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Uncertainties in LEO with electrical propulsion

Kinéis – Mission objectives

Extending the Argos network

- Message of a few bytes
- Bi-directional
- Low power
- Global network

Sciences & Environment



Humanitarian



Maritime



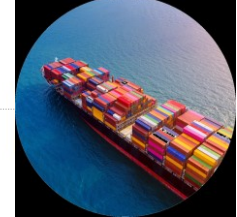
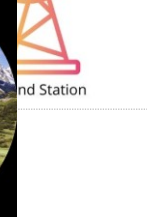
Smart agriculture



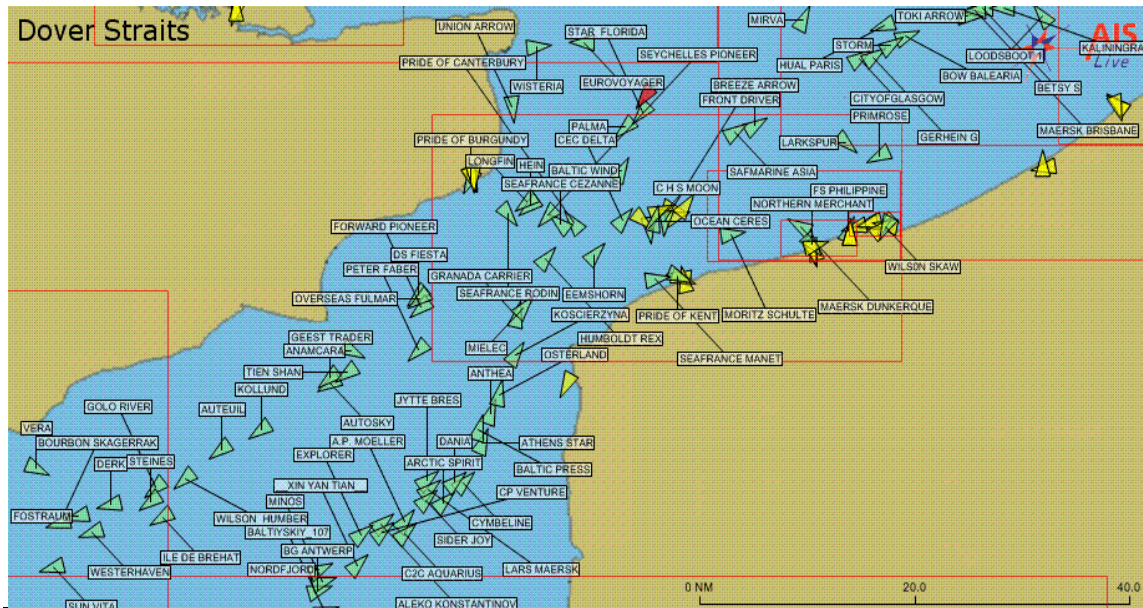
Outdoor activities



Networks & Infrastructures



Transports & Logistics



AIS message collection

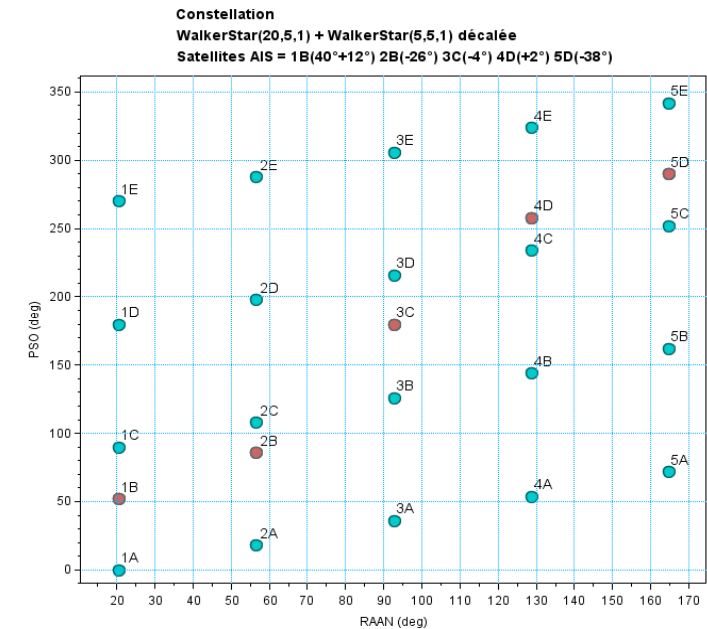
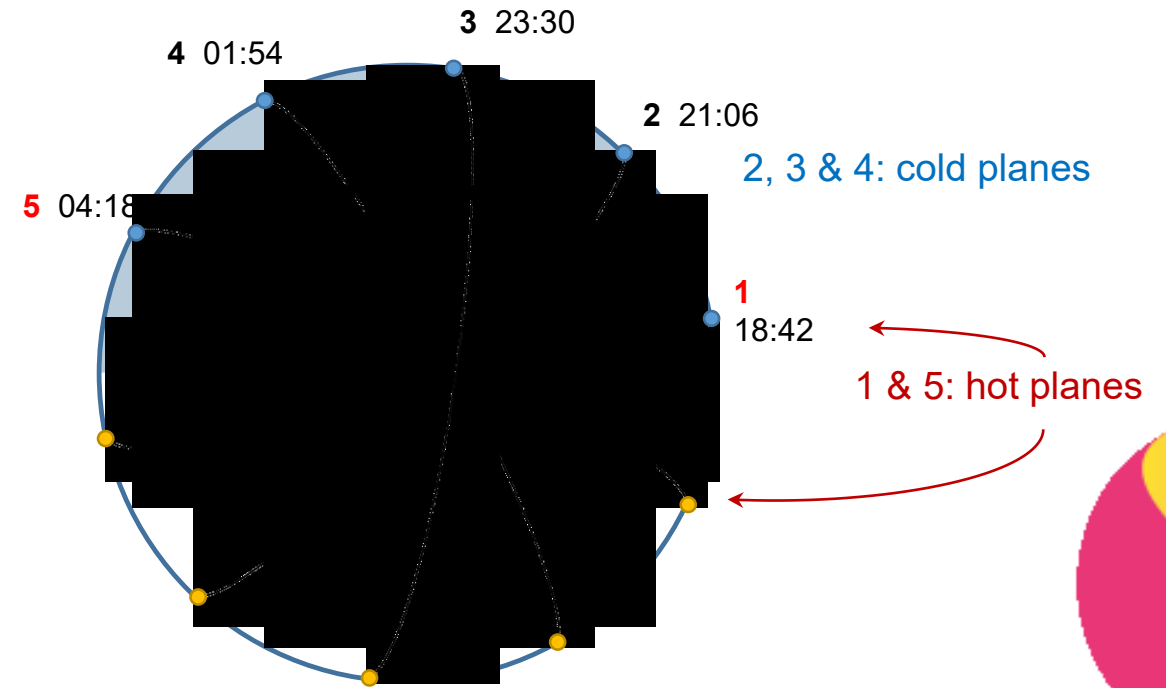
Constellation

- **25 satellites** spread on **5 orbital planes** each with

- **4 ARGOS** satellites (evenly spread at 90deg)
- **1 AIS** satellite
- Angular distance between planes : **36 deg (2h24)**

- **Orbital/Operational parameters**

- Altitude **650 km**
- Eccentricity 0.00119 (frozen orbit)
- Inclination 97.98 deg (sun-synchronous)
- Local Time of AN [18:42 , 21:06 , 23:30 , 01:54 , 04:18]



Satellites



16U Cubesat : ~30 kg

Conceived and assembled by HEMERIA

Sensors:

- Sun sensor
- Magnetometer
- Star-tracker

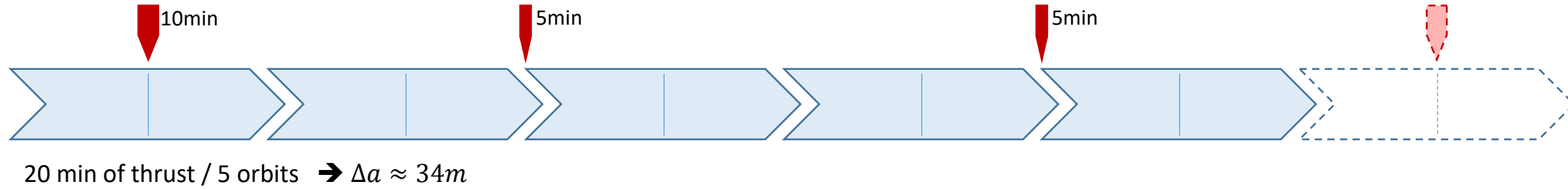
Actuators :

- 4 Reaction wheels
- Magneto-torquers
- Electrical propulsion (Indium)

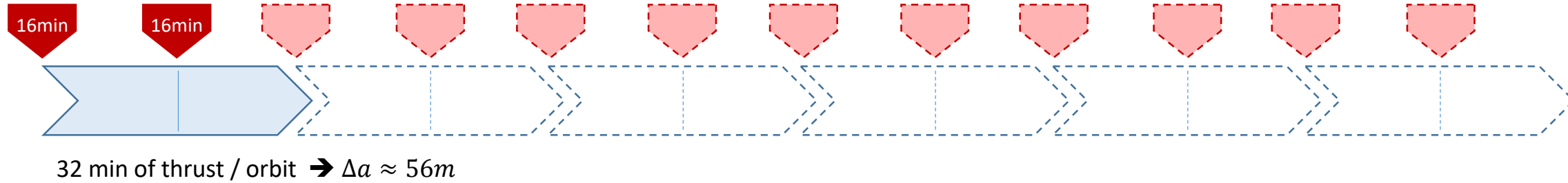
$$F = 410\mu\text{N} / I_{sp} = 2500\text{s} / P = 45\text{W}$$

Maneuver patterns

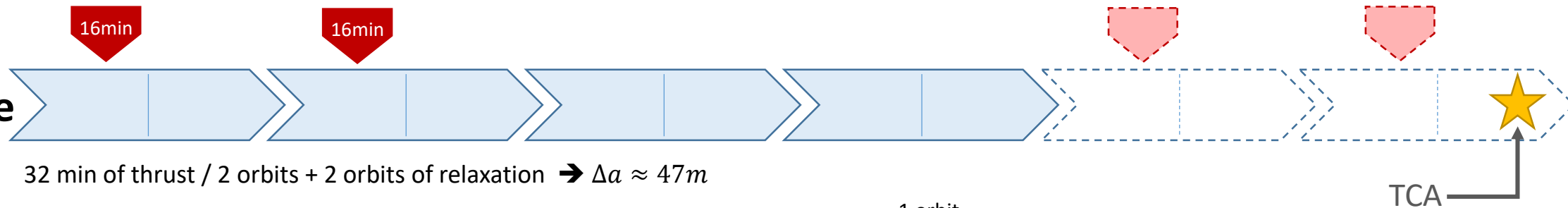
Short



Long

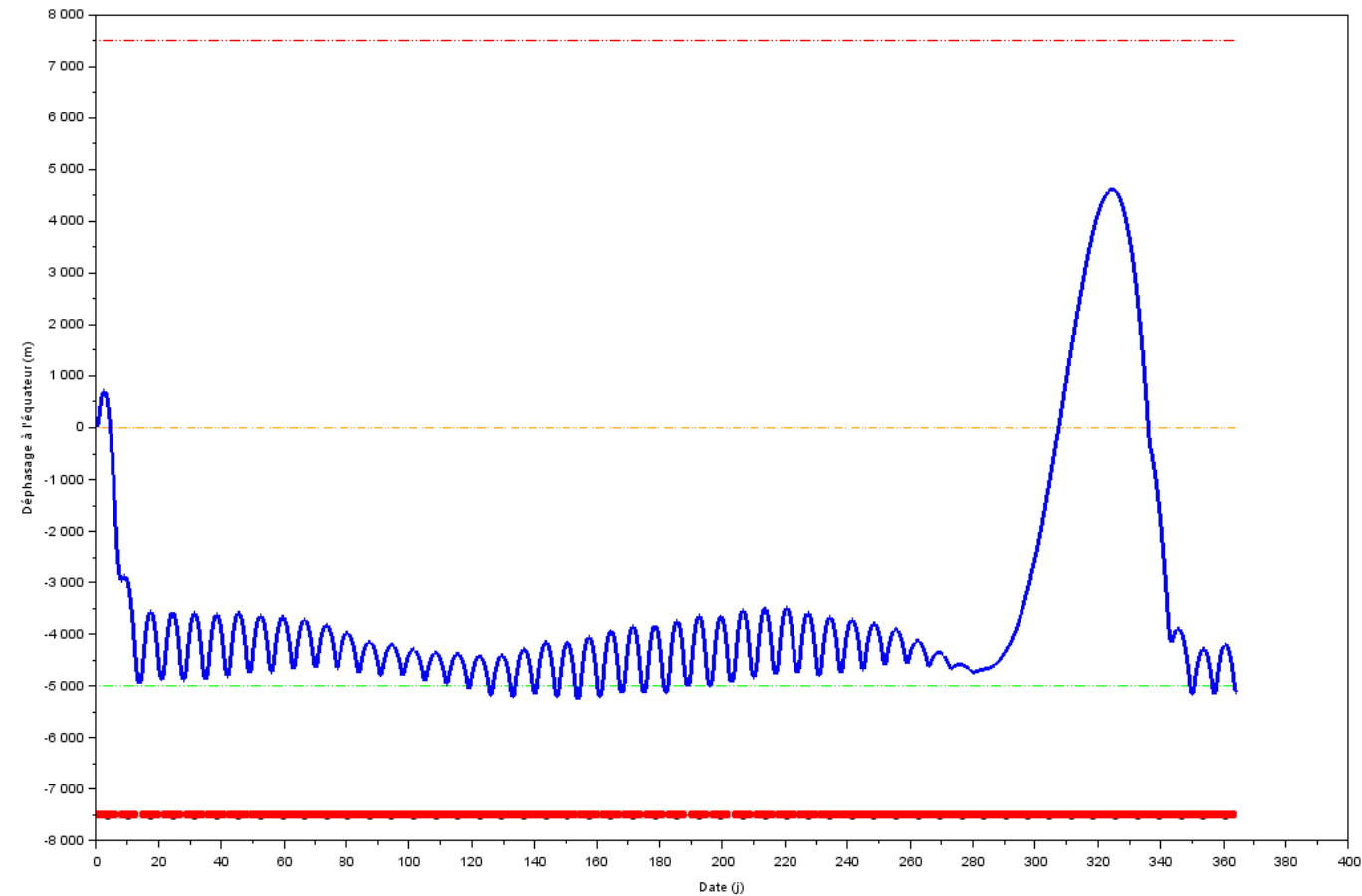


Avoidance



Station Keeping

- SK with fixed frequency (7 days)
- Control in AoL and LTAN
- Combined Maneuvers $\Delta a + \Delta i$
 - Magnitude depends on solar activity
 - $\text{yaw} \propto \frac{\Delta i}{\Delta a}$

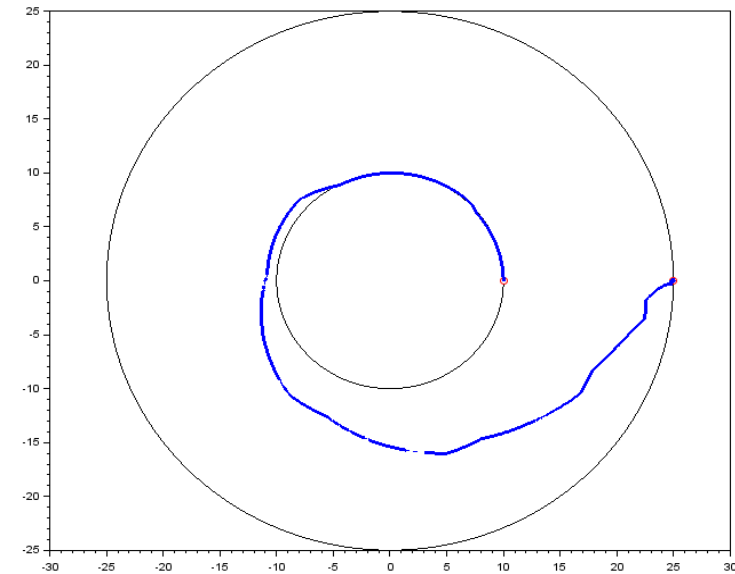
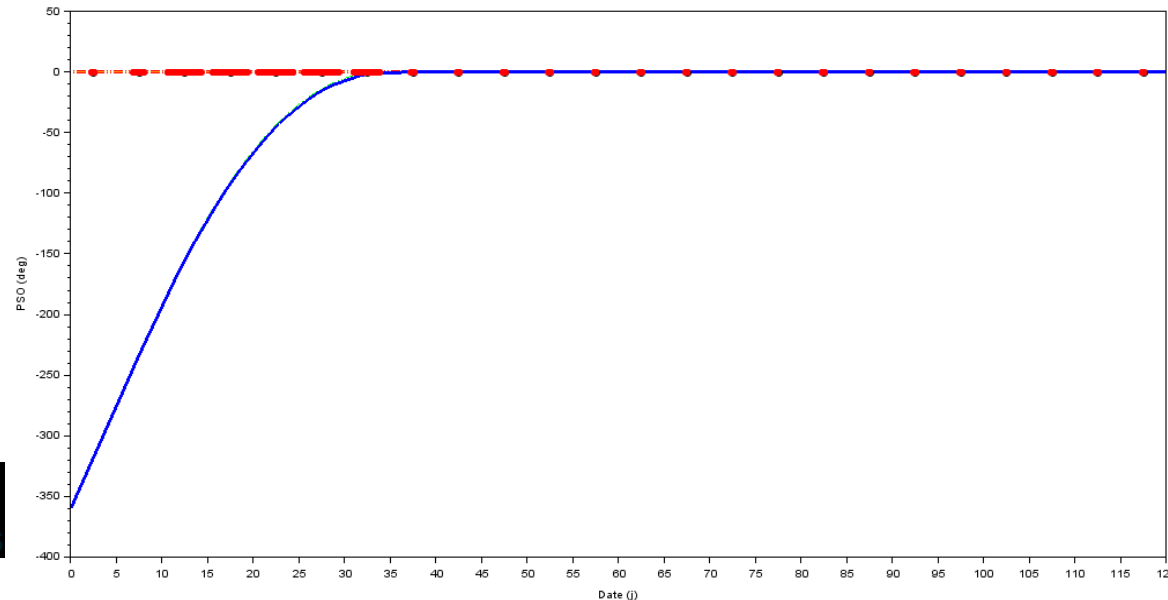
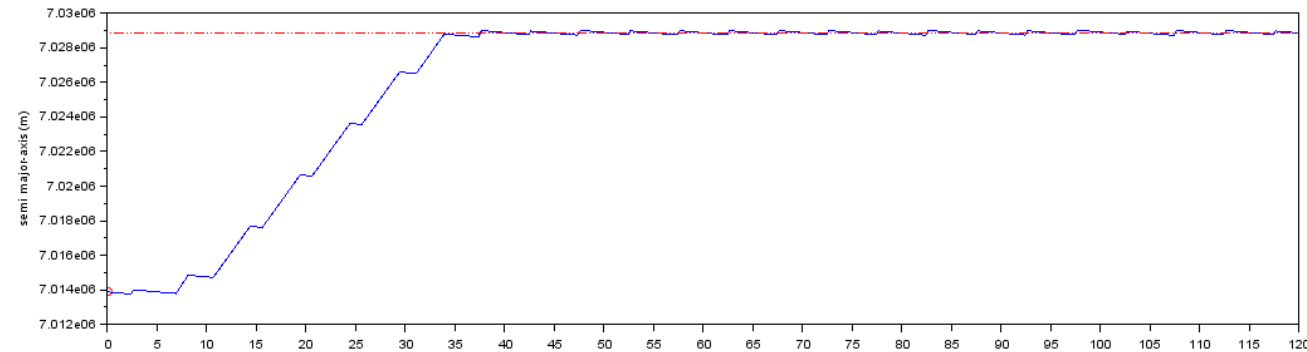


Electrical Orbit raising

EOR

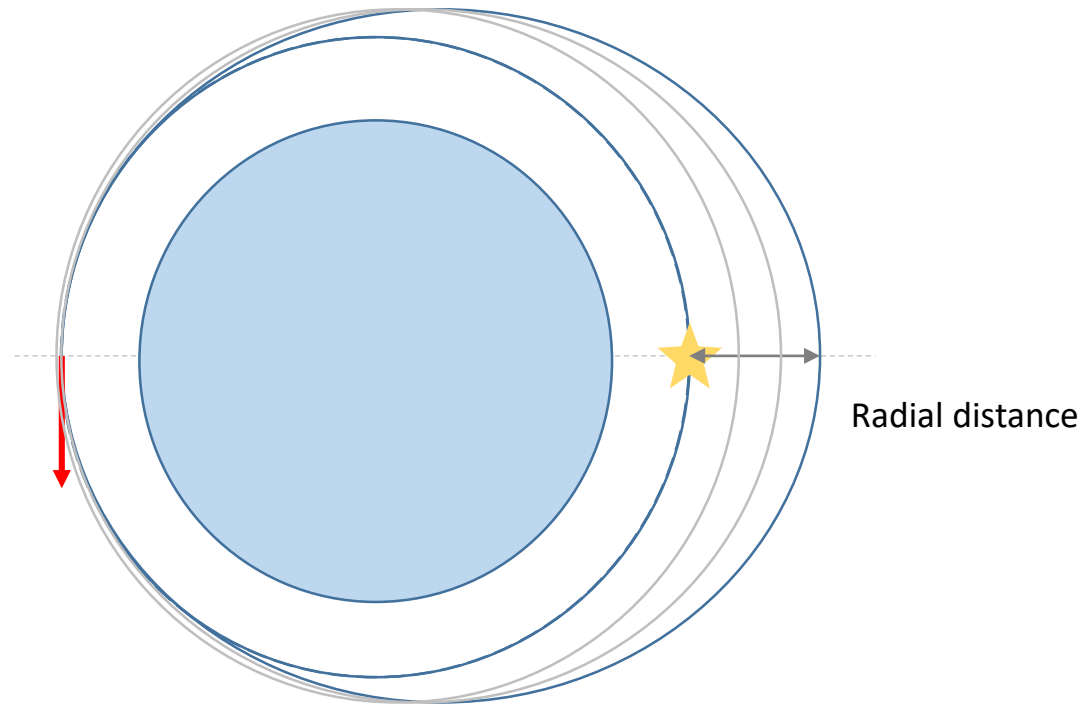


Use Station keeping algorithm with a moving target
Rate dependent on the commissioning of the
propulsion + margin

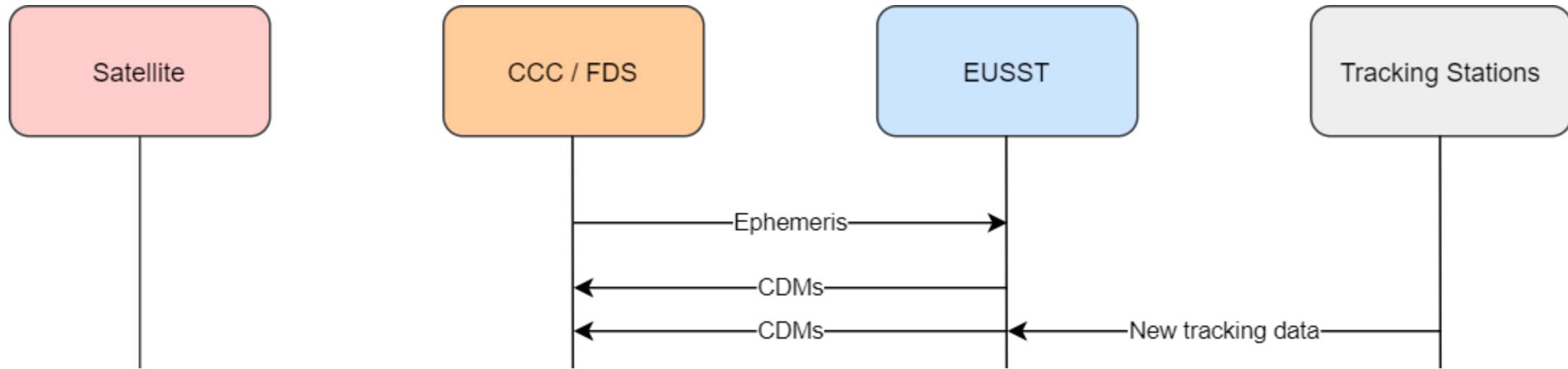


Avoidance

- Maneuvers opposite to TCA



Avoidance Sequence



Uncertainties

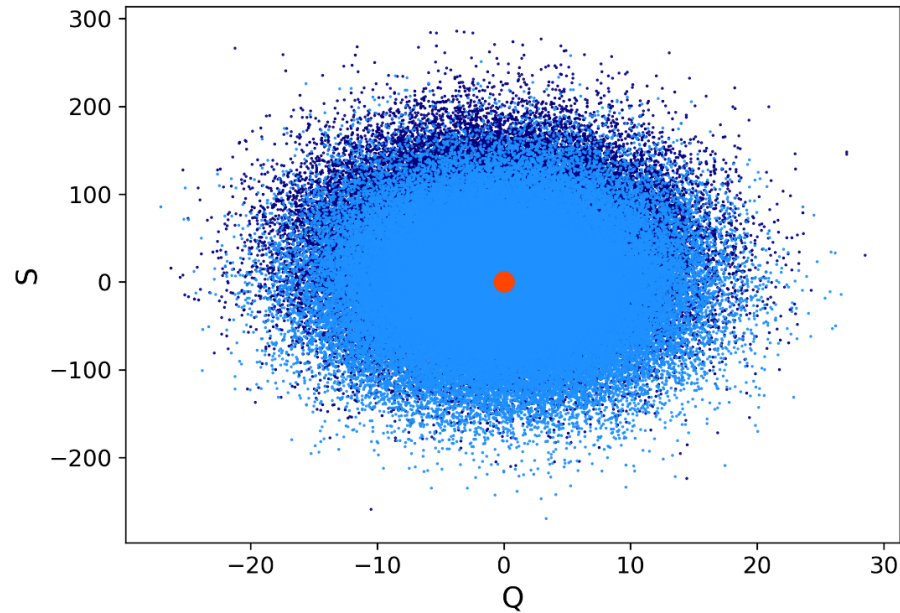
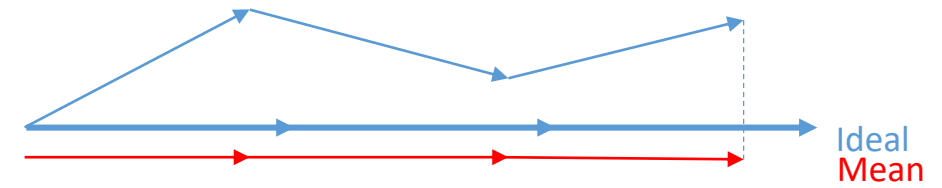
$$\sigma_{mag} = 1\%$$

$$\sigma_{dir} = 2^\circ$$

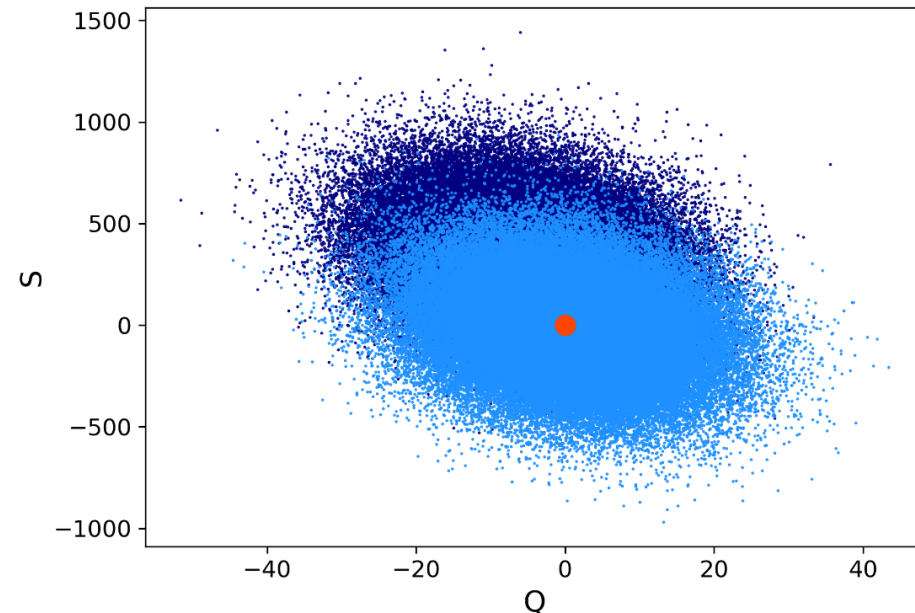


Station Keeping : 18 man / 48h

Orbit Raising : 58 man / 48h



Station Keeping



Orbit Raising

Results :

- Shift needed
- Covariance stays gaussian for up to 4 days → no QtW needed



Thank you