About OMICS Group

OMICS Group International is an amalgamation of Open Access publications and worldwide international science conferences and events. Established in the year 2007 with the sole aim of making the information on Sciences and technology 'Open Access', OMICS Group publishes 400 online open access scholarly journals in all aspects of Science, Engineering, Management and Technology journals. OMICS Group has been instrumental in taking the knowledge on Science & technology to the doorsteps of ordinary men and women. Research Scholars, Students, Libraries, Educational Institutions, Research centers and the industry are main stakeholders that benefitted greatly from this knowledge dissemination. OMICS Group also organizes 300 International conferences annually across the globe, where knowledge transfer takes place through debates, round table discussions, poster presentations, workshops, symposia and exhibitions.

About OMICS Group Conferences

OMICS Group International is a pioneer and leading science event organizer, which publishes around 400 open access journals and conducts over 300 Medical, Clinical, Engineering, Life Sciences, Pharma scientific conferences all over the globe annually with the support of more than 1000 scientific associations and 30,000 editorial board members and 3.5 million followers to its credit.

OMICS Group has organized 500 conferences, workshops and national symposiums across the major cities including San Francisco, Las Vegas, San Antonio, Omaha, Orlando, Raleigh, Santa Clara, Chicago, Philadelphia, Baltimore, United Kingdom, Valencia, Dubai, Beijing, Hyderabad, Bengaluru and Mumbai.

Orbital Debris:
Where do we focus our limited resources?
A view from the field.

Mech-Aero 2015

October 5-7 2015

Dr. Mark A. Skinner

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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

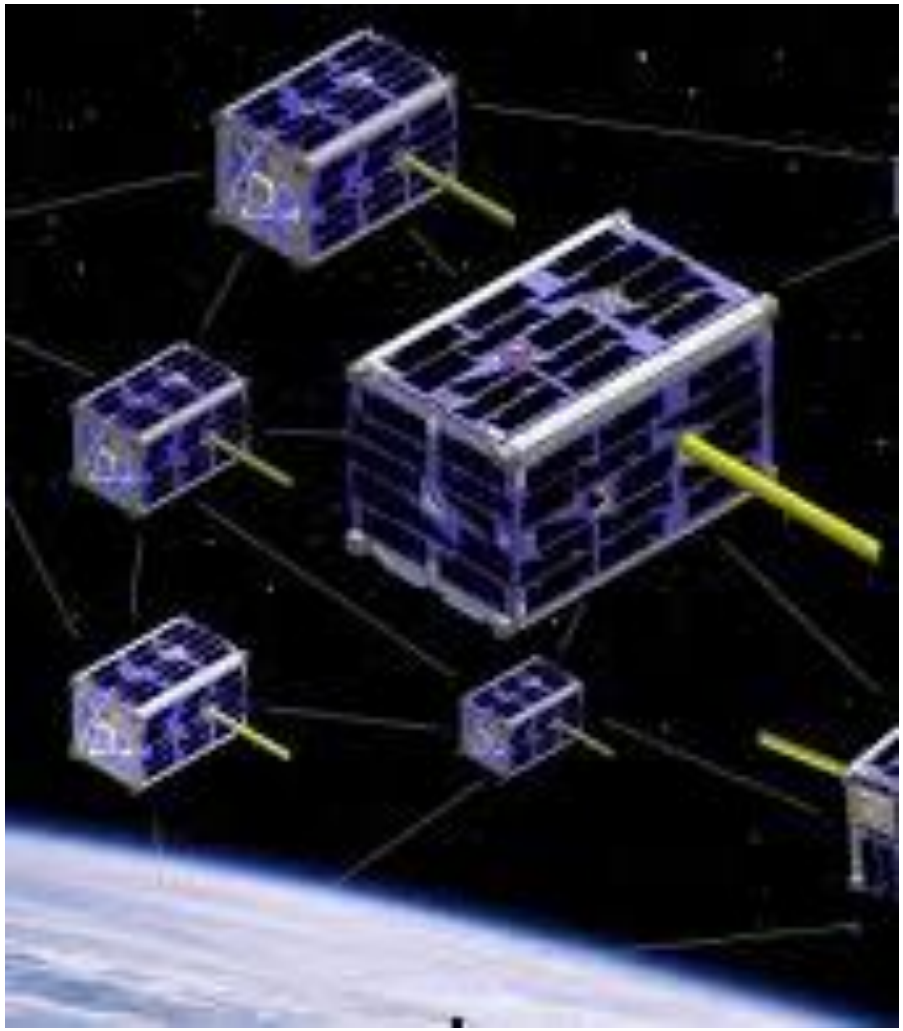
Movement from handful of space actors to much larger number, with more wanting to join: Bi-lateral -> Multi-lateral

State/Military -> Commercial/Non-state actors

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

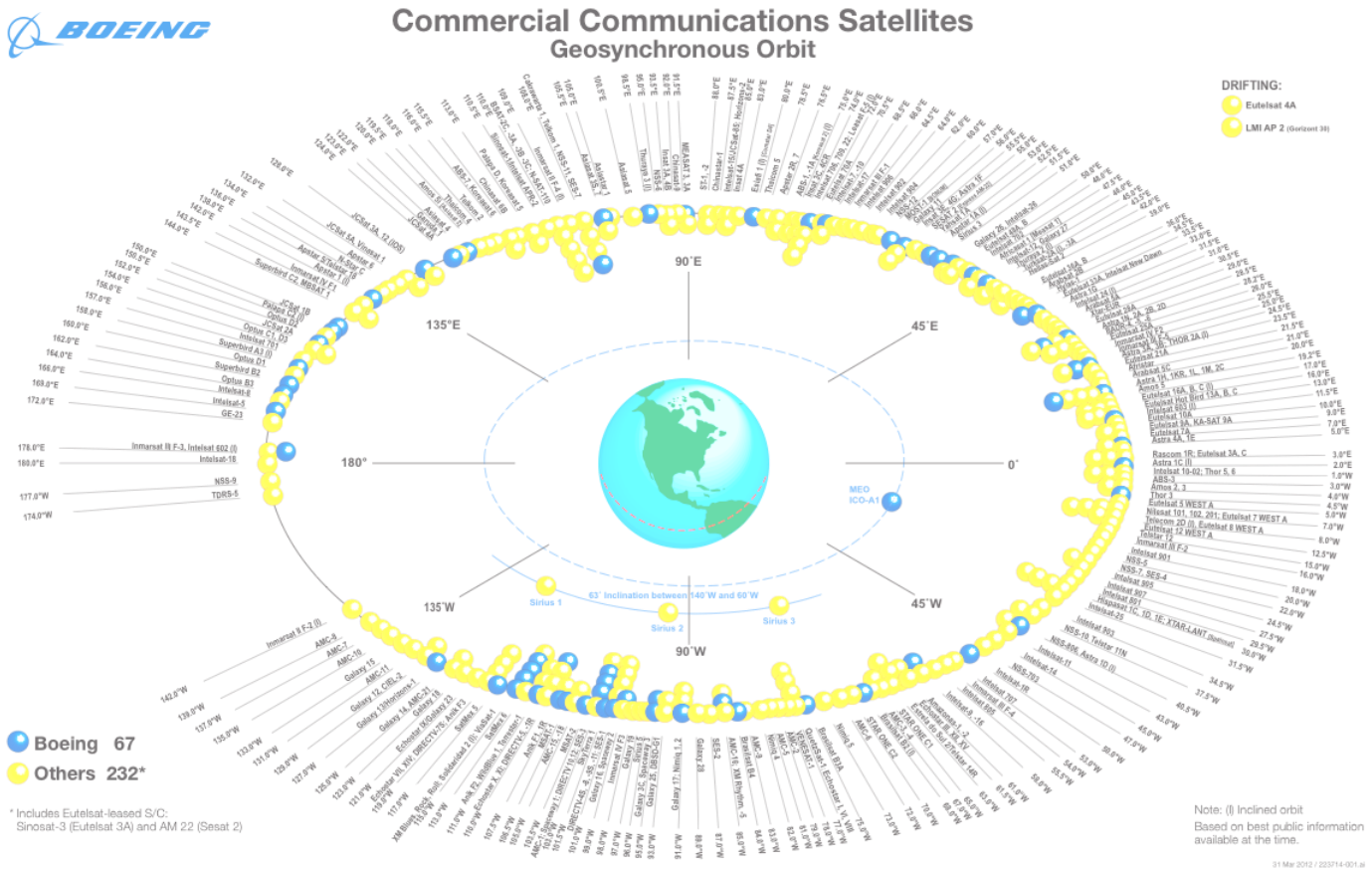
Expensive/Big -> Cheaper/Small = More Stuff

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?

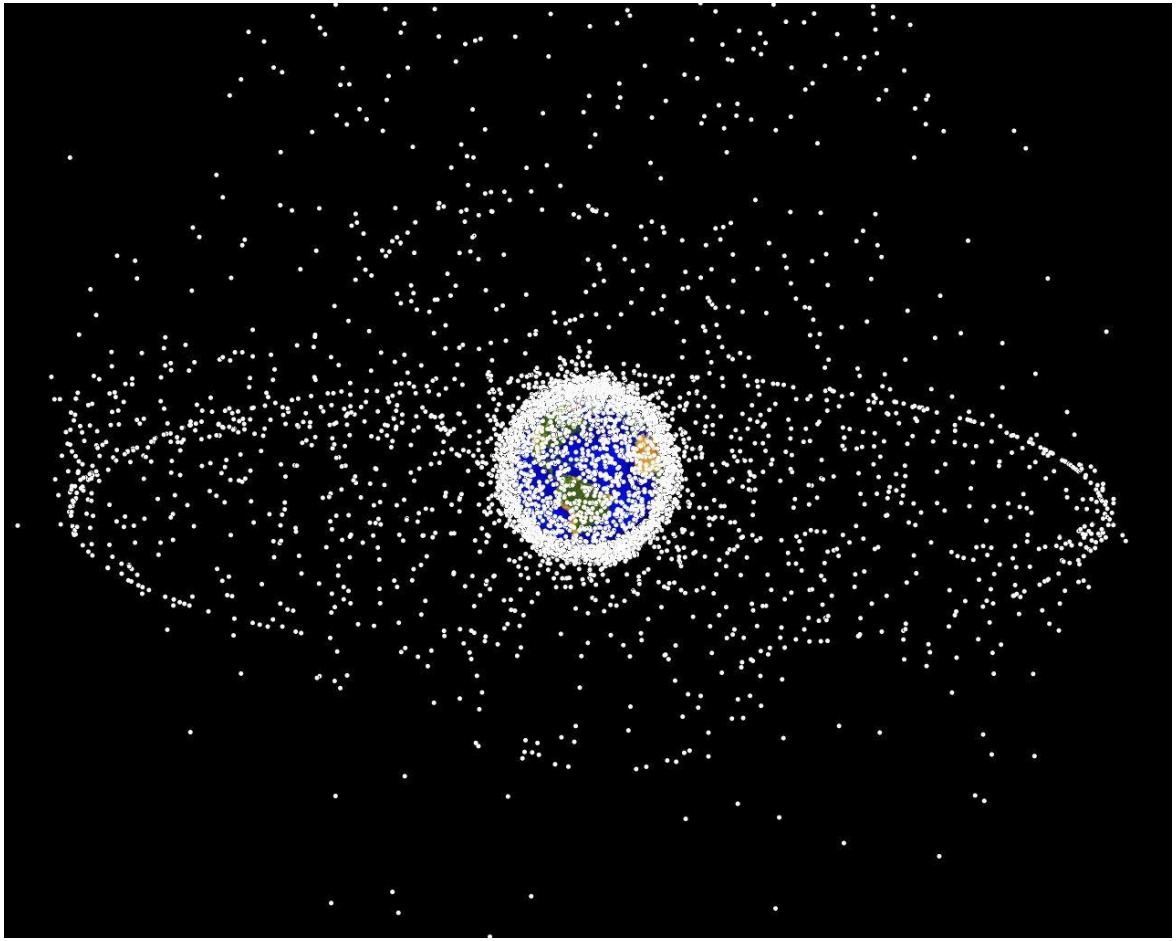


www.boeing.com/defense-space/space/bss/launch/980031_001.pdf, retrieved 6/15/2012

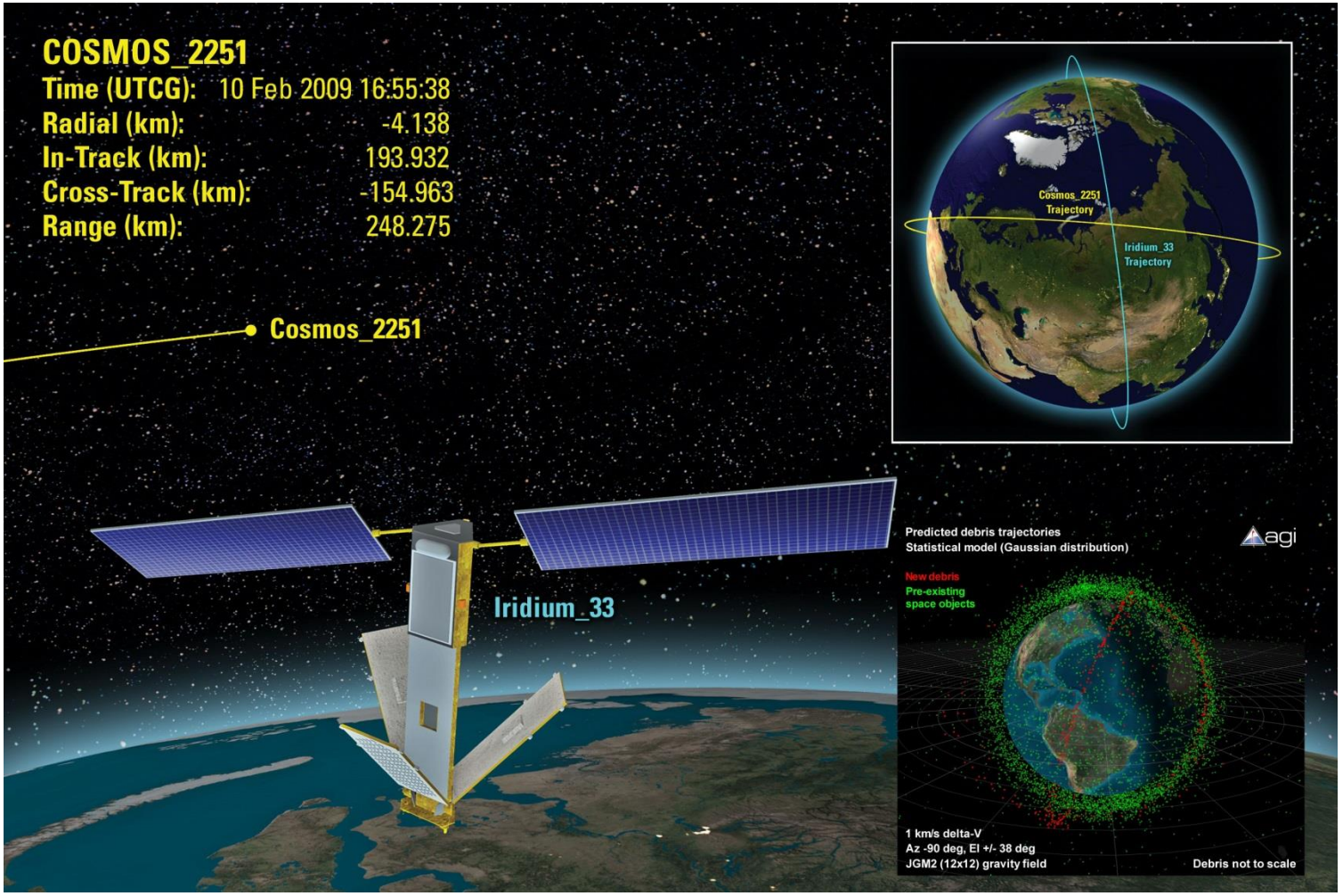
Man-made debris dominates Earth's near-space region

- Computer-generated images shows objects currently tracked by US Space Command
- 95% of objects in image are space debris
- There exist additional debris populations at GEO that are not shown on this image

- Image courtesy of the NASA Orbital Debris Program Office
- http://orbitaldebris.jsc.nasa.gov/photogallery/beehives, accessed 4/12/2012

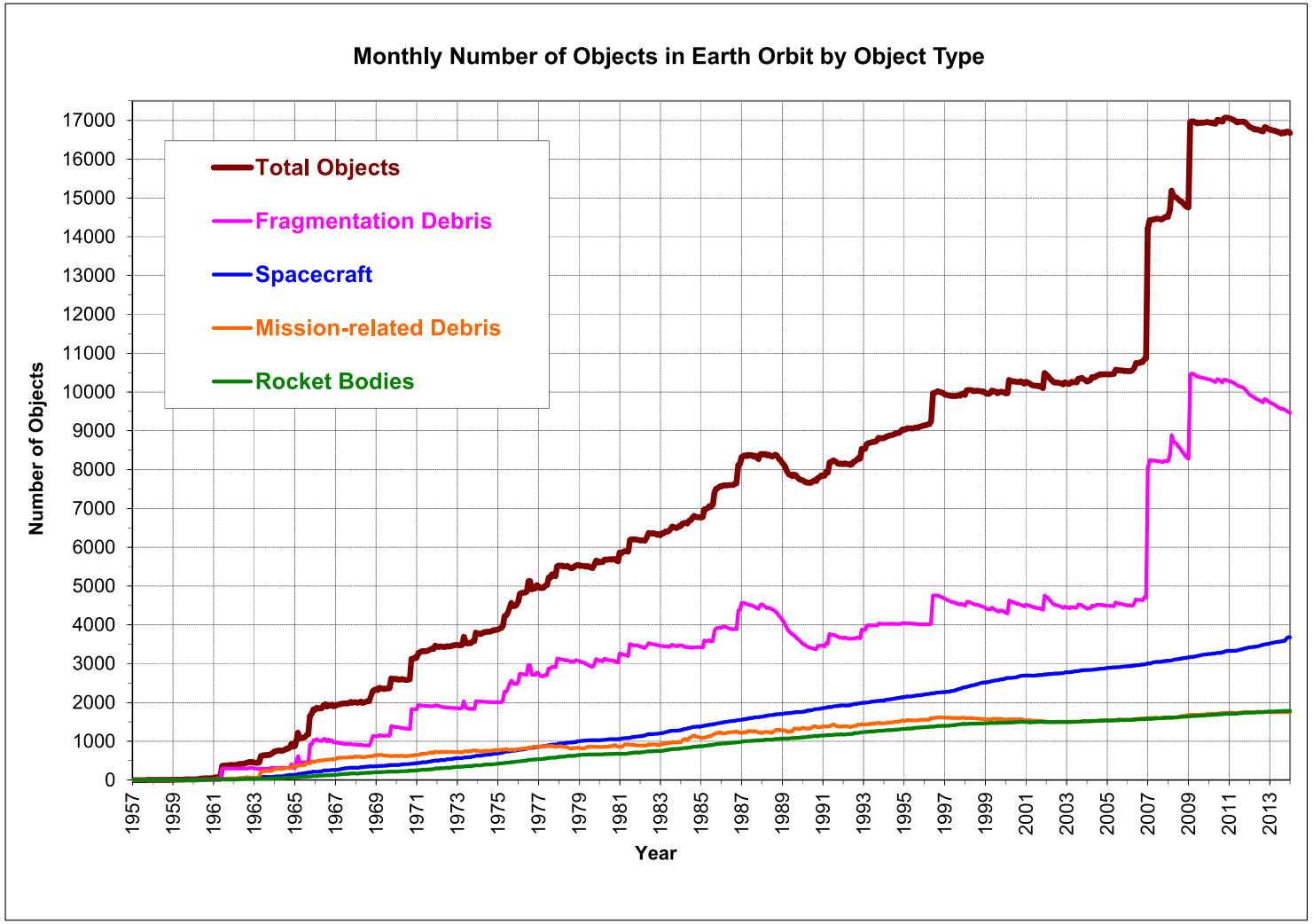


How to create more space debris…



http://blogs.agi.com/agi/tag/iridiumcosmos/, accessed 4/3/14. Used by permission.

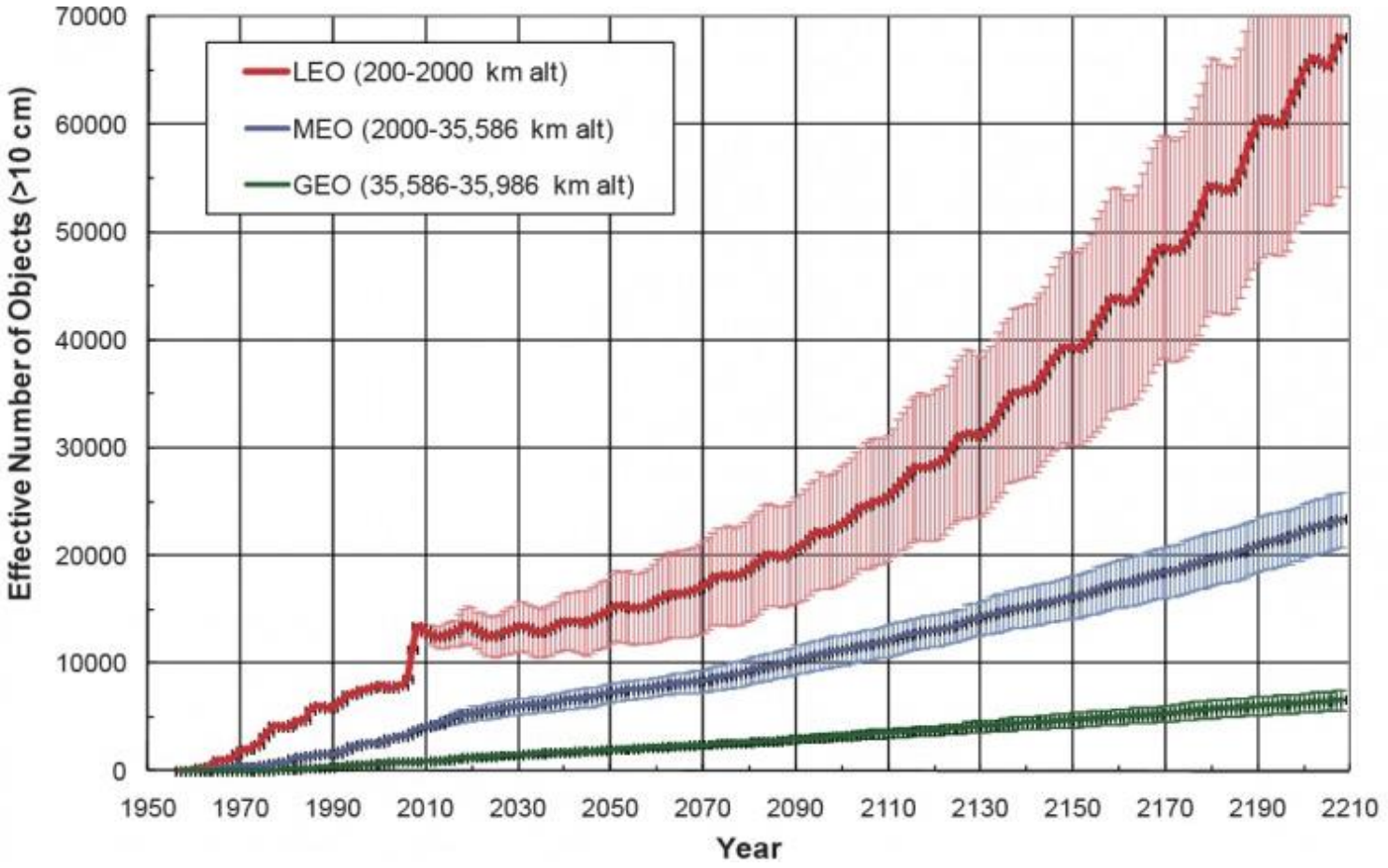
How is the amount changing over time?



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.

Courtesy NASA Orbital Debris Program Office: Orbital Debris Quarterly News, Vol. 18, issue 1, January 2014.

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



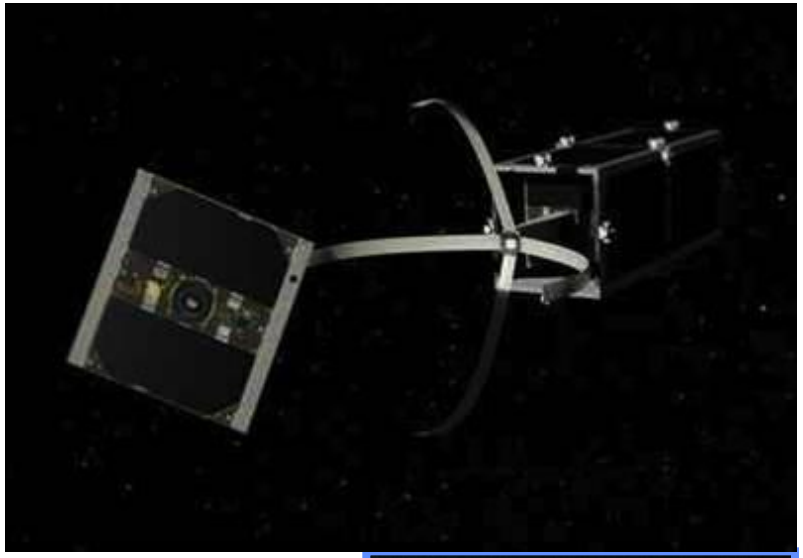
Courtesy NASA Orbital Debris Program Office, Orbital Debris Quarterly News, Vol. 14, Issue 1, Jan. 2010

What can we do about space debris?

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



Photo by the author



http://www.minorplanetcenter.net/,
Accessed 2/2/14



Boeing Photo

Space Data Association

Range of options, and their relative costs and time-scales

- **International cooperation**
  - » **Inexpensive, but medium-term**
    - – **Not fixing existing problem, but for a better future**
- **Data sharing**
  - » **Inexpensive, short-term**
    - – **With some limitations**
- **Additional SSA**
  - » **Inexpensive, short-term**
- **Debris Removal**
  - » **Expensive, long-term**
    - – **But needs to be researched now…**

International Cooperation

UN (HQ, NYC)

UNIDIR* (GVA)

Military/Disarmament issues

-Space-related-

COPUOS (VIE)

1959; 77 members

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

*United Nations Institute for Disarmament Research

UNOOSA= United Nations Office for Outer Space Affairs

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

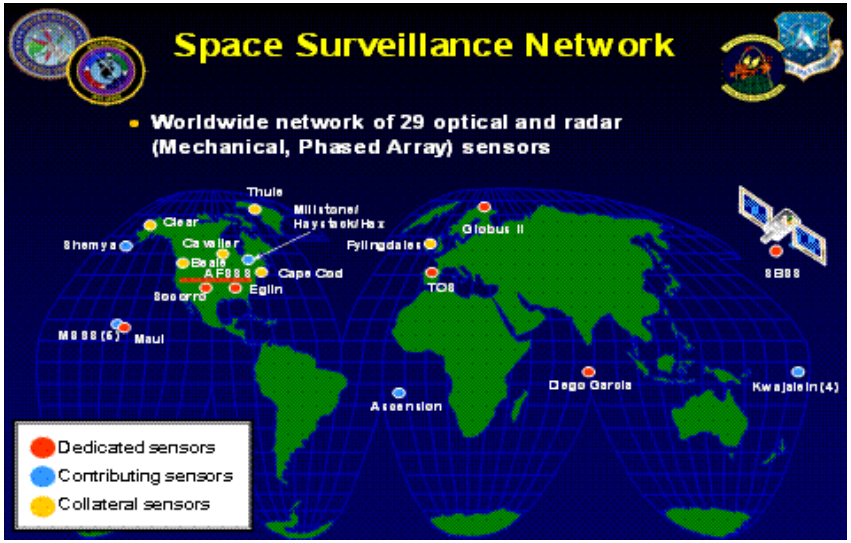
Proposal on the review and consideration of the concept of a United Nations information platform serving common needs in collecting and sharing formation on near-Earth space monitoring in the interests of safety of space operations, and its architectural and programmatic aspects

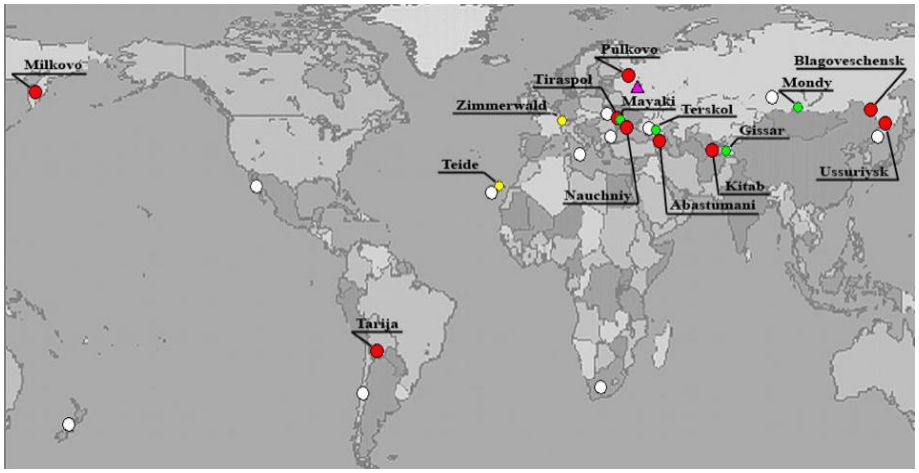
Working paper submitted by the Russian Federation

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…**

SSA & Space Surveillance





http://www.stratcom.mil/factsheets/USSTRATCOM_Space_Control_and_Space_Surveillance/, retrieved 6/15/2012

Perek , Luboš, "*Actual Situation in the Geostationary Orbit*," 49th session of the UN COPUOS Scientific and Technical Subcommittee, Vienna Feb 2012

- **Space Command maintains catalog of space objects**
  - » **Utilizes ground-based optical & radar, space-based optical**
- **ISON has a network of small telescopes**
- **Emerging commercial SSA networks**

The "Catalog"…

SATELLITE CATALOG:

Show 10 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
NORAD	SATNAME	INTLDES	TYPE	COUNTRY	LAUNCH	SITE	DECAY	PERIOD	INCL	APOGEE	PERIGEE	RCS	

Showing 1 to 10 of 39,627 entries First Previous 1 2 3 4 5 Next Last

Country Legend Launch Site Legend

"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
```

Solving the problem- moving beyond the SSN



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, Telesat, SES, etc.)**
- **3 civil satellite operators (includes NASA, NOAA, Eumetsat)**

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.

Minor Planet Center logo used by permission.

But isn't a large, expensive telescope required?

NO! A 40 cm. t/s can detect a ~1 m^2 object at GEO.
That size has been available since the 1700's.



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



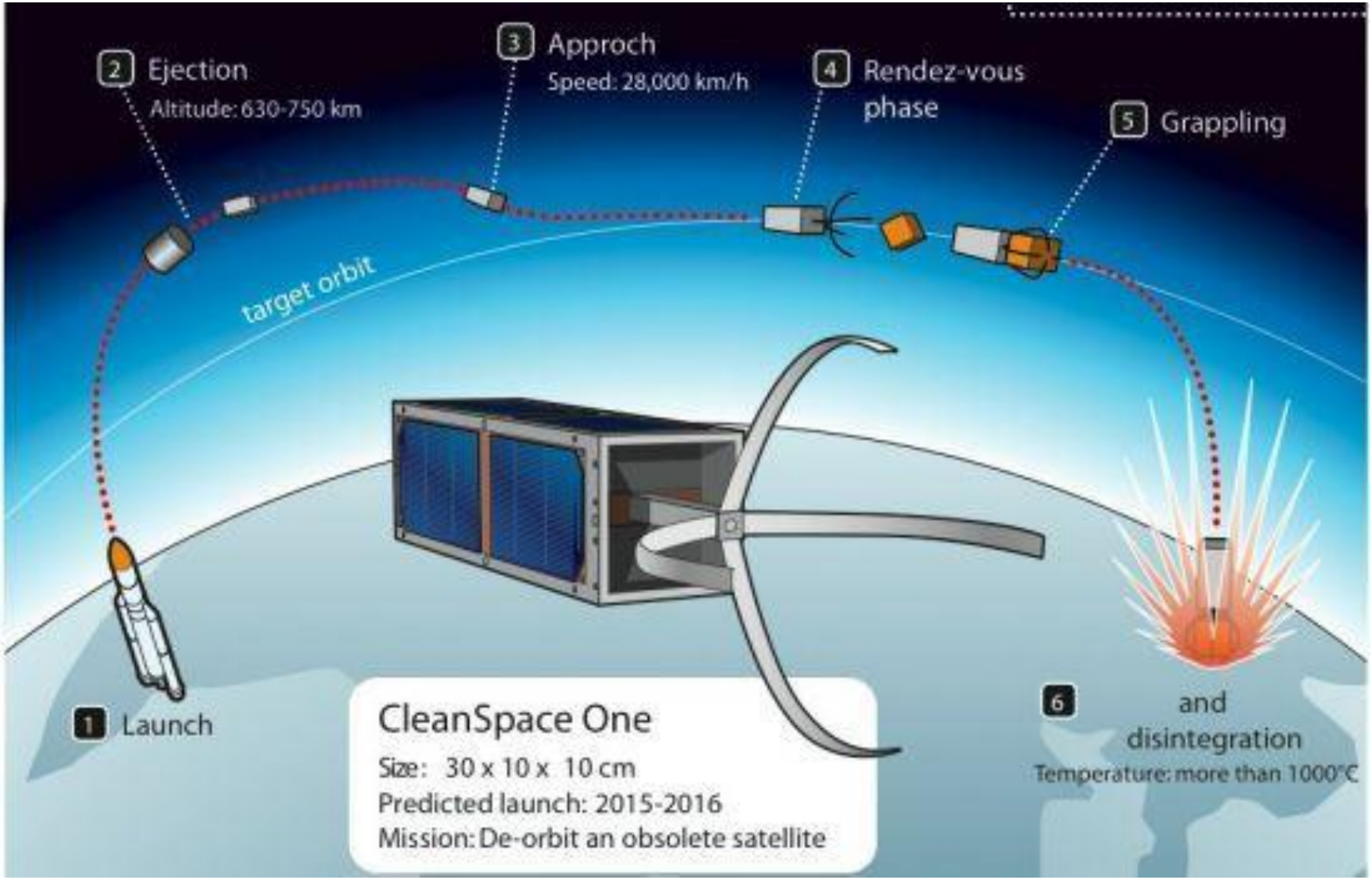


Euro 50	50 m	2035?
TMT	30 m	2030?
GMT	21.4 m	2024
Gran Telescopio Canarias (GTC)	10.4 m	2009
Keck 1	10 m	1993
BTA-6	6 m	1976
Hale Telescope (200 inch)	5.08 m	1948
Hooker 100-Inch Telescope	2.54 m	1917
Leviathan of Parsonstown	1.83 m	1845
Herschel 40-foot (126 cm d.)	1.26 m	1789–1815
Rev John Michell's 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)

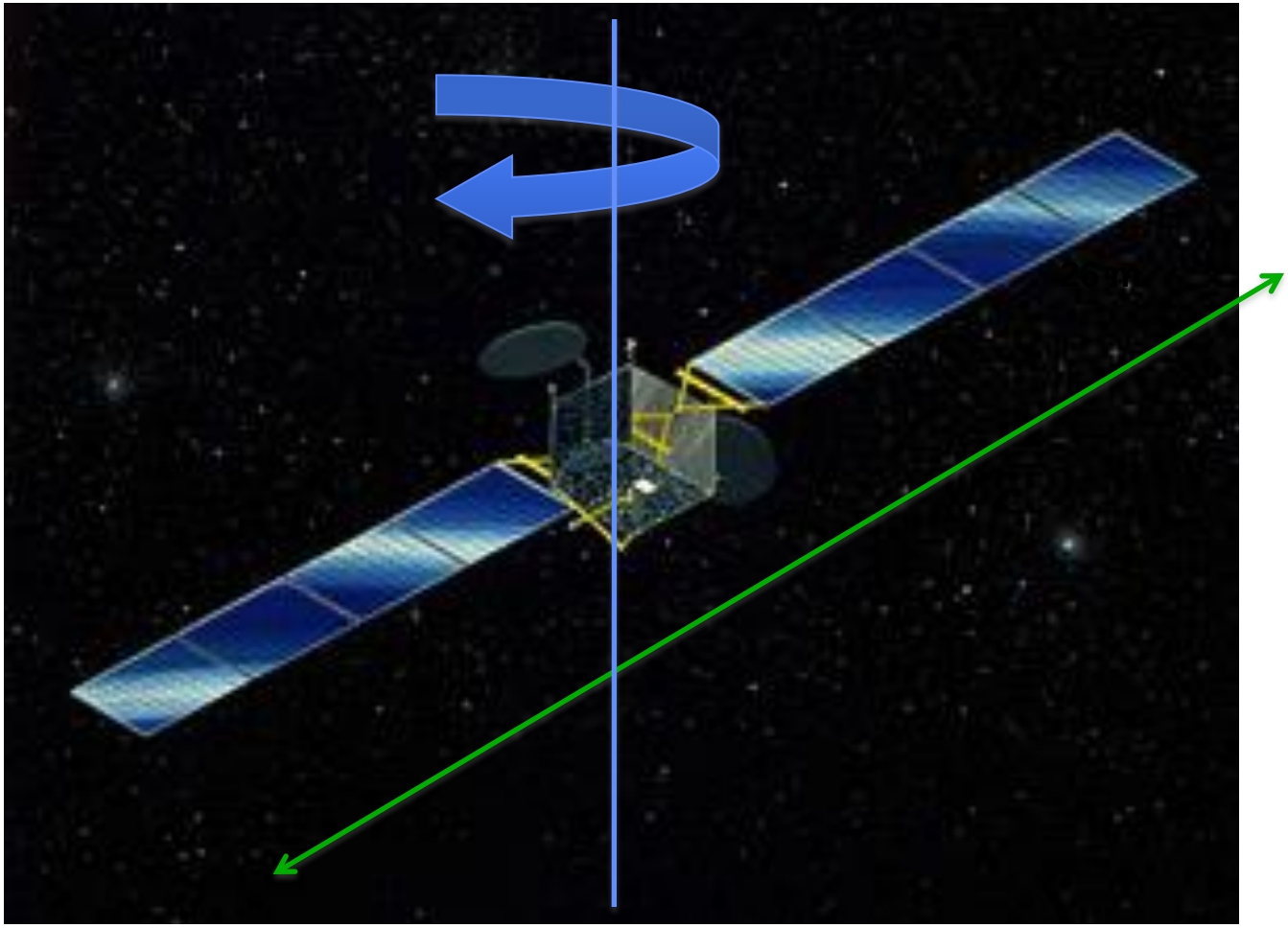
Active Debris Removal (ADR)



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

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



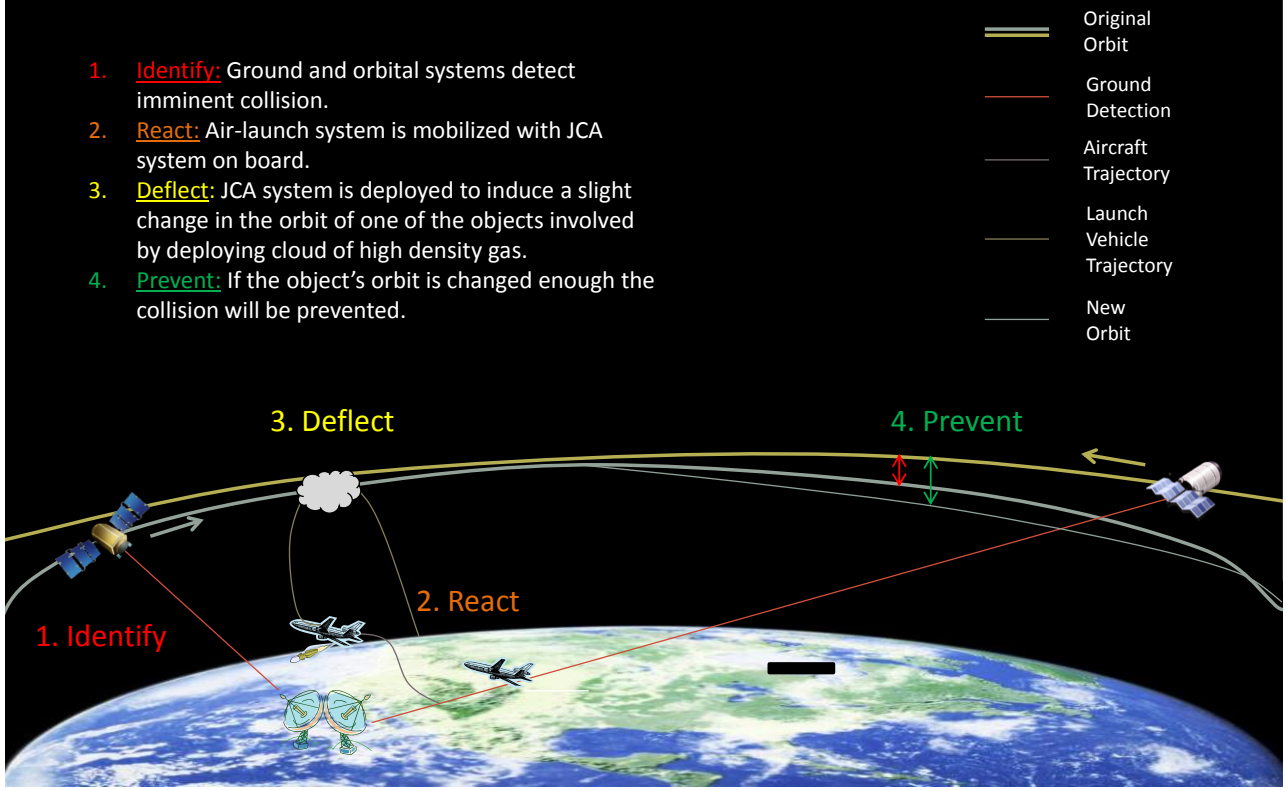
Yaw spin

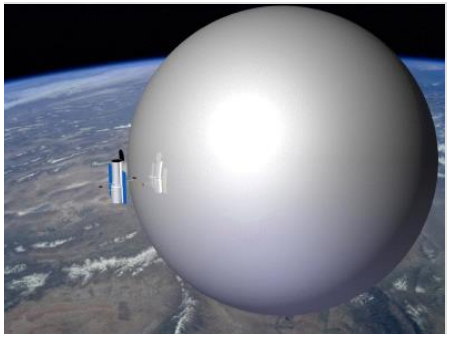
Boeing image

ADR alternatives….

JCA Operations:
Prevent imminent orbital collision w/o going into orbit

1. Identify: Ground and orbital systems detect imminent collision.
2. React: Air-launch system is mobilized with JCA system on board.
3. Deflect: JCA system is deployed to induce a slight change in the orbit of one of the objects involved by deploying cloud of high density gas.
4. Prevent: If the object's orbit is changed enough the collision will be prevented.





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

Image courtesy: Dr. Darren McKnight, SYSTEM ENGINEERING ANALYSIS OF DERELICT COLLISION PREVENTION OPTIONS, 63rd International Astronautical Congress, Naples, IT; October 2012. Used by permission.

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