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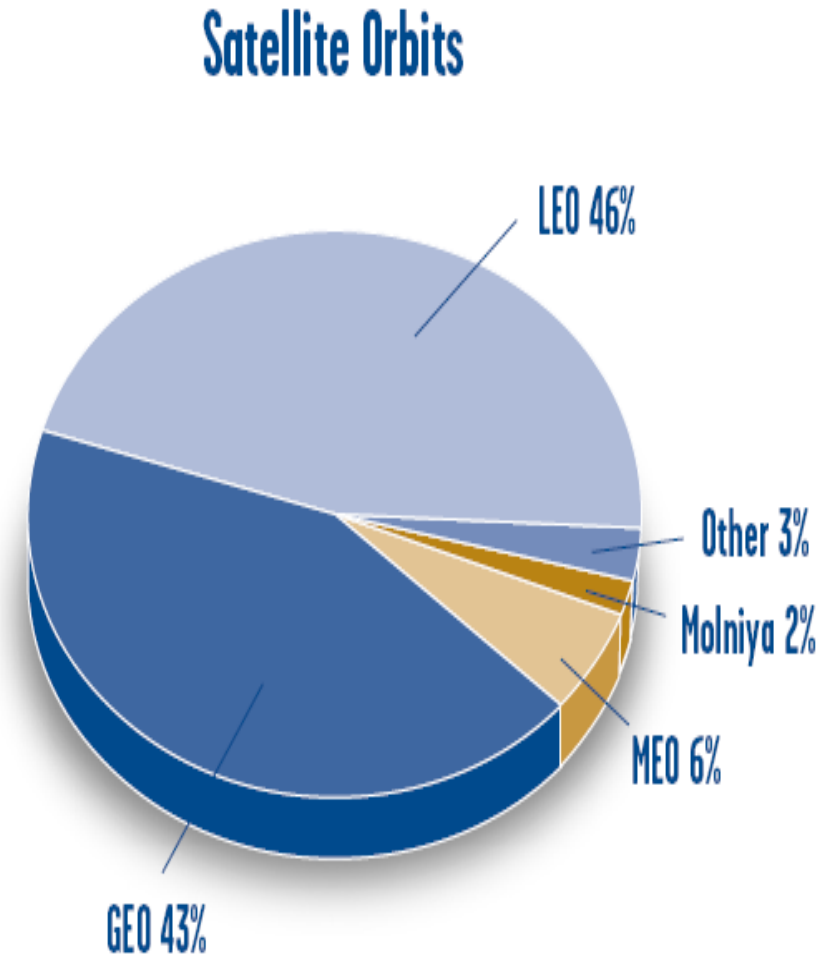
**Reppy Institute, Cornell University**

**Space, Science and Security: The Role of Regional Expert Discussions**

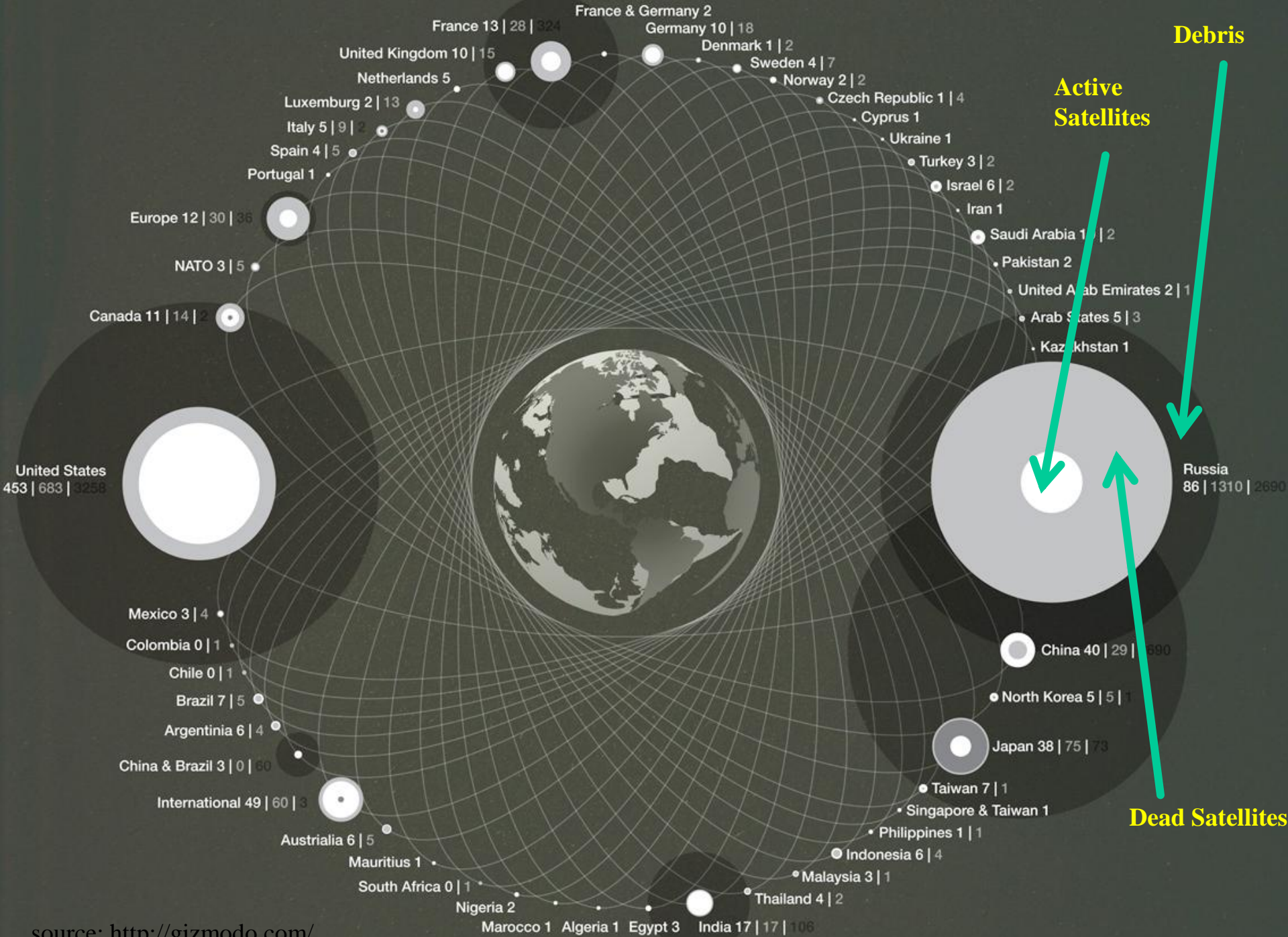
**New Delhi, 20<sup>th</sup> Jan, 2011**

## What's in Space Today?

- Currently ~ 1000 operational satellites
- 3 areas of space contain 95% of operational satellites:
  - **Low earth orbit (LEO)**: 300-2,000 km altitude
    - Mainly reconnaissance satellites
  - **Semi-synchronous (MEO)**: 20,000 km altitude
    - Navigation satellites (eg, GPS)
  - **Geosynchronous (GEO)**: 36,000 km alt.
    - Communication/broadcast satellites



Source: David Wright Union  
Of Concerned Scientists



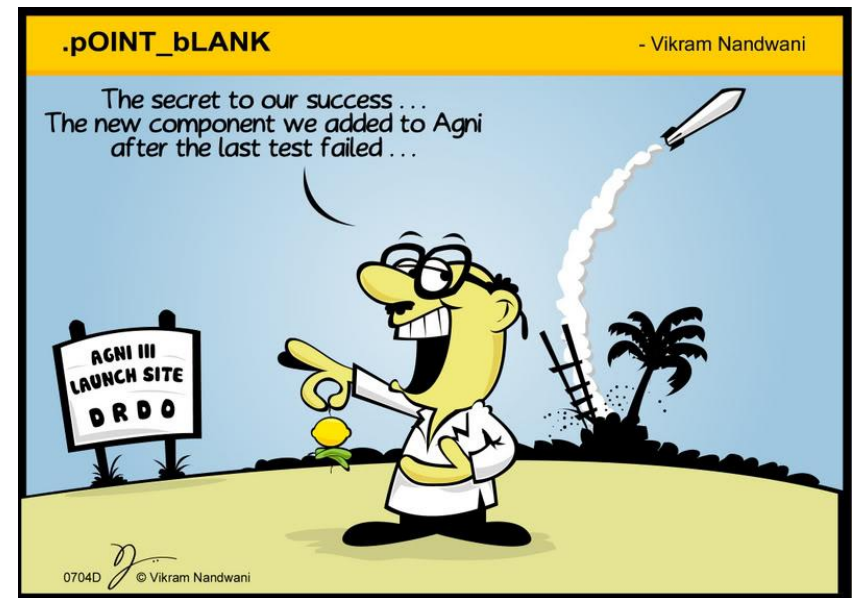
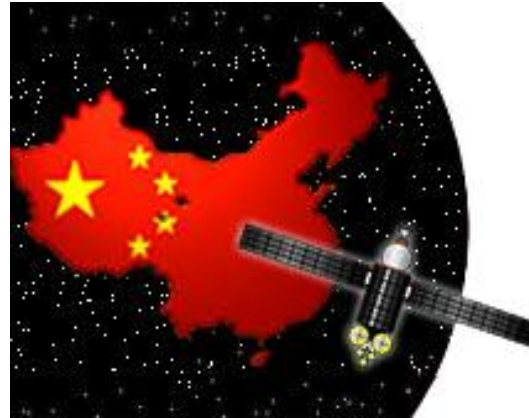
source: <http://gizmodo.com/>

## Indian Investments in Space

<b>Assets</b>	<b>Total Value of Assets</b>	<b>Description</b>
<b>11 INSAT Satellites</b>	<b>\$ 1500 million</b>	<b>211 transponders</b>
<b>7 IRS Satellites</b>	<b>\$ 700 million</b>	<b>Camera systems with spatial resolutions</b>
<b>Search &amp; Rescue</b>	<b>\$ 200 million</b>	<b>Transponders on various satellites</b>
<b>Total Space Assets</b>	<b>\$ 2400 million</b>	
<b>Space Infrastructure</b>	<b>\$ 12, 000 million</b>	<b>R &amp; D Ranges Centres</b>
<b>Total Space Infrastructure</b>	<b>\$ 12, 000 million</b>	
<b>Value added services</b>	<b>\$ 24,000 million</b>	<b>Very large?</b>
<b>Grand Total</b>	<b>\$ 38, 400 million</b>	

Source: S. Chandrashekar, The Emerging World Space Order and Its Implications for India's Security

# Motivations



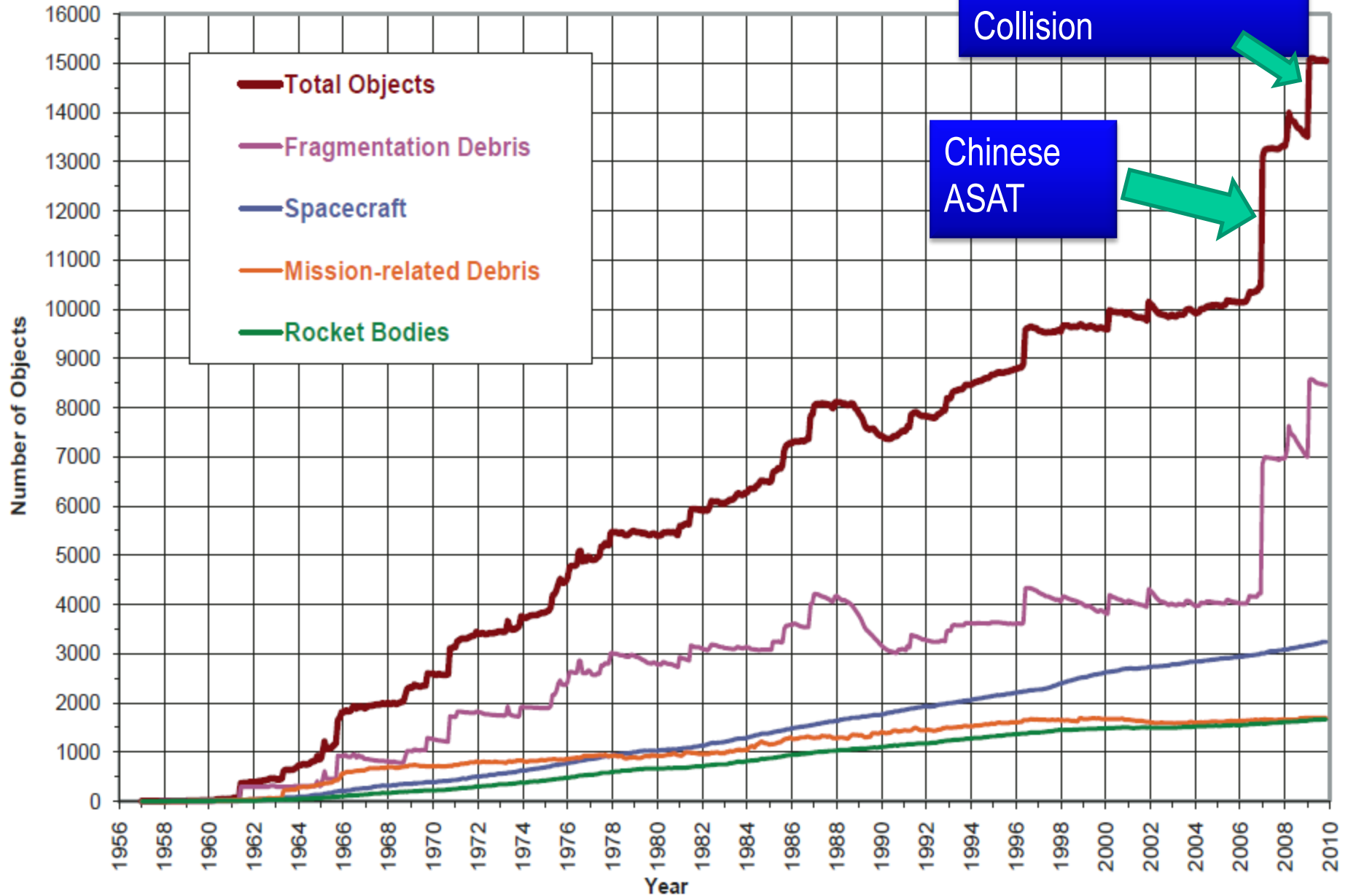
## Debris Classification

<b>Category</b>	<b>Definition</b>	<b>Potential Risk to Satellites</b>
<b>Trackable</b>	<b>&gt; 10 cm</b>	<b>Complete destruction</b>
<b>Potentially Trackable</b>	<b>1-10cm</b>	<b>Complete to partial destruction</b>
<b>Untrackable</b>	<b>&lt; 1 cm</b>	<b>Degradation, loss of certain sensors or subsystems</b>



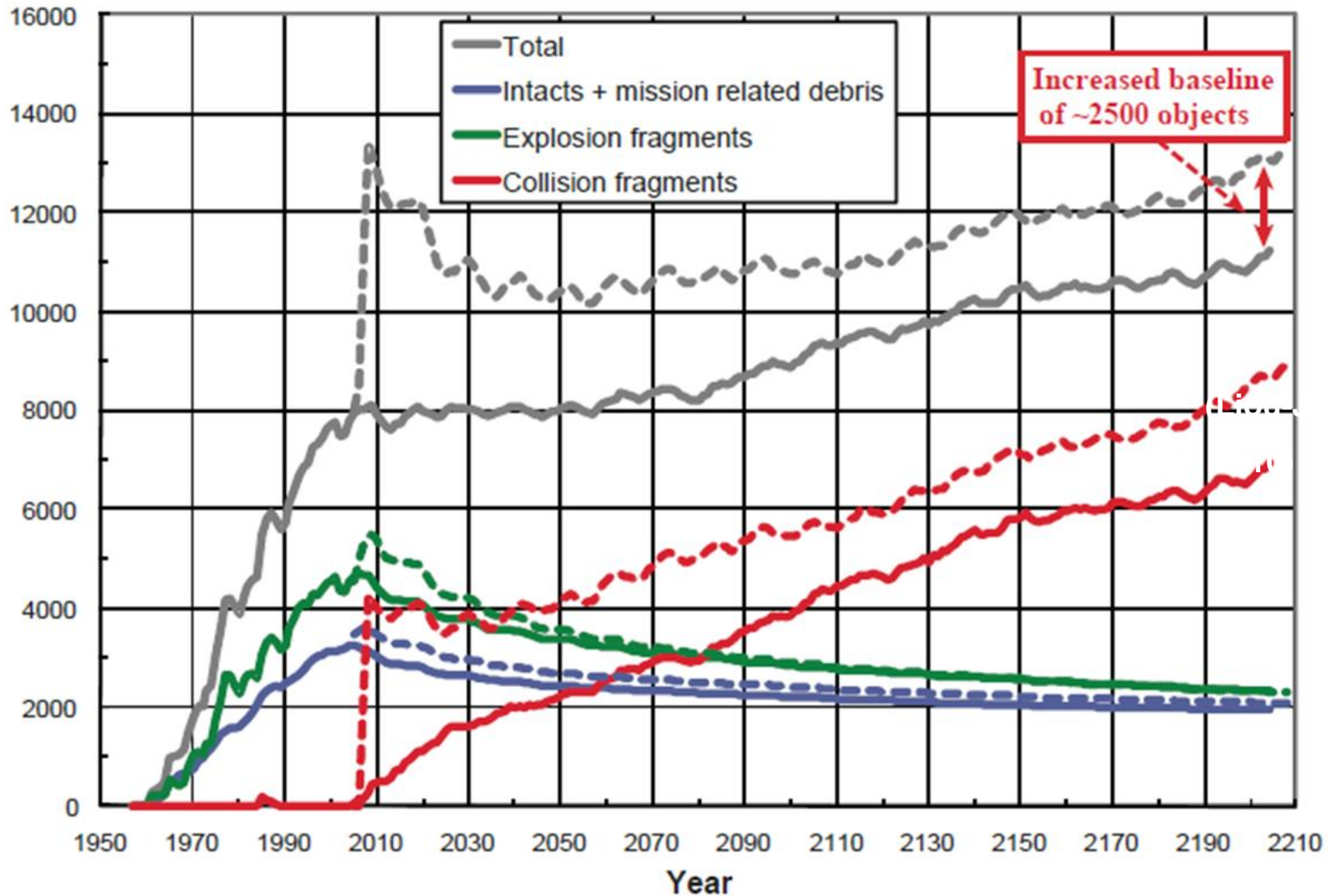
- Sample of an Aluminum block of 18 cm diameter and 8.2 cm thickness that was impacted by **a Aluminum sphere of 1.2 cm diameter** at a velocity of **6.8 km/s**, causing a crater of 9 cm diameter and 5.3 cm depth, and a rear wall spallation of 9.2 cm diameter.

Monthly Number of Objects in Earth Orbit by Object Type





# Debris population in next 200 years (NO New Launch Scenario)



**What will happen, if both India and China decide to attack  
and destroy the other country's LEO satellites?**

## Chinese LEO Satellites- Targets

NORAD ID	COSPAR ID	Name	Apogee (km)	Perigee (km)	Inclination (deg)	Launch Mass (kg)
29092	2006-015A	YAOGAN 1	630	627	97.9	2700
31113	2007-010A	HAIYANG 1B	804	783	98.5	500
31490	2007-019A	YAOGAN 2	657	630	97.9	2700
32289	2007-055A	YAOGAN 3	629	628	97.8	2700
32958	2008-026A	FENGYUN 3A	827	826	98.7	2300
33320	2008-041A	HJ-1A	663	626	98	470
33321	2008-041B	HJ-1B	676	613	98	470
33408	2008-053A	SJ-6E	602	584	97.7	1300
33409	2008-053B	SJ-6F	605	582	97.7	1300
33433	2008-056A	SHIYUAN 3	805	785	98.5	300
33434	2008-056B	CHUANG XIN 1-02	806	785	98.5	100
33446	2008-061A	YAOGAN 4	654	633	97.9	1200
33456	2008-064A	YAOGAN 5	493	488	97.3	2700
34839	2009-021A	YAOGAN 6	513	510	97.6	1800
36110	2009-069A	YAOGAN 7	660	622	97.8	1200
36121	2009-072A	YAOGAN 8	1204	1193	100.5	2600

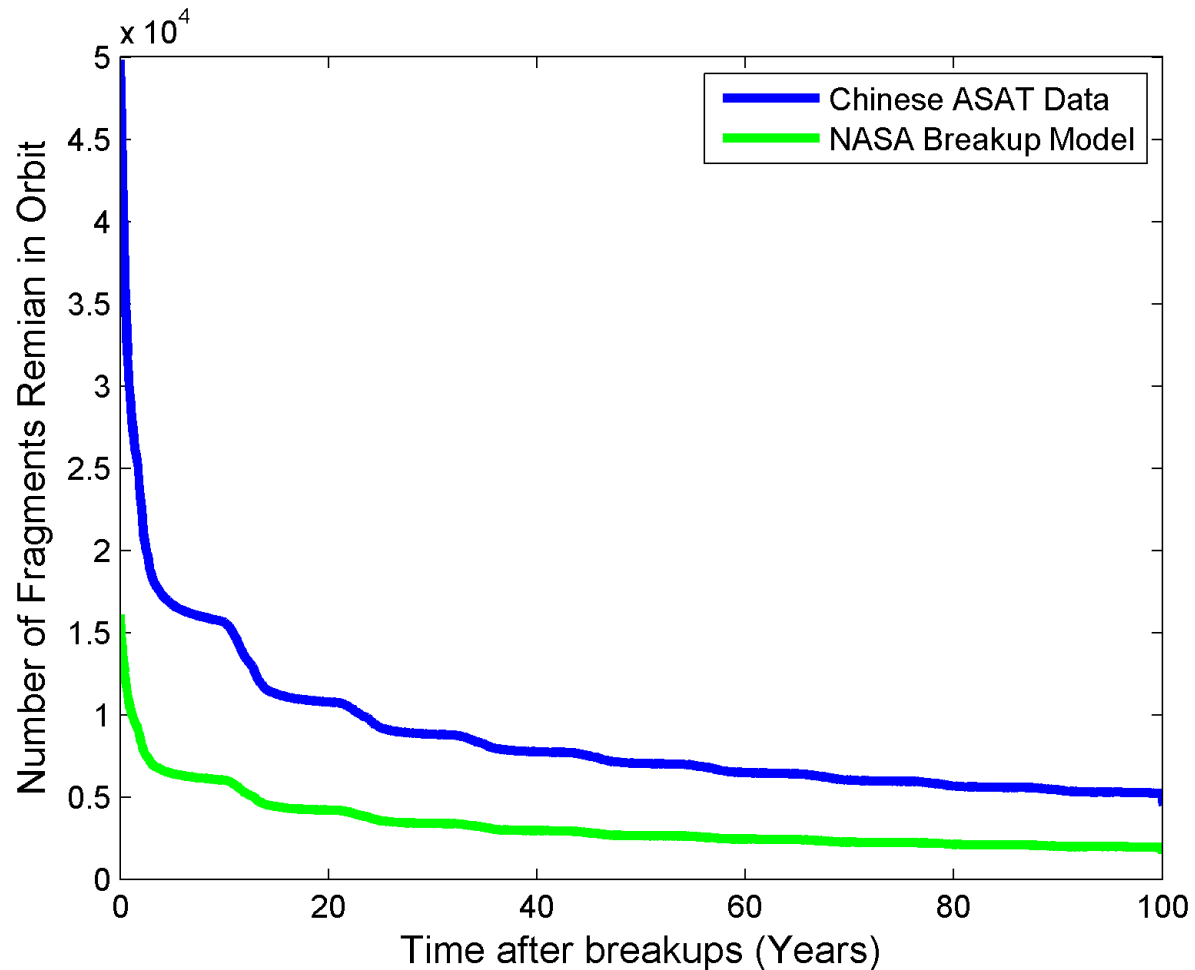
Source: UCS Database

# India Low Earth Orbit Satellites- Targets

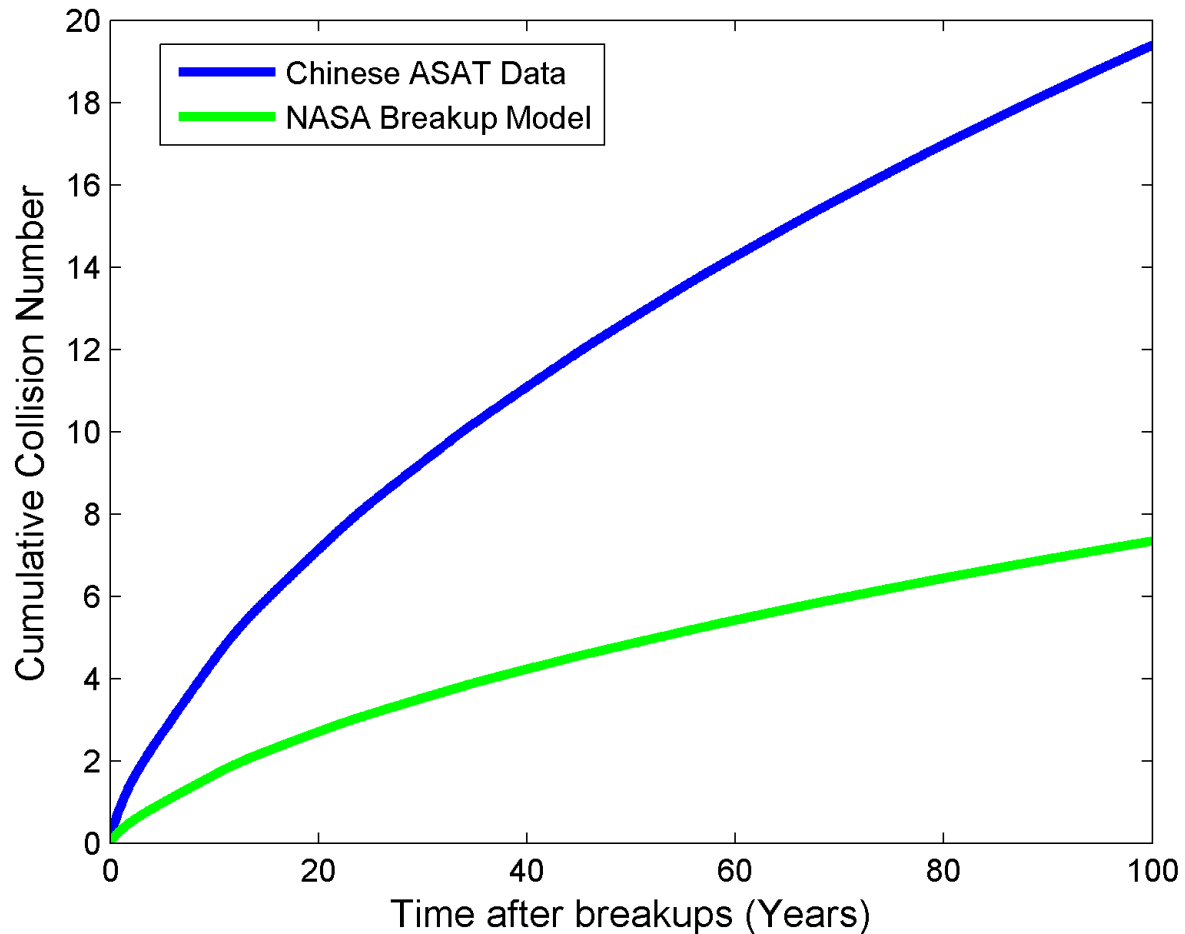
<b>NORAD ID</b>	<b>COSPAR ID</b>	<b>Name</b>	<b>Apogee (km)</b>	<b>Perigee (km)</b>	<b>Inclination (deg)</b>	<b>Launch Mass (kg)</b>
<b>28649</b>	<b>2005-017A</b>	<b>CARTOSAT-1</b>	<b>622</b>	<b>620</b>	<b>97.9</b>	<b>1560</b>
<b>29710</b>	<b>2007-001B</b>	<b>CARTOSAT 2AT</b>	<b>634</b>	<b>633</b>	<b>98</b>	<b>680</b>
<b>32783</b>	<b>2008-021A</b>	<b>CARTOSAT 2A</b>	<b>645</b>	<b>622</b>	<b>97.9</b>	<b>680</b>
<b>34808</b>	<b>2009-019B</b>	<b>ANUSAT</b>	<b>548</b>	<b>400</b>	<b>41.2</b>	<b>40</b>
<b>28650</b>	<b>2005-017B</b>	<b>HAMSAT</b>	<b>643</b>	<b>605</b>	<b>97.7</b>	<b>42.5</b>
<b>32786</b>	<b>2008-021D</b>	<b>IMS-1</b>	<b>638</b>	<b>620</b>	<b>97.9</b>	<b>83</b>
<b>28051</b>	<b>2003-046A</b>	<b>IRS P6</b>	<b>821</b>	<b>818</b>	<b>98.7</b>	<b>1360</b>
<b>35931</b>	<b>2009-051A</b>	<b>OCEANSAT 2</b>	<b>725</b>	<b>721</b>	<b>98.3</b>	<b>960</b>
<b>34807</b>	<b>2009-019A</b>	<b>RISAT-2</b>	<b>551</b>	<b>445</b>	<b>41.2</b>	<b>300</b>

Source: UCS Database

# Number of Debris Left in Orbit after the ASAT Attacks



# Number of Collisions between the ASAT Debris and Intact Objects



# Questions

- **Does the concept of deterrence work?**
- **Is there a difference between the way one thinks about nuclear weapons and ASAT weapons?**
- **Would increasing the redundancy in satellites help?**
- **The US assures satellite coverage in case any country's satellite is attacked**



Discussion