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Human-Autonomy Teaming for drone control and supervision — Methodology and use cases definition

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Table of contents

01 Introduction

02 Use case for collaborative combat : COHOMA challenge

03 Use case for search-and-rescue mission : SEISMEC project

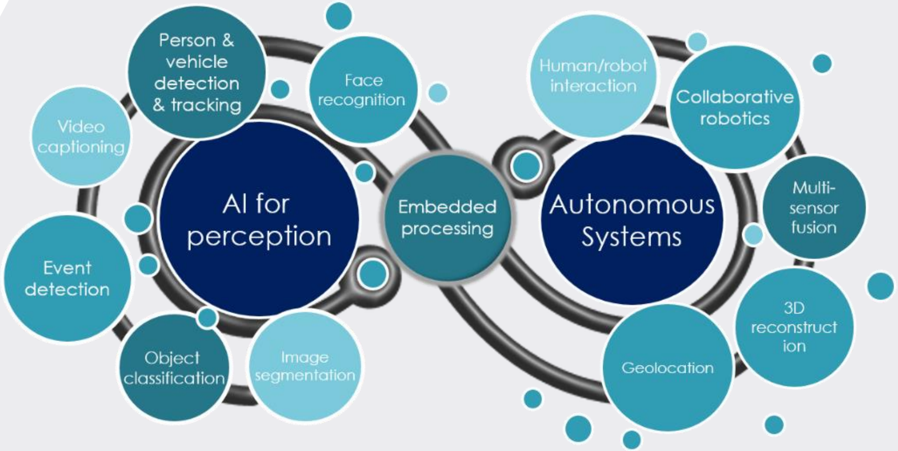
04 Human-Autonomy Teaming and global roadmap with PRODEC

05 First steps on PRODEC methodology

06 Illustration of technical demonstrators

07 Conclusion and perspectives

Introduction



THALES SIX GTS FRANCE – THERESIS – Vision, Autonomy & Robotics Learning

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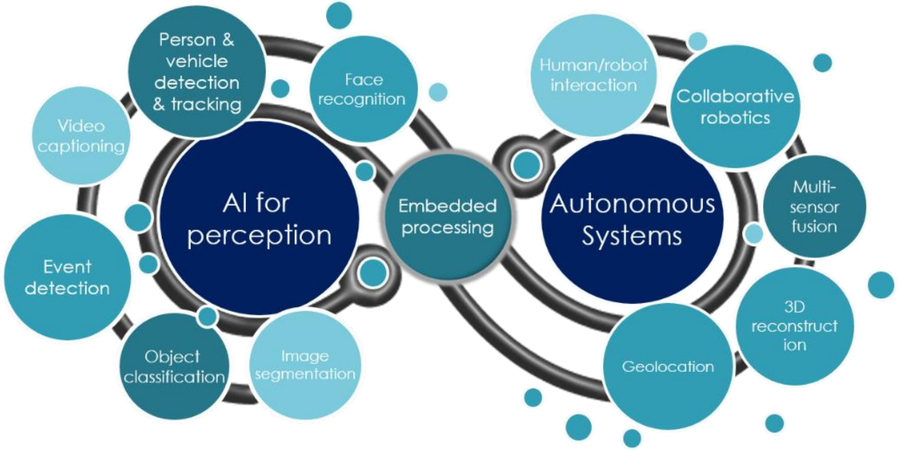
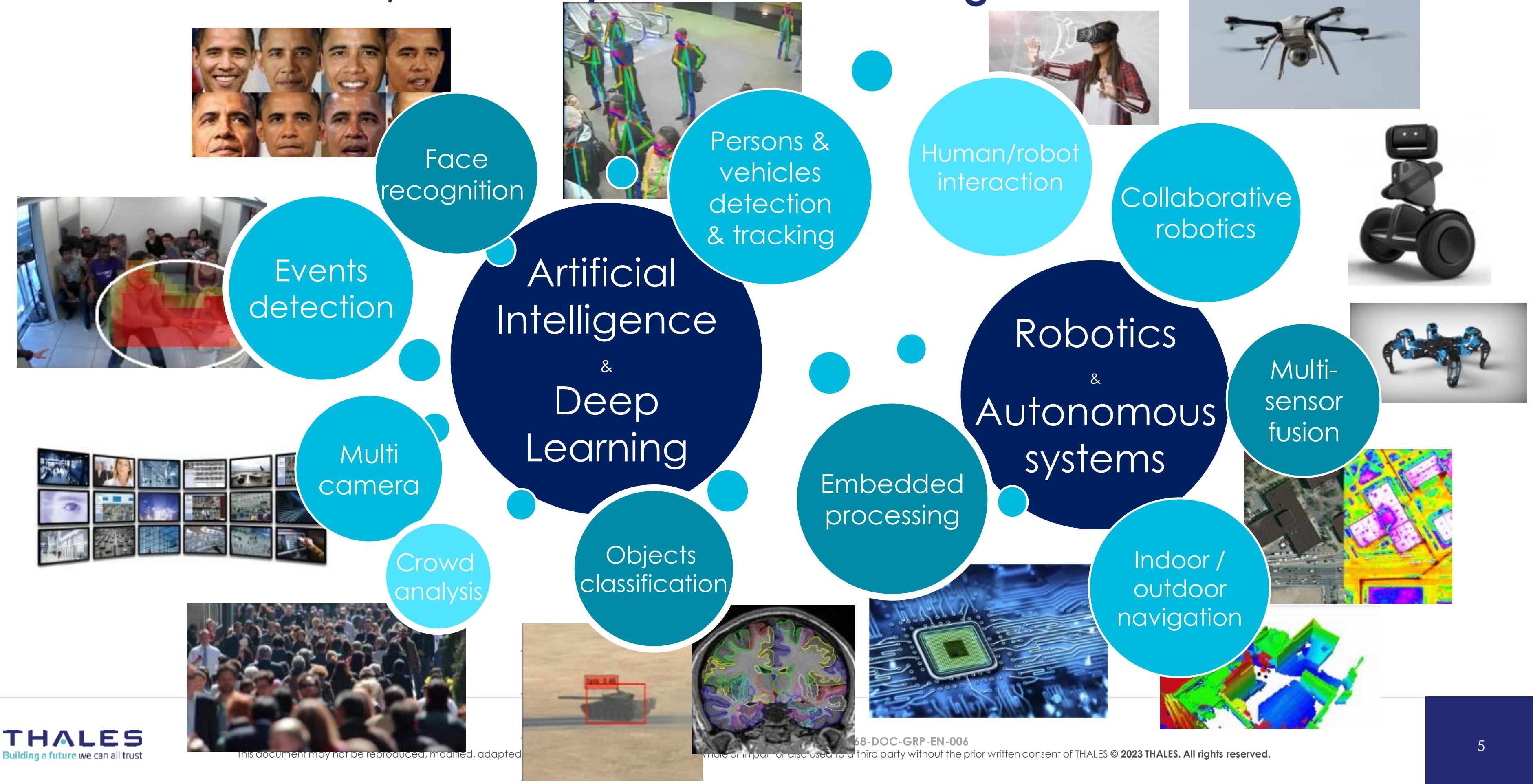
Vision, Autonomy and Robotics learning (VAR)

15 people (8 doctors; 2 on-going PhDs)

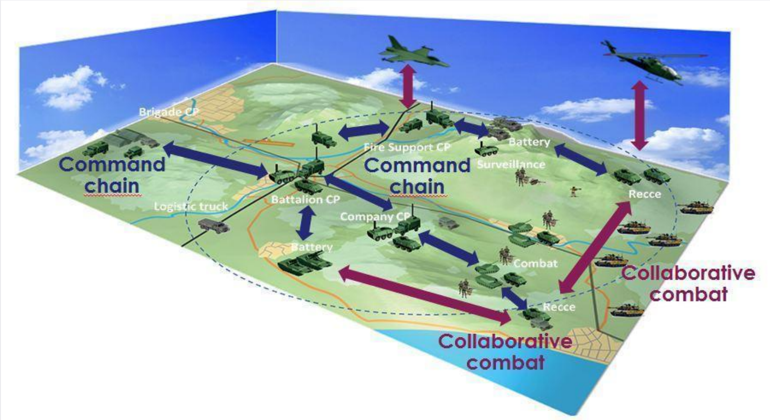
Expertise in AI for perception and Autonomous systems



Activities of Vision, Autonomy & Robotics Learning lab



Use case for collaborative combat



Collaborative Combat context

> **Interest raised by COHOMA (COllaboration HOmme-MAchine) challenge (3rd edition in 2025)**

- **Context :** Collaborative combat requires natural and efficient Human-Machine interactions and interfaces and fine-grained management of autonomy
- **Objective :** increase decisional autonomy of platforms (UGVs, UAVs) and assess impact on cognitive workload of operators
- **Scenario :** multiple UGVs and UAVs supervised by remote operators have to move in a natural environment and to detect targets simulated by red cubes with QR-codes giving information about the nature of the target

How to deal with autonomy?
How to take into account the role of human operators?

Use case for search-and-rescue mission

SEISMEC

11/07/2023 - THALES SIX GTS FRANCE / Template: 87211168-DOC-GRP-EN-006

Pilot scenario : search-and-rescue mission

SEISMEC
Human-centred development, deployment and assessment of the effects of technological innovations on people, employees and workers

Drone with embedded EO/IR sensors & AI capabilities

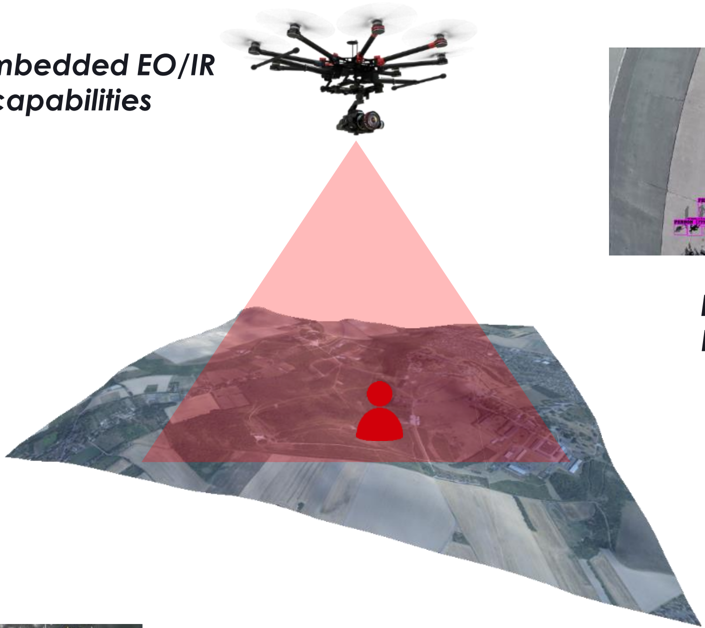


Image & Video AI analysis for DRI (Detection, Recognition, Identification)

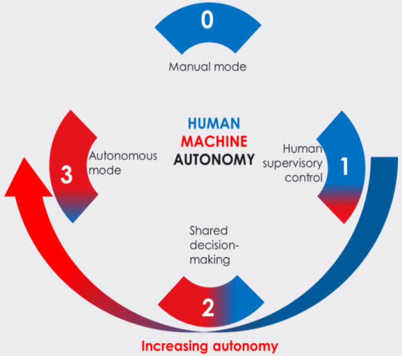
Enable drone and payload control with immersive interfaces

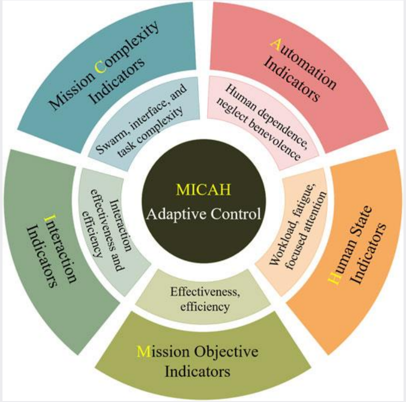
VR supervision

AR direct control

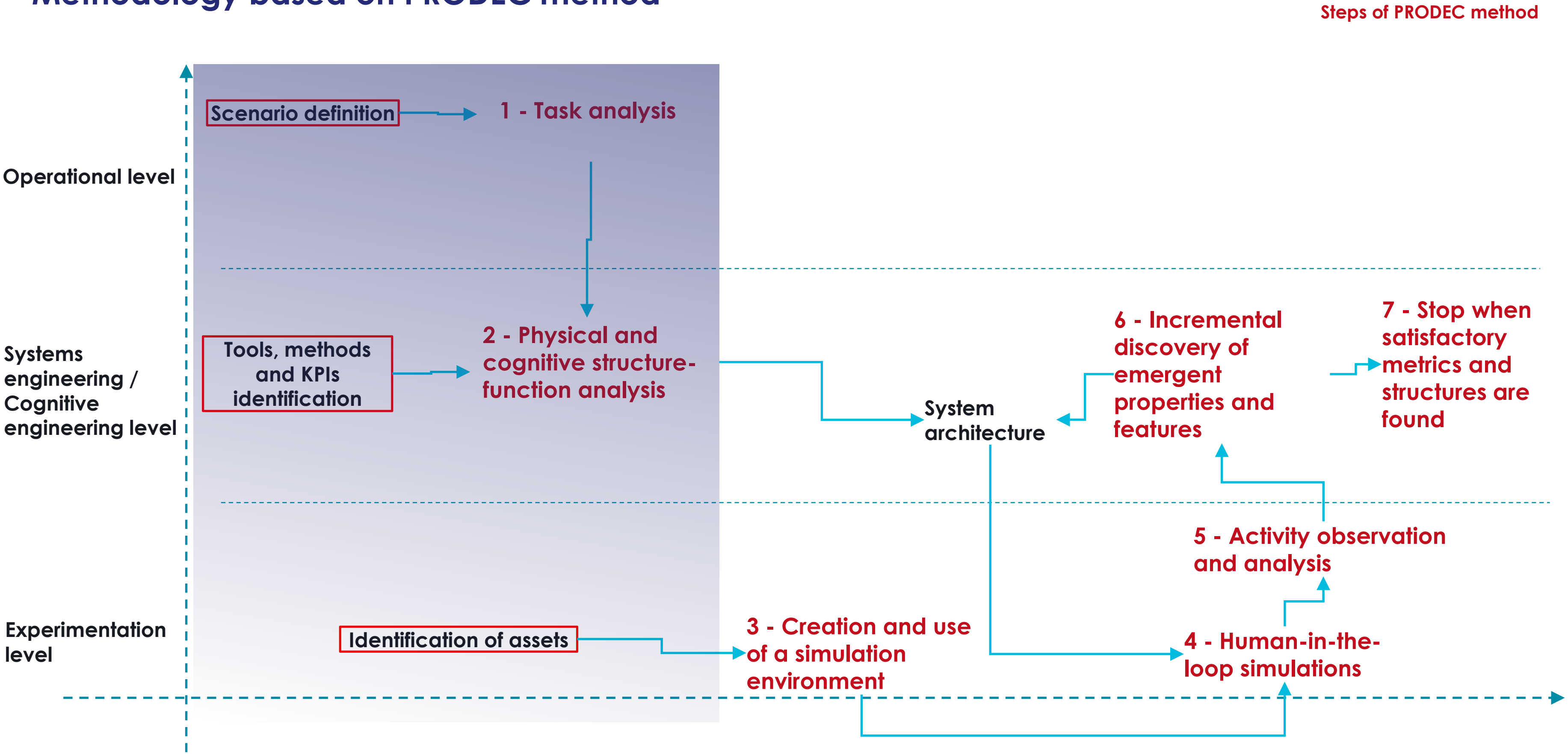
How to design human-centred system with efficient Human-System interactions?

Human-Autonomy Teaming and PRODEC methodology



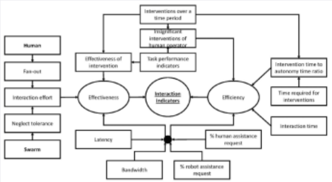


Methodology based on PRODEC method

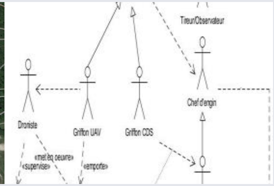


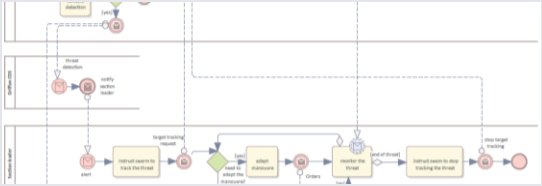
Boy, G. and Morel, C. 'The Machine as a Partner: Human-machine Teaming Design Using the PRODEC Method'. 1 Jan. 2022 : S15 – S30.

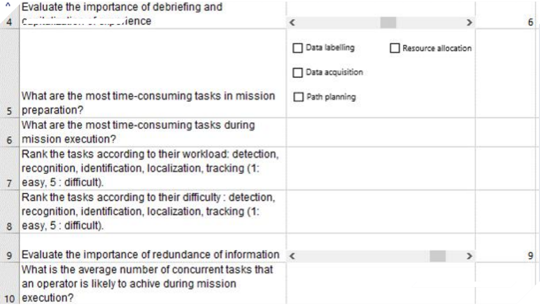
First steps on PRODEC methodology



Task analysis







4	Evaluate the importance of debriefing and capitalization of experience		6
5	What are the most time-consuming tasks in mission preparation?	☐ Data labelling ☐ Resource allocation ☐ Data acquisition ☐ Path planning	
6	What are the most time-consuming tasks during mission execution?		
7	Rank the tasks according to their workload: detection, recognition, identification, localization, tracking (1: easy, 5 : difficult).		
8	Rank the tasks according to their difficulty : detection, recognition, identification, localization, tracking (1: easy, 5 : difficult).		
9	Evaluate the importance of redundance of information		9
10	What is the average number of concurrent tasks that an operator is likely to achive during mission execution?		

> Draw a scenario for collaborative combat missions or assistance to first-responders

- Define involved actors (humans and drones : UGVs, UAVs…) in the scenario and their relations

> Modelling processes using BPMN for each identified actor

- Identify critical decision points
- First view of expected workload and achievable level of autonomy

> Gather expertise from end-users with questionnaires and interviews

- Understand activity of first-responders
- Understand expectations from a system with AI
- Understand reluctance and limitations and potential trust issues

Physical and cognitive function analysis

> **PRODEC is based on 4 categories of cognitive functions**

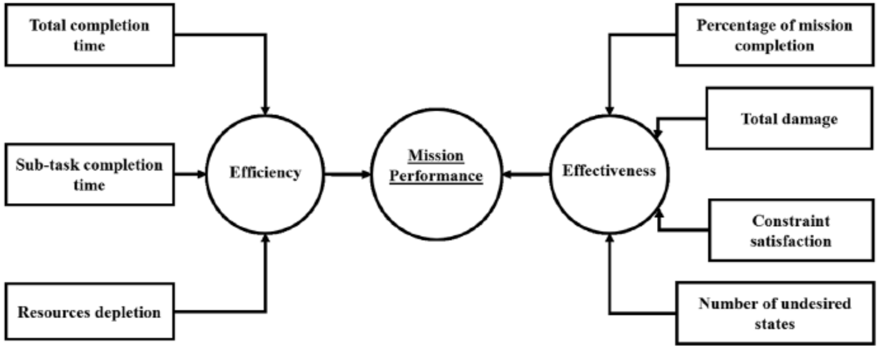
- Situation Awareness
- Reasoning
- Action
- Collaboration

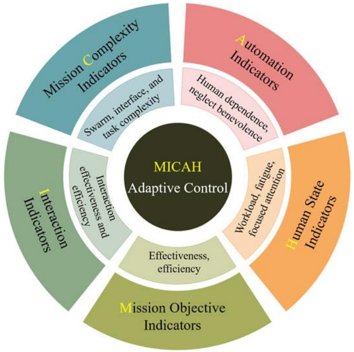
> **Associate cognitive function to each task identified in task analysis**

> **Associate KPIs to each task to assess cognitive workload and feasibility of each task based on expected level of autonomy**

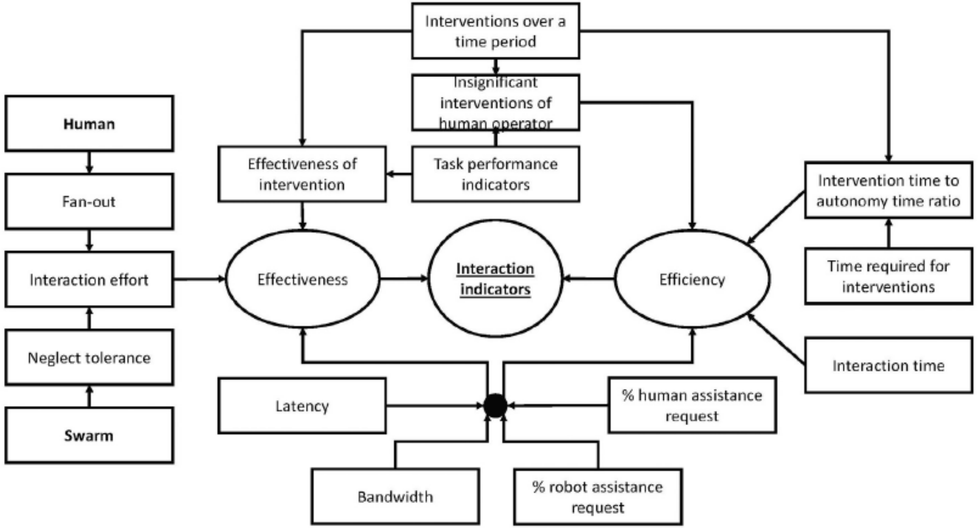
Excerpt of COHOMA scenario				
Plan	**Process**	**Task**	**Resource allocation**	**Cognitive function**
Mission progress on phase *i*	Tactical detection	Allocate trajectory to the UAV	Human or Robot	Reasoning
		Execute trajectory	Robot	Action
		Scan ground	Robot	Situational Awareness
		Detect target	Robot	Situational Awareness
		Transmit detected targets	Robot	Situational Awareness
	Target information extraction	Allocate required UAV(s)	Human or Robot	Reasoning
		Approach phase	Human of Robot	Action
		Detect QR-Code	Robot	Situational Awareness
		Extract information on QR-Code	Robot	Situational Awareness
		Transmit information	Robot	Situational Awareness
	Target deactivation	Allocate required UAV	Human or Robot	Reasoning
		Plan trajectory	Human or Robot	Reasoning
		Interact with target for deactivation	Human	Action

Metrics and KPIs for Human-Autonomy teaming





Analytic Hierarchy Process for the indicators of the MICAH framework : take into account preferences of the human operator



Hussein, A., Ghignone, L., Nguyen, T., Salimi, N., Nguyen, H., Wang, M., Abbass, H. A. Characterization of Indicators for Adaptive Human-Swarm Teaming. Frontiers in Robotics and AI, 9, 2022. https://www.frontiersin.org/articles/10.3389/frobt.2022.745958.

Activity observation and analysis

- **First drafts of questionnaires to obtain feedback after using the system**
- **Iterative process to correct architecture choices**
- **Identify emergent properties and features**
  - Refine Human-Machine Interfaces
- **Identify transitions between modes of autonomy when facing perturbations**
- **Assessment of cognitive workload and situation awareness**
  - NASA-TLX, SAGAT

Assess the effort required to achieve the mission.	Little effort	High effort
Assess your trust in the drone.	Low trust	High trust
Assess the performance of the drone during the mission.	Low performance	High performance
Assess the required level of attention to control the drone.	Low level of attention	High level of attention
Assess the required level of attention to perform the search/observation task.	Low level of attention	High level of attention
Assess how easy it is to understand the drone's actions.	Actions not understandable	Actions highly understandable
Assess your workload wharing between the drone control task and the search/observation task.	Mainly on control	Mainly on observation
Assess to what extent the system contributed to prevent errors.	Few errors avoided	Many errors avoided
Do you think the problems were correctly solved by the system?	Not at all	Completely
Do you think the problems were rapidly solved by the system?	Very slow	Very fast
Assess how much attention you dedicated to the monitoring of tasks performed bby the system.	Low monitoring	High monitoring
Did you understand the solutions proposed by the system?	Not at all	Completely

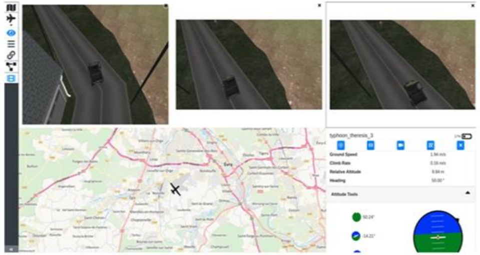
First steps for experimentations and technical demonstrators

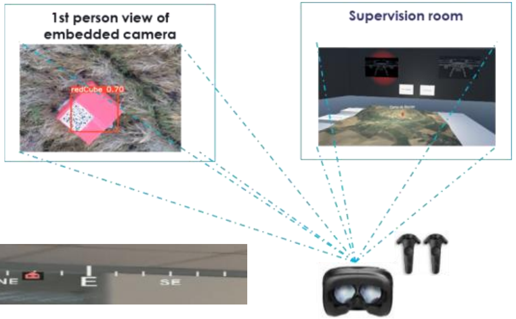
Software and hardware assets in the Lab

> Expertise based on contributions from multiple collaborative projects

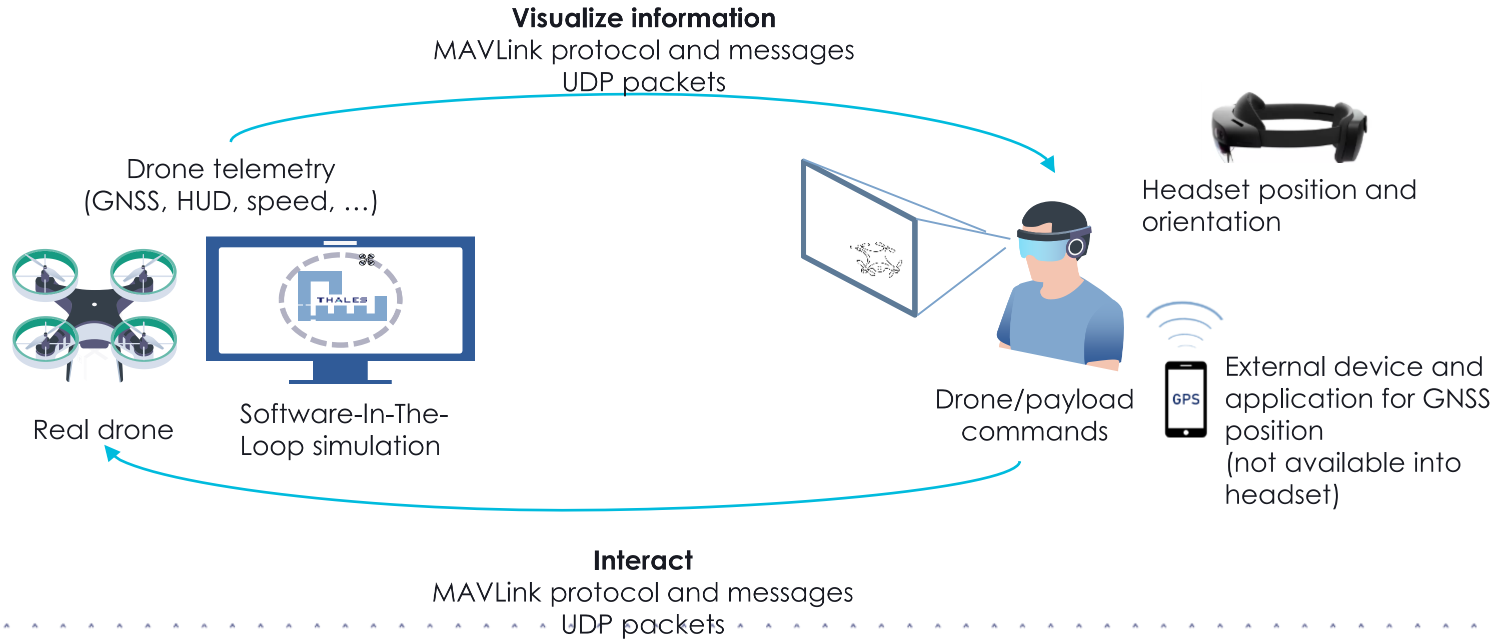
- Intelligent payload for small drones equipped with EO/IR cameras and embedded AI capabilities for video analysis (people and vehicle detection: Yolo, OpenPose…)
- Ground control station for mission planning and monitoring : MAVLink, GIS, Openlayer
- Simultaneous video, drone telemetry and metadata streaming : RTP/RTSP, WebRTC, MAVLink
- Video compression using hardware accelerators on NVidia Tegra X1/X2
- Drone simulation : PX4 Software In The Loop, ROS + Gazebo
- Immersive AR/VR user interfaces




AR Technical demonstrator



Functionalities and User Interface design to ensure Situation Awareness on the field

AR heads-up display for drone direct control

- Highlight drone position for enhanced perception and easier interaction
- Drag and drop drone visualization to new position
- Command sent to the drone in real-time

AR heads-up display for drone control using 3D map

> Interactive 3D map displayed to the user

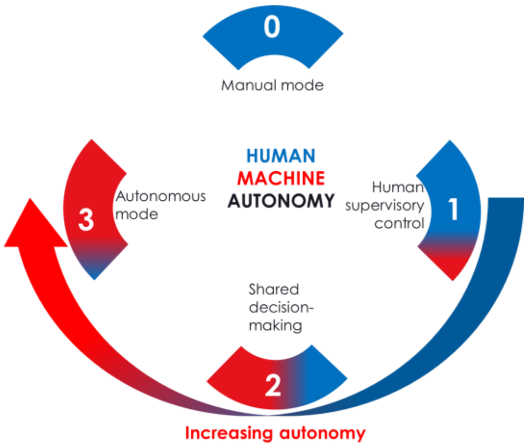
> Position on the map updated in real-time

> Command sent to the drone in real-time

Conclusions and perspectives

Conclusions and perspectives

- Address Human-Autonomy Teaming in dynamic, complex and cooperative systems
- Instantiante methodology to model use cases and scenarios of missions involving operators with heterogeneous robotic platforms
- Choice of PRODEC : methodology centred on human-systems integration, cognitive modelling and experimentations
- Current implementation in different contexts : collaborative combat and search-and-rescue missions



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Thank you for your attention

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