Cyber Physical Systems for Europe

# Euromicro DSD/SEAA 2021
# EPDSD 3 - European Projects on Digital System Design

*Pre-Integrated Architectures for sustainable complex Cyber-Physical Systems*

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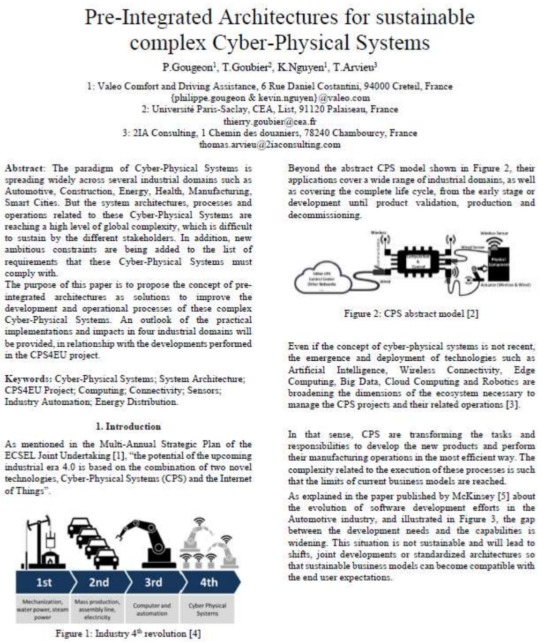
*Videoconference – September 1st, 2021*

# INTRODUCTIONS

## Pre-Integrated Architectures for sustainable complex Cyber-Physical Systems



Pre-Integrated Architectures for sustainable complex Cyber-Physical Systems

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**Abstract**: The paradigm of Cyber-Physical Systems is spreading widely across several industrial domains such as Automotive, Construction, Energy, Health, Manufacturing, Smart Cities. But the system architectures, processes and operations related to these Cyber-Physical Systems are reaching a high level of global complexity, which is difficult to sustain by the different stakeholders. In addition, new ambitious constraints are being added to the list of requirements that these Cyber-Physical Systems must comply with.
The purpose of this paper is to propose the concept of pre-integrated architectures as solutions to improve the development and operational processes of these complex Cyber-Physical Systems. An outlook of the practical implementations and impacts in four industrial domains will be provided, in relationship with the developments performed in the CPS4EU project.

**Keywords**: Cyber-Physical Systems; System Architecture; CPS4EU Project; Computing; Connectivity; Sensors; Industry Automation; Energy Distribution.

**1. Introduction**

As mentioned in the Multi-Annual Strategic Plan of the ECSEL Joint Undertaking [1], "the potential of the upcoming industrial era 4.0 is based on the combination of two novel technologies, Cyber-Physical Systems (CPS) and the Internet of Things".

| 1st | 2nd | 3rd | 4th |
|---|---|---|---|
| Mechanization, water power, steam power | Mass production, assembly line, electricity | Computer and automation | Cyber Physical Systems |

Figure 1: Industry 4th revolution [4]

Beyond the abstract CPS model shown in Figure 2, their applications cover a wide range of industrial domains, as well as covering the complete life cycle, from the early stage or development until product validation, production and decommissioning.

Figure 2: CPS abstract model [2]

Even if the concept of cyber-physical systems is not recent, the emergence and deployment of technologies such as Artificial Intelligence, Wireless Connectivity, Edge Computing, Big Data, Cloud Computing and Robotics are broadening the dimensions of the ecosystem necessary to manage the CPS projects and their related operations [3].

In that sense, CPS are transforming the tasks and responsibilities to develop the new products and perform their manufacturing operations in the most efficient way. The complexity related to the execution of these processes is such that the limits of current business models are reached.

As explained in the paper published by McKinsey [5] about the evolution of software development efforts in the Automotive industry, and illustrated in Figure 3, the gap between the development needs and the capabilities is widening. This situation is not sustainable and will lead to shifts, joint developments or standardized architectures so that sustainable business models can become compatible with the end user expectations.

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This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276. The JU receives support from the European Union's Horizon 2020 research and innovation programme and France, Spain, Hungary, Italy, Germany

# INTRODUCTIONS

## CPS4EU Project

- Managed by ECSEL JU
- 36 Partners from 5 European Countries
- 53 M. Euro budget
- 16 use cases in Automotive, Industry, Energy and for SMEs
- 7/2019 to 6/2022

- Web site: www.cps4eu.eu
- LinkedIn group: www.linkedin.com/groups/12372370/

**10 Large Enterprises**

**10 Academics and RTOs**

**14 SMEs: Technology providers**

**2 Dissemination organizations**



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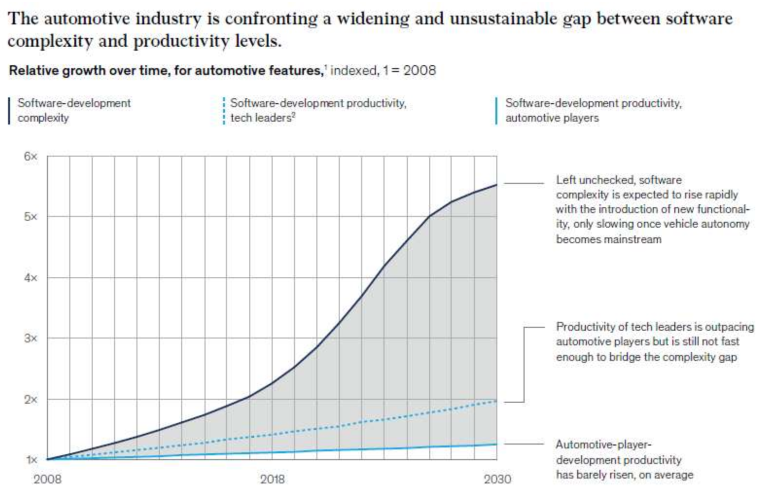
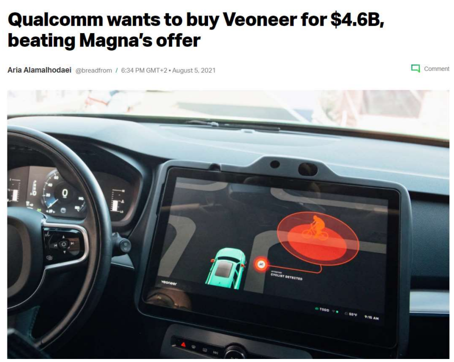
# EVOLUTIONS OF THE CPS* LANDSCAPE




[McKinsey, The case for an end-to-end automotive software platform, January 2020]


[VDA, China strategy, July 2020]




[Tech Crunch, August 2021]

- Increasing complexity of projects
- New powerful aggressive industrial players
- Long term goals, long term business models

(*) CPS: Cyber Physical Systems

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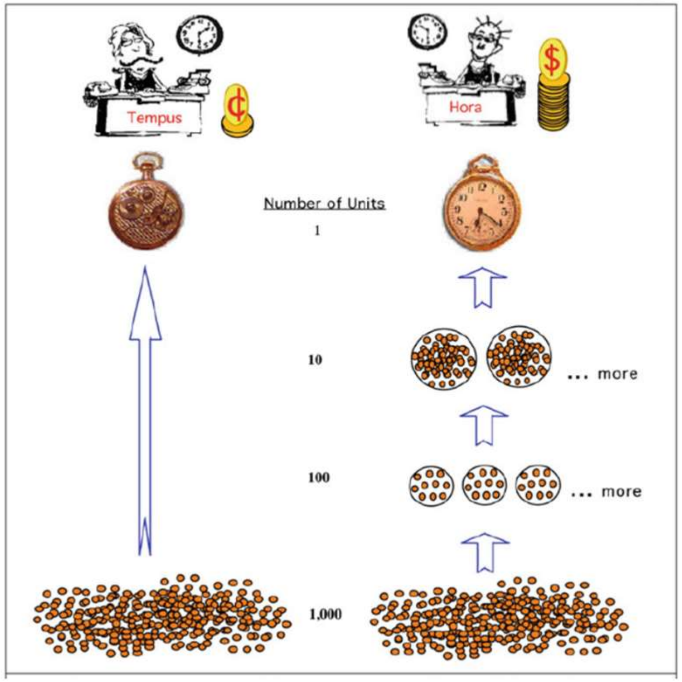
# EVOLUTIONS OF THE CPS* LANDSCAPE

## How to balance end user + societal expectations and sustainability ?

- Functional safety
- Cybersecurity
- Privacy and Ethics
- IP rights
- Export rules
- Liability
- Traceability
- CO2 neutrality
- Minimal usage of natural resources

(*) CPS: Cyber Physical Systems




[J.Wu, Hierarchy theory: an overview, 2013. Illustration of the watchmaker parable, based on the description in H.Simon, 1962 ]

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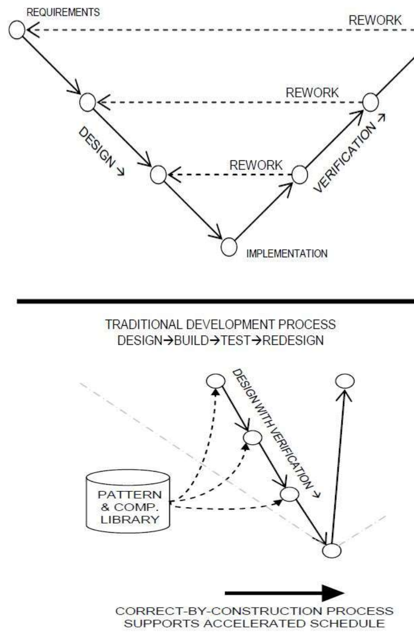
# PRE-INTEGRATED ARCHITECTURES

## Design Pattern concept extended to complex Cyber-Physical Systems

- Reduction of the R&D effort
- Trustworthy-oriented Architectures
- For three CPS layers: Physical, Cyber and Internet of CPS
- Manageable size: not too large, not too small
- Scalability for networked eco-systems
- Compatibility with legacy components,  processes and tools
- Inter-operability with other components or tools
- Pre-validated concepts to ensure homologation
- Flexibility to be configurable for the developer needs
- Possibility to be extended with additional features




**[D.Coffer et al.,Rockwell-Collins, Complexity-reducing design patterns for cyber-physical systems, 2011]**



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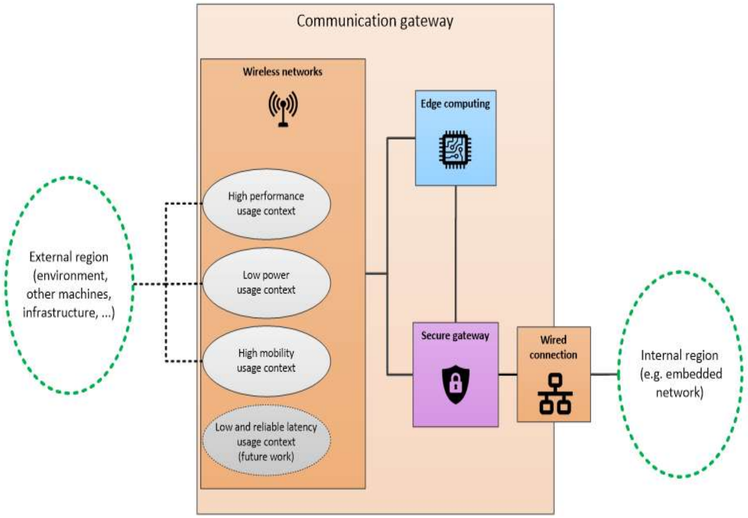
# PRE-INTEGRATED ARCHITECTURES

## 5 PIARCHs from CPS4EU

- Heterogenous computing for AI
- Secure CPS-to-X connectivity
- Cooperative system of systems
- Industrial edge computing gateway
- Sensing perception and localization

- Components come mainly from SMEs
- Tools come mainly from Academics
- PIARCH assemblers
- Use case developers




**Secure CPS-to-X connectivity PIARCH**



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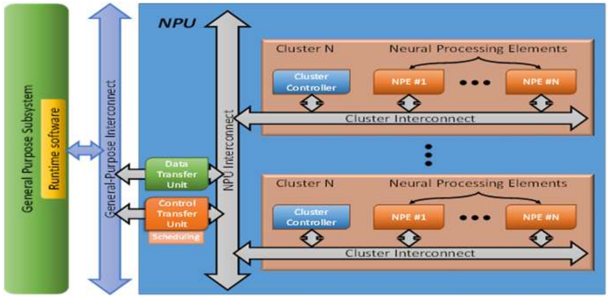
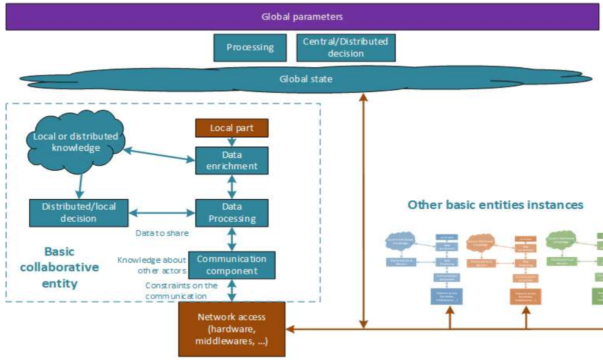
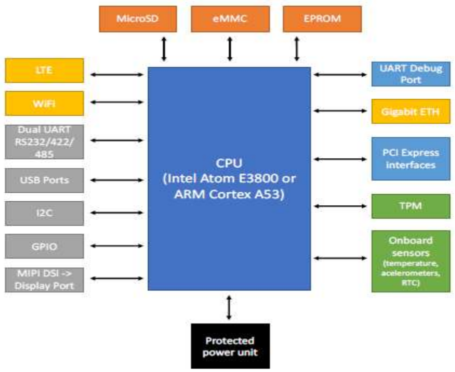


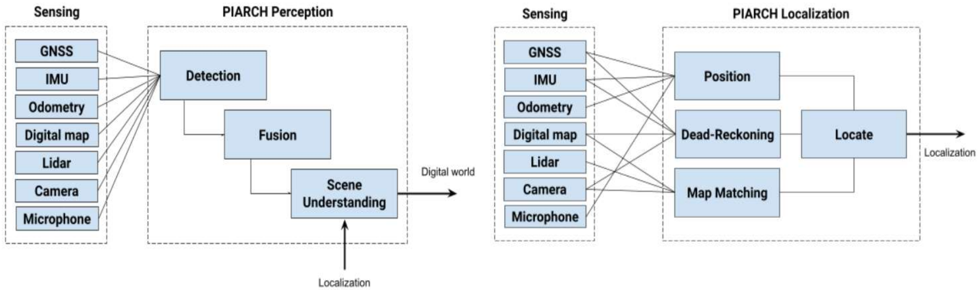

Heterogenous computing PIARCH




Cooperative system of systems PIARCH




Industrial Edge computing gateway PIARCH




Sensing perception and localization PIARCHs





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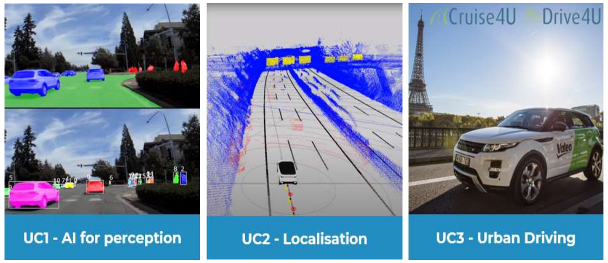
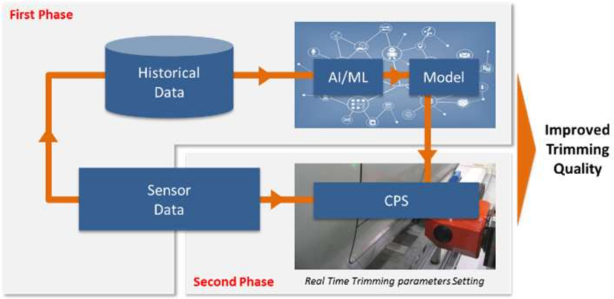
# PRACTICAL IMPLEMENTATIONS

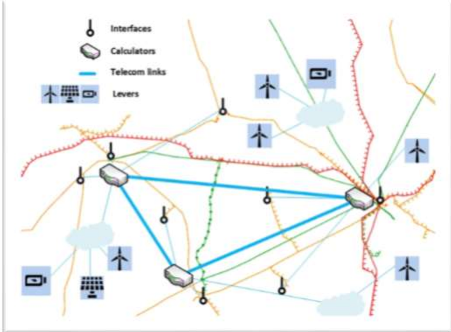
## 16 Use cases using at least 1 PIARCH (TRL 6-7)




**Valeo use case – Urban automated driving**




**Leonardo use case – Improved trimming quality**




**RTE use case – Distributed controls for energy transmission network**



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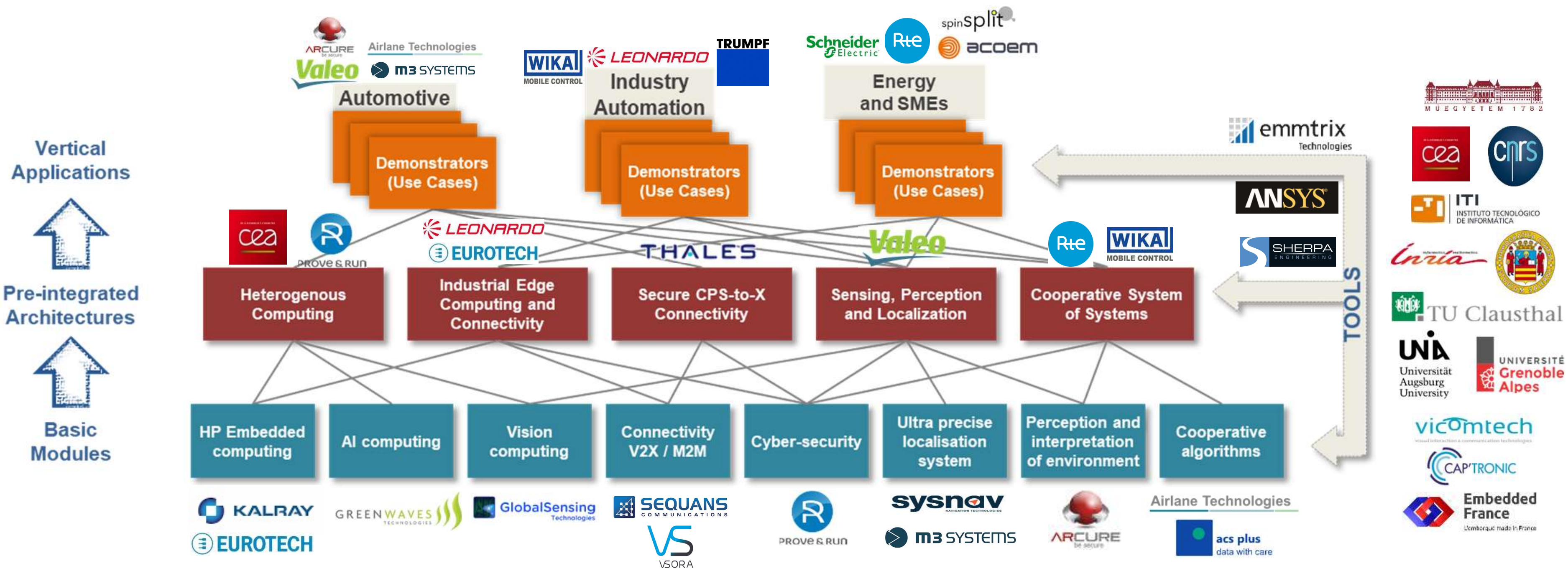
# PRACTICAL IMPLEMENTATIONS

## CPS4EU Eco-system



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# NEXT STEPS

**Main goals for the final year of the project**

- Finalization of PIARCH prototypes, models and tools
- Evaluation of benefits due to PIARCH concept vs traditional design process
- Formalization of PIARCH composability and solution space
- Contribution to project complexity forecast



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## CONCLUSIONS

**Pre-Integrated Architectures for sustainable complex Cyber-Physical Systems**

- Solution to reduce R&D Efforts for complex CPS developments
- Practical approach for current and upcoming challenges
- Fits well to networked eco-systems
- Meets expectations of large companies, SMEs and tool providers

- Contact our project partners for more information:

https://cps4eu.eu/wp-content/uploads/2020/11/CPS4EU-presentation-Summary.pdf

- Or contact by email philippe.gougeon@valeo.com


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THANK YOU FOR YOUR ATTENTION