



Project Deliverable

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611115	CPSoS	D4.2 Report on Public Events
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Abstract :

This document, the Report on public events, provides an overview about each of the public events organised by the project within the first 22 months.

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611115	CPSoS	D4.2 Report on Public Events
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Revision History

The following table describes the main changes done in the document since it was created.

Revision	Date	Description	Author (Organisation)
V1.0	10/07/2015	Creation	Dagmar Marron (inno TSD), Svetlana Klessova (inno TSD)
V1.1	13/07/2015	Contributions	Haydn Thompson (HC), Michel Reniers (TUE), Christian Sonntag (TUDO), Radoslav Paulen (TUDO), Bertrand Copigneaux (inno)
V1.2	15/07/2015	Consolidation	Dagmar Marron (inno TSD)
V2.0	17/07/2015	Initial review and contribution	Sebastian Engell (TUDO)
V2.1	21/07/2015	Consolidation	Dagmar Marron (inno TSD)
V3.0	28/07/2015	Review	Sebastian Engell (TUDO)
V4.0	27/08/2015	Consolidation, last updates and finalisation	Svetlana Klessova (inno TSD)



Table of Contents

1. EXECUTIVE SUMMARY	6
2. LIST OF PUBLIC EVENTS	7
3. REPORTS ON THE PUBLIC EVENTS	8
3.1. Exhibition booth and active promotion at Automotive Megatrends Europe 2015 (Sept. 2014, Brussels/BE)	8
3.1.1. Summary of the Event	8
3.2. Workshop on Tools and Methods for CPSoS (in conjunction with IFM2014) (Sept. 2014, Bertinoro/IT)	12
3.2.1. Agenda	12
3.2.2. Participants	13
3.2.3. Summary of the Workshop	13
3.3. Public Workshop „Engineering and Management of Cyber-physical Systems of Systems (Oct. 2014, Zurich/CH)	16
3.3.1. Agenda	16
3.3.2. Participants	17
3.3.3. Summary of the Workshop	18
3.4. Workshop on Tools and Methods for Management and Engineering of CPSoS (Feb. 2015, Eindhoven/NL)	29
3.4.1. Agenda	29
3.4.2. Participants	29
3.4.3. Summary of the Workshop	30
3.5. Exhibition booth at ARTEMIS Co-Summit 2015 (March 2015, Berlin/DE)	32
3.5.1. Other Potentially Interesting Projects	33
3.5.2. Conclusion	33
3.6. Workshop on Achievements in Systems of Systems Research and Innovation (May 2015, Florence/IT)	34
3.6.1. Agenda	34
3.6.2. Participants	35
3.6.3. Summary of the workshop	36
4. UPCOMING PUBLIC EVENTS	38
4.1. Working Groups Meeting in conjunction with the ARTEMIS Technology Conference 2015 (Torino/IT on Oct. 6, 2015)	38
4.2. Networking Session “Systems of Systems Engineering: What Next?” at ICT2015 (Lisbon/Portugal, Oct 2015)	38
4.3. Final CPSoS Event: Symposium “Cyber-physical Systems of Systems Meeting Societal Challenges”	38
5. ANNEXES	40
5.1. Press Release: Public meetings of the three Working Groups	40



Acronyms and Definitions

Acronym	Defined as
CPS	Cyber-physical Systems
CPSoS	Cyber-physical Systems of Systems
FP7	7 th Framework Programme for Research and Technological Development
ICT	Information and Communications Technology
IP	Integrated Project
KPI	Key Performance Indicator
STREP	Specific Targeted Research Project
WG	Working Group
WP	Work Package

1. Executive Summary

[CPSoS](#), funded by the EC (FP7 programme), is a 30-months Support Action that provides 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.

The project findings will be summarized in a concise strategic policy document "European research and innovation agenda on Cyber-physical Systems of Systems" supported by a set of in-depth technical papers, presented at a symposium "Cyber-physical Systems of Systems Meeting Societal Challenges".

The core activities of CPSoS are three [Working Groups](#), with interactions between them:

- [Working Group 1](#): Systems of Systems in Transportation and Logistics
- [Working Group 2](#): Physically Connected Systems of Systems
- [Working Group 3](#): Tools for Systems of Systems Engineering and Management

Further, the project has initiated the [European Systems of Systems Research and Innovation Cluster](#), consisting of the four EU-funded projects on Systems of Systems – [AMADEOS](#), CPSoS, [DYMASOS](#) and [Local4Global](#).

CPSoS organised 6 public events so far, mostly in conjunction to CPSoS Working Group meetings but also at larger public events organised either by the European Systems of Systems Research and Innovation Cluster or by other related associations and networks. These events are the following:

- September 10/11, 2014, Brussels, Belgium: Exhibition booth at Automotive Megatrends Europe 2015
- September 12, 2014, Bertinoro, Italy: Public Workshop on Tools and Methods for CPSoS (in conjunction with IFM2014)
- October 1, 2014, Zurich, Switzerland: Public Workshop „Engineering and Management of Cyber-physical Systems of Systems“
- February 9, 2015, Eindhoven, The Netherlands: Public Workshop on Tools and Methods for Management and Engineering of CPSoS
- March 10/11, 2015, Berlin, Germany: Exhibition booth at ARTEMIS Co-Summit 2015
- May 28, 2015, Florence, Italy: Public Workshop on Achievements in Systems of Systems Research and Innovation

The present document summarises the information about these public events, and also provide indication about the remaining upcoming public events.



2. List of Public Events

CPSoS organised 6 public events so far, mostly in conjunction to CPSoS Working Group meetings but also at larger public events organised either by the European Systems of Systems Research and Innovation Cluster (example: Open Workshop in Florence, Italy) or by other related associations and networks (example: CPSoS booth attendance at the Artemis Co-summit in Berlin, Germany).

The table below gives an overview of the events. The following chapters present each event in detail.

Date	Venue	Type of Event	Responsible
Sept 10/11, 2014	Brussels, BE	Exhibition booth and active promotion at Automotive Megatrends Europe 2015	CPSoS WG 1
Sept 12, 2014	Bertinoro, IT	Workshop on Tools and Methods for CPSoS (in conjunction with IFM2014)	CPSoS WG 3
Oct 1, 2014	Zurich, CH	Public Workshop „Engineering and Management of Cyber-physical Systems of Systems”	CPSoS WG 2
Feb 9, 2015	Eindhoven, NL	Workshop on Tools and Methods for Management and Engineering of CPSoS	CPSoS WG 3
Mar 10/11, 2015	Berlin, DE	Exhibition booth at ARTEMIS Co-Summit 2015	CPSoS/DYMASOS
May 28, 2015	Florence, IT	Workshop on Achievements in Systems of Systems Research and Innovation	CPSoS/SoS Projects Cluster

3. Reports on the Public Events

3.1. Exhibition booth and active promotion at Automotive Megatrends Europe 2015 (Sept. 2014, Brussels/BE)

The 2nd Working Group Meeting of the Transport and Logistics Working Group took place in conjunction with Automotive Megatrends Europe 2014 which was held in Brussels on the 10th and 11th of September, attracting around 250 participants with key actors from industry and academia.

The aim of this meeting and the chosen venue was to discuss the State-of-the-Art and Future Challenges in Transport and Logistics Report and finalise its content.

CPSoS Working Group members attended the main conference and participated in sessions, discussions and networking activities. This maximized exchange of ideas and provided a number of key insights into the logistics and connected car areas.

A Working Group Meeting was held on the afternoon of the second day to discuss the State-of-the-Art and Challenges in Transport and Logistics Report and overall CPSoS recommendations.

For maximum exposure of the project CPSoS was branded on the Conference website, on a Mobile App and also around the event and on the main conference stages. Additionally, CPSoS had an Exhibition Stand at the event in the Networking Area. This generated a lot of interest and the work of the project was discussed with many conference attendees.

For wider dissemination an advert was placed in the Automotive Megatrends magazine and an article was also published of an interview with Haydn Thompson, Chair of Working Group 1, discussing the role of Cyber Physical Systems of Systems and the challenges faced by the automotive and logistics sectors in the future.

3.1.1. Summary of the Event

Automotive Megatrends Europe 2014

The Automotive Megatrends Conference brings together key stakeholders to network and debate business models, technologies and trends that look set to shape Europe's commercial vehicle and passenger car markets over the next ten years and beyond. The conference attracts over 100 expert speakers and 250 delegates to discuss cutting edge topics including fuel economy, emissions reduction, eMobility and in-car connectivity.

The panel sessions and talks covered a wide range of topics highlighting:

- Megatrends – the key megatrends affecting the automotive and logistics sectors are the ageing population, increased urbanisation, fewer younger people buying cars due to living in cities and starting families later in life, younger consumer expectations for WiFi connected services (for passengers mainly), and the advance of Google with the future being a “Google dashboard”.
- Telematics - Telematics is seen as a key technology for the future. Currently there is a low uptake of telematics due to concerns about tracking but larger companies such as DHL and UPS had many success stories of using telematics for optimising efficiency of operations, maintenance, diagnostics, prognostics and safety. Monitoring of drivers was being used to enhance their driving style to be more fuel efficient. There was a need for harmonisation of different standards across Europe, e.g. for automated tolls for truck drivers – a driver needs to install many different devices to travel across Europe presently. Car-to-car and car-to-infrastructure communications were seen as the future but there were issues of privacy and security. Additionally, there were concerns of Big Data being sent for processing to datacentres in the USA.

611115	CPSoS	D4.2 Report on Public Events
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- Logistics – Key drivers in the logistics sector are reductions in fuel consumption and emissions. Although alternative fuels, use of hybrid vehicles, more efficient engines, more efficient tyres, aerodynamic truck design, larger trucks and double trucks would all reduce fuel consumption and emissions far more significant savings could be made through optimised logistics networks and use of ICT. This requires sophisticated optimisation algorithms and the use of data mining of Big Data. Major savings can be made by reducing the number of part full trucks on the road, return of empty trucks (40% saving) and avoiding operation of trucks in stop-start traffic (50% saving).
- Autonomous Vehicles – The future will see the gradual introduction of ADAS (Advanced Driver Assistance Systems). Fully autonomous cars will be on the roads shortly in tests such as in the Drive Me project in Sweden. Already autonomous trucks have been tested in Sweden. Autonomy is seen as a way of improving safety and fuel efficiency. Platooning of vehicles was highlighted as being problematic. Cars need to communicate with trucks and the truck drivers need to consider whether the truck at the front of the platoon are being driven efficiently and whether they will meet their delivery schedule.
- Emissions regulations – New emission regulations are driving the design of truck engines and it is becoming increasingly difficult to achieve further savings with diesel engines. The future is thus hybrid vehicles or use of alternative fuels. This is being driven by Euro 6/“Euro 7” standards for emissions and there is an industry initiative to provide Green Freight Badging. Already tyres are being provided with energy efficient labels similar to those found for white goods energy efficiency.

The first day ended with a keynote presentation given by Kristian Hedberg, Head of Unit, Land Transport, DG for Mobility and Transport, the European Commission. In this he advocated integration of Automotive, Rail, Maritime and Air Transport systems. Following the presentation the work of CPSoS was discussed with him and he expressed interest in receiving a copy of the State-of-the-Art in Transport and Logistics report.

The second day of the event concentrated on the future of passenger cars and the increased connectivity of cars. The future of the passenger car market was discussed by representatives of the European Commission, General Motors, Toyota, the European Automobile Manufacturers' Association (ACEA) and Verband der Automobilindustrie (VDA). This highlighted that the market is a global market and this introduces challenges of designing vehicles to meet the various regulations around the world. The relatively low uptake of telematics at present was thought to be due to devices not currently being fitted at point of manufacture. The cost of retrofit is far higher. Already CD players were no longer being designed into cars and Apple and Android are producing systems for cars and promoting Apps and connections to wearable devices. Google have intentions to take over the dashboard as they are keen to gather data from cars for their mapping activities. The “Google Dashboard” is likely to be the future but this raises concerns over security and tracking.



The sessions highlighted that increased connectivity is the future and this offers many advantages for both commercial vehicles and passenger cars. Examples of fuel, emissions and maintenance savings made by a number of key companies operating fleets of vehicles were highlighted. It was also noted that the majority of truck fleets in Europe are only around 10 vehicles and there was relatively low uptake of connectivity technology by these companies. Additionally, standards are needed to avoid many disparate systems being

611115	CPSoS	D4.2 Report on Public Events
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used. An example of this is the many different tolling systems used across Europe that requires truck drivers to install a myriad of different devices.

The increased connection of different systems was also highlighted as the future. Here the idea of the “extended” vehicle was introduced that interacted with the wider world and through the connected society. United Parcel Service (UPS) described themselves as moving from a trucking company to a “technology company with trucks”.

Working Group Meeting

The Working Group Meeting was held on the afternoon of the second day of the conference and coordinated with the sessions. The objectives of the Working Group Meeting were twofold:

- 1) Refinement and Comments on State-of-the-Art and Challenges in Transport and Logistics Report
- 2) Discussion of the Draft Overall Research Priorities put forward by CPSoS

The following working group members attended the meeting:

- Haydn THOMPSON Haydn Consulting Ltd.
- Carlos CANUDAS DE WIT CNRS GIPSA-Lab
- Philippe LIATARD CEA – Leti
- Martin Torngren KTH Stockholm (CyPHers)
- John AMOORE Rail Infrastructure Technology Ltd., UK
- Christina DIAKAKI Technical University of Crete – FP7 project Local4Global

All working group members were circulated with a copy of the Draft State-of-the-Art and Challenges in Transport and Logistics Report two weeks in advance of the meeting. Feedback was received by email and telephone. The report was presented over the first half of the meeting and comments were received in the meeting and clarifications given on the key findings. The Working Group Members indicated that they concurred with the findings of the report and that it represented the state-of-the-art well.

Following interest in the CPSoS work from the conference attendees, additional input was also provided by DHL, UPS, and Toyota for the report. The conference provided many other useful pieces of information which were incorporated into the report sections on the automotive and logistics domains.

In summary the Key Recommendations for future research priorities from the Transport and Logistics Working Group are as follows:

Support for Development

- Requirements engineering, model-based systems engineering and validation and verification that support “systems that are never finished” and legacy integration
- Modelling (interdisciplinary) and large-scale simulation of heterogeneous Systems of Systems
 - Multi-objective optimisation of Systems of Systems
 - Proving (economic) benefits of increased integration/system-wide control
 - Giving confidence in safety
 - Identifying any emergent behaviors

Autonomy and Increased Interconnectivity

- Autonomous decision making, system-wide control and coordination
- Socio technical issues of humans interacting with “autonomous” Systems of Systems (noting that not everything will be autonomous)
- Interoperability between systems and development of data exchange standards
- Trust – which becomes more of an issue as systems become more autonomous and highly interconnected (considering security, privacy, and designing to fail safe or operate in presence of security breaches)



Resilience and Monitoring (Situational Awareness)

- Condition monitoring, fault detection and reconfiguration strategies to provide resilience
- Low cost (self-powered) sensor technologies to provide data
- Management of data deluge via large-scale online data analysis to extract information and visualization tools to provide a view of the “real-world in real-time”

Additionally, the draft overall recommendations from CPSoS were discussed. This highlighted the need for clarifications in a number of areas and the need to consider complexity management, risk modelling and management of models.

CPSoS Exhibition Stand

The CPSoS logo was prominently displayed in all publication materials, around the conference venue, and on the stage. Additionally, the project was represented by an Exhibition Stand highlighting the project in the conference networking area over the two days of the event. A CPSoS poster was generated to support this and flyers were distributed. This generated considerable interest and the project was discussed with many conference attendees.

An advert was produced describing the project which was published in the Automotive Megatrends quarterly magazine. This has a readership of 20,000+ readers in the automotive domain. The magazine can be accessed at: <http://www.automotiveworld.com/megatrends-magazine/automotive-megatrends-magazine-q3-2014/>



In addition an interview was provided for the magazine describing some of the findings of the report and giving an overview of how Cyber Physical Systems and Systems of Systems will impact the future of the automotive and logistics sector. The article can be found on pages 104-106 of the magazine.

Concluding remarks

The aim of the 2nd Transport and Logistics Working Group Meeting was to discuss the State-of-the-Art and Future Challenges in Transport and Logistics Report and finalise its content. The Working Group concurred that the report gave a good overview of the state-of-the-art across the different domains and with the recommendations made for future research priorities. The draft overall CPSoS recommendations were also discussed at the meeting and clarifications/modifications were made to these.

The meeting was held in conjunction with Automotive Megatrends Europe 2014 which gave the Working Group members an opportunity to listen to and engage with key industrial, academic and political actors in the transport and logistics area. This maximised exchange of ideas and provided a number of key insights into the logistics and connected car areas. Input from the conference and from interested companies was also incorporated into the State-of-the-Art and Future Challenges in Transport and Logistics report.

The event was also seen as a good opportunity for dissemination and CPSoS was branded on the Conference website, on a Mobile App, around the event and on the main conference stages. Additionally, CPSoS was represented with an Exhibition Stand at the event in the Networking Area. This was very successful in generating interest in the work with the conference attendees.

In addition to this report, you will find more information in the related public deliverable D2.1b “Input paper ‘Analysis of the state of the art and future challenges in the application domain related to WG1’” which is part of the public deliverable D2.1 “Report on the second meeting of Working Group 1, with input paper”, available in the [Deliverable Section](#) of the [CPSoS website](#).

3.2. Workshop on Tools and Methods for CPSoS (in conjunction with IFM2014) (Sept. 2014, Bertinoro/IT)

The second meeting of the Working Group 3 on “Methods and Tools for Engineering and Management of Cyber-physical Systems of Systems” was held as a public workshop “Workshop on Tools and Methods for Cyber-physical Systems of Systems” on September 12th, 2014, at the University Residential Center, Bertinoro, Italy. The programme consisted of invited presentations from Working Group members and submitted presentations.

The second part of the programme consisted of a presentation of key research challenges derived from a study into the state-of-the-art of methods and tools for engineering and management of CPSoS, and a discussion with the participants thereof.

3.2.1. Agenda

4.1 Programme of the Workshop on Tools and Methods for CPSoS

9:30	-	10:30	A process calculus framework for dynamic component structures with sharing Jean-Bernard Stefani
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11:00	-	11:30	Towards a security model for cyber physical systems V. Sassone
11:30	-	12:00	Hierarchical control of large complex plants S. Cristea, R. Mazaeda, C. de Prada
12:00	-	12:30	Optimisation methods for recoverable smart electrical grids M. Kamali, M. Kolehmainen, M. Neovius, L. Petre, M. Rönkkö, P. Sandvik
<hr/>			
13:45	-	14:30	A formal approach to the design and operation of complex systems A. Cimatti
14:30	-	15:00	A decision support system approach for systems of systems management M.P. Fanti, M. Clemente, W. Ukovich
15:00	-	15:30	A vision for future model-based support for dependable cyber-physical systems of systems C. Ingram, K. Pierce
<hr/>			
16:00	-	16:30	State-of-the-art in tools and methods for engineering of CPSoS M. Reniers and W.J. Fokkink
16:30	-	17:30	Discussion on state-of-the-art in tools and methods for engineering of CPSoS

3.2.2. Participants

In total there were 15 participants in the workshop.

Members of Working Group 3:

Fokkink	Wan	(VU Amsterdam, Netherlands)
Reniers	Michel	(TU Eindhoven, Netherlands)
Sonntag	Christian	(TU Dortmund, Germany)
Copigneaux	Bertrand	(inno, France)
Cimatti	Alessandro	(Bruno Kessler Foundation, Italy)

External participants:

Sassone	Vladimiro	(University of Southampton, United Kingdom)
de Prada	Cesar	(Universidad de Valladolid, Spain)
Petre	Luigia	(Åbo Akademi, Finland)
Sandvik	Peter	(Åbo Akademi & Turku Centre for Computer Science, Finland)
Fanti	Maria	(University of Trieste, Italy)
Ingram	Claire	(Newcastle University, United Kingdom)

and four more external ad hoc participants

3.2.3. Summary of the Workshop

The second meeting of Working Group 3 took place in the form of a “Workshop on Tools and Methods for CPSoS” that was co-located with the scientific conferences iFM 2014 (The 11th International Conference on Integrated Formal Methods) and FACS 2014 (The 11th International Symposium on Formal Aspects of Component Software). In total 15 participants gathered for the workshop on September 12th in Bertinoro, Italy to discuss the state-of-the-art and future challenges in the engineering of cyber-physical systems of systems.



The programme of the workshop consisted of three types of presentations: invited presentations, presentations by Working Group members from the CPSoS project, and submitted presentations. The submitted presentations were solicited by means of a Call for Presentations. Proposals for presentation consisted of a paper of at most four pages that clearly shows the relationship to the topic of the workshop and gives an overview of the material to be presented at the workshop. Five such papers were submitted.

Submitted presentation proposals have been evaluated by the organisers of the Workshop (John FITZGERALD, Wan FOKKINK, and Michel RENIERS) and were accepted for presentation at the workshop.

The last part of the programme (16:00 – 17:30) consisted of a presentation of the “State-of-the-art and future challenges in tools and methods for engineering and management of cyber-physical systems of systems” and discussion thereof. The following key challenges were presented

- **(Efficient) Modelling and simulation of large-scale heterogeneous complex systems**
 - formulation of detailed models of the constituent systems, incl. human operators and environment
 - availability of simulation engines capable of dealing with the scale dimension of CPSoS. This requires clear interfaces between heterogeneous models and abstraction methods
 - system-wide simulation techniques that allow to assess the properties of the system prior to effectuating of evolution steps (in case these can be controlled). These should also aid in detecting emerging behavior
- **Abstraction and approximation methods** for reducing model complexity for system-wide functionality and performance analysis
- **Development of control strategies and methods for decision making**
 - that deal well with reconfiguration and partial autonomy of parts of the CPSoS
 - for which reconfiguration and evolution have less impact on the system-wide behavior
 - including methods to detect significant evolutions in the CPSoS in order to react timely with adapted control
- **Techniques for modelling and analyzing threats** to system functionality and performance induced by communication infrastructure
- **Model-based systems engineering approach** is needed that does full justice to the shift from design-time to run-time engineering
- **Tools for the management of models** and relationships between models that allow to keep track of past, current and planned system configurations at the architectural level and provide linkage with the associated models.

The discussion on the state-of-the-art was moderated by Michel RENIERS.

In the discussion of the state-of-the-art the participants indicated that the following issues are to be considered very important:

- Co-simulation is a very important technology for the future. In this context, definition of standardized interfaces for co-simulation that are not linked with or restricted by commercial providers is needed. Another issue that requires attention in the area of co-simulation is the preservation of physical balances (e.g., mass and energy balance) over the boundaries of the individual simulation tools during co-simulation.
- Better algorithms are needed for solving optimization problems. Although solutions for optimization problem formulations are already very general, for real-time optimization, and in particular for such large systems as CPSoS, their application is infeasible.
- More integrated and easier-to-use tools for full life-cycle management is very important.
- In handling the evolutionary aspects of systems of systems there are two issues that need to be separated and that both deserve attention. One is “How do deal with the fact that future evolutions of the system are not known at all?” and the other is “How to decide NOW what actions to apply to a system (e.g., in economic optimization) based on expectations of the future?”
- Uncertainty is an important future challenge in hierarchical and distributed control.

611115	CPSoS	D4.2 Report on Public Events
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- Methods and models for architectural reconfiguration representation and execution are missing. Consensus-building between many different agents is an important topic in dynamic reconfiguration.

During the discussions the following remarks were also collected that may be used for improving the state-of-the-art document:

- Contract-based design actually helps if there is a lack of trust between agents. Agents do not need to publish their internal designs in this approach.
- Several examples of positive emergence have been mentioned and links to papers that may be useful have been made available.
- The COMPASS project has started developing models to represent and analyze cyber-security issues.

Outcomes:

The discussion confirmed that the current state-of-the-art description is valid mostly. Relevant suggestions for improvement were given. Furthermore, in the discussion of the identified key research challenges these were confirmed as key challenges and some of these were identified as having a high priority.

As a part of the second meeting of Working Group 2 (Physically Connected Systems of Systems) which was organized as a public event jointly with STREP DYMASOS (Dynamic Management of Physically Coupled Systems of Systems) in Zürich on October 1st, 2014, a breakout session on tool support was organised. The goal of this session was to validate and prioritize key research challenges. For the breakout session on tools, the results of this prioritization are reported in this deliverable.

The prioritized list of key research challenges for different time horizons will be used in discussions with tool experts and will be used for updating the state-of-the-art description and as input for the European research and innovation agenda.

More detailed information, such as abstracts, presentations and an input paper, is provided in the in Section 4 (Appendices) of the public deliverable D2.3 “Report on the second meeting of Working Group 3, with input paper”, available in the [Deliverable Section](#) of the [CPSoS website](#).



3.3. Public Workshop „Engineering and Management of Cyber-physical Systems of Systems (Oct. 2014, Zurich/CH)

The second meeting of the Working Group 2: Physically Connected Systems of Systems (chaired by Prof. Sebastian Engell from TU Dortmund, Germany), was held as a public workshop in collaboration with the project DYMASOS which is funded under the same call on October 1st, 2014 at ETH Zurich (Switzerland). It consisted of a joint plenary session and of parallel domain-specific breakout sessions.

3.3.1. Agenda

Public Workshop „Engineering and Management of Cyber-physical Systems of Systems“ Agenda

10h30- 11h00 **Introduction of the CPSoS project and presentation of a preliminary proposal on priorities in research and innovation areas** by Prof. Sebastian ENGELL / TU Dortmund

11h00- 12h30 **Presentations from DYMASOS: Management Methods for Cyber-physical SoS**

- Population based management of Systems of Systems (*John LYGEROS / ETH Zürich*)
- Price based coordination for resource allocation in an integrated chemical production site (*Goran STOJANOVSKI / TU Dortmund*)
- Coalitional control for electric vehicles charging (*Eduardo F CAMACHO / Universidad de Sevilla*)

(23 min presentation + 7 min discussion each)

13h30- 15h00 **Tools for SoS Engineering**

- An engineering support platform for large-scale Cyber-physical Systems of Systems (*Christian SONNTAG / euTeXoo*)
- Needs and Tools for Cyber-physical Systems of Systems in the Process Industry (*Prof Cesar de PRADA / Universidad de Valladolid*)
- The Danse EU Project: Consistent Integration of Simulation and Formal Analysis in the Design of SoS (*Valerio SENNI / ALES S.r.l.*)

15h30- 16h45 **Parallel breakout sessions**

- Future challenges and research needs in Cyber-physical Systems of Systems
- **Sessions:**
 - (1) Electric grids and smart buildings (*Moderated by Patrick PANCIATICI / RTE - Réseau de Transport d'Electricité*)
 - (2) Process industries (*Moderated by Sebastian ENGELL / TU Dortmund*)
 - (3) Tool support (*Moderated by Christian SONNTAG / euTeXoo and Michel Reniers / TU Eindhoven*)
- **Goal:** Discuss the state of the art and challenges for the future, prioritize the future research topics in view of the next calls in Horizon 2020.

17h00- 17h30 **Summary of the breakout sessions** 3 x 5 min reports), *Discussion, Next steps and conclusion*

3.3.2. Participants

Members of the CPSoS consortium:

Engell	Sebastian	(TU Dortmund, Germany)
Paulen	Radoslav	(TU Dortmund, Germany)
Reniers	Michel	(TU Eindhoven, Netherlands)
Klessova	Svetlana	(inno, France)
Copigneaux	Bertrand	(inno, France)
Sonntag	Christian	(euTEXoo, TU Dortmund, Germany)

Members of Working Group 2:

Lygeros	John	(ETH Zürich, Switzerland – FP7 Project DYMASOS, Local4Global)
Isaksson	Alf	(ABB, Sweden)
Brancati	Francesco	(ResilTech SRL, Italy - FP7 Project AMADEOS)
Havlena	Vladimir	(Honeywell, Czech Republic)
Panciatici	Patrick	(RTE - Réseau de Transport d'Electricité, France)

Other participants of the workshop:

Hosseini	Alireza	(BASF, Germany)
Pakasin	Goran	(HEP - ODS d.o.o., Croatia)
Bolfek	Martin	(HEP - ODS d.o.o., Croatia)
Habijan	Danijel	(HEP - ODS d.o.o., Croatia)
Beisheim	Benedikt	(INEOS, Germany)
Senni	Valerio	(ALES S.r.l., Italy)
del Real Torres	Alejandro	(IDENER, Spain)
Blanco Polo	Santiago	(AYESA, Spain)
Guidi	Luca	(ENEL, Italy)
Marijan	Sinisa	(KONČAR Electrical Engineering Institute Inc., Croatia),
Sielemann	Michael	(MODELON, Germany)
Lewis	Mark	(NEPIC, United Kingdom)
Schwingenschloegl	Christian	(Siemens, Germany)
Nazari	Shaghayegh	(TU Dortmund, Germany)
Stojanovski	Goran	(TU Dortmund, Germany)
Maxeiner	Lukas	(TU Dortmund, Germany)
Camacho	Eduardo F.	(University of Seville, Spain)
Baotic	Mato	(University of Zagreb, Croatia)
de Prada	Cesar	(University of Valladolid, Spain)
Sanz	Ricardo	(Universidad Politecnica de Madrid, Spain)
Findeisen	Rolf	(Otto-v.-Guericke Univ, Magdeburg, Germany)
Damm	Gilney	(L2S, Supelec, France)
Jost	Michael	(Ruhr-Universität Bochum, Germany)
Jäschke	Johannes	(NTNU Trondheim, Norway)
Koch	Stephan	(ETH Zurich, Switzerland)
Basilio	Gentile	(ETH Zürich, Switzerland)
Grammatico	Sergio	(ETH Zürich, Switzerland)
Kampert	David	(RWTH Aachen, Germany)

3.3.3. Summary of the Workshop

An input paper “Analysis of the state of the art and future challenges in the domain of physically connected systems of systems” had been developed based on the findings of the kick off meeting of the Working Groups (held in January 2014) and on discussions and interviews with domain experts and practitioners. It was circulated to the participants before the meeting as a basis for the discussions during the meeting.

The discussions were organised around the following main questions:

- What are the main difficulties encountered in the engineering, realization and operation of these systems?
- What are the specific demands and challenges for advanced methods and tools for CPSoS in the areas of electric grids, process industries and smart buildings?
- What are the most important open research questions for CPSoS on short-, medium-, and long-term horizons?

This second meeting of the Working Group 2 attracted 39 participants who represented a broad spectrum of domain experts, researchers, developers and industrial practitioners. The meeting was organized jointly with the FP7 STReP DYMASOS in order to discuss the currently pursued research activities in the domain of SoS and to broaden the view on the present challenges. An input paper “Analysis of the state of the art and future challenges in the domain of physically connected systems of systems” was developed based on the findings of the kick off meeting of the Working Groups (held in January 2014) and on the discussions and interviews with domain experts and practitioners performed by Radoslav Paulen (TUDO). It was distributed among the participants prior to the meeting and provided the basis for the discussions during the meeting. The paper is included as an Annex of this report.

The meeting started with a plenary session where the CPSoS project and the definition of the scope of Cyber-physical Systems of Systems and their research challenges as developed by the consortium in consultations with experts outside the project were presented.

In order to stimulate the discussions of the current and future research challenges in the domain of physically coupled systems of systems, the morning plenary session included three talks that were given by the researchers of the DYMASOS project on advanced management methods for CPSoS. Theoretical developments as well as application studies on SoS management were presented.



The afternoon plenary session was focused on the discussion on the state of the art and future developments of engineering tools for physically connected CPSoS. One presentation was contributed by DYMASOS, the other two by external experts, one of them with a background in chemical process management and control and the other one from the DANSE IP on Systems of Systems. The second part of the afternoon was organized as domain-specific breakout sessions on (1) Smart grid and smart buildings, (2) Process Industries, and (3) Tool support for physically coupled Systems of Systems. The parallel discussions were focused on the present challenges and the future research needs in the respective

domains. The prioritization of the discussed topics was done based on anonymous voting polls where the participants of the workshop prioritized the research topics according to the time frame of the expected deployment of solutions in practice or their commercial availability.

The final plenary session consisted of presentations of the outcomes of the breakout sessions presenting the prioritized lists of the research topics for the most urgent future developments in the domain of physically connected SoS, a joint discussion on the presented topics and, and an outlook on the next steps.

Morning plenary session: Management Methods for Cyber-physical SoS

The meeting started with the welcome by Sebastian Engell, the Project Coordinator who introduced the CPSoS project to the participants. He gave an overview of the workflow in the project and of the definitions and research challenges for CPSoS. Hand-out slides with a summary of the results from the kick off meeting of WG2 (see Annex) were distributed to the participants.

Three talks were given by the representatives of FP7 STREP DYMASOS in order to stimulate the discussion on the development of methods and tools for engineering and management of cyber-physical systems of systems. The talks were focused on the recent research in DYMASOS and were given on

- “Population-based management of Systems of Systems” by John Lygeros (ETH Zurich)
- “Price-based coordination for resource allocation in an integrated chemical production site” by Goran Stojanovski (TU Dortmund)
- “Coalitional control for electric vehicles charging” by Eduardo F Camacho (Universidad de Sevilla)

John Lygeros presented the recent developments in the WP1 of the DYMASOS project that build upon the population-based methods for coordination of systems of systems using ideas of mean field theory and games theory. An example concerning the coordination of charging of electric vehicles was presented to evidence the usability of the methods. The subsequent discussion addressed the issues of the modeling depth that is required for the correct representation of the system behavior, the stochastic aspect of the load prediction in the power grid and the convergence properties of the presented coordination algorithms.

Goran Stojanovski presented the recent developments in the WP2 of the DYMASOS project that are concerned with price- and market-based methods for the coordination of systems of systems. An example of the coordination needs arising in a petrochemical plant based on a case study provided by an industrial partner of the project highlighted the challenges, and first applications of price-based coordination algorithms were presented. The following discussion concerned aspects of the practical applicability of the presented coordination methods.

Eduardo Camacho presented the recent developments in the WP3 of the DYMASOS project that investigate coordination following the principle of coalitions’ formation and coalitional games theory. An example concerning the coordination of charging of electric vehicles was presented as a case study of usability of the developed methods. Practical aspects of the coalition formation in electric vehicle charging were stressed in the discussion as well as the level of autonomy and the nature of the demands of the users.

Afternoon plenary session: Tools for SoS Engineering

The afternoon plenary session was devoted to the state-of-the-art and current developments of the tools that support the engineering and the management of SoS. Three talks were given on

- “An engineering support platform for large-scale Cyber-physical Systems of Systems” by Christian Sonntag (euTeXoo, DYMASOS)
- “Needs and Tools for Cyber-physical Systems of Systems in the Process Industry” by Cesar de Prada (Universidad de Valladolid)
- “The Danse EU Project: Consistent Integration of Simulation and Formal Analysis in the Design of SoS” by Valerio SENNI (ALES S.r.l.)



Christian Sonntag presented the concept of the engineering support platform that currently is developed in the WP4 of the DYMASOS project. A tool originating from these developments will support the simulation of the coordination of systems of systems supporting co-simulation for integration of models written in different languages. The discussion stressed the need for co-simulation tools and raised concerns about the ability to handle co-simulation of really large-scale systems by the state-of-the-art tools.

Cesar de Prada gave a survey presentation on the state-of-the-art and the future needs of tools used for Cyber-physical engineering and management. The talk was oriented towards the needs arising in the process industry. The main concerns were inconsistencies of the models being used at different levels of the process automation pyramid and the sustainability and deployment of advanced tools for simulation and optimization. Distributed simulation and management strategies were discussed. It was confirmed in the discussion that task of modeling and maintenance of models is a time-consuming one. The further development of methods for distributed optimization was stressed as distributed optimization is currently regarded as a technology that can cope with the increased complexity of optimization problems when a greater modeling depth is employed for the sake of consistency of the models.

Valerio Senni presented the developments of the project DANSE. It was pointed out that DANSE mainly addresses the integration of available tools into a coherent tool chain. The tool chain supports modelling, verification and simulation of hybrid systems and system of systems. In the discussion, it was clarified that verification tools are only available for the discrete part of the systems, hybrid elements are validated based on simulation scenarios.

Parallel breakout sessions

Afterwards, the participants of the meeting split into three groups in order to discuss and to prioritize the research and development challenges in the domains of

- Electric grids and smart buildings (Session moderated by Patrick PANCIATICI from RTE - Réseau de Transport d'Electricité)
- Process Industries (Session moderated by Sebastian ENGELL from TU Dortmund)
- Tool support (Session moderated by Christian SONNTAG from euTeXoo and by Michel Reniers from TU Eindhoven)



Electric grids and smart buildings

The session was attended by 12 participants, 7 of them coming from industrial and 5 from academic domain. The session was chaired by Patrick Panciatici who described the objective of the session at its opening. He afterwards presented his view on the challenges encountered in the domain of smart grids and power grids. The presented topics included:

- Spatial complexity (from Pan European power grid to active distribution grids)
- Temporal complexity (from decades to milliseconds)
- Stochastic complexity (from failures, weather conditions to grid users' behaviours)
- Aging of grid assets
- Multi-stage decision making under uncertainty (decisions changing the structure of the system, policies or control/protection schemes, the operating points of the system)
- Mixed integer non linear programming, "Convexification" of ACOPF (scalable implementation for large SDP)
- Robust optimization (bi-level programs and semi-infinite programs, chance constraint programming)
- System stability ("Lyapunov like" approach, sum of squares, flatness, ...)
- Distributed (decentralized) controls at substation Level (MPC, setting less protection, ...)

611115	CPSoS	D4.2 Report on Public Events
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- Massive integration of inverter-based components (synchronization issue, lack of “inertia”, ...)
- Requirement for the associated ICT systems (latency, reliability, communication delays)
- Taking advantage of high performance computing.

The presented topics were subsequently discussed. The participants mostly agreed on the relevance of the topics. Radoslav Paulen additionally presented a set of topics that were indicated as key challenges in the domain of smart grids and power grids in the interviews with domain experts and practitioners that he performed in the framework of the CPSoS project. These topics included:

- Modelling and simulation of distributed generation
- Generic and automated building of dynamic models
- Modelling the power system jointly with the communication system
- Simulation of large-scale systems
- Reliable simulation (What depth should be simulated at which level?)
- Demand side management via virtual power plants (subsidies to big consumers; how to do it optimally?)
- Negotiation between market and technical system for the feasibility when planning
- Cultural change of frequency management due to renewables

Additional topics were raised by the participants of the breakout session and discussed subsequently. These included: System integration of active distribution, Data availability and new business models, Better use of measurements (estimation), Cyber-security (privacy), Revision of the communication protocols, Remote control of substations, Dynamic reconfiguration and re-engineering while performing a migration from the existing grid to the optimal one, possibilities of synchronization without using GPS and possibilities of establishing DC transmission and distribution.

An anonymous voting poll was conducted at the end of the session in order to prioritize the discussed topics. The prioritization was performed for different time frames based on the expected availability and deployment of the solutions to the research and innovation challenges. The participants prioritized the research topics in short- (less than 4 years), medium- (4 to 8 years), and long-term (more than 8 years) horizons. The participants’ votes were distinguished based on the affiliation of the participants in industry or academia. Each participant could cast two votes for each time horizon. The following table summarizes the results:

	Industry		Academia	
Short-term horizon	System Integration of Active Distribution	4 votes	System Integration of Active Distribution	2 votes
	Data availability & new business models	3 votes	Massive Integration of Inverter-based Components	2 votes
	Modelling and Simulation for Distributed Generation	2 votes	Demand Side Management via Virtual Power Plants	1 vote
	System Stability (new concepts)	1 vote	Data availability & new business models	1 vote
	Spatial Complexity	1 vote		
	Distributed (Decentralized) Controls at Substation Level	1 vote		
	Massive Integration of Inverter-based Components	1 vote		
	Better Use of Measurement and Estimation	1 vote		
Medium-term horizon	Requirement for Associated ICT Systems (new control and protection)	3 votes	System Stability (new concepts)	2 votes
	Multi-stage Decision Making under Uncertainty	2 votes	Better Use of Measurement and Estimation	2 votes



611115	CPSoS	D4.2 Report on Public Events
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	Demand Side Management via Virtual Power Plants	2 votes	Stochastic Complexity	1 vote
	Distributed (Decentralized) Controls at Substation Level	1 vote	Modelling the Power System Jointly with Communication System	1 vote
	Stochastic Complexity	1 vote		
	Massive Integration of Inverter-based Components	1 vote		
	Simulation of large-scale systems	1 vote		
	Negotiation between Market and Technical System for the Feasibility When Planning	1 vote		
	Cultural Change of Frequency Management due to Renewables	1 vote		
	Better Use of Measurement and Estimation	1 vote		
Long-term horizon	Taking Advantage of High Performance Computing	3 votes	Distributed (Decentralized) Controls at Substation Level 2	2 votes
	Cyber-security (privacy)	2 votes	Cyber-security (privacy) 1	1 vote
	Requirement for Associated ICT Systems (latency, reliability, ...)	2 votes	System stability 1	1 vote
	Stochastic Complexity	1 vote		
	Aging of Grid Assests	1 vote		
	Mixed Integer Non Linear Programming, "Convexification" of ACOPF	1 vote		
	Distributed (Decentralized) Controls at Substation Level	1 vote		
	Simulation of large-scale systems	1 vote		

Process industries

The session was attended by 15 participants, nearly equally distributed among participants from the industrial and the academic domains. The session was chaired by Sebastian Engell who described the objective of the session at its opening and presented the engineering and management challenges in the domain of process industries as identified by the members of the Working Group 2.

- Modeling optimization and simulation tools
- Reduction of the modelling effort
- Model integration, co-simulation
- Distributed management and control
- Handling of faults and abnormal situations
- Using large amounts of data to monitor and improve system operation
- User/operator interaction
- Requirements management over the life cycle
- Holistic model-based design
- Deployment, maintenance, and continuous upgrade / re-engineering
- Dynamic reconfiguration
- Validation and verification

Further he presented a list of topics that originated from the interviews with practitioners in industry performed by TUDO. These concerned the issues of:

- Modelling:
 - How to go quickly from P&ID to high-fidelity simulation of a process? Need to simulate different possible equipment (e.g. pumps) and automation systems (different vendors)
 - How to handle incomplete information in simulation?



611115	CPSoS	D4.2 Report on Public Events
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- Exchange of information between models on different levels
- Doubts on application of co-simulation for large-scale systems
- Modelling with incomplete or generic information
- Model building and maintenance is time-consuming; very detailed models needed for control purposes; very hard task for batch plants (hybrid data-based + first-principles models did not penetrate to industry)
- Information on models -> Limits-aware models
- Full Automation and modelling of human behavior:
 - People and their interaction with the system is the biggest challenge
 - Model the human behavior and decision process; planning is very hard otherwise
 - Building near-autonomous system management because of the demographic changes in Europe
 - People should be taken out of the real-time operation; need to build trust in system and software
 - Decision-support systems (e.g. to support people who decide on the maintenance of equipment)
- Information systems and systems integration:
 - Big data handling at different levels (SAP(ERP)/MES/APC)
 - Plug-n-play solutions to harmonize the communication across SAP(ERP)/MES/APC, data synchronization
 - Each layer (planning, scheduling, control) uses different model; how to link and integrate these?
 - Integration of different software tools used at different departments (engineering vs. automation and control)
 - Information security – where does the information go (model the flow of information); cyber attacks
 - Integrity, security and trust
- Other topics:
 - Degree of reliability of academic solutions is unknown
 - Need for “non PhD” tools
 - How to control the modules in modular plants; there should be a joint effort of vendors of control systems to develop plug-n-play solutions for those plants.

A collection of topics was discussed further. These included:

- Integrity, security and trust (Lack of understanding in commercial structures, making people aware of benefits, economic benefits for coordinated work in industrial parks)
- Lack and inconsistency of models on higher hierarchical levels, e.g. on the supply chain and production planning layer (possible to build up high level models from lower level models? model simplifications?)
- Standardization (using developed models for several needs)
- Feasibility of set-points provided by high level models is unclear for lower levels
- Supply chain and production should be modelled and optimized simultaneously
- Industrial demand response
- Unmanned operation / remote operations / maintenance
- „Data mining“, using historical data for process monitoring, e.g. Baseline calculation from historical data, debottlenecking
- Integration of supply chain, production scheduling, demand planning, and control
- Standardization of model interfaces.

An anonymous voting poll was conducted at the end of the session in order to prioritize the topics discussed. The prioritization was performed for different time horizons based on the expected availability



611115	CPSoS	D4.2 Report on Public Events
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and deployment of the solutions to research challenges. The participants prioritized the research topics in short- (less than 4 years), medium- (4 to 8 years), and long-term (more than 8 years) horizons. The participants' votes were distinguished based on the affiliation of the participants in industry or academia. Each participant cast two votes for each time horizon. The following table summarizes the results:

	Industry		Academia	
Short-term horizon	Modeling optimization and simulation tools	4 votes	Modeling optimization and simulation tools	2 votes
	Standardization of Interfaces	3 votes	Standardization of Interfaces	2 votes
	Dynamic reconfiguration	1 vote	Dynamic reconfiguration	1 vote
	Reduction of the modeling effort	1 vote		
Medium-term horizon	Validation and verification	3 votes	Integration of supply chain, scheduling and control	5 votes
	Integration of supply chain, scheduling and control	2 votes	Modeling optimization and simulation tools	2 votes
	Standardization of Interfaces	1 vote	Standardization of Interfaces	1 vote
	Dynamic reconfiguration	1 vote	Dynamic reconfiguration	1 vote
Long-term horizon	Integration of supply chain, scheduling and control	5 votes	Reduction of the modeling effort	4 votes
	Reduction of the modeling effort	4 votes	Validation and verification	3 votes
	Dynamic reconfiguration	1 vote	Dynamic reconfiguration	2 votes
	Standardization of Interfaces	1 vote		

Tool support

The breakout session on tool support was attended by 8 participants (1 from industrial domain, 7 from academic domain). The goal of the session was to validate and to prioritize the key challenges in four areas that are seen as crucial for future research and innovation in industrial CPSoS. These areas are "Modeling, Simulation, and Model Management", "Engineering and Run-time Platforms", "Model- and Data-based Engineering Tools", and "Integration and Deployment of Advanced Solutions".

The following key challenges were presented, discussed, and prioritized during the breakout session.

Modelling, Simulation, and Model Management

1. Keeping all models up to date and consistent (model management)
2. Reducing the effort and cost of modeling by model re-use (object-oriented or modular modelling) and predefined and adaptable standard models.
3. Coupling of many different simulation tools of different strengths (co-simulation)
4. Dynamic on-the-fly reconfiguration of simulation models
5. Integrated modeling and simulation with distributed management schemes, failures, and abnormal states
6. Large-scale, faithful, efficient simulation algorithms for CPSoS with different time scales and on-the-fly reconfiguration

Engineering and Run-time Platforms



611115	CPSoS	D4.2 Report on Public Events
--------	-------	------------------------------

7. Development of new engineering frameworks that support the requirements specification, adaptation, evolution, and maintenance of CPSoS not only during design, but over their complete life-cycle
8. Collaborative engineering and run-time environments that enable providers to jointly work on aspects of the CPSoS while competing on others
9. Engineering platforms that support an integrated cross-layer design of fault-resilient management architectures, and early testing facilities to detect errors as soon as possible

Model- and Data-based Engineering Tools

10. New (distributed/hierarchical/decentralized) methods and tools that take CPSoS properties (autonomy, dynamic reconfiguration, ...) into account
11. More powerful optimization algorithms and tools that enable real-time optimization of large-scale CPSoS
12. New algorithms and tools for stochastic optimization and risk management
13. New algorithms and tools for large-scale CPSoS validation and verification, including reconfiguration (e.g. hybrid simulation/verification approaches, assume-guarantee / contract-based reasoning, ...)
14. (Real-time) processing, synchronization, and management of large data sets for monitoring, optimization, fault detection, ...

Integration and Deployment of Advanced Solutions

15. Consistently integrating engineering and operational data and engineering artefacts from heterogeneous, structured and unstructured data sources with advanced solutions
16. Integrating new engineering and operational software and hardware tools with existing infrastructure

Part of the discussion was centered on clarification of the contents of the presented list of key research topics.

- The challenges are formulated from the point of view of industry.
- Modelling in practice is not only restricted to modelling of behavior. Nevertheless, in the key research challenges modelling mostly refers to modelling of the dynamic behavior of the system.
- Automatic tearing and algebraic loop breaking should also be considered under challenge 6 (Large-scale, faithful, efficient simulation algorithms)
- Combine challenges 4 and the second part of challenge 5 (Integrated modelling and simulation of failures and abnormal states) from the above list into a new challenge named "Dealing with Unmodelled Aspects". The first part of challenge 5 (Integrated modelling and simulation with distributed management schemes) is considered part of challenge 1 (Model management).
- Enlarge the scope of challenge 6 (Large-scale, faithful, efficient simulation algorithms) to include model execution as a generalization of model simulation.
- Challenge 9 (Integrated Cross-layer Design) also includes computing hardware problems.
- A challenge Conceptual Model Alignment is added as an important key research area.

An anonymous voting was conducted at the end of the session. Each participant prioritized the research topics in three different time horizons, using up to 2 votes per time horizon:

- Short-term horizon: less than 4 years
- Medium-term horizon: 4 to 8 years
- Long-term horizon: more than 8 years

The challenge of managing the large number of models that arise during the engineering and operation of complex CPSoS received the most votes, followed by challenges such as improving simulation and optimization algorithms, CPSoS developing new management methodologies and tools, CPSoS engineering and runtime frameworks, and providing consistent system integration of advanced solutions. The discussions from this session brought valuable input for the Working Group 3. The following table summarizes the results of prioritization of discussed research topics:



611115	CPSoS	D4.2 Report on Public Events
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	Industry		Academia	
Short-term horizon	Model Re-use and Predefined and Adaptable Standard Models	1 vote	Model Management	5 votes
	Large-scale, Faithful, Efficient Simulation Algorithms	1 vote	Co-simulation	2 votes
			Large-scale, Faithful, Efficient Simulation Algorithms	2 votes
			Consistent Integration of Data, Engineering, and Operational Artefacts and Tools	2 votes
			Model Re-use and Predefined and Adaptable Standard Models	1 vote
			New CPSoS Engineering Frameworks	1 vote
			Collaborative Engineering and Runtime Environments	1 vote
Medium-term horizon	New CPSoS Engineering Frameworks	1 vote	More Powerful Optimization Algorithms/Tools	4 votes
	More Powerful Optimization Algorithms / Tools	1 vote	New System-wide Management and Coordination Tools	3 votes
			Collaborative Engineering and Runtime Environments	2 votes
			Model Management	1 vote
			Co-simulation	1 vote
			Large-scale, Faithful, Efficient Simulation Algorithms	1 vote
			Stochastic Optimization and Risk Management	1 vote
Long-term horizon	New System-wide Management and Coordination Tools	1 vote	Extending Models with New Aspects (3 votes)	3 votes
	Stochastic Optimization and Risk Management	1 vote	Large-scale Data-based Methods	3 votes
			Stochastic Optimization and Risk Management	2 votes
			Large-scale, Faithful, Efficient Simulation Algorithms	1 vote
			Conceptual Model Alignment	1 vote
			New CPSoS Engineering Frameworks	1 vote
			Collaborative Engineering and Runtime Environments	1 vote
			New System-wide Management and Coordination Tools	1 vote
			Validation and Verification of Large-scale CPSoS	1 vote
			Extending Models with New Aspects	1 vote



Summary of the breakout sessions, Discussion, Next steps and conclusion

The closing session of the meeting was held after the breakout sessions. The results of the discussions during the domain-specific parallel sessions were presented by the chairs (P. Panciatici, S. Engell and M. Reniers) and discussed among the participants. The main research topics put forward in the breakout sessions were summarized as follows:

Smart grids and smart buildings:

- System Integration of Active Distribution (7 votes, short-term horizon)
- Requirement for the Associated ICT Systems (5 votes, industry: medium-term to long-term horizon)
- Massive Integration of Inverter-based Components (4 votes, mostly short-term horizon)
- System Stability (4 votes, predominantly from academia)
- Data availability and new business models (4 votes, short-term horizon)
- Better Use of Measurements (Estimation) (4 votes, medium-term horizon)
- Cyber-security (privacy) (4 votes, long-term horizon)
- Distributed (Decentralized) Controls at Substation Level (4 votes, mostly long-term horizon)

Process industries:

- Integration of supply chain management, scheduling, and control (12 votes, industry: long-term horizon, academia: medium-term horizon)
- Reduction of the modelling effort (9 votes, mostly long-term horizon)
- Modelling, optimization and simulation tools (8 votes, mostly short-term horizon)
- Standardization of interfaces on the higher automation layers (8 votes, mostly short-term horizon)
- Dynamic reconfiguration (6 votes, long-/medium-term horizon)
- Validation and verification of the proper functioning of systems (6 votes, academia: long-term horizon, industry: medium-term horizon)
- Integrity, security and trust (6 votes, short- to medium-term horizon)
- Industrial demand response (5 votes, short- to medium-term horizon)
- Handling of disturbances, faults and abnormal situations (5 votes, medium-term horizon)

Tool support:

- Model Management (6 votes, short-term horizon)
- Large-scale, Faithful, Efficient Simulation Algorithms (5 votes, mostly short-term horizon)
- New System-wide Management and Coordination Tools (5 votes, mostly medium-term horizon)
- More Powerful Optimization Algorithms/Tools (5 votes, medium-term horizon)
- Stochastic Optimization and Risk Management (4 votes, long-term horizon)
- Collaborative Engineering and Run-time Environments (4 votes, mostly medium-term horizon)

After the presentation of the results of the prioritization of the research topics, a subsequent discussion was conducted. Referring to the results of the session on tools, Patrick Panciatici stressed openness of models, transparency of the modelling procedure and tracking of the modelling process. Michel Reniers elaborated the topic mentioning the problem of openness of the data collected over time.

Sebastian Engell concluded the meeting by thanking the participants for their collaboration and for fruitful and focused discussions. He mentioned that the CPSoS consortium will further analyse and process the gathered prioritization results and will synthesize a few research topics that are general and not domain-specific and that could become headlines for the next calls of the EU on research and innovation in the domain of systems of systems.

Conclusion

The discussions provided very useful input for the further elaboration of the document on the state-of-the-art and the future challenges in the domain of physically connected systems of systems, confirming its current content for the most part. Several research challenges were proposed by the

611115	CPSoS	D4.2 Report on Public Events
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CPSoS consortium and by the participants of the workshop. These were discussed and prioritized in terms of time frames of the research development and technological implementation of the solutions in practice. The findings have been further discussed with domain experts and within the consortium and were presented to the European Commission in December 2014.

More information, such as the input paper and results of the first meeting of Working Group 1 is provided in Section 7 (Annexes) of the public deliverable D2.2 “Report on the second meeting of Working Group 2, with input paper ‘Analysis of the state of the art and future challenges in the application domain related to WG2’”, available in the [Deliverable Section](#) of the [CPSoS website](#).



3.4. Workshop on Tools and Methods for Management and Engineering of CPSoS (Feb. 2015, Eindhoven/NL)

On February 9th, 2015 the *“Workshop on Tools and Methods for Management and Engineering of CPSoS”* took place at TU/e, Eindhoven, Netherlands. The purpose of this workshop was to discuss research challenges in the area of Engineering of Cyber-Physical Systems of Systems proposed by CPSoS.

3.4.1. Agenda

Programme		
10:30 - 11:00	Introduction to the CPSoS project	<u>SEBASTIAN ENGELL, TUDO & HAYDN THOMPSON, HAYDN CONSULTING</u>
11:00 - 11:45	Modeling, analysis and co-design of control tasks over wireless networking protocols: state-of-the-art and challenges	<u>ALESSANDRO D’INNOCENZO & MARIKA DI BENEDETTO, UNIVERSITA AQUILA</u>
11:45 - 12:30	Model Driven Engineering for high-performance servo control – from research to industrial practice	<u>JEROEN VOETEN & RAMON SCHIFFELERS, ASML</u>
13:30 - 14:15	Real-time capable mobile devices as a platform for CPSoS implementations	<u>STEFAN KOWALEWSKI, RWTH AACHEN</u>
14:15 - 14:45	Cyber-Physical Systems Challenges – A Needs Analysis for Collaborating Embedded Software Systems	<u>GARETH THOMAS & JAN WILLEM POLDERMAN, THE MATHWORKS</u>
15:15 - 16:30	Key CPSoS Research and Innovation Challenges	<u>SEBASTIAN ENGELL, TUDO & MICHEL RENIERS, TU/E</u>
16:30 - 17:15	The Future of Model Driven Software Engineering	<u>ROBERT HOWE, VERUM SOFTWARE TOOLS</u>

3.4.2. Participants

In total, 31 participants from different backgrounds were present, amongst which 12 representatives of local industry and 9 members of the CPSoS Working Group 3.



611115	CPSoS	D4.2 Report on Public Events
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1. Robert Howe (Verum Software Tools)
2. Gareth Thomas (The MathWorks)
3. Rachid Kherrazi (Nspyre)
4. Ivo ter Horst (ASML)
5. Vincent Gijssen (Alewijnse)
6. Joost van Eekelen (Vanderlande Industries)
7. Willem van Veggel (ASML)
8. Maarten Kuijper (FEI)
9. Paul Hoogendijk (Verum Software Tools)
10. Amin Mannani (Alten Mechatronics)
11. Lou Somers (Océ)
12. Matti Kinder (ASML)
13. Stefan Kowalewski (RWTH Aachen)
14. Erwin Schoitsch (AIT – Austrian Institute of Technology)
15. Alessandro D’Innozenzo (Universita l’Aquila)
16. Martin Törngren (KTH Stockholm – Delegate FP7 project CyPHERS)
17. Michel Reniers (TU/e, Department of Mechanical Engineering)
18. Christian Sonntag (TUDO, euTexoo)
19. Wan Fokkink (TU/e, Department of Mechanical Engineering)
20. Bertrand Copigneaux (inno TSD)
21. Sebastian Engell (TUDO)
22. Radoslav Paulen (TUDO)
23. Haydn Thompson (Haydn Consulting, Think)
24. Svetlana Klessova (inno TSD)
25. Maurice Heemels (TU/e, Department of Mechanical Engineering)
26. Bram van der Sande (PhD student ASML from TU/e, Department of Electrical Engineering)
27. Ernesto Romero Sahagún (Master student ASML from TU/e, Department of Mechanical Engineering)
28. Bert van Beek (TU/e, Department of Mechanical Engineering)
29. Yorrick Vissers (Master student ASML from TU/e, Department of Mechanical Engineering)
30. Robinson A. Medina Sánchez (PhD student, TU/e, Department of Electrical Engineering)
31. Lennart Swartjes (PhD student Vanderlande Industries from TU/e, Department of Mechanical Engineering)

3.4.3. Summary of the Workshop

The program of the workshop was composed of presentations by members of Working Group 3, by representatives of local industry and a presentation and discussion of the research challenges that have been identified by the project.

At the beginning of the meeting, Sebastian Engell (TU Dortmund) briefly presented the CPSoS project, its goals and structure, for the participants in the audience that were unfamiliar with the project. Haydn Thompson then informed about recent developments of ideas of the European Commission in the areas of Internet of Things and Cyber-Physical Systems.

This introduction was then followed by the intervention from Alessandro D’Innozenzo (University of l’Aquila), who discussed the state-of-the-art and challenges for modelling, analysis and co-design of control tasks over wireless networking protocols. Advantages of the use of wireless communications are their low cost, broader scope of sensing and control, and reconfiguration enabledness. Drawbacks are increased complexity of the overall system, nonideal behaviour, and security issues. Reported challenges are the formal specification of interfaces (for both control and communication), quality of experience metric of control, robustness to package loss, formal verification and automatic co-design of networked systems, absence of acceptable co-simulation tools for control and communication, and real-time protocols for wireless communication and control.

Ramon Schiffelers (ASML) then illustrated the challenges in the realization of high-end servo control in lithography applications. A platform-based and model-driven engineering approach was proposed. Platform-based design offers a separation of concerns of application configuration data and platform configuration data through a mapping of configuration data. For convenient specification, domain-specific



611115	CPSoS	D4.2 Report on Public Events
--------	-------	------------------------------

languages are proposed. By means of (automated) model transformations models are transformed to general purpose formalisms that can be used for analysis and synthesis.

This presentation was followed by the intervention from Stefan Kowalewski (RWTH Aachen), who demonstrated how the integration of control systems with the cloud / web may be achieved and which hurdles need to be taken. Devices with the operating system Android can be used for control if real-time behaviour can be assured. It was shown how Android can be made real-time capable, however at the expense of lower energy efficiency. The second part of the talk focused on on-the-spot validation of PLC code applying techniques from model checking using invariants and over-approximation techniques such as value sets and intervals, bit sets and k sets to obtain the necessary abstraction for scalability purposes. The last part of talk demonstrated the software architecture of a system for extra-corporal membrane oxygenation.

Gareth Thomas (The Mathworks) then presented three focal points from which several needs for collaborating embedded systems are identified by The Mathworks. These focal points are (1) research in CPS is fundamental, (2) identifying needs/challenges is key in moving the needle, and (3) software tools play a key role in connecting academia and industry. The identified needs are the following: (1) collaborative planning, guidance and control, (2) distributed multi-rate architectures (extracting and deriving specific value from general information), (3) multi-use functionality post deployment and feature extraction, and (4) systematic test suite generation and automated test evaluation (test results reproduction under minimum uncertainty). From the discussion afterwards it was noted that tools should fit into industrial workflows, otherwise they are not taken up.

During the following session, Sebastian Engell and Michel Reniers (TU/E) presented the current status of the research agenda of the CPSoS project. Three main research and innovation challenges were presented:

- Distributed, reliable and efficient management of CPSoS,
- Engineering support for the design-operation continuum of CPSoS, and
- Cognitive CPS

From the discussion with the audience it is noted that the challenges seem very ambitious. For example in the area of verification scalability is known to be a problem for systems much simpler than CPSoS already. It was agreed that an ordering into short, medium and long-term challenges is needed.

Robert Howe (Verum Software Tools) then stated during his presentation, that software is increasingly embodying the value of a product and that conventional software engineering is failing to meet the needs of the businesses that depend on it. Model driven software engineering must be used to improve the engineering process. For this to be successful it must be easy for customers to adopt the approach, it must cope with legacy software, offer a total solution and foremost provide compelling, measurable benefits. Model driven software engineering needs to be about people, customer business cases and making money. There are enough workable model driven design technologies around. All the elements to be successful are in place. We just need a determined drive to bring them all together.

Presentations given at the Workshop have been made available on the [CPSoS website](#), via the related [news](#).



3.5. Exhibition booth at ARTEMIS Co-Summit 2015 (March 2015, Berlin/DE)

The CPSoS project participated to the [ARTEMIS Co-summit 2015 exhibition](#) in Berlin with a joint booth with the [DYMASOS](#) project.

The objective of the project participation to the event was to reach out to the ARTEMIS/ECSEL/ITEA communities and to increase project visibility in these communities. The event was also a good opportunity to launch and promote the [project public consultation](#) on the initial roadmap document.



Objectives

The objectives of the joint ARTEMIS participation of CPSoS and DYMASOS were:

- To find out what is going on in Artemis; what are the plans, what are the key topics proposed
- To increase visibility of the preliminary roadmap of CPSoS and of the SOTA paper
- To launch the promotion of the public consultation
- To reach out to the ARTEMIS/ECSEL/ITEA communities and to increase project visibility in these communities
- To connect with the companies that are in ARTEMIS projects, to collect business cards, and initiate discussions, with a special interest in SMEs and system integrators
- To establish contact with ARTEMIS/ECSEL/ITEA SMEs and with the ARTEMIS Working Group “SME Involvement”

Dissemination and Discussion Results

- 26 ARTEMIS/ITEA projects proactively contacted and made aware of CPSoS, DYMASOS, and the public consultation
- 90 public consultation invitations distributed
- 41 CPSoS flyers distributed
- Approx. 60 DYMASOS flyers distributed
- 25 roadmap documents distributed (many more people were referred to the online version and the online State-of-the-Art paper)
- 29 business cards of interested participants collected

Dissemination Activities

Overall, more than 100 projects were present at the event, and contact with the projects most relevant to the area covered by CPSoS was actively sought. During these face-to-face meetings:

- CPSoS & DYMASOS were introduced (based on flyers),
- the CPSoS “Public Consultation” questionnaire was promoted and interlocutors were asked to circulate it within their consortia,

611115	CPSoS	D4.2 Report on Public Events
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- Where appropriate, it was enquired about SMEs and system integrators in the projects

These activities helped to widely spread information about the project, but also to obtain a big amount of information on organisations involved, specific interests, and contacts and led to numerous interactions.

3.5.1. Other Potentially Interesting Projects

Due to time constraints, it was not possible to interact with all the projects that may possibly be of relevance to DYMASOS and/or CPSoS, but a list of these projects not yet contacted –namely those specialised in Engineering, Safety and security, Mobility and last not least in Knowledge-based society – was established so that they can easily be contacted at another occasion.

3.5.2. Conclusion

The participation in the ARTEMIS Co-Summit was a good opportunity to disseminate information about the projects, and to establish first contacts and interactions with related projects and organisations, which will be very useful during the remaining lifetime of the project.



3.6. Workshop on Achievements in Systems of Systems Research and Innovation (May 2015, Florence/IT)

On May 28th, 2015 the European research community on Cyber-physical Systems and Systems of Systems met in Florence for the Workshop on Achievements in Systems of Systems Research and Innovation. Representatives from current ([AMADEOS](#), CPSOS, [DYMASOS](#), [LOCAL4GLOBAL](#)) and previous ([CyPHERS](#), [COMPASS](#), [DANSE](#)) EU-funded research projects were present to the workshop along with representatives from the European Commission.

3.6.1. Agenda

Workshop on Achievements in Systems of Systems Research and Innovation

Thursday, May 28th, 2015 – Florence/Italy

Venue: Auditorium Al Duomo

Room: Vasari – Address: Via de' Cerretani, 54/R - 50123 Florence - Italy

The Workshop is organized by the Cluster of European Projects on Systems of Systems that includes the projects AMADEOS, CPSOS, DYMASOS and LOCAL4GLOBAL. The purpose of the workshop is to highlight the results that were obtained during the first 18 months and the achievements of the finished EU-funded projects in the area of Cyber-physical Systems and Systems of Systems, and to exchange ideas on the research challenges in the area of systems of systems and on steps towards innovation.

Agenda

08h30-09h00	<i>Arrival of participants, registration & networking</i>
Opening	
09h00-09h10	Welcome from the organisers
09h10-09h30	Welcome from the European Commission
Roadmap on Cyber-physical Systems	
09h30-10h00	Presentation from CyPhERS Vision and Challenges in CPS Saddek Bensalem (Université Joseph Fourier and Verimag, Grenoble)
Technical Session 1: Systems of Systems Dynamics, Management and Control	
10h00-10h30	Presentation from LOCAL4GLOBAL Acting Locally for Optimizing Globally Elias Kosmatopoulos (CERTH - Centre for Research and Technology Hellas), Iakovos Michailidis (CERTH), Angelos Gerghiou (ETH Zurich), John Lygeros (ETH Zurich)
10h30-11h00	<i>Coffee break</i>
11h00-11h30	Presentation from DYMASOS A population control approach for large-scale electricity demand coordination Sergio Grammatico (ETH Zurich), Basilio Gentile (ETH Zurich), Francesca Parise (ETH Zurich), John Lygeros (ETH Zurich)
11h30-12h00	Presentation from AMADEOS Complexity Management in Cyber-physical Systems-of-Systems Hermann Kopetz (TU Vienna)



Technical Session 2: Models and Tools for Systems of Systems Engineering	
12h00-12h30	Presentation from COMPASS Model-based Engineering for Systems of Systems Claire Ingram (Newcastle University)
12h30-13h00	Presentation from DANSE Designing for adaptability and evolution in system of systems engineering Valerio Senni (ALES S.r.l. – United Technology Systems and Control Engineering)
13h00-14h30	<i>Lunch break</i>
14h30-15h00	Presentation from AMADEOS The AMADEOS SYSML Profile for Cyber-physical Systems-of-Systems Paolo Lollini (University of Firenze)
15h00-15h30	Presentation from DYMASOS Integrated design, validation, and deployment of CPSoS control architectures <u>Christian Sonntag</u> (euTeXoo), Shaghayegh Nazari, Sebastian Engell (TU Dortmund)
15h30-16h00	<i>Coffee break</i>
Towards a European Roadmap on Cyber-physical Systems of Systems	
16h00-16h30	Presentation from CPSoS and Discussion Core Research and Innovation Areas in Cyber-physical Systems of Systems Sebastian Engell (TU Dortmund)
Future plans of the on-going projects and steps towards innovation	
16h30-17h15	Presentations by AMADEOS, DYMASOS, and LOCAL4GLOBAL and discussion
17h15-18h00	General Discussion: Joint activities, dissemination and innovation
18h00	<i>End of the workshop</i>

3.6.2. Participants

82 attendees overall

Elias Kosmatopoulos	Wenzel, Simon	Andrea, Bondavalli	Valerio Senni
Iakovos Michailidis	Grammatico, Sergio	Paolo, Lollini	Cannizzaro, Giovanni
Angelos Georghiou	Baotic, Mato	Andrea, Ceccarelli	Esen, Hasan
John Lygeros	Novoselnik, Branimir	Marco, Mori	Chelini, Lorenzo
Alonso, Itziar	Epple, Ulrich	Michele, Vadursi	Gabrielli, Letizia
Garcia, Alvaro	Maxeiner, Lukas	Benessa, Defend	LaManna, Mario
Gilabert, Eduardo	von Trotha, Christian	Klaus, Kursawe	Zanichelli, Paola
Christina Diakaki	Beisheim, Benedikt	Hermann, Kopetz	Paganelli, Federica
Diamantis Manolis	Pawlucka, Dorota	Bernhard, Frömel	Alberts, Maris
Roozbeh Sangi	Nazari, Shaghayegh	Oliver, Höftberger	Giuli, Dino

611115	CPSoS	D4.2 Report on Public Events	
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Thomas Schild	Del Real, Alejandro	Sara Bouchenak	Cianchi, Paolo
Michael Krause	Camacho, Eduardo	Mihaly Berekmeri	Schoitsch, Erwin
Walid Fourati	González Naranjo, Alfredo	Lucas Perronne	Turchi, Stefano
Paul Beauchat	Gentile, Basilio	Francesca Flamigni	Pola, Giordano
Klessova, Svetlana	Bolfek, Martin	Barry Lennox	Andreia Magali Rossi
Copigenaux, Bertrand	Boskovic, Marin	Werner STEINHOEGL	Silvia Mazzini
Engell, Sebastian	Davide, Iacono	Patrick Hartigan	Shaya Alshaya
Paulen, Radoslav	Francesco, Brancati	Philippe Baufreton	Abdullah Alsaleh
Sonntag, Christian	Claudio, Fantacci	Ricardo Sanz	Valerio Senni
Thompson, Haydn	Arun, Babu	Claus Thybo	
Reniers, Michel	M. IACOB, Sorin	Claire Ingram	

3.6.3. Summary of the workshop

During the workshop, the projects presented research results on **Systems of Systems Dynamics, Management and Control** and on **Models and Tools for Systems of Systems Engineering**. This exchange enabled the projects to recognize a shared definition of Systems of Systems and to clarify each project's focus. While all current projects share connections to the past projects (COMPASS and DANSE), AMADEOS is mostly focusing on developing tools and requirements and understanding of fundamentals, while DYMASOS and Local4Global are more control-oriented projects (DYMASOS being on higher-level management while Local4Global addresses more control-theory-related issues).



The workshop was also the occasion of sharing ideas on steps towards innovation in the domain with presentation of the running projects on their vision of exploitation and innovation strategy. The potential for SoS innovation is considered important as significant gains in economics terms and efficiency can be achieved. The timing is right as advance in ICT makes it possible to establish the advanced solutions and tackle the newly arising problems, such as changes in structures of the systems and drivers for management decisions. However legacy systems could raise issues, especially when the structure of the systems is not clear and the modelling not straightforward. In addition the expectations are high, as Industry expects radical changes (5% improvement in energy

611115	CPSoS	D4.2 Report on Public Events
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savings considered not enough), and could lead to discontinuity in investment (hype cycle and trough of disillusionment).

During the last part of the workshop, the roadmap on [Core Research and Innovation Areas in Cyber-physical Systems of Systems](#) developed by CPSoS was presented to the audience and discussed, bringing additional comments from the various project participants that complement the [public consultation](#) that was run by CPSoS. The importance of interactions between the technical aspects of the Systems of Systems and their human users was discussed and cognitive systems and user behavior studies were considered to be an important aspect by the audience.

The potential impacts of Systems of Systems are considered of key importance for future society, as they will enable trusted resilience and optimal balancing of supply and demand, while making systems resilient to negative emergent behavior and preventing negative emergent behavior.

The presentations of the workshop are available on the CPSoS web site: <http://www.cpsos.eu/open-workshop-on-may-28th-2015/>



4. Upcoming Public Events

4.1. Working Groups Meeting in conjunction with the ARTEMIS Technology Conference 2015 (Torino/IT on Oct. 6, 2015)



The next (third) meeting of all CPSoS Working Groups is planned to be held at the ARTEMIS Technology Conference 2015, which is taking place on October 6-7, 2015 in Turin, Italy.

Interactions with ARTEMIS have led to the possibility to organise this meeting as a workshop, which will be open to all participants of the conference.

6 overarching research and development topics, comprising several sub-topics, have been defined by the CPSoS project as main challenges for the next 5-7 years. The aim of the meeting will be to communicate and discuss the medium-term research priorities, suggested by the CPSoS project to be included in the research agenda.

Besides these general topics, domain-specific topics for different areas shall be put forward.

4.2. Networking Session “Systems of Systems Engineering: What Next?” at ICT2015 (Lisbon/Portugal, Oct 2015)



CPSoS has been selected to organise a Networking Session during ICT 2015 Innovate, Connect, Transform, event organised by the European Commission, together with the Fundação para a Ciência e a Tecnologia on October 20-22, 2015 in Lisbon, Portugal.

The objective of this Networking session will be to discuss the “what next?” in the systems of systems engineering and its challenges from the point of view of industrial reality, and to obtain cross-domain feedback and validation of the research and innovation priorities with experienced representatives of industry and academia, based on the [Roadmap](#) the project has set up.

The session will be opened by short statements from the project coordinator and from two leading representatives of the European industries that develop and deploy components of systems of systems, and then be followed by an interactive session, where discussions will be moderated by an experienced project partner. In the end, each participant will be asked to fill a questionnaire, and thus take the opportunity to (a) rank research topics and to and provide comments and new insights on the existing research and innovation priorities, and to (b) provide own ideas for new challenges in a free-text section.

The outcomes of the session will be captured by creating a session summary report based on minutes that are created by an experienced rapporteur, and on the questionnaires.

4.3. Final CPSoS Event: Symposium “Cyber-physical Systems of Systems Meeting Societal Challenges”

A symposium “Cyber-physical Systems of Systems Meeting Societal Challenges” shall be organised as at the end of the CPSoS project, and shall also represent the fourth and last meeting of the CPSoS Working Groups. The goal of this event will be to present the policy proposal “European Research Agenda for Cyber-physical Systems of Systems and their engineering needs” and technical papers supporting it, currently being developed and worked on by the project, to a wide public.

The final CPSoS event will be divided in two complementary parts, and will be organised in conjunctions with the two large-scale international events:

611115	CPSoS	D4.2 Report on Public Events
--------	-------	------------------------------

- Between April 11-14, 2016, at the CPS Week in Wien, Austria. CPS Week is the premier event on Cyber-Physical Systems, bringing together four top conferences, HSCC, ICCPS, IPSN, and RTAS, 10-15 workshops, a localization competition, tutorials and various exhibitions from both industry and academia. Altogether the CPS Week program covers a multitude of complementary aspects of CPS, and reunites the leading researchers in this dynamic field. This CPSoS event targets academic participants.
- On April 26th 2016 at the Hannover fair, the biggest industrial fair in Europe. A two-hour meeting and networking lunch is planned, to be announced in the Hannover fair advertising materials. This CPSoS event targets specifically industrial participants.



5. Annexes

5.1. Press Release: Public meetings of the three Working Groups



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

Press Release: Public meetings of the three CPSoS Working Groups

The CPSoS project launched discussions of its three Working Groups with experts from industry and academia to prepare the European Roadmap on Cyber-physical Systems of Systems.

Cyber-physical Systems of Systems are of crucial importance for the well-being of the citizens of Europe. The most important examples are the systems for the generation and distribution of electric energy, drinking water and gas, rail, road, air and marine transportation systems and their elements, and industrial production processes. To tackle the challenges posed by the engineering and the operation of technical systems in which computing and communication systems interact with large complex physical systems, the CPSoS project provides a forum and an exchange platform for Systems of Systems related communities and ongoing projects.

CPSoS has organized public Working Group meetings with experts from industry and academia to progress the "European Research and Innovation Agenda on Cyber-physical Systems of Systems".

Two Working Groups analyse the state of the art in specific application domains of transportation and logistics, and physically connected SoS (electric grids, industrial complexes, smart buildings) in a bottom-up fashion and collect needs for research and development in methods and tools for Systems of Systems engineering and operation. The third Working Group analyses the available tools and methods and the existing gaps from a methodological point of view.

Working Group 1: Transportation and Logistics



The 2nd Working Group Meeting of the Transport and Logistics Working Group took place in conjunction with Automotive Megatrends Europe 2014 which was held in Brussels on September 10-11. The Conference brought together key stakeholders from industry and academia to network and debate business models, technologies and trends that will shape Europe's commercial vehicle and passenger car markets over the next ten years and beyond. The conference attracted over 100 expert speakers and 250 delegates discussing cutting edge topics including fuel economy, emissions reduction, eMobility and in-car connectivity. CPSoS sponsored the event and widely circulated the work and the outcomes of the Transport and Logistics Working Group over the two days, including an Exhibition Stand for the promotion of the project. The sessions and panel discussions highlighted that increased connectivity is the main trend

for the future in this sector and offers many advantages for both commercial vehicles and passenger cars. Examples of fuel, emissions and maintenance savings made by a number of key companies operating fleets of vehicles were highlighted and greater safety and fuel economy are promised by increased use of autonomous driving features in future vehicles. On the second day of conference a Working Group Meeting was held. The objectives of the Working Group Meeting were twofold:

- 1) Refinement and Comments on State-of-the-Art and Challenges in Transport and Logistics Report



This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No 611115.

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2) Discussion of the Draft Overall Research Priorities put forward by CPSoS

The report was presented over the first half of the meeting, comments were received and clarifications given on the key findings. The Working Group concurred that the report gave a good overview of the state-of-the-art across the different domains and with the recommendations made for future research priorities. Additionally, the draft overall recommendations from CPSoS were discussed. This highlighted the need for clarifications in a number of areas and the need to consider complexity management, risk modelling and management of models. Find out more [here](#).

Working Group 2: Physically Connected Systems

The public meeting of the CPSoS Working Group 2 on physically connected Cyber-physical Systems of Systems took place on October 1st 2014 at ETH Zürich. 39 European experts from the domains of process industries, smart grids, smart cities, automation, and systems engineering met to discuss the state of the art and future developments in the engineering and operation of physically connected CPSoS. The workshop was organised jointly by CPSoS and the [DYMASOS](#) project and the DYMASOS project consortium and the members of the DYMASOS Industrial Advisory Board participated in the CPSoS breakout sessions.



First two plenary sessions were held on management methods for physically connected CPSoS and tools to support their engineering. Then domain-specific breakout sessions on smart grids, process industries, and tool support for physically coupled SoS took place. The main goal of the breakout sessions was to discuss the future research needs in the respective areas. Lists of research topics in the different domains were discussed and prioritized. Find out more [here](#).

Working Group 3: Tools for SoS Engineering and Management



The second WG meeting and public event of Working Group 3 took place as a Workshop on Tools and Methods for CPSoS on September 12th in Bertinoro, Italy in conjunction with [IFM2014](#). For the workshop an open call for presentations had been issued. Five contributed presentations were given on security models for cyber-physical systems (V. Sassone), hierarchical control of large complex plants (C. de Prada), optimization methods for recoverable smart electric grids (L. Petre), a decision support system for Systems of Systems management (M. Fantì) and on model-based support for dependable Cyber-physical Systems of Systems (C. Ingram). An invited presentation was made by A. Cimatti (WG 3 member) on a formal approach to the design and operation of complex systems. After the technical presentations,

the analysis on the state of the art and future challenges in the domain of tools for CPSoS was presented and discussed. Find out more [here](#).





Towards a European Roadmap on CPSoS

Based on the results of these discussions, the CPSoS project will present a first draft of [a document on the Scope and Research Needs in the area of Cyber-physical Systems of Systems](#) to the European Commission in December. This paper will later be complemented by detailed technical papers written by the members of the Working Groups and will contribute to the definition of the future EU research policy on CPSoS.

About the project:

CPSoS Consortium	About the CPSoS Project
<p>TU Dortmund, <i>Germany</i> </p> <p>Haydn Consulting Ltd., <i>UK</i> </p> <p>TU Eindhoven, <i>Netherlands</i> </p> <p>inno TSD, <i>France</i> </p>	<p>Supported by the European Commission under the FP7-ICT programme (contract no. 611115)</p> <ul style="list-style-type: none"> > Start date: October 1, 2013 > Duration: 30 months > Budget: 640 000 € (with an EC contribution of 560 000 €) > Coordinator: Prof. Sebastian Engell TU Dortmund, Germany

MORE information on CPSoS : www.cpsos.eu.

Read the newsletters and subscribe for the joint [newsletter](#).

