



Current issues in Space Situational Awareness (SSA) and Space Traffic Management (STM)

**Satellite and Space Missions
Berlin Germany,
July 21-23, 2016**

Dr. Mark A. Skinner

Agenda

- **What are we trying to protect?**
- **So what's the problem?**
 - » **Detritus of the Space Age**
 - » **Debris begets debris: the Kessler syndrome**
- **So what can we do about it?**
 - » **International cooperation**
 - » **SSA**
 - » **Data sharing**
 - » **Debris removal**
- **Next best steps**
- **Conclusions**

Trends in Space

Movement from handful of space actors to much larger number, with more wanting to join: Bi-lateral -> Multi-lateral

State/Military ->

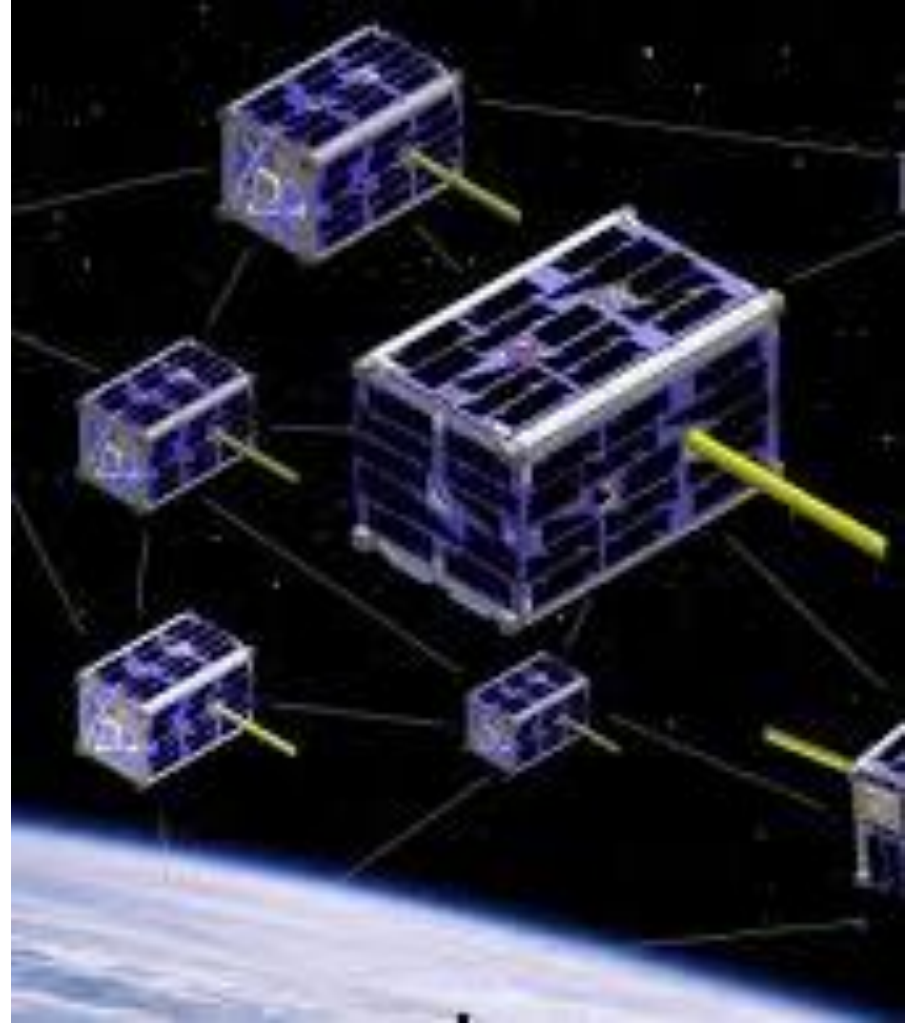
Commercial/Non-state actors

“Big Sky” mindset -> Growing realization of *congested* nature of near-space

Expensive/Big ->

Cheaper/Small = More Stuff

Desire for enhanced *transparency* in space activities, and *confidence building measures* between states



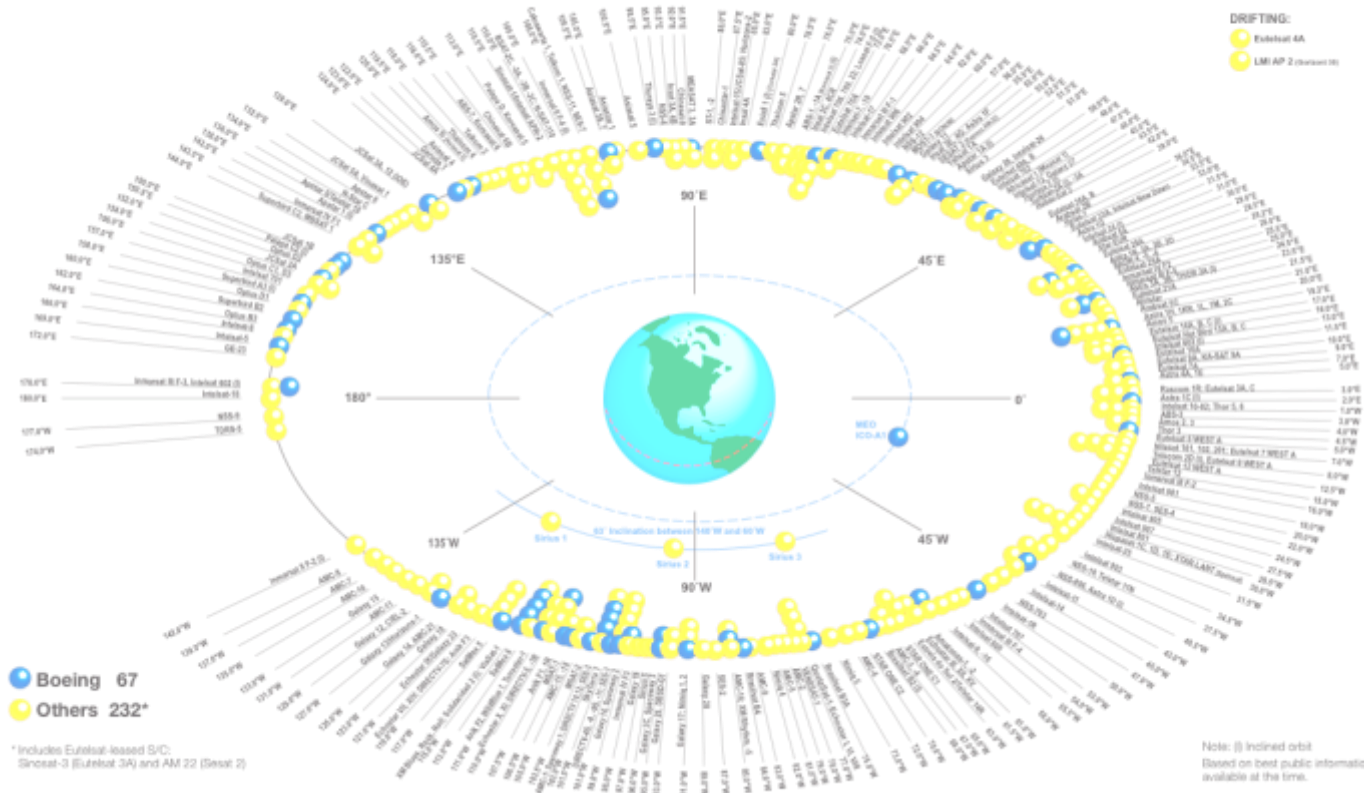
EDSN CubeSat Swarm – NASA image
<http://www.nasa.gov/content/what-are-smallsats-and-cubesats>



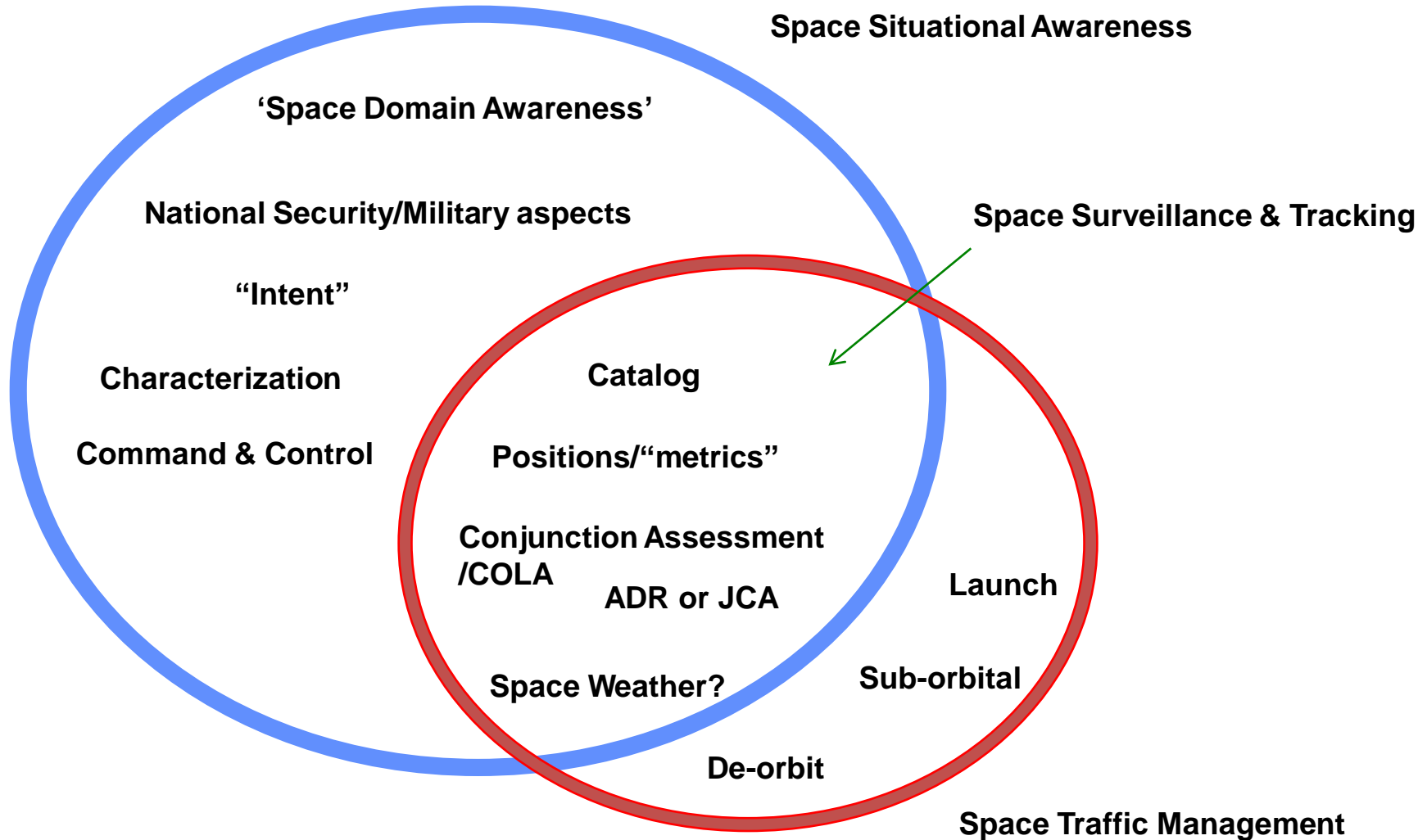
How to assure continued use of space for the future?



Commercial Communications Satellites Geosynchronous Orbit



Rosetta Stone for SSA elements

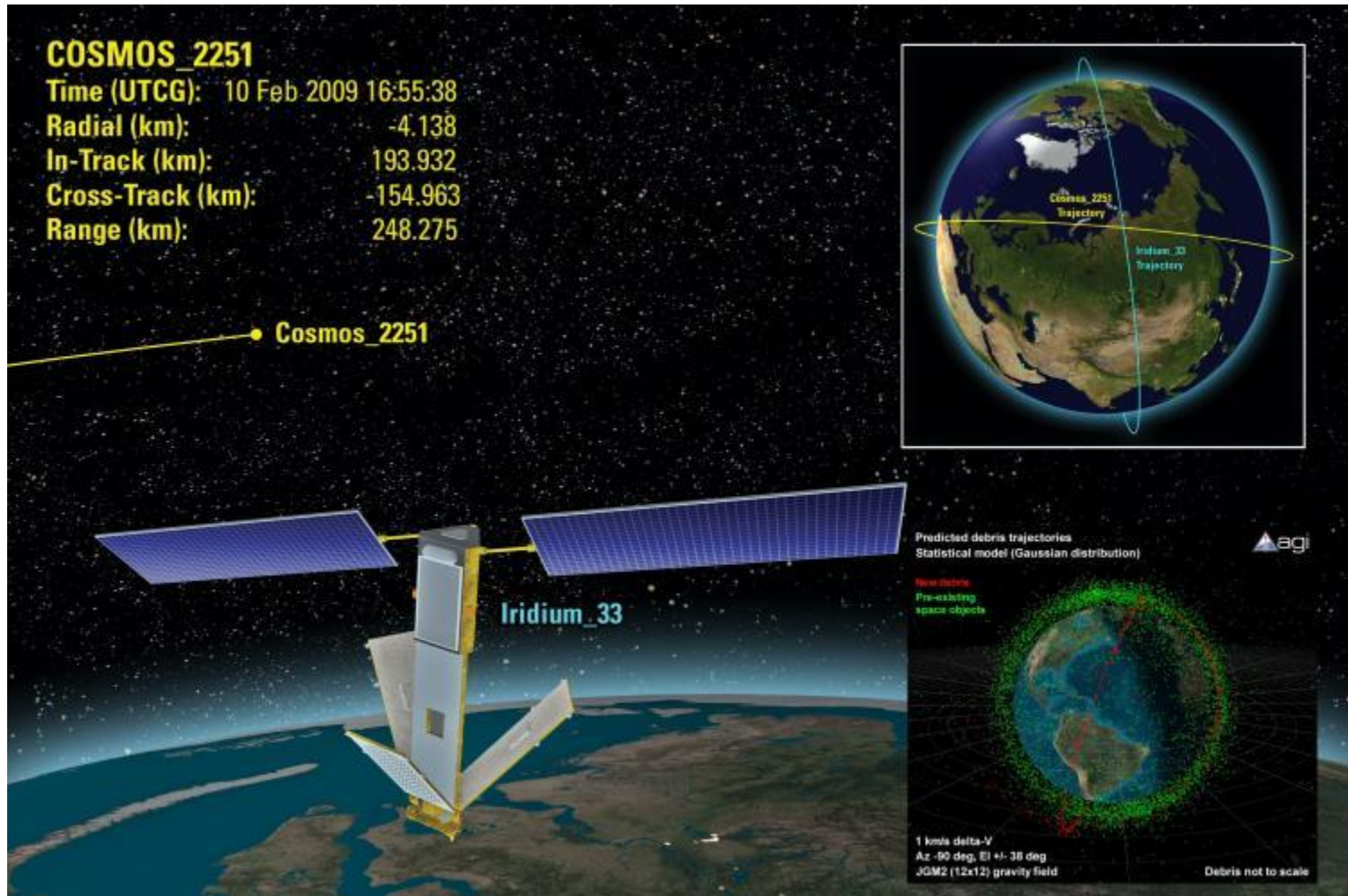


Military

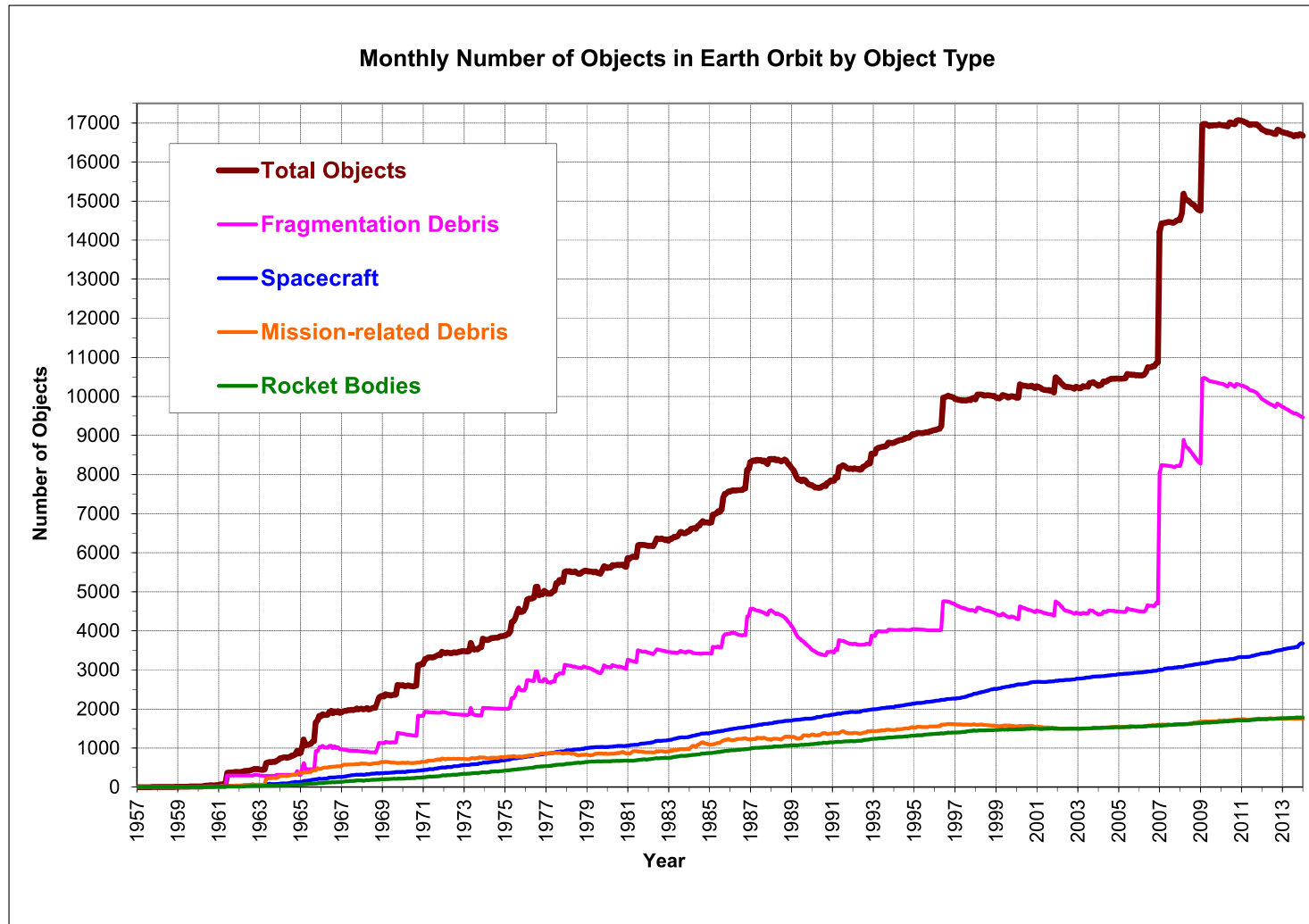


C
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How to create more space debris...

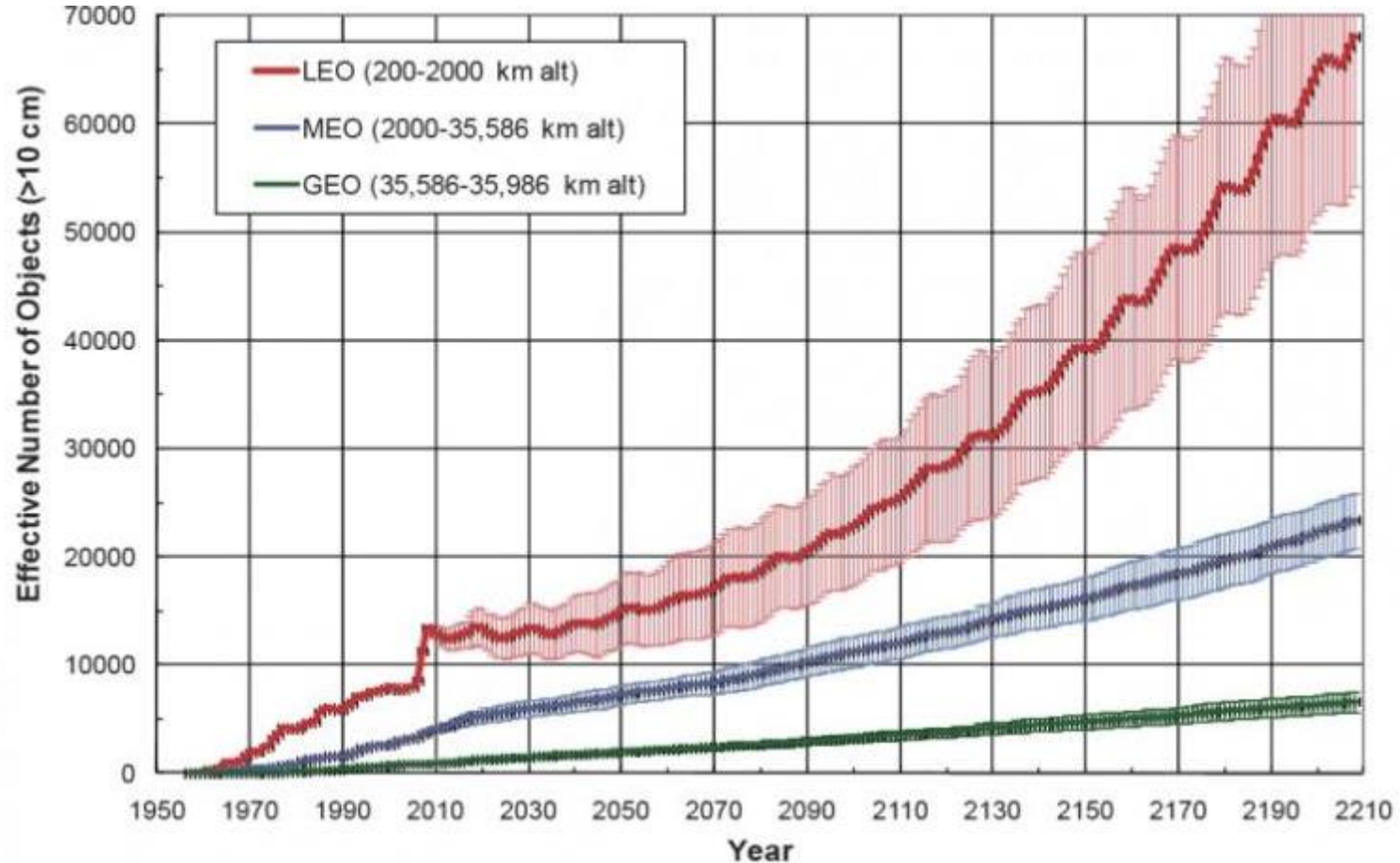


How is the amount changing over time?



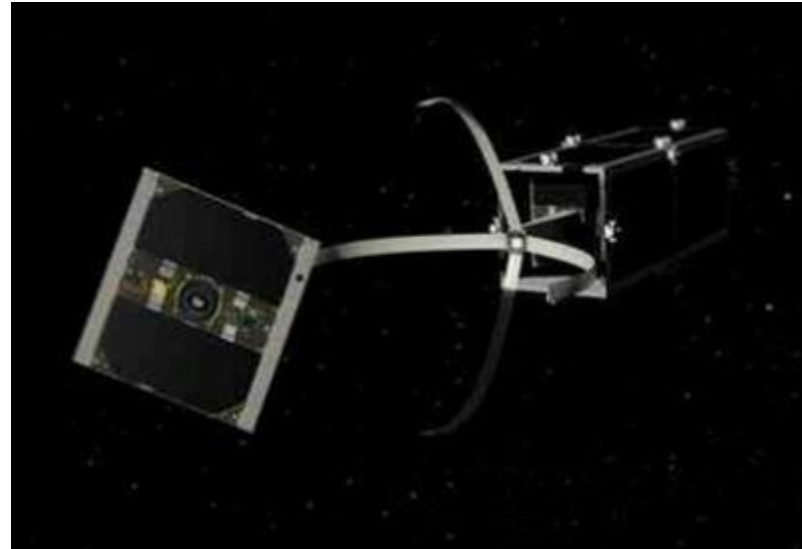
Monthly Number of Cataloged Objects in Earth Orbit by Object Type: This chart displays a summary of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. "Fragmentation debris" includes satellite breakup debris and anomalous event debris, while "mission-related debris"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

The Kessler Syndrome: a run-away cascade of space debris...



What can we take care of space debris?

<http://actu.epfl.ch/news/cleaning-up-earth-s-orbit-a-swiss-satellite-tack-2/>, accessed 4/6/14



<http://www.minorplanetcenter.net/>,
Accessed 2/2/14, used by permission

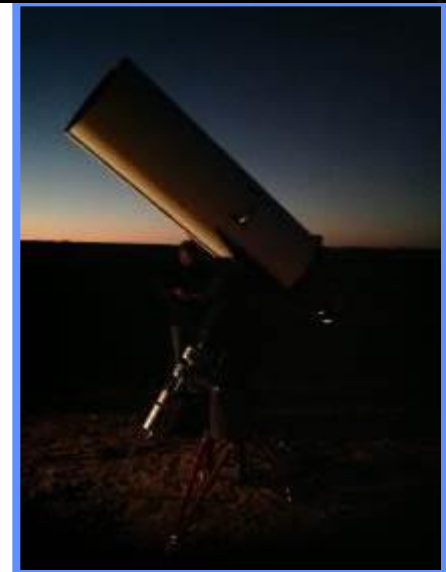


Photo by the author

**Space Data
Association**

Boeing
Photo

Elements that support control of space debris

- **International cooperation**
 - » **Inexpensive, but medium-term**
 - Not fixing existing problem, but for a better future
- **Data sharing, on an international basis**
 - » **Commercial Aerospace is global**
 - » **Inexpensive, short-term**
 - With some limitations
- **Additional Space Surveillance**
 - » **Inexpensive, short-term (ground-based)**
- **Debris Removal/Collision Avoidance**
 - » **Expensive, long-term**
 - But needs to be researched now...

International Cooperation

UN (HQ, NYC)

UNIDIR* (GVA)

-Space-related-

COPUOS (VIE)

Military/Disarmament issues

1959; 77 members, plus Observers (ISU)

Legal SC

-Secretariat is UNOOSA-

Science & Tech SC

Outer Space Treaties
Principles of use of NPS in space
Capacity building in Space Law
National mechanisms for space debris
National legislation on peaceful uses of space

Nuclear Power Systems
SPIDER+ (disaster management)
Space Debris
Space Weather
Use of GEO
Long-term sustainability

Decisions are reached by absolute consensus

+United Nations Platform for Space-based Information for Disaster Management and Emergency Response

UNOOSA= United Nations Office for Outer Space Affairs

*United Nations Institute for Disarmament Research

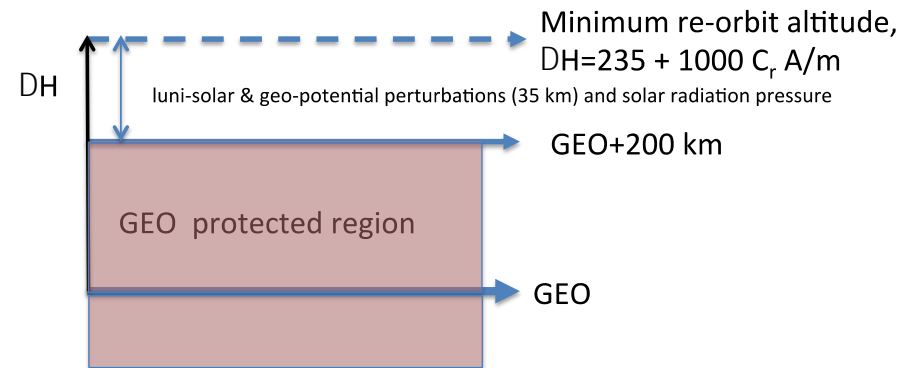
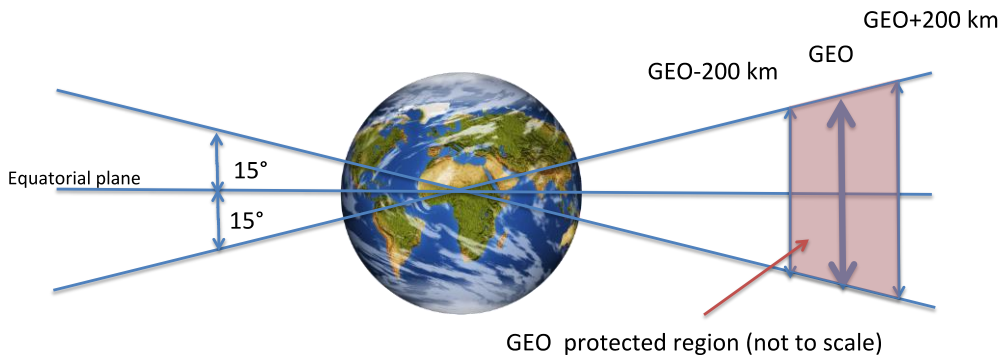
Geosynchronous region & post-mission disposal

GEO protected region¹:
Geostationary altitude ± 200 km
Equatorial latitude $\pm 15^\circ$

Post mission disposal for geosynchronous region²,
Height above GEO:
 $\Delta H = 235 \text{ km} + (1000 C_r A/m)^*$

$\epsilon \leq 0.003$

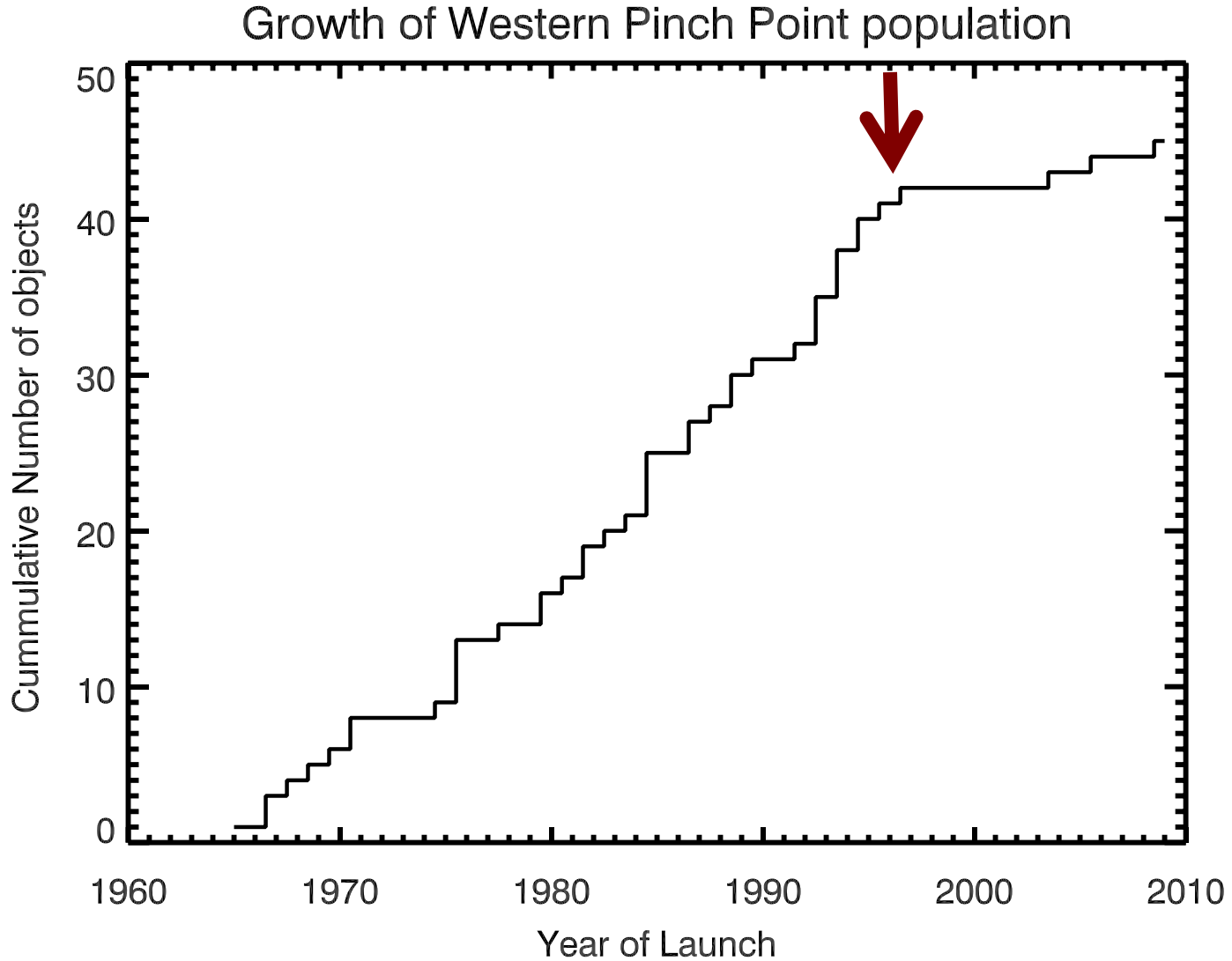
Graveyard orbit



¹IADC guideline 3.3.2
²IADC guideline 5.3.1

* C_r = solar radiation pressure coefficient,
 A/m = aspect area to dry mass ratio (m^2/kg)

How well are we doing at re-orbiting?





The existing public "Catalog"...

SATELLITE CATALOG:

Show entries Search All Columns:

NORAD CAT ID	SATNAME	INTLDES	TYPE	COUNTRY	LAUNCH	SITE	DECAY	PERIOD	INCL	APOGEE	PERIGEE	RCS	TLE
1	SL-1 R/B	1957-001A	ROCKET BODY	CIS	1957-10-04	TTMTR	1957-12-01	96.19	65.1	938	214	20.42	TLE OMM
2	SPUTNIK 1	1957-001B	PAYLOAD	CIS	1957-10-04	TTMTR	1958-01-03	96.1	65	945	227		TLE OMM
3	SPUTNIK 2	1957-002A	PAYLOAD	CIS	1957-11-03	TTMTR	1958-04-14	103.74	65.33	1659	211	0.08	TLE OMM
4	EXPLORER 1	1958-001A	PAYLOAD	US	1958-02-01	AFETR	1970-03-31	88.48	33.15	215	183		TLE OMM
5	VANGUARD 1	1958-002B	PAYLOAD	US	1958-03-17	AFETR		132.79	34.26	3840	648	0.1187	TLE OMM
6	EXPLORER 3	1958-003A	PAYLOAD	US	1958-03-26	AFETR	1958-06-28	103.6	33.5	1739	117		TLE OMM
7	SL-1 R/B	1958-004A	ROCKET BODY	CIS	1958-05-15	TTMTR	1958-12-03	102.74	65.14	1571	206		TLE OMM
8	SPUTNIK 3	1958-004B	PAYLOAD	CIS	1958-05-15	TTMTR	1960-04-06	88.43	65.06	255	139	11.84	TLE OMM
9	EXPLORER 4	1958-005A	PAYLOAD	US	1958-07-26	AFETR	1959-10-23	92.81	50.25	585	239		TLE OMM
10	SCORE	1958-006A	PAYLOAD	US	1958-12-18	AFETR	1959-01-21	98.21	32.29	1187	159		TLE OMM

Showing 1 to 10 of 39,627 entries
[Country Legend](#) [Launch Site Legend](#)

Navigation: First Previous **1** 2 3 4 5 Next Last

"TLE" for the ISS:

```

0 ISS (ZARYA)
1 25544U 98067A 14094.03144353 -.00138552 00000-0 -24245-2 0 65
2 25544 051.6463 107.0810 0003978 337.2202 062.8076 15.50434083879826

```

Catalog incomplete, missing useful information (AMR, covariance)

Solving the problem- moving beyond the SSN





What could be done that would be a better fit to limited resources?

Data Sharing... for active space objects

Space Data Association

Multi-national, open to all space operators in all orbital regimes

Current Participants:

- 24 contributing operators (includes Intelsat, Inmarsat, SES, etc.)
- 3 civil satellite operators (includes NASA, NOAA, Eumetsat)

- Possible source of “free” information on active space objects
- But care needs to be maintained to protect IP

Feb. 2015 proposal for a UN space object data sharing centre...

A/AC.105/C.1/2015/CRP.32

9 February 2015

English only

Committee on the Peaceful
Uses of Outer Space
Scientific and Technical Subcommittee
Fifty-second session
Vienna, 2-13 February 2015
Long-term sustainability of outer space activities

Proposal on the review and consideration of the concept of a United Nations information platform serving common needs in collecting and sharing formation on near-Earth space monitoring in the interests of safety of space operations, and its architectural and programmatic aspects

Working paper submitted by the Russian Federation

This proposal, and the reaction to it, has led to the establishment of a new UN COPUOS Expert Group at the June 2015 meeting to study the issue of space data sharing

- 1. This Working paper has been prepared in the context of the continuing discussion within the STSC Working Group on the Long-Term Sustainability of Outer Space Activities of concepts of information support aimed at meeting common needs in the field of safety of space operations and developing procedures for maintaining informational awareness of States and international intergovernmental organizations of objects and events in outer space.
- 2. The Russian Federation, having proposed for consideration the basic elements of the concept of establishing a unified Centre for Information on Near-Earth Space Monitoring under the auspices of the United Nations... without prejudice to the functionality and feasibility of any other forms of developing and leveraging capabilities to support the objective of information sharing in this area.
- 3. It may be presumed that a United Nations information platform could potentially be accommodated within the United Nations Office for Outer Space Affairs (OOSA)...
- 4. It is also presumed that the initial implementation phase of establishing a platform may involve gathering, collation and dissemination of information on monitoring space objects and events using information connectivity to interested States and authorized users...

What existing models do we have for this?

Proposed: International Space Object Data Exchange (ISODEX)
Existing organizations we can look to:

Minor Planet Center (MPC)

- Following 120,000 natural space objects with 6 FTEs
- NASA, IAU ties



Int'l GNSS Service (IGS)

- Voluntary federation of >200 int'l entities to share GNS data
- Participant funded



ISODEX

- Crowd-sourced observations
- UN COPUOS, IADC ties
- Funded by participants (cash or in-kind)
- Virtual, International, non-profit LLC

Space Data Association
23 Commercial Operators
3 Civil Space Agencies
Participant funded
Isle of Man Limited Corp.

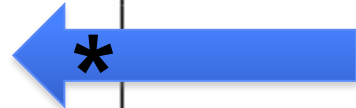
But isn't a large, expensive telescope required?



<http://www.tmt.org/gallery/>
photo-illustrations

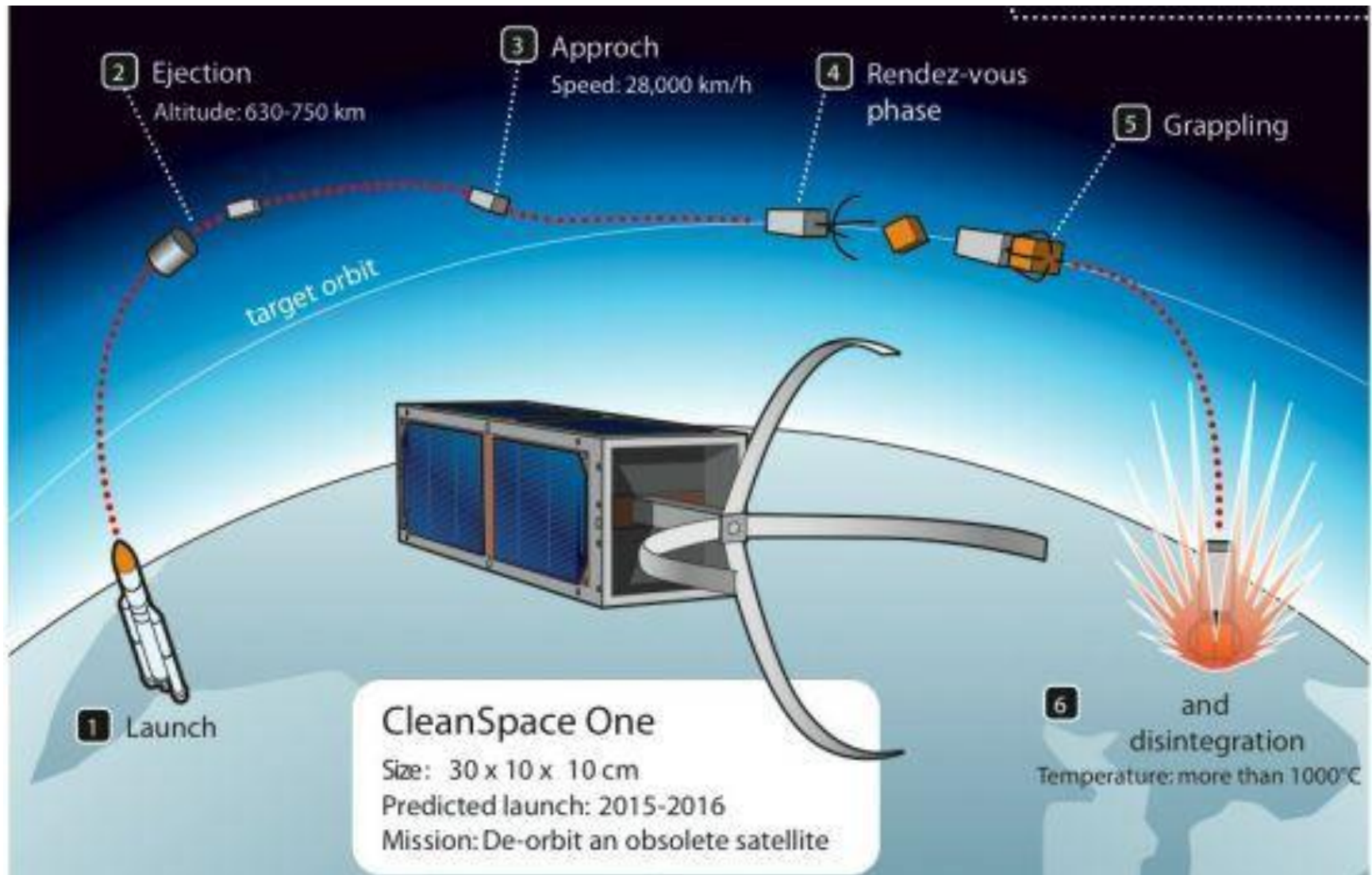


Euro 50	50 m	2035?
TMT	30 m	2030?
GMT	21.4 m	2024
Gran Telescopio Canarias (GTC)	10.4 m	2009
Keck 1	10 m	1993
BTA-6	6 m	1976
Hale Telescope (200 inch)	5.08 m	1948
Hooker 100-Inch Telescope	2.54 m	1917
Leviathan of Parsonstown	1.83 m	1845
Herschel 40-foot (126 cm d.)	1.26 m	1789–1815
Rev John Michell's Gregorian reflector	75 cm	1780–1789
Fr Noel's Gregorian reflector	60 cm	1761
James Short's Gregorian reflector	50 cm	1750
James Short's Gregorian reflector	38 cm	1734
Christiaan Huygens 210 foot refractor	22 cm	1686
Christiaan Huygens 170 foot refractor	20 cm	1686
Christiaan Huygens 210 foot refractor	19 cm	1686
Hooke's reflector	18 cm	16??
Hevelius refractor	12 cm	1645
Hevelius Scheiner's helioscope	6 cm	1638
Galileo's 1620 telescope	3.8 cm	1638
Galileo's 1612 telescope	2.6 cm	1612
Galileo's 1609 telescope	1.5 cm	1609



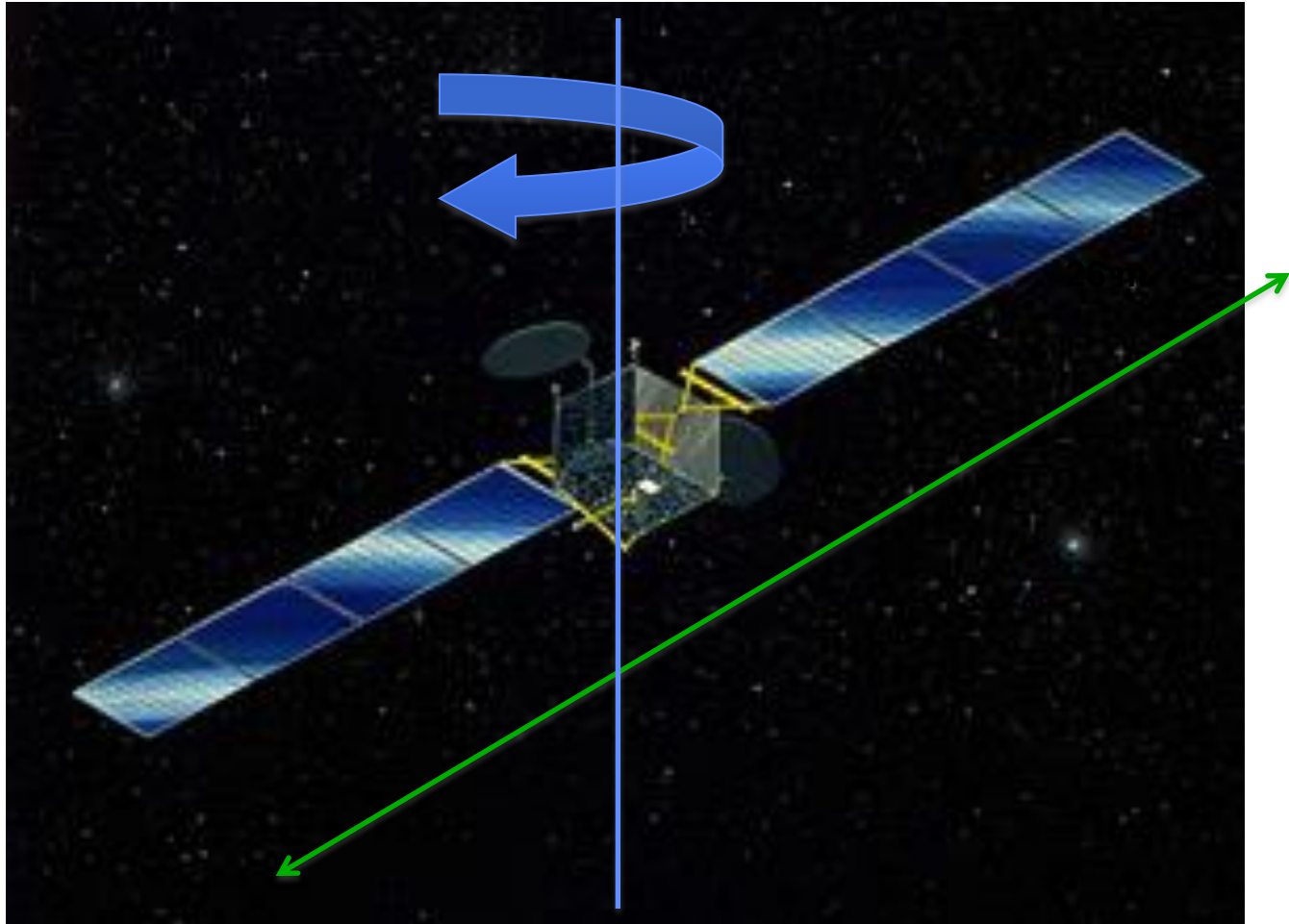
*But need a sensitive CCD camera (happily, a Moore's law device)

Active Debris Removal (ADR)



One "hard" technical problem with ADR...

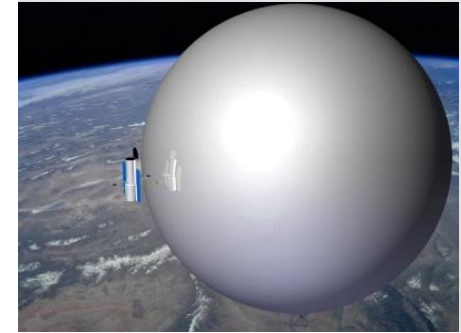
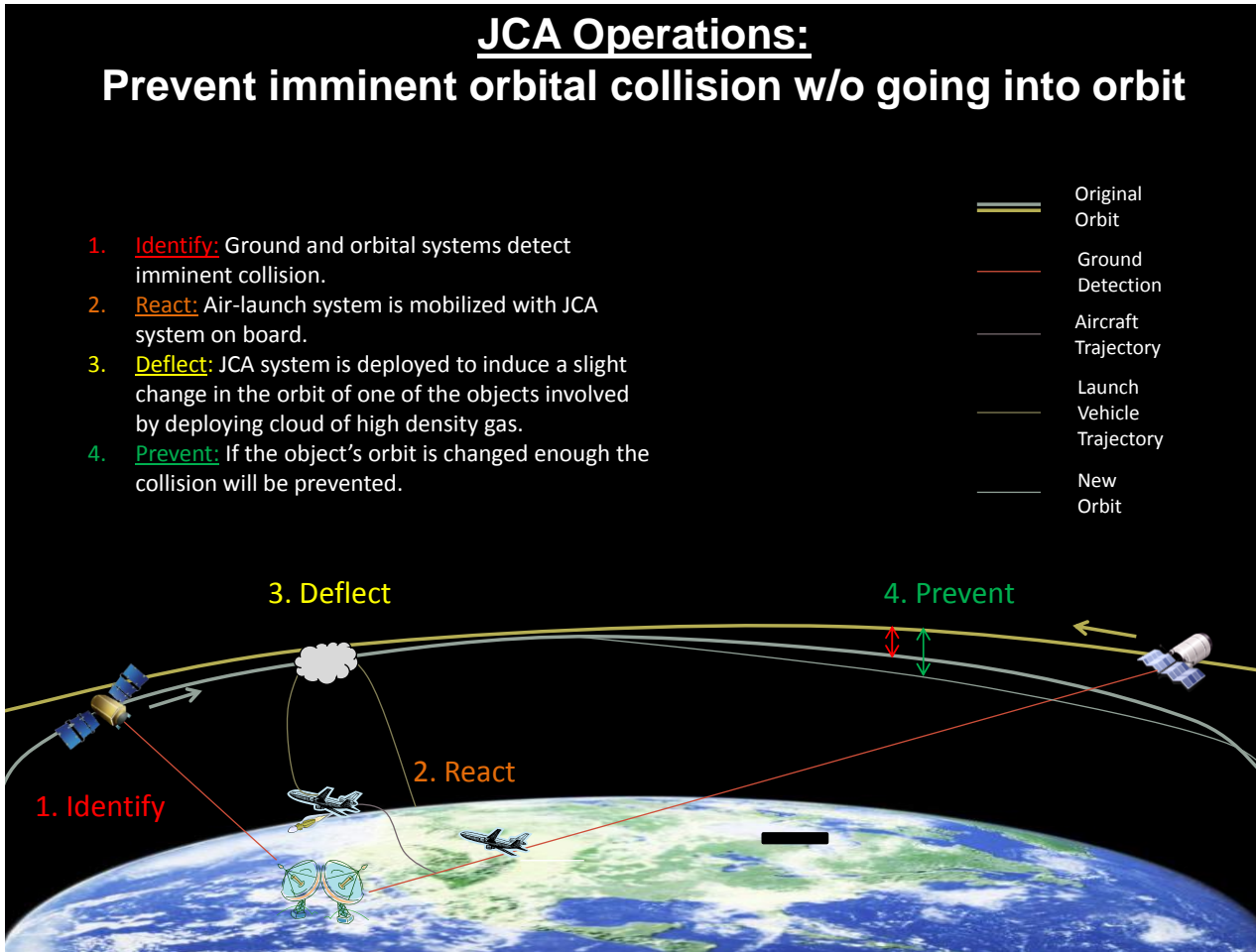
- Most defunct payloads, rocket bodies, and debris pieces are spinning/tumbling.
- "Non-cooperative"
- 0.33-20 RPM:
~30 km/hour
- Would require extraordinary amounts of energy (Δv) to capture and remove



Yaw spin

Boeing image

ADR alternatives....



<http://www.gaerospace.com/projects/GOLD/index.html>, accessed 5/15/14

So where should we spend the next dollar?

- **Additional SSA capabilities provide most efficient use of any additional funding**
 - » There are potentially many sources of new data that aren't being exploited
- **Need to share data on debris internationally**
 - » **New low-cost *Space Debris Data Center***
- **Continue international discussions to develop best practices & guidance**
- **Research into how to accomplish collision avoidance and/or debris removal**

CONCLUSIONS

- **Space debris is caused by us**
- **10,000's of objects & growing**
- **Danger to the near-Earth space environment and the long-term sustainable use of space**
- **Danger to humans; astronauts and people on the ground**
- **Studied by governments and industry**
- **Under international discussion**
- **Need to do something now and in the future-**
- **multi-phased approaches**
- **Need better knowledge of objects in space**
- **collect more and distribute it better**