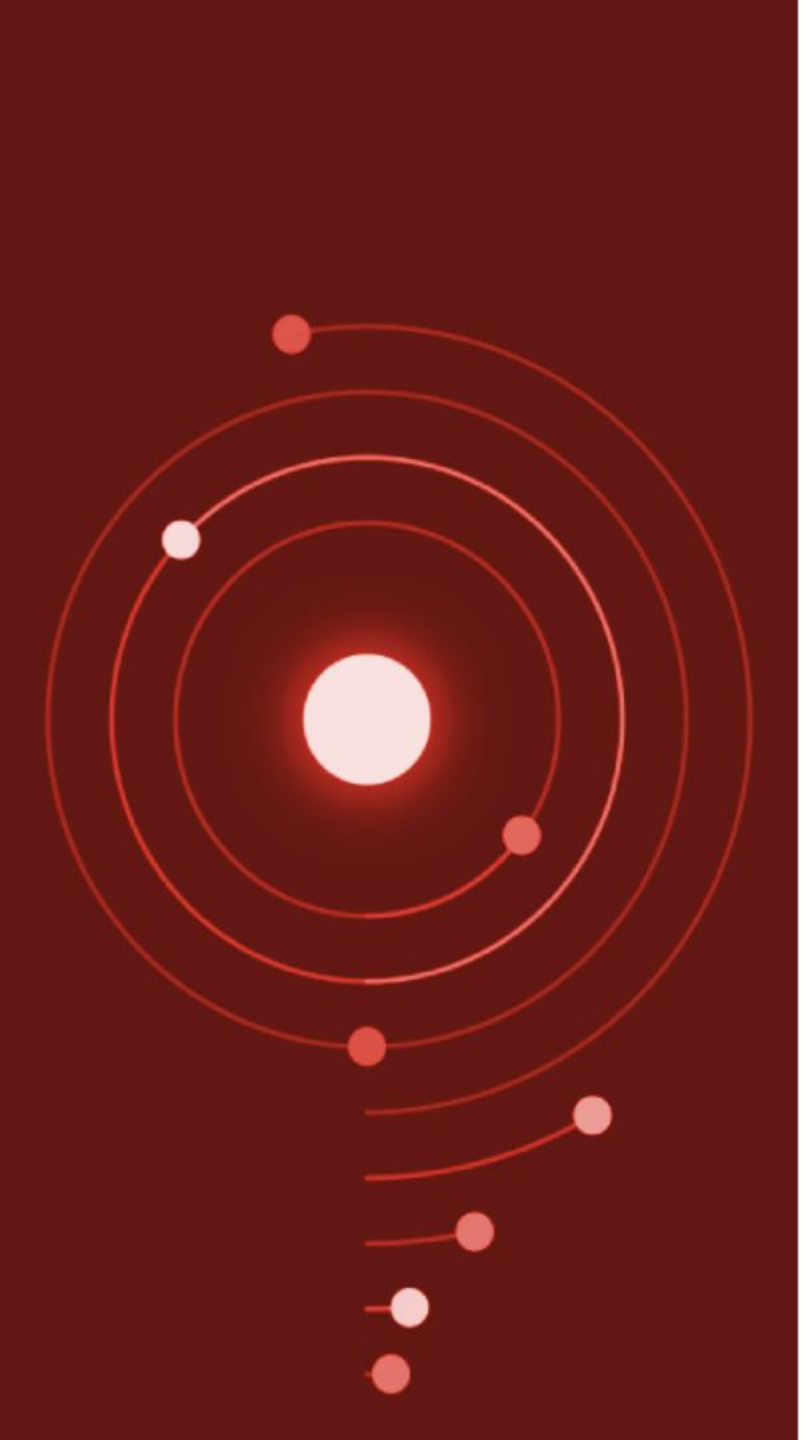

Orbital Mechanics
Final Project

POLITECNICO
MILANO 1863

Group 2163

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Luca Ciavirella 10574079 988304

Enrico Raviola 10864213 988668

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Interplanetary Mission – Preliminary Analysis

Jupiter – Earth – Venus

- **Earliest departure date:**

  2025/08/01

- **Latest arrival date:**

  2065/08/01

Selected ToFs:

	ToF1	**ToF2**
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max	3000	1500

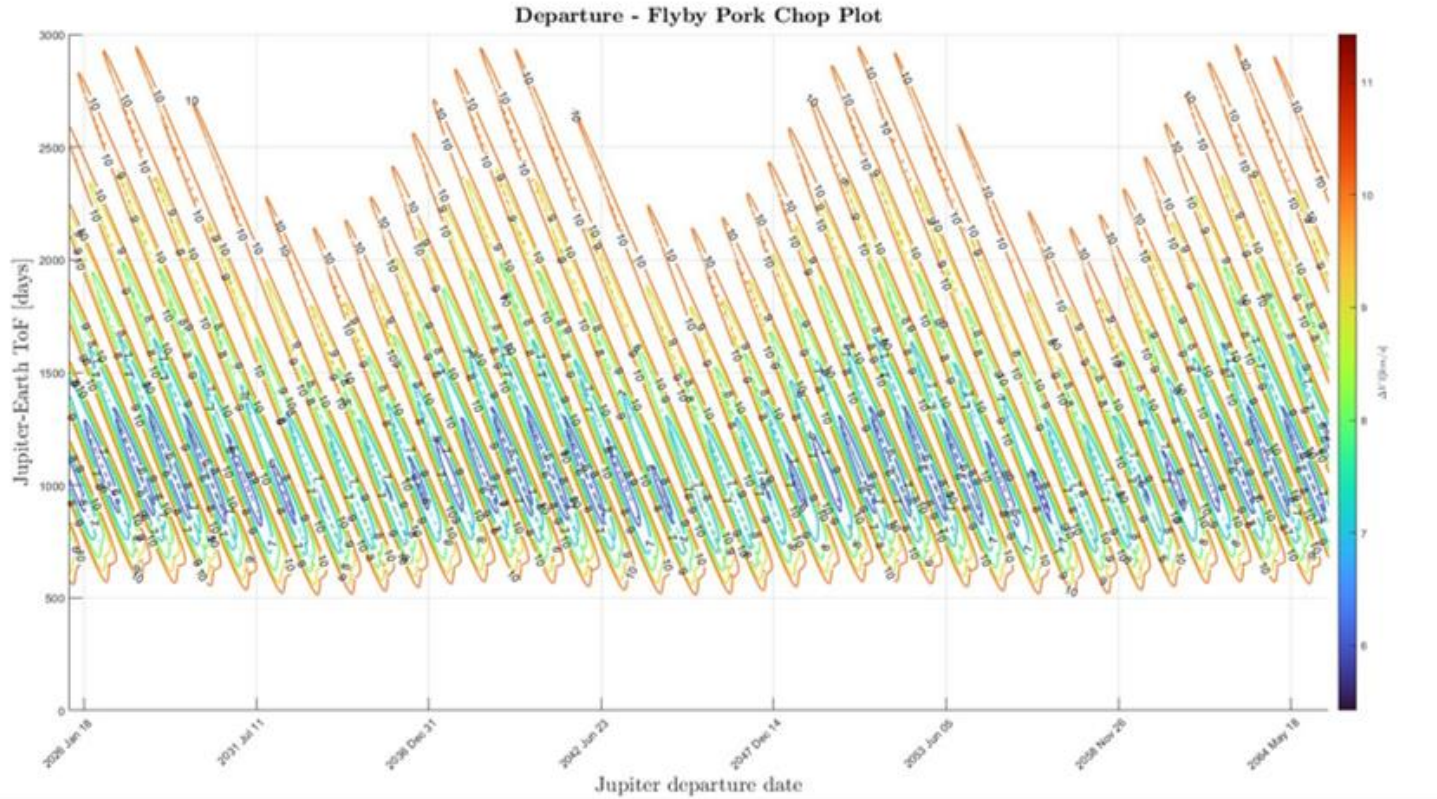


Figure 1: Departure – Flyby Pork Chop Plot

Interplanetary Mission – Preliminary Analysis

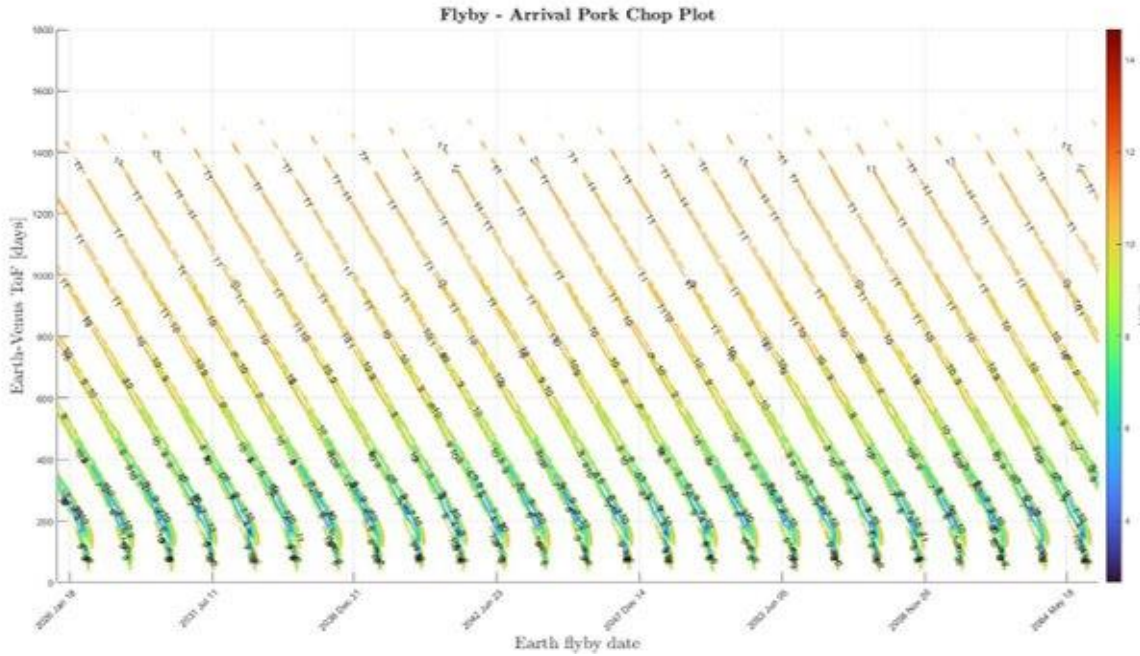


Figure 2: Flyby – Arrival Pork Chop Plot

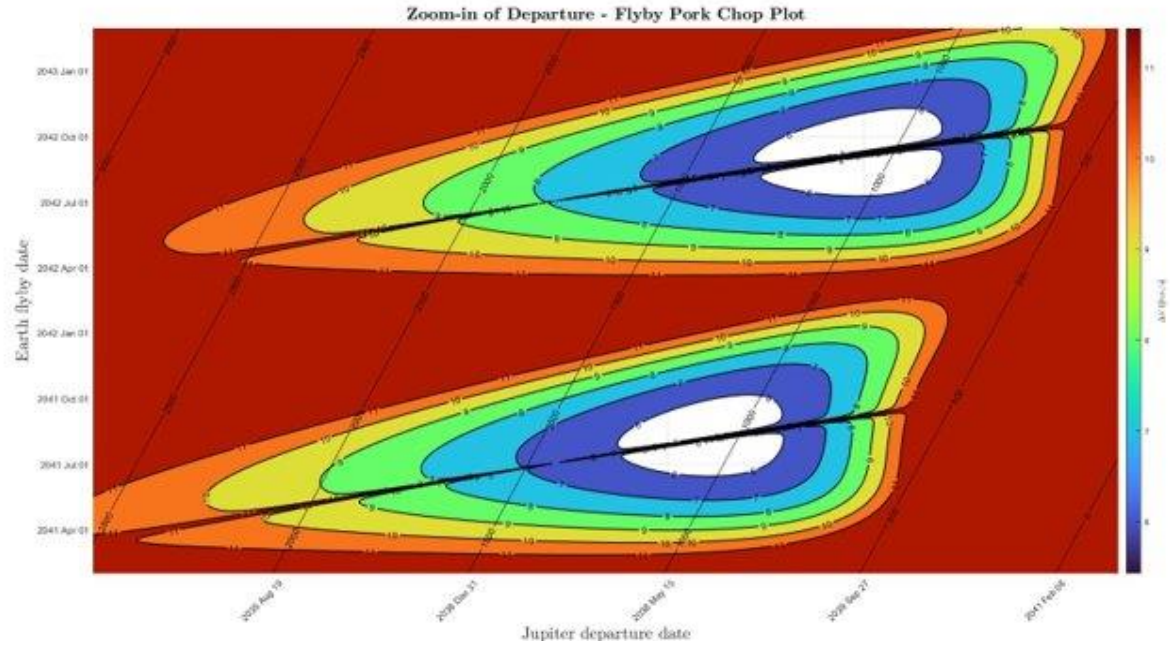


Figure 3: Zoomed Departure – Flyby Pork Chop Plot

Interplanetary Mission – Preliminary Analysis

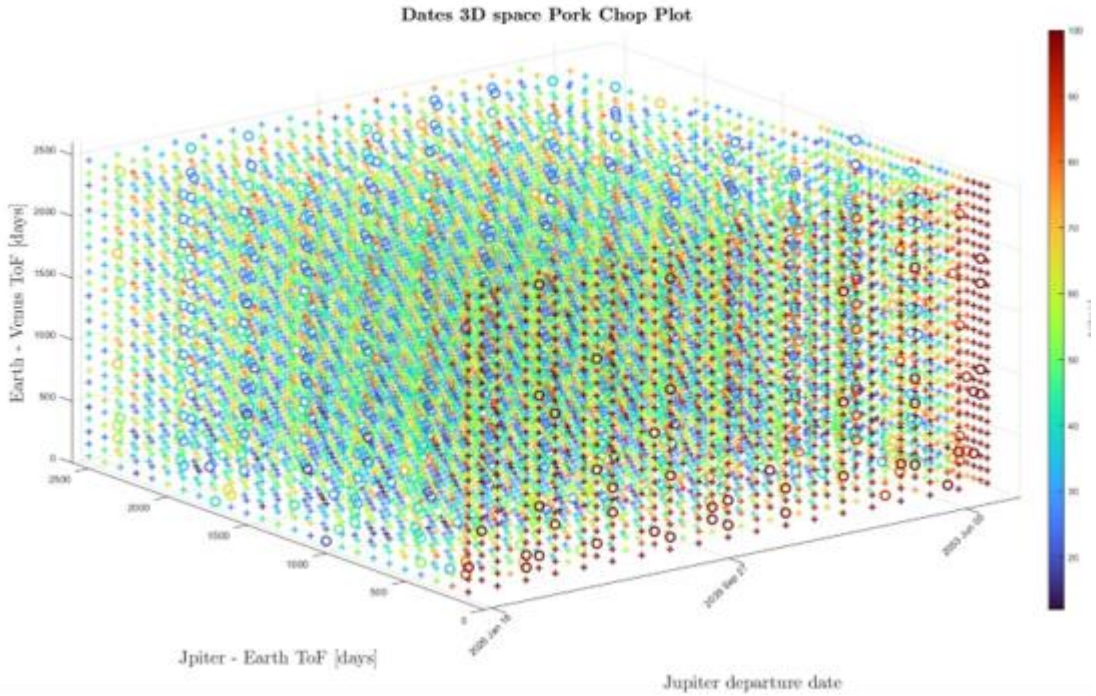


Figure 4: 3D Pork Chop Plot in ToFs space

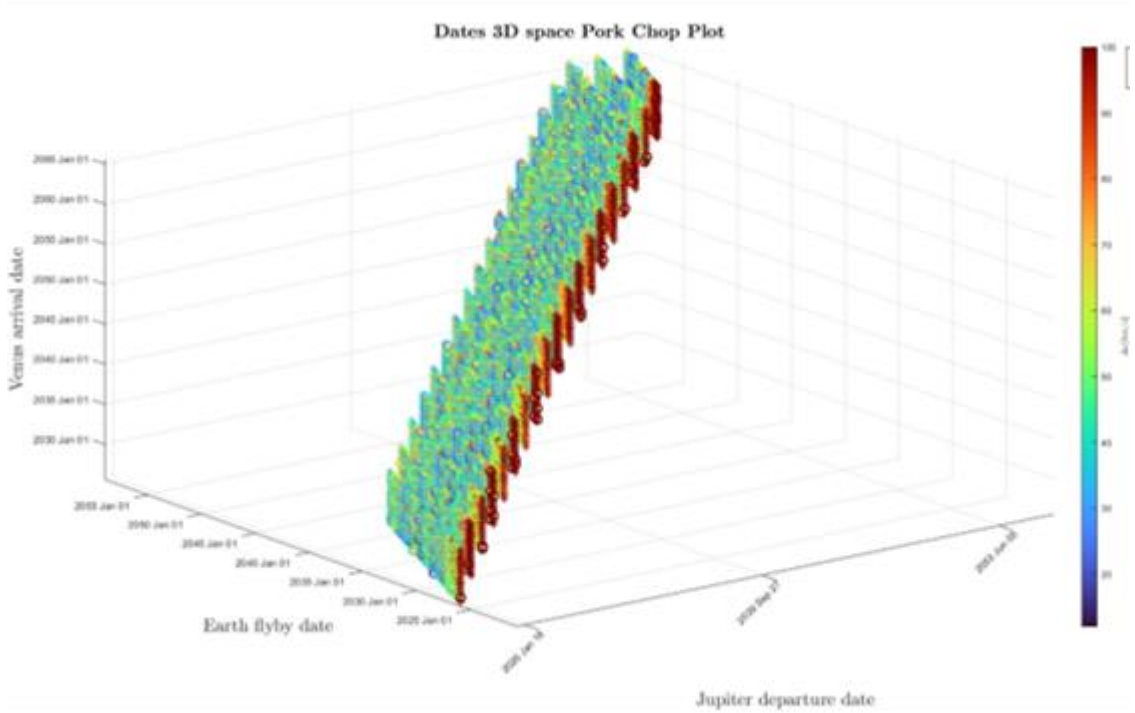
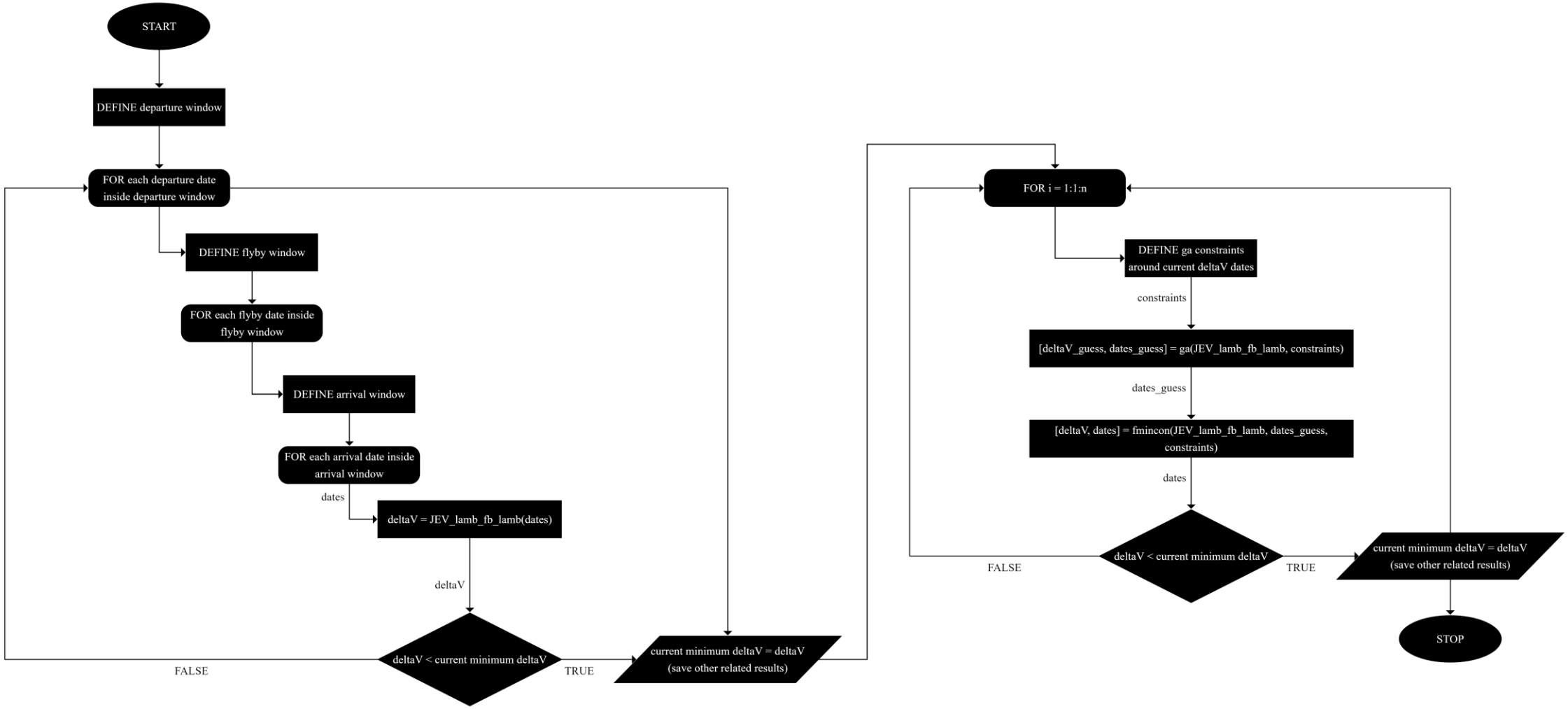


Figure 5: 3D Pork Chop Plot in dates space

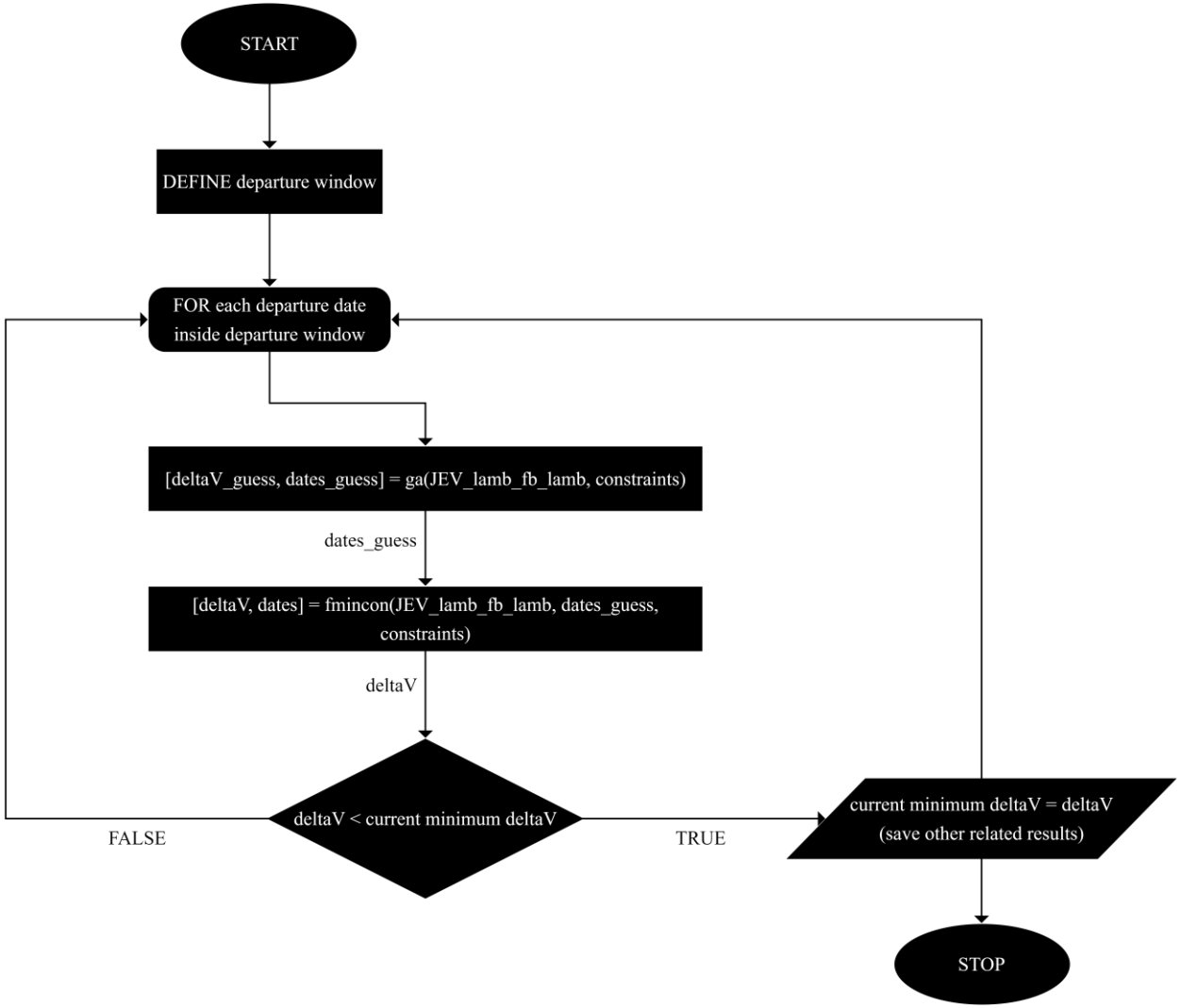
Interplanetary Mission – Method 1



Interplanetary Mission – Method 1 Mesh Convergence

Discretization Grid	Departure window time step [days]	First ToF time step [days]	Second ToF time step [days]	Run time [sec]	Δv [km/sec]
250x75x75	58.4	33.3	33.3	1115	13.8063
250x100x100	58.4	25	15	2547	13.4847
250x150x150	58.4	16.7	10	4470	13.2796
300x150x150	48.6	16.7	10	7286	13.3454
300x200x200	48.6	12.5	7.5	9498	13.3211
350x200x200	41.7	12.5	7.5	12664	13.3311
350x250x250	41.7	10	6	15832	13.3046
400x250x250	36.5	10	6	17558	13.2169

Interplanetary Mission – Method 2



Interplanetary Mission – Method 2 Mesh Convergence

Departure discretization	**Departure window Time step [days]**	**Run Time [sec]**	**Δv [km/sec]**
175 sub-windows	83.5	3159	13.5385
200 sub-windows	73.1	5073	13.5084
225 sub-windows	65	6872	13.4163
250 sub-windows	58.4	6692	13.4229
300 sub-windows	48.7	8147	13.4158
500 sub-windows	29.2	12432	13.2534
600 sub-windows	24.3	16364	13.2702

Interplanetary Mission – Results

	Departure	Flyby	Arrival
Date	12/30/2040	11/21/2043	03/03/2045
Natural Flyby Δv		6.71739 [km/sec]	
Total Δv required		13.2169 [km/sec]	
Perigee passage altitude		301 [km]	
Time inside Earth SOI		138138 [sec	

Interplanetary Mission – Results

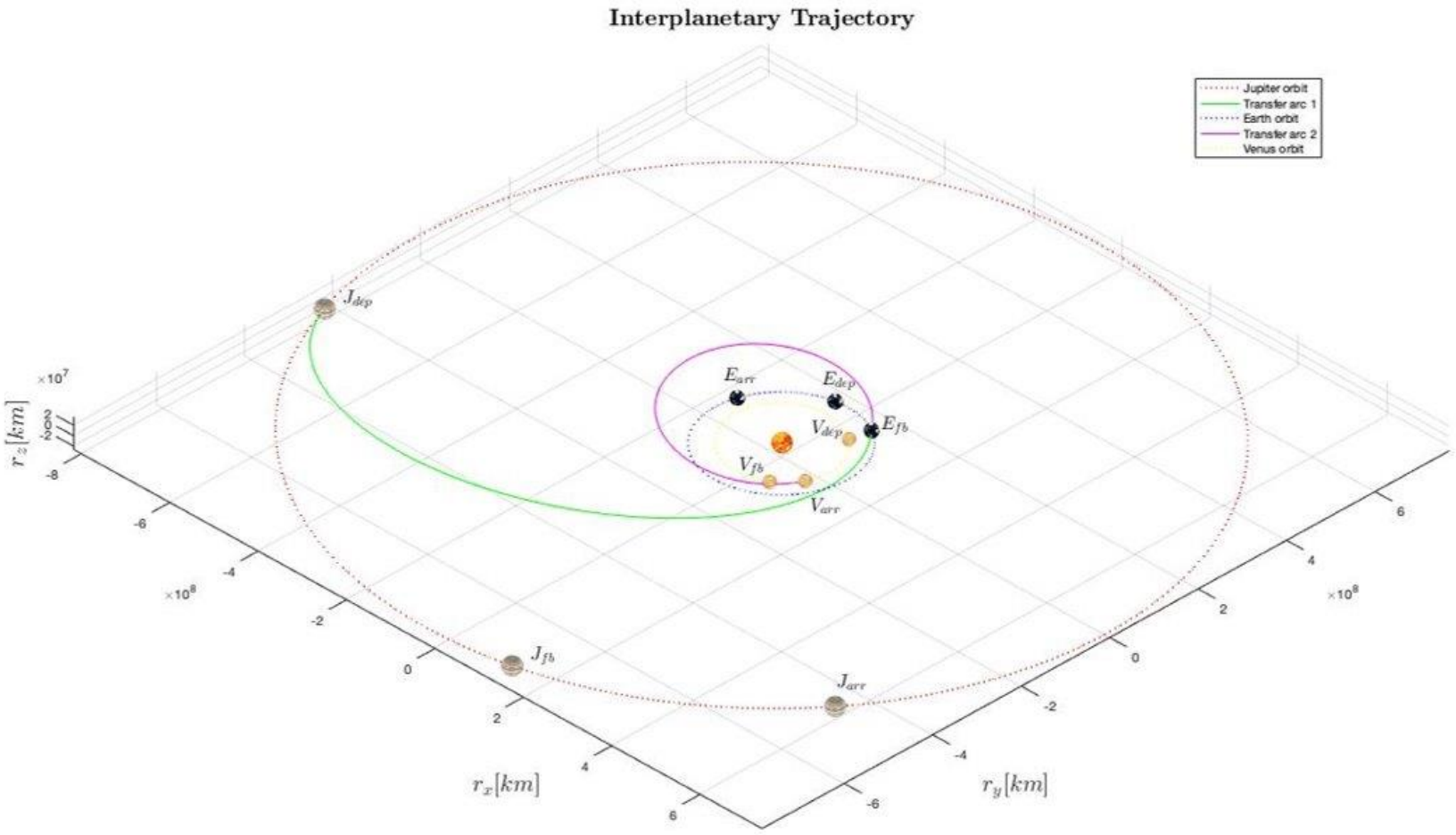


Figure 6: Interplanetary Trajectory

Interplanetary Mission – Results

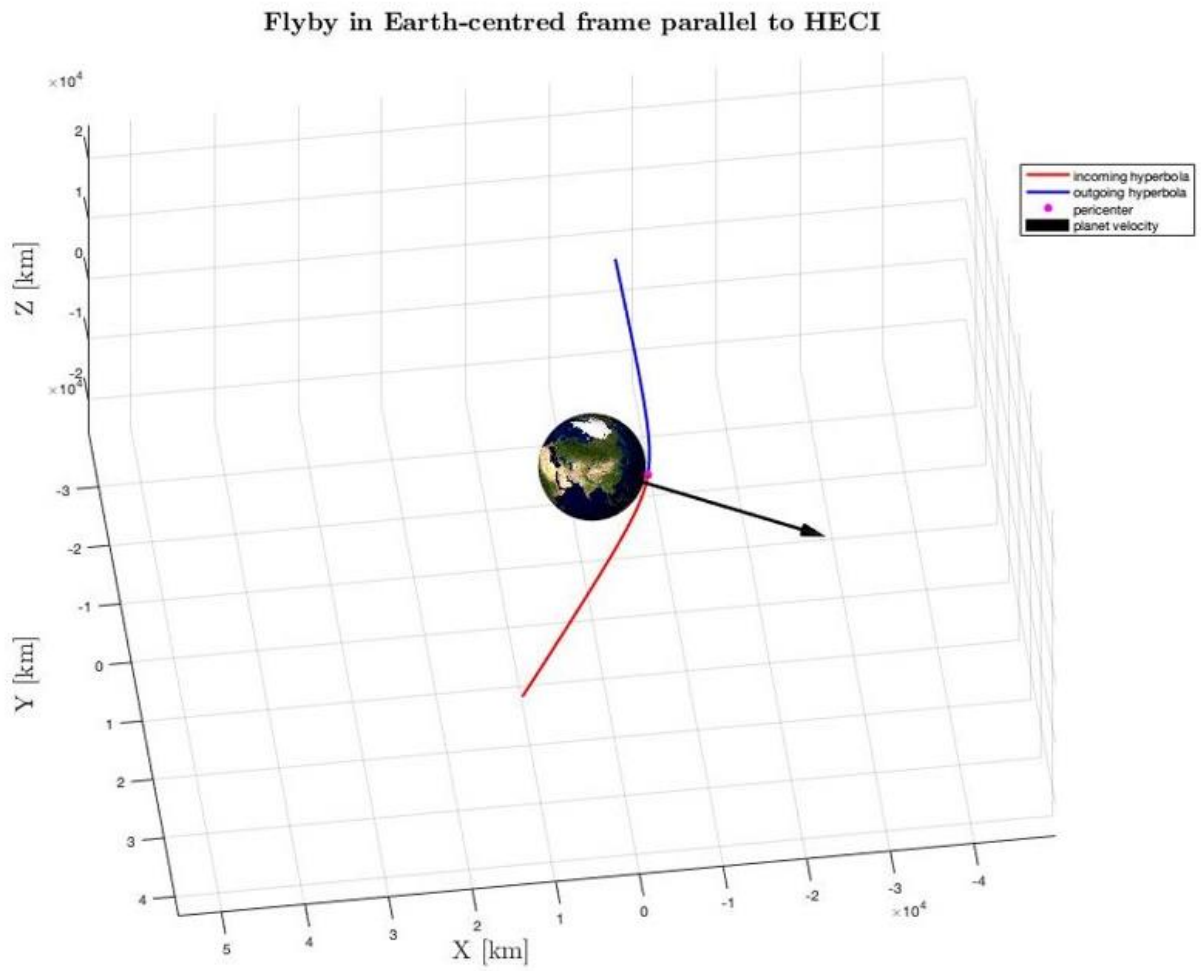


Figure 7: Flyby Trajectory

Planetary Mission – Objectives

Aim of the mission : Earth's observtion

- Ground track estimation
- J2 and SRP perturbed orbit analysis
- Real satellite comparison

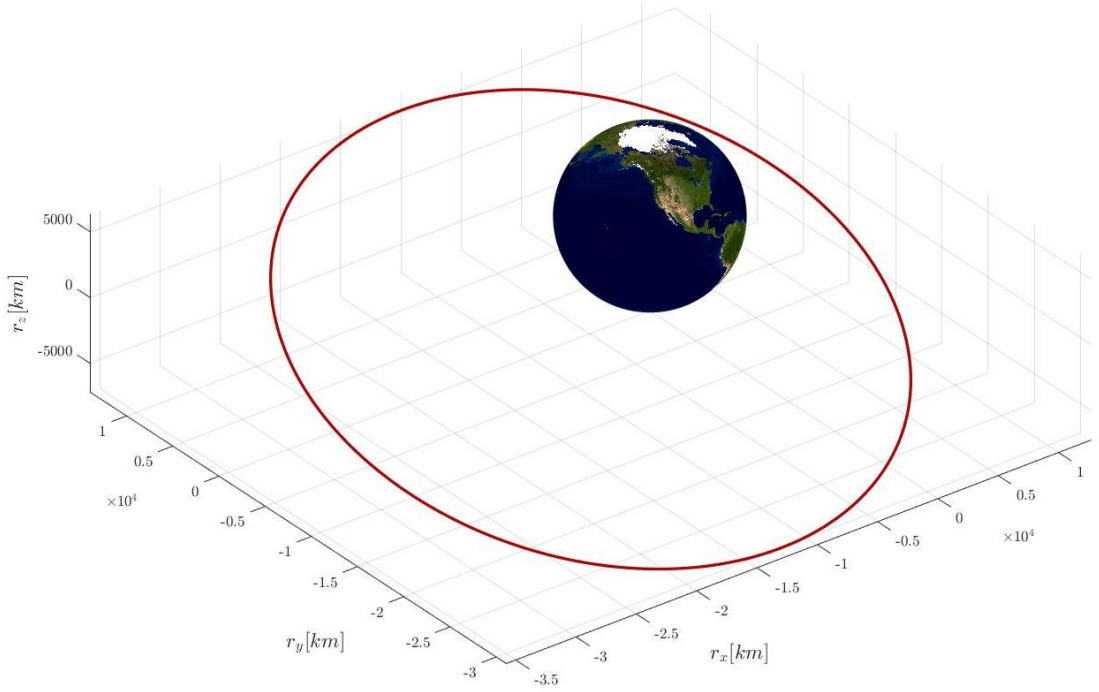


Figure 8: Nominal Orbit

Planetary Mission – Ground Tracks

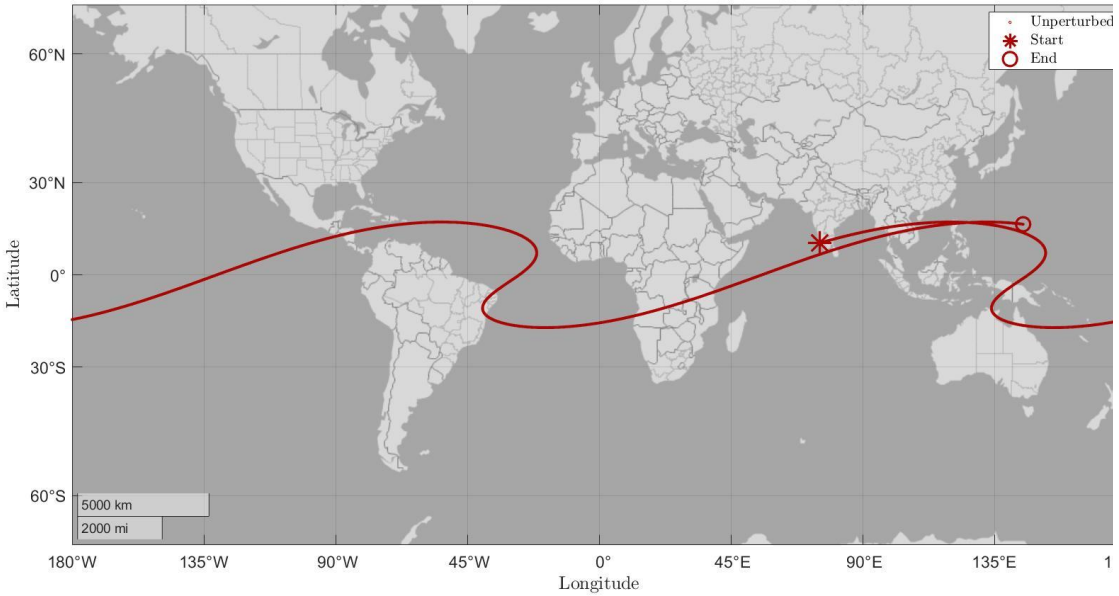


Figure 9: Unperturbed Ground track – 1 day

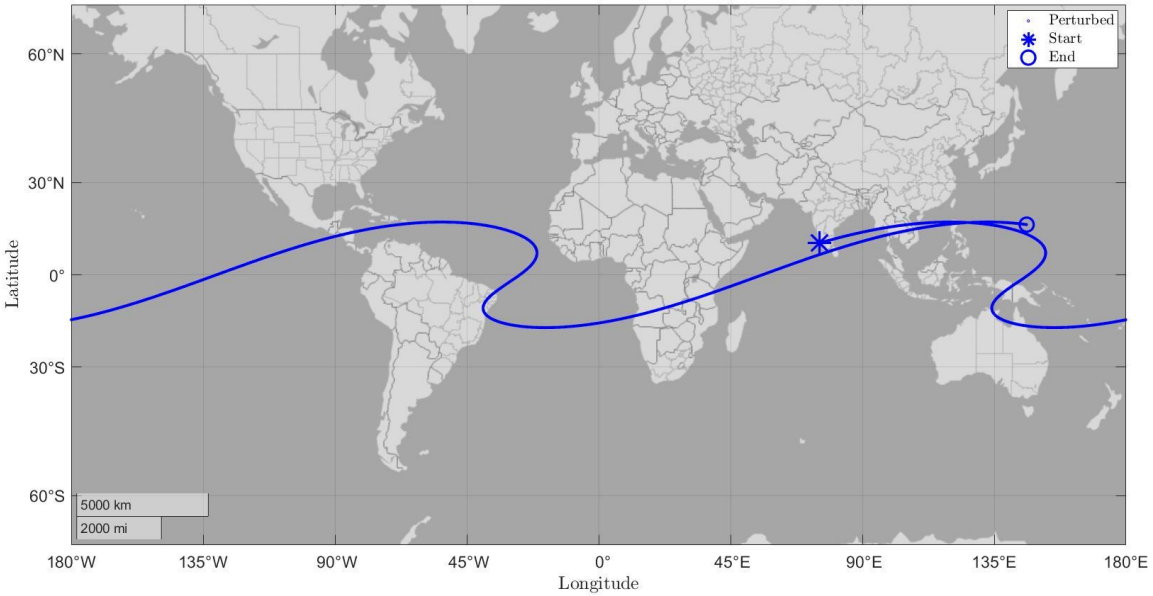


Figure 10: Perturbed Ground track – 1 day

Planetary Mission – Repeating Ground Tracks

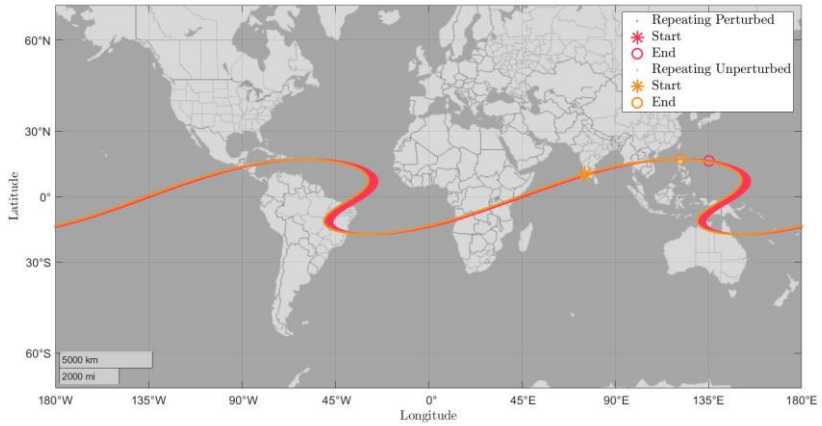


Figure 11: Repeating Ground tracks – 10 day

Figure 12: Repeating Ground tracks – 1 day

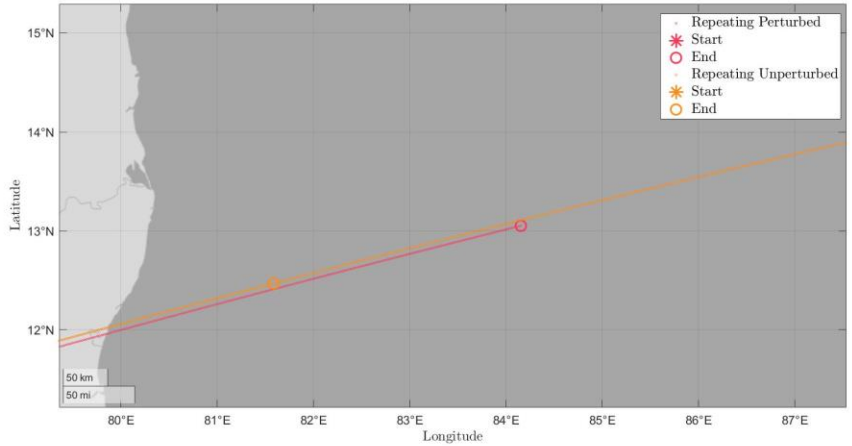


Figure 13: Repeating Ground tracks zoom-in – 1 day

Planetary Mission – Propagation

The evolution of Keplerian elements through two different methods:

- Gauss planetary equations
- Cartesian equation of motion

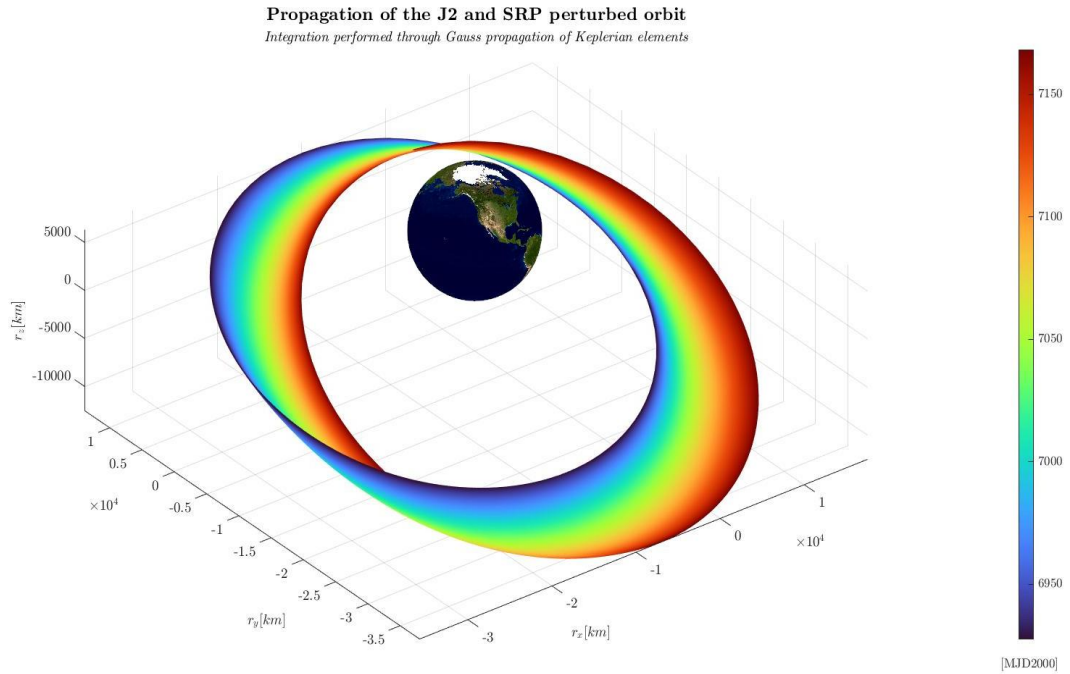


Figure 14: Perturbed Orbit

Planetary Mission – Propagation

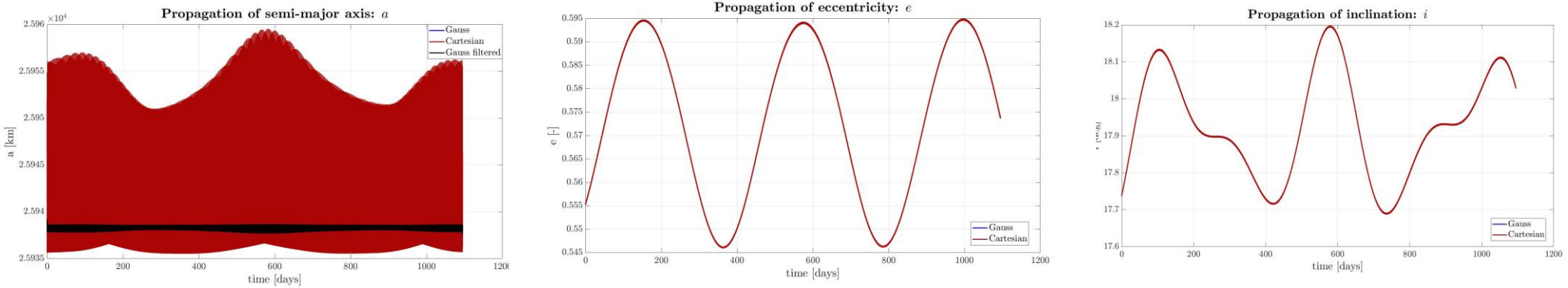


Figure 15: Evolution of Perturbed Orbit's Keplerian Elements

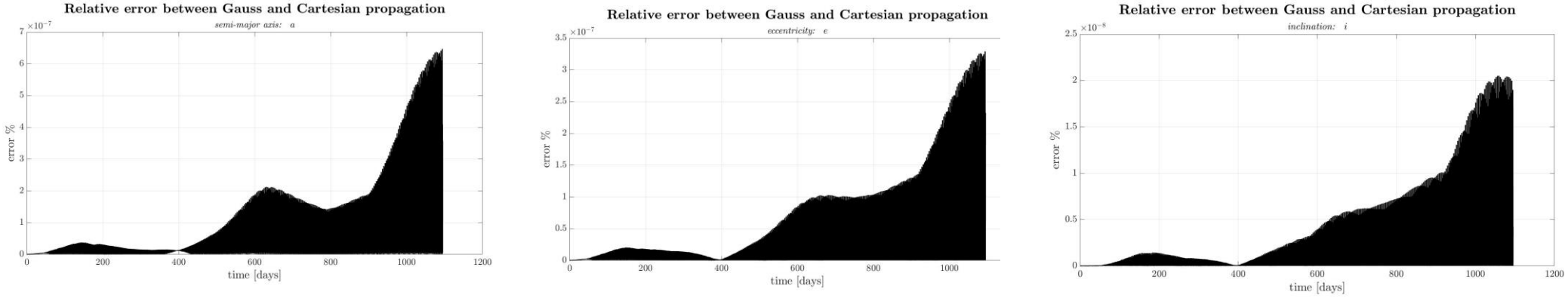


Figure 16: Evolution of Perturbed Orbit's Keplerian Elements – Error between direct integration and Gauss propagation

Planetary Mission – Propagation

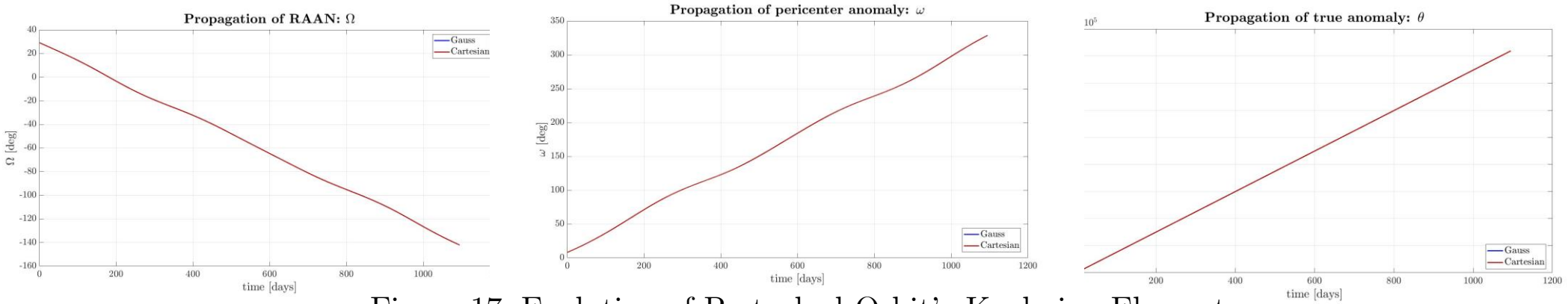


Figure 17: Evolution of Perturbed Orbit's Keplerian Elements

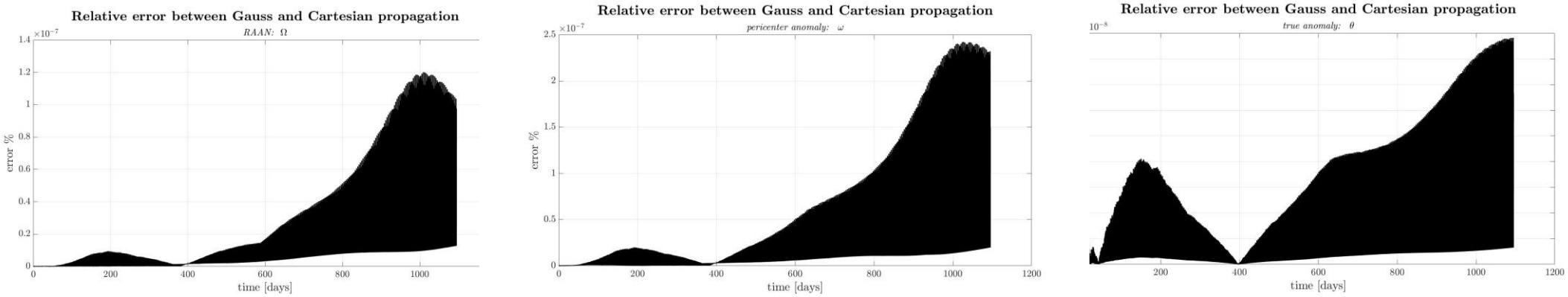


Figure 18: Evolution of Perturbed Orbit's Keplerian Elements – Error between direct integration and Gauss propagation

Planetary Mission – HF Filtering

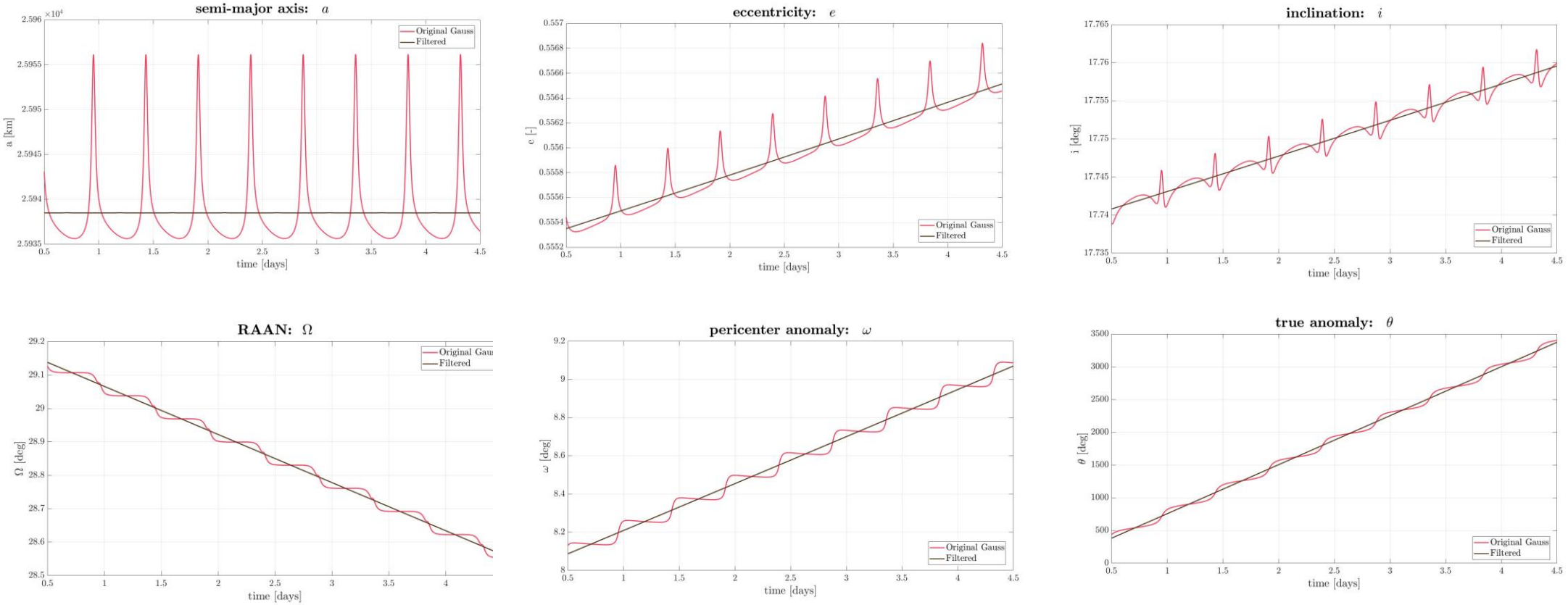


Figure 19: Filtering of Keplerian Elements

Planetary Mission – Real Satellite Comparison

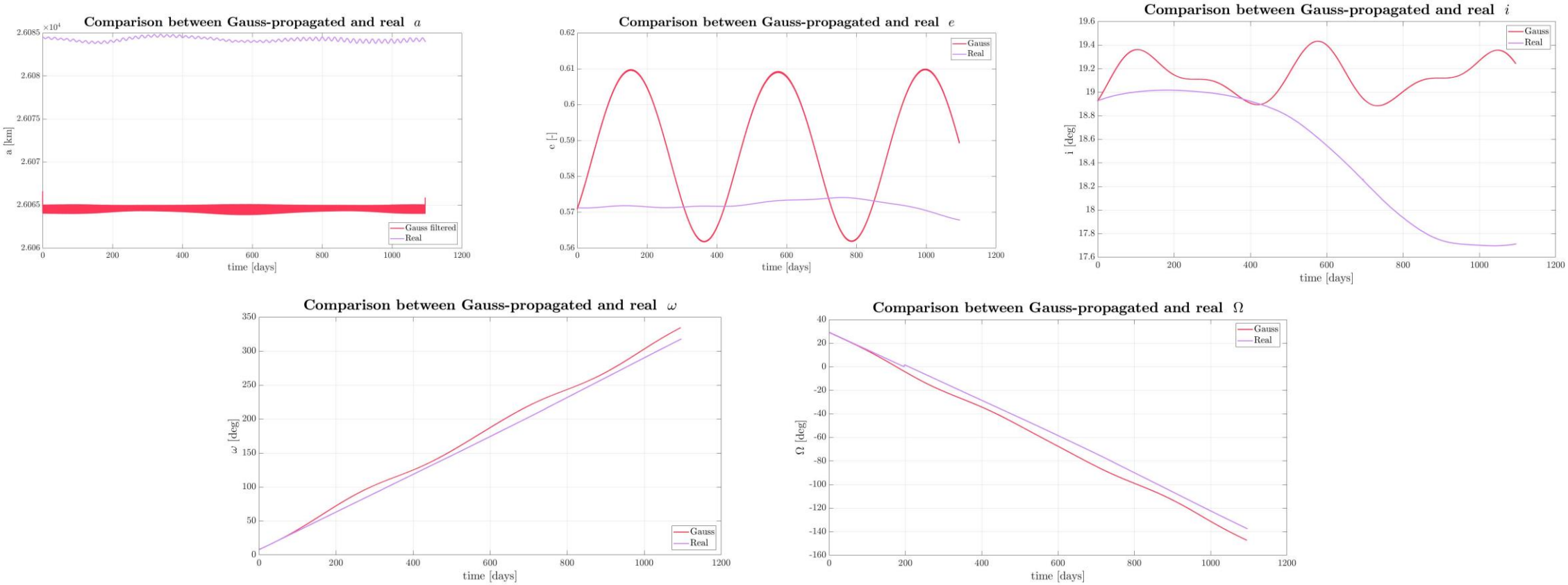
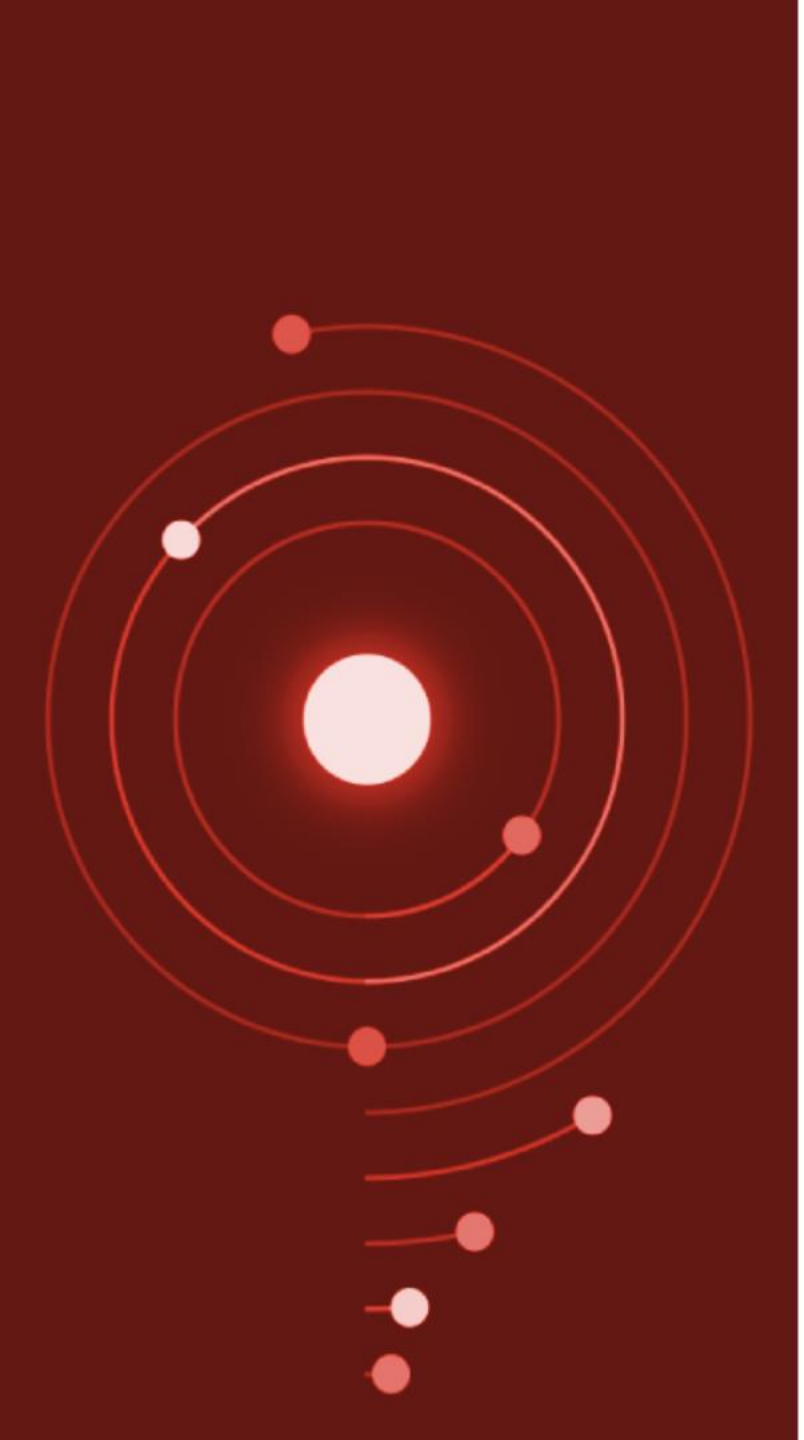


Figure 20: Comparison of Kepler Element's Propagation with a Real Satellite



Thank you for your attention

Alberto Boffi
Andrea Campagna
Luca Ciavirella
Enrico Raviola