Final Workshop

Towards Smart Autonomous Cyber-Physical Systems: Unmanned Aerial/Ground Vehicles and Robots

CPSwarm Project

Claudio Pastrone, LINKS Foundation, CPSwarm

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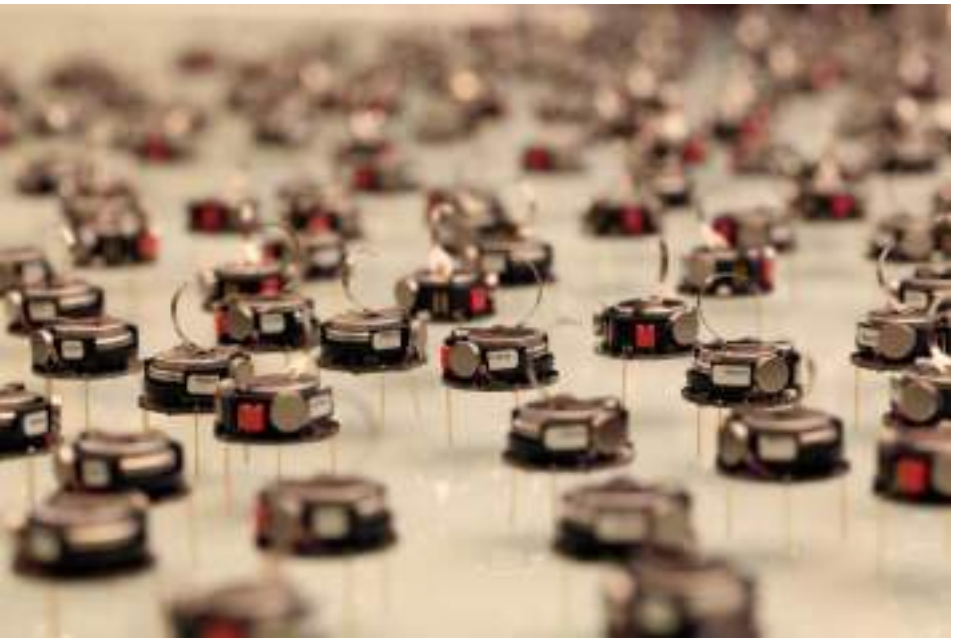
Swarm Concept

- ***Swarm***
  A large number of self-driven entities with local intelligence on board overall presenting collective behavior
- ***Swarm intelligence***
  emerging ability to solve problems not as single entities but as a swarm

Cyber-Physical Systems

Vision



Interactions *amongst self-driven CPSs might lead to* ***new behaviors*** *and* ***emerging properties****, often with unpredictable results.*

Rather than being an unwanted byproduct, these interactions can become an ***advantage*** *if explicitly managed since early* ***design*** *stages.*

High-Level Objective

CPSwarm proposes a new science of system integration and tools to support engineering of CPS swarms.

*CPSwarm tools will ease development and integration of **complex herds** of **heterogeneous CPS** that collaborate based on local policies and that exhibit a **collective behavior** capable of solving complex, industrial-driven, real-world problems.*

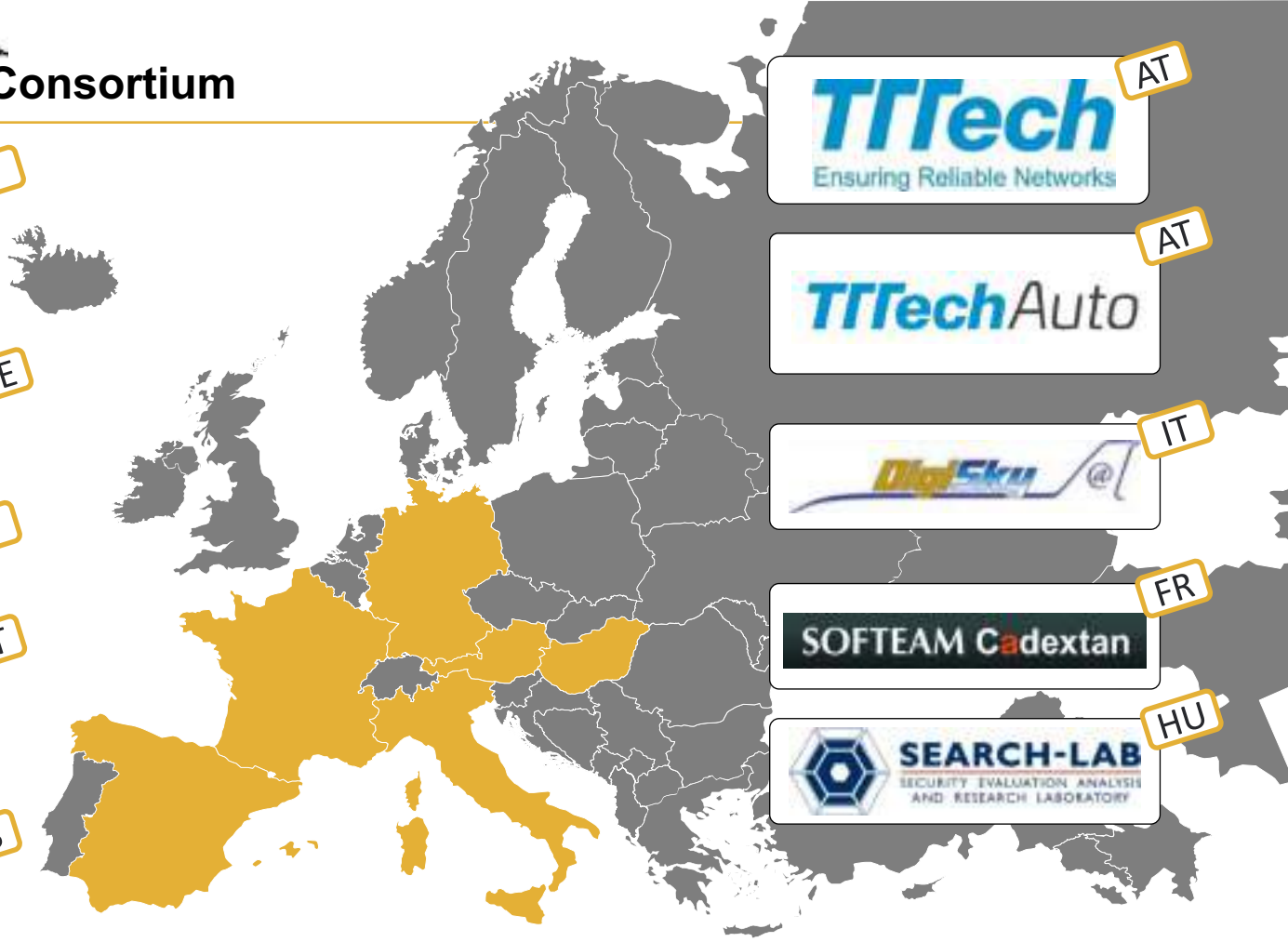
CPSwarm at a Glance

- CPSwarm is a **36-months R**esearch and **I**nnovation **A**ction (**RIA**) funded under H2020 call ICT-01-2016
- **Scope**: **science of system integration** in the domain of **swarms of CPS**
- **10 partners** (3 Research Institutes, 1 University, 3 Large Enterprises, 3 SMEs) from **6** EU countries
- Around 4.9 M€ total costs (578 PMs ≈ 16 FTE)

The CPSwarm Consortium

Coordinator

- LINKS Foundation — IT
- Fraunhofer FIT — DE
- Lakeside Labs — AT
- Alpen-Adria Universität Klagenfurt | Wien | Graz — AT
- Robotnik — ES
- TTTech — AT
- TTTech Auto — AT
- DigiSky — IT
- SOFTEAM Cadextan — FR
- SEARCH-LAB — HU



Focus

Drastically Improve support to design of complex, autonomous CPS

Provide a self-contained, yet extensible library of re-usable models for describing Cyber Physical Systems

Support the developer with a library of swarm and evolutionary algorithms for design of Cyber Physical Systems of Systems

Establish reference patterns and tools for integration of CPS artefacts

Overall enable a sensible reduction in complexity and time of CPS development workflow also automating deployment

Address real industrial needs in CPS design, with a particular focus on the autonomous robotic vehicles, smart logistics domain and freight vehicles

Main Outcome

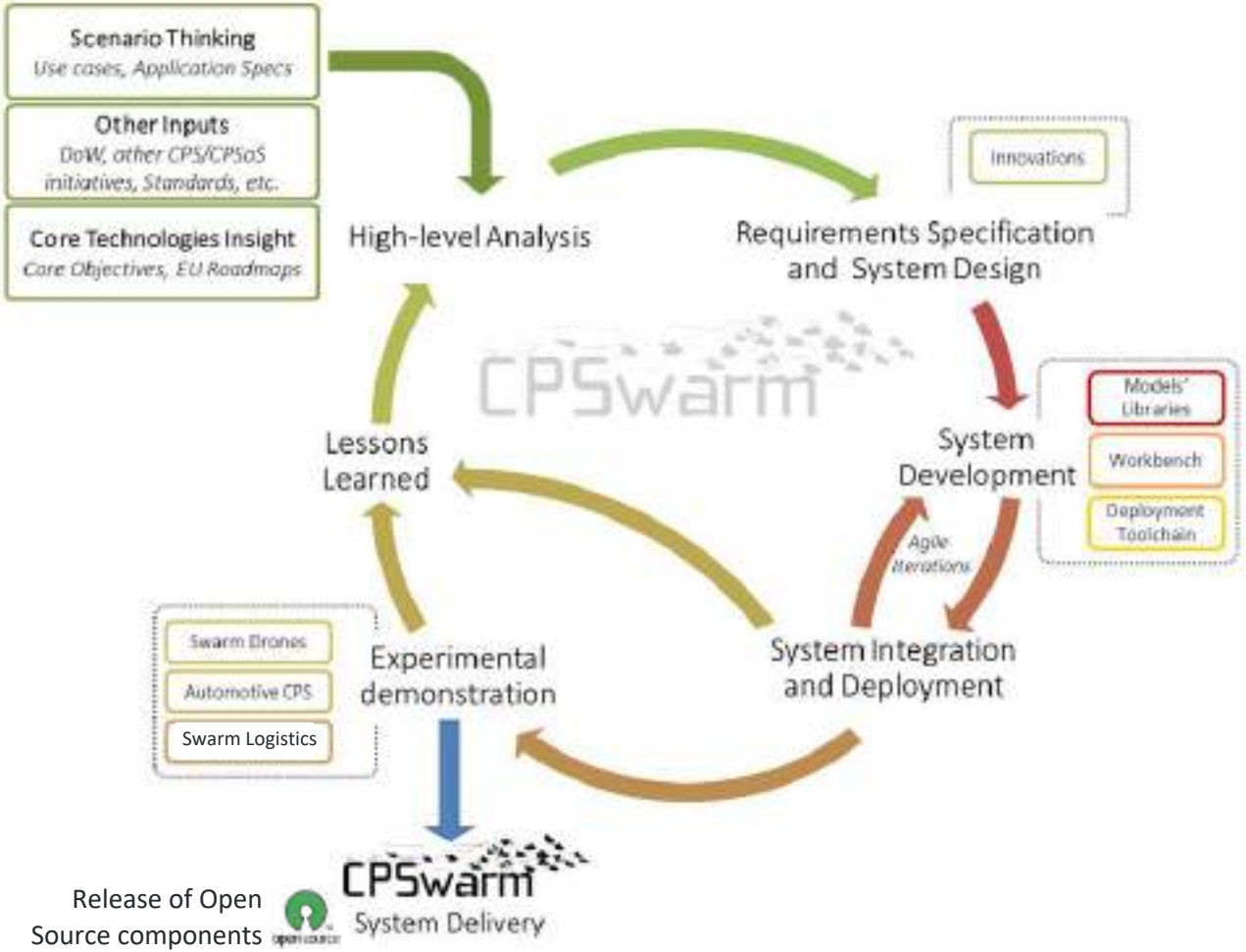
- The project has defined a **complete toolchain**, enabling the designer to:
  - Set-up **collaborative autonomous CPSs** using model-based approaches
  - Simulate the **swarm performance** with respect to the design goal
  - Massively **deploy solutions of "reconfigurable" CPS devices** and **CPSoS**.

Design IDE and Workbench for CPS Swarms

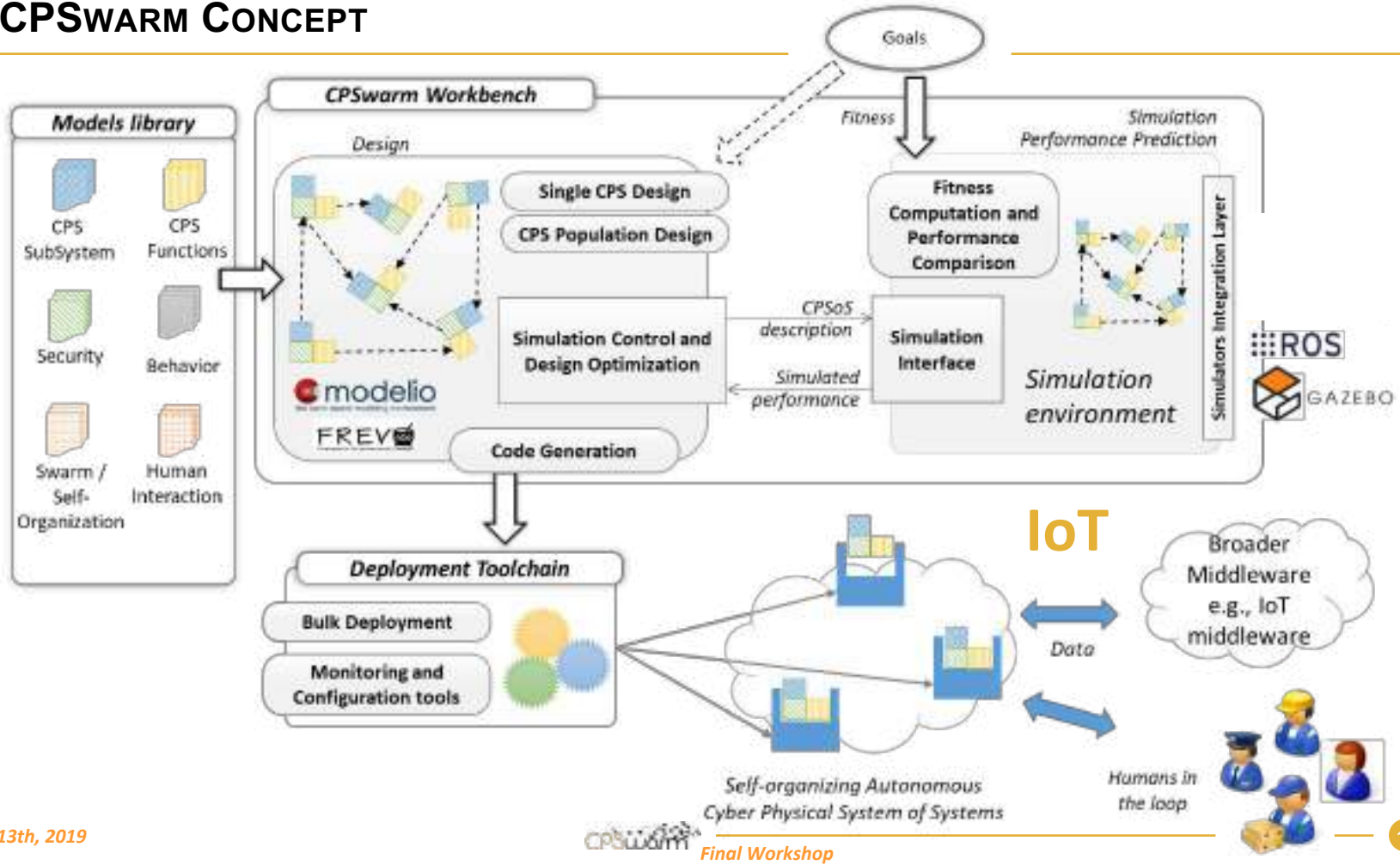
A fully-fledged design and simulation environment, namely the **CPSwarm Workbench**, natively supporting iterative, **computer-aided model based design of CPSs**, with a particular focus on **swarms** of heterogeneous systems.

Methodology

- CPSwarm follows an **agile**, **iterative project methodology**, starting from the analysis of **three application scenarios** for swarms of CPSs.



THE CPSWARM CONCEPT



Application Scenarios

Three reference Application Scenarios drive the collection of requirements for the development of the **complete CPSwarm toolchain** *supporting the engineering and deployment of CPS swarms*

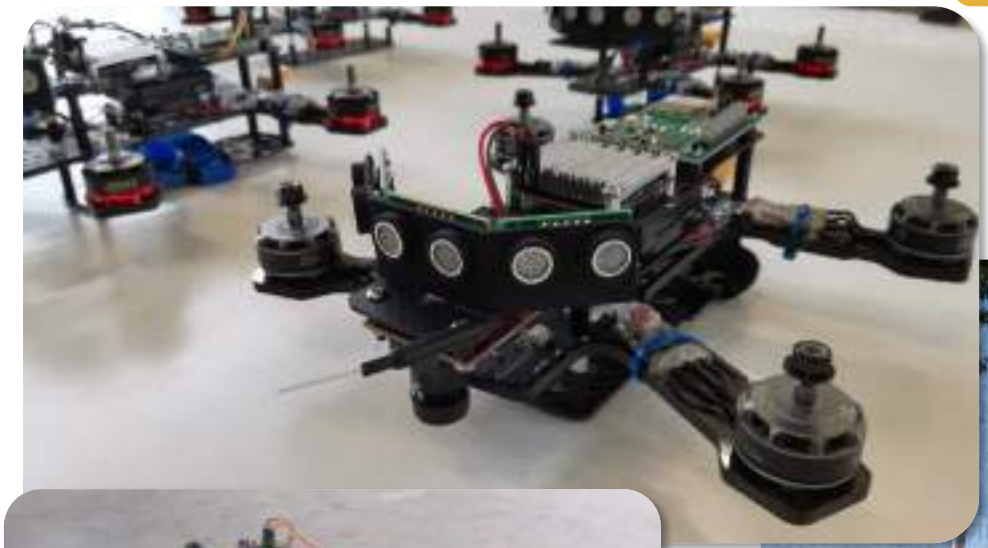
Swarm Drones

Automotive CPS

Swarm Logistics Assistant

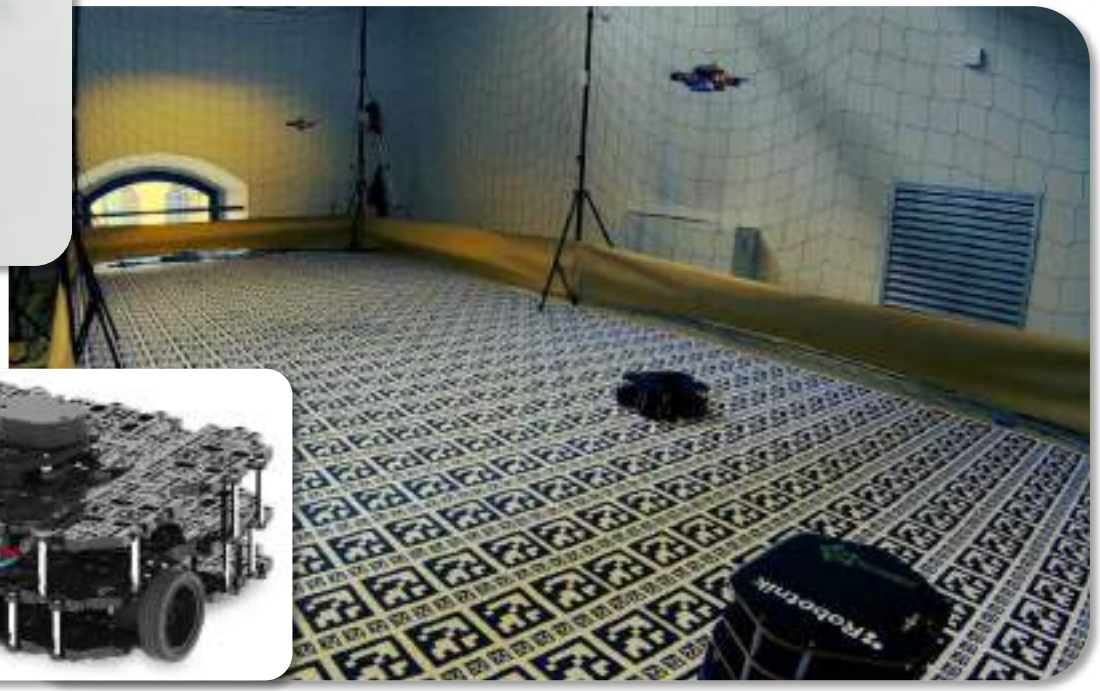
Search & Rescue

Search & Rescue Scenario



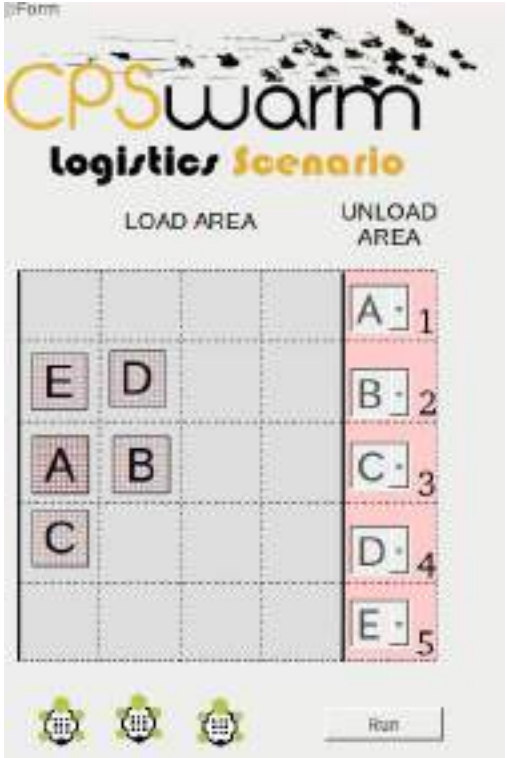
Search & Rescue

Search & Rescue Scenario



Vision Scenarios

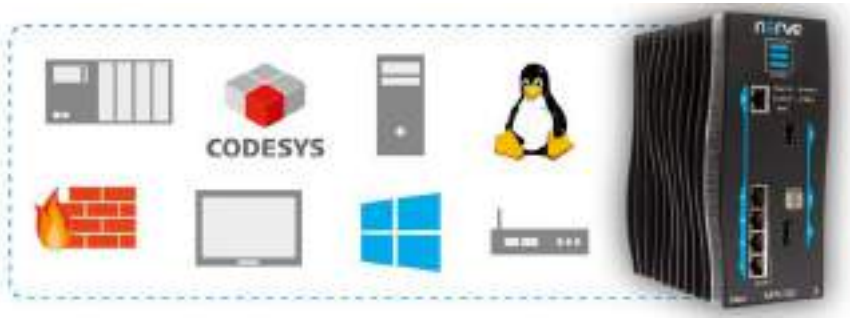
Swarm Logistics Assistant scenario



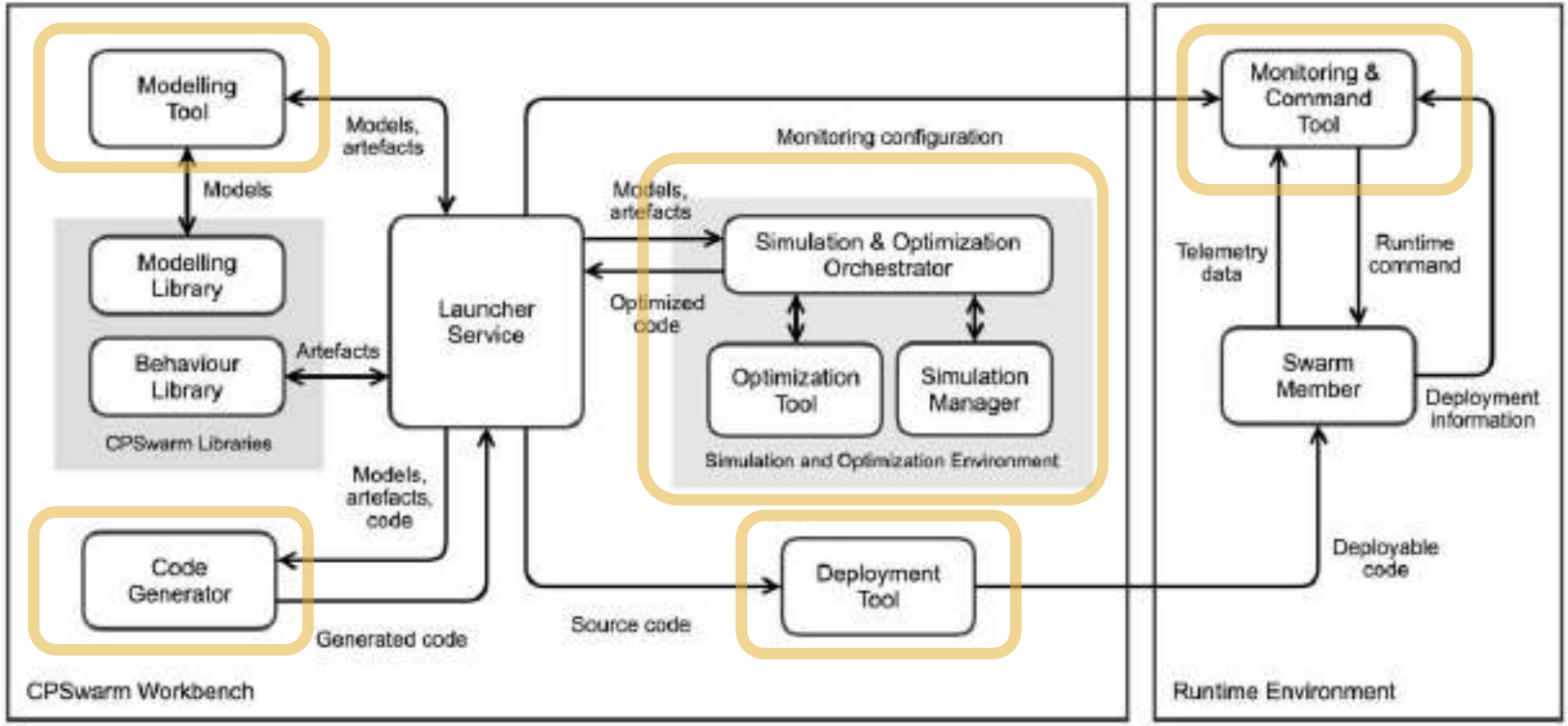
Vision Scenarios

Automotive CPS:
Autonomous Freight Vehicles

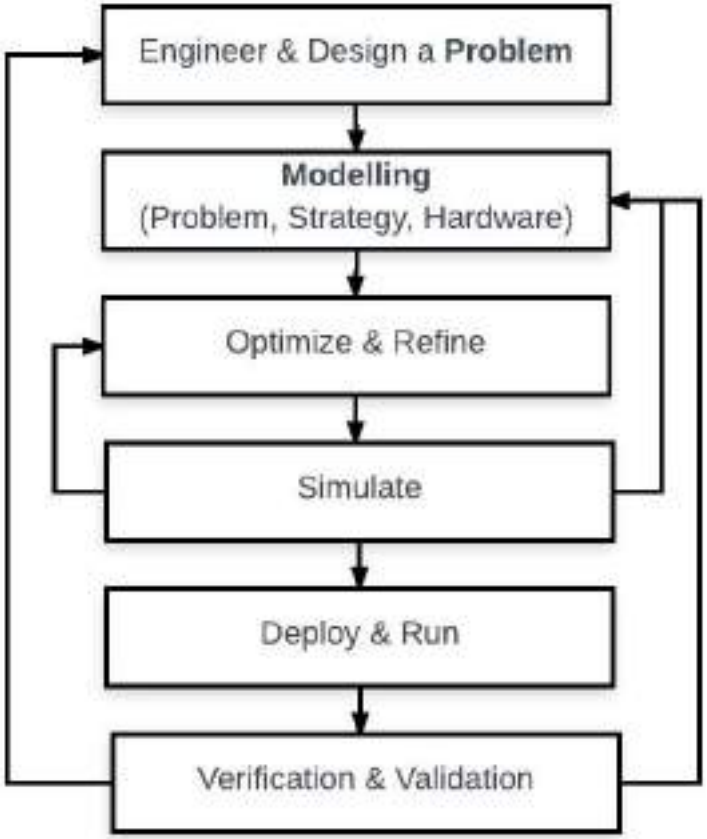
- Vehicles can create a platoon in the common part of the route

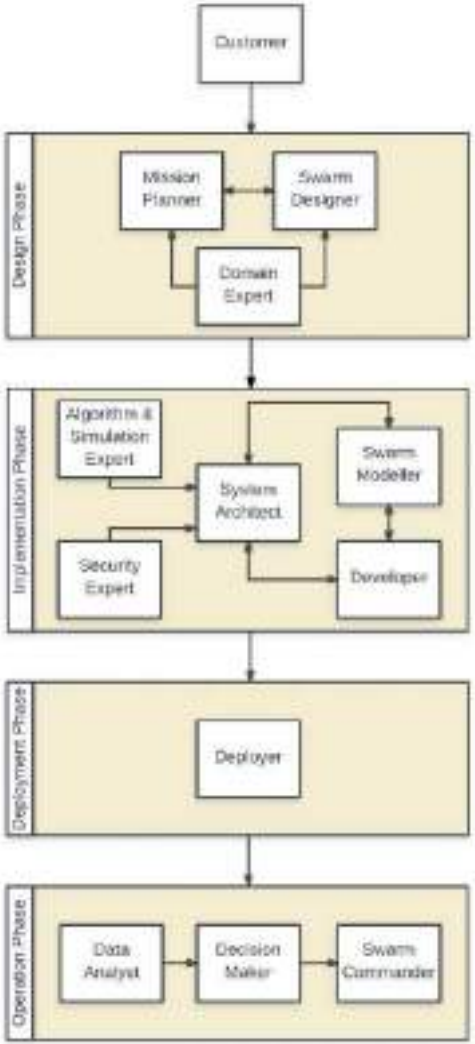


Latest CPSwarm Architecture



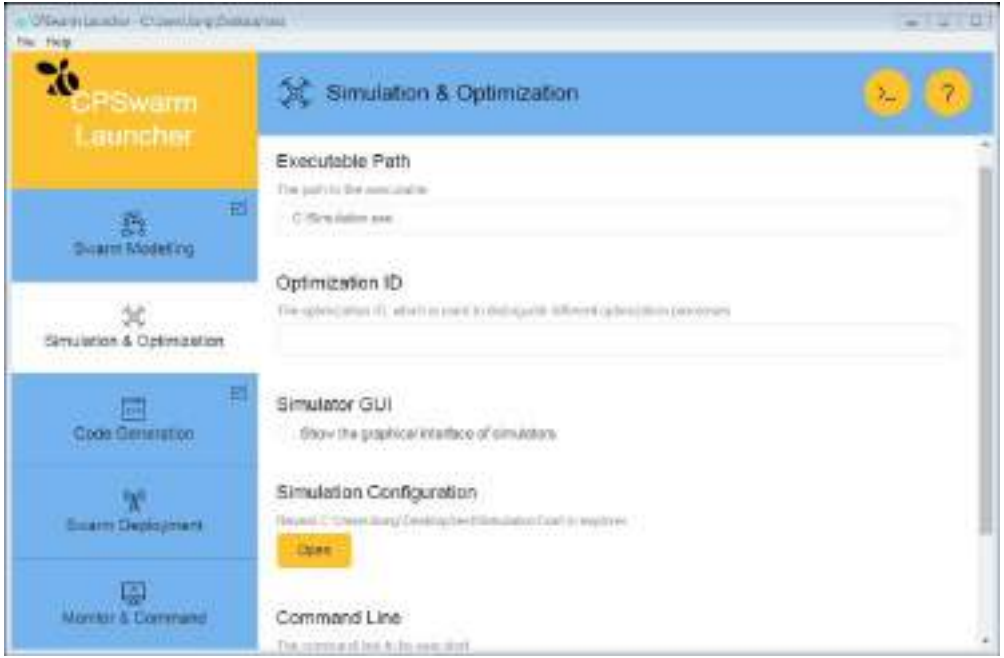
From Design to Deployment Workflow and Roles





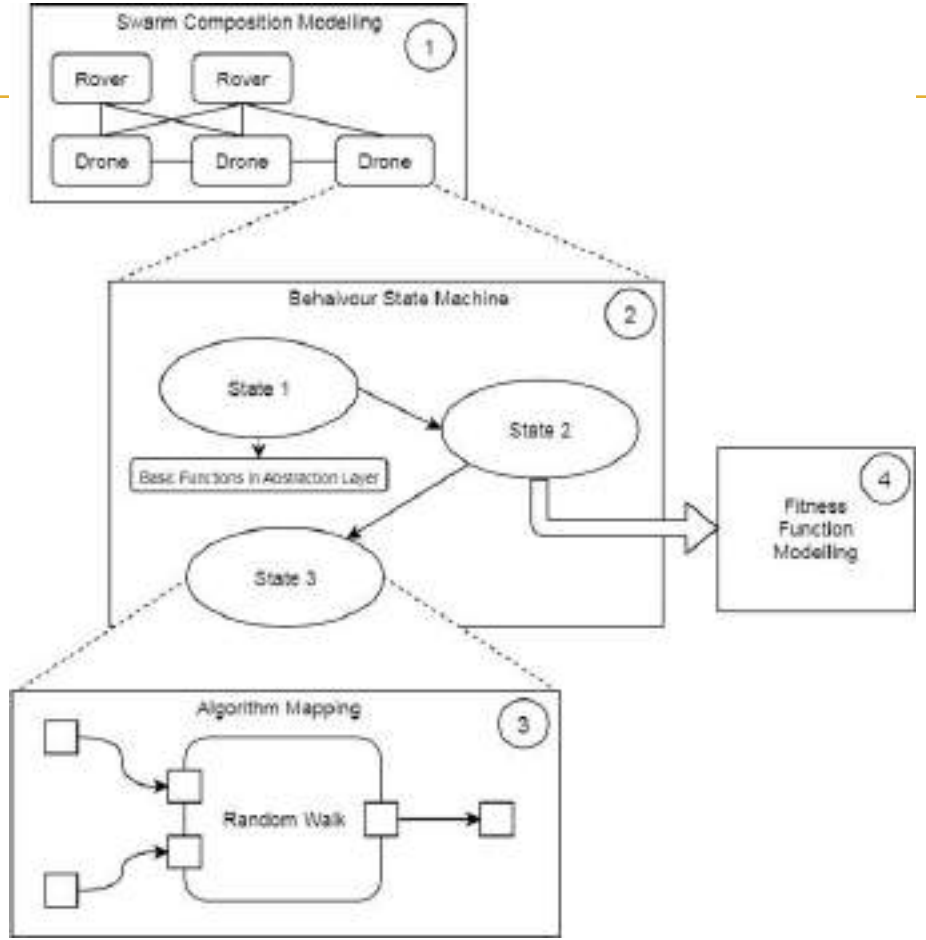
THE CPSWARM LAUNCHER

- The binding glue for different CPSwarm components
- Provides the ***GUI*** for user to ***launch different components***
- Provides the GUI for user to manage assets files
- Assists user to ***navigate through swarm design workflow***

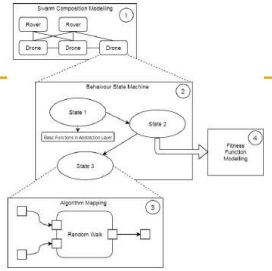


SWARM MODELING

- ***Modeling*** of
  - ***single CPSs***
  - ***swarm composition***
  - ***behavior (State Machine)***
- Extend SysML standard
- ***Libraries*** of reusable components



SWARM MODELING



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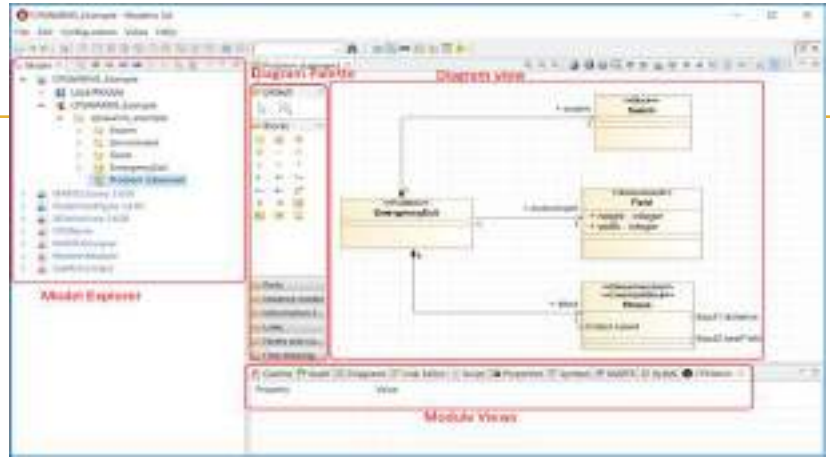
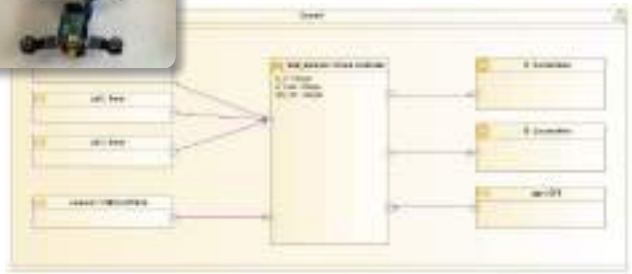
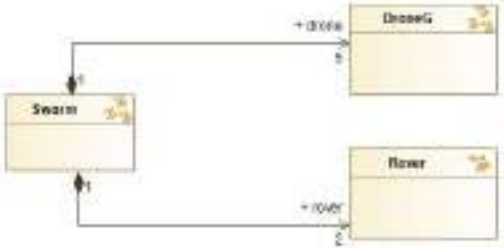
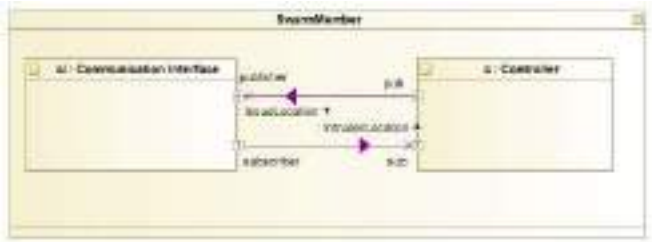
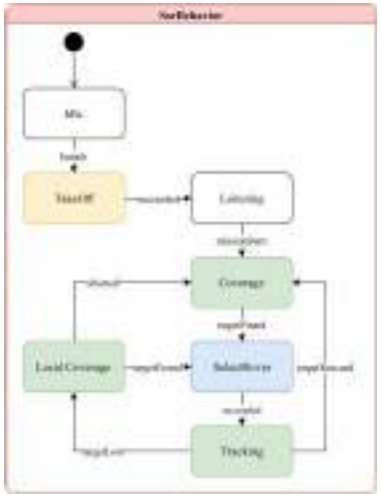




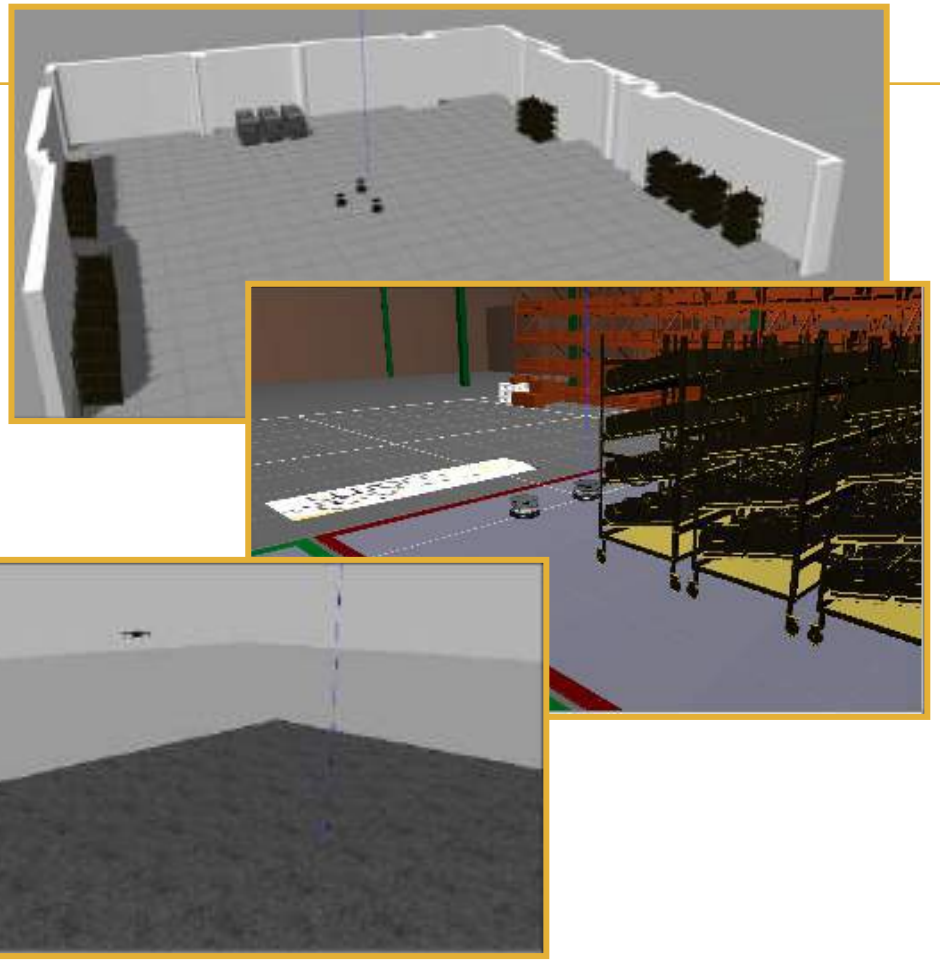


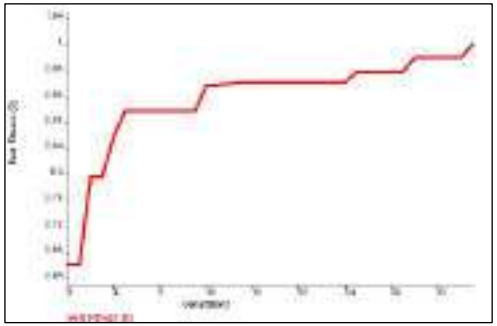




SIMULATION & OPTIMIZATION

- The ***Simulation Environment*** is used to ***evaluate the performance*** of a swarm solution.
- It can be used as a stand-alone component or in combination with the ***Optimization Tool*** (i.e. FREVO) to iteratively improve the controller algorithm/module considering specific ***fitness functions***





SIMULATION & OPTIMIZATION

Integration of **standard opensource** technologies and tools (i.e., Docker, Kubernetes, Thingsboard, ROS) to enable **rapid deployment, orchestration and monitoring** of large scale distributed cluster of simulation servers.

docker

kubernetes

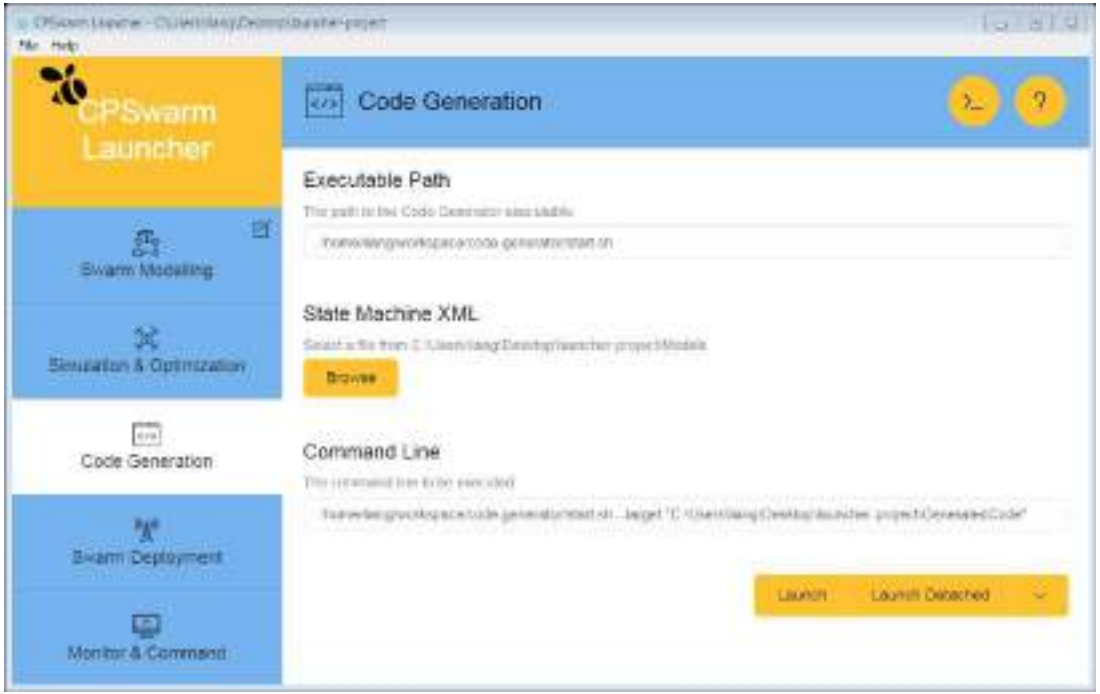
ThingsBoard

ROS.org

CODE GENERATION

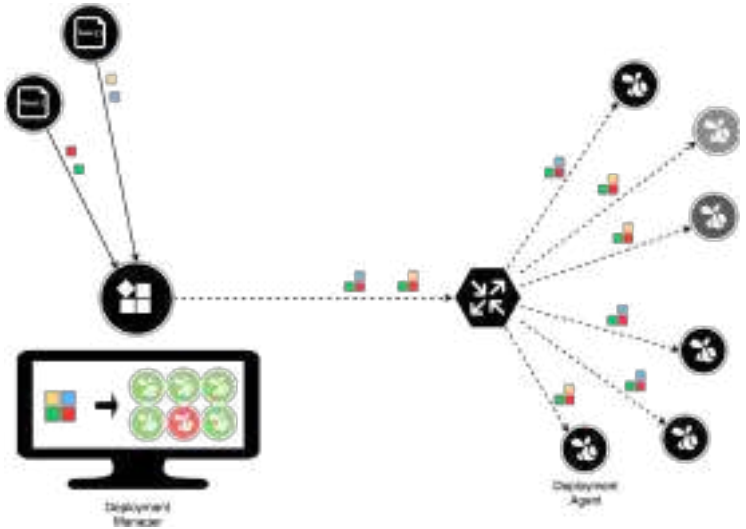
Two different tasks are performed

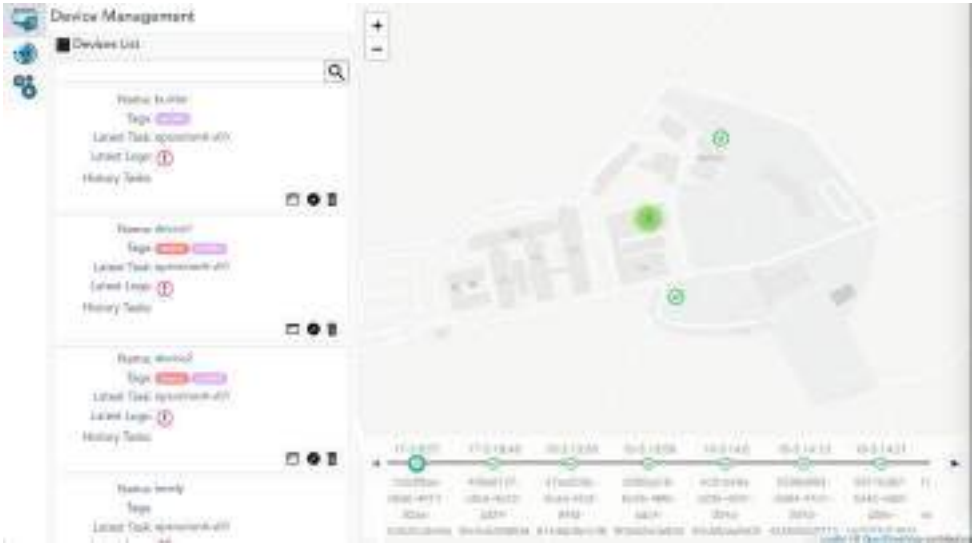
- ***Interpret CPS models*** using specific formalisms.
- ***Generate CPS modules*** and ***libraries*** that can be passed to the Deployment Tool to be installed on the actual CPSs.



SWARM DEPLOYMENT

Over-the-air deployment of platform-specific code to actual CPSs.





MONITORING & COMMAND

The Monitoring and Command Tool

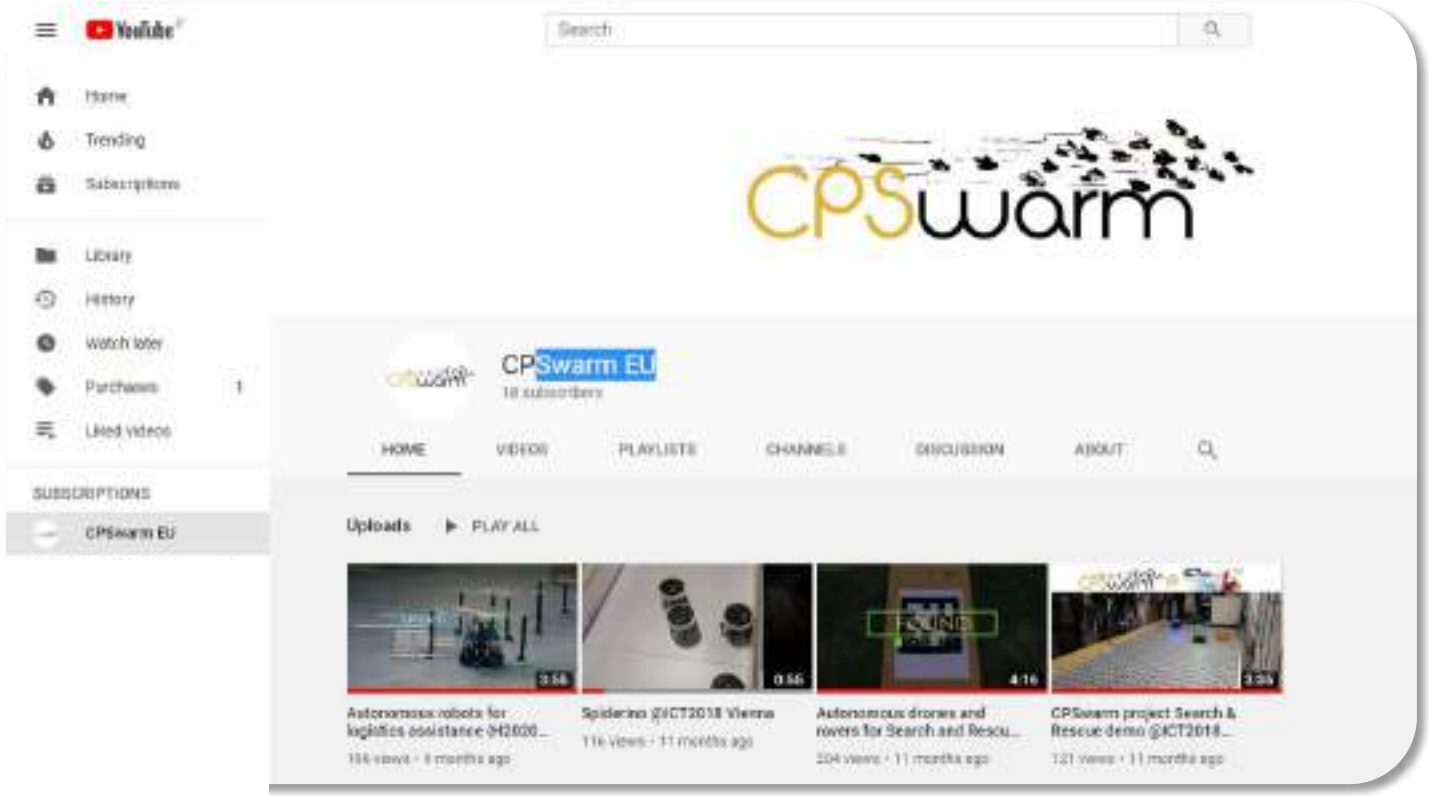
- **monitors** the swarm members' **behavior**
- **sends** configuration **commands** to modify the swarm behaviour

Open Source Components

https://github.com/cpswarm

https://www.cpswarm.eu

YouTube Channel



THANKS!
ANY QUESTIONs?

Final Workshop

Towards Smart Autonomous Cyber-Physical Systems: Unmanned Aerial/Ground Vehicles and Robots

Claudio Pastrone

LINKS Foundation - CPSwarm

claudio.pastrone@linksfoundation.com

https://www.cpswarm.eu

The projects leading to this application have received funding from the European Union's Horizon 2020 research and innovation program

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731946.