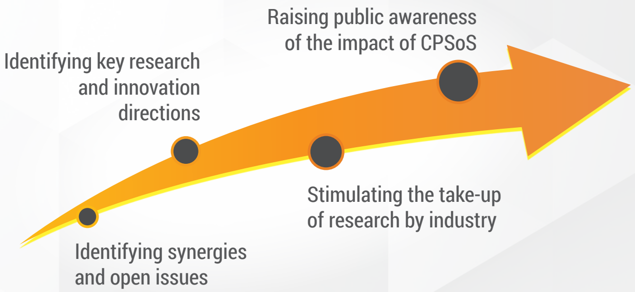
What will CPSoS deliver ?

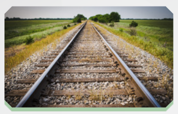
CPSoS will provide a research agenda for Cyber-physical Systems of Systems that:

- Identifies **synergies** and **open issues** based on industrial and societal needs, and the state of the art of tools, theories, and methods,
- Proposes **promising trans-disciplinary research directions**,
- Is driven by the needs of **real-world applications**,
- Takes a **broad**, **trans-disciplinary** view on theories, tools, and methods from several domains,
- Is developed with the help of **key researchers and application domain experts.**



CPSoS Working Groups

The three CPSoS Working Groups consist of 35 renowned experts in complex systems engineering and applications from industry and academia.



Working Group 1
Systems of Systems in Transportation and Logistics
Chair: Prof. Haydn Thompson, Haydn Consulting Ltd.

Working Group 2
Physically connected Systems of Systems
Chair: Prof. Sebastian Engell, TU Dortmund

Working Group 3
Tools for Systems Engineering and Management
Chair: Prof. Wan Fokkink, TU Eindhoven

About the CPSoS Project

Supported by the European Commission under the FP7-ICT programme (contract no. 611115)

- **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

CPSoS Consortium

TU Dortmund, *Germany*

Haydn Consulting Ltd., *UK*

TU Eindhoven, *Netherlands*

inno TSD, *France*

CPSoS is part of the

European Systems of Systems Research Cluster

AMADEOS
Architecture for Multi-criticality Agile Dependable Evolutionary Open System-of-Systems,
www.amadeos-project.eu

CPSoS
Towards a European Roadmap on Research and Innovation in Engineering and Management of Cyber-physical Systems of Systems, **www.cpsos.eu**

DYMASOS
Dynamic Management of Physically Coupled Systems of Systems, **www.dymasos.eu**

Local4Global
SoS that Act Locally for Optimizing Globally,
www.local4global-fp7.eu

More information: www.cpsos.eu
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CPSoS

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

Scan this with your phone

What are Cyber-physical Systems of Systems?

Large, complex, often spatially distributed Cyber-physical Systems that exhibit the features of Systems of Systems

Cyber-physical Systems (CPS)

Tight interaction

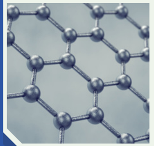
of many distributed, real-time computing systems and physical systems

Examples

- Airplanes
- Cars
- Ships
- Buildings with advanced HVAC controls
- Manufacturing plants
- Power plants
- ...

Systems of Systems (SoS)

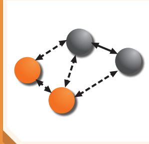
Many interacting components



Examples

- Large industrial sites with many production units
- Large networks of systems (electric grid, traffic systems, water distribution)

Dynamic reconfiguration



Components may...

- be switched on and off (as in living cells)
- enter or leave (as in air traffic control)

Physical connections

- Material/energy streams
- Shared resources (e.g. roads, airspace, rails, steam)
- Communication networks

Continuous evolution

Continuous addition, removal, and modification of hardware and software over the complete life cycle (often many years)

Partial autonomy

Local actors with local authority and priorities

Autonomous systems ...

- cannot be fully controlled on the SoS level
- need incentives towards global SoS goals

Examples

- Local energy generation companies
- Process units of a large chemical site

Emerging behavior

The overall SoS shows behaviours that do not result from simple interactions of subsystems

Usually not desired in technical systems, may lead to reduced performance or shut-downs

Examples

- Power oscillations in the European power grid
- Oscillations in supply chains

Examples of Cyber-physical Systems of Systems

Integrated large production complexes

- Major source of employment and income in Europe
- Major consumer of energy and raw materials
- Many interconnected production plants that are operated mostly autonomously with distributed management structures

Transportation networks (road, rail, air, maritime, ...)

- Vital to the mobility of EU citizens and the movement of goods
- Large integrated infrastructures with complex interactions, also across national borders
- Involve multiple organizational and political structures

Many more examples, e.g. smart (energy, water, gas, ...) networks, supply chains, or manufacturing

Cyber-physical Systems of Systems make use of advances in a large number of technological areas:

- High-performance computing and distributed computing technologies
- Dependable computing and communications
- Management and analysis of huge amounts of data (***big data***).
- Security of distributed/cloud computing and of communication systems
- Next-generation smart sensors
- Advances in human-machine interfaces (HMIs)
- Communication technologies and communication engineering

Research and Innovation Challenges

Modelling and large-scale simulation

- **Key** to design, operation, and improvement of CPSoS
- Models of CPSoS are **large-scale** and **heterogeneous**, and can consist of **many components** in different languages, software tools, and on different **time scales**

Needed:

- **Large-scale, efficient simulation** of heterogeneous Cyber-physical Systems of Systems, including **human interactions**
- Dynamic **on-the-fly reconfiguration** of simulation models
- **Coupling of simulation tools** of different strengths without remodelling
- **Management** of and **consistency guarantees** for many different models of different types, time scales, and levels of abstraction

Management and coordination

- Traditional management and coordination methods are not suitable due to the **partial autonomy** of the subsystems (which are often managed by humans)
  - → Performance is not only driven by technical, but also by **economic, social, and ecologic** criteria

Needed: New methods and tools for such **socio-economic systems** that take CPSoS properties (**autonomy, dynamic reconfiguration**, ...) into account

Fault-detection, testing, and error handling

- Faults and unwanted emerging behavior are the **norm** in CPSoS
  - → Extensive **system analysis** and **fault-resilient design** are **key issues**

Needed:

- New methods for the **analysis, testing, and verification** of CPSoS
- New methods for the integrated design of **resilient CPSoS across all automation and system layers**

Collaborative run-time engineering

Needed: New **engineering frameworks** that support the **adaptation, evolution, and maintenance** of CPSoS not only during design, but over their complete life-cycle

Security and trust

Needed: Methods for the **detection of and protection** against unauthorized access and data manipulation in internet-connected CPSoS

Data and systems integration

Needed: Integration and management of data collected and stored in heterogenous systems with different syntax and semantics