



Smart Cyber-Physical Systems Clustering and Communication Event Synergies

Haydn Thompson

Projects Presented

ARTEMIS/ECSEL

CRYSTAL

MANTIS

ARROWHEAD

H2020 – ICT1 IAs

CP-SETIS

EoT

EuroCPS

CPSELabs

H2020 – ICT1 RIAs

AXIOM

COSSIM

IMMORTAL

INTO-CPS

SAFURE

UnCoVerCPS

TAPPS

U-Test

CSAs

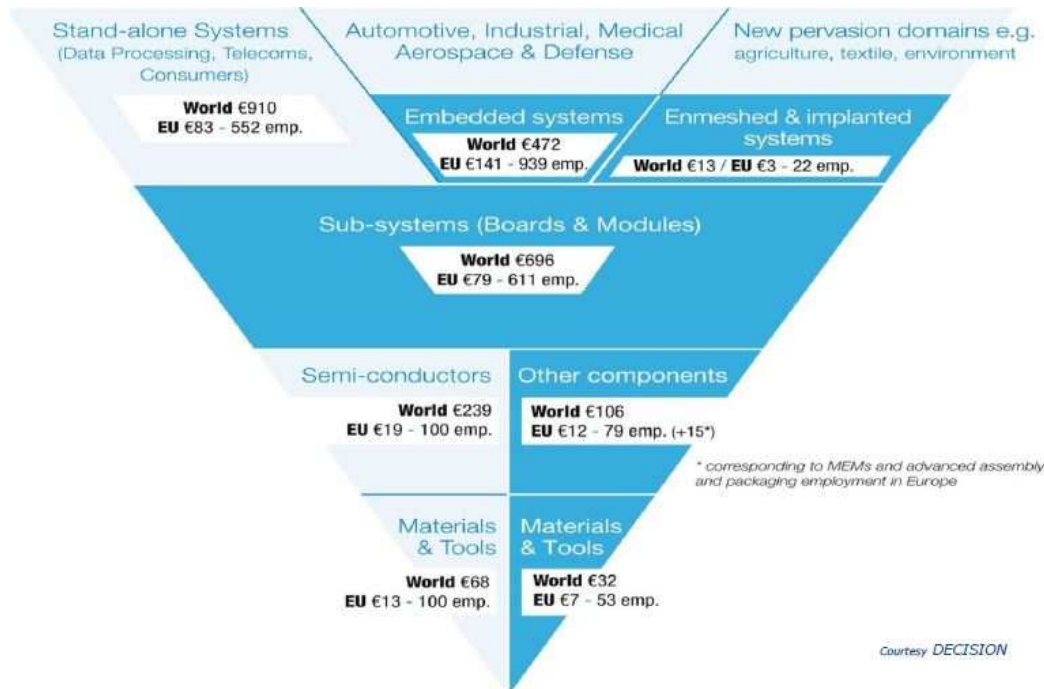
CPSOS

CPS Summit

TAMS4CPS

ROAD2CPS

EC - Werner Steinhögl



Importance for Europe 30% of market

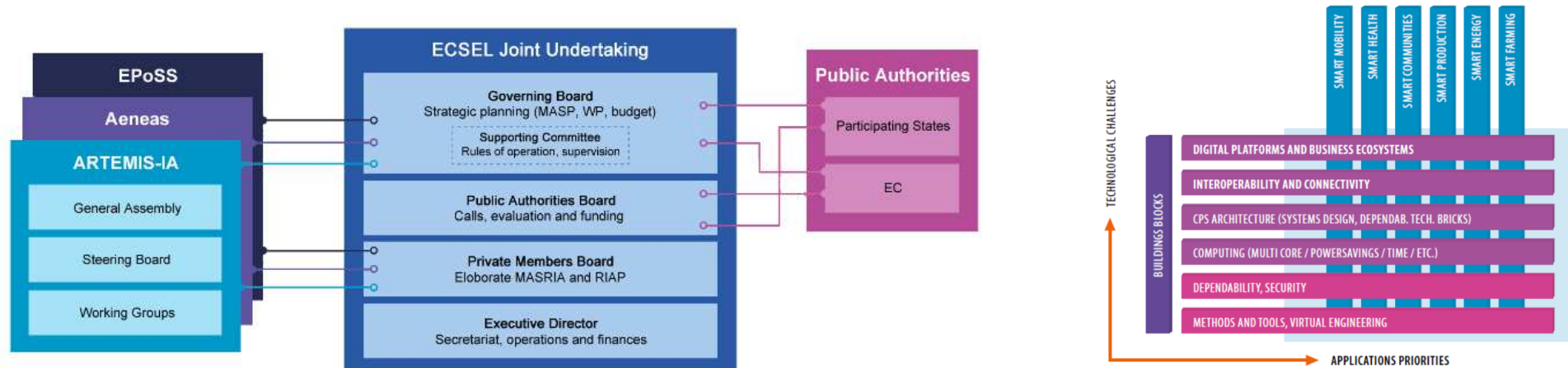
Digitising European Industry

- Leadership in digital technologies value chains
- From vertical markets to mainstream
- Access to latest technology (SMEs, Midcaps, non tech.)
- Skilling our workforce for digital change
- Adapting the legislation

Two Key Drivers

- European Leadership in Platforms (and technology gateways)
- Innovation Hubs

ARTEMIS-IA



- ARTEMIS Industry Association is the association covering Embedded & Cyber-Physical Systems with more than **170 members** and associates from all over Europe
- The multidisciplinary nature of the membership provides an excellent network for the exchange of technology ideas, **cross-domain fertilisation**, as well as for **large innovation initiatives**
- ARTEMIS- IA promotes the R&I interests of its members to the European Commission and the Public Authorities of the participating states.
- Continues the work of the European Technology Platform ARTEMIS and is responsible for the ARTEMIS Strategic Research Agenda (SRA) on Embedded & Cyber-Physical Systems

ARROWHEAD

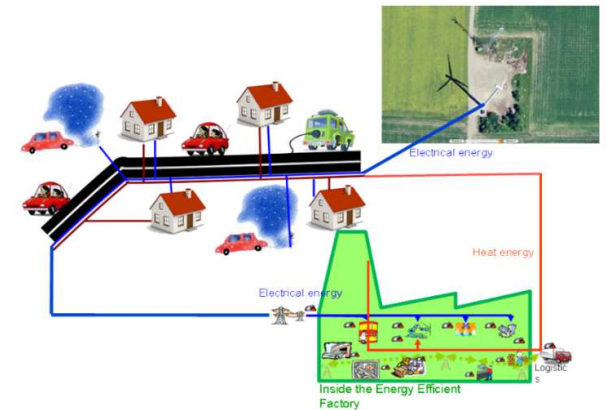
Arrowhead is addressing efficiency and flexibility at the global scale by means of service-based approach to **collaborative automation** for manufacturing, smart buildings and infrastructures, electro-mobility and energy.

The objective of the Arrowhead project is to address the technical and applicative challenges associated to cooperative automation:

- Provide a technical framework adapted in terms of functions and performances
- Propose solutions for integration with legacy systems
- Implement and evaluate the cooperative automation through real experimentations in applicative domains: electro-mobility, smart buildings, infrastructures and smart cities, industrial production, energy production and energy virtual market
- Point out the accessible innovations thanks to new services
- Lead the way to further standardization work

Strategy

- Business and technology gap analysis paired with a market implementation strategy based
- Application pilots
- A technology framework enabling collaborative automation
- Coordination methodology for complex innovation “orchestration”

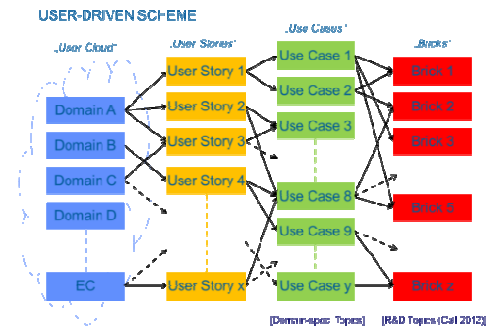


- **Local Clouds – Open Source**
- **4-5 times reduction in engineering time**

CRYSTAL CRITICAL sYSTem engineering AcceLeration



- The ARTEMIS JU CRYSTAL project is establishing an **Interoperability Specification (IOS)** Reference Technology Platform (RTP) as a European standard for safety-critical systems
- Budget of **82 million Euro** and **71 partners from 10 different European countries** including OEMs, suppliers, tool vendors and academia
- CRYSTAL is strongly industry-oriented and will provide ready-to-use integrated tool chains having a mature technology-readiness-level (up to TRL 7)
- The aim is to allow loosely coupled tools to share and interlink their data based on standardized and open Web technologies that enables common interoperability among various life cycle domains
- Real-world industrial use cases from the automotive, aerospace, rail and health sector



MANTIS

The main objective of MANTIS is set to “develop a Cyber Physical System based **Proactive Maintenance Service Platform** Architecture enabling Collaborative Maintenance Ecosystems”

Technical objectives

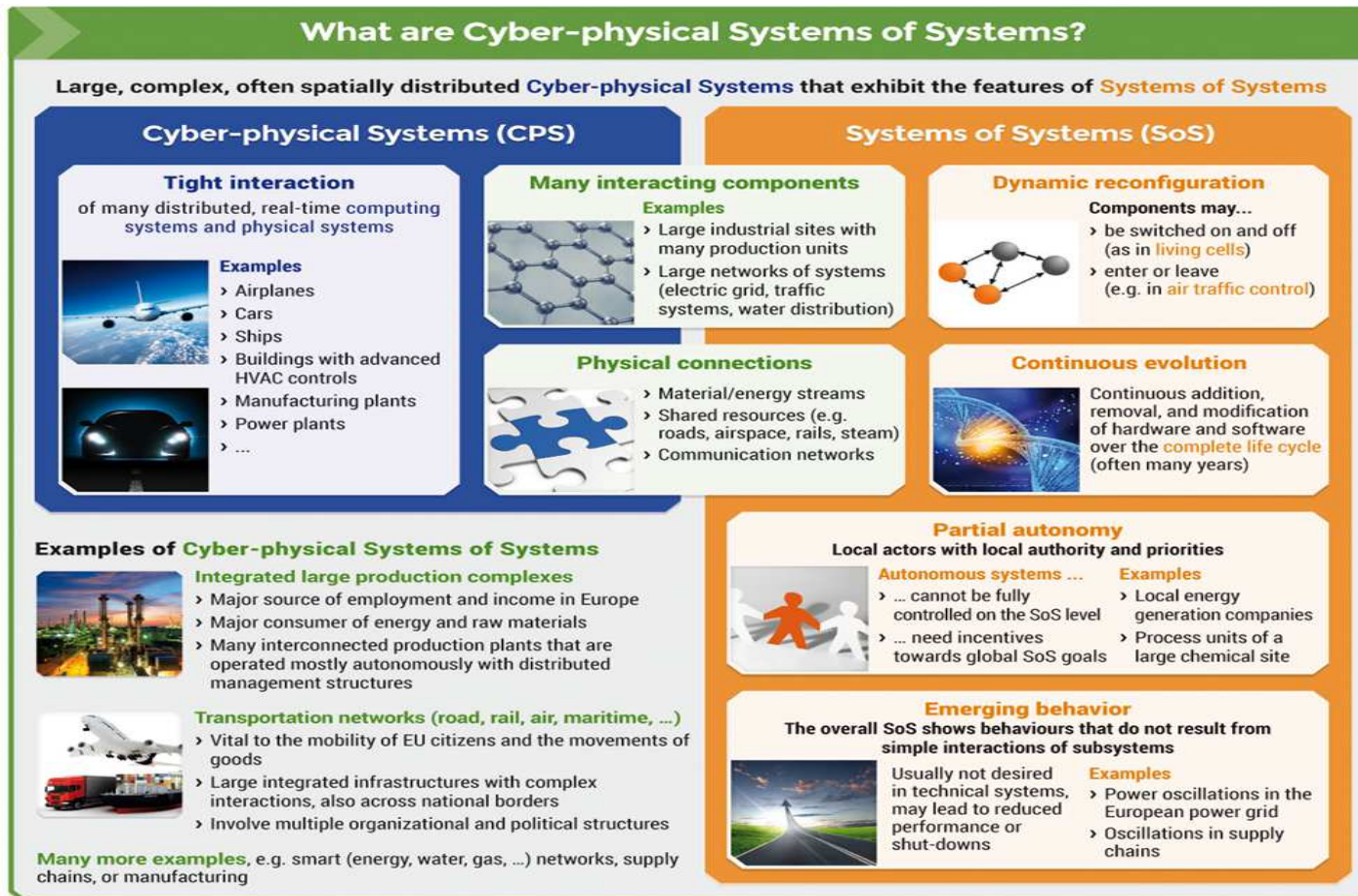
- To define the overall service platform architecture of the MANTIS distributed system for proactive maintenance
- To develop the next generation framework for highly distributed sensing, including pre-processing, data acquisition and adaptive information processing maintenance, the MANTIS Framework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

Exploitation objectives

- To identify, define and implement new business opportunities through services provided by the MANTIS Framework
- Establishing a higher maturity in the partner organisations regarding maintenance support
- To generate society, business and technology awareness supporting the rapid exploitation of solutions demonstrated by MANTIS



CPSoS



- Distributed management of cyber-physical systems of systems
- Engineering support for the design-operation continuum of cyber-physical systems of systems
- Cognitive CPSoS

CP-SETIS



- A common, **European wide open Interoperability Specification** for the development of critical Cyber-Physical Systems, which will lead to several improvements like:
- Achieve cross-sectorial reusability of Embedded Systems devices and architecture platforms (for example, for interoperable software components for automotive, railways, aerospace and manufacturing)

Objectives

- Build-up a consensus across key stakeholders (i.e., end-users organisations, tool providers, research organisations) and projects on a common IOS Standardisation Strategy
- Define a concrete model for sustainable IOS Standardisation Activities
- Support implementation of **Sustainable IOS Standardisation Activities** within sustainable structures, that have a far longer lifespan than a single project
- Get commitment from key stakeholders for supporting common IOS Standardisation Strategy and its implementation
- Generalise findings of IOS Standardisation Activities to update the ARTEMIS/PROSE Strategic Agenda for Standardisation, and to support further Standardisation Activities within ARTEMIS/ECSEL

Eyes of Things EoT



- To be “smart everywhere” we will need to have “eyes everywhere” e.g. wearable applications, augmented reality, surveillance, ambient-assisted living, etc.
- Vision is our richest sensor, allows mining big data from reality
- Vision is the most demanding sensor in terms of power consumption and required processing power

Objective

- Build a **power-size-cost-programmability optimized core vision platform** that can be embedded into all types of artefacts
- Maximize inferred information per milliwatt
- Adapt the quality of inferred results to each particular application

EuroCPS



- EuroCPS gathers several design centres in order to boost and initiate synergies between innovative companies, major CPS-platforms and CPS-competency providers
- **Provides 8 Technology Platforms across 9 countries to SMEs for experiments**
- The aim is to enable companies making new CPS products to get access to leading edge technology platforms from large companies and support from competency partners
- A second goal is to link user and supplier across value-chains and region within the help of the competence partners (**coaching, development plan definition, service providers**).
- Support, management and monitoring are provided by the cascade funding partners coming from RTOs and technology transfer-oriented university institutes.
- EuroCPS will support projects considering their excellence, their impact on the ecosystem and their industrialization implementation possibility and prospects through 3 open calls.

CPSELabs

- Cyber-Physical Systems Engineering Labs (CPSE Labs) is an initiative designed to provide technical support and funding for European technology businesses to develop **trustworthy CPS**
- **CPSELabs funds experiments.** Businesses (and other organisations) can submit experiment proposals
- Provide a **number of platforms** across a number of domains
- Experiments are expected to be focused and fast-track. They need to have explicit objectives which will clearly improve your business's ability to innovate, and they need to meet some specific criteria in terms of technology use and overall objective.



CPSE Labs Design Centres

Research Challenges in CPS (Radu Grosu)

Trends

- Embedded systems 1980 -> Networked embedded systems 1990 -> CPS 2010
- Autonomous trains, cars, UAVs, AUV, factories, etc. and Cyber Biological
- The Cloud, The Mobiles, Terra Swarm (actuators and sensors) - 7 trillion devices by 2020

Challenges

- Mathematics – discrete/continuous
- Huge architectural complexity (CPS-OS platform)
- Spacetime (need ST aware programs)
- Uncertainty (partial knowledge) – precision
- Safety
- Smartness – neural circuits

Need education – multidisciplinary for Systems Engineering

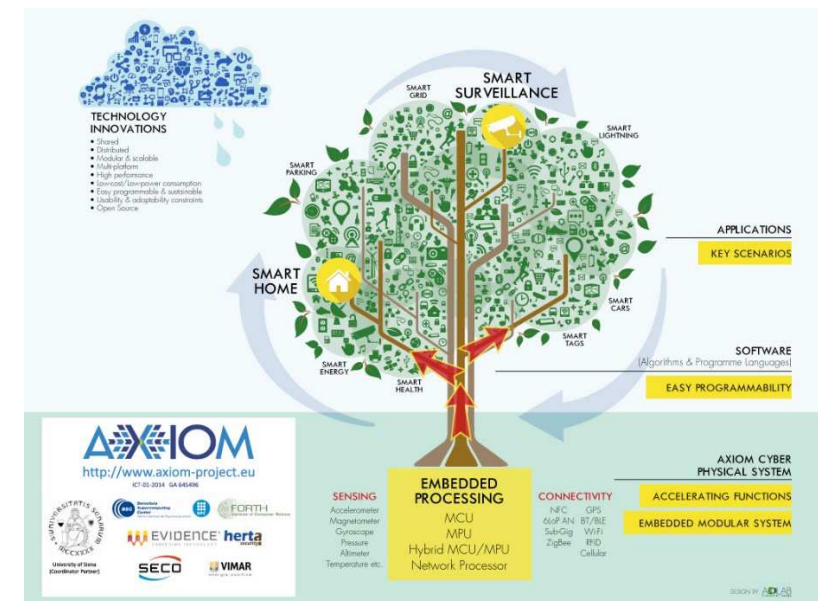
AXIOM

The AXIOM project (**Agile, eXtensible, fast I/O Module**) aims at researching new software/hardware architectures for CPSs considering:

- Objects and people will become nodes of the same digital network
- Rapid and close interaction: system-system, human-system, system-human.
- Smart systems will improve and simplify human behaviour

Cyber-Physical Systems (CPS) will at least react in real-time, provide enough computational power for the assigned tasks, consume the least possible energy for such task (energy efficiency), scale up through modularity, allow for an easy programmability across performance scaling, and exploit at best existing standards at minimal costs.

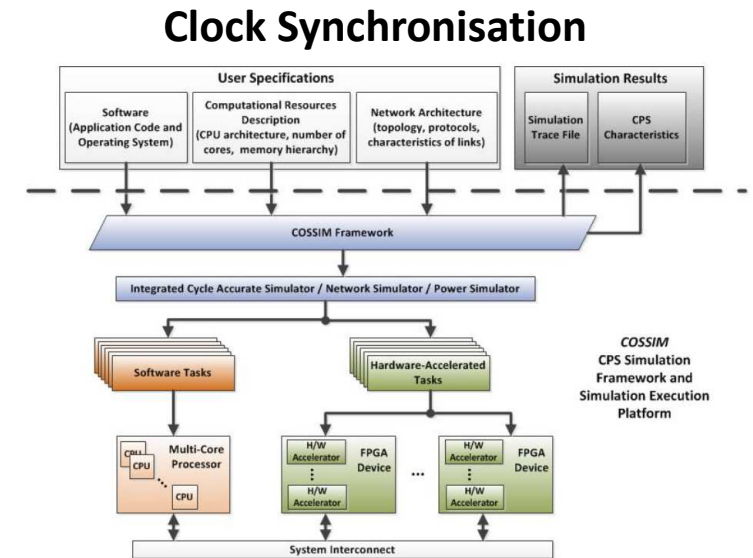
Quad Core ARM/FPGA Board -> 6 ARM cores



COSSIM

The COSSIM (“Novel, Comprehensible, **Ultra-Fast, Security-Aware CPS Simulator**”) project will develop a novel simulator framework which will be integrated with a novel network simulator that will:

- Seamlessly simulate, in an integrated way, both the **networking and the processing parts** of the CPS
- Perform the simulations orders of magnitude faster
- Provide much more accurate results especially in terms of power consumption
- Power consumption and security measurement models will also be developed
- Hardware acceleration using field programmable gate arrays (FPGAs)





IMMORTAL

IMMORTAL (Integrated Modelling, Fault Management, Verification and Reliable Design Environment for Cyber-Physical Systems) is developing an **integrated, cross-layer modelling based tool framework for fault management, verification and reliable design** of dependable Cyber-Physical Systems (CPS)

IMMORTAL will enable development of dependable CPSs with improved reliability and extended effective lifetime, aging and process variations

The project will develop:

- **A cross-layer CPS model spanning device (analogue and digital), circuit, network architecture, firmware and software layers**
- A holistic fault model for fundamentally different error sources in CPSs (design bugs, wear-out and environmental effects) will be proposed
- A fault management infrastructure will be built for ultrafast fault detection, isolation and recovery in many-core based CPS networked architectures
- The tool framework will be evaluated on a satellite on-board computer

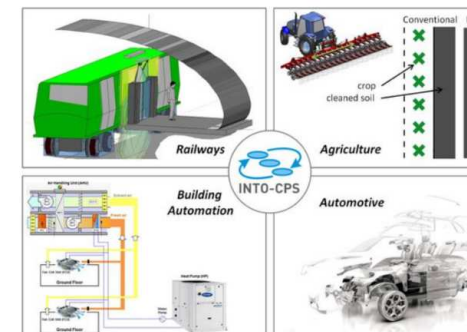
INTO-CPS

The aim of the INTO-CPS project is to create an integrated **“tool chain” for comprehensive Model-Based Design (MBD) of Cyber-Physical Systems (CPSs)**. The tool chain will support the multidisciplinary, collaborative modelling of CPSs from requirements, through design, down to realisation in hardware and software. This will enable traceability at all stages of the development.

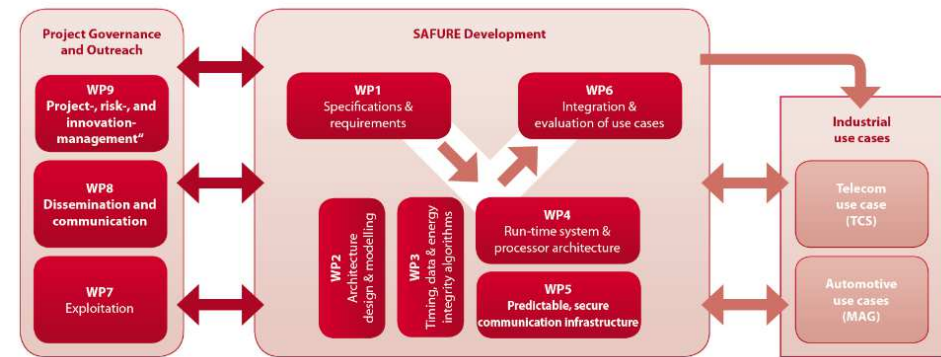
Objectives

Build an open, well-founded tool chain for multidisciplinary model-based design of CPS that covers the full development life cycle of CPS. The tool chain will support **multiple modelling paradigms** and will cover multiple development activities, including requirements modelling, analysis, simulation, validation, verification, and traceability

- Provide a sound semantic basis for the tool chain. We will produce mathematical foundations to support CPS co-modelling and to underpin the tool chain. This will include semantics for FMI **co-simulation**, as well as SysML, discrete-event and continuous-time paradigms.
- Provide practical methods in the form of guidelines and patterns that support the tool chain.
- Demonstrate in an industrial setting the effectiveness of the methods and tools (automotive, agricultural, railways and building automation)
- Form an INTO-CPS Association



SAFURE



SAFURE - **Safety And Security By Design** For Interconnected Mixed-Critical Cyber-Physical Systems targets the design of cyber-physical systems by implementing a methodology that ensures safety and security "by construction". The goals of the SAFURE project are:

- to implement a holistic approach to safety and security of embedded dependable systems, preventing and detecting potential attacks,
- to empower designers and developers with analysis methods, development tools and execution capabilities that jointly consider security and safety,
- to set the ground for the development of **SAFURE-compliant mixed-critical embedded products**.
- It will produce a framework with the capability to detect, prevent and protect from security threats on safety with the the ability to monitor system integrity from application level down to the hardware level including time, energy, temperature and data integrity
- **3 industrial use cases in automotive and telecommunications**

TAPPS



The main goal TAPPS (Trusted Apps for open CPS) project is to extend and customize CPS devices with new **3rd party services and features in an Apps platform in an efficient, secure and trusted way**. TAPPS is based on a dedicated execution environment for distributed, safety-critical CPS applications offering multiple layers of security and a holistic, open end-to-end tool chain for developing and deploying CPS Apps.

The project will:

- Design, implement and validate a separate, dedicated, real-time **Trusted Execution Environment (TEE) for highly-trusted CPS Apps**. The TEE is located inside the system control units and uses TAPPS' processor- and network-centric security mechanisms and a hypervisor for virtualization
- Provide and validate an end-to-end solution for development and deployment of trusted Apps
- Validate the multi-level trusted Apps platform and tool chain in several application domains using industrial, realistic use cases and to develop domain-specific exploitation plans
- **ARM multicore with normal and secure regions**

UnCoVerCPS



The Unifying Control and Verification of Cyber-Physical Systems (UnCoVerCPS) will develop new methods for de-verticalisation of the development processes by a generic and holistic approach towards reliable cyber-physical systems development with **formal guarantees with the aim to synthesise and verify controllers on-the-fly during system execution**. Completely new methods will be developed, which are integrated in tools for modelling, control design, verification, and code generation that will leverage the development towards reliable and at the same time open cyber-physical systems.

Objectives

- Develop novel on-the-fly control and verification concepts
- Develop methods for unifying control and verification to quickly react to changing environments
- Provide seamless integration of modelling and conformance testing
- Develop a unique tool chain to integrate modelling, control design, formal verification, and automatic code generation
- Applications include **automated vehicles and human-robot collaborative manufacturing, wind turbines and smart grids**

U-Test

The U-Test (Testing Cyber Physical Systems under Uncertainty) project aims at ensuring that CPSs are **tested adequately under uncertainty** using systematic and automated techniques such as model and search-based testing to guarantee their correct operation in real environment.

Overall Aim and Concept

- U-Test will improve dependability of CPSs by defining extensible MBT frameworks supporting holistic testing of the systems under uncertainty in a cost-effective manner by:
 - Providing a comprehensive and extensible taxonomy of uncertainties, classifying uncertainties, their properties, and their relationships.
 - Creating an Uncertainty Modelling Framework (UMF) to support modelling uncertainties at various levels (relying on exiting modelling/testing standards).
 - Developing the **Uncertainty Testing Framework (UTF) that can smartly discover unknown uncertainties and generate cost-effective test cases to test CPSs under known and unknown uncertainties.**
- Two case studies: Handling Systems and Geo Sports

CPS Summit

The Transatlantic CPS Summit is an 18-month support action with the goal of facilitating and creating an enduring and sustainable collaboration campaign on CPS research and development between Europe and the US. The support action achieves its overall aim by means of a series of **CPS Summit Workshops** to:

- Identify and evaluate possible **R&D co-operations between Europe and the US**
- Investigate and promote implementation of opportunities for cooperation
- Prepare a roadmap for R&D cooperation on CPS engineering between the EU and US together with recommendations for action
- Present final results to interested stakeholders (e.g. public bodies, industry, academic researchers) on both sides of the Atlantic

TAMS4CPS



TAMS4CPS has a mission to develop a strategic research and collaboration agenda to foster **Trans-Atlantic research in Modelling and Simulation (M&S) for Cyber-Physical Systems (CPS)**.

TAMS4CPS Mission

- Lay the foundations for concrete EU-US collaboration in modelling and simulation for CPS
- Define the scope of CPS for US and Europe and, based on this, an agreed scope for collaboration
- Identify priority research and development needs for modelling and simulation for CPS
- Create a **strategic research agenda** for collaboration in modelling and simulation for CPS, which is endorsed by European and US industry and academia
- Provide key enablers for Trans-Atlantic collaboration in modelling and simulation for CPS
- Disseminate the findings of the project widely and freely

Road2CPS

Road2CPS is a 24-month coordination and support action in the area of Smart Cyber-Physical Systems. The project aims to carry out strategic action for future CPS through **roadmaps, impact multiplications and constituency building** by:

- identifying the gaps of current research and bridging the efforts,
- analysing future research priorities and business opportunities and,
- bringing the relevant stakeholders together to facilitate mutually beneficial collaborations between them

The project will not only **build a constituency united by the commonly faced challenges** but will also create a joint action plan for the future development of CPSs.

Industry Engagement
ARTEMIS Industry Association

Tool Chains

- CRYSTAL is strongly industry-oriented and will provide ready-to-use integrated tool chains
- IMMORTAL (Integrated Modelling, Fault Management, Verification and Reliable Design Environment for Cyber-Physical Systems
- INTO-CPS integrated “tool chain” for comprehensive Model-Based Design (MBD) of Cyber-Physical Systems

Development and Integration

V&V

- Unifying Control and Verification of Cyber-Physical Systems (UnCoVerCPS)
- U-TEST Testing Cyber Physical Systems under Uncertainty

Interoperability

- CP-SETIS European wide open Interoperability Specification for the development of critical Cyber-Physical Systems

Factory Automation

- Arrowhead collaborative automation for manufacturing, smart buildings and infrastructures, electro-mobility and energy.
- EoT “eyes everywhere”

Applications

Maintenance

- MANTIS is set to develop a Cyber Physical System based Proactive Maintenance Service Platform Architecture

Hardware/Software

- AXIOM (Agile, eXtensible, fast I/O Module) aims at researching new software/hardware architectures for CPSs

Hardware/Software

Simulators

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

Simulation

Safety and Security

Safety/Security

- SAFURE - Safety And Security By Design For Interconnected Mixed-Critical Cyber-Physical Systems
- TAPPS (Trusted Apps for open CPS)

Outreach to SMES

- EuroCPS several design centres
- CPSE Labs several design centres

Engaging with Community

Roadmaps

- Road2CPS The project aims to carry out strategic action for future CPS through roadmaps, impact multiplications and constituency building
- CPSOS
- Distributed management of cyber-physical systems of systems
- Engineering support for the design-operation continuum of cyber-physical systems of systems
- Cognitive CPSoS

Engaging with US

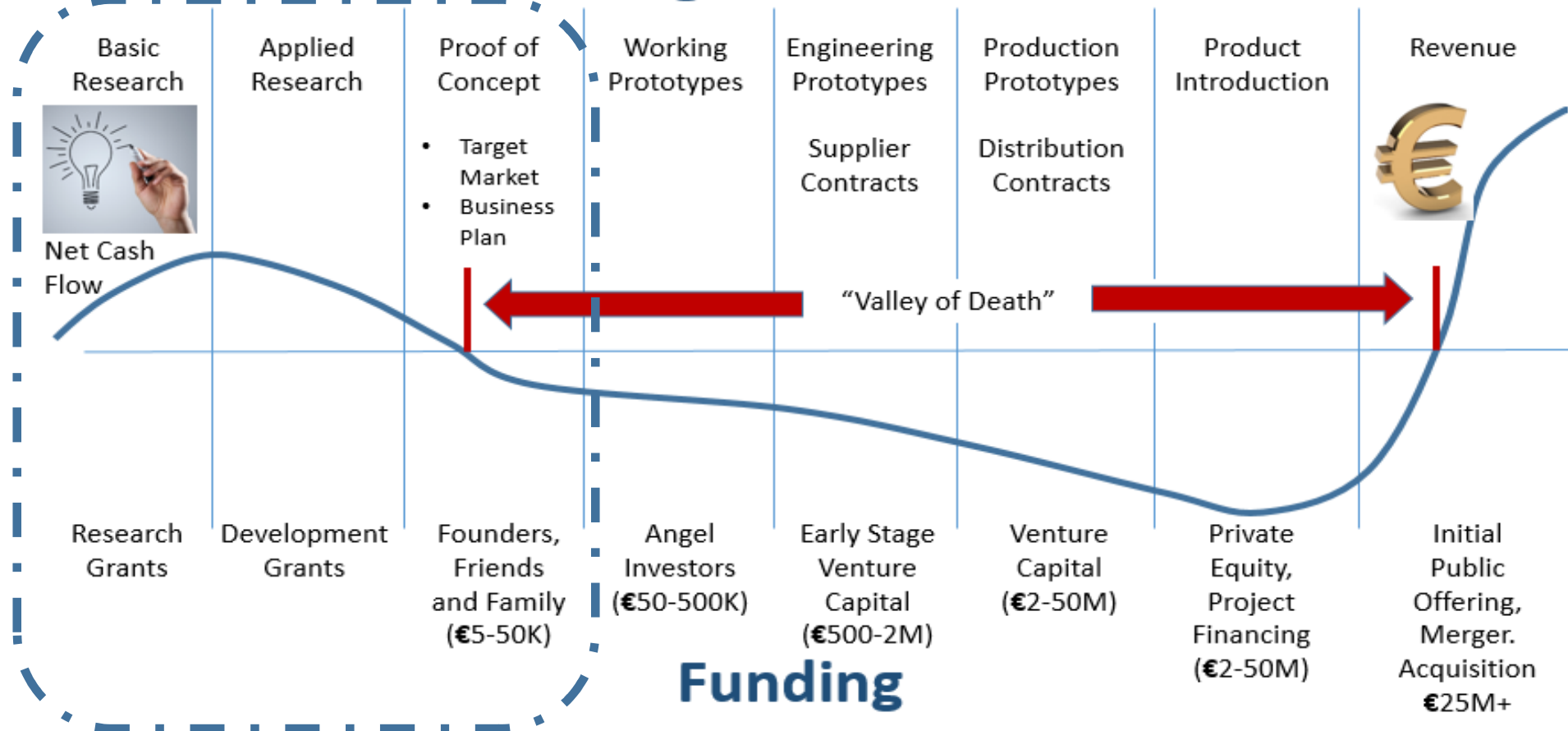
EU-US Collaboration

- CPS Summit collaboration on CPS research and development between Europe and the US
- TAMS4CPS strategic research and collaboration agenda to foster Trans-Atlantic research in Modelling and Simulation (M&S) for Cyber-Physical Systems (CPS).

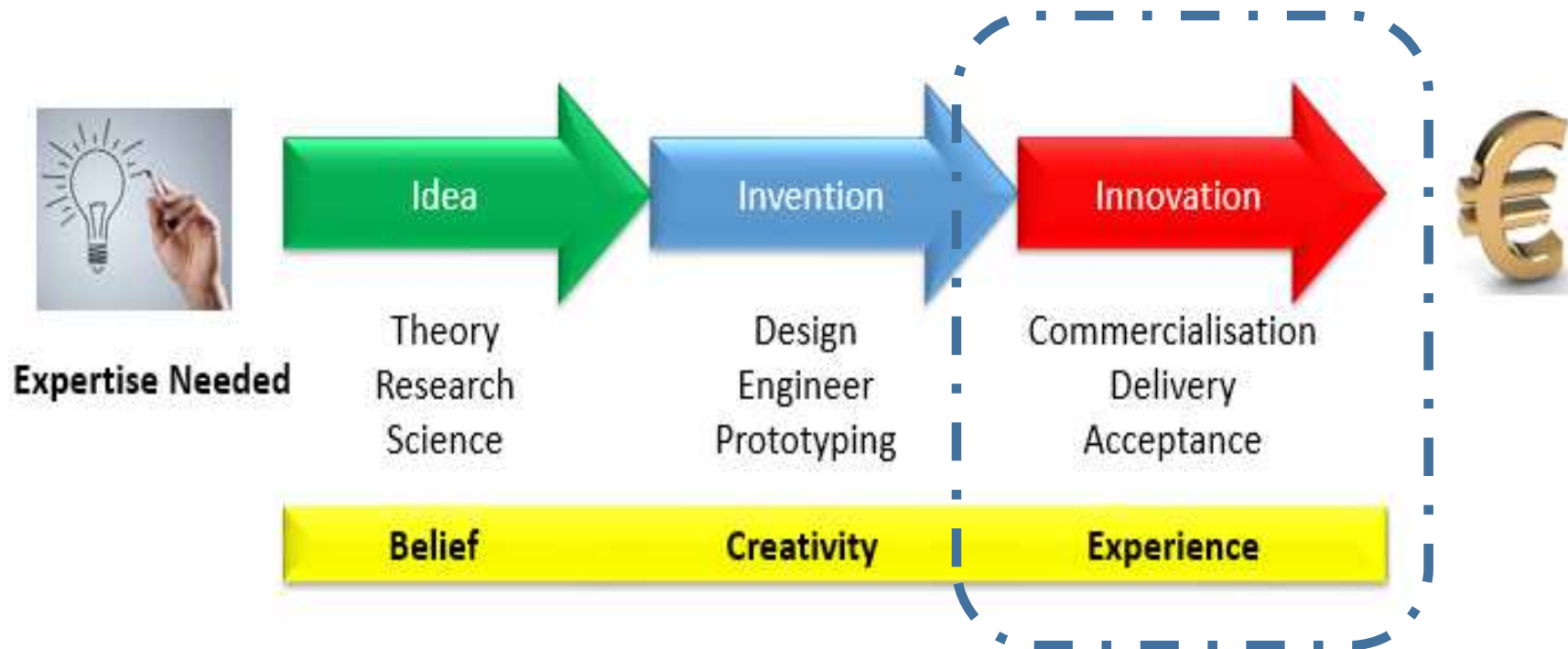
Three Types of Action

- Research and Innovation Actions
 - Innovation Actions
 - Coordination and Support Actions
-
- Is there more we can do to support innovation to get research to market?

Development Stage of Commercial Product



Have we got everyone involved?



Joint Action Plan for CPS

- Have we got every research priority covered?
 - Is there sufficient funding for these areas?
 - Are there any key gaps, e.g. cognitive systems, sociotechnical issues?
- Are we doing enough to get over the valley of death to get research to the market place?
 - How could the EC better support the collaboration/exploitation of synergies?
 - Have we got all the right people engaged, demand side, the commercialisation people, customers?
- Ideas on co-operation across projects and programme?
 - How do the activities of your project link to digital platforms and digital innovation hubs?
- What are the barriers for industry?
 - Sociotechnical, e.g. developing trust, raising awareness with public?
 - Need for regulation, safety, privacy, legal (SLAs, liability)?
 - Standards for interoperability?