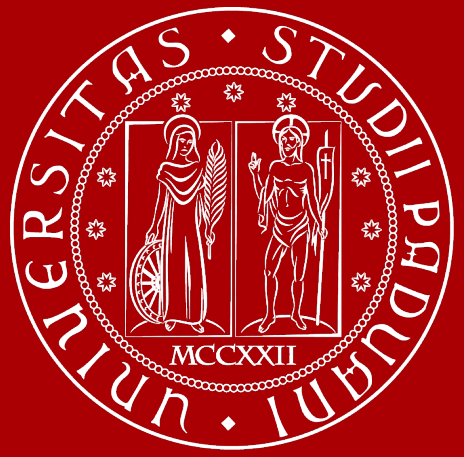

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Development of tether-in-space technology for propellant-less propulsion and artificial gravity

Anese Giovanni - 39th Cycle

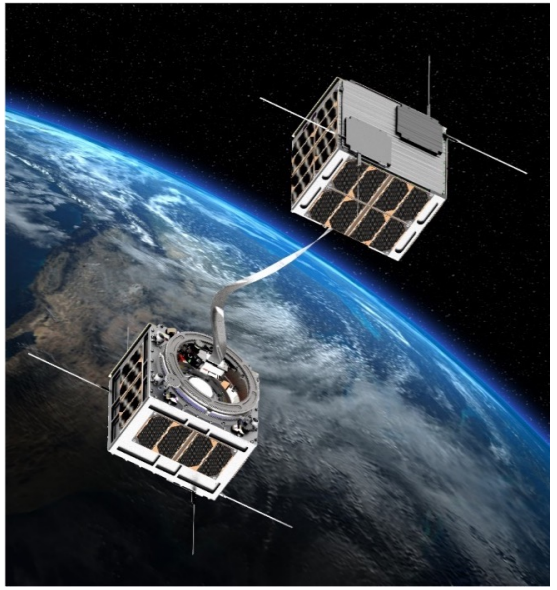
Supervisor: Prof. Enrico Lorenzini

Admission 2nd year - 16/09/2024

Research topic

Tethered satellites

- Electrodynamic Tethers (EDTs)
- Momentum Exchange Tethers (METs)
- Artificial Gravity Spinning System (AGSS)



Software devlopment for simulation.

Research topic

Tethered satellites

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- Momentum Exchange Tethers (METs)
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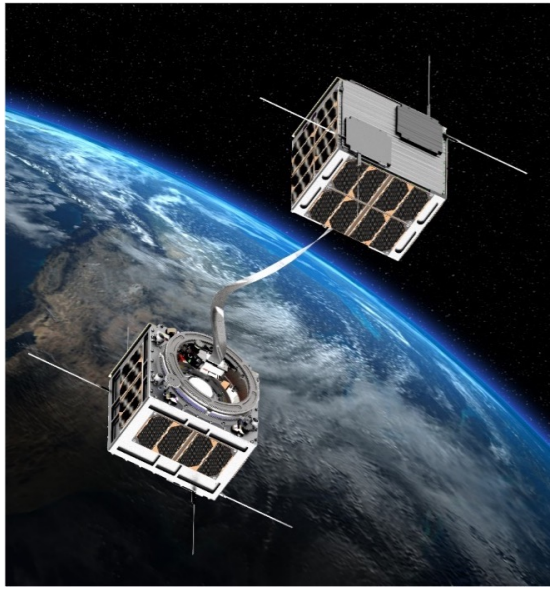


Software devlopment for simulation.

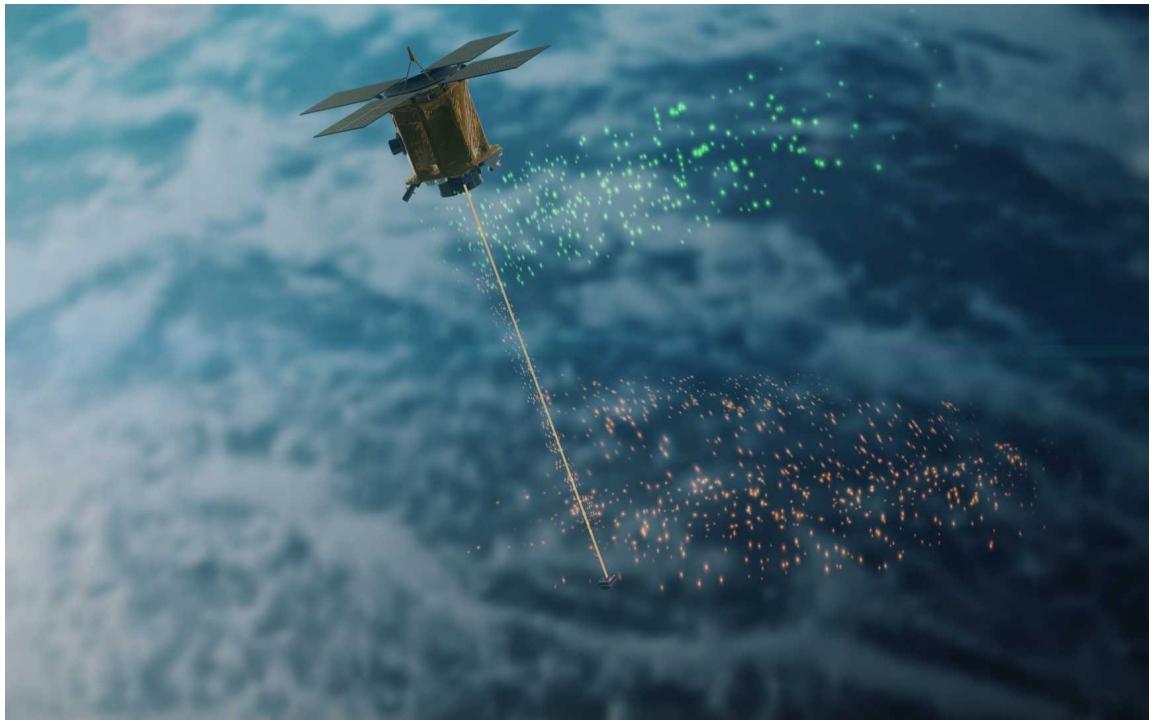
Software development

Electrodynamic Tethers (EDT)		Deployment
Passive	Active	
Environmental forces Current routine	Environmental forces	/
Power input Cathode control	Current routine Power input Cathode control	Control based on a reference deployed length and length rate profiles Lumped masses Tension-Damping routine

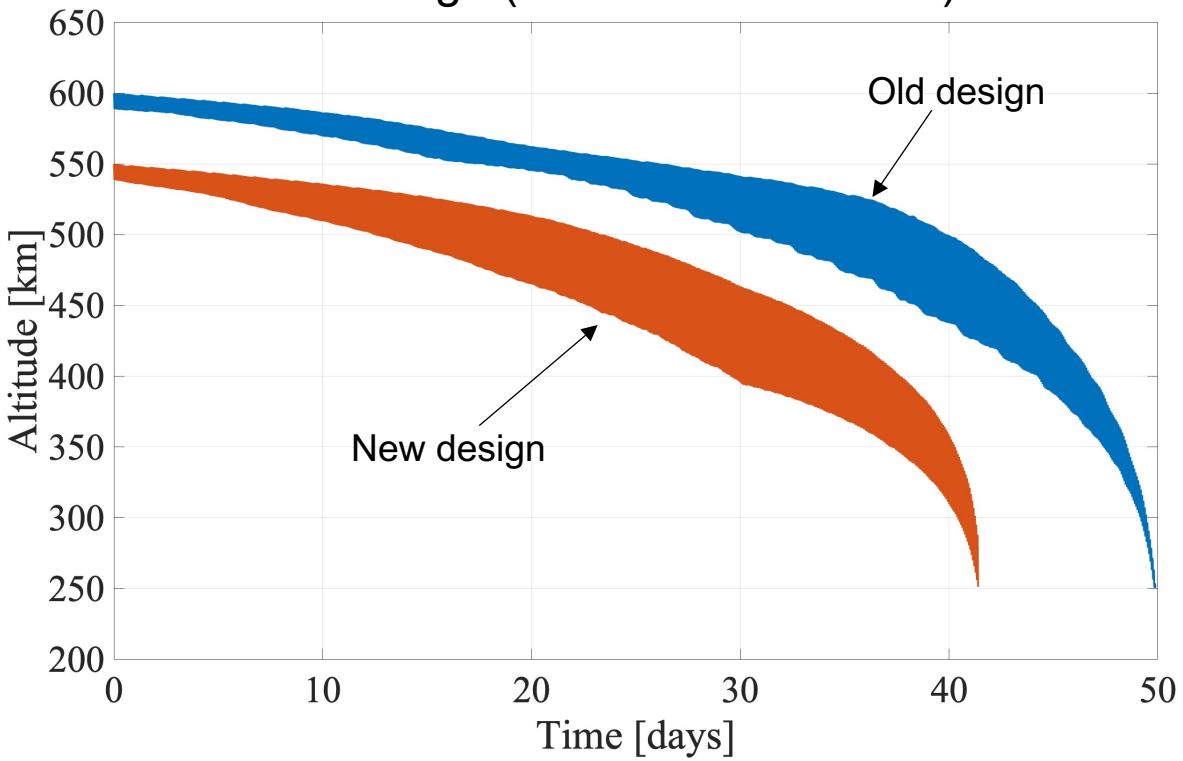
E.T.PACK-F project

E.T.PACK-F

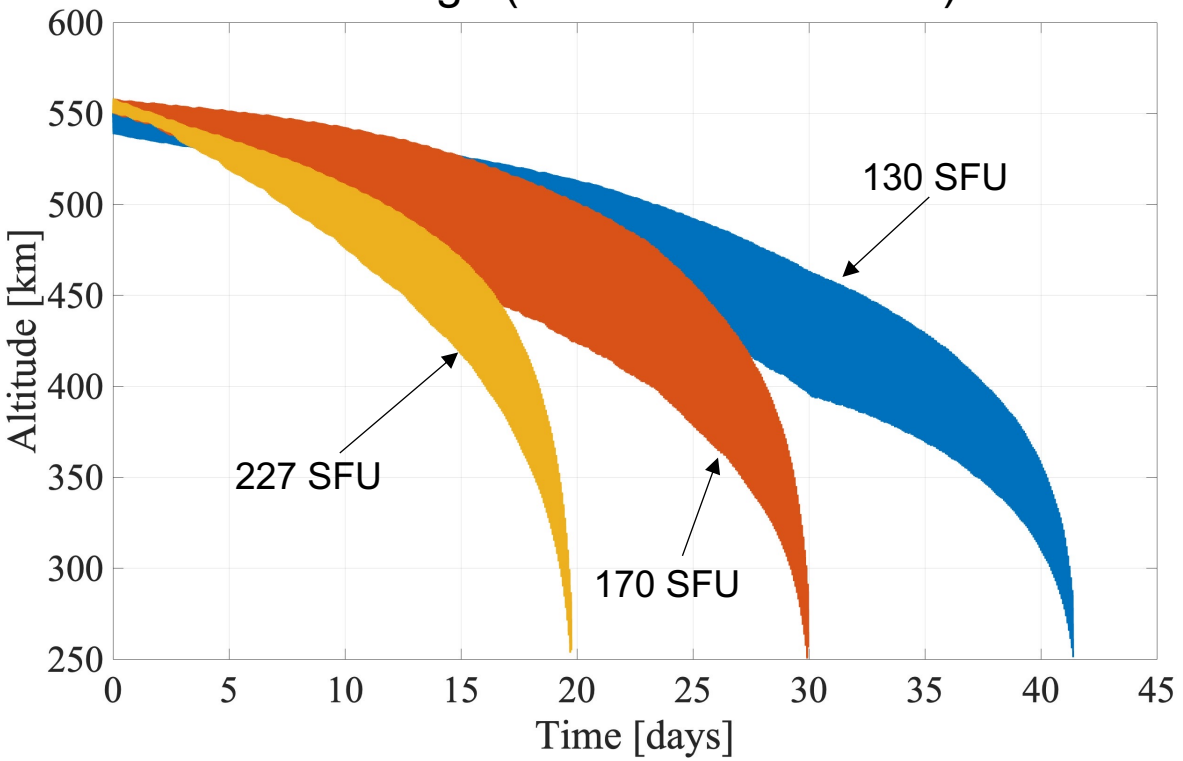
Orbit inclination [deg]	51.5	51.5
Starting altitude [km]	600	550
Altitude limit [km]	250	250
m_1 (EEM) [kg]	12	12
m_1 (DMM) [kg]	12	10
Alluminum length [m]	450	410
Peek length [m]	50	10
Thickness Al [m]	4e-5	4e-5
Thickness PEEK [m]	5e-5	5e-5
Width [m]	2.5e-2	2.5e-2
Imax [mA]	500	500
Imin [mA]	200	300
DVc [V]	30	30
P [W]	0.0	4.0
Duty cycle [% of orbital period]	100	30
Cathode life [hours]	∞	216



Old design (450m Al + 50 PEEK)
vs
New design (410m Al + 10 PEEK)



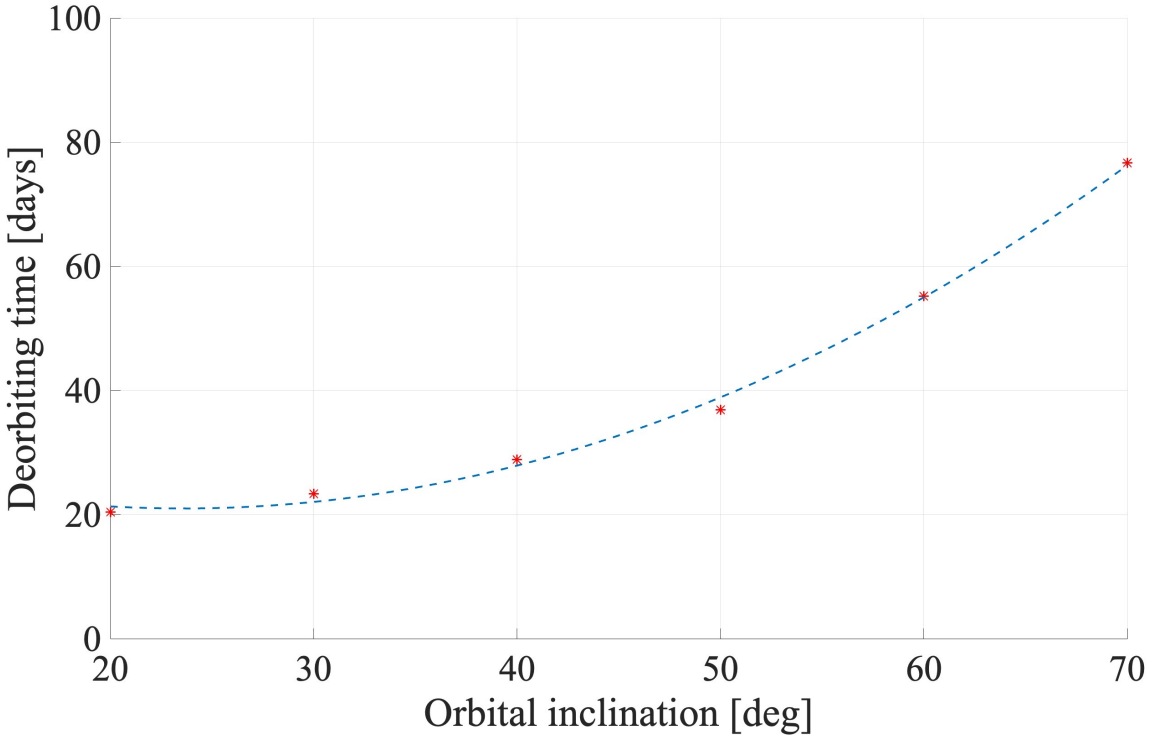
New design (410m Al + 10 PEEK)



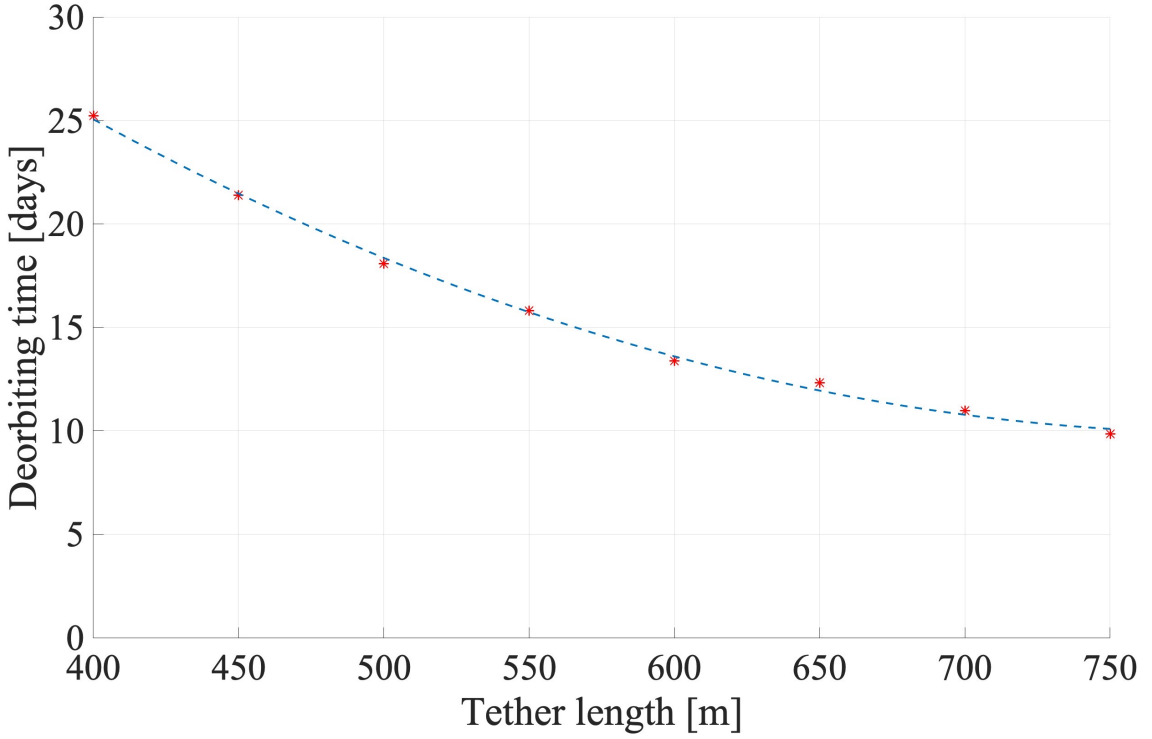
@ mean solar activity (F10.7 ≈ 130 SFU)

Analysis of Deorbiting relative to different factors with EDT

Deorbiting with EDT

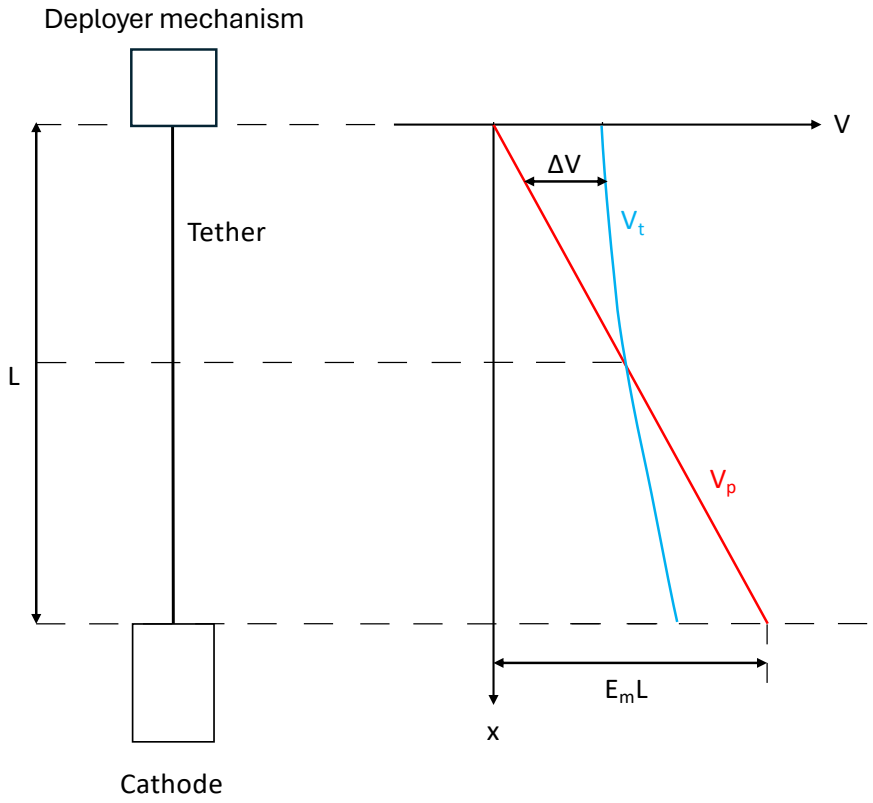


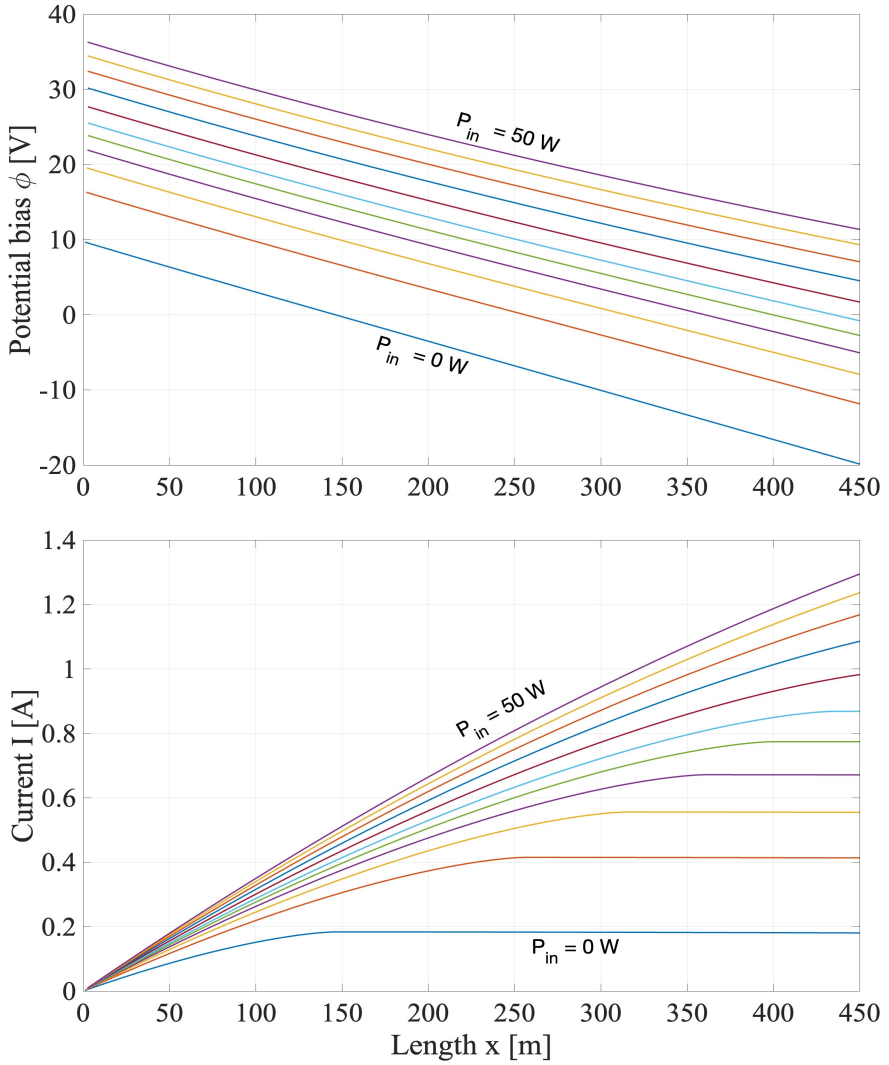
Tether: 450 m Al, 50 m PEEK
High solar activity



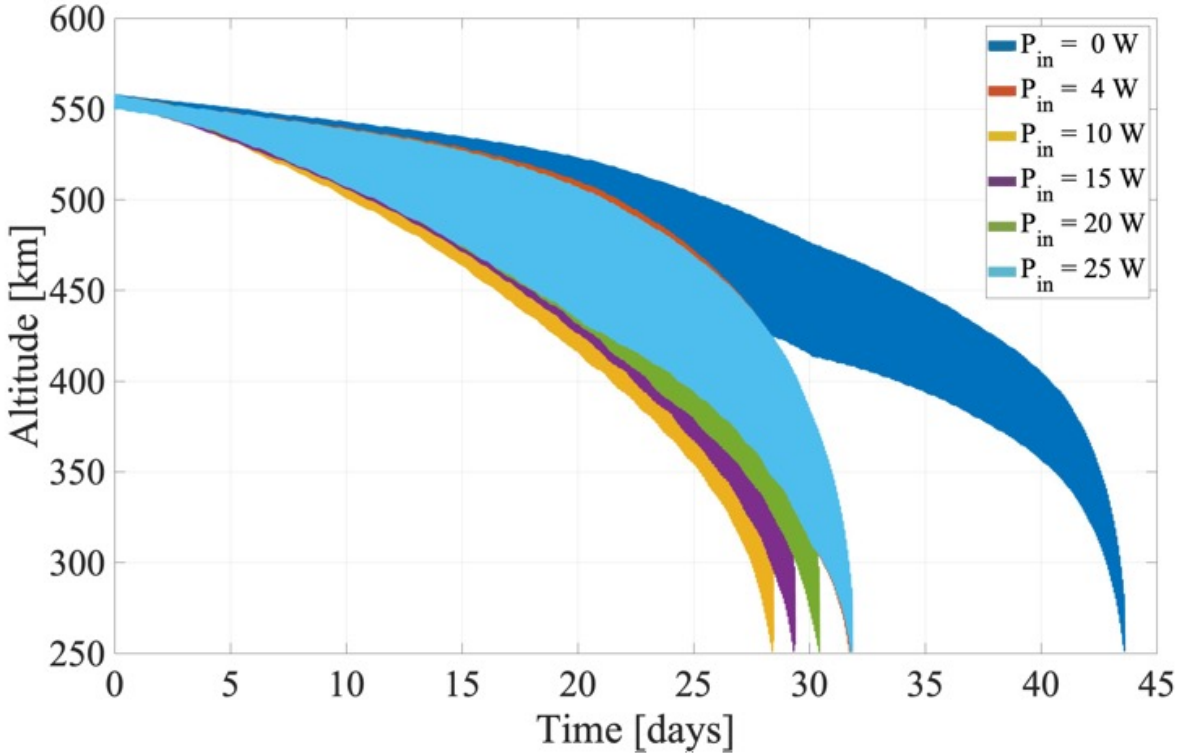
Medium inclined orbit
High solar activity
Tether: 90% Al, 10% PEEK

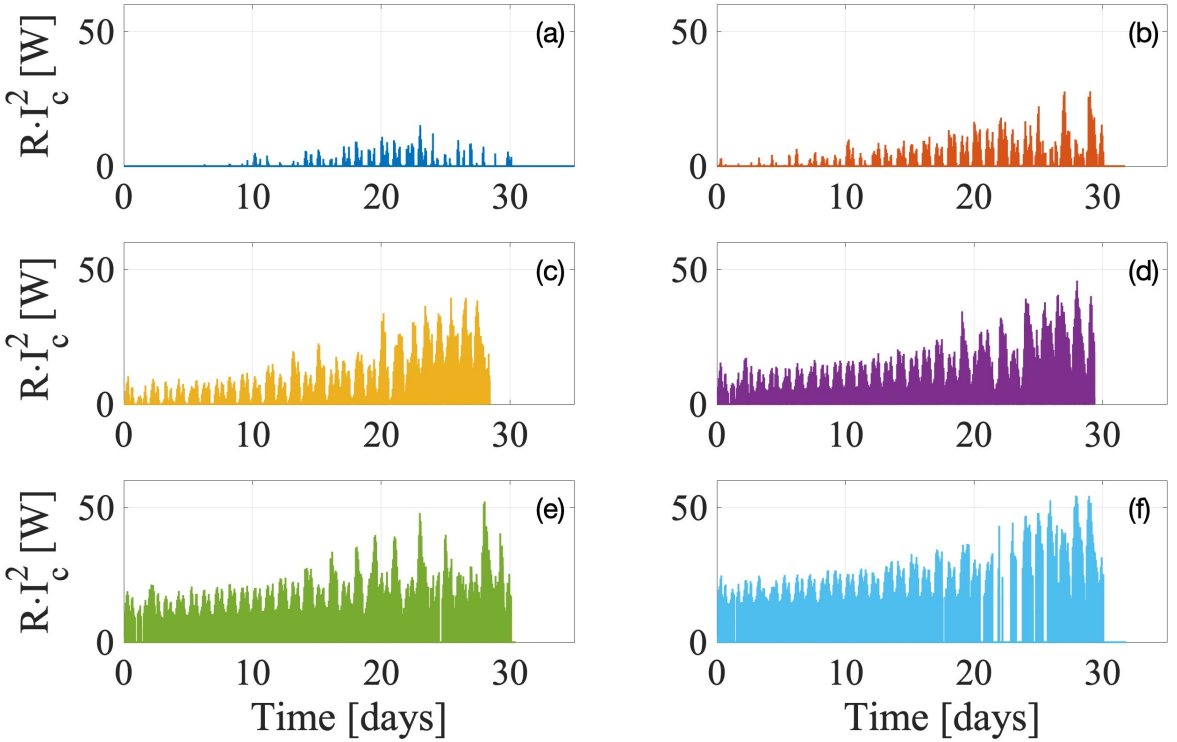
Effects of power supply





Effects of power supply

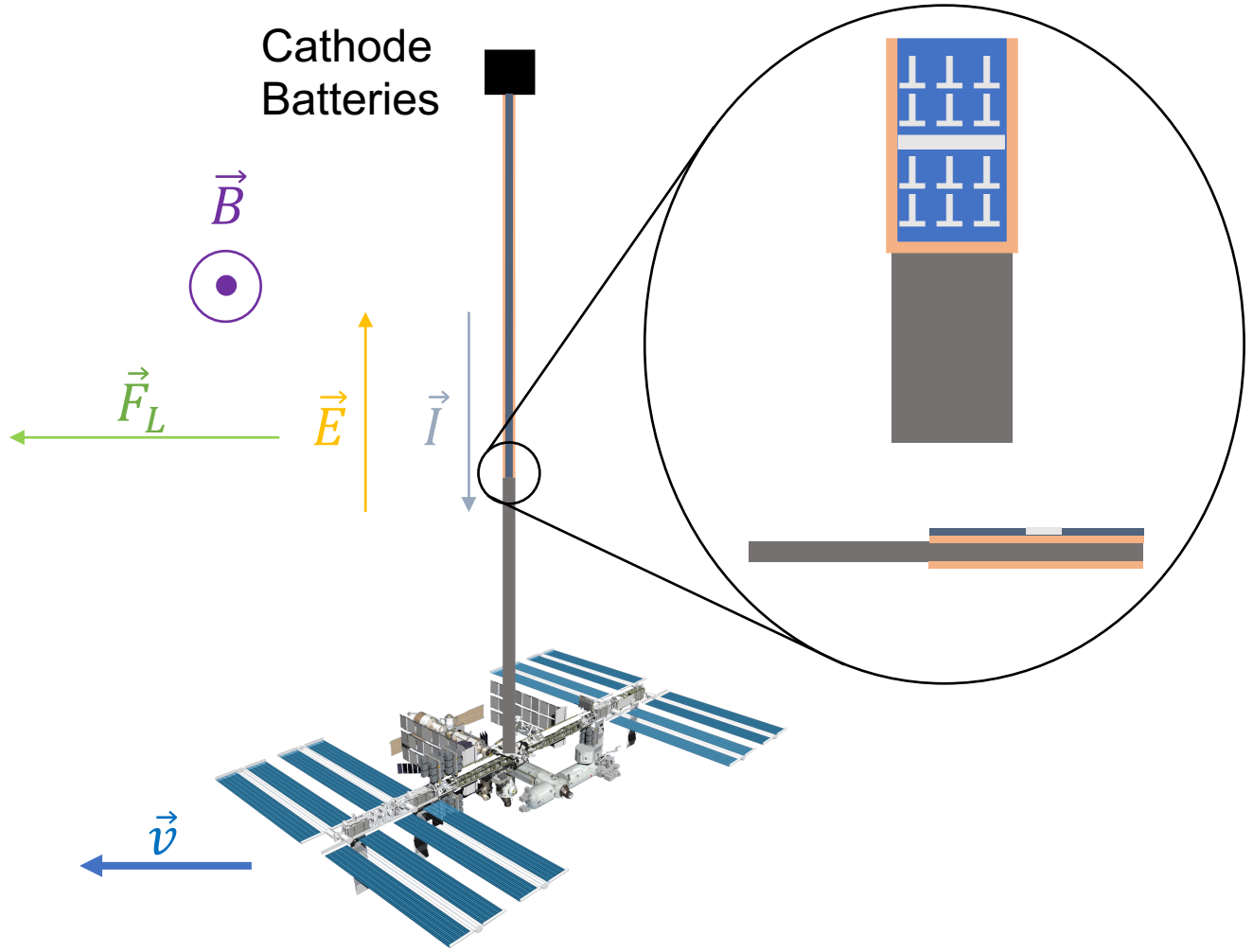




Tethers for Reboost

Bare Photovoltaic Tether

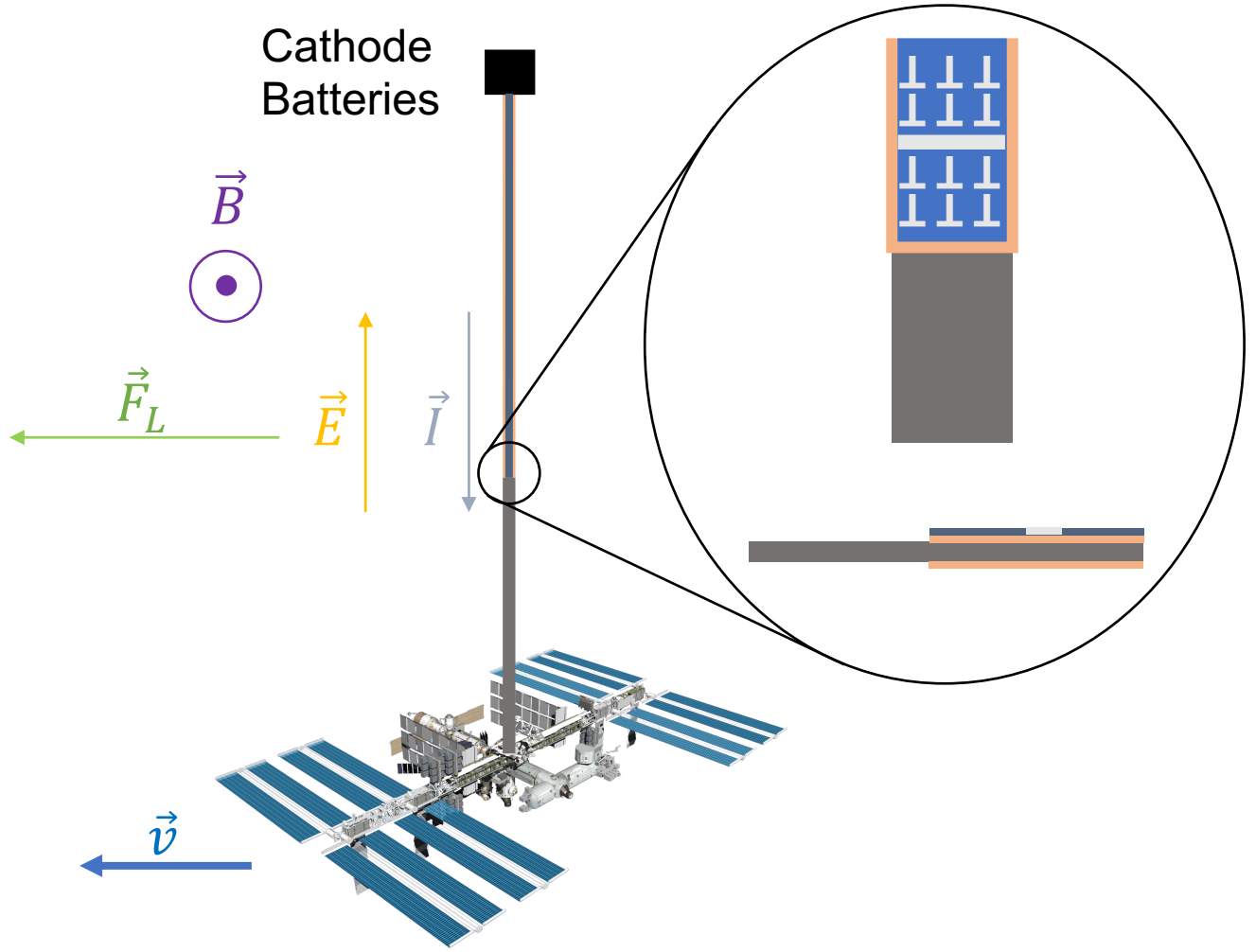
- Electro dynamic tether (EDT) architecture
- Thin film of solar cells
- Solar cells harvest power when illuminated by solar rays
  - Fully autonomous system



Bare Photovoltaic Tether

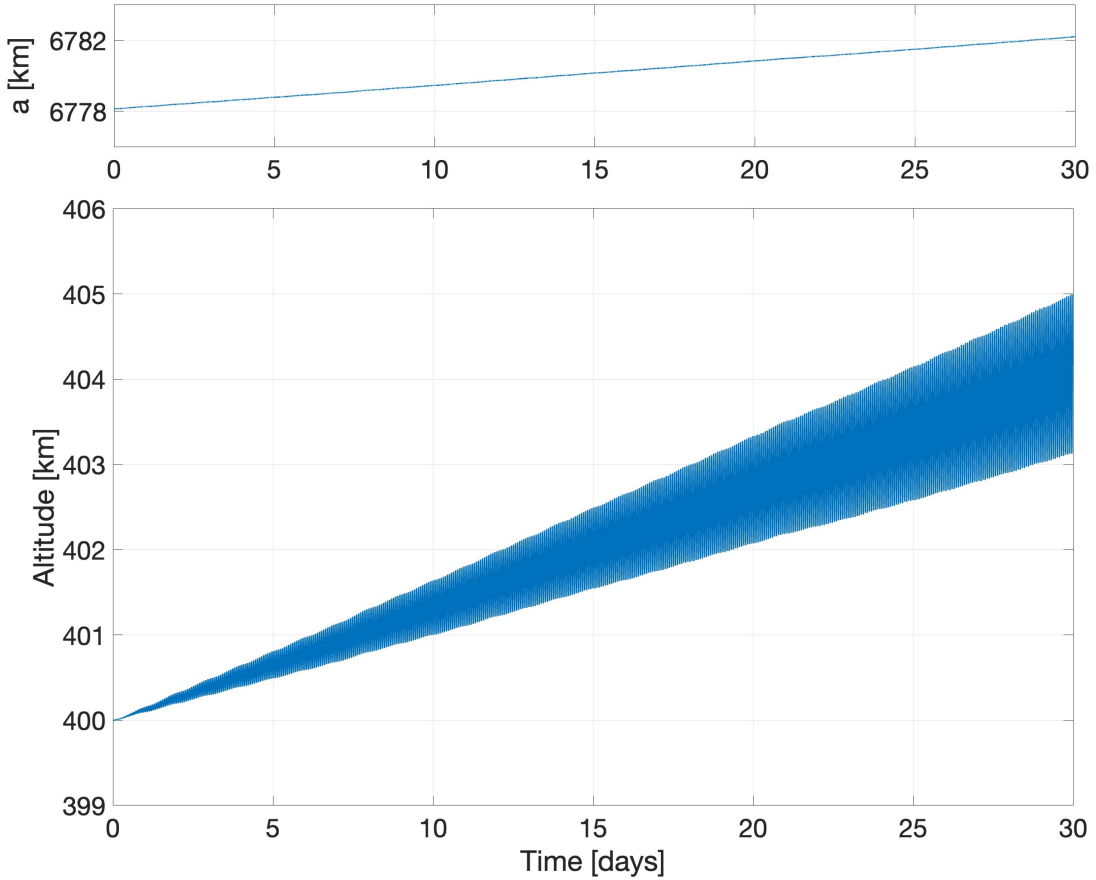
Study the ISS reboost (increase the semimajor axis of 4 km in 30 days)

	$F_D = 0.4\ N$	$F_D = 0.8\ N$
L_t	$15.00\ km$	$15.00\ km$
f_i	97.6%	97.0%
L_{pv}	$14.64\ km$	$14.45\ km$
η_{pv}	$4.23\ \%$	$7.23\ \%$

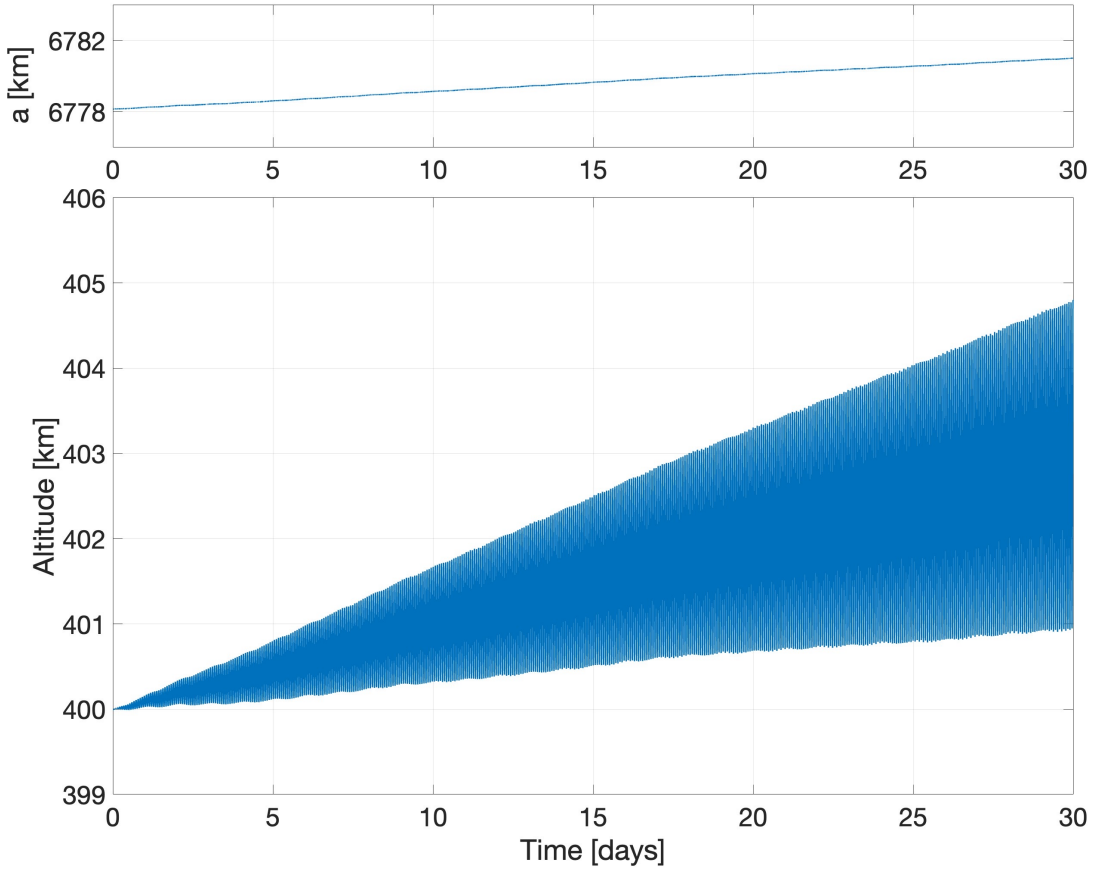


Bare Photovoltaic Tether

$F_D = 0.4\ N$

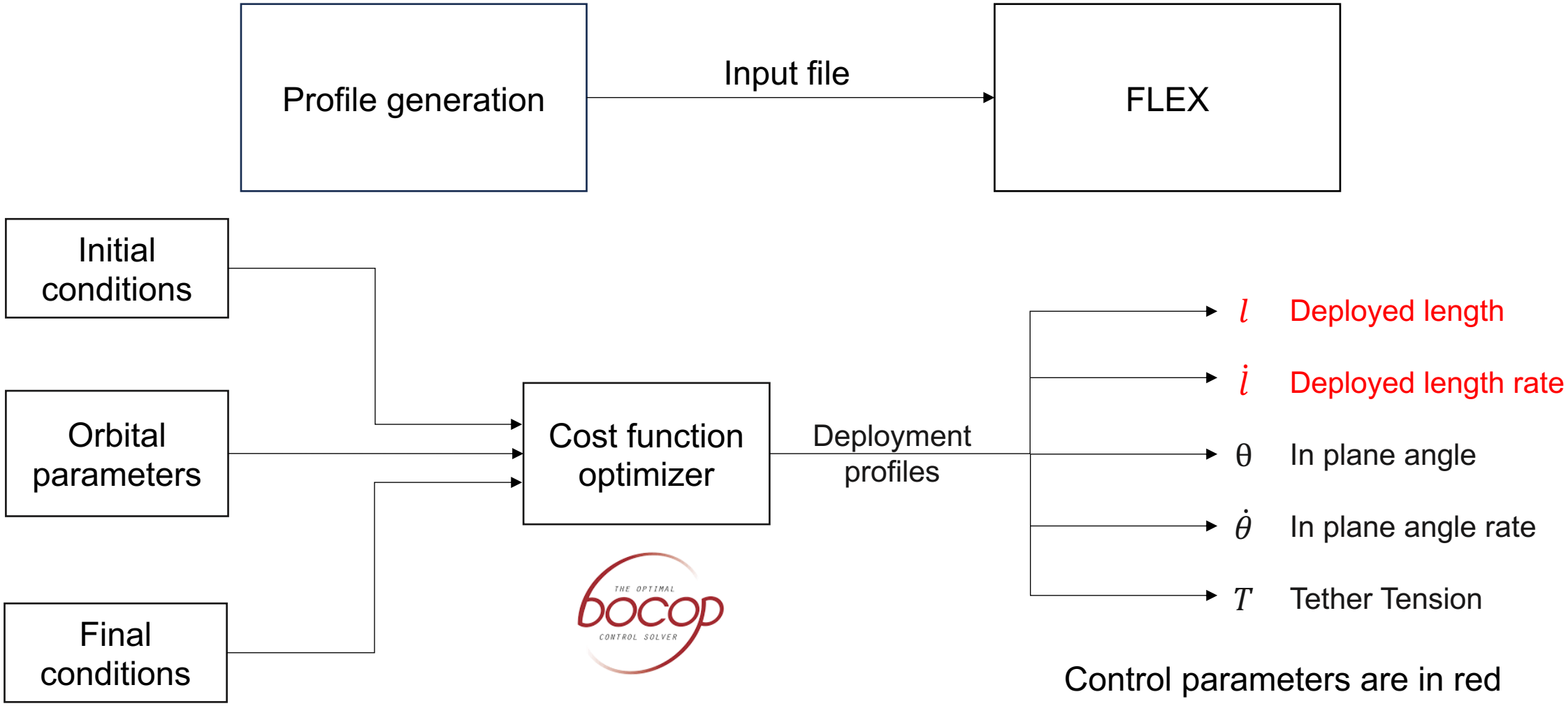


$F_D = 0.8\ N$

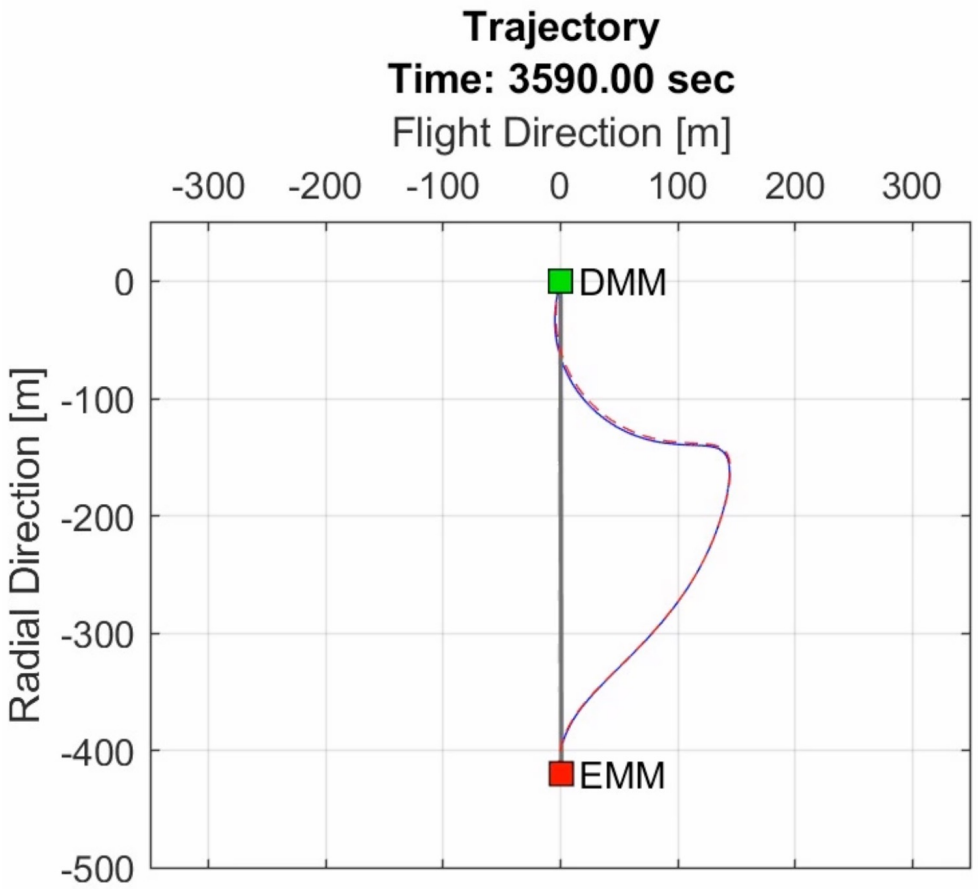


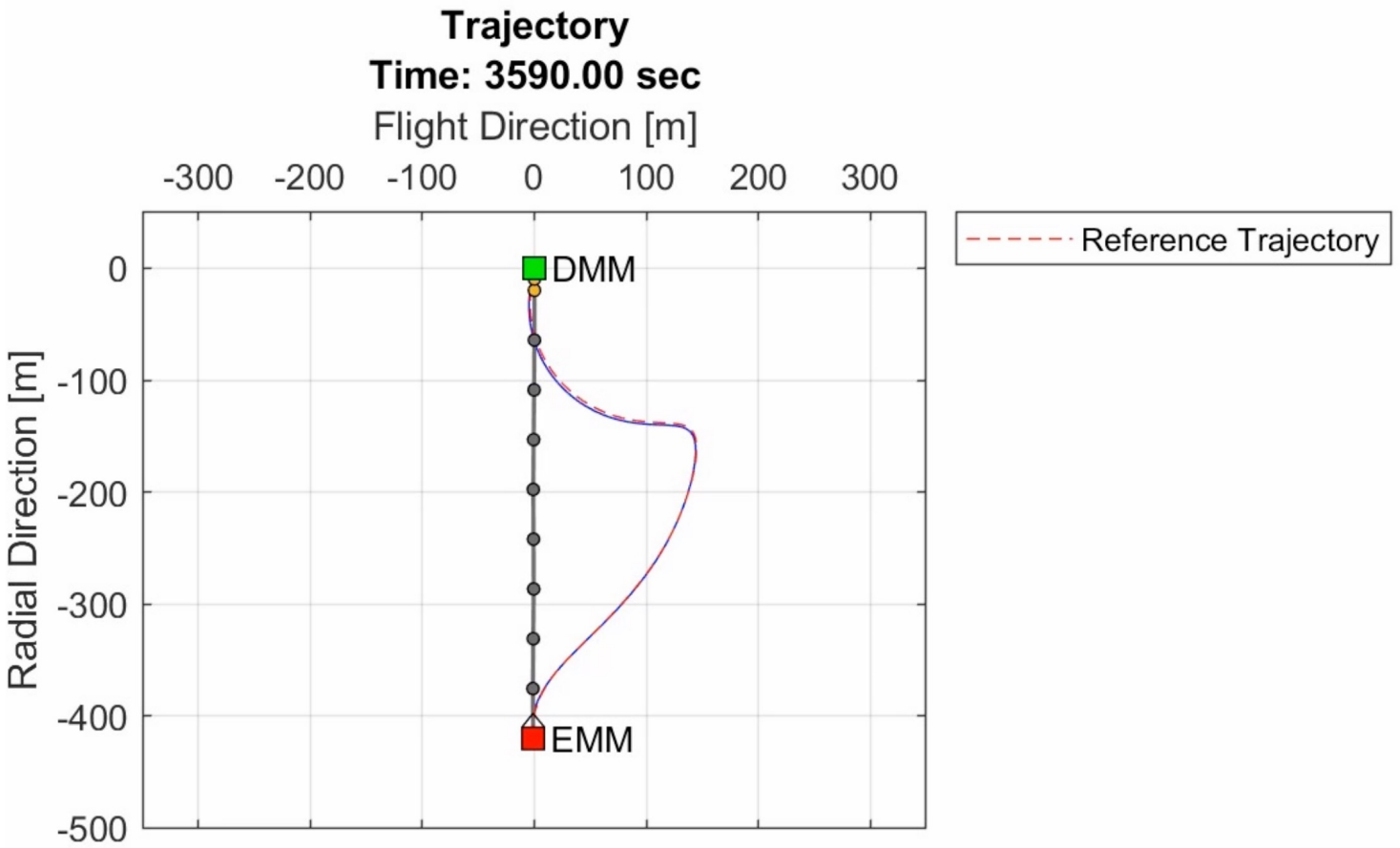
Deployment phase

Deployment


Profile generation
Input file
FLEX
Initial conditions
Orbital parameters
Final conditions
Cost function optimizer
Deployment profiles
l Deployed length
$\dot{l}$ Deployed length rate
θ In plane angle
$\dot{\theta}$ In plane angle rate
T Tether Tension
Control parameters are in red

Deployment


Trajectory
Time: 3590.00 sec
Flight Direction [m]
-300
-200
-100
0
100
200
300
Radial Direction [m]
0
-100
-200
-300
-400
-500
DMM
EMM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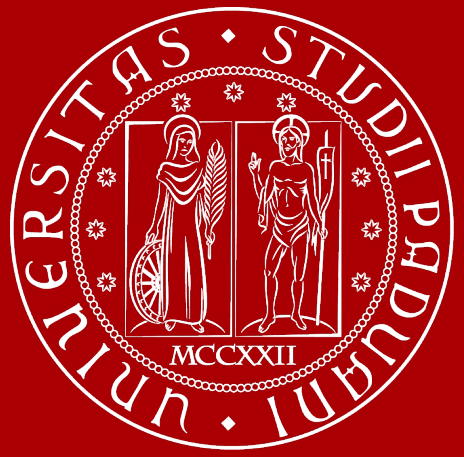
Time: 3590.00 sec
Flight Direction [m]
-300
-200
-100
0
100
200
300
Radial Direction [m]
0
-100
-200
-300
-400
-500
DMM
EMM
Reference Trajectory



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THANK YOU FOR THE ATTENTION!