration of execution model • Programming model based on the OpenMP standard	• First specification of AXIOM board (production in progress)

Impact/Successs

- Open-Source, Open-Hardware models
- Production of AXIOM based boards (more advanced that Raspberry, Zynqberry, and similar ones)
- Extending the Programming Model based on OpenMP

• Products/Services • Patents • Spin-offs	• Standardisation aspects: **OpenMP** • Demonstrators/pilots • Other: **Scientific Publications**

Gaps/Challenges

- Bringing a powerful programming model into the embedded and CPS arena
- Easily programming multiple boards and FPGAs

3 to 4 bullet points • embedded system scalability • easy programmability for accelerated and distributed embedded systems	

Recommendations/ Work to be continued

Easily programmable, open-source toolchains are essential in order to provide a substantial wider adoption of smart systems. Currently, for every new chip, system, or application the toolchains are too highly customized and force the developer to substantial efforts and the user to sustain higher costs. Systems should be scalable with a minimal effort and without forcing the consumers to change completely the pre-existing investments. Smart Homes and Video-surveillance could sooner benefit from the scalability and easy-programmability provided by the AXIOM platform.

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

Prof. Apostolos Dollas (TSI) (speaker)

Short-CV

Apostolos Dollas (SM), received his Ph.D. in CS from the University of Illinois at Urbana Champaign (1987). He is currently Professor and Dean of the School of Electronic and Computer Engineering, Technical University of Crete (TUC), where he served one term as ECE Dept. Chairman. He was previously on the faculty of ECE and CS at Duke University (1986-1994). Dollas was the Director of the Microprocessor and Hardware Laboratory at TUC (1994-2009). He is conducting research, teaching, and publishing in reconfigurable computing, embedded systems and application specific high-performance digital systems, with emphasis on fully functional prototypes. Dollas is a member of HKN and ΤΒΠ, and has been awarded the IEEE Computer Society Golden Core Member Award and the IEEE Computer Society Meritorious Service Award. He is co-founder of several IEEE-sponsored international conferences, including FCCM, FPT, RSP, SASP, and TAI and serves in several international conference program committees, including FPL (2011 General co-Chair), FPT and VLSISoC; he is co-inventor in two issued US Patents.

Abstract of presentation

Nowadays, Cyber Physical Systems (CPS) are growing in capability at an extraordinary rate, promoted by the increased presence and capabilities of electronic control Units as well as of the sensors and actuators and the interconnecting networks. One of the main problems CPS designers face is the lack of simulation tools and models for system design and analysis. This is mainly because the majority of the existing simulation tools for complex CPS handle efficiently only parts of a system (only the processing or network) while none of them support the notion of security. The presented system is a "Novel, Comprehensible, Ultra-Fast, Security-Aware CPS Simulator" (COSSIM). COSSIM is the first known simulation framework that allows for the simulation of a complete CPS utilizing complex SoCs interconnected with sophisticated networks. Finally, the COSSIM system support accurate power estimations while it is the first such tool supporting security as a feature of the design process.

Coordinator of related projects (H2020-ICT-Programm – CPS): AXIOM (645496)

Project Information

Project Name: **A Novel, Comprehensible, Ultra-Fast, Security-Aware CPS Simulator**
Acronym: COSSIM / Ref.nr.: 644042 / Duration: 01/02/2015 – 31/01/2018

COSSIM

Project Facts / Website: www.cossim.org

Funding: 2,882,030 Euros
Funding Scheme: RIA - Research and Innovation action
Topic(s): ICT-01-2014 - Smart Cyber-Physical Systems
Call for Proposal: H2020-ICT-2014-1
Related Projects: ARTEMIS/ECSEL
Coordinator: Synelixis Solutions Ltd (Greece)

TRL: 4-5

Consortium:
- Synelixis Solutions Ltd (Greece)
- ST Microelectronics (Italy)
- Maxeler (UK)
- Tecnalia (Spain)
- Search-Lab (Hungary)
- Chalmers University (Sweden)
- Politecnico di Milano (Italy)
- Telecommunication Systems Institute (Greece)

Main Objectives / Aims / Goals

One of the main problems CPS designers face **is the lack of simulation tools and models for system design and analysis**. This is mainly because the majority of the existing simulation tools for complex CPS handle efficiently only parts of a system (e.g. only the processing or only the network) while none of them support the notion of security. Moreover, the existing simulators need extreme amounts of processing resources and computation time to simulate a system at a low level (e.g. including the Operating System in a target platform at a close to cycle accurate level). Faster approaches are available however they function at higher levels of abstraction and cannot provide the necessary precision and accuracy. COSSIM will address all those important needs by providing a novel open-source framework. In order to create such a novel framework addressing the requirements of the CPS designers, there are some clear and measurable objectives that will be met:

- Obj1: Develop an open-source simulation framework backed by a large community that can, for the first time, simulate a complete CPS comprising of CPS nodes incorporating multi-core CPUs, complex accelerators and peripherals, and interconnected with complex and heterogeneous networks
- Obj 2: Accelerate simulation of complex CPS especially in power models when compared with the existing solutions.
- Obj 3: Provide at least 50% more accurate power consumption estimations than existing solutions
- Obj 4: Support for the first time in a CPS tool security features/levels as aspects of the system simulation
- Obj 5: Simulate two real-world applications from different domains so as to demonstrate all the above unique features in highly demanding commercial environments

Achievements/Highlights/Results/most striking achievements

Until now, COSSIM achieves most of the above main objectives with success. Specifically, COSSIM is the first known simulation framework that allows for the simulation of a complete CPS utilizing complex SoCs interconnected with sophisticated networks. Finally, the COSSIM system support accurate power estimations while it is the first such tool supporting security as a feature of the design process. The novel COSSIM framework combines a state-of-the-art processing simulator (GEM5[1] full-system simulator) with an

[1] http://www.m5sim.org/

established network simulator (OMNET++[2] real network simulator). These tools are integrated with high-level power estimators and the overall framework provides appropriate interfaces to security testing tools. Especially, COSSIM:

• Seamlessly simulates, in an integrated way, the networking and the processing parts of the CPS. **GEM5** which can efficiently simulate different CPS processing units from simple μ-controllers to multicore CPUs is used aAs full system simulator. In addition, **OMNET++** network simulation tool is used as the basis for the network simulation sub-system.	• Incorporates **MacPat** and the **MiXiM** open-source tools which provide accurate power consumption estimations for processing and network sub-systems respectively. • Incorporates **Fuzz testing & DoS** detection components so as to allow for simulation of the security features of a CPS.

Impact/Successes

COSSIM will trigger a significant impact in the area of CPS, while also in the, some-how related, area of High Performance Computing (HPC) since parts of the simulator designed and implemented can be used in the development of HPC systems. Regarding the impacts listed in **ICT 1 – 2014: Smart Cyber-Physical Systems,** COSSIM addresses all of them:

- ✓ Reduction of development time for CPS by 30% as compared to the state-of-the-art in 2013 and significant reduction in maintenance costs
- ✓ Stronger pan-European collaboration across value chains and technology levels from the components and hardware to higher systems level creating open innovation eco-systems and stimulating consensus building on open tools, platforms and standards
- ✓ Development in Europe of a competitive offer for next generation core ICT platforms spanning from operating systems and middle ware to application development and deployment tools with built-in security. This should translate into a significant increase of Europe's market share in this area and in higher added value generated from embedded ICT
- ✓ Uplifting Europe's innovation capacity and competitiveness across all economic sectors with the wider adoption of networked embedded ICT, notably in SMEs

• Products/Services - Development of open source framework • Spin-offs – Yes, under development	• Standardisation aspects – Development of open source framework could lead to a new standard • Demonstrators/pilots – Two demos, Management System and Visual Server

Gaps/Challenges

The main risk in the project, as in most of such novel projects, is that critical results could be delayed due to critical dependencies or unexpected extra-complexity due to the highly innovative rate of those challenges. The risk is minimised since all the partners have considerable experience in their field and the estimations of the time and effort needed for each task utilizes this vast experience as well as due to the fact that certain already existing sub-systems were utilized. Following bullets presents some of the most significant challenges:

• The Processing simulator is prohibitively slow for complex SoCs • There are no power Models matching the requirements of all CPS components	• There are issues with using the framework for precise simulation of (network or CPU) security features • No tool tackling security-related inputs/outputs

[2] https://omnetpp.org/

IMMORTAL - Integrated Modelling, Fault Management, Verification and Reliable Design Environment for Cyber-Physical Systems

Heinz Riener (speaker)

Short-CV
Heinz Riener is a PhD student in the University of Bremen and in the Institute of Space Systems of the German Aerospace Centre DLR, Bremen. His area of expertise in the IMMORTAL RIA is modelling and verification of cyber-physical systems.

Jaan Raik (coordinator)

Short-CV
Jaan Raik is a Professor of digital systems verification at the Department of Computer Engineering of Tallinn University of Technology (TUT). His research interests include test, verification and fault tolerant design of computing systems. He received his M.Sc. and Ph.D. degrees from TUT in 1997 and in 2001, respectively. He is a member of IEEE Computer Society and HiPEAC, a member of steering/program committees of several conferences and has co-authored more than 200 scientific publications. He is the General Chair of the IFIP/IEEE VLSI-SoC'16 Conference and the Program Co-Chair of CDN-Live'16. He served as the General Chair of IEEE DDECS'12 and the Program Chair of IEEE DDECS'15. Currently, he is also coordinating the Horizon 2020 Twinning project TUTORIAL and is the local lead of the FP7 collaborative research project BASTION. Previously, he has acted as the scientific coordinator of the EU's FP7 DIAMOND collaborative research project and the local lead of the FP6 STREP VERTIGO.

Abstract of presentation

In the Horizon 2020 Research and Innovation Action IMMORTAL, a consortium of leading European academic and industrial players aim at combining their expertise in developing an integrated, cross-layer modelling based tool framework for fault management, verification and reliable design of dependable cyber-physical systems. IMMORTAL consortium consists of Tallinn University of Technology, IBM, Testonica Lab, Recore Systems, German Aerospace Center DLR, TU Graz and Twente University.

Partner in/ Coordinator of related projects (H2020-ICT-Programm – CPS/IoT or ECSEL/ITEA)

FP7-ICT-BASTION (2014-2016) (coordinator: Testonica Lab, partners: Tallinn UT and Twente Univ.)

Project Information

Project Name: **Integrated Modelling, Fault Management, Verification and Reliable Design Environment for Cyber-Physical Systems**

Acronym: IMMORTAL / Ref.nr.: 644905 / Duration: 1.3.15-28.2.18

IMMORTAL
CYBER-PHYSICAL SYSTEMS

Project Facts / Website: http://www.h2020-immortal.eu/

Funding: 4 MEUR Funding Scheme: RIA Topic(s): Call for Proposal: ICT-Call 1-CPS Related Projects: FP7 BASTION, H2020 Twinning TUTORIAL Coordinator: Tallinn University of Technology (Estonia) TRL: 6	Consortium: • Tallinn University of Technology • IBM Israel • Testonica Lab • Recore Systems • German Aerospace Center DLR • Graz University of Technology • The University of Twente	Relevant Domains • Modelling • Verification • Debug • Reliability • Fault-tolerant design • Fault management • System health monitoring • Many-core systems

Main Objectives / Aims / Goals

The general objective of IMMORTAL is addressing the above-mentioned challenges by developing an integrated, cross-layer modelling based tool framework and a methodology for fault management, verification and reliable design of dependable cyber-physical systems.

3 to 4 bullet points • Minimisation of the verification effort in CPSs by a factor of 2 by enabling automated debug (error localisation and correction) in such systems. • Speeding up fault detection, isolation and recovery in CPSs by a factor of 4 by implementing a cross-layer approach, a holistic fault model and a new fault management architecture.	• Graceful degradation: by resumption of correct operation with up to 15% of CPS network resources failed. • Up to 40% reduction in the effort designers put in reliability related tasks by developing an automated and complete sign-off tool. • Up to 10% savings in the total area as well as power consumption achieved by optimising hardware protection logic overhead.

Achievements/Highlights/Results/most striking achievements

The project has lasted for exactly one year and the first reporting period conclusions have not been fully collected and analysed. However, the main results may be highlighted by the following bullets.

3 to 4 bullet points • Development of cross-layer models for CPS verification • Development of fault management architectures for	• Development of novel ways for low-latency, cost-effective error checking and system health monitoring

many-core based CPSs	

Impact/Successes

The IMMORTAL project contributes to high-level KPIs specified for Horizon2020 as we estimate at least 3 patents to be filed and 40 scientific articles in top-ranked scientific journals and conferences as well as 10 articles in popular scientific journals in national and international media to be published as a result of the project. This will have a significant impact on the academic visibility and industrial usability of the project innovations.

• **Products/Services** IMMORTAL is expected to contribute to new products and services for the European SMEs Recore Systems and Testonica Labs and to the internal design flow of IBM. • **Patents** At least 3 patents expected to be filed within IMMORTAL. • Spin-offs	• **Standardisation aspects** Fault management solutions developed by Testonica Lab conform to the IEEE 1687 IJTAG standard. • **Demonstrators/pilots** IMMORTAL foresees implementation of its health monitoring infrastructure as a silicon IC in 40 nm technology. • other

Gaps/Challenges

Recently, the world has seen emerging Cyber-Physical System (CPS) modelling frameworks addressing various design aspects such as control, security, verification and validation. However, there have been no considerations for reliability and automated debug (i.e. design error localisation and correction) aspects. The main aim of IMMORTAL is to fill this gap by introducing reliable design and automated system debug into CPS modelling.

3 to 4 bullet points • Reliable design • Fault management	• Automated debug

INTO-CPS - Integrated Tool chain for model-based design of CPSs

Prof. Peter Gorm Larsen (coordinator and speaker)

Short-CV

Peter Gorm Larsen is professor at the Department of Engineering, Aarhus University, leading the software engineering research group. After receiving his MSc at the Technical University of Denmark in 1988, he worked in industry before completing an industrial Ph.D. in 1995. He returned to academia in 2005. His prime research goal is to improve the development of complex mission-critical applications using well-founded technologies, in particular in the design of robust tools for the early design in particular in the area of Cyber-Physical Systems. He is the author of over 100 peer-reviewed publications and books and has an h-index at 26.

Abstract of presentation

INTO-CPS will support the holistic modelling of CPSs, allowing system models to be built and analysed that would otherwise not be possible using standalone tools. We will integrate existing industry-strength tools with high Technology Readiness Levels (TRL 6–9) in their application domains, based centrally around Functional Mockup Interface (FMI)-compatible co-simulation. The project focuses on the pragmatic integration of these tools, making extensions in areas where a need has been recognised. The tool chain will be underpinned by well-founded semantic foundations that ensures the results of analysis can be trusted.

Coordinator of the INTO-CPS H2020 project

Project Information

Project Name: **Integrated Tool Chain for Model-based Design of Cyber-Physical Systems**
Acronym: INTO-CPS /644047/ Duration: 1 January 2015-31 December 2017 Project Logo: INTO-CPS

Project Facts / Website: www.into-cps.au.dk

Funding: 8 million Euro Funding Scheme: EU Horizon 2020 Topic(s): Related Projects: DESTECS, COMPASS, MODELISAR, OPENPROD, MODRIO, MADES Coordinator: Prof Peter Gorm Larsen, Aarhus University, Denmark TRL: Right now 3 - 4	Consortium: • Aarhus University (AU), Denmark • Newcastle University (UNEW), UK • University of York (UY), UK • Linköping University (LIU), Sweden • Verified Systems International (VSI), Germany • Controllab Products (CLP), The Netherlands • ClearSy (CLE), France • TWT GmbH - Science & Innovation (TWT), Germany • Agro Intelligence (AI), Denmark • United Technologies (UTRC), Ireland • Softeam (ST), France	Relevant Domains • Railways • Agriculture • Building automation • Automotive • Simulation tool support

Main Objectives / Aims / Goals

Build an open, well founded tool chain for multidisciplinary model based design of CPS that covers the full development life cycle of CPS.
Provide a sound semantic basis for the tool chain.
Provide practical methods in the form of guidelines and patterns that support the tool chain.
Demonstrate in an industrial setting the effectiveness of the methods and tools in a variety of application domains.
Form an INTO-CPS Association to ensure that project results extend beyond the life of the project.

• FMI based co-simulation • OSLC traceability support	• Design Space Exploration • Test Automation

Achievements/Highlights/Results/most striking achievements

An initial tool chain supporting the full life cycle of a CPS has been developed, based around a Co-Simulation Orchestration Engine supporting version 2.0 of FMI. It is connected with a number of modelling and simulation tools (20-sim, OpenModelica and Overture/VDM) and connected to SysML (Modelio) where a new CPS profile has been developed. The tool chain will also contain support for code generation, HiL and SiL simulations, test automation (using RT Tester), model management and design space exploration. The initial semantic foundations (targeting semantics for SysML, FMI, discrete and continuous models) as well as initial methodological guidelines have been developed. The industrial case studies have produced initial models using the existing baseline technologies and as a consequence derived new industrial needs that are incorporated in the overall collection of requirements.

3 to 4 bullet points • Industrial Follower Group with currently 48 members • The INTO-CPS tool chain will be released outside the consortium in 2016	• The use of the baseline technologies on the industrial case studies has demonstrated issues with existing systems • Small public pilot studies demonstrate the capabilities of the INTO-CPS technology

Impact/Successes

The initial modelling of the industrial case studies using the baseline technologies has already been able to detect issues with existing systems. The initial INTO-CPS tool chain is well underway and the automation in connections between tools is getting established. The first year review has successfully been passed and all deliverables have been accepted.

• Products/Services The INTO-CPS Tool Suite Modelling guidelines for heterogeneous CPSs Formalisations of different modelling technologies An INTO-CPS Association (under construction)	• Standardisation aspects Involved in the FMI and SysML standardisation • Demonstrators/pilots Distributed interlocking system Agricultural robot system called Robotti Building automation focusing on HVAC Energy-focussed route planning for electric vehicles

Gaps/Challenges

The challenges targeted by the INTO-CPS project are to provide an open, well-founded coherent solution that enables the development of heterogeneous models and subsequent realisations of CPSs. Here full traceability between the different development artefacts is needed in order to save costs with expensive prototypes and physical tests and the corresponding argumentation of the dependability of CPS products in a context where time-to-market needs to be shortened and complexity is increasing.

SAFURE - Safety and Security by design for interconnected mixed-critical cyber-physical systems

Short-CVs

Coordinator:
Klaus-Michael Koch holds a Dr.-Ing. from RWTH Aachen in engineering and has worked as staff member at Research Center Jülich, Los Alamos National Laboratory and at Paul Scherrer Institute in Switzerland. He was founding director and Dean for Electronics at the University of Applied Sciences Carinthia and established the first Fraunhofer Joint Venture (Carinthian Tech Research AG) in Austria. Since 1999, he has been Director of Research and Development at Technikon Forschungsgesellschaft mbH in Villach Austria. He has published several papers, books and proceedings in the field of data communication and delivers a lecture course on risk and innovation management at Halmstad University in Sweden and at the University of Klagenfurt in Austria.

Speaker:
Carolina Reyes received her PhD on wireless communications from TU Vienna in 2013. Since then, she has gathered further experience in research and project management at TTTech Computertechnik AG, where she coordinates strategic research projects in the domain of safety-critical and autonomous systems.

Abstract of presentation:
SAFURE targets the design of cyber-physical systems by implementing a methodology that ensures safety and security by construction. This methodology is enabled by a framework developed to extend system capabilities so as to control the concurrent effects of security threats on the system behaviour. With this in mind, the project aims at allowing European suppliers of safety critical embedded products to develop more cost and energy-aware solutions.

The current approach for security of safety critical embedded systems is generally to keep subsystems separated, but this approach is now being challenged by technological evolution towards openness, increased communication and use of multicore architectures. SAFURE will push forward the limits of current approaches on safety and security mixed-critical systems. In this talk, the current status and latest results achieved within this project will be presented.

Project Information

1 - Project Name

Acronym: SAFURE / Ref.nr.: 644080 / Duration: 36 months

Project Logo:

Project Facts / Website: www.safure.eu

Funding: € 5 231 375.00 Funding Scheme: Topic(s): safety, security, safety-critical, mixed-criticality, dependable systems, methodology, framework Call for Proposal: H2020-ICT-2014-1 Related Projects: ARAMIS, ACROSS, EVITA, SafeCer, GENESYS, MERASA, PARMERASA, etc. Coordinator: TECHNIKON Forschungs- und Planungsgesellschaft mbH, Klaus-Michael Koch (Austria) TRL: 3-4	Consortium: • TECHNIKON FORSCHUNGS- UND PLANUNGSGESELLSCHAFT MBH • ESCRYPT GMBH EMBEDDED SECURITY • MAGNETI MARELLI S.P.A. • TTTECH COMPUTERTECHNIK AG • SYSGO AG • SYMTAVISION GMBH • THALES SA • TECHNISCHE UNIVERSITÄT BRAUNSCHWEIG • BARCELONA SUPERCOMPUTING CENTER • SCUOLA SUPERIORE DI STUDI UNIVERSITARI E DI PERFEZIONAMENTO SANT'ANNA • EIDGENÖSSISCHE TECHNISCHE HOCHSCHULE ZÜRICH • THALES COMMUNICATIONS & SECURITY SAS	Relevant Domains • Automotive • Telecommunications

Main Objectives / Aims / Goals

5-10 lines text

Objective 1: Holistic approach to safety and security by construction. SAFURE aims to implement a holistic approach to safety and security by construction of embedded dependable systems, preventing and detecting potential attacks and increasing end-to-end system performance for security and safety-critical domains.

Objective 2: Empowering designers and developers with analysis methods, development tools and execution capabilities that jointly consider security and safety, communications and runtime system support requirements.

Objective 3: Opportunity to extend current standards. This aims at providing extensions to current safety-related standards that will set the ground for the development of SAFURE-compliant safe and secure mixed-critical embedded products.

3 to 4 bullet points	• Enhance performance and resource usage with

• Execution on multi-core chips and distributed systems • Extension of tools and system capabilities	safety/security constraints •

Achievements/Highlights/Results/most striking achievements

5-10 lines text

1. Identification and characterization of temperature as a covert communication channel.
2. Started work on the implementation of algorithms and benchmarks. Work on definition of the framework for a coherent presentation of mixed-critical characteristics and on security aspects and scheduling on OS level.
3. Formal worst-case timing analyses for Ethernet TSN and for basic Software Defined Networking (SDN) timing have been developed. A first prototype of a worst-case timing analysis based on compositional performance analysis in Symtavision's SymTA/S tool is now available. In the context of deterministic network technologies, a first prototype of a Stream Cypher encryption algorithm has been realised. We have also evaluated the feasibility/timing analysis of CAN-to- Ethernet gateways.
4. Total of 11 publications in 15 months.

Impact

5-10 lines text

- Reduction of development time for CPS by 30% as compared to the state-of-the-art in 2013 and significant reduction in maintenance costs.
- Stronger pan-European collaboration across value chains and technology levels from the components and hardware to higher systems level creating open innovation eco-systems and stimulating consensus building on open tools, platforms and standards.
- Development in Europe of a competitive offer for next generation core ICT platforms spanning from operating systems and middle ware to application development and deployment tools with built-in security. This should translate into a significant increase of Europe's market share in this area and in higher added value generated from embedded ICT.
- Uplifting Europe's innovation capacity and competitiveness across all economic sectors with the wider adoption of networked embedded ICT, notably in SMEs.

• Products/Services • Patents • Spin-offs	• Standardisation aspects • Demonstrators/pilots • other

Gaps/Challenges

Max 5 lines text

Criticalities including safety, security, timing and resource sharing, and data integrity need to be tackled on the whole system stack – from HW, through OS integrating automotive applications. Design mixed-criticality systems able to exploit the different safety requirements of the applications and to run only a subset of the applications at their minimum required safety level. Support of mixed-criticality scheduling on multiprocessors when threads belonging to different criticality levels need to interact and synchronize.

Recommendations/ Work to be continued

The SAFURE project that was kicked-off in February 2015 is divided into 9 different work packages, all of which have been active. Specifications & Requirements definition were successfully completed together with the first milestone MS1 (specifications and requirements) in M09. Additionally, the consortium submitted 8 deliverables so far and is well on track for managing the upcoming tasks.

Currently, the consortium is heavily engaged in the analysis of the intended integrity algorithms and in the integration of first communication prototypes. Further, some partners are busy working on the Operating System and Run-Time Environment prototypes. At last, further work regarding the architecture of the telecommunication as well as the automotive prototype is currently being defined.

TAPPS - Trusted Apps for open CPS

Dr. Christian Prehofer (Coordinator)

Dr. Christian Prehofer obtained his PhD at the Technical University of Munich in 1995, where he also received the habilitation degree in 2000.
From 1998 to 2001 he was system architect and group leader at Siemens in the area of communication systems. Starting 2002, he established a research group with a focus on self-organized systems at DoCoMo Euro Labs. From 2006 to 2009 he held positions as distinguished research leader and director in the area of Internet services at Nokia in Finland. Following this, he acted as chief researcher at Fraunhofer and in parallel as professor at the LMU München as a deputy of Prof. Martin Wirsing. His research interests are Internet-applications as well as software technology and architecture for mobile and embedded systems. Since 2013, he is leading the research group on Internet of Things & Services at fortiss. Starting from 2014, he is Docent at TU München and Adjunct Professor at Chang'an University since 2015.

Nora Koch (Speaker)

Nora Koch studied Computer Science at the Universidad de Buenos Aires in Argentina and obtained her PhD at the Ludwig-Maximilians-Universität München (LMU) in 2001.
From 2002 until September 2015 Nora worked part time at several EU projects in the area of Future Emerging Technologies (FET) and a Network of Excellent in the security domain at the LMU. In parallel, she worked as project manager at FAST, Cirquent and NTTDATA. Since October 2015 she works at fortiss in the TAPPS project.
Her research interests comprise software development methods and processes, requirements engineering,

modelling, model-driven development and security. In addition to her research activities, she focuses on coordination, management and dissemination activities of EU projects.

Abstract presentation

The presentation will focus on the objectives, achievements and challenges of the TAPPS (Trusted Apps for open CPS) project as well as on the role played by the partners to achieve the project results. The main goal of the TAPPS project is the development of a platform for CPS apps, which can also access and modify device internals. The TAPPS solution addresses all necessary layers from hardware over software to an app store concept always ensuring security and full real-time support for the applications.

As current, rich execution platforms for apps are limited in security, the project will develop a parallel, real-time trusted execution environment for highly-trusted CPS apps, which ensures app isolation, access control to critical interfaces, and safe and secure resource management.

Furthermore, TAPPS will provide and validate an end-to-end solution for development and deployment of trusted apps, including an app store and a model-based tool chain for trusted application development including verification tools.

This multi-level trusted apps platform and tool chain are matured and validated in the health and automotive application domains.

Project Information

Project Name Trusted Apps for Open CPS
Acronym: TAPPS / Ref.nr.: 645119 / Duration: 3 years (2015-2017)

Project Facts **/ Website:** www.tapps-project.eu

Funding: Euro 3.885.484,51 Funding Scheme: RIA (Research and Innovation Action) Topic(s): trusted apps, app execution environment, development tool chain Call for Proposal: H2020-ICT-2014-1 Related Projects: Coordinator: fortiss GmbH (Germany) TRL:	Consortium: • Fortiss GmbH • ST Microelectronics • TTTech • Virtual Open Systems • Actility • Fondazione Centro San Raffaele • Technological Educational Institute of Crete • CRP GROUP /Energica Motor Company S.R.L	Relevant Domains • Cyber-Physical Systems • Real-Time Systems • Open Systems • Security • Automotive • Healthcare

Main Objectives / Aims / Goals
The TAPPS project goal is to offer a new approach towards extensibility of cyber-physical systems (CPS) platforms, going beyond traditional solutions for safety, security and reliability in the CPS domain. 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.

• Design, implement and validate a separate, dedicated, real-time Trusted Execution Environment (TEE) for highly-trusted CPS Apps. • Provide and validate an end-to-end solution for development and deployment of trusted Apps providing an application store and a tool chain for the development of apps.	• Validate the multi-level trusted Apps platform and tool chain in several application domains using industrial, realistic use cases.

Achievements/Highlights/Results/most striking achievements

The architecture we propose within the scope of the TAPPS project addresses all necessary layers from hardware over software to an app store ensuring security and full real-time support for the applications. For ensuring safe communication. For ensuring safe execution of CPS apps, we focus on four key features: the Execution Environments and Apps Platform, the Trusted Inter-EE and Inter-App Communication, the Trusted System and Network Architecture, and the Trusted Development / Model-based Toolchain.

• Spatial and temporal app isolation • App development tool chain providing state-machine based modelling framework, verification trough model checking, and code generation. • Access control to critical interfaces, e.g. restricted CAN bus access	• Multi-layered defence against malicious attacks using highly secure mechanism provided by the ARM TrustZone, virtualization techniques and mechanisms for communication control at the middleware layer.

Impact/Successes

The ambition is to impact in the automotive and healthcare domains by innovative solutions, which have the potential to rapidly enter the market for motorbike and smart health trolley products. These results shall have a showcase effect on other related domains, which can take up the TAPPS solution and exploit it in their target markets.

The innovative solutions by trusted Apps can also improve the user experience and flexibility of such devices, as well as providing more resource-efficient, customized solutions. This has a general benefit to quality of life and resource efficient society. For instance, in the medical domain vertical solutions for specific treatments are typical. By using Apps on the smart trolley, we can bring new treatments to the market much faster, compared to such vertical solutions.

• Demonstrator implementing the key concepts of the TAPPS approach for the Energica motorbike product platform, and the open smart trolley developed by FCSR. • Products/Services • Patents • Spin-offs	• Standardisation aspects • other

Gaps/Challenges

The TAPPS approach for a trusted apps platform will implicitly guarantee the integrity, safety, security, and real-time requirements of each app, and the overall system itself under all circumstances.

• Attract app developers providing rich developer support and compatibility with existing platforms and tools. • Restricted access control to resources and communication with critical interfaces.	• Strong isolation and real-time properties for trusted apps platforms for open CPSs. • Multi-layered security and resource protection.

Recommendations/ Work to be continued

In the future, solutions that involve other domains, such as industrial automation and Internet of Things (IoT) should be investigated. In the automotive domain it would be interesting to consider breakdown by ASIL and EAL.

UnCoVerCPS: Unifying Control and Verification of Cyber-Physical Systems

Matthias Althoff (Coordinator, speaker)

Short-CV

Matthias Althoff received the diploma in Mechatronics and Information Technology from the department of mechanical engineering at the Technische Universität München, Germany, in 2005. He received his PhD degree (summa cum laude) in electrical engineering from the same university under the supervision of Univ.-Prof. Dr.-Ing./Univ. Tokio Martin Buss in 2010. From 2010 - 2012 he was a postdoctoral researcher at Carnegie Mellon University, USA, with a joint appointment in electrical engineering and the Robotics Institute. He joined the computer science department at Ilmenau University of Technology, Germany, in 2012 as assistant professor for automation systems. Since 2013 Matthias Althoff is assistant professor in computer science at the Technische Universität München.

His research interests include the design and analysis of cyber-physical systems, formal verification of continuous and hybrid systems, reachability analysis, planning algorithms, robust and fault-tolerant control. Main applications of his research are automated vehicles, robotics, power systems, and analog and mixed-signal circuits.

Abstract of presentation

Functionality, autonomy, and complexity of cyber-physical systems is steadily increasing due to growing computing resources. The advanced capabilities of new cyber-physical systems make it possible to automate tasks that were previously performed by humans, such as (semi-)automated operation of road vehicles, surgical robots, smart grids, flight control systems, and collaborative human-robot systems, to name only a few. It is obvious that most of those systems are either safety- or operation-critical, demanding methods that automatically verify their safety and correct operation. Cyber-physical systems are very hard to control and verify because of the mix of discrete dynamics (originating from computing elements) and continuous dynamics (originating from physical elements).

In this talk, I present UnCoVerCPS, which develops a generic and holistic approach towards reliable cyber-physical systems development with formal guarantees. In order to guarantee that specifications are met in unknown environments and in unanticipated situations, we synthesize and verify controllers on-the-fly during system execution. This requires to unify control and verification approaches, which were previously considered separately by developers. For instance, each action of an automated car (e.g. lane change) is verified before execution, guaranteeing safety of the passengers. I present new methods, 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. Our approach leverages future certification needs of open and critical cyber-physical systems.

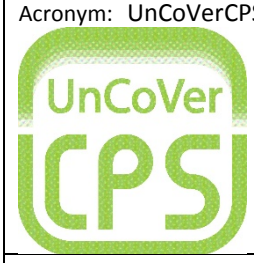
Partner in/ Coordinator of related projects (H2020-ICT-Programm – CPS/IoT or ECSEL/ITEA)

Marie-Curie Project SMART-E

Project Information

Project Name

Acronym: UnCoVerCPS / Ref.nr.: 643921 / Duration: 01/2015 – 12/2018



Project Facts / Website: http://cps-vo.org/group/UnCoVerCPS

Funding: 4.9mEUR
Funding Scheme: RIA
Topic(s): formal verification, control, tool development
Call for Proposal: ICT-1, H2020
Related Projects: other ICT-1 projects
Coordinator: Matthias Althoff (Germany)
TRL: mostly TRL 1-3

Consortium:

- Technische Universität München (TUM) Germany
- Université Joseph Fourier Grenoble 1 (UJF) France
- Universität Kassel (UKS) Germany
- Politecnico di Milano (PoliMi) Italy
- GE Global Research Europe (GE) Germany
- Robert Bosch GmbH (Bosch) Germany
- Esterel Technologies (ET) France
- Deutsches Zentrum für Luft- und Raumfahrt (DLR) Germany
- Tecnalia (Tec) Spain
- R.U.Robots Limited (RUR) United Kingdom

Relevant Domains

- Automotive
- Robotics
- Power systems

Main Objectives / Aims / Goals

The overall goal in UnCoVerCPS is to develop holistic model-based design methods of future cyber-physical systems with a special focus on researching essentially new methods to guarantee safety and reliability in (partially) unknown environments. This is realised by a cross-domain approach for synthesising and verifying controllers on-the-fly, i.e. during operation. In order to quickly react to situations that become critical, a tight integration between the control software and the verification software is realised.

3 to 4 bullet points

- Novel on-the-fly control and verification concepts.
- Unifying control and verification to quickly react to changing environments.
- Seamless integration of modelling and conformance testing.
- integrate modelling, control design, formal verification, and automatic code generation.
- Prototypical realisations of the novel methods in automated vehicles, human-robot collaborative manufacturing, wind turbines and smart grids.A unique tool chain that makes it possible to

Achievements/Highlights/Results/most striking achievements

In UnCoVerCPS, one of the most advanced algorithms for controlling and formally verifying cyber-physical systems are developed. We have already begun to strengthen this position by merging the capabilities of the state-of the-art tools for formal verification of cyber-physical systems: SpaceEx (http://spaceex.imag.fr/) and CORA (http://www6.in.tum.de/Main/SoftwareCORA). The tool SpaceEx also provides a modelling language for systems with mixed discrete and continuous systems, which has become a de-facto standard for exchange of cyber-physical systems in the academic community. The academic tools are integrated into the commercially available tool SCADE. We have further developed a tool for generating formal specifications from structured text, called formalSpec. We are also leading in the field of conformance checking of cyber-physical systems, i.e. we detect the maximum error between an implementation and the used models for developing the implementation.

3 to 4 bullet points

- Development of leading techniques for verifying cyber-physical systems.
- Integration of formal methods into real systems with a special focus on automated driving and human-robot co-existence.

• Integration of tools SpaceEx and CORA. • Semi-automatic generation of formal specifications.	• On-the-fly controller synthesis in conjunction with formal verification methods.

Impact/Successes

UnCoVerCPS will have a significant impact on the reduction of development costs of smart cyber-physical systems used in safety and operation-critical applications. Examples are fully automated systems (e.g. cars, farms, mining, robotic surgery), collaborative human-robot applications (e.g. manufacturing, robotic assistance) and performance-focused systems (e.g. smart grid, energy equipment). The project will support frontloading of verification actions for smart cyber-physical systems in the development process. The deep integration and unification of control and verification techniques will also help overcoming the formal verification barrier that exists for safety- and operation-critical cyber-physical systems. UnCoVerCPS develops cyber-physical systems that prove safety of their own actions during runtime, which is a key enabler for the successful deployment of systems like civil autonomous vehicles and systems with a tight interaction between humans and robots. Each of the potential application domains mentioned above are within the product portfolio of the industrial partners of the consortium.

• Products/Services: Tool chain for developing critical cyber-physical systems	• Demonstrators/pilots: automated vehicles (DLR, Tecnalia), human-robot co-existence (RURobot)

Gaps/Challenges

We would like to find a tool developer that commercializes parts of the tool chain developed in UnCoVerCPS. Further, we aim at working closer with certification agencies. For our application domain 'smart grids' we are seeking additional data from real field experiments.

3 to 4 bullet points • Further tool vendor. • Closer contact to certification agencies.	• Data from real smart grids.

U-TEST: Testing Cyber-Physical Systems under Uncertainty

Waqar Ahmed (Coordinator)

Coordinator of U-Test - Mr. Waqar Ahmed is a PMI certified project management professional and holds M.Sc. in Telecommunications from Technical University of Demark. He has experience in dealing with a global and cross-cultural and cross-sector business environments and has a broad business and engineering background in the telecommunications, energy, and healthcare. Waqar has more than 9 years of experience of managing R&D projects funded under Framework program 6, 7 and Horizon 2020 in areas of environmental monitoring, home automation, medical devices, transportation, energy and communications. He has been extensively involved in project concept development and project formulations as part of his 7 years employments with international consultancy and R&D organisations. Waqar has managed several EU funded project under framework program 6, 7 and Horizon 2020. Since May 2013, Waqar is working for Oslo Medtech as European Program Manager to its cluster members and establishment of EU project and consortium management capacities within the Oslo Medtech.

Hong-Linh Truong (speaker)

Short-CV

Hong-Linh Truong currently is an assistant professor and a Priv.Doz for Service Engineering Analytics at the Distributed Systems Group, Institute of Information Systems, TU Wien (Vienna University of Technology). His research contributes to numerous national and international projects funded by, e.g., European Commission (EU), FWF, WWTF, and ESA (European Space Agency). His research interests are various fields pertained to distributed systems and distributed computing with a systems-oriented focus. His main research interest focuses Software, Data and Service Engineering Analytics by monitoring, analysis and optimizing. His research has been applied to: Monitoring, Analysis and Optimization Techniques for Programs, Data and Systems; Parallel, Grid and Cloud Computing, and IoT; Data Service Models and

Analytics; Socio-technical Services Engineering; and Elastic Computing. Furthermore, he is interested in (free) ICT solutions for (under) developing countries. He published more than 160 refereed papers in books, conferences/workshops and journals. He (co)receives an outstanding paper award, five best paper awards, one best paper run-up award, and one best poster award. He is a member of ACM, the IEEE and the IEEE Computer Society. Contact him at truong@dsg.tuwien.ac.at (http://dsg.tuwien.ac.at/staff/truong).

Project Information

Project Name : Testing Cyber-Physical Systems under Uncertainty: Systematic, Extensible, and Configurable Model-based and Search-based Testing Methodologies

Project Facts / Website: http://cordis.europa.eu/project/rcn/194326_en.html

Funding: € 3,713,233.75 Funding Scheme: RIA - Research and Innovation action Topic(s): Smart Cyber-Physical Systems Call for Proposal: H2020-ICT-2014-1 Related Projects: NA Coordinator: Oslo Medtech (country) TRL: 6	Consortium: • Oslo Medtech • Technical University if Wein • ULMA Handling Systems • Future Position X • Easy Global Market • Simula Research Laboratory • Fraunhofer FOKUS • IK4-IKERLAN • Nordic MedTest	Relevant Domains • Logistics • Healthcare • Cyber physical systems • Model based testing • Uncertainty testing • … • … • …

Main Objectives / Aims / Goals

Cyber-Physical Systems (CPSs) are the next generation of highly connected embedded systems. These systems have applications in varied domains including industrial automation, healthcare, robotics, and maritime industry. Even in the presence of uncertainty, CPSs must be dependable, i.e., trustworthy, robust, efficient, and safe. Inappropriate handling of uncertainty in CPSs during their real operations may have devastating effects on their users and/or environment. The U-Test 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 dependable operation in real environment. The overall objective will be met by the following project objectives:

O1: Provide unified and precise definitions of uncertainties in CPSs and systematically classify and characterize them, by developing a comprehensive Uncertainty Taxonomy (U-Taxonomy) with the ultimate aim of enabling the reuse, potentially via standardization, of the taxonomy across a wide range of diverse domains.

O2: Enable systematic, holistic and standard-based modelling of uncertainties in CPSs by developing a configurable and extensible Uncertainty Modelling Framework (UMF) utilizing existing standards.

O3: Developing a smart, systematic and automated approach of discovering realistic unknown uncertainties relying on existing search algorithms to support testing.

O4: Develop a standard-based and configurable Uncertainty Testing Framework (UTF) to generate cost effective test cases (e.g., achieving high coverage and having high chances of catching faults with lowest possible cost (in terms of e.g., test case execution time, test case generation time) possible by utilizing search algorithms (e.g., genetic algorithms).

Achievements/Highlights/Results/most striking achievements

At the current state-of-the-art and practice, Uncertainty in CPS, in general, is not explicitly studied. With this aim in mind, U-Taxonomy is designed relying on investigating the existing works on uncertainty from other fields, where uncertainty has been explicitly studied, e.g., in philosophy and and healthcare. The U-Taxonomy is then specialized to the three testing levels of CPS including Application, Infrastructure, and Integration. In addition, in parallel, a set of uncertainty requirements were collected from the use case providers of U-Test, i.e., FPX and ULMA Handling systems. The collected uncertainty requirements were classified into the three levels of CPS.

We have carried out validation of the taxonomy and the requirements and studied with the following two aims in our mind, 1) To precisely define the requirements the requirements such that those can be manually transformed into test ready models, 2) Validating that the U-Taxonomy is sufficiently complete with respect to the two use cases.

We have developed an initial version of Uncertainty Modeling Framework (UMF). At the core of framework is the implementation of U-Taxonomy as a UML profile, with which uncertainty can be modelled at the three levels of CPS using UML structural and behavioural models. The UMF also uses exiting standards including UML Profile for Modeling Real-Time and Embedded Systems (MARTE) and the UML Test Profile V.2. An initial set of model libraries has been developed including model libraries for uncertainty measurement, patterns, and risks.

Finally, first version of the evaluation plan has been developed that will be used for assessing cost-effectiveness of test cases generated with the Uncertainty Testing Framework (UTF) and is associated with O4.

Impact/Successes

26 potential sources of revenue have been identified and 13 of them have been prioritized with regards to U-Test's key predetermined results; Uncertainty Taxonomy (UTX), Uncertainty Modelling Framework (UMF) and Uncertainty Testing Framework (UTF). These potential sources of revenue, or value opportunities, take the form of products, services and collaborations. Also, key issues that can affect the potential market success of these value opportunities have been identified through the Technology, Market and Enablers-Barriers layers' analyses. These issues will be monitored along the project development.

The 13 preselected value opportunities have been further elaborated in the form of value propositions: Extended description of the products/services; What Customer segment(s) do they expect to reach, whom do they create value for, what specific Value (problems or needs solved) are they creating to these customer segments, who are the Competitors.

Finally, each partner has stated its Background and Foreground for the identified 13 value opportunities and related business concepts and, following MULO methodology for collaborative exploitation, they have stated initial exploitation claims: Making and selling it; Providing services; Licensing it to 3rd parties; Use it internally to make something else for sale.

Gaps/Challenges

Proper handling of uncertainty, specially unknown uncertain behaviours, is one of the key challenges of

future CPSs. There exist several solutions to test CPSs under uncertainty focusing either on known uncertainties with a limited scope or being insufficiently mature to thoroughly handle unknown uncertainties at the three levels. The key issues and gaps of testing uncertainties in CPSs include:

1. Systematic Approaches for Modelling and Testing Uncertainty
2. Standardized Classification of Uncertainty
3. Standardized and holistic Modelling Solutions
4. Unified Tool Support for Testing Uncertainty
5. Advanced Techniques to Test CPSs under Unknown Uncertainty

U-Test is one attempt to overcome these challenges and gaps, but there is a room and opportunity to build further on U-test results and strengthen European position in forefronts on future smart Cyber Physical Systems.

TAMS4CPS – Trans-Atlantic Modelling and Simulation of Cyber-Physical Systems

Michael Henshaw (coordinator and speaker)

Short-CV Professor Michael Henshaw leads the Engineering Systems of Systems (EsoS) Research Group at Loughborough University. His research focuses on integration and management of complex socio-technical systems, with a particular emphasis on the challenges of through-life management of systems and capabilities. He graduated with BSc (Hons) and PhD in Applied Physics, researching laser-plasma interactions. He worked for seventeen years for BAE Systems in aeronautical engineering and was appointed to the chair in Systems Engineering at Loughborough University in 2006. He is a co-chair of the IEEE SMC Technical Committee for Systems of Systems (SoS), and a member of the INCOSE SoS working group core team. He led the European support action: Trans-Atlantic Research & Education Agenda in SoS that completed in 2013 and is currently leading the Trans-Atlantic Modelling & Simulation for Cyber-Physical Systems Project.
Abstract of presentation Trans-Atlantic Modelling & Simulation for Cyber-Physical Systems Project (TAMS4CPS) is a two year project seeking to establish collaborative opportunities between the US and EU in the area of M&S for CPS. The project will produce 3 main outputs: a strategic research agenda for collaboration, and state of the art that will support the agenda, and a set of test cases that support initiation of collaboration. The project is about halfway complete and during the presentation the main results so far achieved will be outlined together with information about how interested parties can influence the development of the agenda.
Partner in/ Coordinator of related projects Road2CPS, TAreaSoS

Project Information

1 - Project Name: Trans-Atlantic Modelling and Simulation for Cyber-Physical Systems Acronym: TAMS4CPS / Ref.nr.: 644821 / Duration: 01/02/2015 – 31/01/2017

Project Facts / Website: www.tams4cps.com		
Funding: 0.4M€ Funding Scheme: H2020-ICT-2014-1 Topic(s): Trans-Atlantic Cooperation in CPS Coordinator: Prof Michael Henshaw, Loughborough University (UK)	Consortium: • Loughborough University, UK • Steinbeis-Europa-Zentrum, DE • Newcastle University, UK	Relevant Domains • Cross-cutting

Main Objectives / Aims / Goals

To fully exploit CPS, further advances in the modelling and simulation (M&S) of CPS are needed. The TAMS4CPS project aims to lay the foundations for concrete EU-US collaboration in M&S for CPS by creating

- A Strategic Research Agenda for Collaboration (SRAC), endorsed by researchers in the EU and US,
- A set of openly available test cases for model developers and dream projects to be used for collaborative evaluation,
- A report on the state-of-the-art in M&S for CPS.

The SRAC will feature the following five themes:

- Theme 1: Architectures principles and models for safe secure Cyber-Physical Systems,
- Theme 2: Systems design, modelling and virtual engineering for Cyber-Physical Systems,
- Theme 3: Real time modelling for autonomous adaptive and cooperative Cyber-Physical Systems,
- Theme 4: Model-Based Systems Engineering applied to computing platforms and energy management,
- Theme 5: Integration of socio/legal/governance models within modelling frameworks.

Achievements/Highlights/Results/most striking achievements

By workshops and web-based meetings, industry and academic stakeholders prioritise M&S research challenges and create the basis for future collaboration. In these workshops, possible **dream projects** and **test cases** are elaborated to sketch concrete possibilities for future trans-Atlantic cooperation. Dream projects describe what the aims of a collaborative project might be as well as the potential types of contributions from EU and US. For test cases, participants identify both properties of an ideal test case as well as real test cases that meet these requirements.

The dream projects identified so far include:

- Federated EU/US testbeds
- Characterization and improvement of entry and use of CPS
- Combining Formal Verification and Simulation Technology
- Common foundation for security metrics
- Hybrid dynamic system verification
- Integration and interoperability models and approaches
- Characterize and model dynamic human interaction with CPS
- Case studies for autonomous transportation in EU/US cities.

All results obtained so far, as well as additional resources can be downloaded from the website at:
www.tams4cps.eu/resources/
Also, TAMS4CPS encourages stakeholders to **become a member of the TAMS4CPS constituency** to influence the agenda, participate in project events, and perhaps offer a webinar on your work at
www.tams4cps.eu/project-details/expert-community/.

Recommendations/ Work to be continued

Investigation and development of suitable funding schemes for trans-Atlantic collaboration projects in M&S for CPS.

Road2CPS – Strategic action for future CPS through roadmaps, impact multiplication and constituency building

Meike Reimann (coordinator)

Short-CV Dr. Meike Reimann has worked as a project manager at SEZ specializing in EU-ICT, EEB and FoF projects for 5 years. She has over decade of experience in the scientific and administrative coordination of EC-funded IPs, CPs, IAs and CSAs. Furthermore, she has an expertise in project management & coordination, roadmapping, workshop organisation, dissemination, exploitation activities. She works as a management partner in various projects e.g. CPSELab, as a exploitation partner in BRICKER, (concluded project INTUITEL), as a roadmapping and dissemination Partner in TAMS4CPS and as the coordinator of CSAs e.g. Road2CPS (ICT-1).
Abstract of presentation The miniaturisation of sensing, actuating, and computing components together with the increasing number of interacting systems in strongly connected environments, and the growing complexity of such systems have triggered a paradigm shift. CPS concepts address challenges for system implementation such as increasing complexity and flexibility. These challenges and the need to optimise performance and comply with essential requirements like safety and security raise many questions that are already partially addressed by current research in areas such as transport, health, production, smart grids and smart cities. Nevertheless, there is still a huge gap between theoretical concepts, technical developments and successful application, as well as considerable differences with regard to propagation and maturity of CPS between application domains and along the value chain. Strategic action is needed to bring the relevant stakeholders together and to facilitate mutually beneficial collaborations between them. Road2CPS was conceived to respond to this situation by analysing 'impact' from past and ongoing projects, identifying gaps and bridging efforts towards impact multiplication as well as developing technology, application and innovation strategy roadmaps for CPS to serve as a catalyst for early adoption of CPS technologies. In addition, Road2CPS seeks to enhance CPS implementation and identify exploitation opportunities via case studies. As a result, the development of recommendations for future research priorities and implementation strategies will be achieved by the end of project. It is furthermore important to bring key players together – this will be reached by building a CPS Constituency of Experts, who will be allocated to special targeted task forces to contribute to the Road2CPS action plan.
Partner in/ Coordinator of related projects Partner in CPSELabs, Tams4CPS

Project Information

1 - Project Name: Strategic action for future CPS through roadmaps, impact multiplication and constituency building

Acronym: Road2CPS / Ref.nr.: 644164 / Duration: 01/02/2015 – 31/01/2017

Project Facts / Website: www.road2cps.eu

Funding: 0.8M€ Funding Scheme: H2020-ICT-2014-1 Topic(s): CPS Roadmap Coordinator: Meike Reimann, Steinbeis-Europa-Zentrum, DE	Consortium: • Steinbeis-Europa-Zentrum, DE • Loughborough University, UK • Newcastle University, UK • Commissariat à l'énergie atomique et aux énergies alternatives, FR • Fraunhofer Institute for Manufacturing Engineering and Automation IPA, DE • Anysolutions, ES • Atos, ES	Relevant Domains • Manufacturing • Transport • Energy • Smart City • Health

Main Objectives / Aims / Goals

The overall objectives of Road2CPS are as following:

- To assess and multiply the impact of past and ongoing projects in CPSs and related fields, accompanied by raising awareness and disseminating programme achievements to support the timely uptake of novel approaches.
- To develop technology, application and innovation strategy roadmaps, to tailor the roadmaps to the industrial contexts via case studies and to derive recommendations for future research and innovation strategies.
- To bound and build a Constituency aware of – and united by – their commonly faced CPS challenges and demands and to develop task forces for specific actions (e.g. CPS and society; CPS and business; CPS towards platforms; CPS connection).

Achievements/Highlights/Results/most striking achievements

54 of past and ongoing CPS projects were analysed and reported in relevant project deliverables as well as in three project workshops and integrated into the Road2CPS roadmap building activities. In particular, the 8 CPS-related projects, CPSoS, CyPhERs, Road2SoS, T-AREA-SoS, Compass, Road4FAME, sCorPiuS, ProcessIT and ARTEMIS-IA were involved in the first roadmapping workshop and contributed much about the results found in their projects. The results of all 54 CPS-related projects and the insights gained were disseminated to industry, academia, and relevant associations – taking into account a variety of domains such as manufacturing, energy, transport, smart city, and health as well as different stages of the value chains.

Regarding the second overall objective, the development of technology, application and innovation strategy roadmaps, the 'Roadmap Validation Workshop' was held in Paris on 24th of June 2015 to build the baseline for the roadmapping activities. In total, 15 research priorities and CPS-specific technologies were identified and ranked by the experts of the first roadmapping workshop – the highest three prioritised topics were the following: 1) Integration, Interoperability, Standards; 2) Safety, Reliability, Resilience, Fault Tolerance; 3) Modelling and Simulation. Moreover, besides the suggestions that emerged, one exemplary case study was additionally elaborated in order to marry theory and practice. In total three workshops were hold: 1) 'Roadmap Validation Workshop' held in Paris on 24th of June 2015, 2) ´ARTEMIS Strategic Research Agenda Workshop´ held in Turin on 7th of October 2015, and 3) the first ´Constituency Building Workshop´ held in Turin on 8th of October 2015.

The Road2CPS experts group was created. The 51 group members from academia, industry, and associations from interdisciplinary and technology fields joined the group, mostly at the beginning of the project. Four task forces were established: TF1: CPS business models, regulations and service enablers, TF2: CPS awareness and education, TF3: CPS technology and platforms, TF4: CPS connection - with ICT-1a, b, Artemis/ ECSEL, Industrie 4.0. The members of the four task forces contributed by developing visions regarding further deployment of CPS-related issues as well as evaluating insights gained from the project.

3 to 4 bullet points

- Connecting ICT1 projects, ARTEMIS with Road2CPS
- Analysing 54 CPS-related projects
- Implementation of three workshops
- Creating an experts groups of 51 CPS experts and 4 CPS specific task forces

Gaps/Challenges

- The following main barriers were identified during the first roadmapping workshop: 1) Standards, interoperability, and integration, 2) Skills, knowledge training, 3) policy, regulatory, security, and safety, 4) business model, system, and 5) financial.

Recommendations/ Work to be continued

- Elaboration of the CPS final roadmap
- Case Studies and success stories to show applicability
- Extending and deepening of constituency building activities