CyPhers Project: Main Results

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Support Action
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Duration: 18 months

Objectives

The goal was to systematically survey, analyse, and evaluate the economic, technical, scientific, and societal significance of Cyber-Physical Systems for Europe by

- providing a systematic classification of the CPS domain;
- modelling of the markets and their players relevant for CPS;
- developing a structured analysis and assessment of core technologies and the current state in science and technology related to CPS;
- analysing the future technological, economic and social implications of CPS, and
- assessing challenges, bottlenecks and risks for research and development in CPS.

Main results: Development of a comprehensive research agenda and related recommendations for actions in regard to the design and promotion of CPS

CyPhERS
Cyber-Physical European Roadmap & Strategy

CyPhERS Approach

State of the art

NIST CPS, PCAST reports

SoS, CPSoS,

Data Acquisition/Control

ICTLabs SIA, ARTEMIS SRA, H2020

Industrie 4.0, ITEA roadmap

Expert workshops and interactions

CPSWeek 2014

Stockholm

Munich

National Meetings

feedback

Preliminary recommendations

SWOT analysis

Technology assessment

CPS characterization

Domain analysis

CPS in the world

Market analysis model

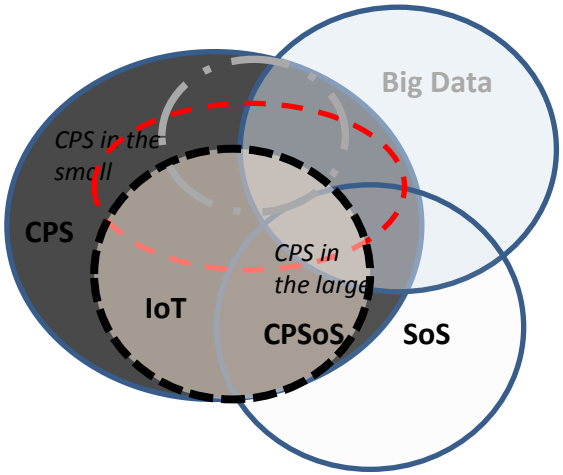
Outline

1. Introduction:
   - *Objectives*
   - *CyPhERS approach*
2. Main Results
   - Characterization of the CPS domain
   - Market and innovation potential of CPS
   - CPS Technologies
   - CPS: Significance, Challenges and Opportunities
   - Recommendations for Action
3. Conclusion

Characterization of the CPS domain

Findings – characterization

- Related terms mirror different perspectives
  - Many perspectives emphasize "digitalization"
  - CPS, Mechatronics, SE and SoS have a systems emphasis
- CPS encompasses many related concepts
  - The concepts contribute to the the complex, "cross-" technology/domain/discipline nature of CPS – key to CPS
- 10 characteristics to describe systems/domains



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CPS characterization

- Physical vs. Embedded vs. IT Dominated
- Single Domain vs. Cross Domain
- Closed vs. Open
- Degree of Autonomy
- Centralized vs. decentralized organization
- Governance and jurisdiction
- Adaptability
- Human In-/Outside the Loop
- Level of integration

CPS Technologies

Scenario-based Approach

- Five sectors of the economy:
  - *Manufacturing, Smart Grid, Transportation and Mobility, Healthcare and Medical Devices, Smart Cities*
  - For each sectors*:*
    - ***key drivers for CPS technology and use, technology push and demand pull, current and future vision,***
    - ***challenges and obstacles (technical and non-technical).***

- Why these five sectors of the economy?
  - *Prime areas of opportunity as they are emerging in many applications*
  - *Critical to the development of EU and society in general*

Future vision of CPS in Smart Cities (1)

"Smart City": *Two scenarios are of special interest*

The Best of Time

- *Helps run the infrastructure more effectively (desires and needs of the occupants and on the common good),*
- *Empowers the occupants in their daily activities by providing more effective interfaces, better mobility, etc*

The worst of time

- *Is able to safely and securely align both stationary (e.g., biohazard detection sensors) and mobile (e.g., UAVs, robots, humans) resources needed to protect itself and its inhabitants.*

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Future vision of CPS in Smart Cities (2)

In both scenarios:

The Best of Time

The worst of time

SmartCities *combine* the ***management of fixed infrastructure*** (e.g., environmental monitoring, energy-usage, tracking and mapping), ***mobiles*** (automatic vehicles, UAVs, robots), and ***immersive humans*** in an integrated whole.

This involves seamless discovery and integration of sensing, actuation and computation, with the use feedback to manage uncertainty

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Smart Cities: Key Drivers (1)

- ***The constantly increasing urbanization***.
- ***Insufficient infrastructures***: *traffic in cities, garbage collection, garbage disposal, energy distribution, internet connection.*
- ***Managing vital services***: *crime prevention, health care, and transportation better*.
- ***Making the city competitive in attracting people*** (tourists and professionals) ***and investments***. (*Modern cities are becoming almost states in their own and need to worry about the composition of their population.)*

Smart Cities: Key Drivers (2)

- ***Technology push***
  - *Comes from: sensor technology, big data analytics, cloud computing, control and optimization.*
  - *Can be disruptive if it is not corralled by strong integration capabilities and validation techniques.*
- ***Demand pull***
  - *Increasing demands on safety, security, better health care, traffic and resource management, better energy efficiency and more responsible production to prevent the destruction of the environment.*
  - Has to be fulfilled with reliability and without damaging privacy.

Technology Providers: Vision & Key Drivers

Vision

- ***Large data*** *sets will require new levels of controls for* ***privacy*** *and* ***security****.*
- ***Multi-disciplinary approaches*** *will* ***shape*** *future CPS.*
- ***New liability issues*** *will arise and need to be addressed.*
- ***Global standardized data*** *will be available for expert systems to extract.*
- ***Advanced testing and modeling*** *will lower the life cycle costs – operations and maintenance as design – and improve efficiency.*
- *IT, networking, manufacturing, and automation* ***will converge****.*

Key Drivers

- *Solving hard problems in* ***security*** *will continue to* ***drive CPS design*** *and* ***use*** *(both safe and secure).*
- ***Payback*** *will drive the implementation and expansion of CPS and infrastructures.*
- ***Industry requirements will shape future CPS****: advanced human-in-the-loop systems; accident-free actions; and monitoring and control integrated with data.*

Industry Users: Vision & Key Drivers

Vision

- ***Increasing cyber threats*** *are changing their* ***view*** *of* ***security****.*
- *The EU must* ***think globally*** *to realize the potential of CPS.*
- *Great* ***strides*** *are needed in* ***multi-disciplinary*** *system-level thinking.*
- ***Human factors*** *must be effectively addressed.*
- *Systems must be* ***adaptable*** *to changing environments and events.*

Key Drivers

- ***Attacks*** *and* ***intrusions*** *on networks will* ***grow****, making protection of data harder and more* ***expensive****.*
- ***Societal needs*** *for CPS will* ***increase consumer demand*** *for functionality and* ***reliability****.*
- ***EU leadership*** *in CPS could* ***open strategic markets*** *in vital industries and* ***grow*** *domestic* ***jobs****.*

Scientific, Education & Societal: Vision & Key Drivers

Vision

- *A **common science** for CPS **will be established**.*
- ***Availability**, **security**, and **safety** of systems will be **assured** by integrated **multi-disciplinary scientific approaches**.*
- ***Risk assessment** and **management metrics** will **link technical** and **business** issues.*
- *A **skilled CPS workforce** will remain **a high priority**.*
- *Breakthroughs, synergies, and new frontiers will epitomize future CPS.*

Key Drivers

- *Sectors and agencies will demand a **secure** CPS **infrastructure** and **technology**.*
- *The ease and cost of **systems integration** and **validation** is a key driver for implementation.*
- ***Security**, **energy**, and **public health** and **safety** are **major drivers** for CPS.*

Recommendations for Action

Recommendations: Science

Strengthen Key Sciences

- **Enabling Sciences**: "Research and Innovation Activities in core fields – from physical via ICT and data to system level – must be intensified."
- **Human-Machine Interaction**: "Integration of behavioral science and technical disciplines – from multi-modal ergonomics to modeling human behavior – must be key research."
- **Cross-Disciplinary Research**: "Research programs must address integration of participating disciplines, homogenization and integration of ontologies, domain models and languages."

Recommendations: Technology

Accelerate Maturation

- **Maturation Initiatives**: "Public- private partnerships should set up 'technology demonstrators' or 'show cases' accessible to a wider audience."
- **Available Infrastructure**: "Public-private partnerships must ensure the availability and affordability of dependable and trustworthy ICT infrastructure."
- **Key System Installation**: "Trans-European large- scale public-private partnerships should implement systems in key fields of societal importance like European Smart Grid or Smart Traffic."

Recommendations: Technology

Facilitate Interoperability

- **Reference Platforms**: "Research activities should provide medium-TRL reference platforms along stack of disciplines with a potential to be applied in several domains."
- **Interoperability Standards**: "Interoperability standards for components from different domains and organizations must be established and homogenized."
- **System-Level Design**: "Methodologies must be defined that support modular development of system-level services chains of physical, technical, and organizational processes ."

Recommendations: Innovation

Open Innovation

- **Open Standards**: "Funding programs must promote definition, provision, and evolution of open – both pre-normative and normative – standards."
- **OpenSource & Licence**: "Funding programs for Research Activities should promote the provision of open-source or open/free license results ."
- **Open Data**: "Support activities should facilitate access to open data, and specifically availability of live data."

Recommendations: Business

New Business Models

- **Open Innovation**: "Platforms should be provided facilitating initialization of contacts between innovators trying to enter service ecosystems and existing providers of services."
- **Service Infrastructure**: "Set-up of necessary technological and regulatory service infrastructure for providing highly dependable services must be supported."
- **Liability Frameworks**: "Regulation frameworks and supporting technologies must provided that non-refutably identify continued and temporary acceptance and delegation of responsibilities for services."

Recommendations: Education/Training

Enabling Education/Training

- **Collaboration**: „Incentives for academic and industry stakeholder should be provided to stimulate the cross-fertilization of pragmatic and theoretic knowledge.“
- **Live-Long Learning**: „Academic-industrial alliances should engage established engineers in life-long learning to ensure re-qualification.“
- **Education Platforms**: „Private-public cooperations for the operation of educational platforms must be supported, facilitating experimentation with new technologies and interdisciplinary learning .“

Recommendations: Society

Societal Awareness

- **Decisions Makers**: "Coordinated actions including European academies of engineering and science, societies of engineers, and management organizations should enable decision maker to understand impact on society and markets ."
- **Public Discussion**: "Dissemination activities addressing the wide public outside the scientific community should be established to to obtain public support and ensure an understanding of the necessary responsibilities."
- **Societal Consensus**: "Sciences of engineering and humanities must initiate and moderate process for defining publicly acceptable responsibilities of suppliers and users of technology."

Recommendations: Public

Trustworthiness

- **Infrastructure**: "Joint public private investments are needed to assess and improve security of both public and private ICT to protect critical infrastructures from cyber-attacks."
- **Data Ownership**: "Legal regulations clarifying treatment of data ownership including granting and revoking access, as well as corresponding technical implementations are needed."
- **Dependability Regulations**: "Research programs must address provision of mechanisms for highly automated operations and live update of dependable systems, and adaption of relevant standards and regulations ."

Conclusion

- The main aim of the CyPhERS project was to shape future directions of the European research and innovation in the area of cyber-physical systems. Subsidiary aims of CyPhERS are to influence industry and educational institutions to adopt a CPS agenda.
- The fundamental impact sought by the project is to secure the EU's position in the growing and fundamentally important CPS marketplace.
- There are many direct benefits of these CPS – corresponding to a number of societal goals – including lower energy/power consumption, improved safety, reduced environmental impact, increased efficiency and further economic benefits, and improved functionality and user experience.
- CyPhERS does not, of itself, deliver these ultimate impacts; however, it enables them and makes them more likely to come about. CyPhERS contributes to this by having built an understanding of technologies, markets, trends, opportunities and international competition as a basis to define a strategy for Europe.
- The CyPhERS project website is located at http://www.cyphers.eu

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