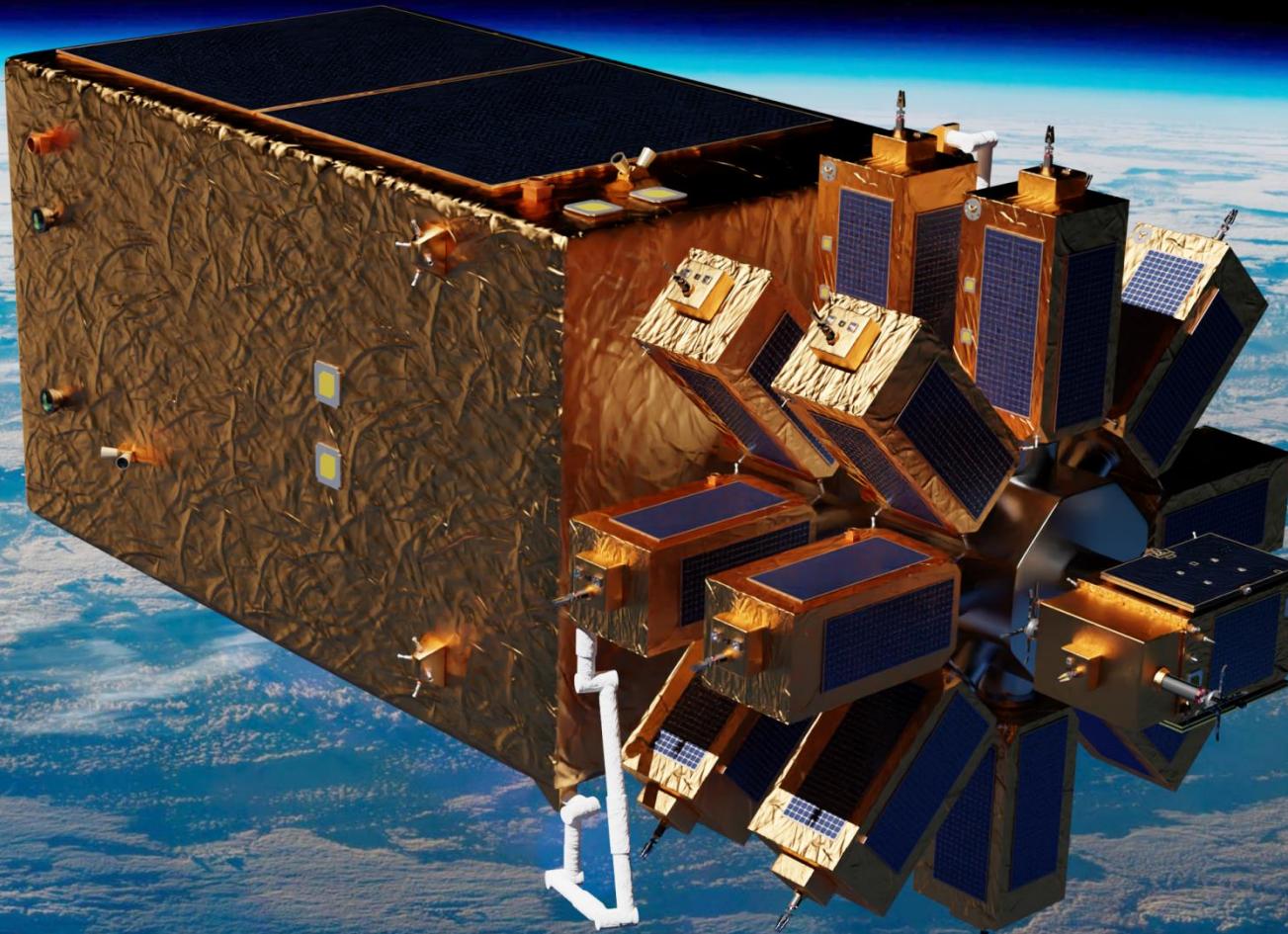


Team STARFLEET COMMAND



Members :
Jacob
Surya



Why is Space Important to You ?

Weather Forecast



GPS



Traffic Control



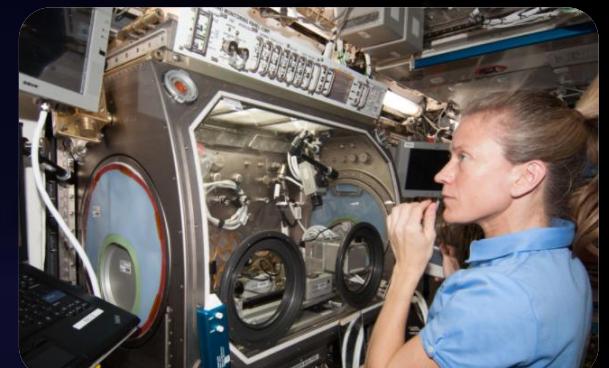
Financial Market



Agriculture



Research (Biomedical etc.)

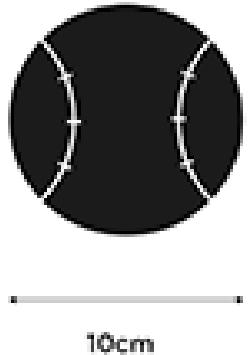


Gravity – The **Kessler Syndrome**



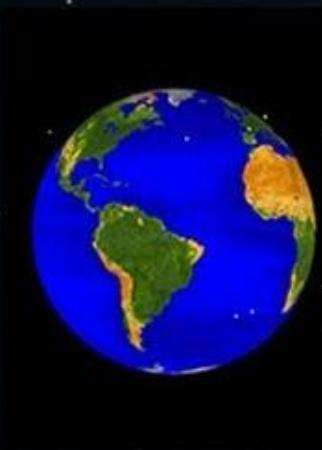
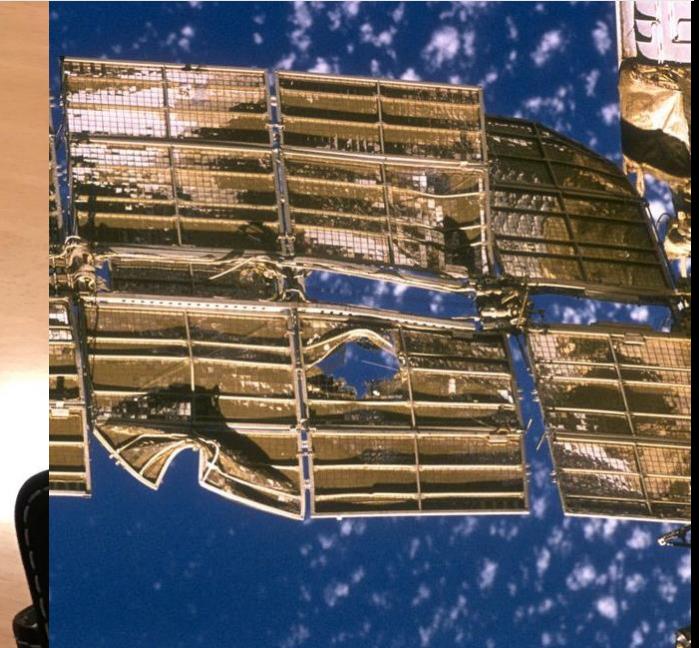
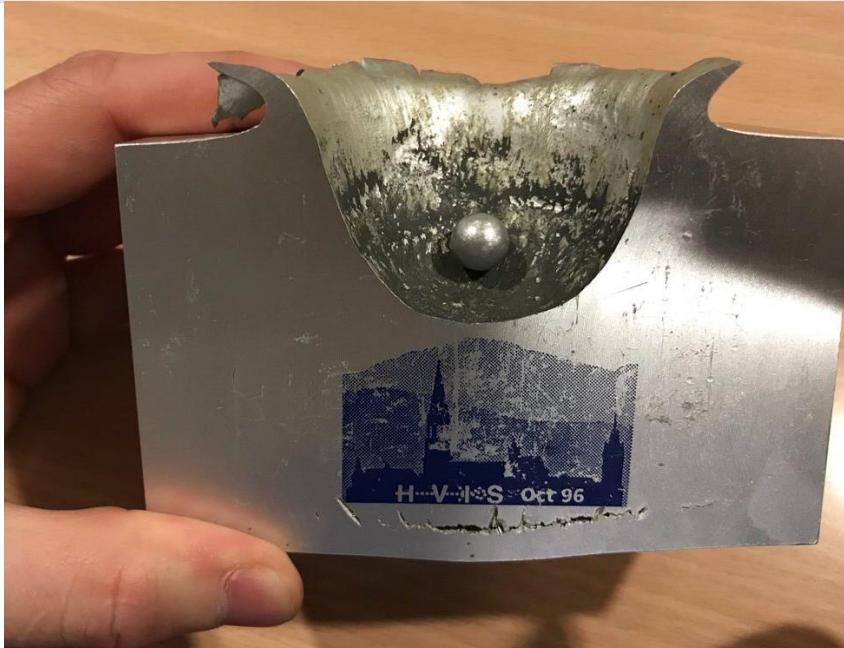
Space Debris

20,000-22,000
OBJECTS

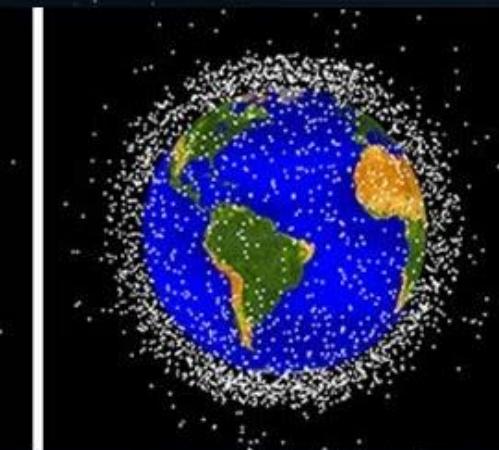


1,000,000
OBJECTS

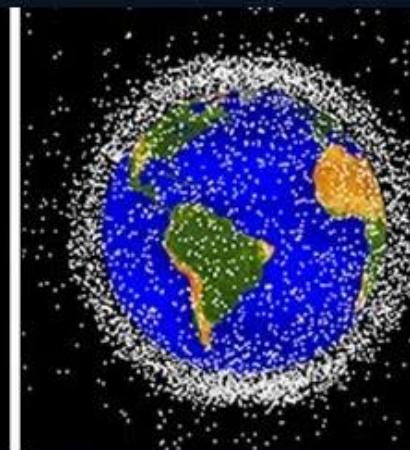
1,000,000,000
OBJECTS



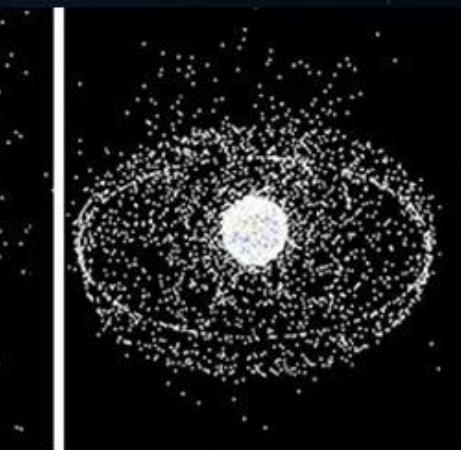
1957



2005



2018



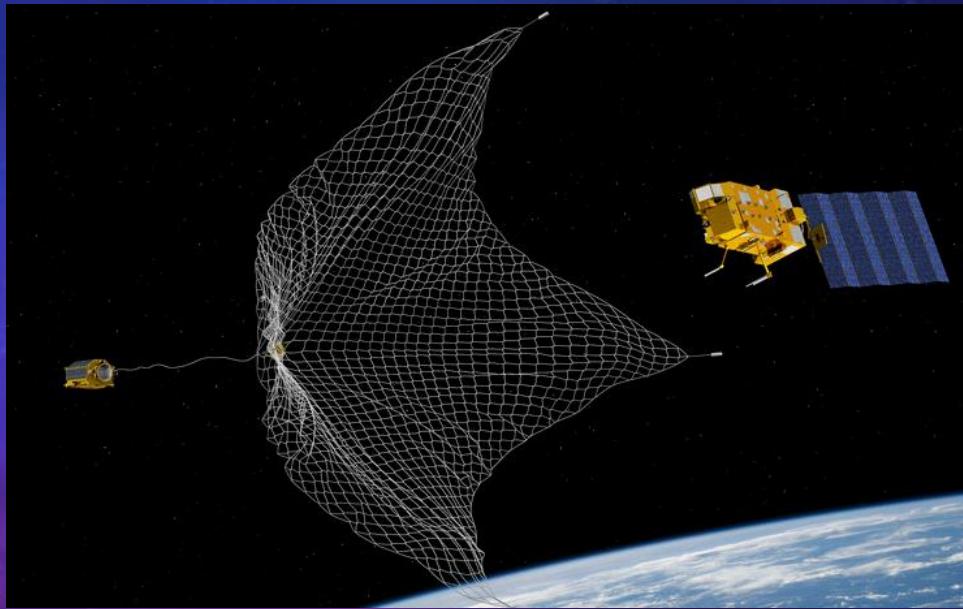
2030??

**99% of all
Objects in
space are
Debris !**

Our Solution Compared To Others

Other Solutions ...

- Non-reusable, once off.
- Most only target large debris.
- > \$10,000,000 USD per Mission.

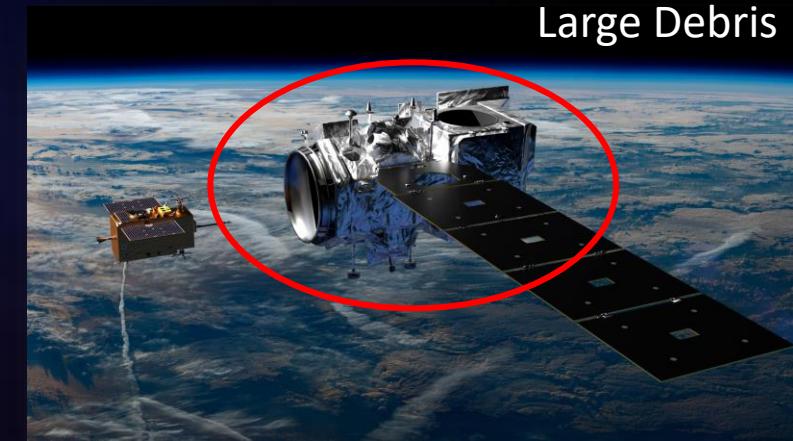


Our solution ...

- Multi-reuse .
- Ability to target wide range of debris sizes .
- < \$20,000 USD per small debris *



Small Debris



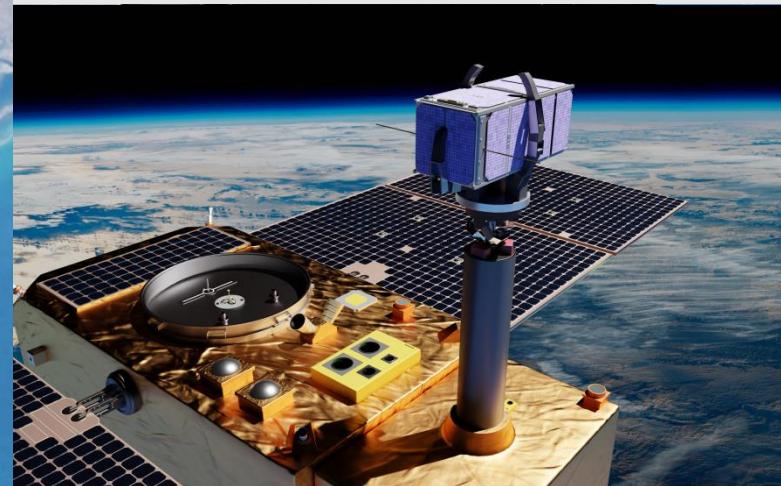
Large Debris

3 Pillars of efficiency

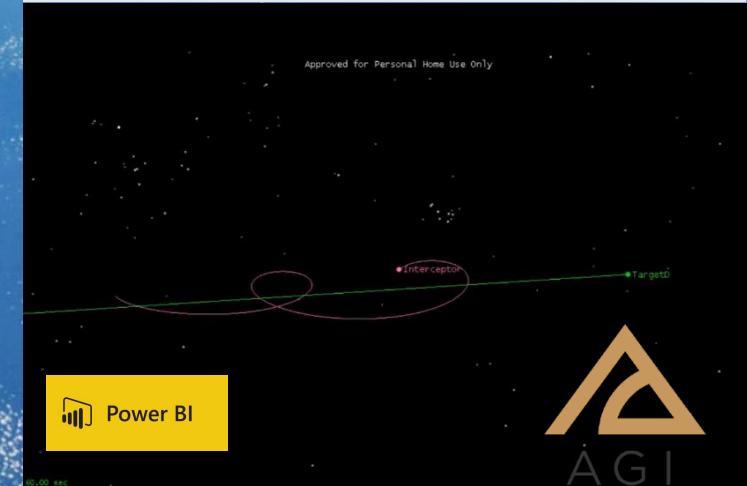
1. Spacecraft Config



2. Deorbit Design



3. Mission Design



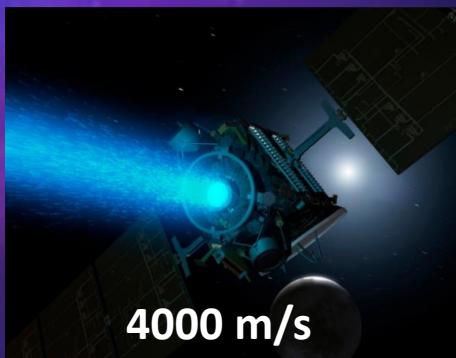
1: Spacecraft Configuration

Delta-Velocity (Δv) Requirements

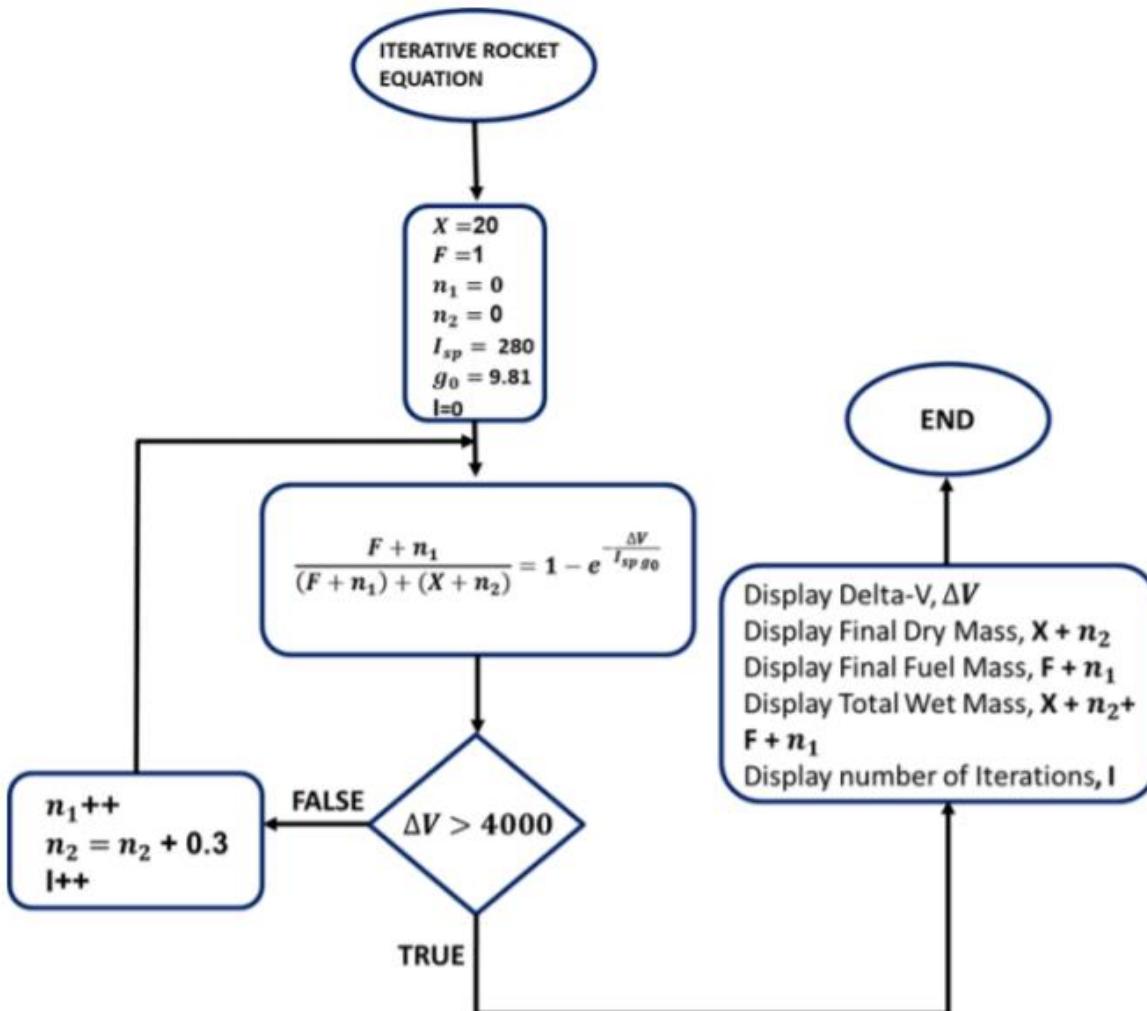
- Multiple de-orbit missions/Reusable
- In Plane/Out-of-Plane manoeuvres
- Inclination changes
- High-energy orbital transfers



Total preliminary delta-V requirement amounts to **20,000 m/s**



Preliminary Derivation of Approximate Mass and Size of Space Vehicle based on Delta-V Requirements



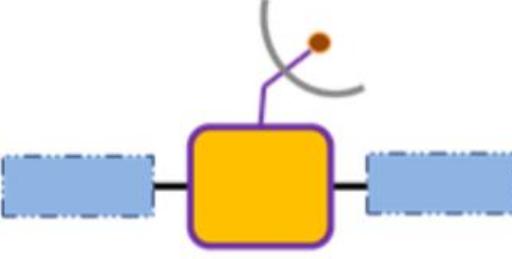
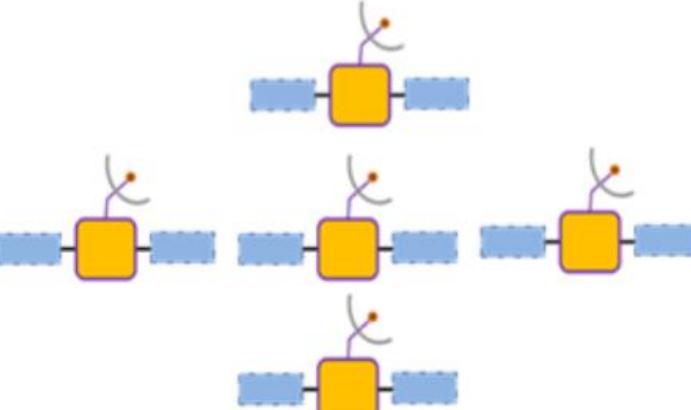
Iterative Solver based on the Rocket Equation

Solution Converged after 1298 Iterations.
Final Servicer Specifications:

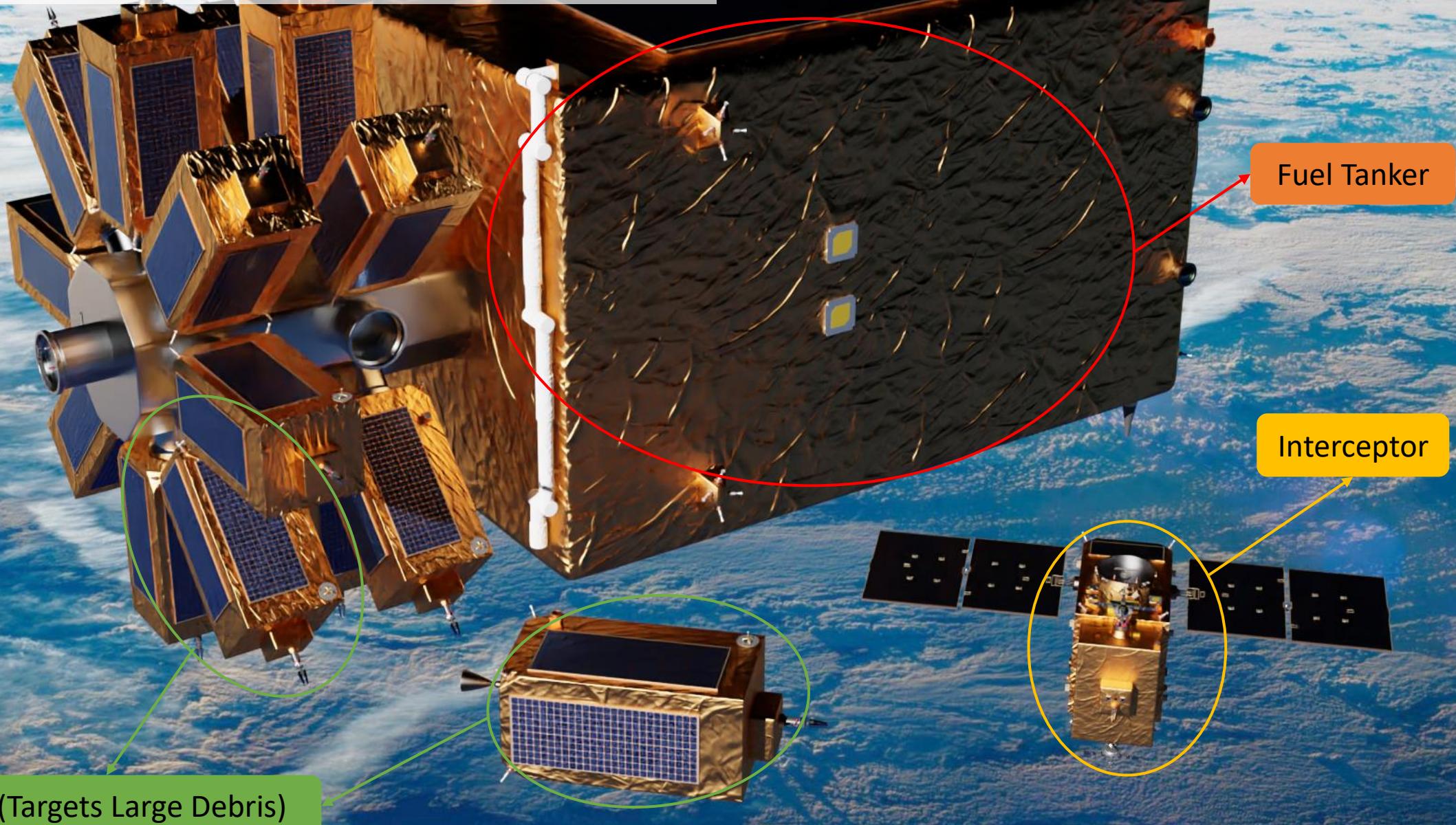
Delta V: 4000.05669966374 m/s
Dry Mass: 409.4000000001 kg
Fuel: 1299 kg
Wet/Total Mass: 1708.4000000001 kg

Team STARFLEET COMMAND

Preliminary Cost Analysis

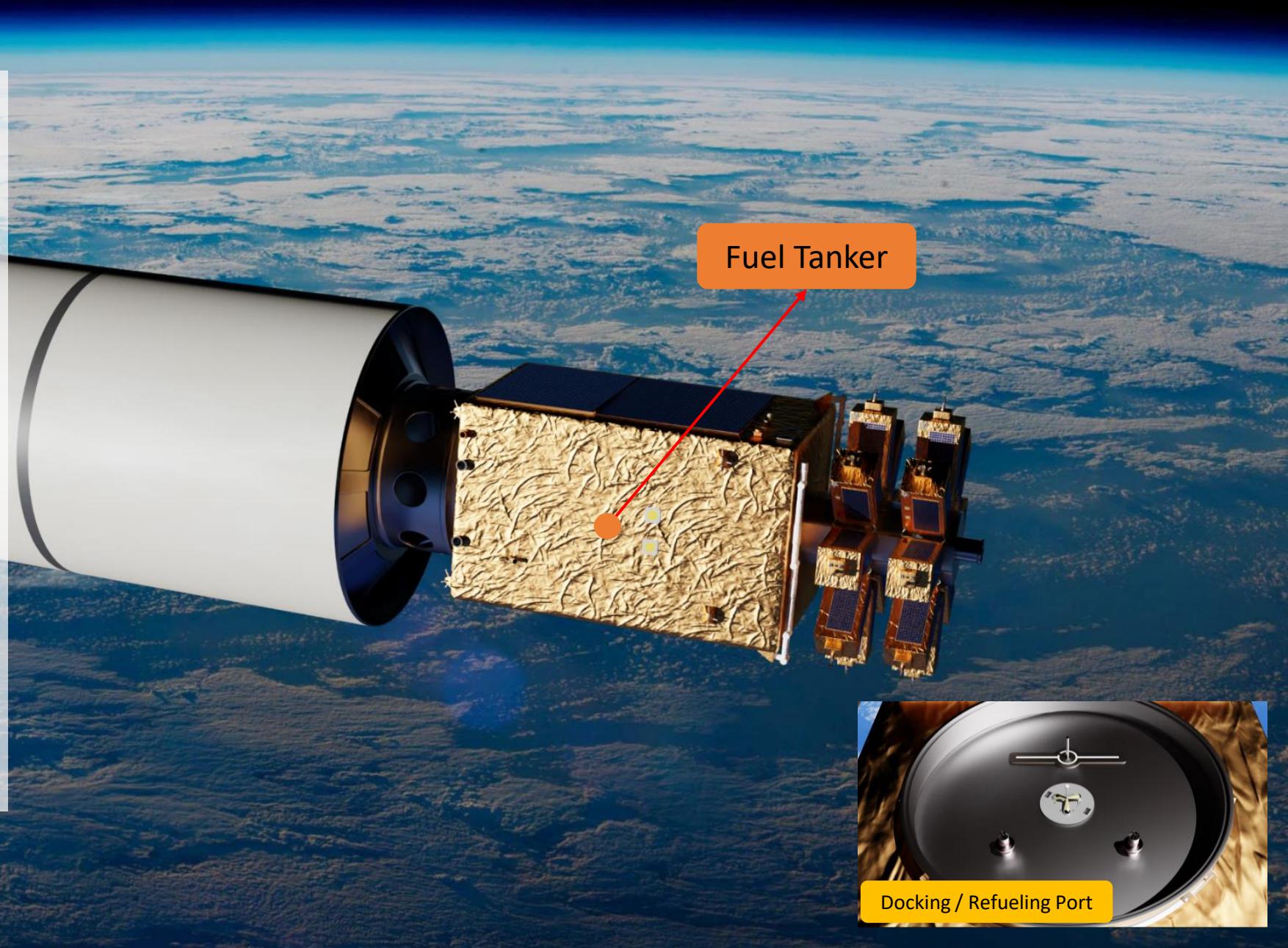
SERVICER	SPECIFICATIONS
	WET/TOTAL MASS: 1708 KG DELTA-V: 4,000 m/s NUMBER OF MISSIONS: 8 (ESTIMATED) UNIT COST: 100 Million USD
5 SERVICER CONFIGURATION	SPECIFICATIONS
	TOTAL DELTA-V: 20,000 m/s TOTAL NUMBER OF MISSIONS: 40 TOTAL (ESTIMATED) MISSION COST: 574 Million USD (ESTIMATED) COST PER DEBRIS: 14.4 Million USD/Debris

Spacecraft Design



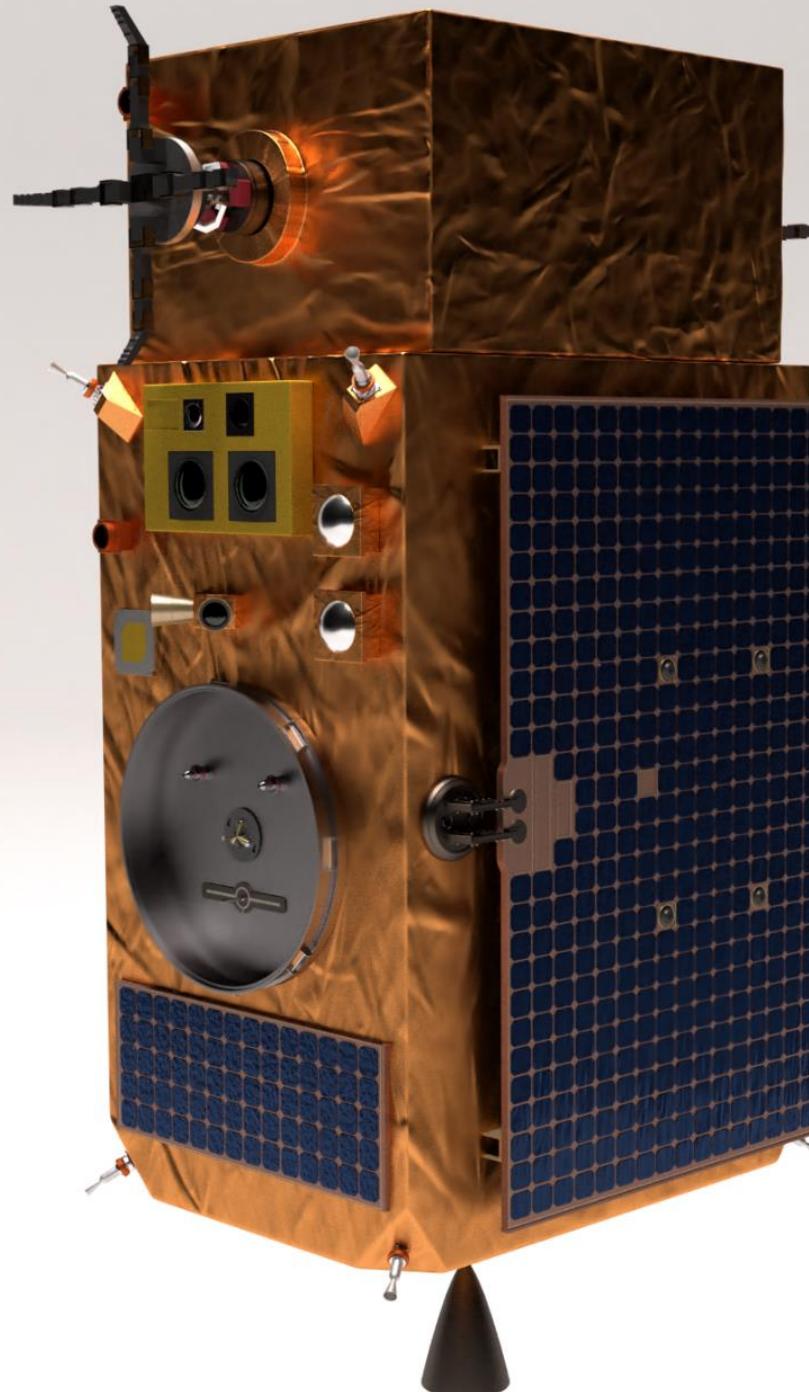
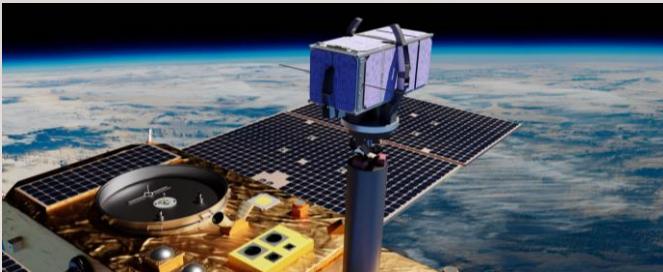
Fuel Tanker

- Key component for reusability.
- Carries up to 2 tons non toxic fuel.
- Hydroxylammonium nitrate Mixture fuel , 50% higher density
- Docking Ports for in space refueling
- Reducing cost of rockets means space fuel tanker is more economical.

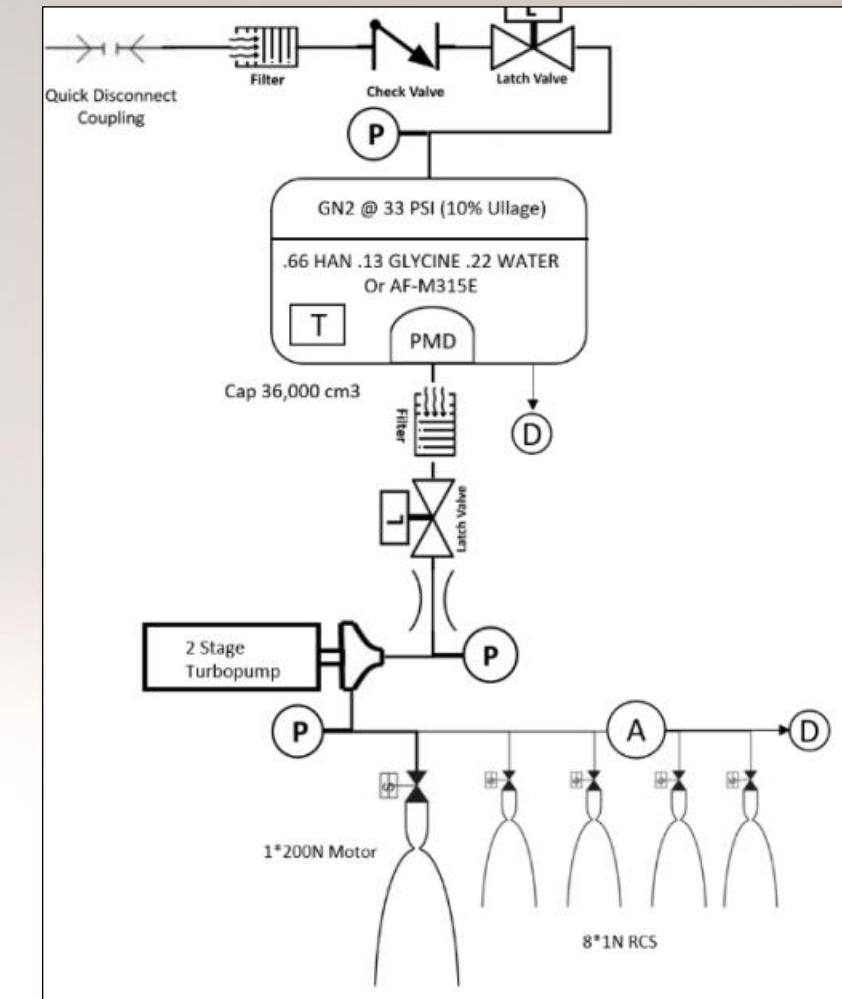


Interceptor

- Intercepts debris and deorbits it.
- Very Light Weight (75kg)

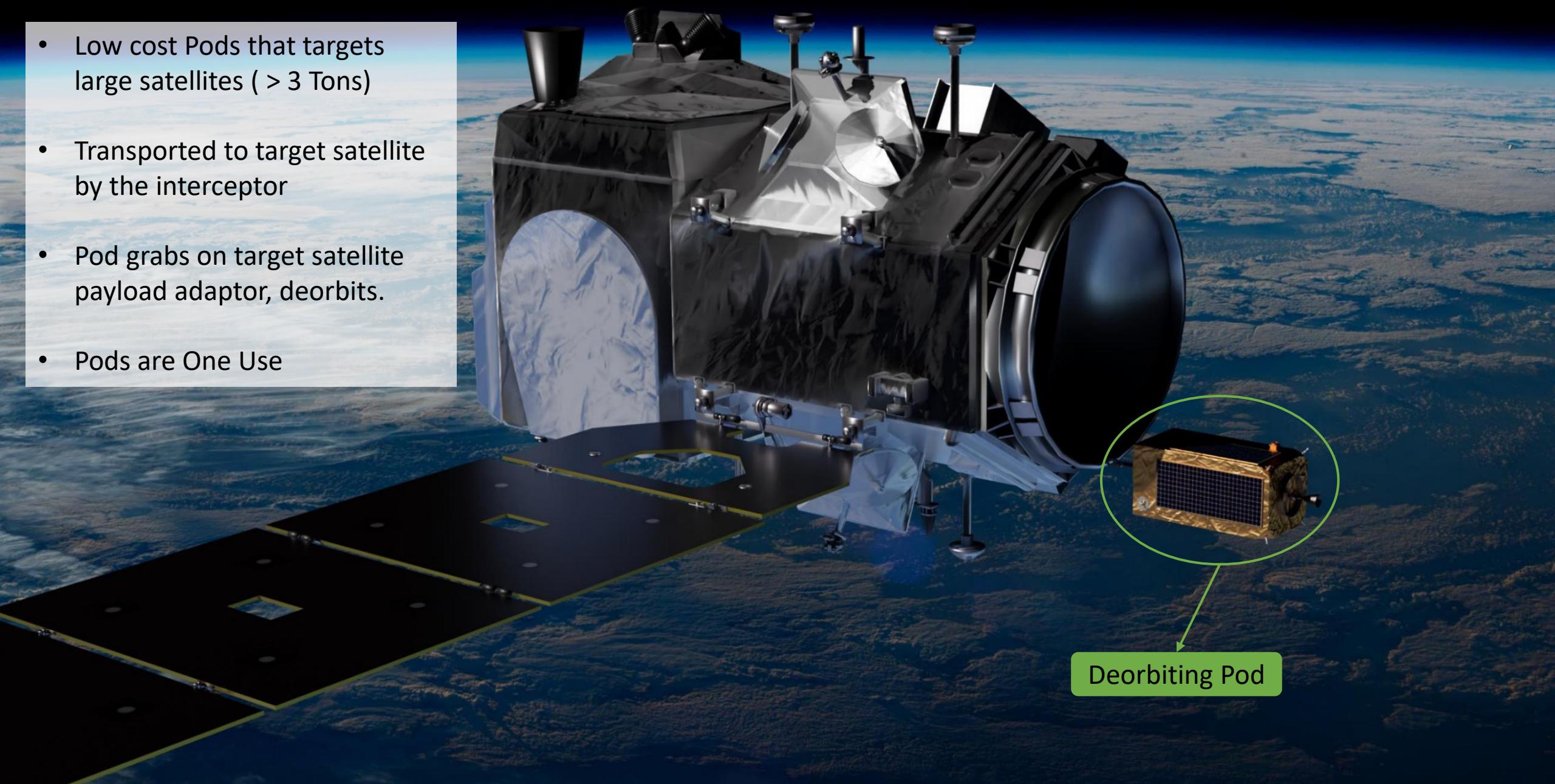


Propellant System Schematic



Pods

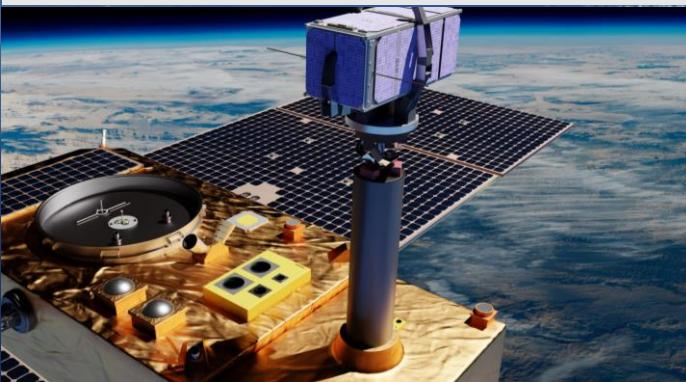
- Low cost Pods that targets large satellites (> 3 Tons)
- Transported to target satellite by the interceptor
- Pod grabs on target satellite payload adaptor, deorbits.
- Pods are One Use



Deorbiting Pod

2: Deorbit Design – Small Debris Deorbit without Fuel

Composite Deployable
booms (MR60H Composite)

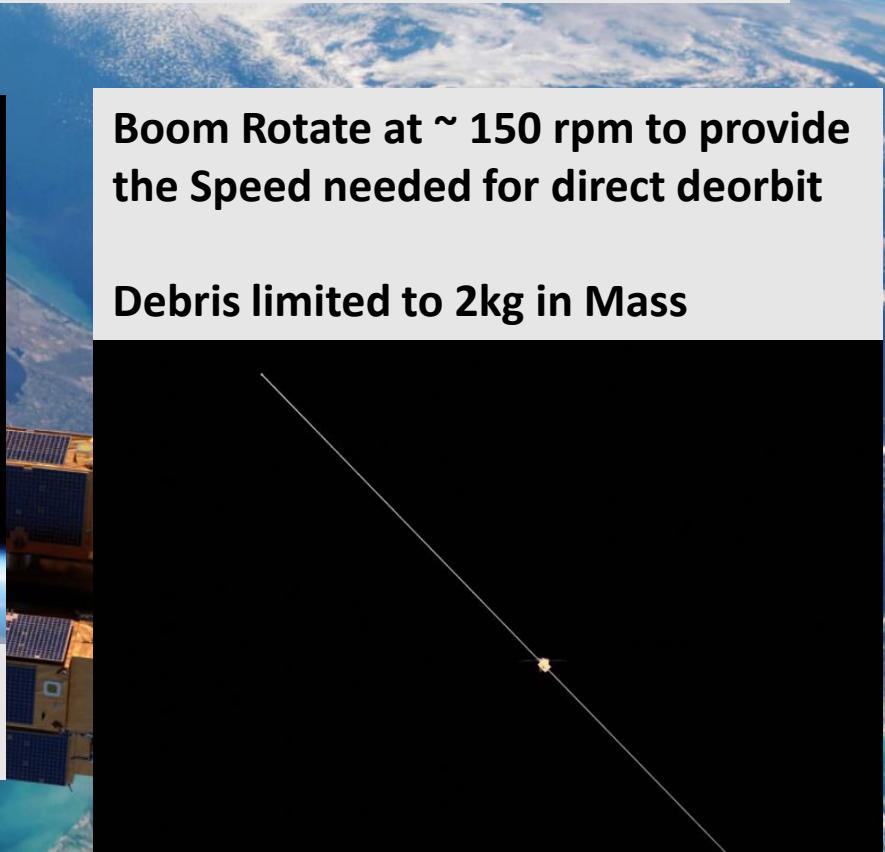


End Effector Used to Capture Rotating
Debris

- 4kg fuel saved per debris
- >20 deorbits before Refueling

Boom Rotate at ~ 150 rpm to provide
the Speed needed for direct deorbit

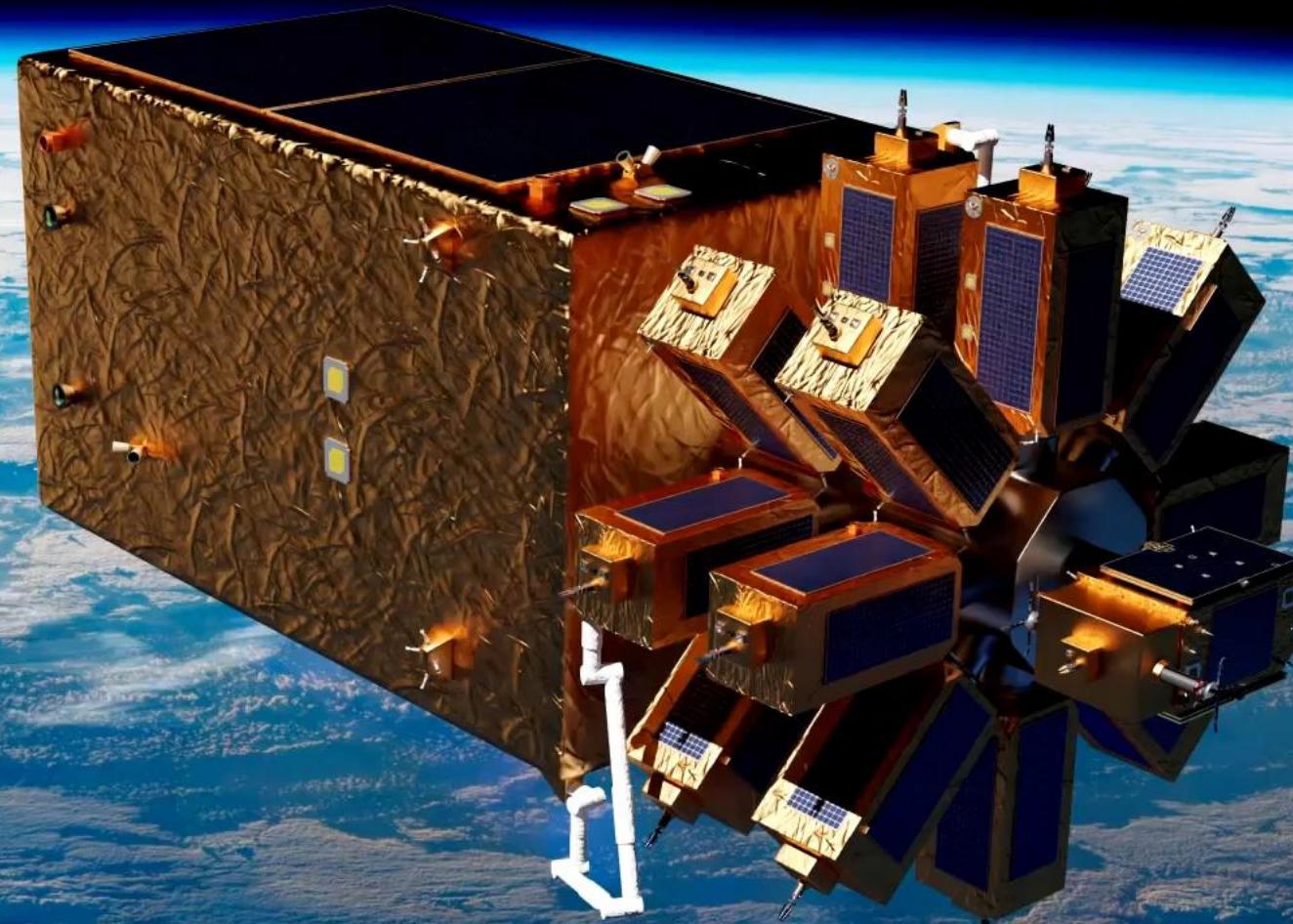
Debris limited to 2kg in Mass



Team StarFleet

SSC 2020

All animation scenes made by team
starfleet in Blender 2.80



3 : MISSION DESIGN

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Powered By :

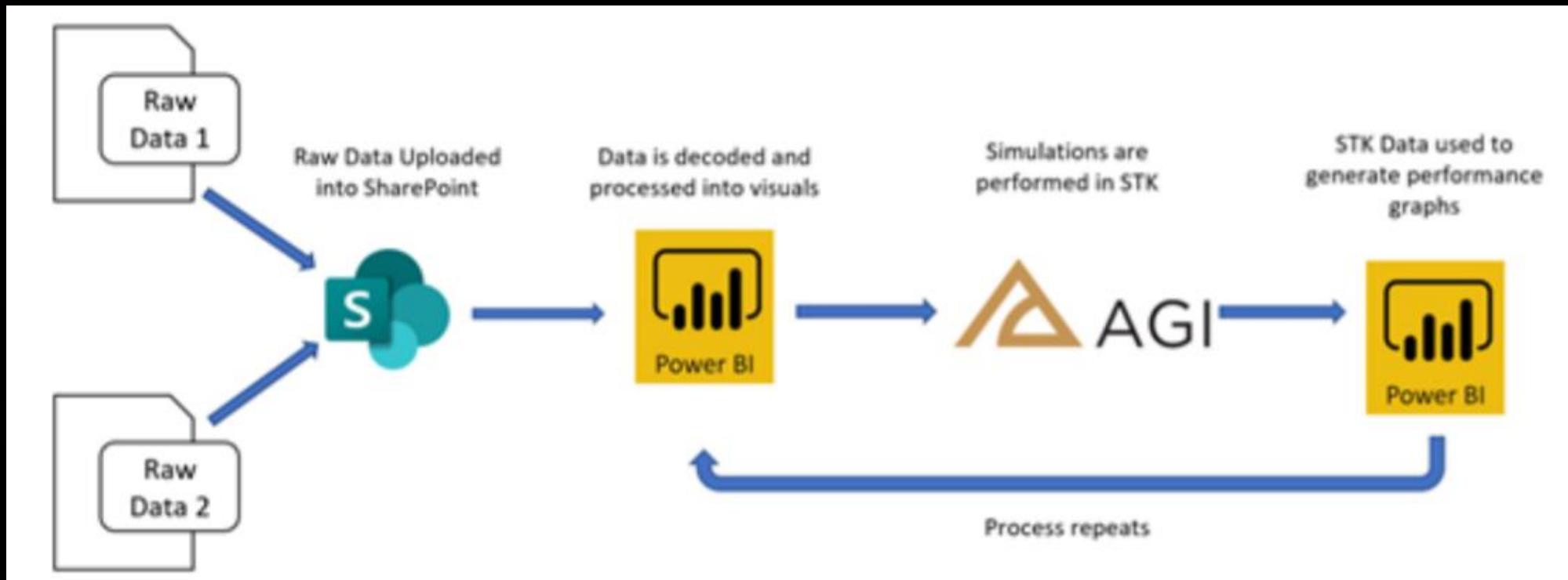


Interceptor ICR Axes
Apr 2020 20:16:30.000 Time Step: 60.00 sec

Data Processing & Analysis



Analytics Workflow



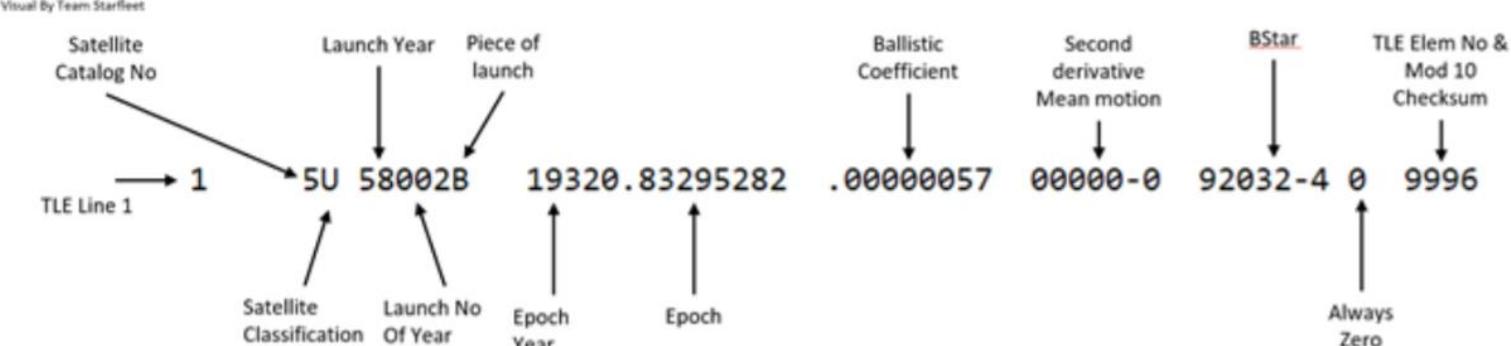
Decoding & Processing and Compiling TLE Data

America's Forth satellite Vanguard

```
0 VANGUARD 1
1      SU 58002B   19320.83295282 .00000057 00000-0 92032-4 0 9996
2      5 34.2403 166.3762 1843710 111.0861 269.6113 10.84784984182154
```

Breakdown of the TLE Line No 1:

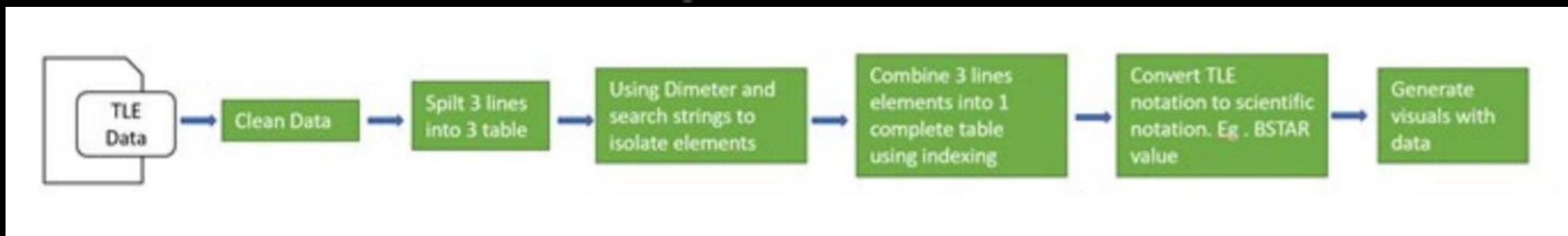
Visual By Team Starfleet



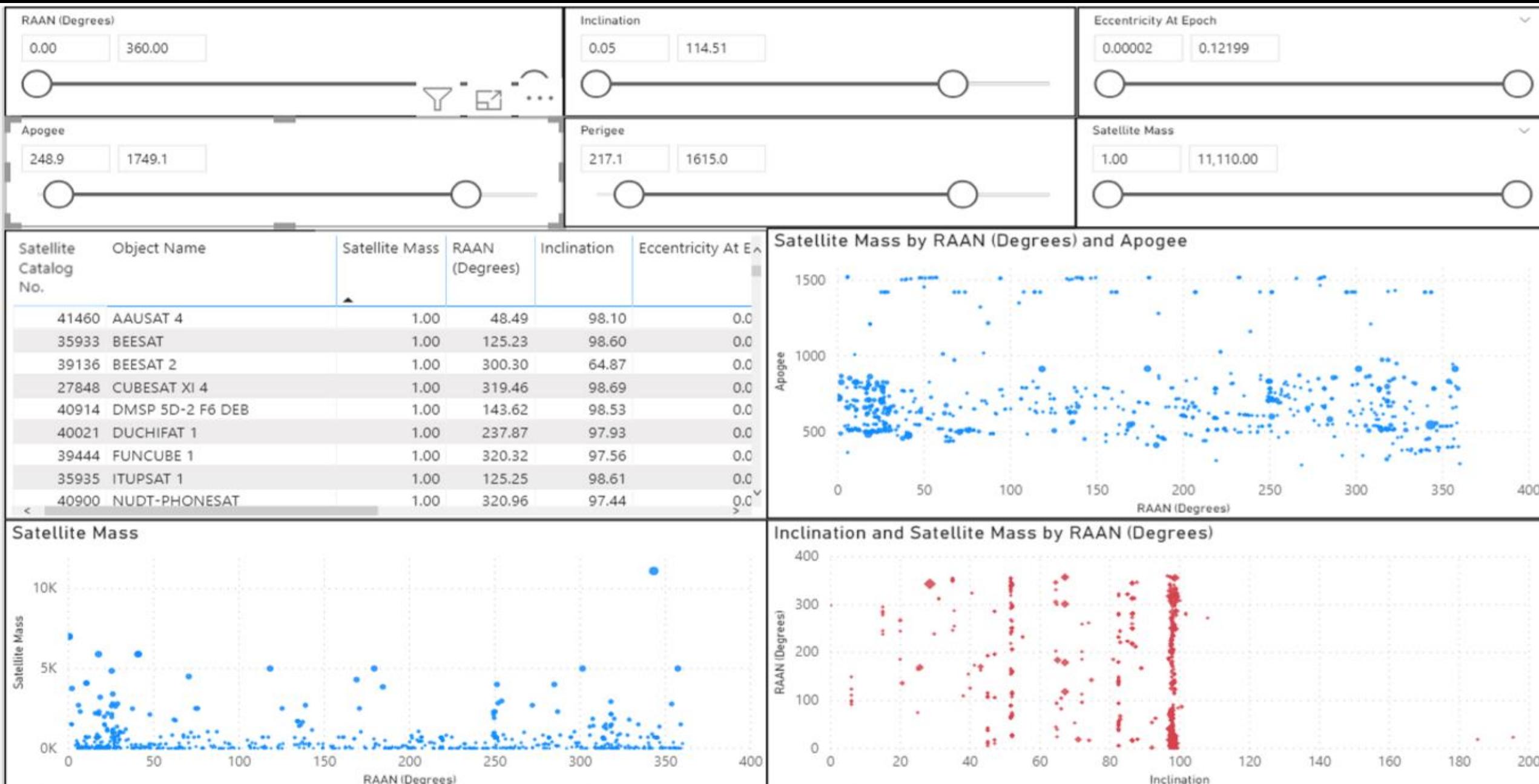
The diagram illustrates the breakdown of TLE Line No 1 elements. Arrows point from each element to its corresponding field in the TLE line. Labels below the line indicate the meaning of each field.

TLE Element	Description
Satellite Catalog No	The NORAD Catalog number
Classification	Elset classification. U = Unclassified, C = Classified
International Designator	Launch Year Launch of the year Piece of launch
Epoch Year, Epoch	Defines the time where all of the time varying fields like semi major axis in TLE line 2.
Ballistic Coefficient	Rate at which mean motion (angular speed with respect to earth center) with respect to time. The higher the number the lower the drag.
Second derivative of mean motion	Zero most of the times
BSTAR	Radiation pressure coefficient
TLE Elel No & Mod 10 Checksum	Always Zero

Decoding & Processing and Compiling TLE Data



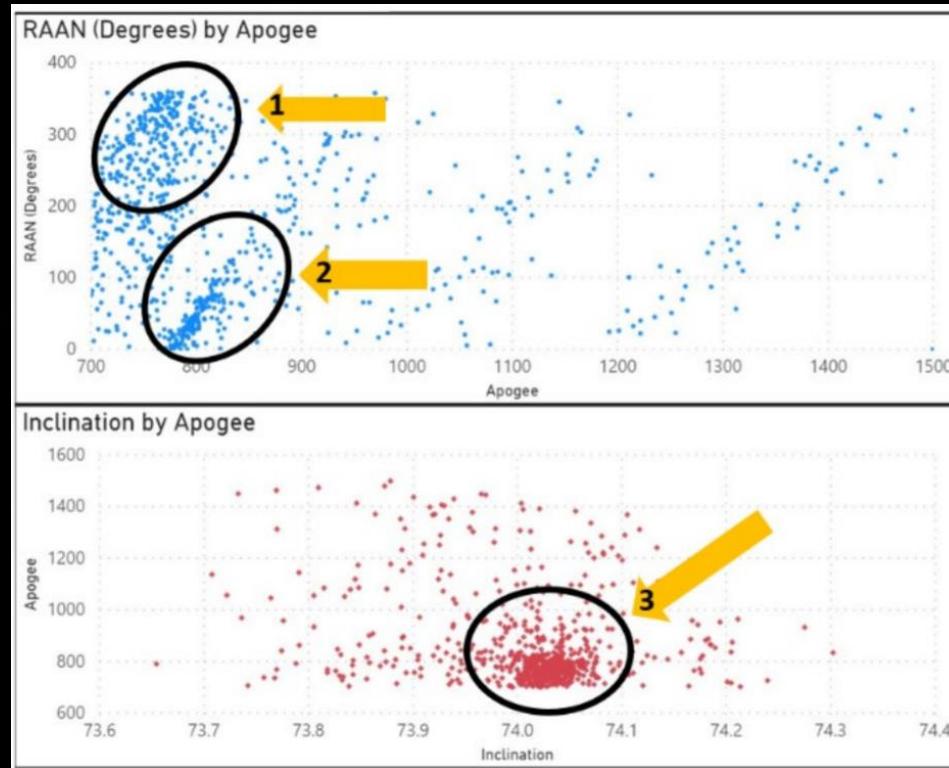
Data Processing & Analysis



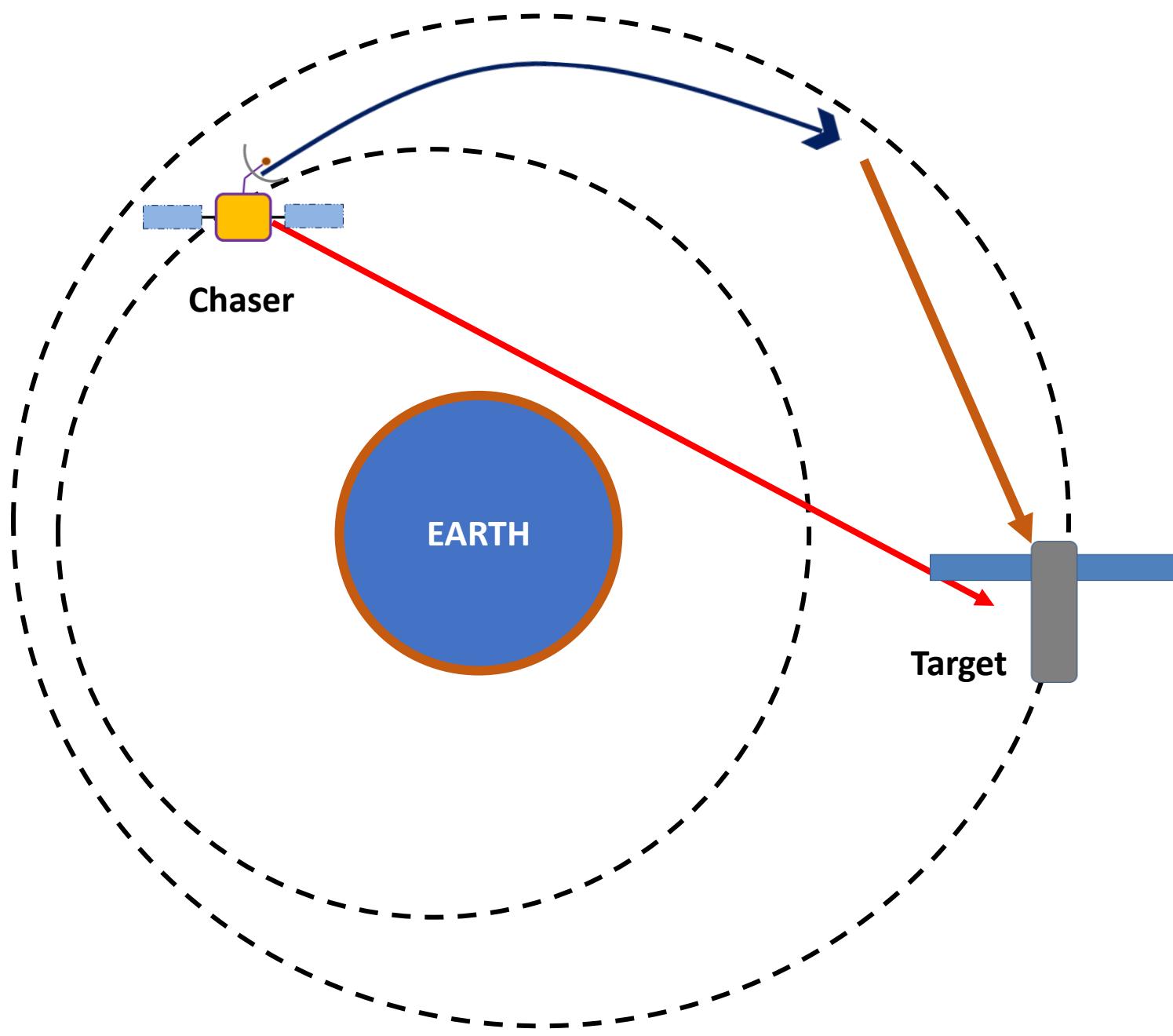
Data Processing & Analysis



Target Selection



TARGET SELECTION				
Target Designation				
Target Name	COSMOS 2251 DEB (TARGET A)	COSMOS 2251 DEB (TARGET B)	COSMOS 2251 DEB (TARGET C)	COSMOS 2251 DEB (TARGET D)
Target Type	Debris	Debris	Debris	Debris
(Estimated) Target Mass	1 kg	1 kg	1 kg	1kg
RCS	0.0636 m^2	0.0734 m^2	0.0072 m^2	0.001 m^2
NSSDC ID	93036EZ	93036BGS	93036BQJ	93036ATK
NORAD ID	33944	37120	37983	35837
Eccentricity	0.0121558	0.0054155	0.0020524	0.0472454
Apoapsis Altitude	865 km	794 km	637 km	1085.8 km
Periapsis Altitude	691 km	717 km	609 km	709.5 km
Inclination	74.0435°	74.0168°	74.0093°	72° (modified)
RAAN	67.3115°	67.3868°	69.4300°	229.6042°
Argument of Periapsis (AOP)	336.2828°	301.6485°	30.4015°	102.7695 °
Mean Anomaly	161.4052°	57.9393°	329.8347°	11.6226°
Mean Motion	14.3319 revolutions/day	14.4016 revolutions/day	14.8112 revolutions/day	13.4523 revolutions/day



Segment One

Out-of-Plane

- Match Target RAAN
- Match Target Plane/Inclination

In-Plane

- Match Target Semi-major axis
- Match Target Eccentricity
- Match Target Period
- Match Target True Anomaly
- Match Target Argument of Periapsis

Segment Two

- Locating target
- Communicating with Target
- Closing Relative Distance to Target
- Synchronization of speed with target
- Manoeuvring around the target
- Docking with target

MCS Segment Type: Maneuver: Impulsive

Name: RAANmatch.Maneuv

User Comment: Maneuvers Interceptor with an impulsive out-of-plane burn to match RAAN of TargetD

Maneuver Summ

Maneuver Start: 29 Dec 2019 04:00:00.000 UTCG; 2458846.66666667 UTC Julian Date

Maneuver Stop: 29 Dec 2019 04:00:00.000 UTC G: 2458846.66666667 UTC Julian Date

Duration: 0 s

Fuel Used: 11.87311987296097 kg

DeltaV Magnitude: 660.3632757321263 m/sec

Estimated Equivalent Finite Burn Duration: 163.0097434030417 sec

Estimated Fuel Used: 11.8731 kg (Update mass ON)

Estimated Fuel Used: 11.3731 kg (Update mass) Maneuver Direction Specification: Thrust Vector

Maneuver direction specification: Thrust vector

DeltaV vector with respect to VNC(Earth) axes

X (Velocity) : 44.97422240315016 m/sec

Y (Normal) : 658.1139338272909 m/sec

Z (Co-Normal) : -30.70871793586278 m/sec

Azimuth: 86.09059639322879 deg

Elevation: -2.665373382418479 deg

Magnitude: 660.3632757321263 m/sec

Right side: *Convolvulus sepium* L., *C.*

User-selected results

Rel Mean RAAN = -0.000398314390040403 deg



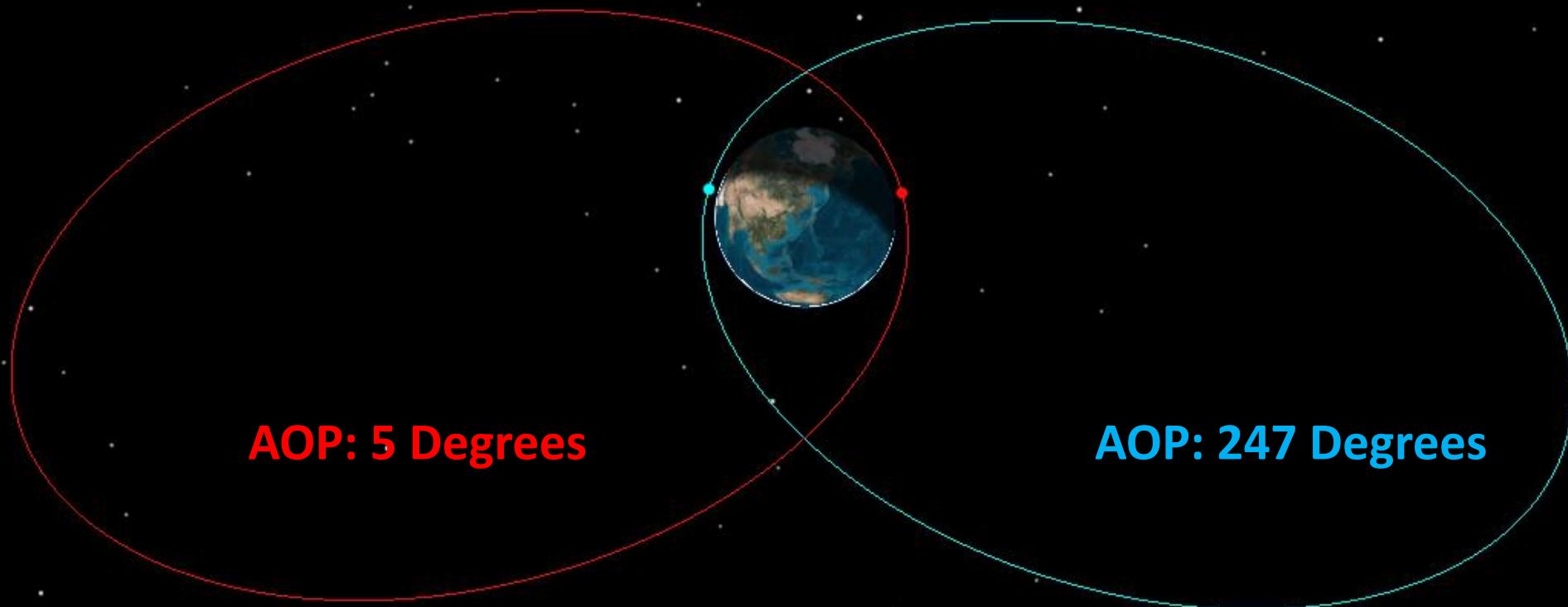
Same Apogee

Same Perigee

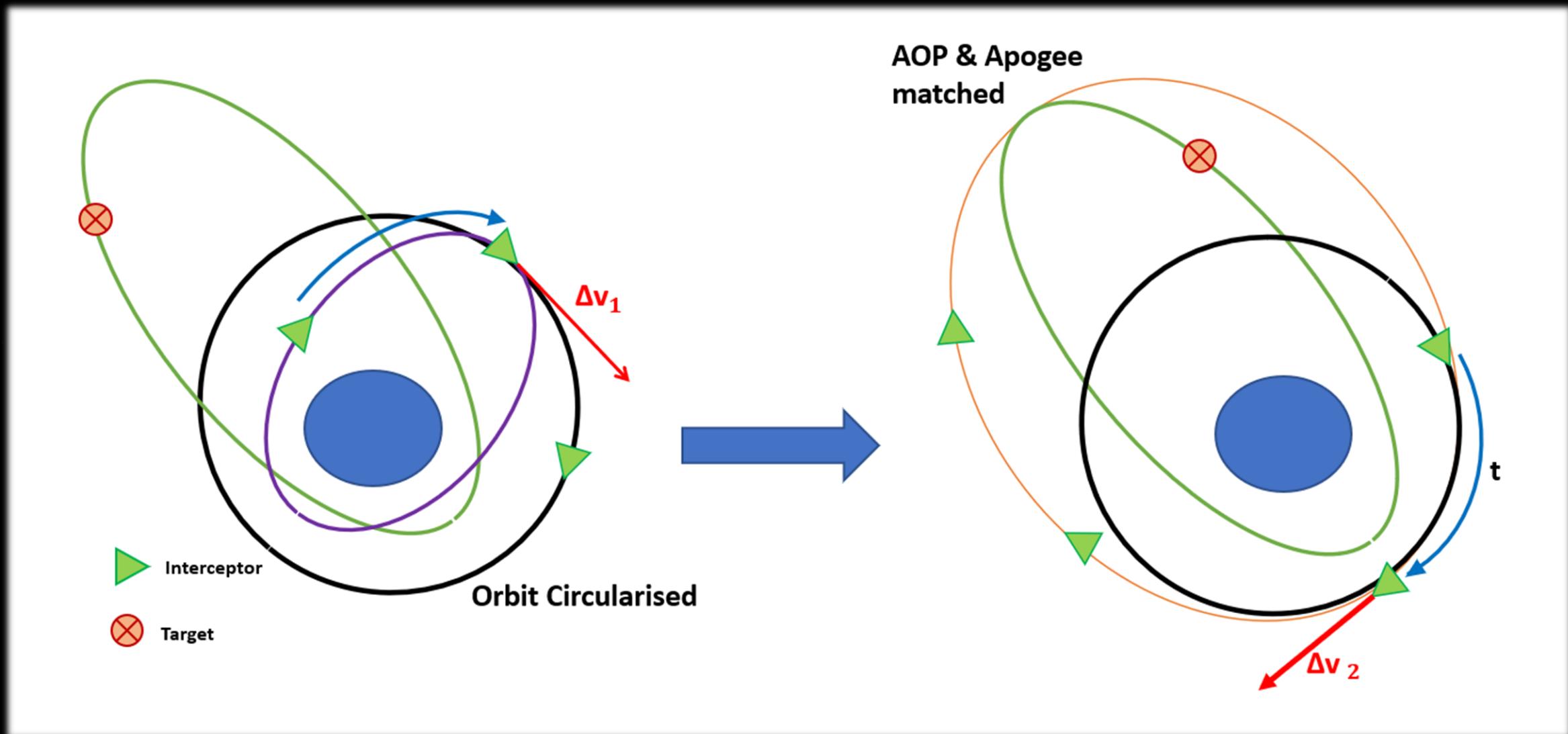
Same Inclination

Same RAAN

Different Argument of Periapsis (AOP)



MATCH AOP

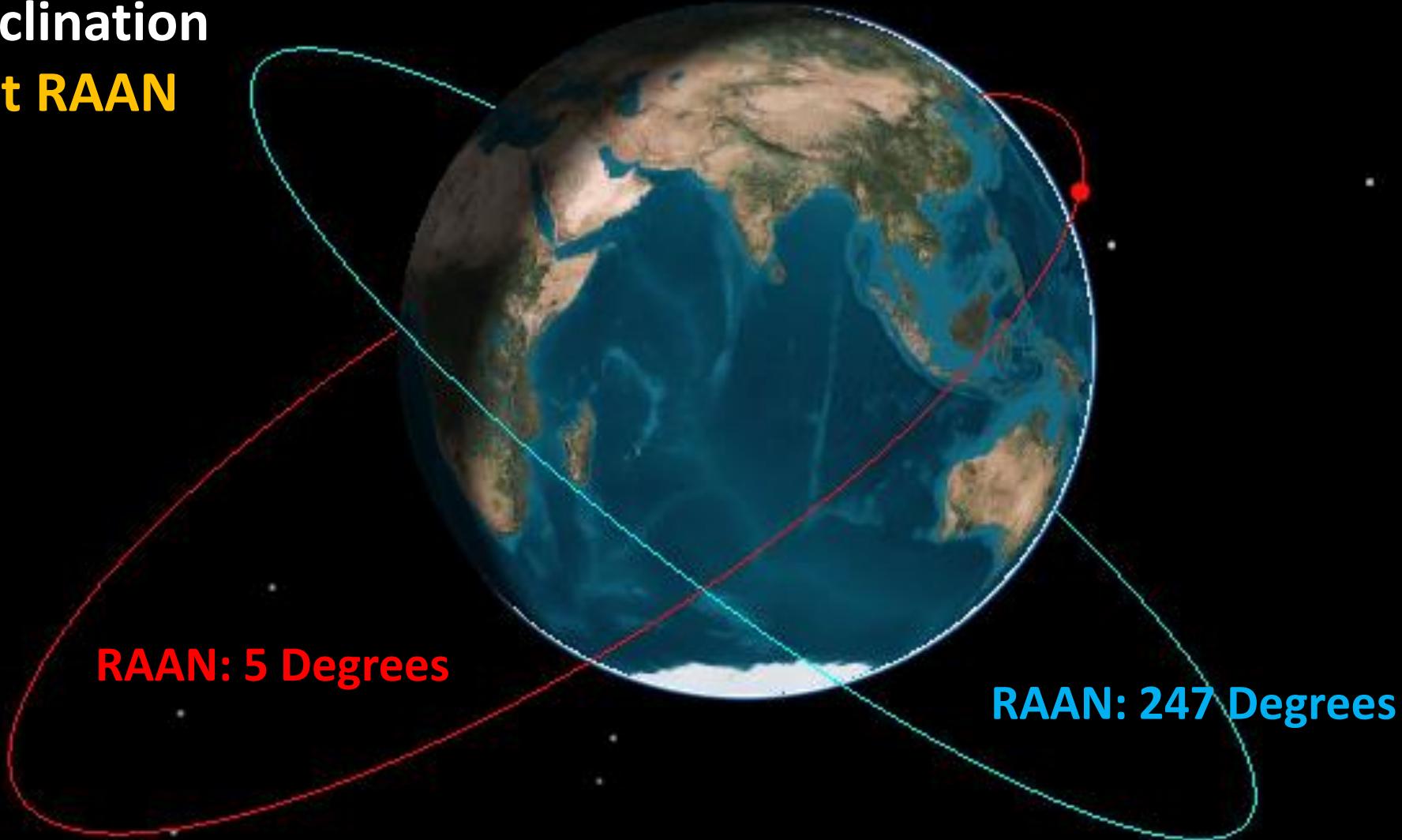


Same Apogee

Same Perigee

Same Inclination

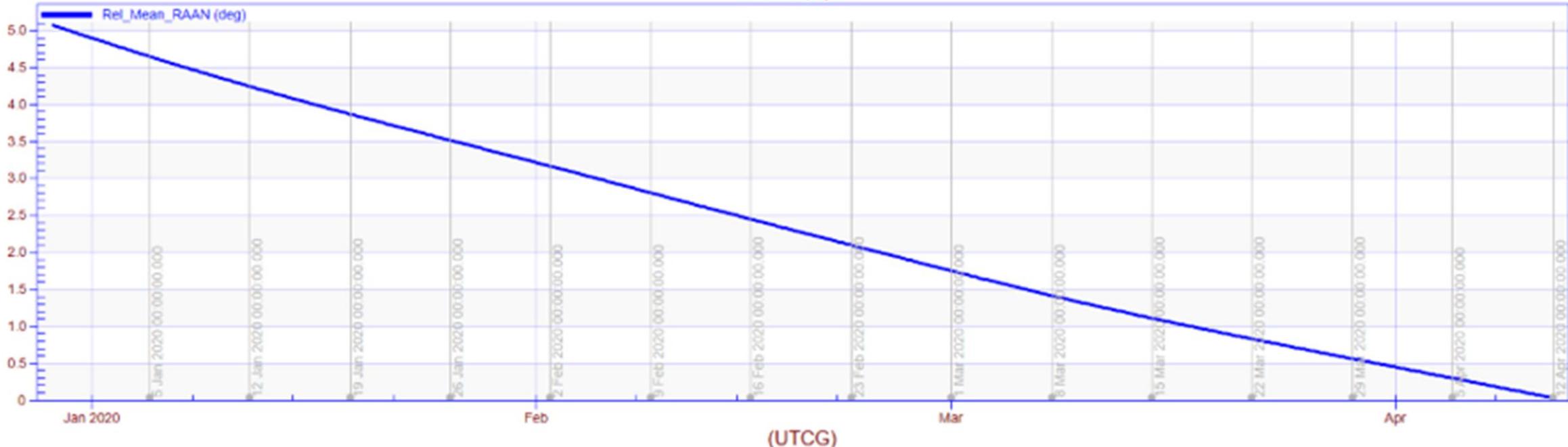
Different RAAN



HPOP Propagator



RelativeRAAN/Time
HPOP Propagator



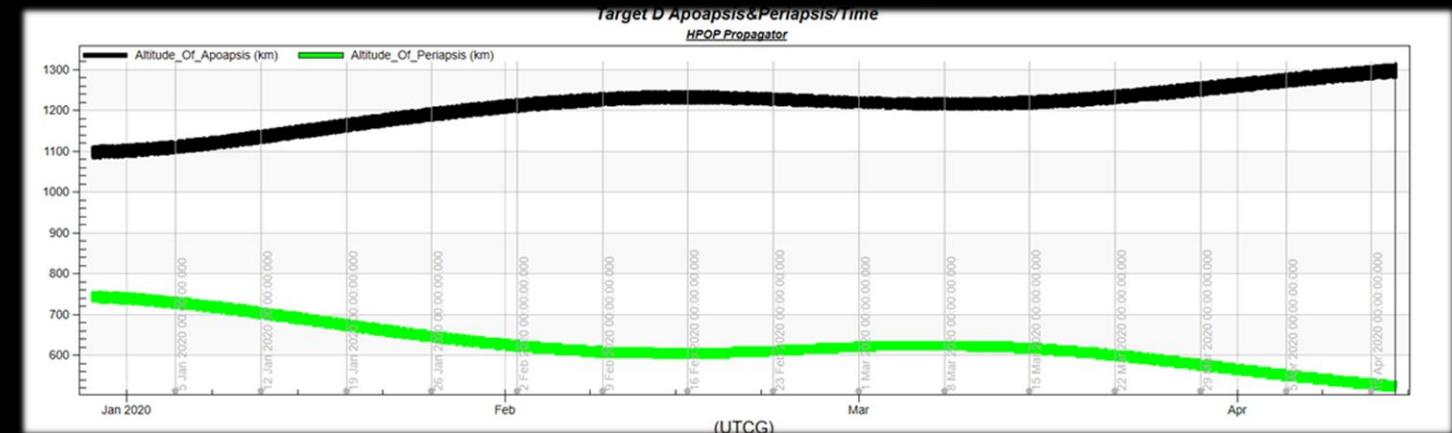
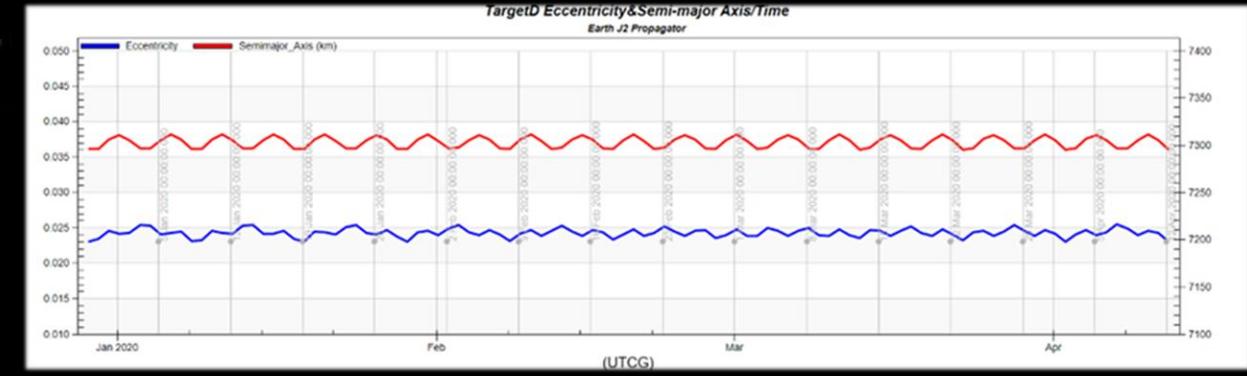
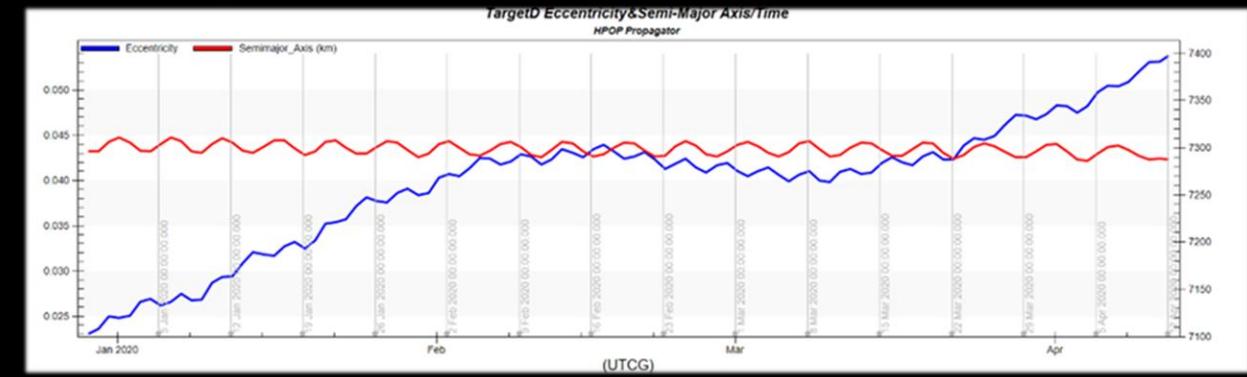
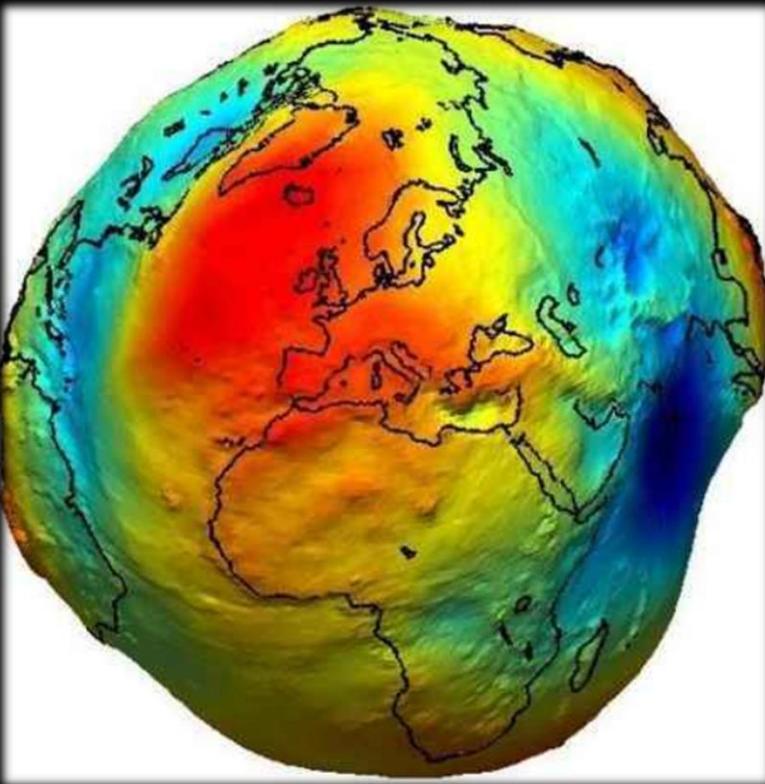
Analysis Start Time: **29 Dec 2019 04:00:00.000 UTCG**

Analysis End Time: **12 Apr 2020 00:46:21.802 UTCG**

Duration (Time taken for RelRAAN to reach zero): **105.668 days/2536 hours**

Orbital Perturbations

Non-Spherical Earth, Gravity from Moon, Sun, Solar flux.



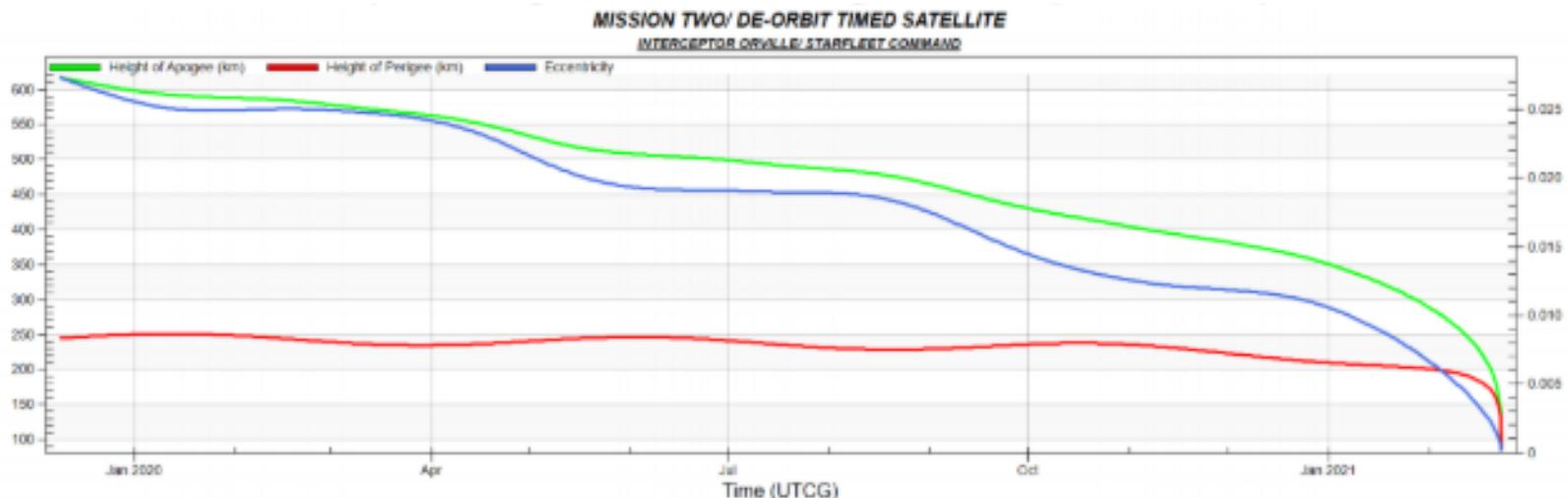
Large Debris Capability



Satellite Mass: 660 kg (Timed)

De-orbit: Successful

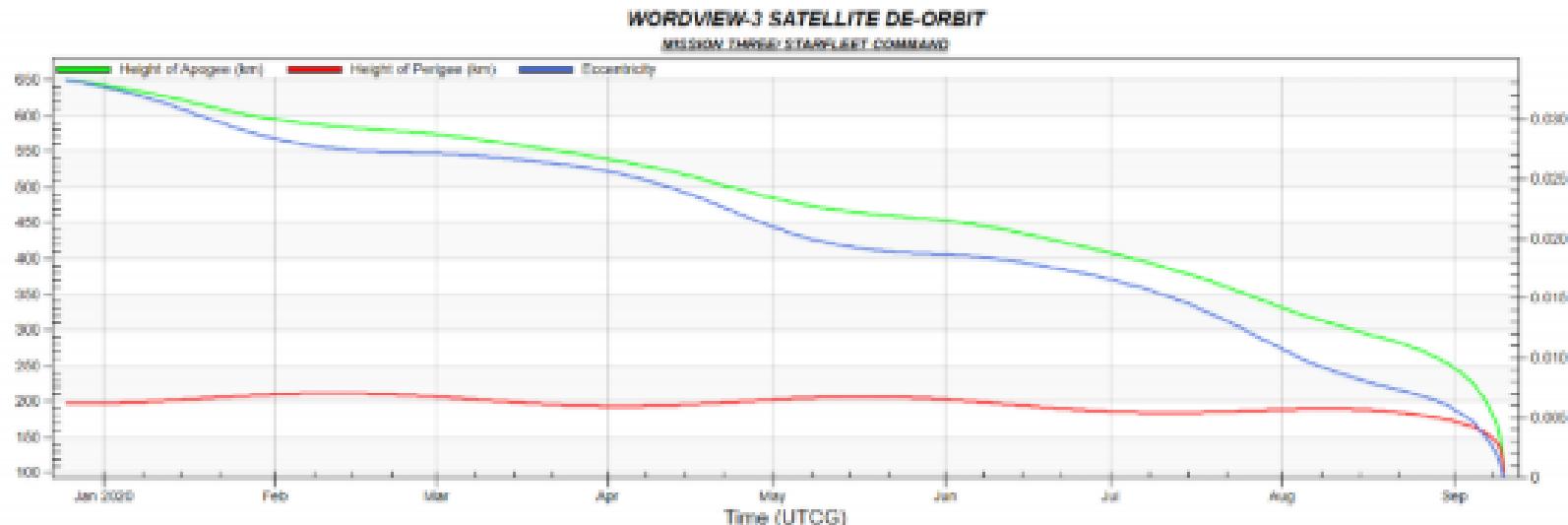
Return to Fuel Station: Successful



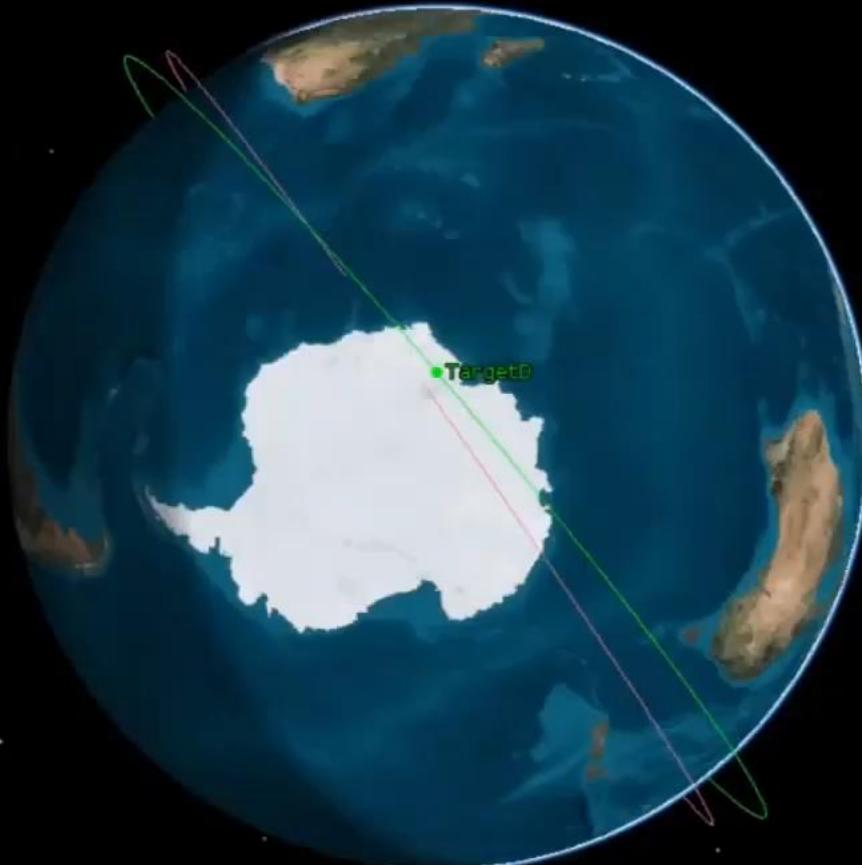
Satellite Mass: 2800 kg (Worldview-3)

De-orbit: Successful

Return to Fuel Station: Successful



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TargetD ICR Axes
29 Dec 2019 04:45:00.000 Time Step: 300.00 sec



Interceptor begins RAAN match with target

Thank You !
Q&A Session

