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DEGLI STUDI
DI PADOVA

Development of tether-in-space technology for propellant-less propulsion and artificial gravity

Anese Giovanni - 39th Cycle

Supervisor: Prof. Lorenzini Enrico

Admission to the third year – 10/09/2025

Overview

Electrodynamic tethers

- E.T.PACK-F
- Dynamics analysis
- Active EDT

Spinning Tether for Artificial Gravity

- Mission drivers definition
- Experimental test champaign
- Mission design

Spinning EDTs

- E.T.COMPACT
- Spin-up strategies
- Current control

Momentum Exchange Tethers

- Software development
- Orbital maneuvers

E.T.COMPACT project

- EIC Pathfinder Project
- Goals:
  - reach TRL 4 for a miniaturized device with capability for propellant-less propulsion and power generation
  - prepare a bare-photovoltaic tether based with PVK/CIGS thin film solar cell
- Partners: UC3M, DEIMOS, UNIPD, TU Dresden, Hallocell Europe, Sunplugged, and PERSEI Space

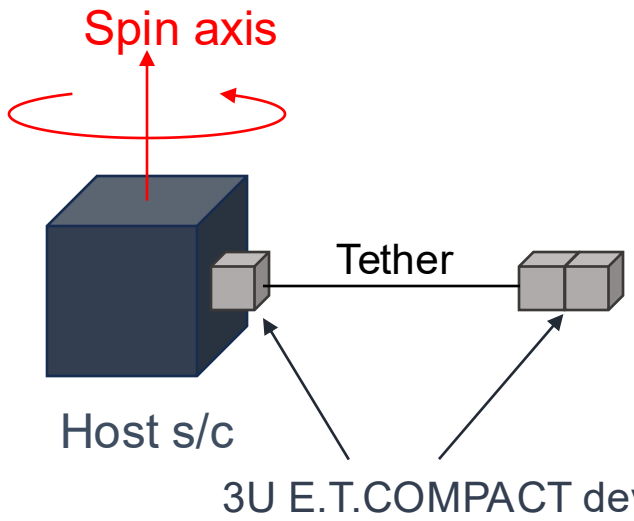
	E.T.PACK-F	E.T.COMPACT
Dimensions	12 U	3 U
Tether length	420 m	~ 300 m
Capabilities	Deorbiting	Deorbiting Reboost Retrieval Spin

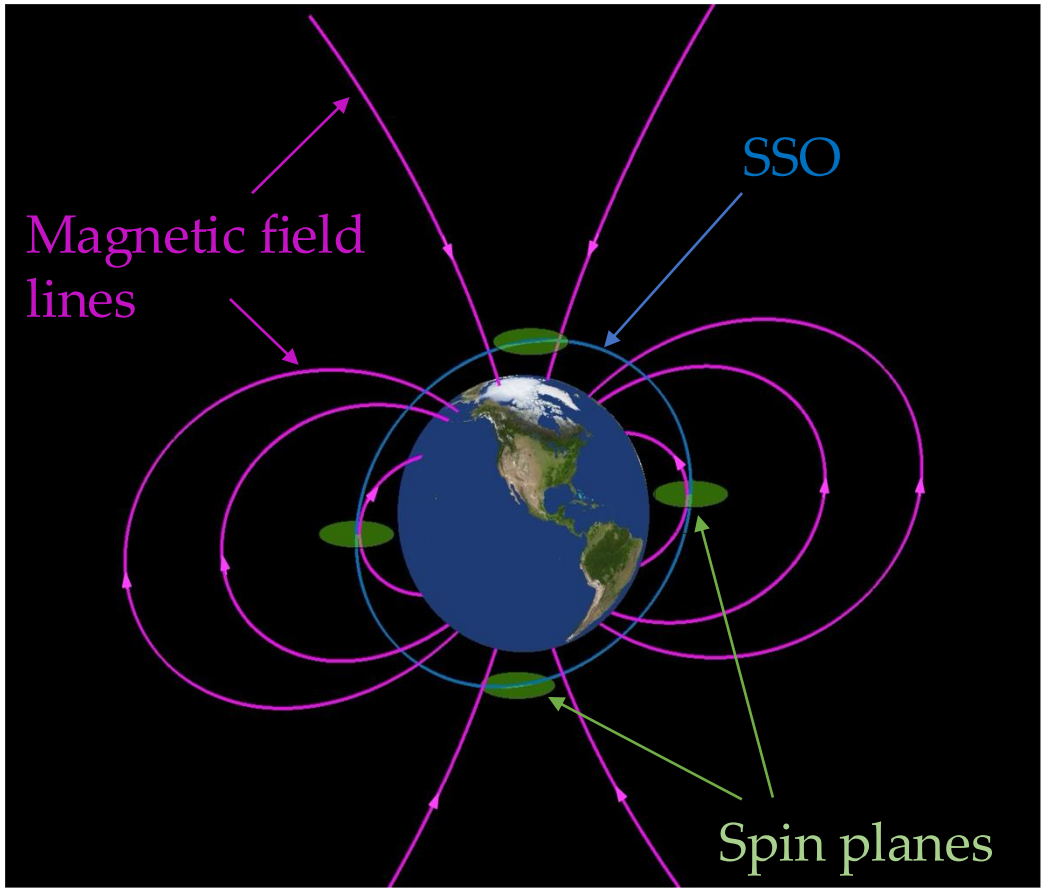
E.T.COMPACT

European Innovation Council

E.T.COMPACT project

- 3U CubeSat divided in 1U for the cathode and 2U for the deployment mechanism.
- Attached to a host satellite of a few hundreds kilos.
- Set to work in Sun-synchronous orbits.
- Spinning system to improve electrodynamic performances.

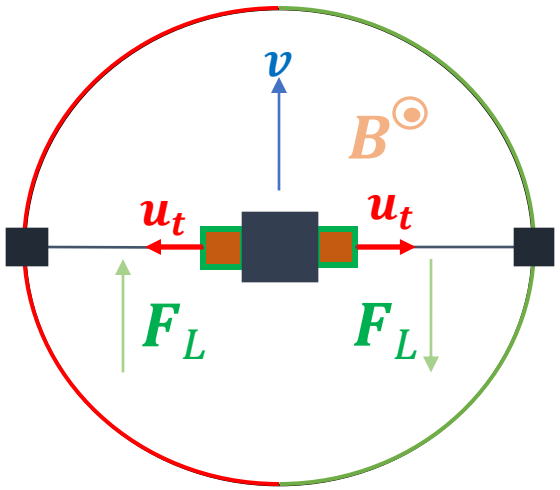




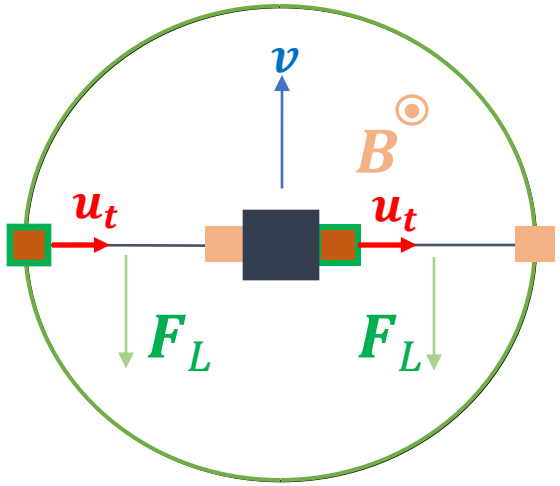
E.T.COMPACT project

Deorbiting

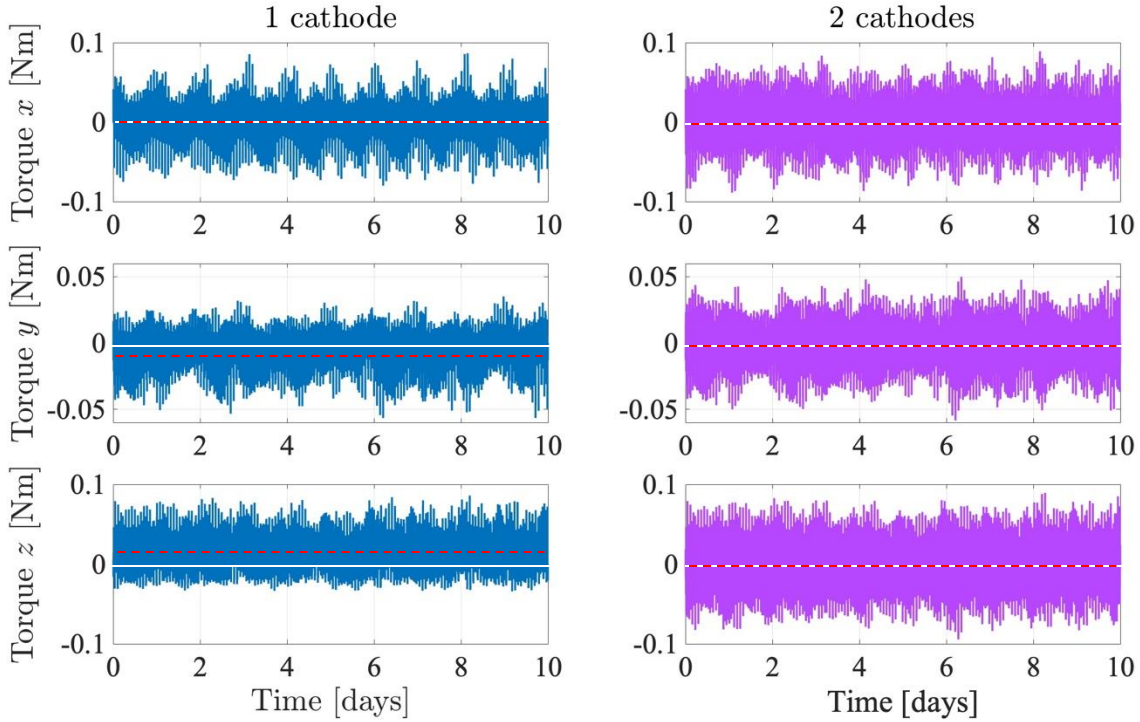
1 cathode



2 cathodes

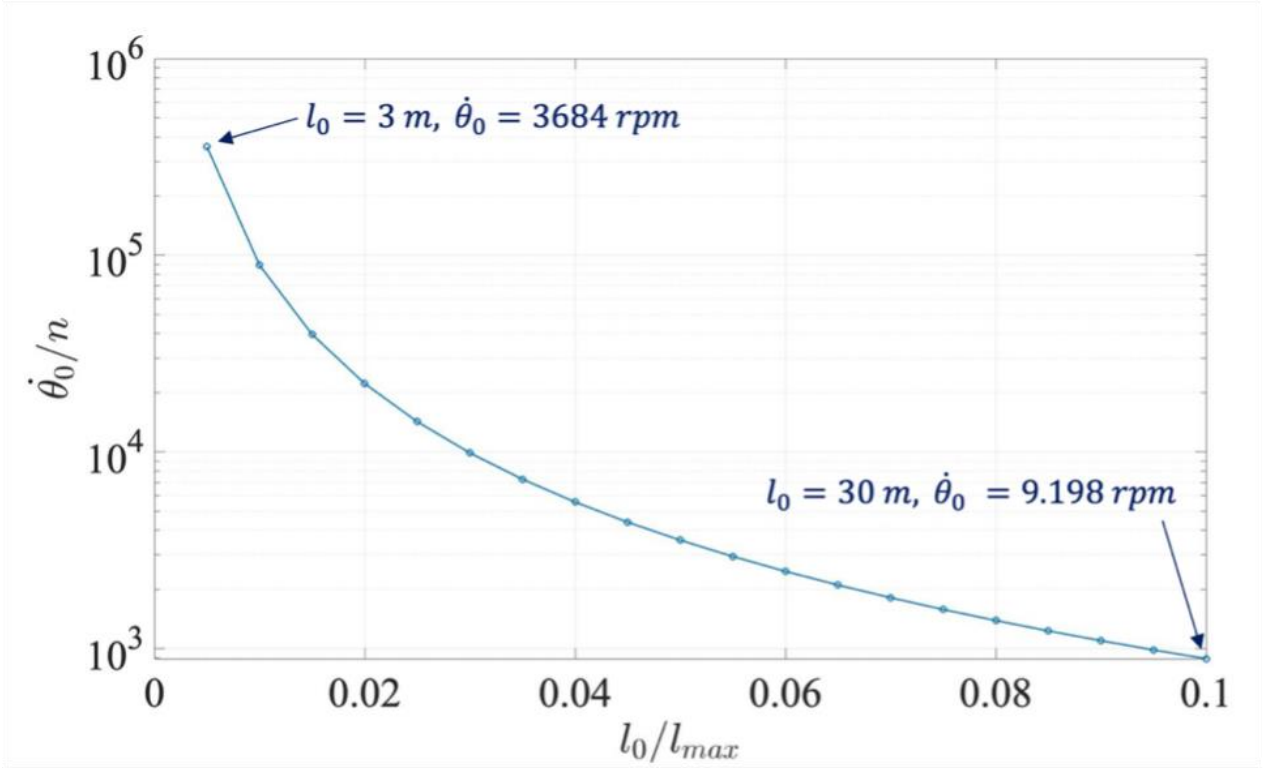


Torques associated to the Lorentz force



Deployment and Spin-up strategies

- Angular momentum conservation
- Deployment and Spin-up in plane + Precession



Desired final conditions

- $l = 300\ m$
- $\dot{\theta} = 8\ rpo$ (rev per orbit)

Deployment and Spin-up strategies

- Angular momentum conservation
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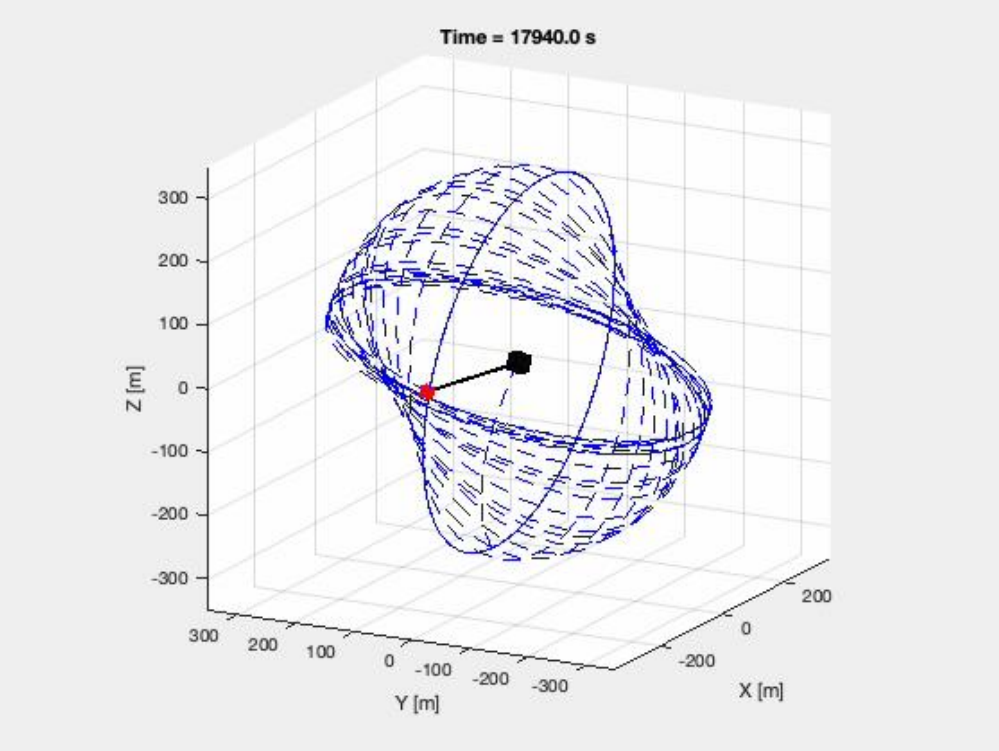
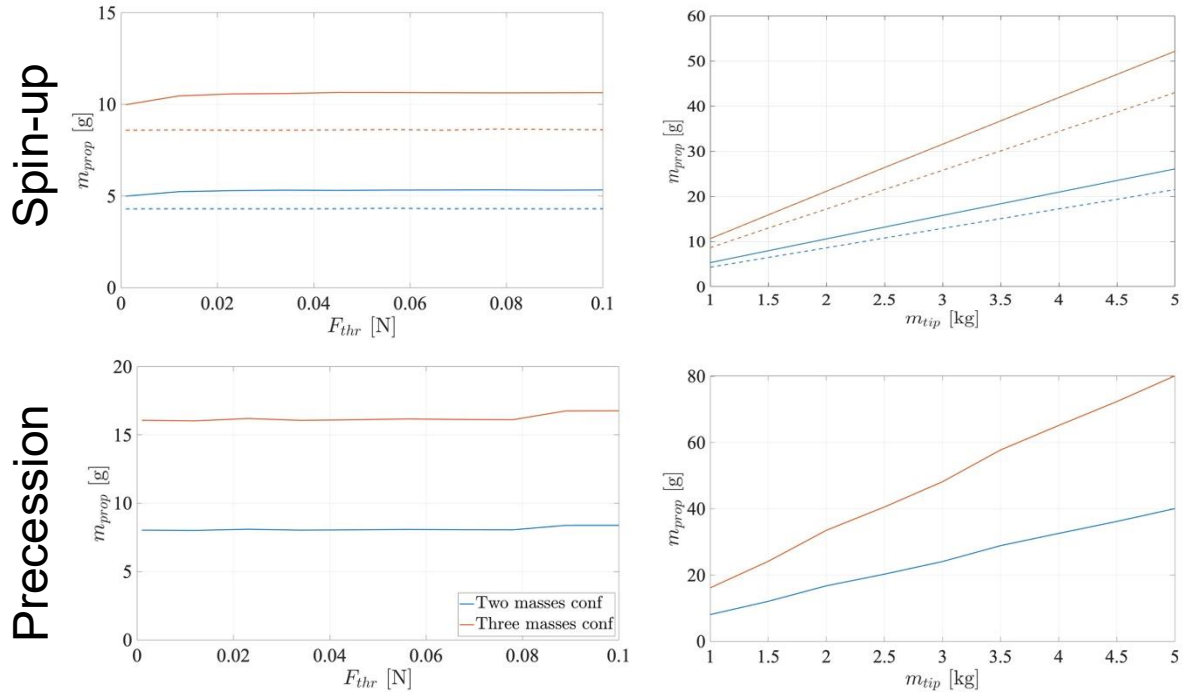




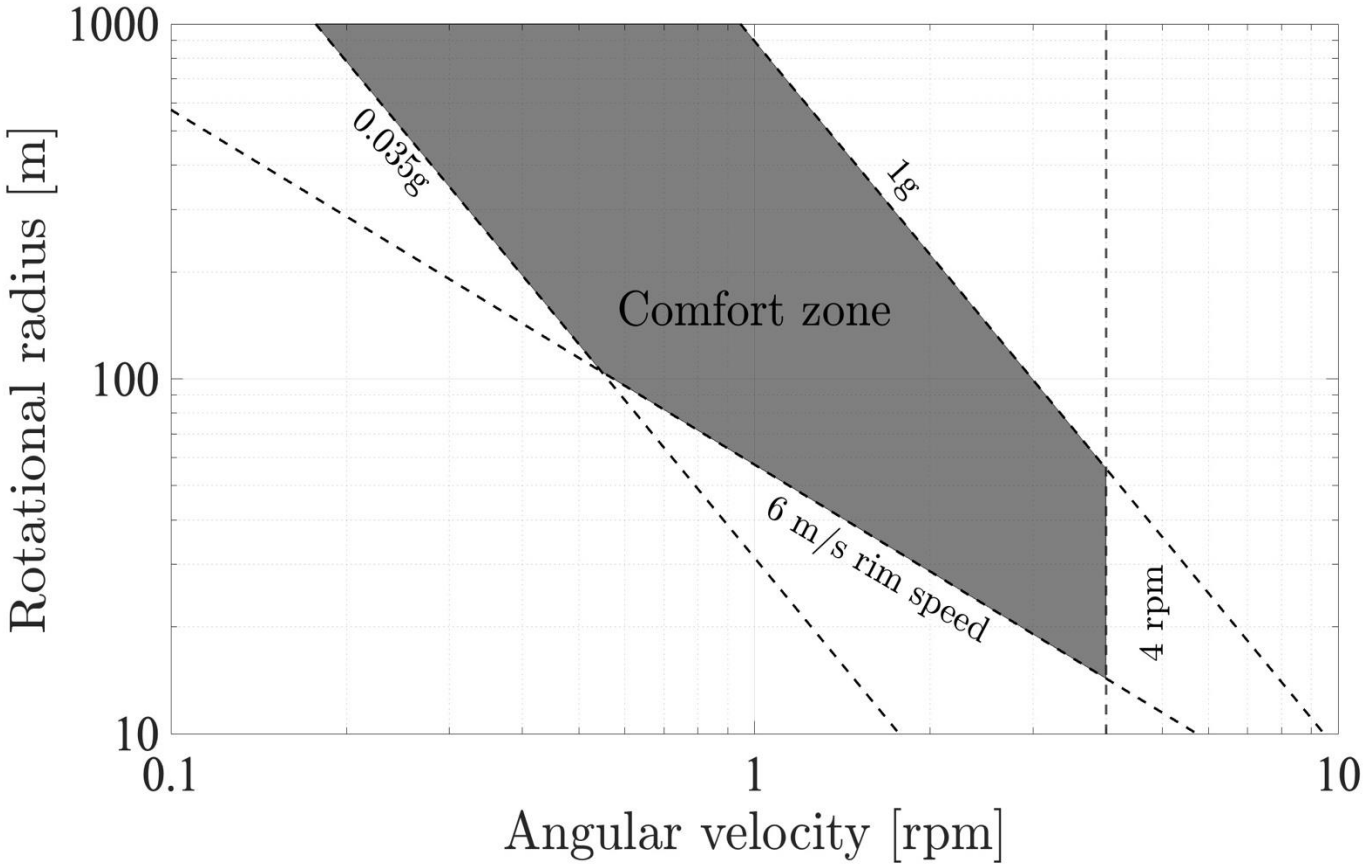
Artificial Gravity

Centrifugal acceleration

$$a_{cent} = r\omega_{spin}^2$$

Short tether
Fast spin

Long tether
Slow spin



Thedore Hall, *Artificial Gravity Visualization, Empathy, and Design*, In Space 2006. DOI: 10.2514/6.2006-7321.

Artificial Gravity

Mission concept

Orbit:

LEO → altitude ~600 km
Dawn-dusk sun-synchronous
($incl = 97.8°$)

Spin rate:

1-4 rpm (comfort zone)

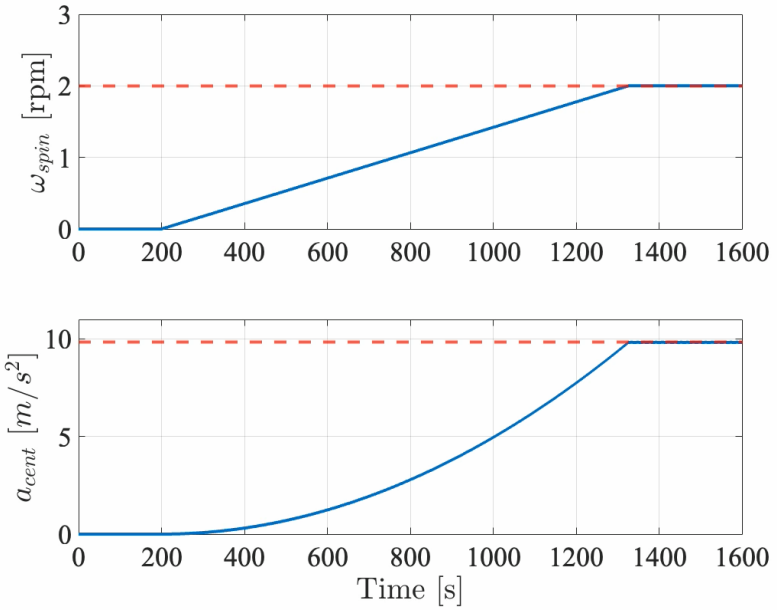
Artificial gravity level:

Earth-g
Mars-g

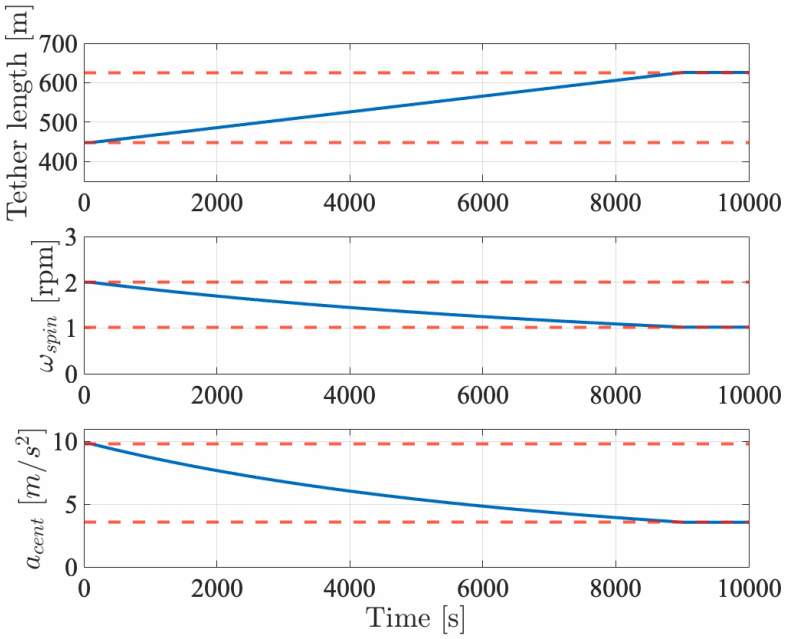
System:

Two 12 U cubesats (24 kg each)

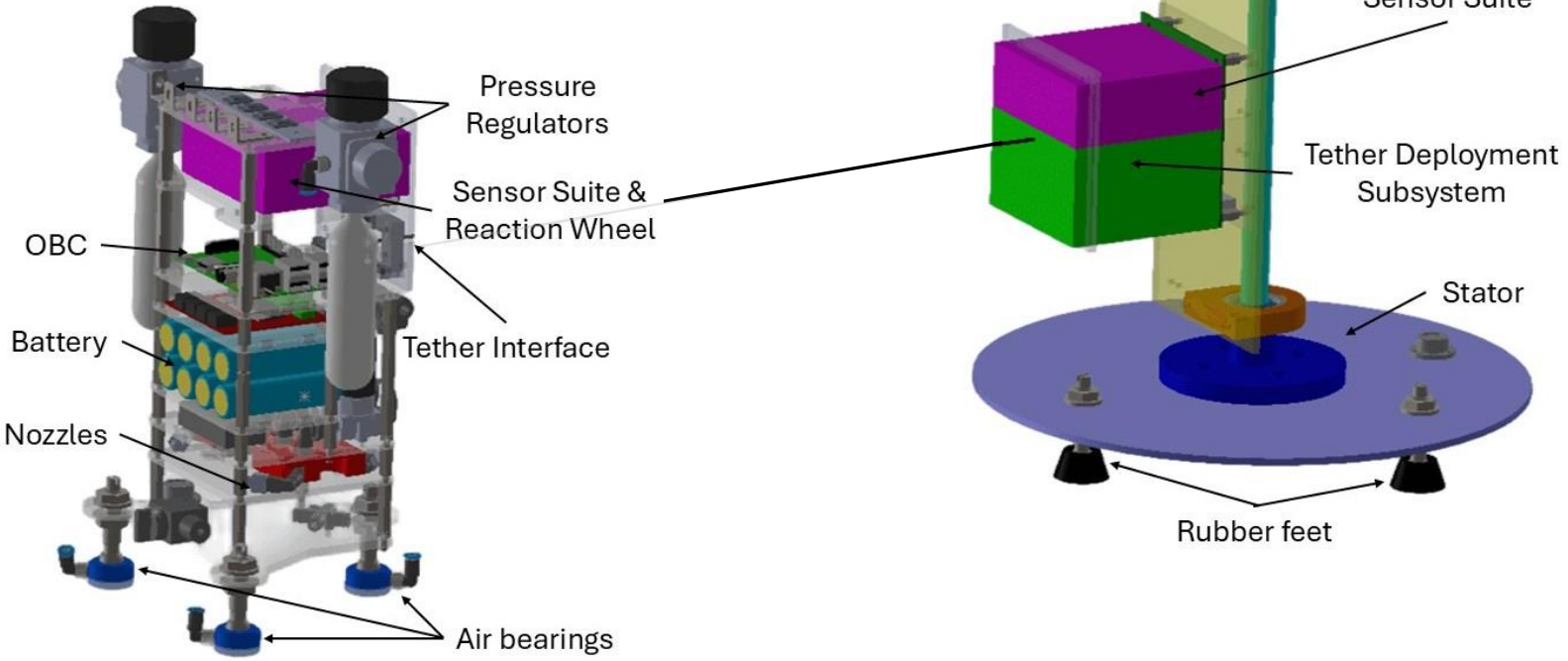
Spin-up

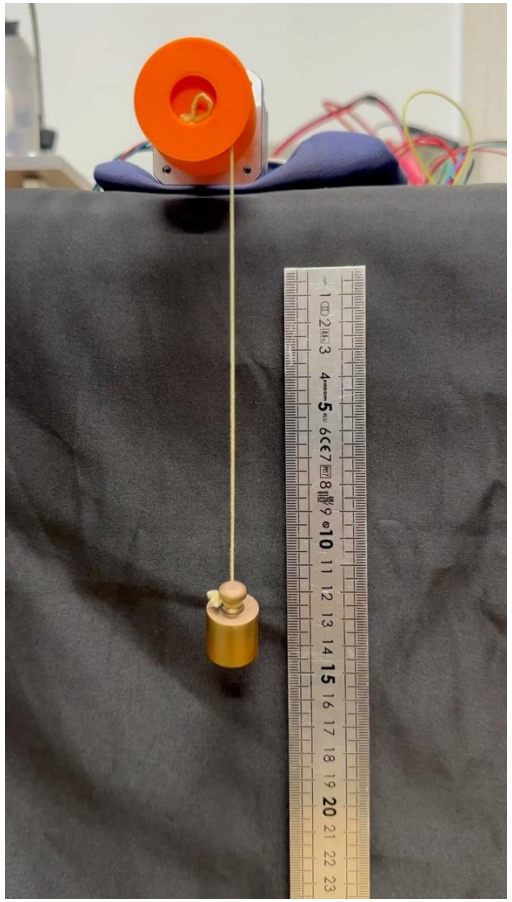


Reel-out



Experimental setup





Deployment mechanism

Future activities

- **EDTs**
  - Continue with the E.T.COMPACT project
- **Artificial Gravity**
  - Optimization of the interplanetary correction maneuvers for spinning systems
- **METs**
  - Investigate their potentials
  - Develop a simulation tool
  - Evaluate possible applications

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THANK YOU FOR THE ATTENTION!

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