



Joint Authorities for
Rulemaking on Unmanned
Systems

UAS automation, autonomy and the missing ring

How to certify highly complex systems in a highly complex
environment

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Rome, 3 November 2022

AAM
is coming



(source: internet)



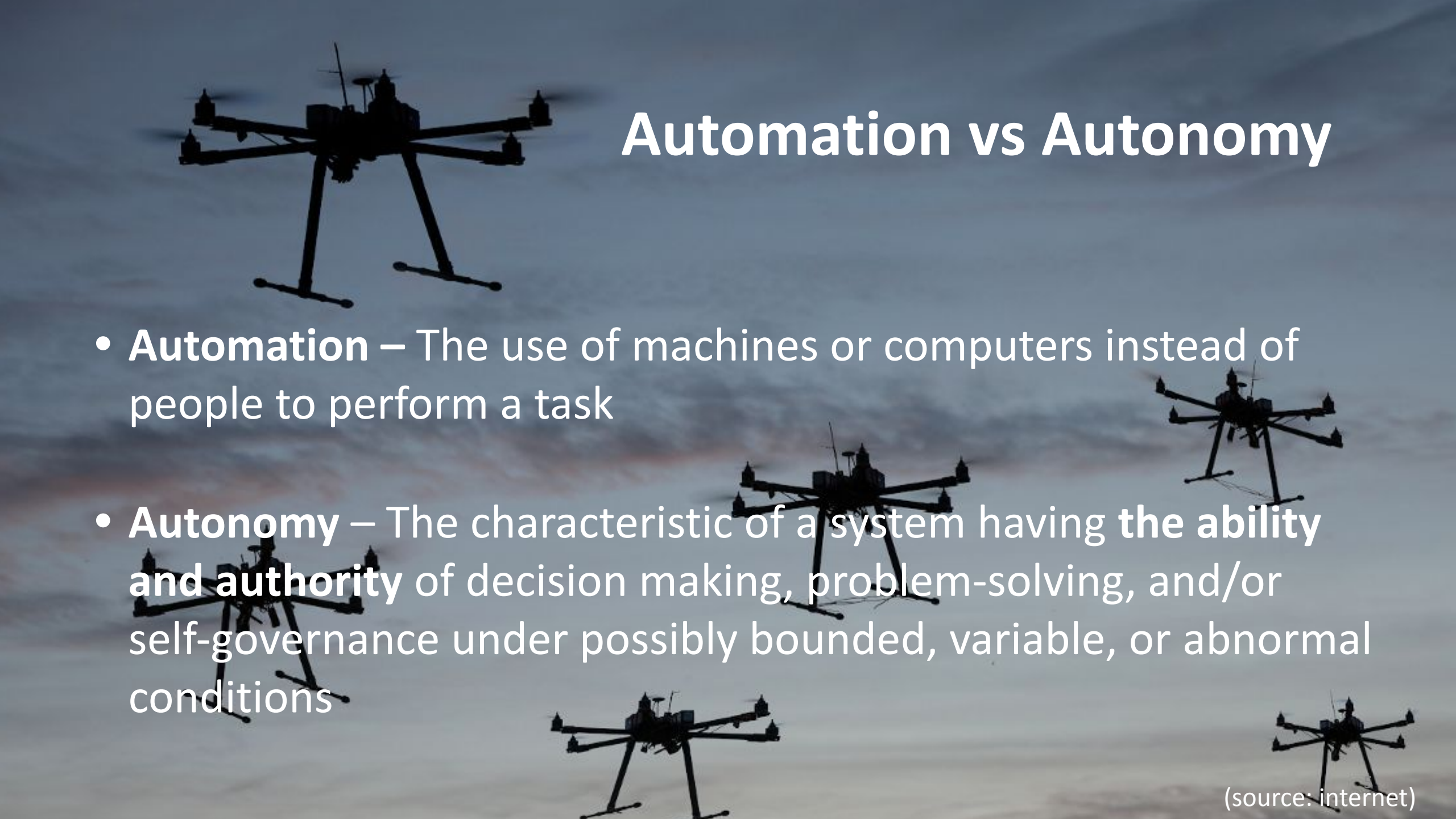
(source: internet)

REGULATION

A hand is shown interacting with a futuristic digital interface. The interface features a large, circular gauge with a blue and orange color scheme, which is the central focus. The word "REGULATION" is prominently displayed in white, bold, uppercase letters across the center of the image. To the left of the gauge, there are several smaller data visualizations, including a horizontal bar chart with segments in blue, orange, and grey, and two circular gauges labeled "01" and "02". The background is a blurred image of a person in a white lab coat, suggesting a medical or scientific setting. The overall aesthetic is high-tech and futuristic.

[The missing ring]

(source: internet)



Automation vs Autonomy

- **Automation** – The use of machines or computers instead of people to perform a task
- **Autonomy** – The characteristic of a system having **the ability and authority** of decision making, problem-solving, and/or self-governance under possibly bounded, variable, or abnormal conditions

Embedding
AI technology
may be easy

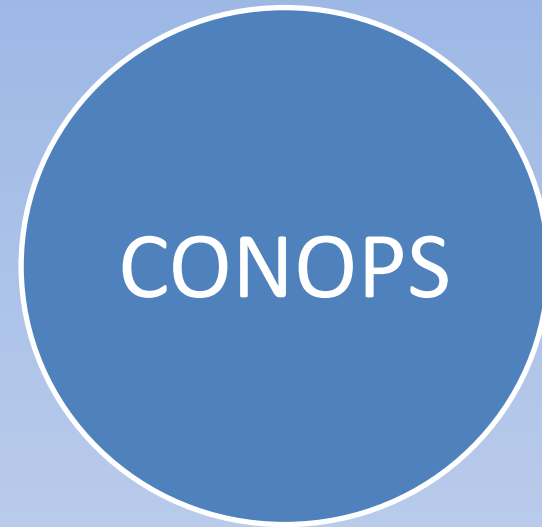
Exploitation not easy
without a favorable
environment



(source: internet)

“Reliable AI ecosystem”

(Prof. Maria Rosaria Taddeo - Cambridge University)



WG AUTOMATION



WG AIRWORTHINESS

Automation and Autonomy CONOPS

For integration of

- **Automated Aircraft Systems (UAS flight ops)**
- **Automated Airspace Systems (traffic management, aerodromes, etc.)**

within aviation regulatory frameworks including challenges with existing regulatory structures and opportunities for future regulatory development

JARUS

methodology for evaluating autonomy of UAS ops



Levels of Automation

Safety dependence of automated functions

Trustworthiness of automated functions

UAS Automation Levels in Flight Operations						
Level Functions	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
	Manual Operation	Assisted Operation	Task Reduction	Supervised Automation	High Automation	Full Autonomy
Human-Machine Teaming	Human led	Human-In-the-loop	Human-In-the-loop	Human-In/On-the-loop	Human-On-the-loop	Human-Off-the-loop
Sustained Aircraft Maneuver Control	Human	Human <i>AND</i> Machine	Machine (Managed by Human)	Machine (Supervised by Human)	Machine	Machine
Object and Event Detection and Response (OEDR)	Human	Human	Machine (Managed by Human)	Machine (Supervised by Human)	Machine	Machine
Fallback (Integrity Thresholds Exceeded)	Human	Human	Human	Human	Fall back Ready Human	Machine (Limited or Segregated Operations)
Communication with External Systems (Ground and Airspace systems)	Human	Human	Human <i>OR</i> Machine (Managed by Human)	Machine (Supervised by Human)	Machine	Machine

Fully autonomous UAS could operate in an airspace environment with a lesser level of autonomy

(human in/on the loop as ultimate safety layer)

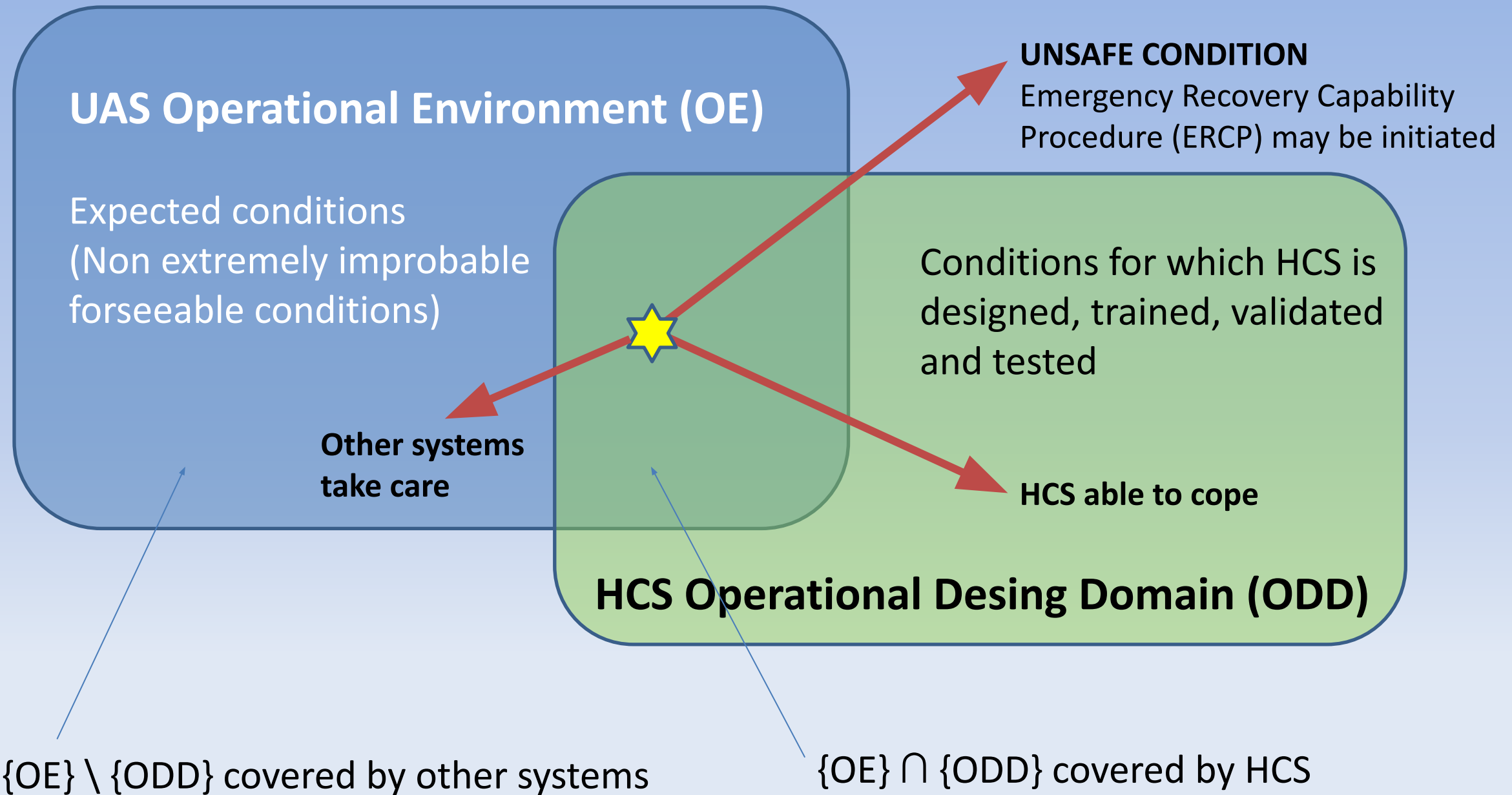
UAS performance-based certification requirements

Performance-Based Airworthiness Requirements
for UAS which contain functions performed by
High Complex Systems (HCS) including AI

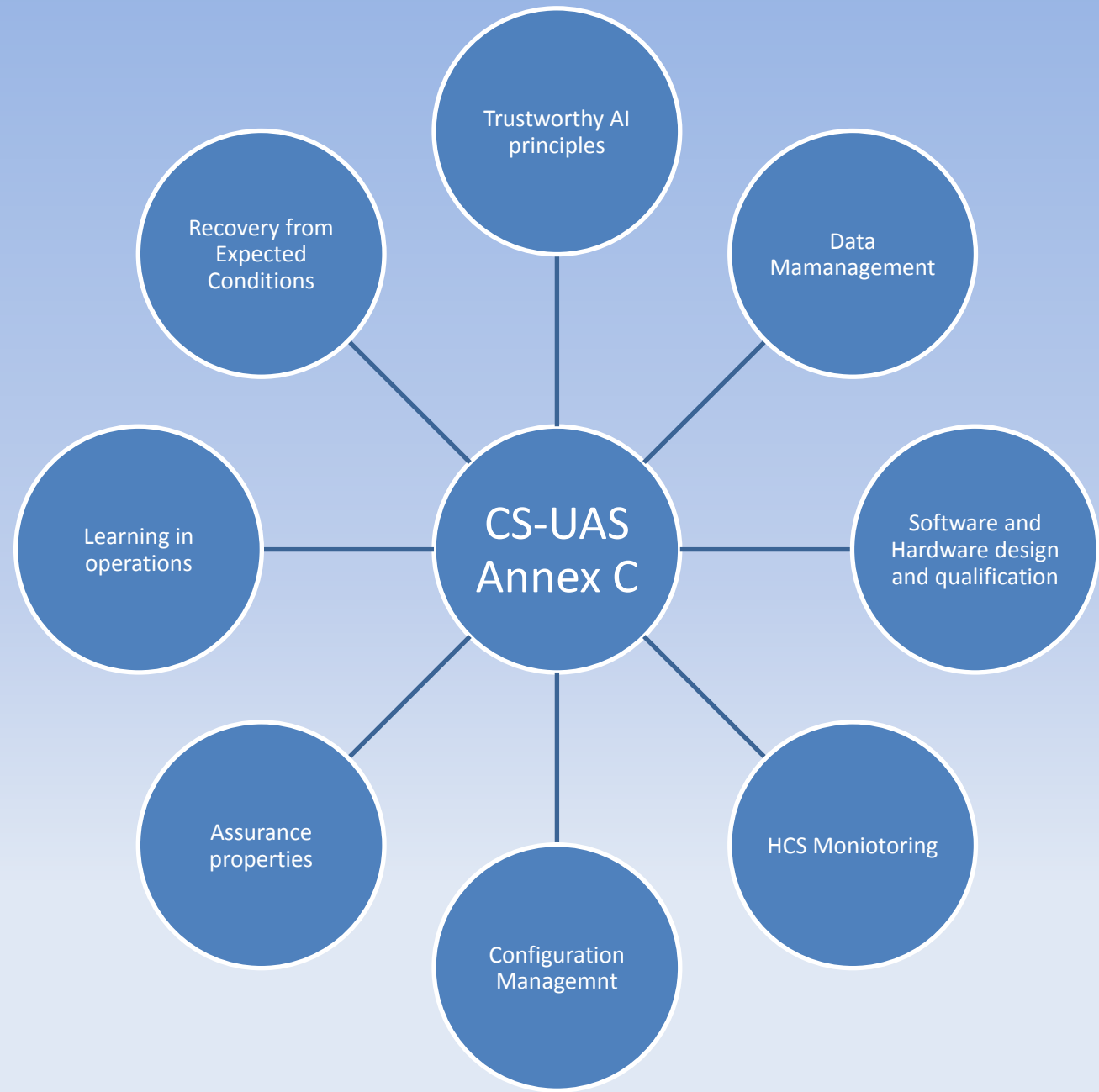
- Machine Learning
- Symbolic AI
- Numerical analysis

□ **CS-UAS Annex C**

	Joint Authorities for Rulemaking of Unmanned Systems																		
CS-UAS, Annex C - Additional requirements for UAS which contain functions that are performed by High Complex Systems (HCS) incl. AI, Machine Learning, Neural Networks etc.																			
DOCUMENT IDENTIFIER : JARUS WG-AW Certification of HCS																			
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Objective Requirements



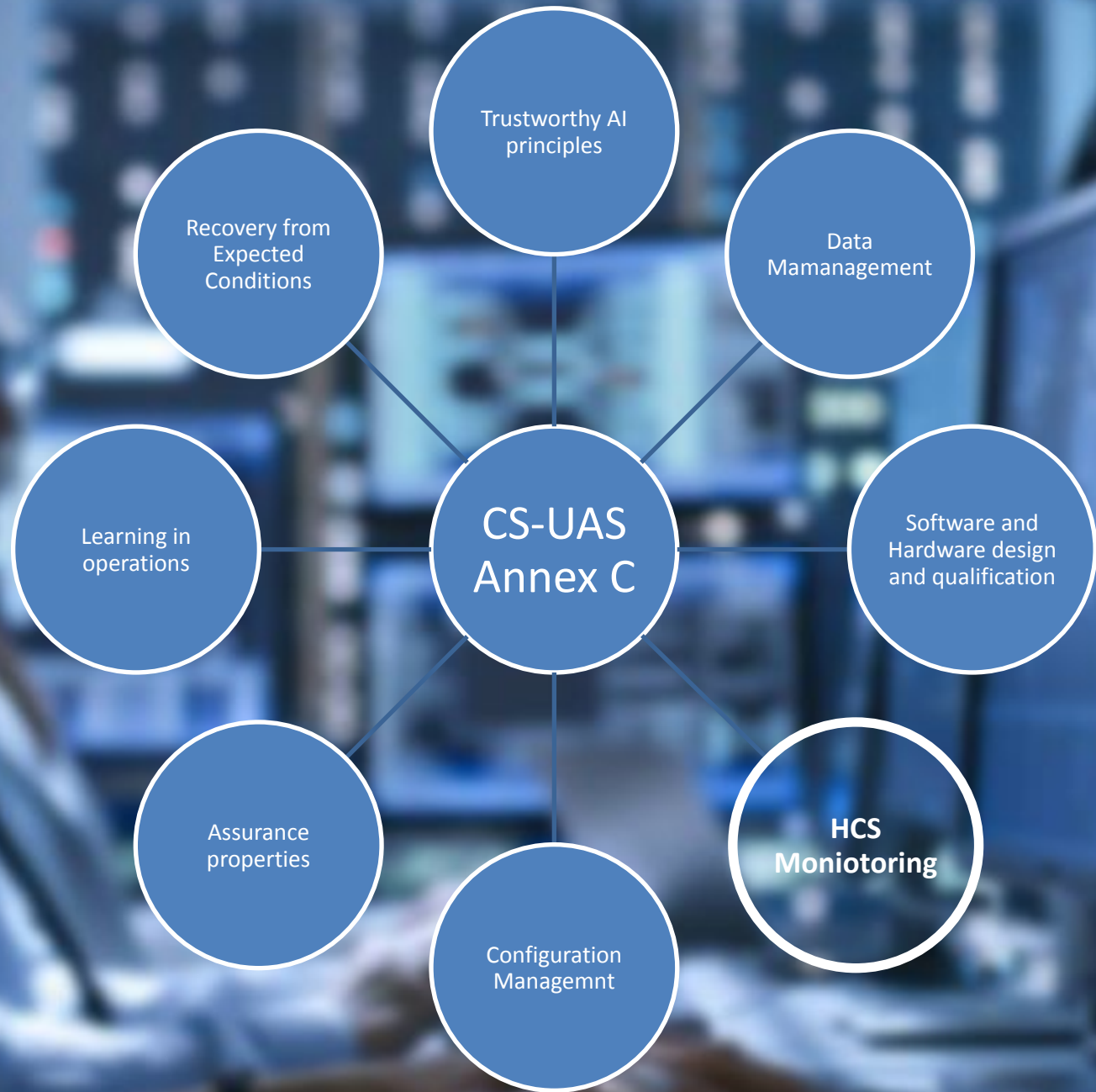
Trustworthy AI

- Lawful
- Ethical
- Safe & secure
- Explainable



Monitoring levels

- HCS output
- Superordinate systems that make use of HCS output
- UAS



Learning in operations (ML)

- Offline
- Online – during ops
(adaptive behaviour)

Design change to be
(re)certified, unless
otherwise foreseen



Conclusions

- **JARUS** is developing **performance-based requirements and recommendations** for **autonomous UAS operations in autonomous airspace environment** making use of AI, unlocking the possibility for Authorities to authorize operations
- Detailed standards can be developed in compliance with the performance-based requirements to allow high TRL projects in order to prof **actual system in operational environment**
- To support this process the Authorities (incl. ENAC, the Italian CAA) are developing **Regulatory Sandbox** approaches



First Italian Veritport at Fiumicino Airport – Rome



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Thank you for attention

<http://jarus-rpas.org/>

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