Removal of Geostationary Debris in light of Commercialized Space Activities.

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1. Introduction

In the geostationary orbit (GEO), there are only 360 slots where active telecommunication satellites can operate. Each one of them has to be safely distant from 0.5° or 366.5 km apart in order to avoid collision and interference. Most of these slots are occupied by active satellites or sometimes by a dead satellite which has not been moved when it was still active. It occurs the fact that designing a space tug, capable of pushing those debris and freeing slots up, seems pertinent, this way satellite operators would invest to use this zone for other more interesting purpose. Current Active Debris Removal (ADR) concepts are efficient with small size objects or require complex technologies which may be risky and costly. Herein we present Removal of Geostationary Debris in light of Commercialized Space Activities (ReGDeCSA) – a concept for GEO debris which will remove 10 debris with a single ReGDeCSA satellite.

2. A cost-effective solution: Ion Beam Shepherd

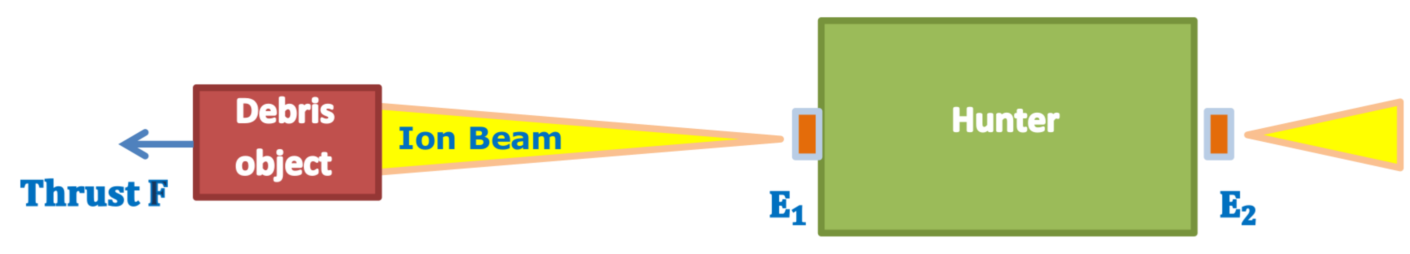
Trade-offs

Parameters	Weighting factors	LEO Ranking [1-5]	LEO Score	GEO Ranking [1-5]	GEO Score
Hunter Mass	0,15	3	0,45	4	0,6
Clients	0,3	1	0,3	5	1,5
Cost of satellite	0,2	2	0,4	4	0,8
Risk of collision	0,25	2	0,5	4	1
Complexity	0,1	1	0,1	3	0,3
	1		**1,75**		**4,2**

Notes:
Weighting factor: - from 0 (less important) to 1 (more important)
- Overall sum should be equal to 1

Ranking: from 5 (better) to 1 (worst)

A contactless method (Claudio Bombardelli, 2011)



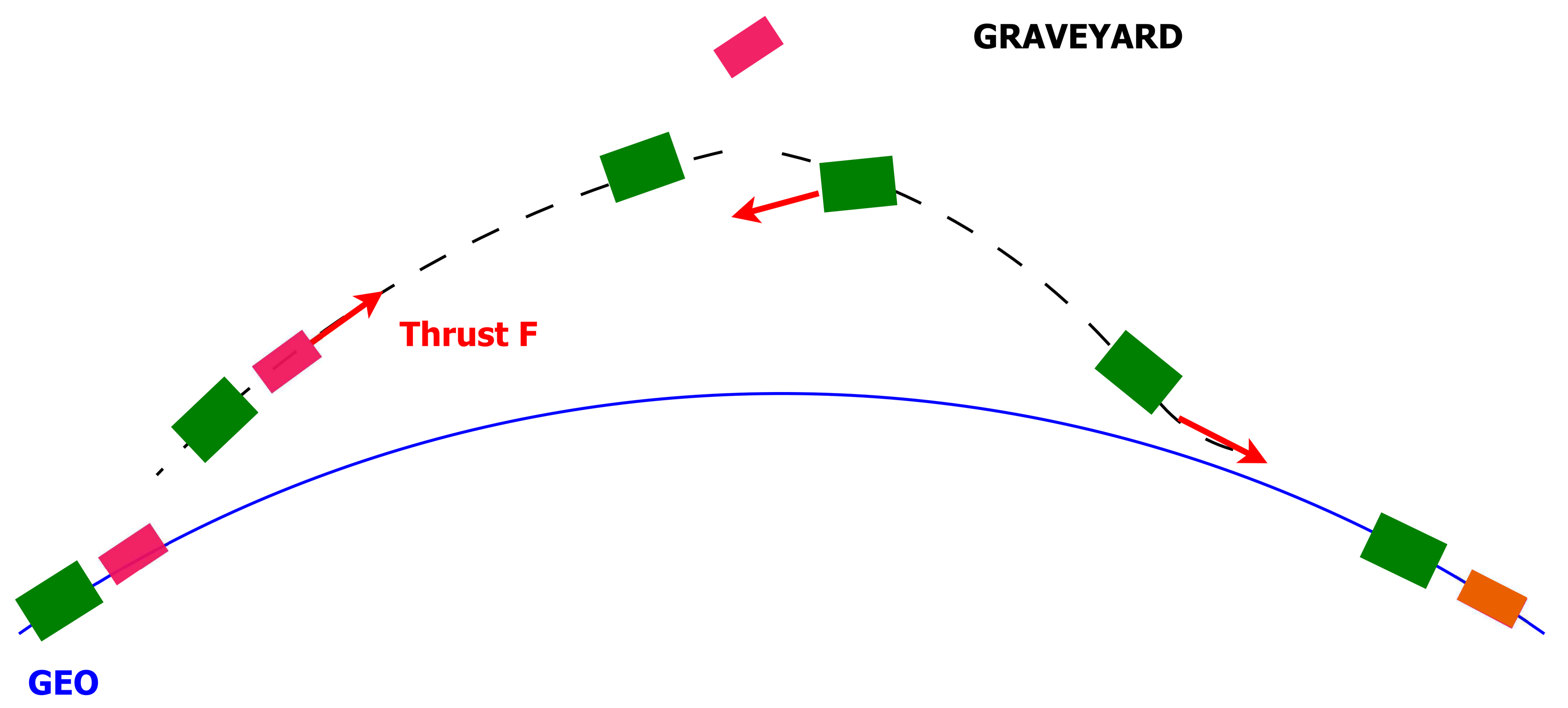
E_1: Primary engine is used to push the debris

E_2: Secondary engine is used to keep a constant distance between the debris and the hunter

- No need for complicated mechanisms to physically grab the tumbling object
- No need for docking or berthing
- Provides a solution to the problematic attitude and motion of space debris

3. Debris Removal

Low thrust transfer from GEO to the graveyard orbit



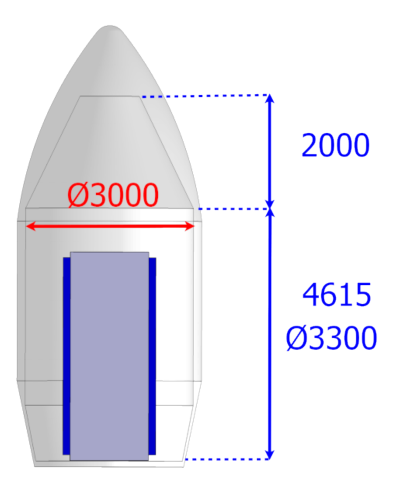
ΔV Budget

Maneuvers	ΔV [m/s]	Days	Number of times
Launch with Vega C	0	1	1
Injection from LEO to GEO	4 429.6	326	1
Rendezvous	30	14	10
Push	55.8	2	10
Back to GEO	11	2	9
Transfer to the next debris	85	44	10
TOTAL (+ 5% margin)	6 549	991	

ReGDeCSA mission begins upon arrival in the GEO, 342 days (including 5% margin) after launch. The disposal phase begins after the nominal 2 years of operations.

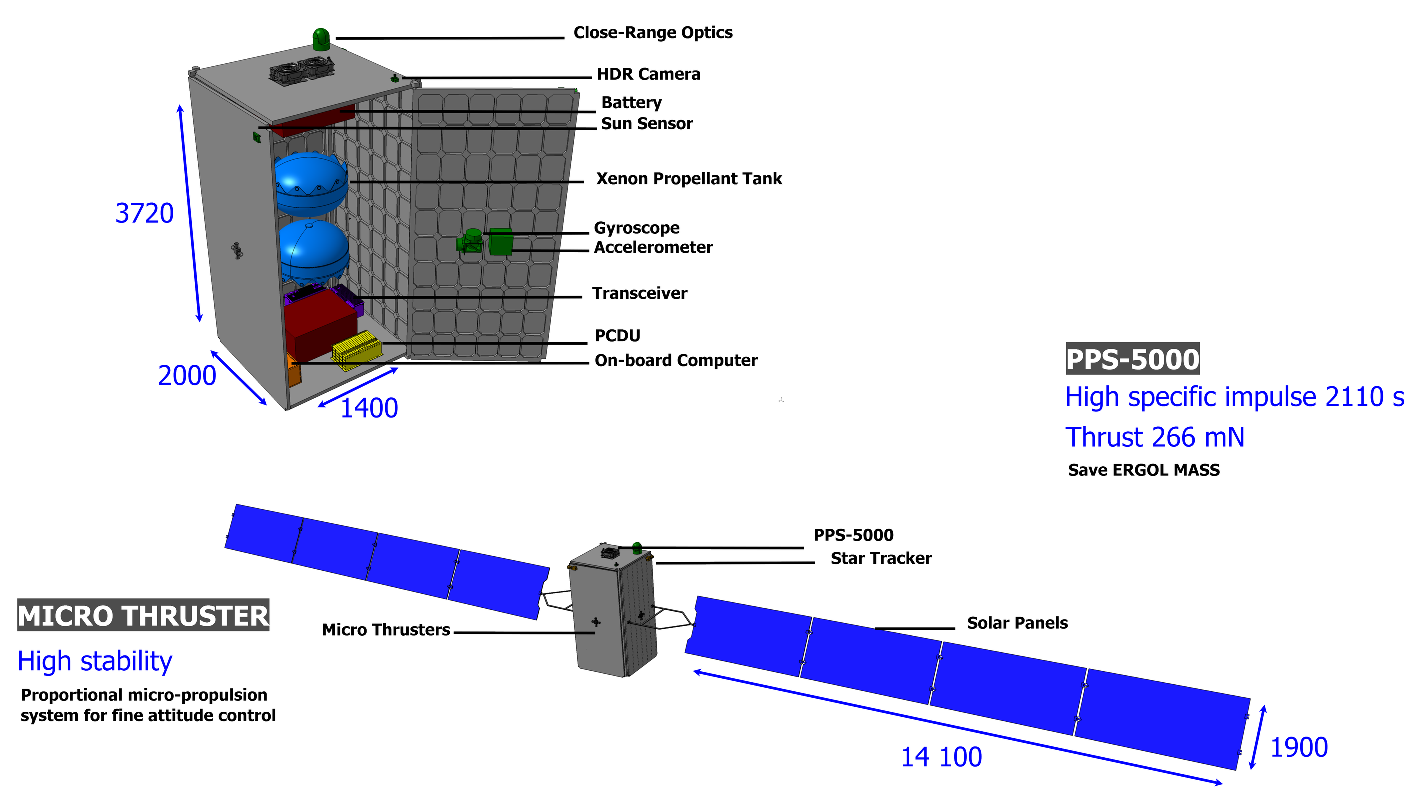
4. ReGDeCSA Systems

Vega C



Launch Vehicle: Vega C
Injection: 700 km LEO

Satellite



Main budgets

Subsystem	Margin [%]	Mass [kg]	Power [W]
Payload	35	47	6 008
Telecom	20	245	264
OBDH	20	22	72
Power	20	429	37
AOCS	20	21	111
Propulsion	20	13	6 000
Thermal	20	156	42
Structure	20	224	0
Propellant	20	722	0
TOTAL		1 879	12 534

5. Conclusions

Over expertise, we found many arguments that proved ReGDeCSA is reliable:

1. ReGDeCSA seems less risky than other comparable projects;
2. Less than 7 years are needed to make ReGDeCSA profitable aka at the beginning of the fourth mission;
3. Most material already exist on the market such as launch vehicle or propulsive and power subsystems. However, we must enhance systems' software in order to adapt to our expectations.