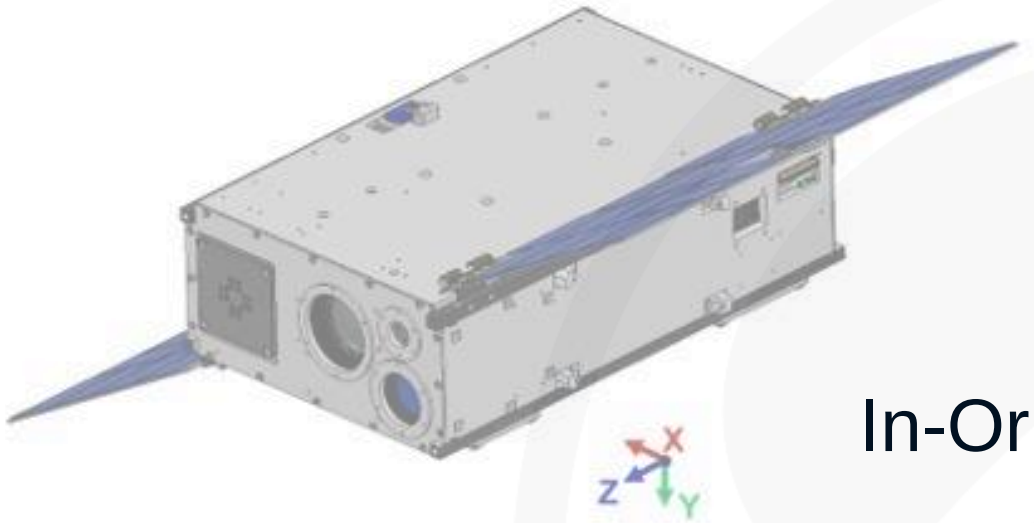

ASI CubeSat Workshop

IPERDRONE

In-Orbit demonstration for Proximity Operations

July 2024

Tyvak**: Margherita Cardi**, Giorgio Taiano, Emanuele Sanguineti, Filippo Corradino

ASI: Marta Albano, Silvia Natalucci, Marco di Clemente

Tyvak International
A Terran Orbital Corporation

agenzia spaziale italiana

CIRA
Italian Aerospace Research Centre

KAYSER ITALIA

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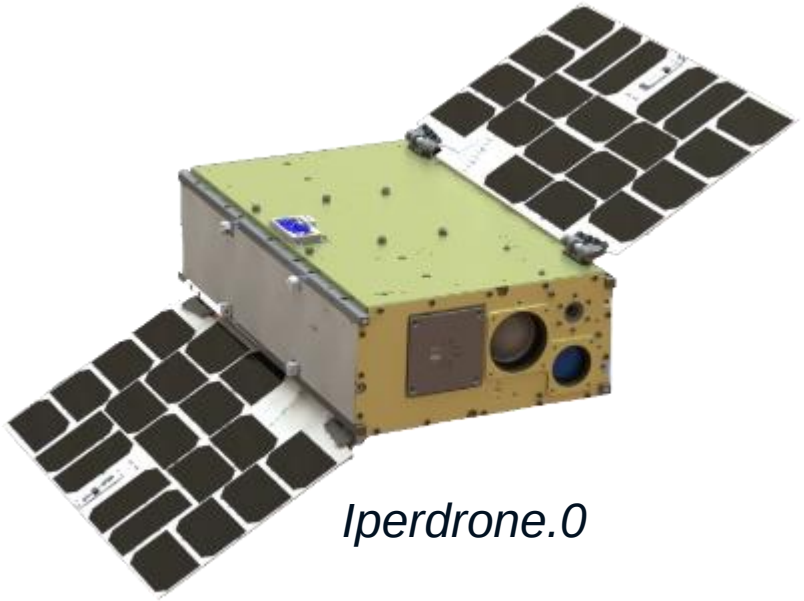
Introduction: IPERDRONE Program

- **Funded by the Italian Space Agency Iperdrone program aims at developing a drone for in-orbit servicing**
- **Multiple missions with incremental objectives**
- **First mission is Iperdrone.0 has the aim of demonstrating the capability of a CubeSat to perform**
  - Proximity operations
  - Visual inspection
  - Controlled re-entry in a pre-defined corridor

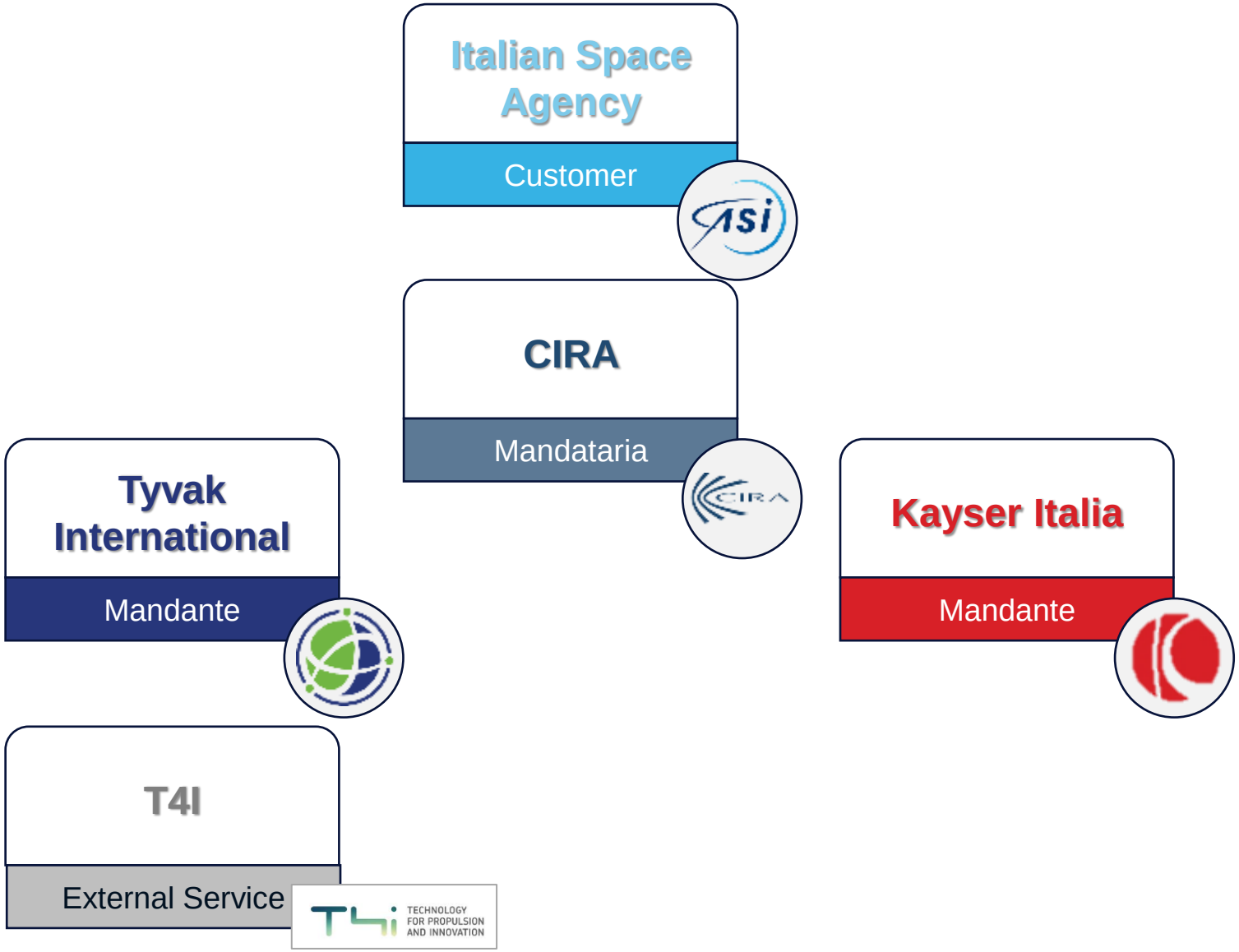


Iperdrone.0

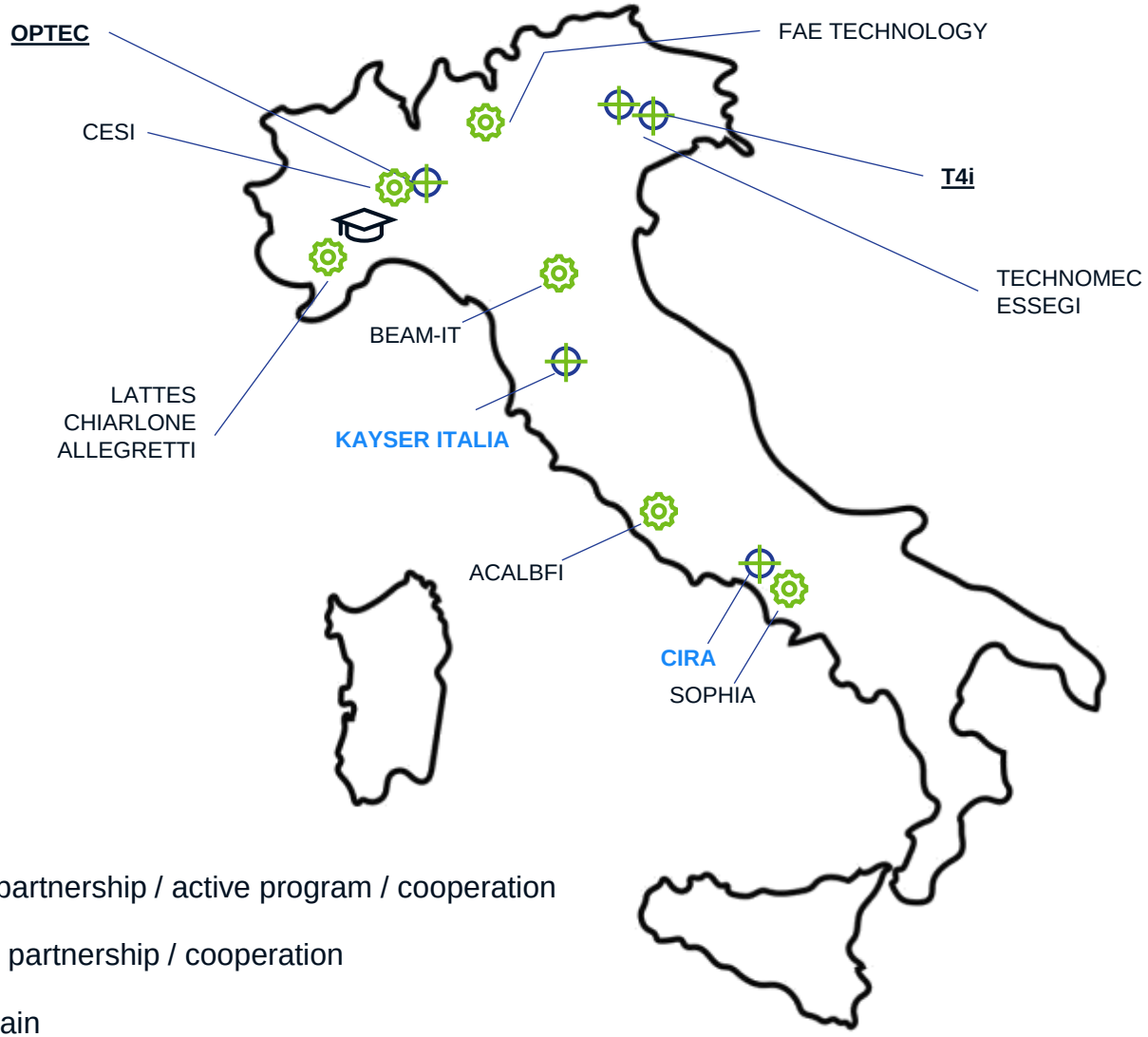
Introduction: IPERDRONE project team

- **Italian Consortium**

  - **CIRA**
    - Qualification Tests
  - **TYVAK INTERNATIONAL**
    - Satellite development and integration
    - Launch Services
    - Operations
  - **KAYSER ITALIA**
    - ISS Safety Requirements
  - **T4I**
    - External service for propulsion system development



Italian supply chain



- **Consortium**
- **Main strategic partners**

- Joint development (Tyvak and T4I) of the Cold gas propulsion system (“Perseus”)

- Provision of NavCam lenses optimized for the mission

Strategic partnership / active program / cooperation

Academic partnership / cooperation

Supply chain

Institutional relations

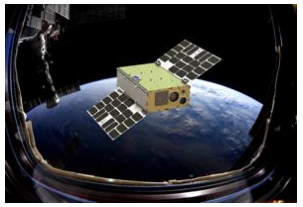
Proximity Operations / IOS Roadmap

- **Key technologies**
  - GNSS-based navigation to non-collaborative targets
  - Relative positioning around in-orbit target considering keep out zones
  - ***Inspection Cameras*** Visible (NFOV + WFOV) and Infrared Cameras (Tyvak + Optec)
  - ***Propulsion System*** Cold-Gas Propulsion System (Tyvak + T4i)
    - "Perseus" (Iperdrone); "Ianus" (Hera Milani); Both systems successfully qualified and undergoing vehicle level AIT
  - Intersatellite Link (Hera Milani), with main spacecraft Hera and the other nanosatellite; three objects navigating around the asteroids

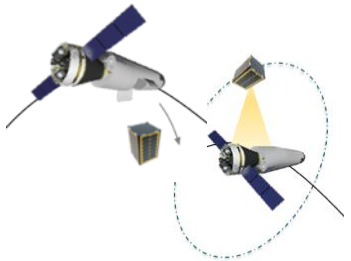
CubISSat (ESA)
Feasibility study for a nanosatellite around the ISS (support to EVA)

Fsscat / PhiSat-1 (ESA)
Development and in-orbit test of relative pointing algorithms. Relative positioning through atmospheric drag compensation
Launch: 2020

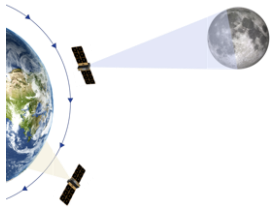
IPERDRONE (ASI)
Demonstration for proximity operations manoeuvres and visual inspection of a target body
Launch: 2024



S.R.O.C. (ESA)
Proximity operations around ESA's Space Rider, rendezvous and docking



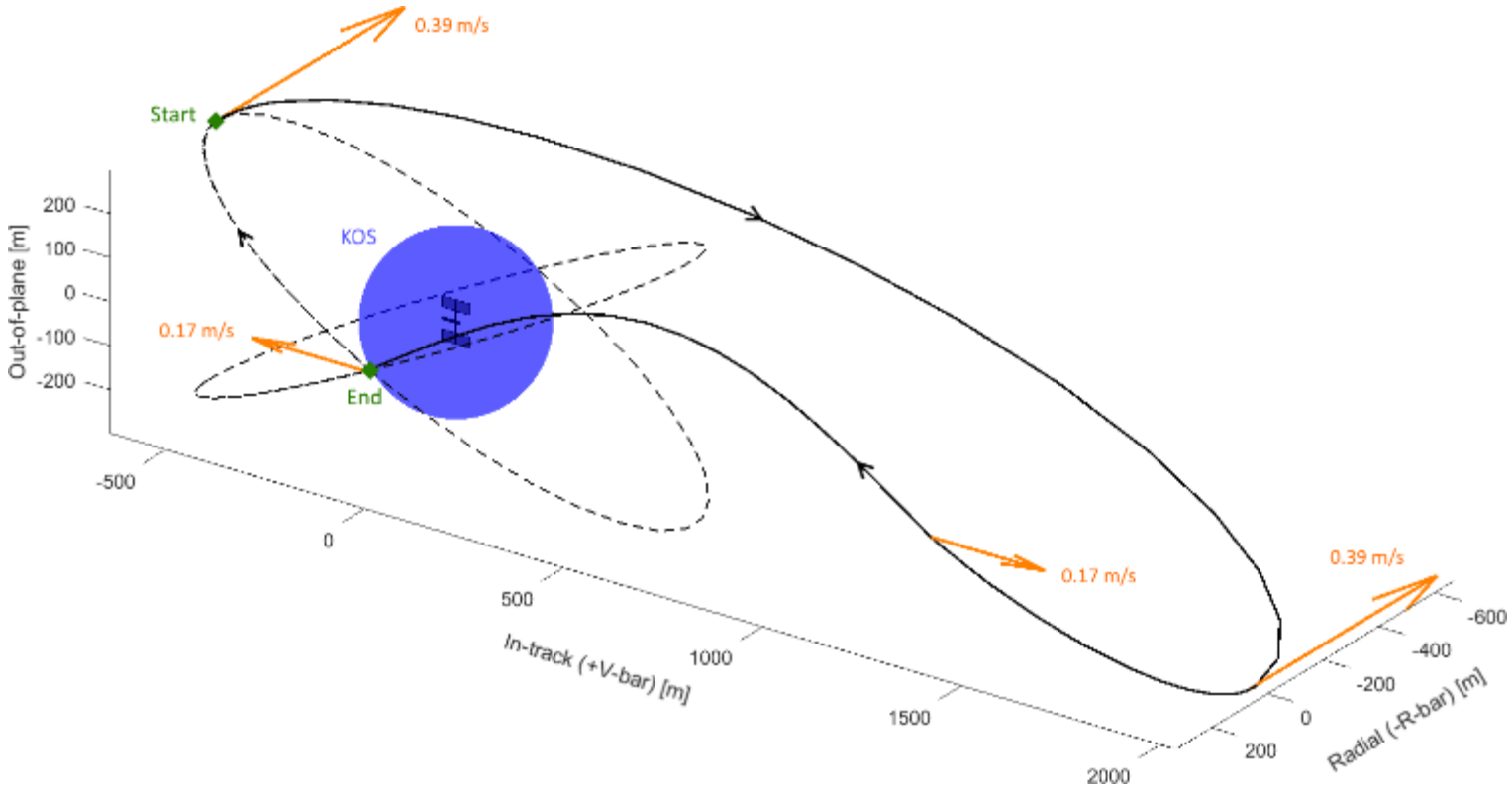
F.U.T.U.R.E. (ASI)
Visual-based Autonomous Navigation (position determination) in support of future deep-space missions
Launch: 2024



Hera Milani (ESA)
Planetary defence mission. Visual inspection and dust detection of Dimorphos asteroid system after DART impact
Launch: 2024

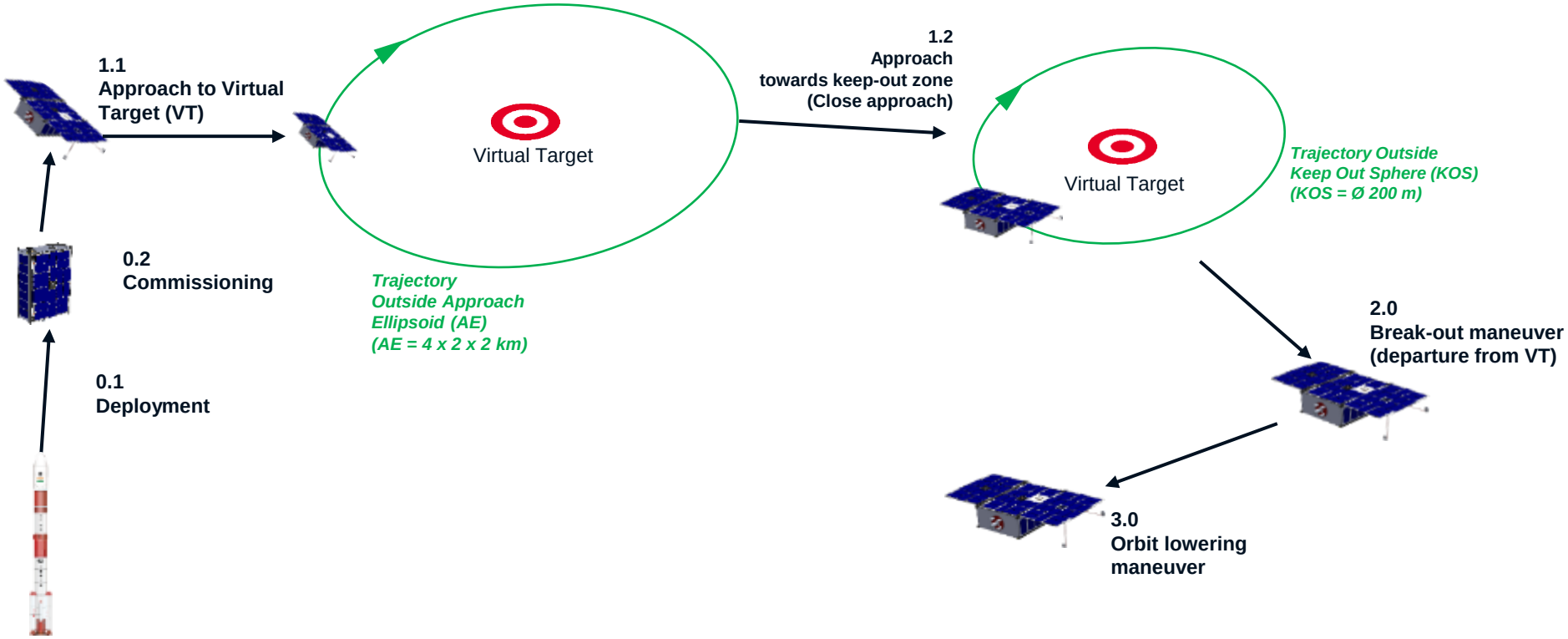
Iperdrone.0 Mission Objectives

- Simulation of **proximity operations** with virtual target inspection
- Rendez-vous in-orbit demonstration (**relative positioning** around in-orbit target considering **keep out zones**)
- Qualification of mission enabling technologies



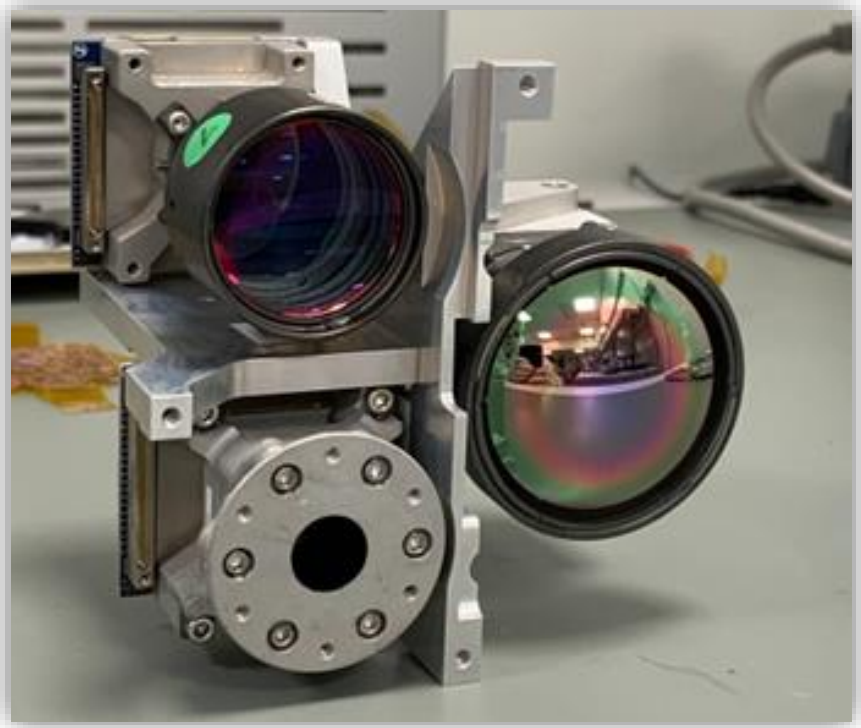
Iperdrone.0 Mission Phases

1. **Release and commissioning**
2. **Non-collaborating target inspection.**
3. **Rendezvous demonstration with a virtual orbiting target**
4. **De-orbiting demonstration**



Iperdrone.0 Enabling technologies

- **Tyvak International has selected and designed three optical payloads and a as cold-gas propulsion system family to enable the proximity operations missions:**
  - Inspection Cameras
  - Propulsion System
  - GNC and navigation algorithms



Iperdrone Cameras

PERSEUS Propulsion System

Inspection Cameras

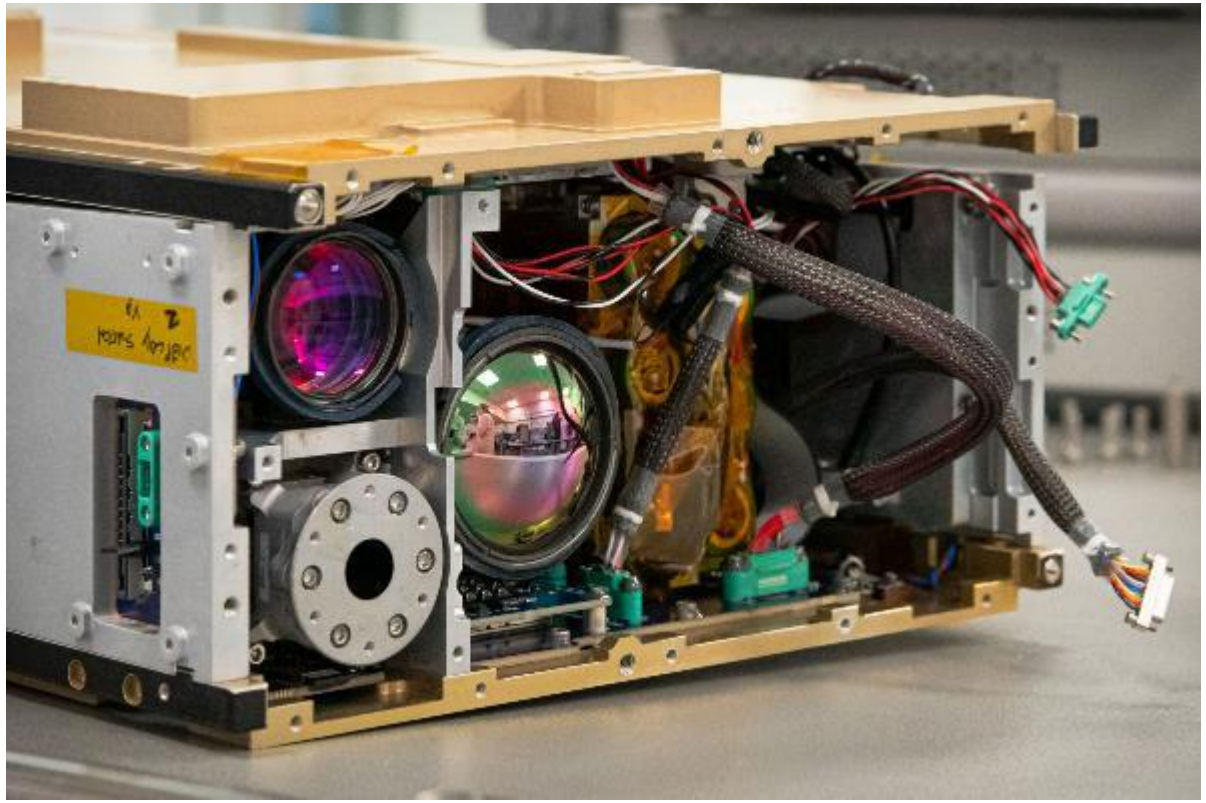
- **Visible Cameras (Wide FOV and Narrow FOV) leverage on Tyvak heritage (Star Tracker)**

  - Narrow FOV resolution:
    - 13 mm @ 300 m distance
    - 66 mm @ 1500 m distance

  - Wide FOV resolution:
    - 70 mm @ 300 m distance
    - 350 mm @ 1500 m distance

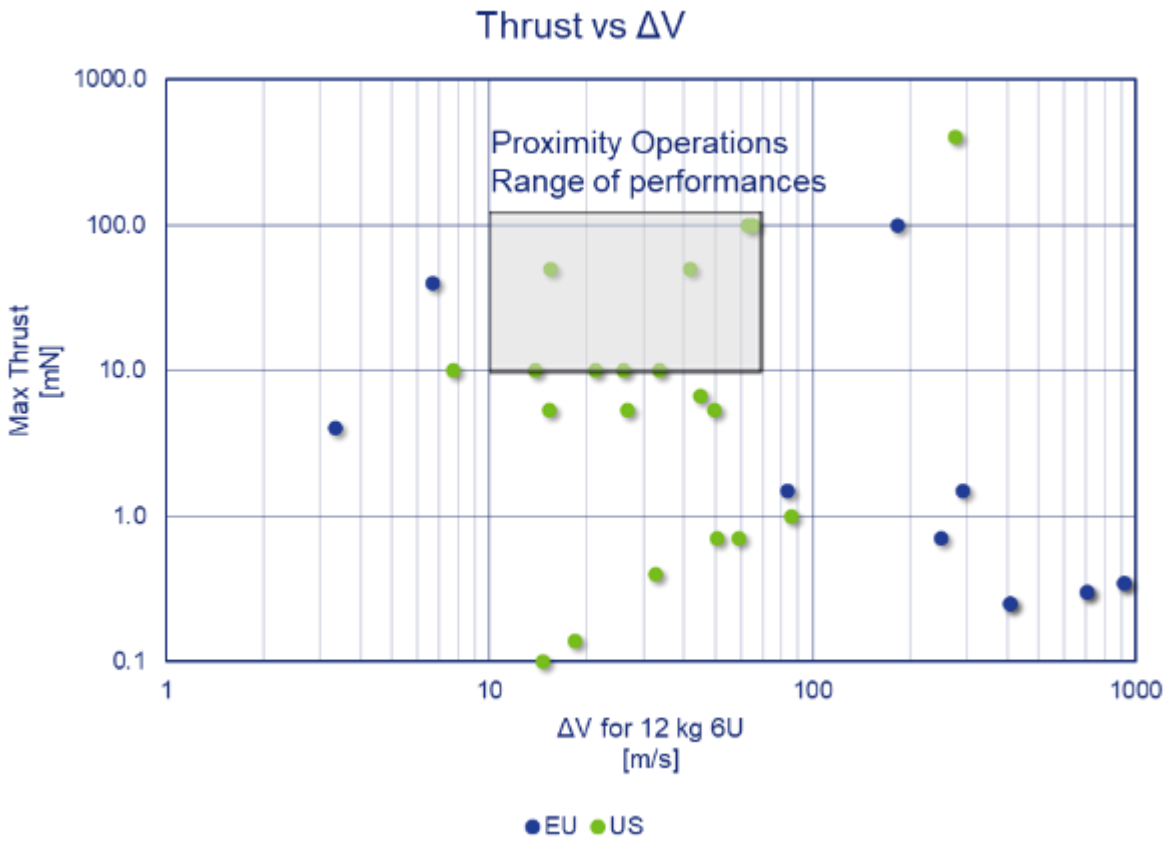
- **FLIR TAU 2 (COTS Infrared Camera)**

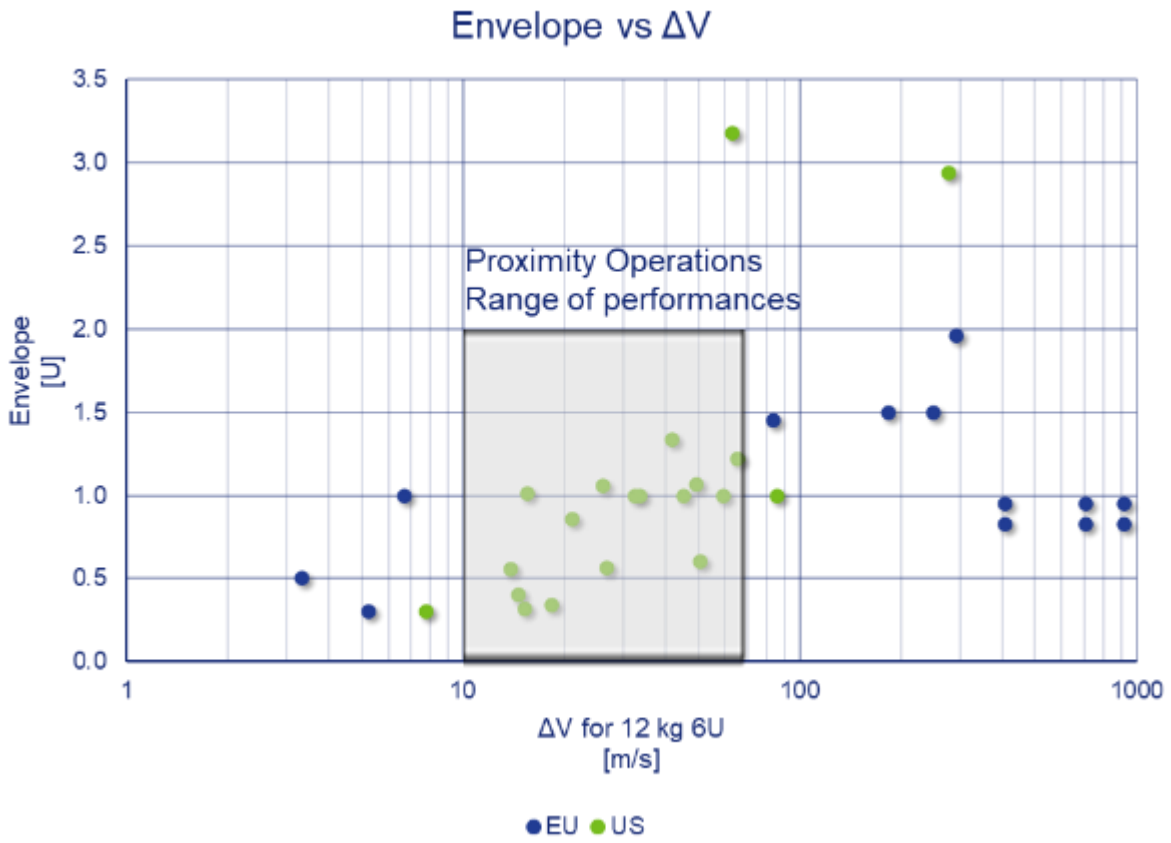
  - Infrared WFOV resolution:
    - 160 mm @ 300 m distance
    - 780 mm @ 1500 m distance



Cold gas propulsion system: Perseus

- **Market analysis: a technological “gap” of European suitable propulsion systems was highlighted**





Cold gas propulsion system: Perseus

- **Tyvak International identified as industrial partner Technology for Innovation (T4i), supporting the development of a cold-gas propulsion system family enabling proximity operations missions**

	Tyvak proposed Prox-Ops CGP (Perseus)	Best Performing EU Cold Gas	Best Performing EU Electrical Thruster
SAFETY	2+ Fault Tolerance Cold Gas (R134a) No hot exhaust / No plasma	2+ Fault Tolerance Cold Gas (Butane) No hot exhaust / No plasma	Fault Tolerance n/a Hall Effect Thruster (Xenon) Plasma exhaust
MAX THRUST	25 ÷ 100 mN	4 ÷ 40 mN	1.5 mN
MINIMUM IMPULSE BIT	< 5 mNs	0.1 mNs	n/a
TOTAL IMPULSE	480 Ns	80 Ns	1000 Ns
THRUST VECTORING	Full 3-axis thrust vectoring Full 3-axis attitude control	No thrust vectoring 2-axis attitude control (pitch, yaw)	No thrust vectoring No attitude control
ENVELOPE	< 200 x 100 x 125 (2.5 U)	200 x 100 x 50 (1.0 U)	100 x 100 x 200 (2.0 U)

Cold gas propulsion system: Perseus

- **Results is development and qualification of cold gas propulsion system compatible with a wide range of proximity operations mission concepts**

	Value
TYPE	6 DoF cold-gas thruster
MAXIMUM PRESSURE	< 50 bar
TOTAL IMPULSE	~480 Ns
ENVELOPE	246x148.5x95 mm
MASS	<4 kg
POWER CONSUMPTION	<30 W
TEMPERATURE RANGE	-10 ÷ 50 °C operative -20 ÷ 60 °C survival
THRUST	9/9/27 mN along X/Y/Z axis
TORQUE	0.4/1.6/0.4 mN*m about X/Y/Z axis

- Cold-gas technology
- 6 degrees-of-freedom
- Safe propellant
- Low Mass
- Reduced envelope
- Availability (time-to fire)
- No Max Impulse bit

Iperdrone.0 AI&T Phase

- **Including:**
  - Functional tests
  - Performance tests
  - Thermal tests


Tyvak
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Iperdrone.0

Stowed

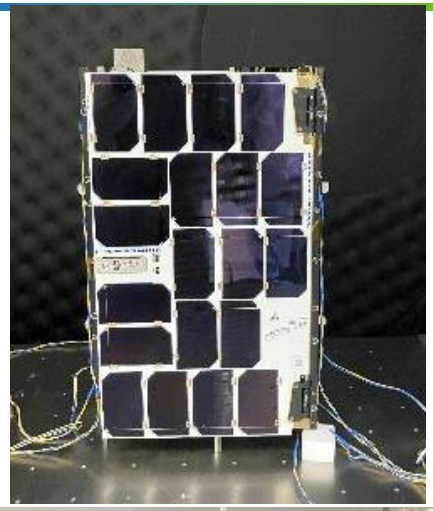
Deployed

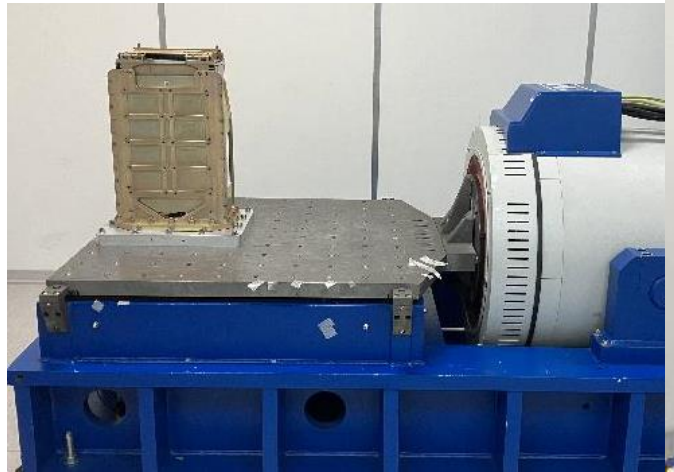
Iperdrone.0 Environmental Test

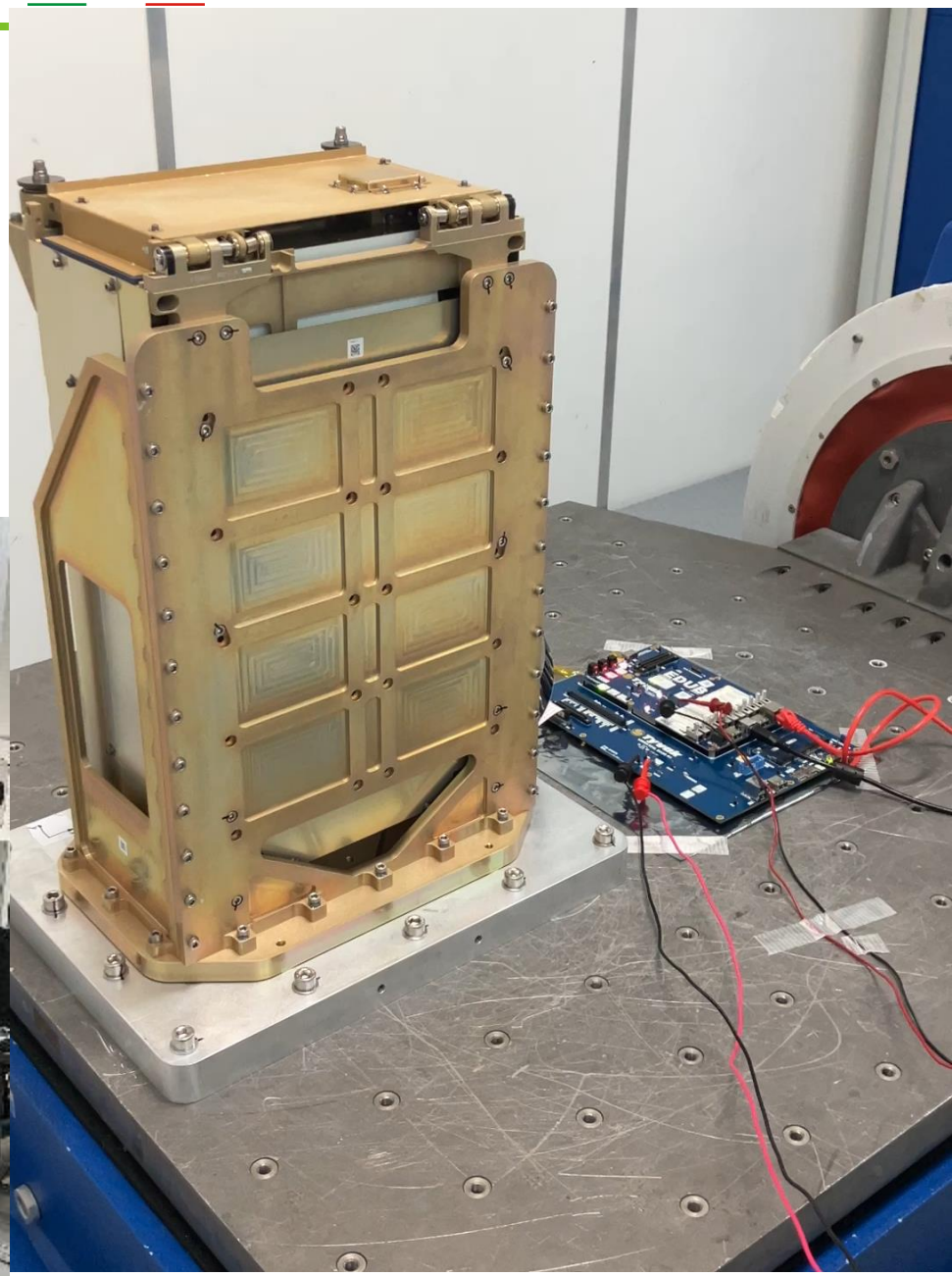
- **Vibration on three axis**
  - Random
  - Sine
  - Quasi-Static

- **Thermal vacuum**
  - Bakeout
  - Cycles

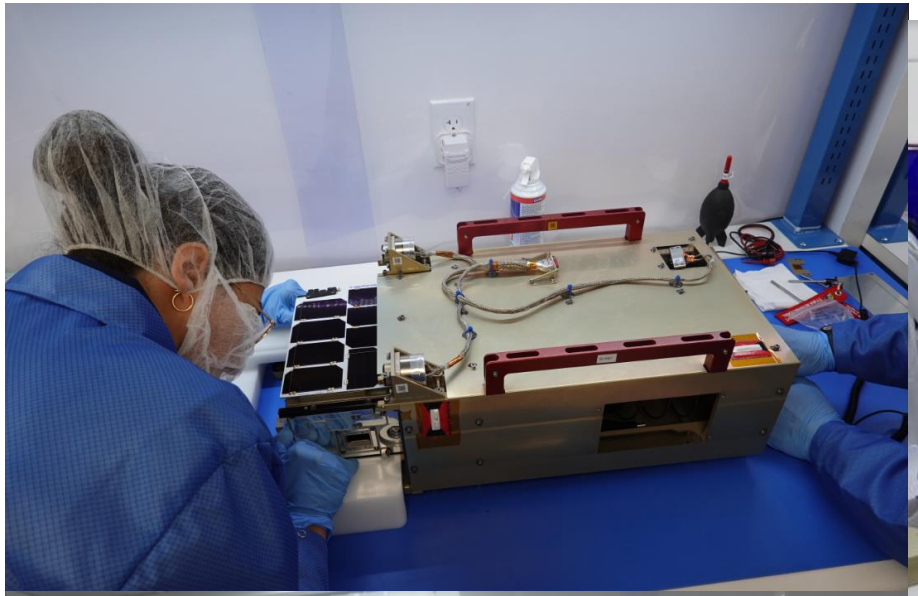
- **Mass properties measurements**
  - Moments of Inertia
  - Products of Inertia
  - Center of Gravity





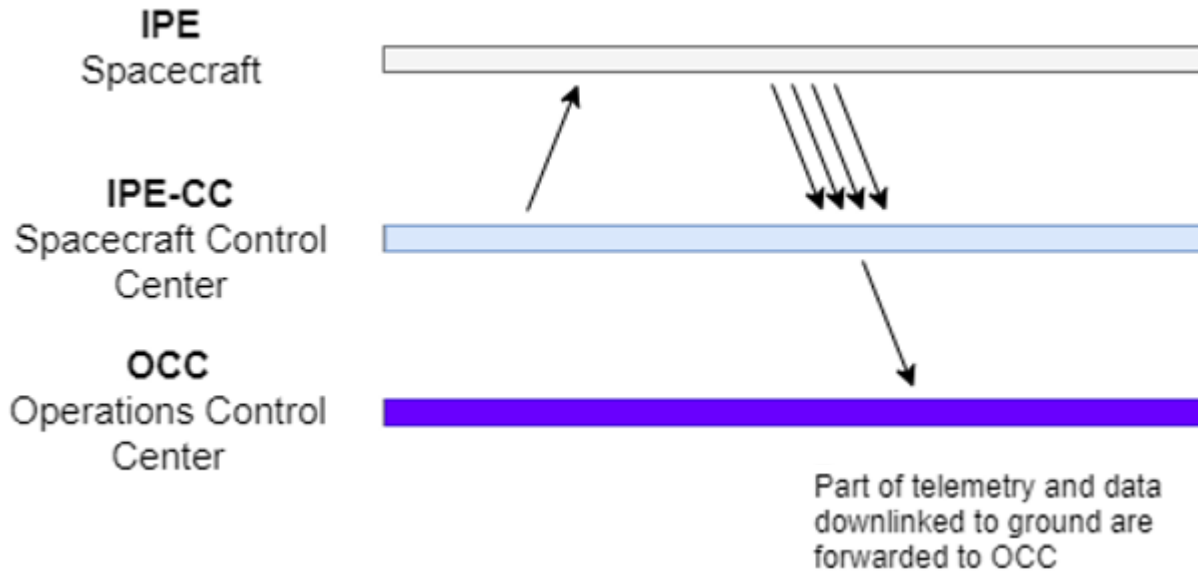


Launch campaign



Operations

- **Iperdrone operations:**
  - Commissioning
  - Nominal mission (demonstration)
- **During the entire mission, Iperdrone will be operated by Tyvak International team, from the mission control center in Torino (IPE-MCC)**
- **Operations Control Center, located at Kayser Italia premises, will receive telemetry and images from IPE-MCC, aiming at validating this capability**
- **IPE-MCC and OOC are connected through VPN**



Conclusions and Future Developments

- **IPERDRONE.0 is planned to be launched during summer 2024**

- **IPERDRONE.1 will follow the development of IPERDRONE.0 and will have the following mission objectives:**


Launched inside a satellite carrier


- Payolad to be transported inside


- Release and in-orbit inspection around the satellite carrier


- Docking-undocking demonstration


- Re-entry and payload recovery

Flawless Execution Sustains Growth

Contacts: margherita@tyvak.eu