

# Difficulties of Space Debris Removal and Valuable Collaborates Suggested

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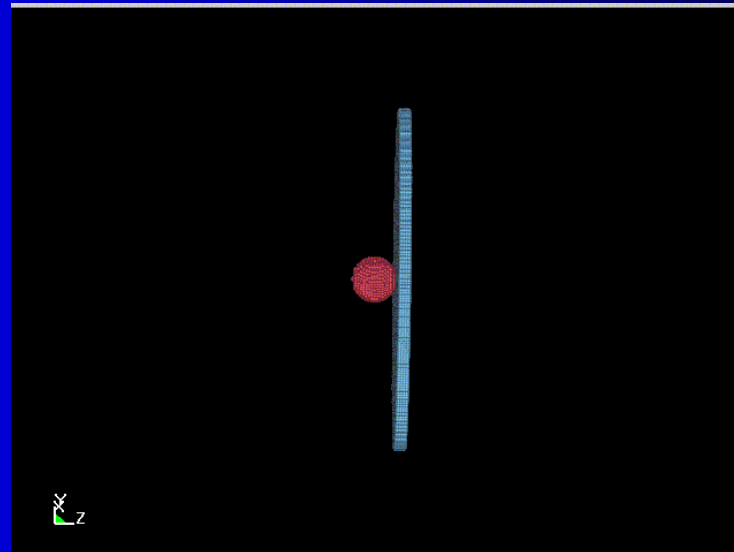


# OUTLINE

1. Current Situation of Space debris
2. Common Effort on Space Debris Affairs
3. Ideas of Active Removal for Space debris and problems to face
4. Suggestions on space debris cooperation
5. Conclusions

# 1. Current Situation of Space debris

- Space debris is more and more concerned because of more aerospace activities  
manned spacecraft
- A fatal damage could be occurred by a debris even with very small mass.

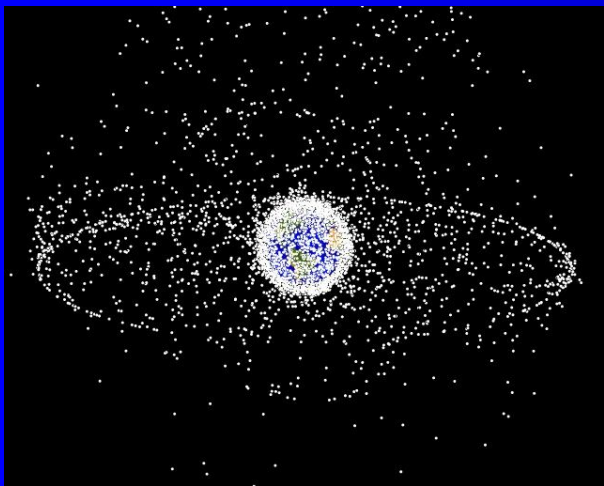




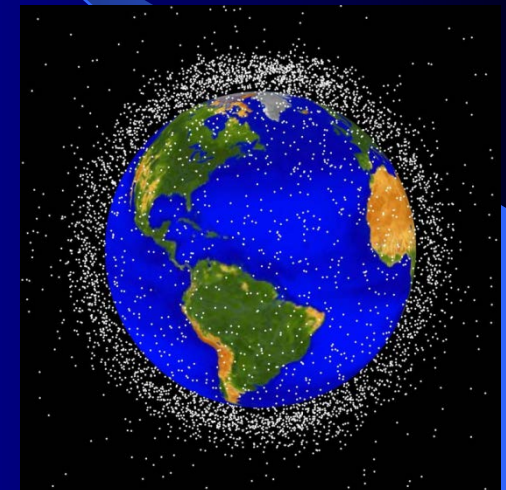
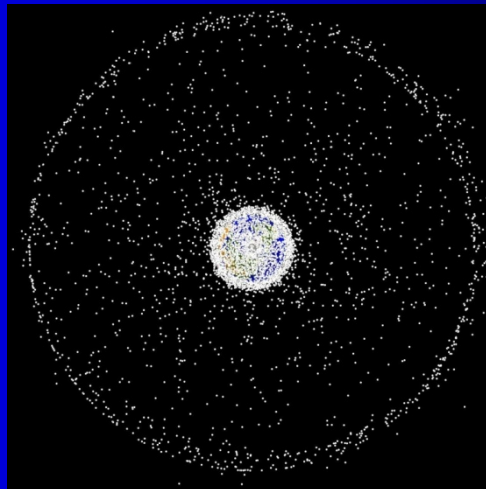
## Number of Space debris

- debris > 10 cm ~ 24,000 objects (traceable)
- debris 1 ~ 10 cm > a million
- debris < 1 cm tens of million

## Distribution of space debris



Global view



LEO region

An illustration of a satellite or space station in orbit, with a yellow starburst effect indicating a collision or debris event.

Space debris is constantly increasing

**(1) human aerospace activities**

- **Seperation of satellite from luanch vehicle**
- **Space orperation**
- **last stage of luanchers**
- **Dead satellites (out of use)**

**(2) Collision between orbital objects (most severe)**

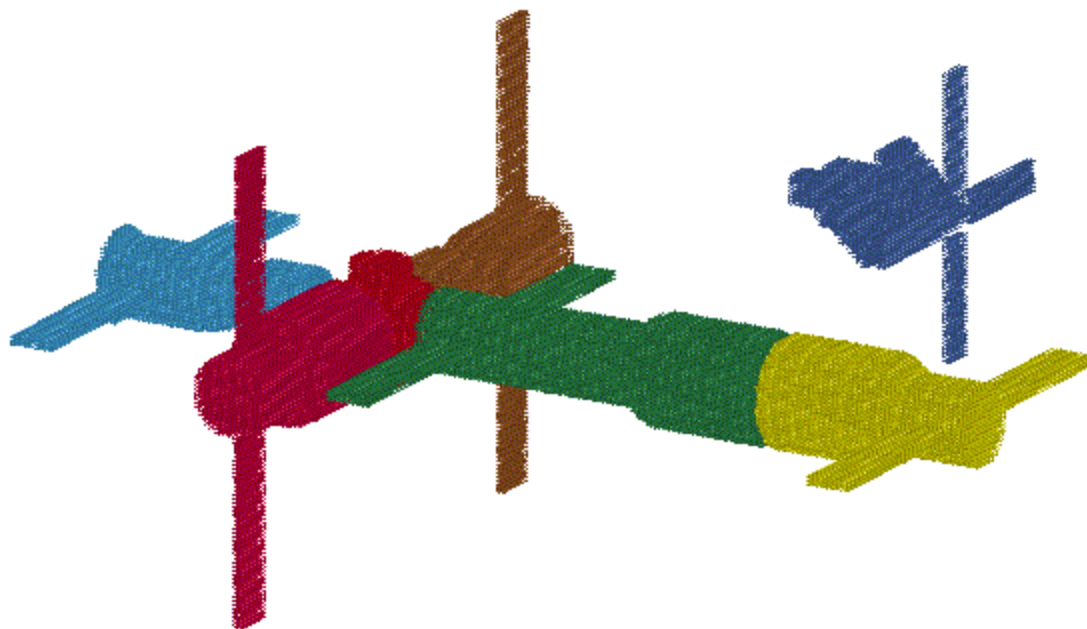
10 cm debris collision ---- new debris cloud containing more than one million fragments 1 mm in size and larger can be created.

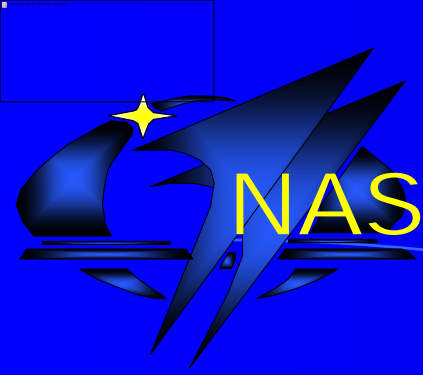
----The debris will still increase even if stopping all launch

# Large mass object collision on orbit

LS-DYNA KEYWORD DECK BY LS-PRE

Time = 0



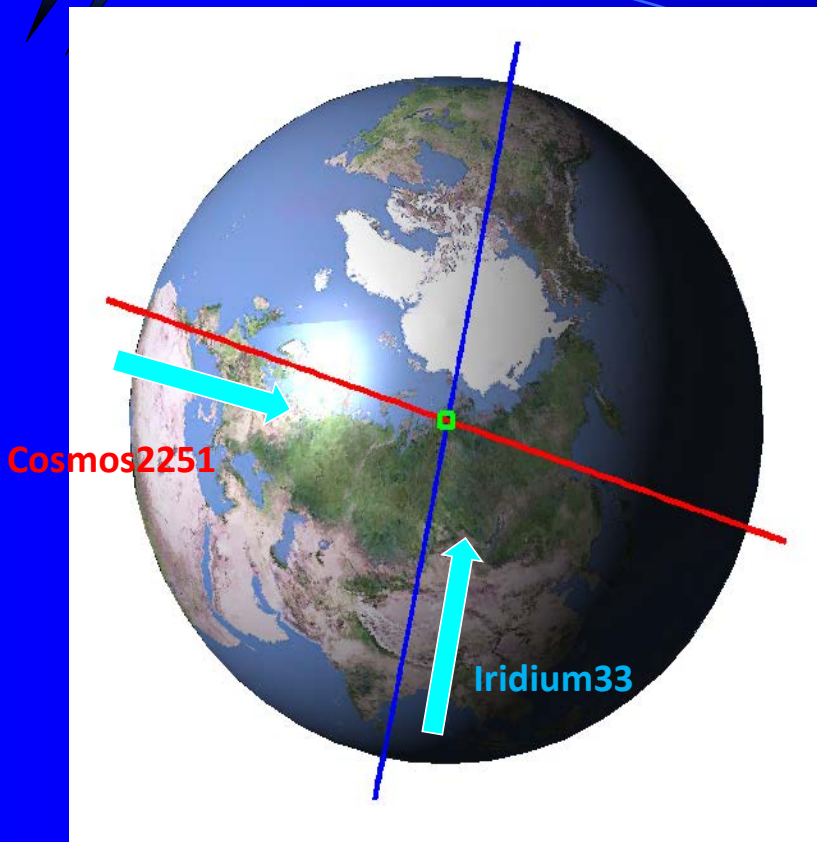


# NASA Model for debris creation

$$N_{\geq L_c}(L_c) = 0.1(MV)^{0.75} L_c^{-1.71}$$

- NASA model is built based on the test and space surveillance data.
- NASA Model cannot consider the material property and the configurations of impact objects.

# Example for real happened space collision



David Wright for the fig.



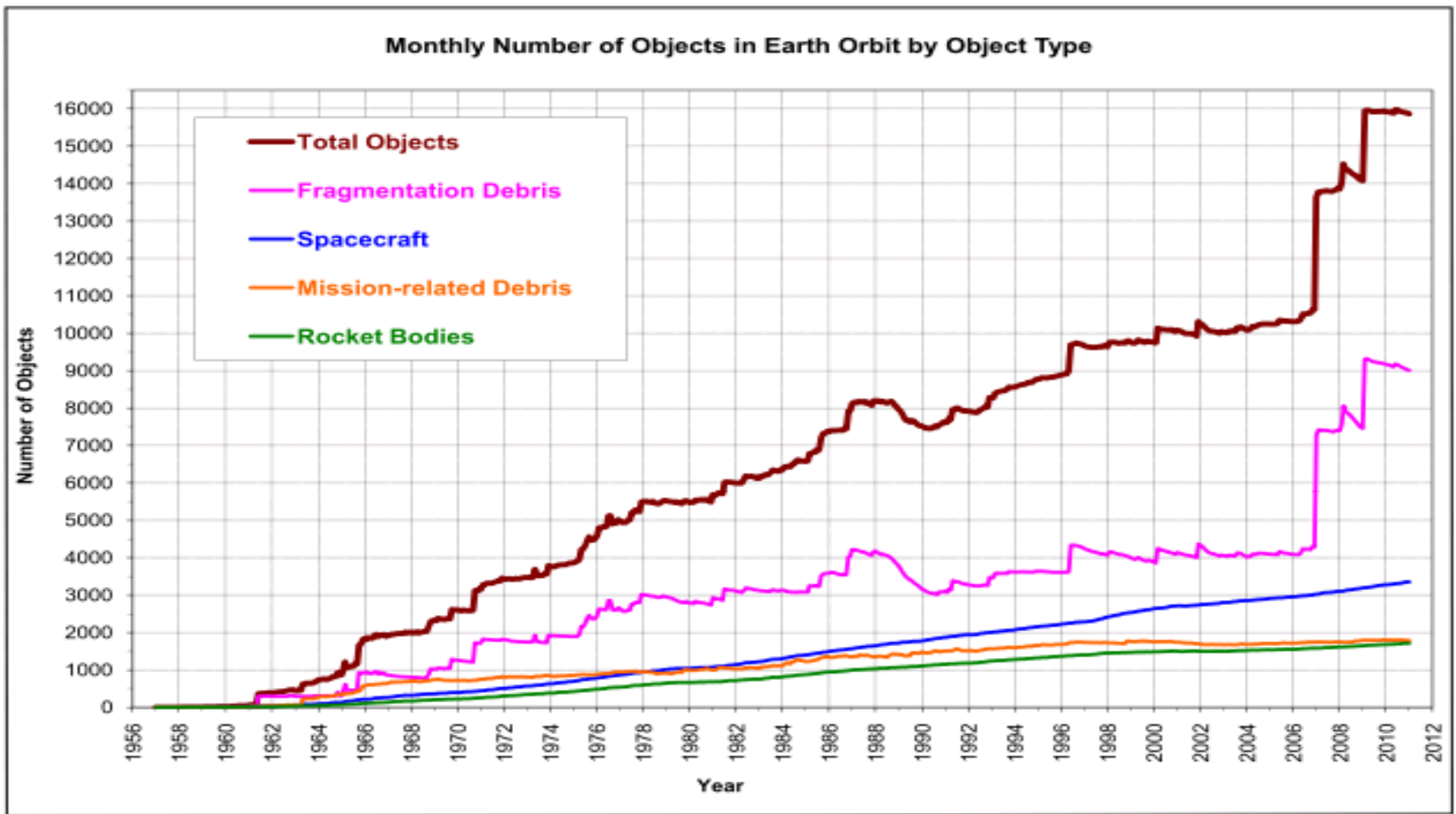
**IRIDIUM 33 COSMOS 2251**



**COSMOS 2251**



# Traceable debris increasing trend



*Monthly Number of Cataloged Objects in Earth Orbit by Object Type: This chart displays a summary of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. "Fragmentation debris" includes satellite breakup debris and anomalous event debris, while "mission-related debris" includes all objects dispensed, separated, or released as part of the planned mission.*



## 2. Common Effort on Space Debris Affairs

### ■ Observation and Tracking of Space Debris

Facilities: SSN – Space Surveillance Network

Data Base: TLE – Two Line Elements

(some of debris data may not be released)

Direct Purpose: Warning the impact threaten, providing information for considering to avoid or maneuver

### ■ Mitigation

Using Special methods or operations, to reduce the increment of space debris, and let orbital objects more quickly to de-orbit

# Protecting of spacecraft

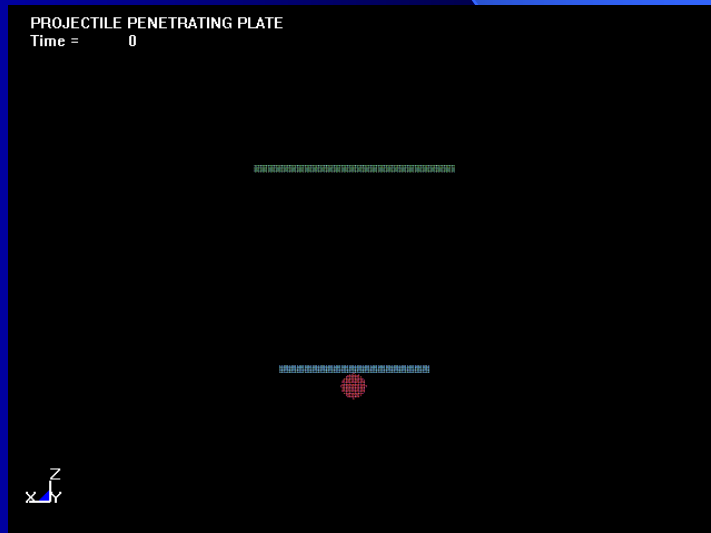
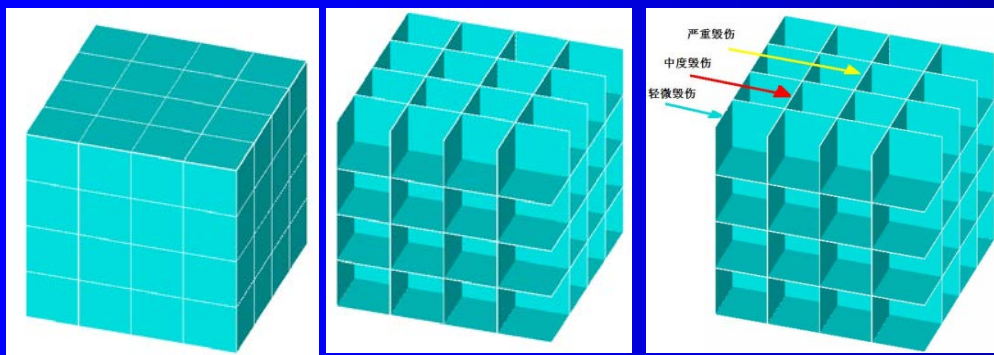
Hypervelocity Impact: Numerical Simulation SPH  
Physical Test light gas Gun

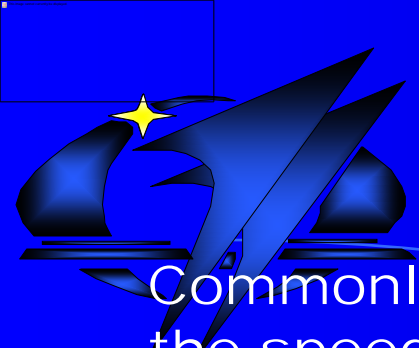


Protect structure design: For Satellites  
For Manned Spacecraft

Two layers, Whipple Structure

## Damaging Grade Model





Commonly space debris mitigation can only reduce the speed of debris increase, but not the debris amount.

Debris active removal is especially attractive in aerospace engineering.

However, no real flight test of debris removal has been done so far. Only many constructed Ideas or concepts.



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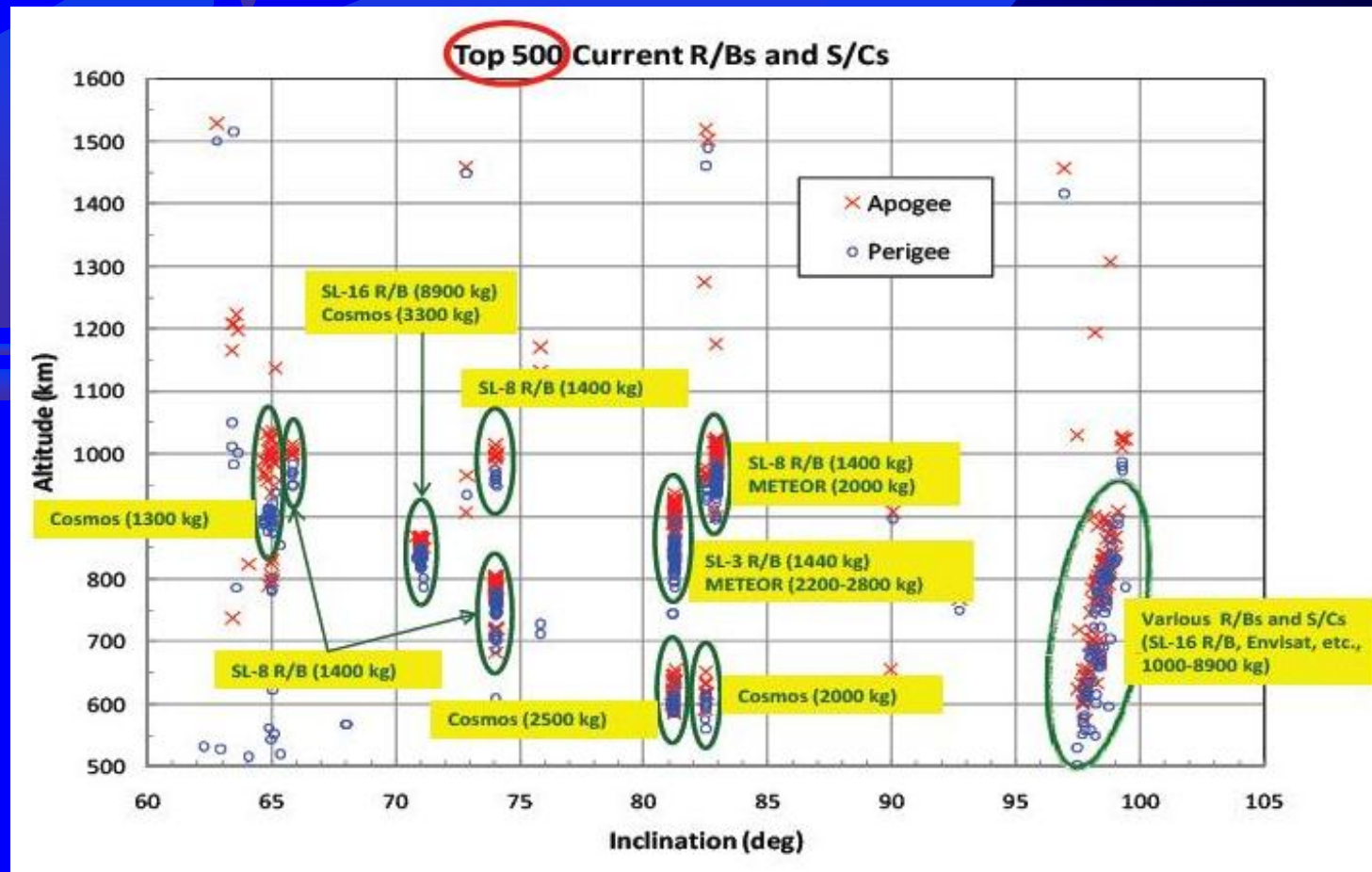
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# 3. Ideas of Active Removal for Space debris

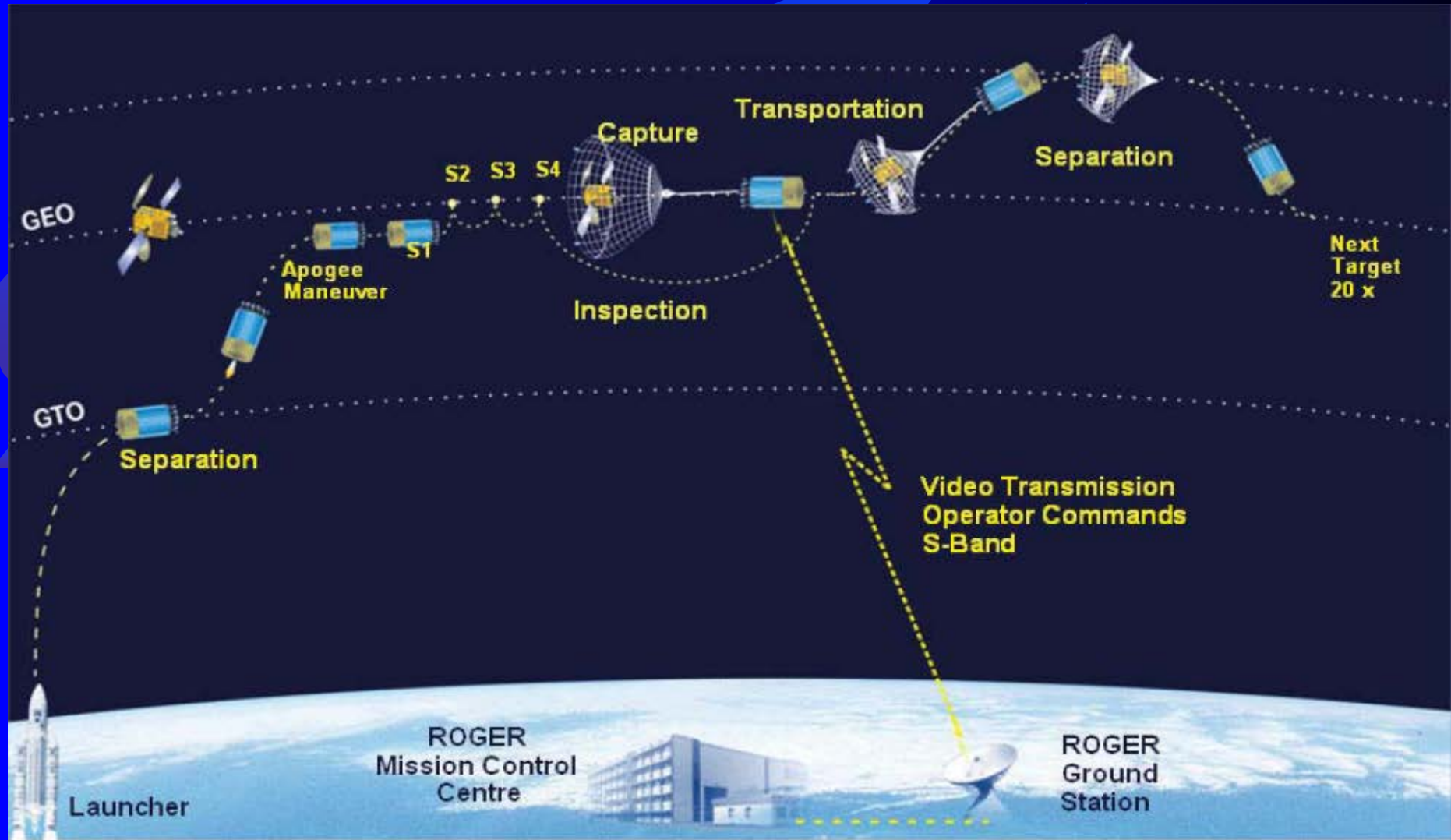
## Removal large debris

### Top 500 largest Debris positions



# ROGER

## ACTIVE DEBRIS REMOVAL FOR LARGE DEBRIS OR DEAD SATELLITE

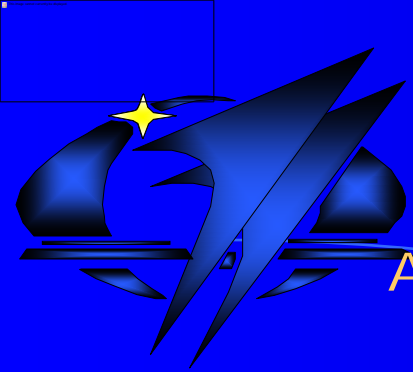


# Active Removal for small debris



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## ACTIVE DEBRIS REMOVAL TECHNIQUES

	Size<1cm		Size 1-10cm	Size>10cm	
	metal	other		cooperating	tumbling
Orbit LEO	Magnetic Field gen.		Ground/Air/Space based Laser Foams Thruster exhaust	Ret. Surf. Tethers Magnetic sail Prop. Module Tentacles	Net Tentacles
	Retarding surface Sweeping surface Space based Laser Foams Thruster exhaust				
Orbit grave yard GEO	Foams Thruster exhaust [trackability is difficult]			Capture Vehicle Momentum Tether Solar sail	Net Tentacles

# Problems of current Active debris Removal

Techniques are not mature.

How to

- identify a object
- approach a space debris or dead Sat ;
- catch or grasp the object(s)

orbital maneuver

mechanism design and control

large velocity increment  $\Delta V$

propulsion system and propellant

Efficiency and reliability of above ways is poor, at least not satisfactory.

# Problems of current Active debris Removal

Financial Cost is extremely expensive

large amount of money

large professional team for the removal

who pay? (should pay? Will pay?)

Politically the practice is possible ?

## 4. Suggestions on space debris cooperation

Space is no boundary of country. Any debris disaster will surely result in effect on others, so cooperation in this issue has a natural basis.

**No body can escape or be released !**

### **(1) Data Share**

USA and Russia have the most completed ground facilities and Data base, should share more information, even can provide **warning services**.

## 4. Suggestions on space debris cooperation

### (2) higher resolution debris track

TLE 10cm ==> 20,000 objects

Try promoting current resolution

10cm ==> 5cm ==> 20,000 X 4~5 times objects

Study the fine distribution of smaller debris (>1mm)

## 4. Suggestions on space debris cooperation

### (3) Joint flight test program for debris removal

So far there exist many ideas and related technical verification, but not aims to real debris.

Swiss Space Center project *Cleanspace*

-----*using Cube-Sat platform*

----- *object to "removal" is another Cube-Sat*

It is time to launch a joint debris removal program

----- joint invest

-----joint team

----- aims to a moderate orbital debris



## 5. Conclusions

- (1) Current space debris situation is getting worse and worse even if no new launch is taken place.
- (2) The common effects of mitigation is not enough to solve the space debris problem.
- (3) Real program of active removal for space debris has not been taken into practice. The difficulties are both technical and financial, as well as political aspects.
- (4) Data share, higher resolution debris track and joint flight test for debris removal are suggested as the key steps of international cooperation on space sustainability.



Thank You  
for Attention!