SCI-328 Research Symposium

Flight Testing of Unmanned Aerial Systems (UAS)

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Development and flight test of a UAV for Search and Rescue missions

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Summary

I. Project “SABYR”: Background
II. The UAS: UAV and subsystems
III. Particularities of flight testing in SABYR
IV. Testing approach
V. Flight tests
VI. Concluding remarks

Background

- Search and Rescue ops (Europe, the Mediterranean countries, etc.)
- Conventional **air assets** to cover large areas and capture video
- Observers work under **stress, fatigue** and it may lead to miss targets. Several hours looking at a screen, many times in a moving vehicle.
- The detection **time is key: chance of survival** drops from 50% after 48h to 20% after 72h

SABYR project

- The use of **AI-powered drones** would alleviate this issue
- **SABYR** (**S**istema **A**utómono de **B**úsqueda **Y** **R**escate): Autonomous System for Search and Rescue
- SABYR is a set of AI algorithms onboard a UAV and detect, classify stranded people, vehicles or boats in real-time to guide the UAV towards the target

SABYR project

- Development of two pillars (**VTOL UAV** and **AI algorithms**), including flight testing
- AI-powered mode generates references for the autopilot
- Led by **Aurea Avionics**
  - Contributions from the Technical University of Madrid (**UPM**)
  - Co-funded by the Centre for the Development of Industrial Technology (**CDTI**), Ministry of Science and Innovation of Spain

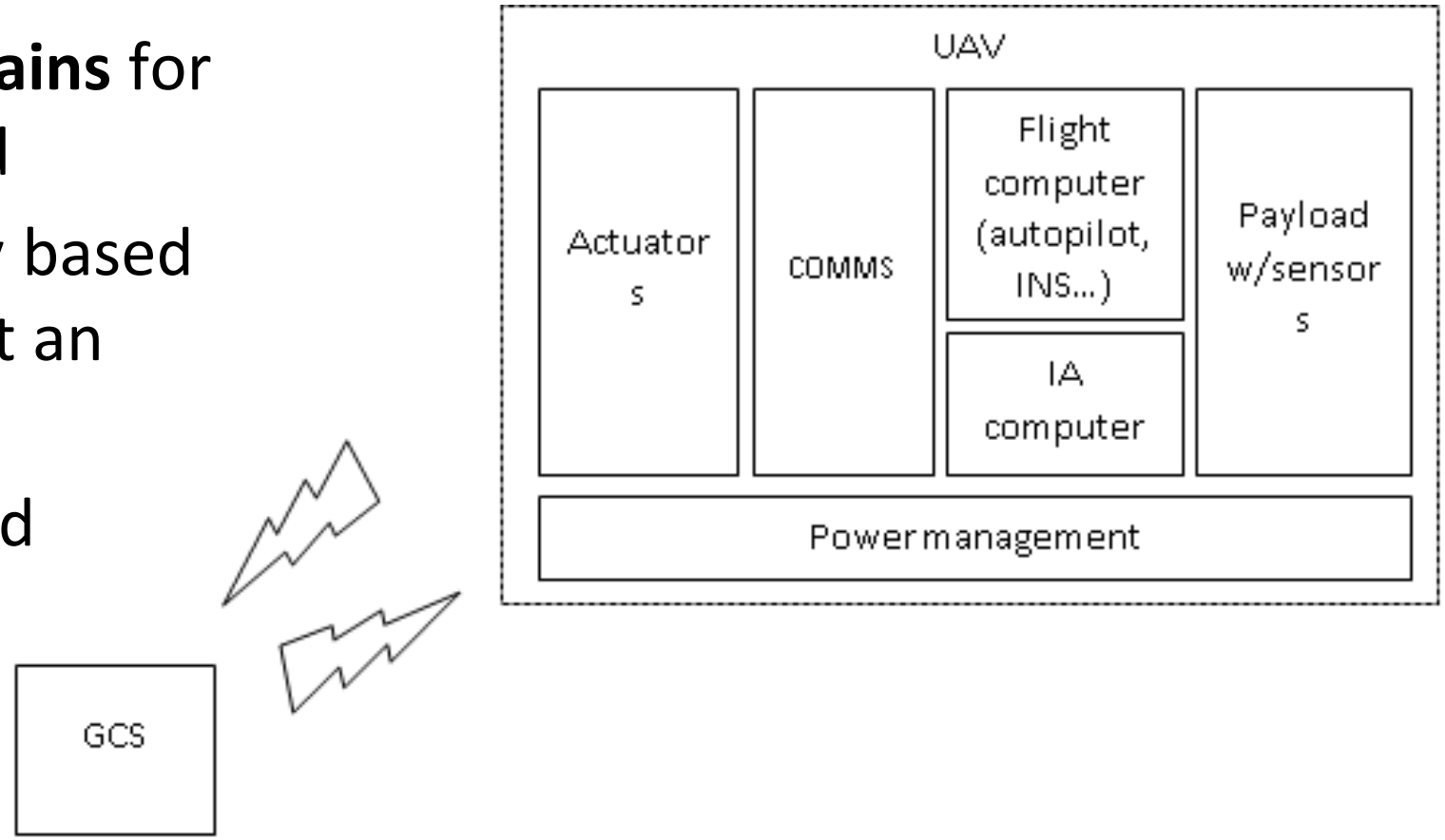
UAV

- Class I Mini UAV
- VTOL configuration with 5 tilting rotors

Parameter	Value
MTOW	**4.5 Kg**
Wingspan	2.65 m
Length	0.9 m
Wing surface	0.8 m^2
Propulsion	Electric
Configuration	VTOL flying wing

Subsystems

- Strong **SWaP constrains** for equipment on board
- Physical redundancy based safety strategy is not an option
- AI computer onboard



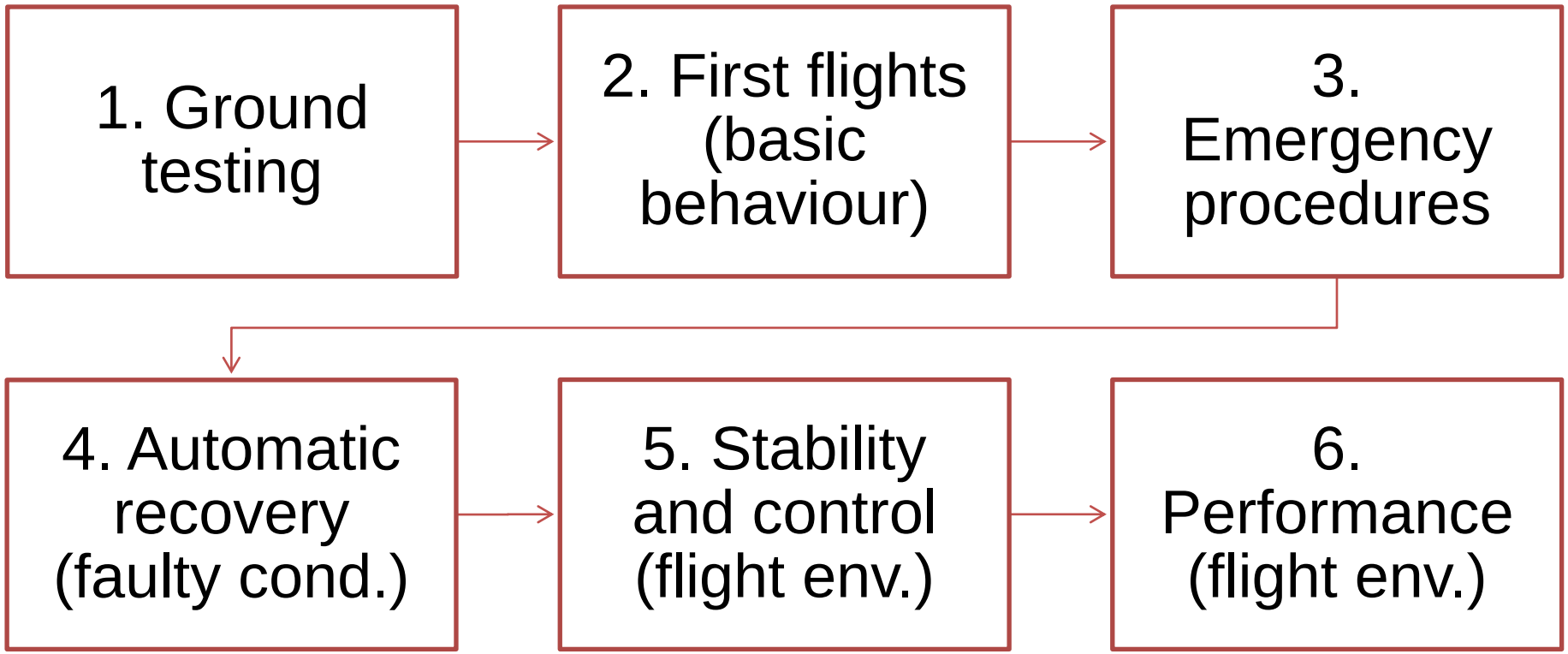
Summary of particularities

- **Class I Mini UAS** without physical redundancy nor crew
  - Intensive ground testing
  - Special procedures
  - Incremental approach

- **AI-powered** guidance mode
  - Onboard
  - Outputs may be difficult to foresee or even erratic
  - Split from the autopilot

Flight testing approach

- Inspired by the ASTM F2245 (FW LSA certification)



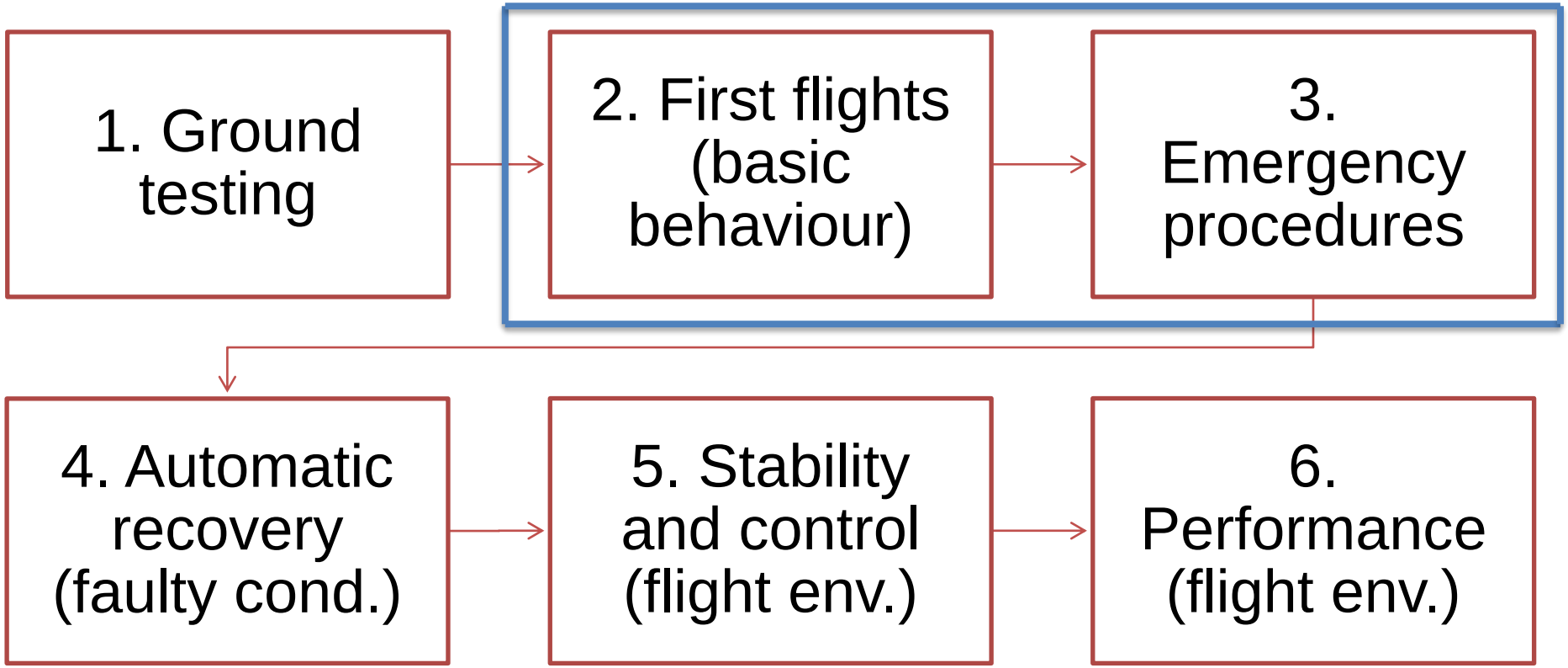
Ground testing

- Goal: Early identification of errors that concern safety (cost and time saving)
  - –Replicate conditions found in the air
  - –Test conditions that are difficult to replicate in the air, or risky in a first attempt

1. Software-in-the-loop (SIL)
2. Hardware-in-the-loop (HIL): whole UAS (PL, AP, COMMS…)
3. Tests on the field/outdoors, but not flying (GNSS, RF…)

Flight testing approach

- Inspired by the ASTM F2245 (FW LSA certification)



Special safety cosiderations

- Additional radiolink for manual piloting in emergency situations
- Start testing in a small air volumen (VLOS), increasing it in final stages
- Start with bare minimum equipment on board
- Other means, specific for particular tests

AI-powered mode

- AI outputs are fed into the autopilot, generating new references
- Hypothese: AI may be unpredictable, producing degenerated references
- Strategy: keep the AI engine isolated and test the stability and control of the UAS against bad references previously

Flight testing approach

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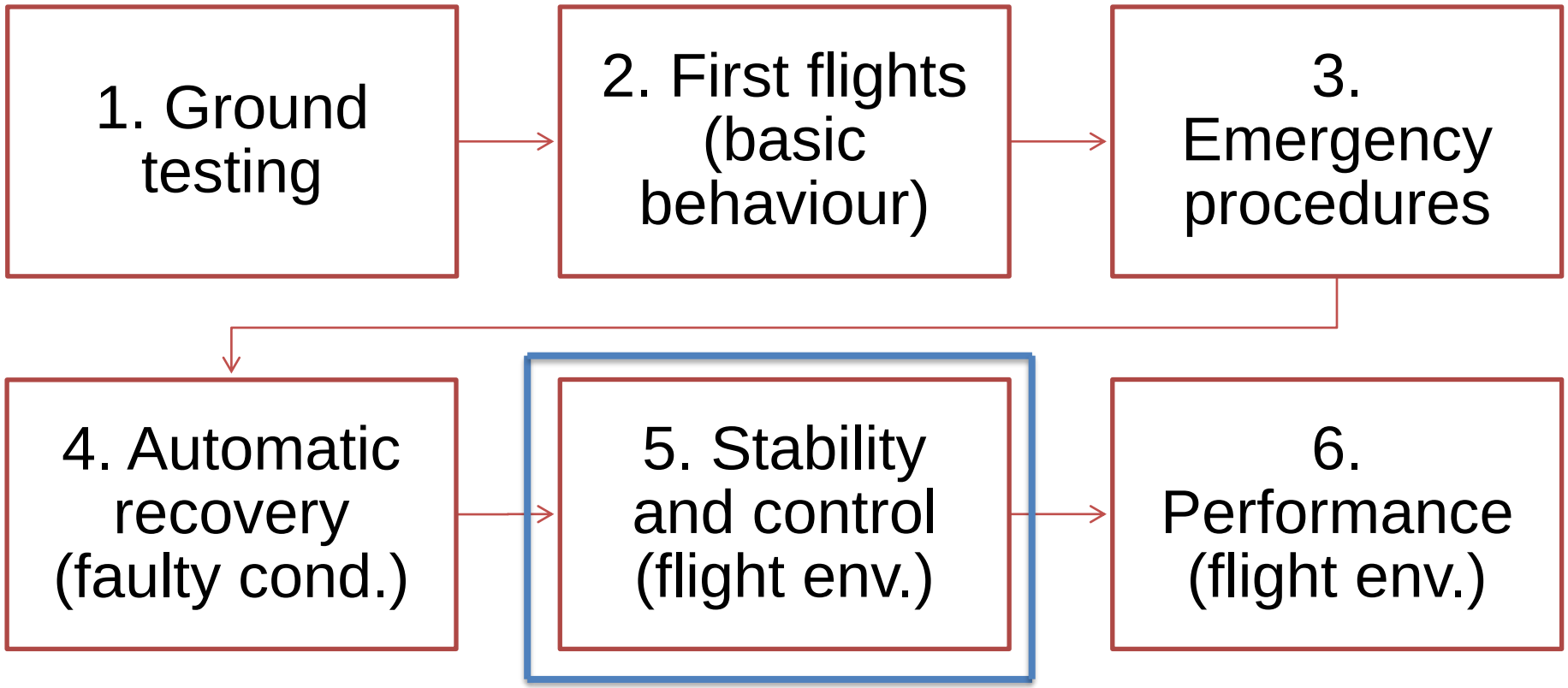
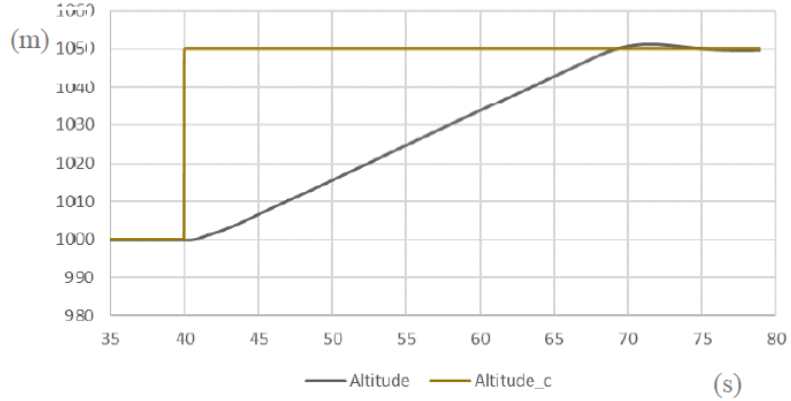
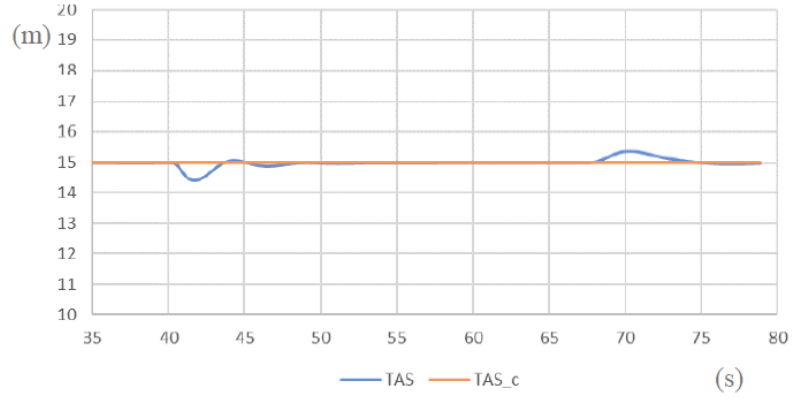
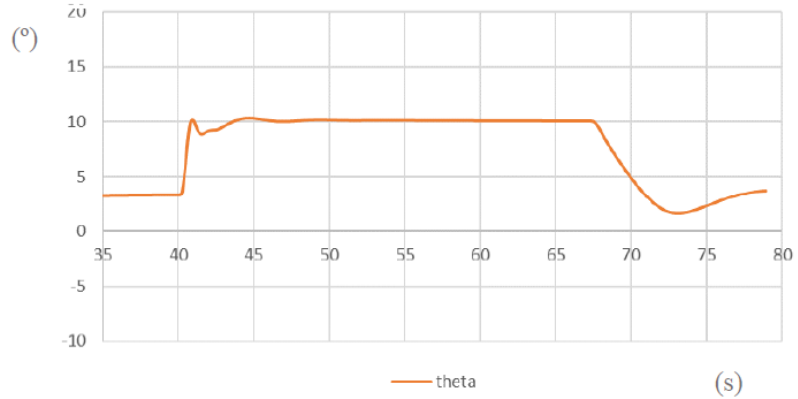


Stability and control

- Climbing test
  - Change in reference altitude

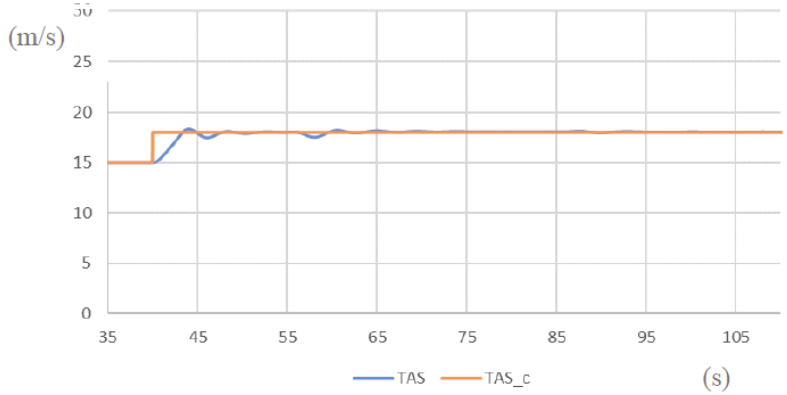


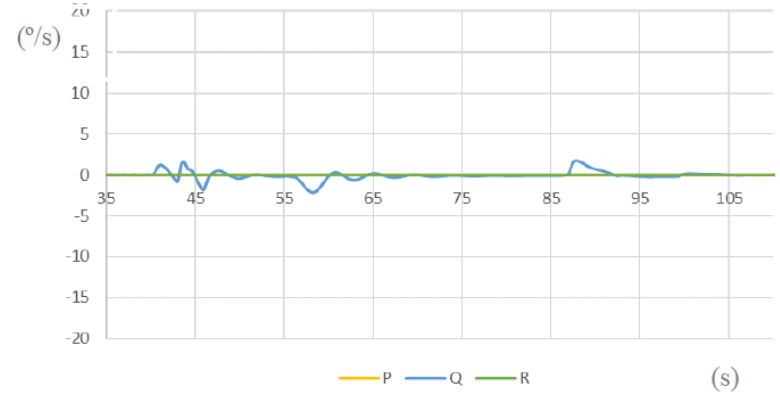


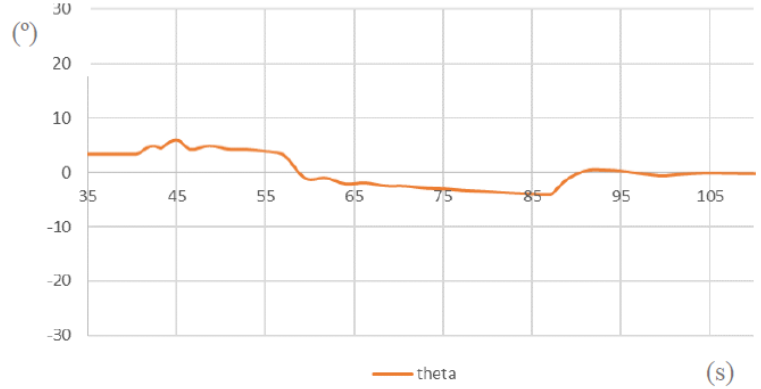


Stability and control

- Acceleration test
  - Change in reference airspeed

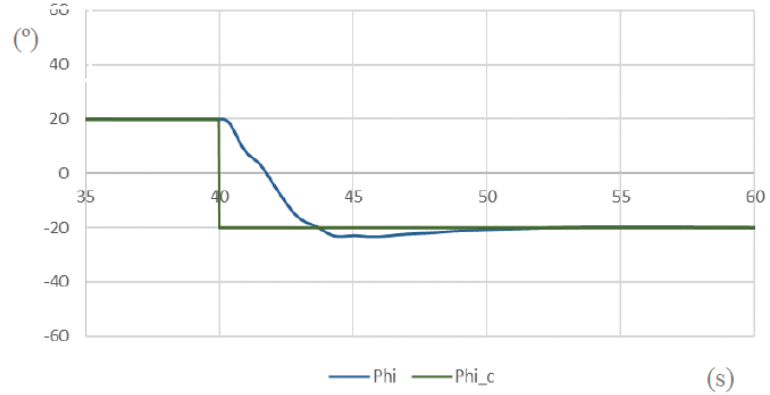


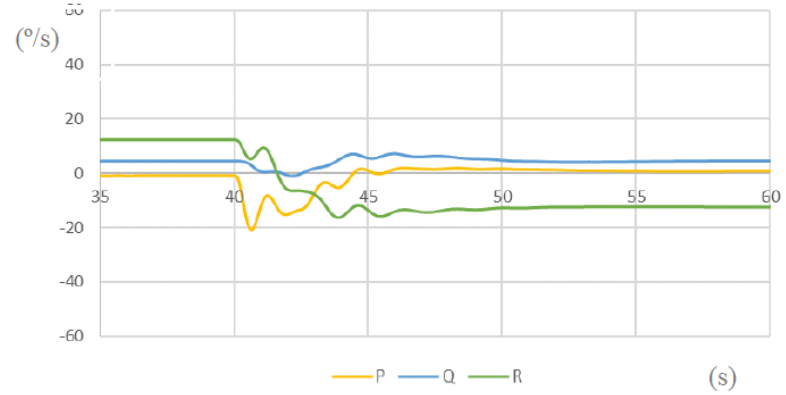


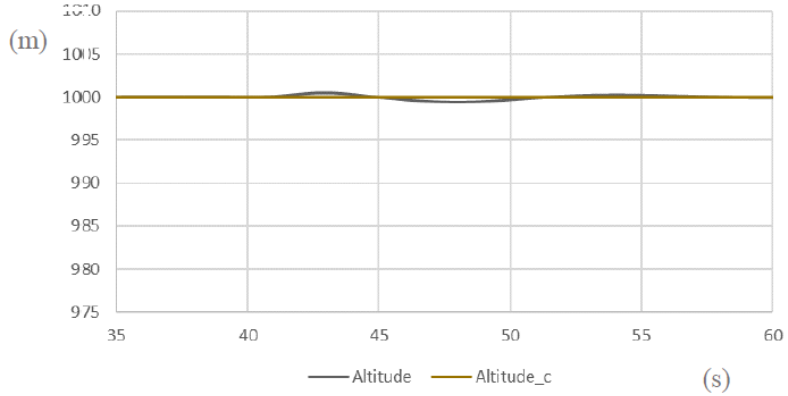


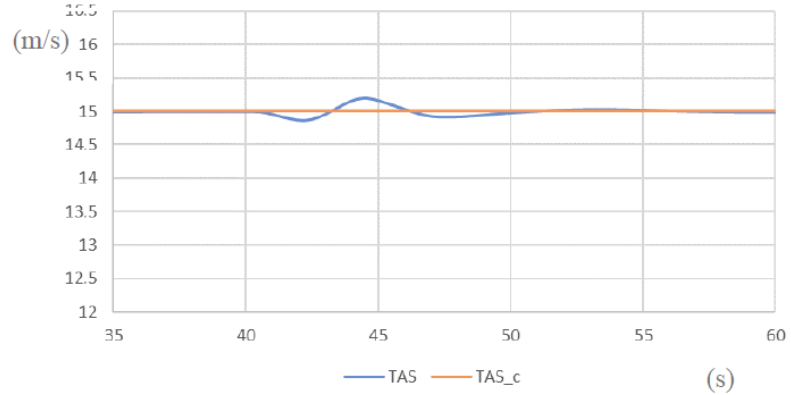
Stability and control

- Roll angle test
  - Change of roll reference or turn



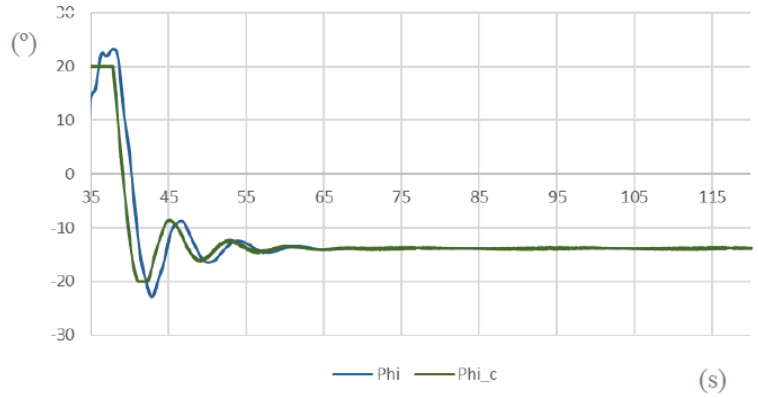


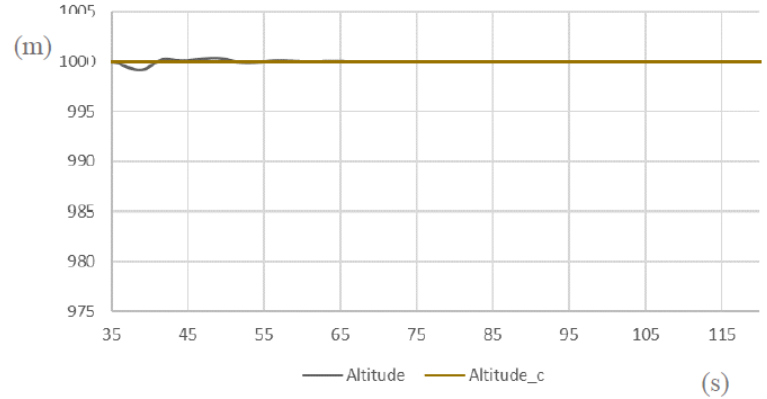


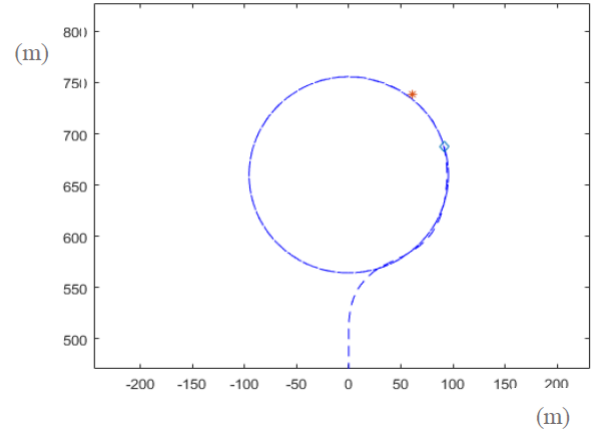


Stability and control

- AI-powered mode
  - Target identified







Flight testing approach

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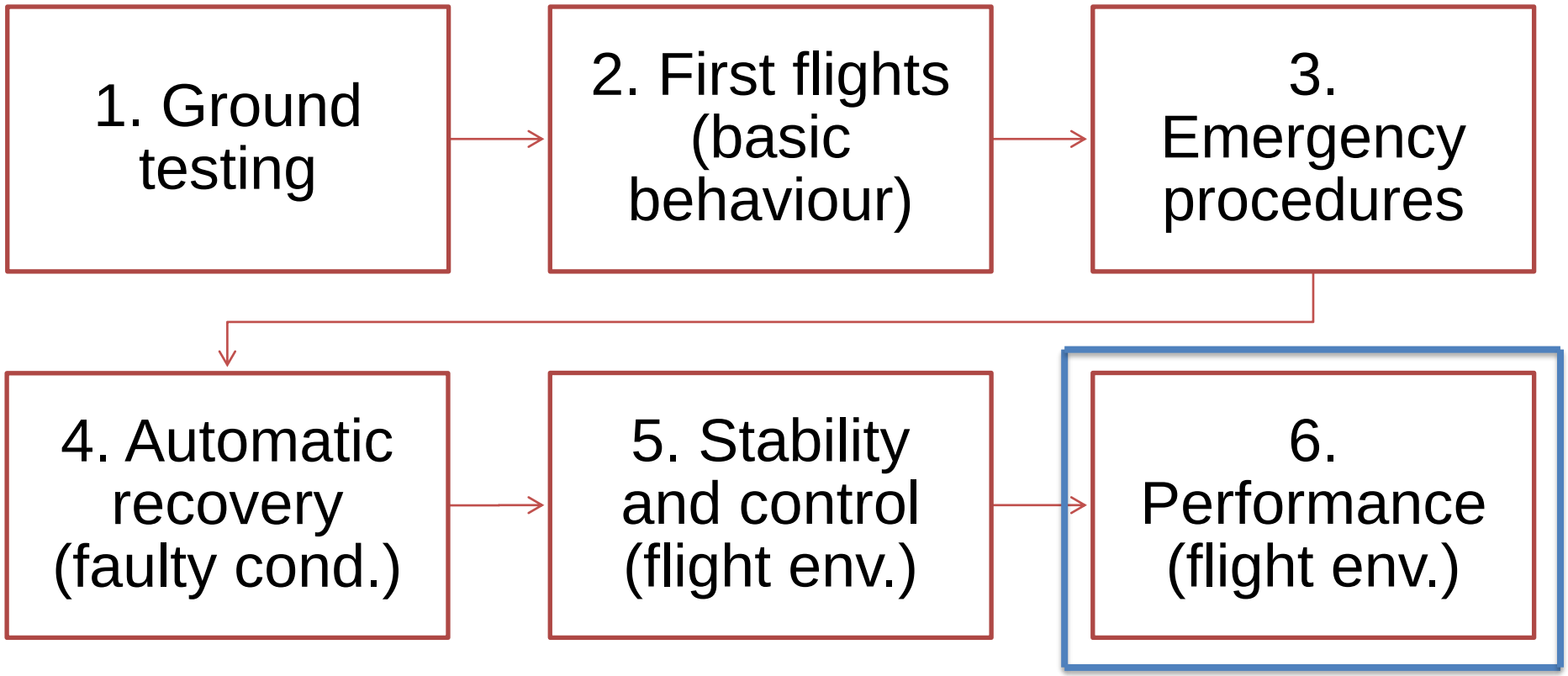

AI-powered mode

Concluding remarks

- The absence of physical redundancy in the UAS impacts both the systems architecture and flight testing
- Solid methodical approach is fundamental: special procedures earn relevance to guarantee acceptable safety levels and avoid overcosts
- AI-powered guidance mode feeding the classic control in the autopilot allows phased flight testing

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