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Panel on the Challenge of Orbital Debris

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Session Moderator

Space Studies Board
National Academies of Sciences, Engineering, Medicine
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A little history of “man”-made debris

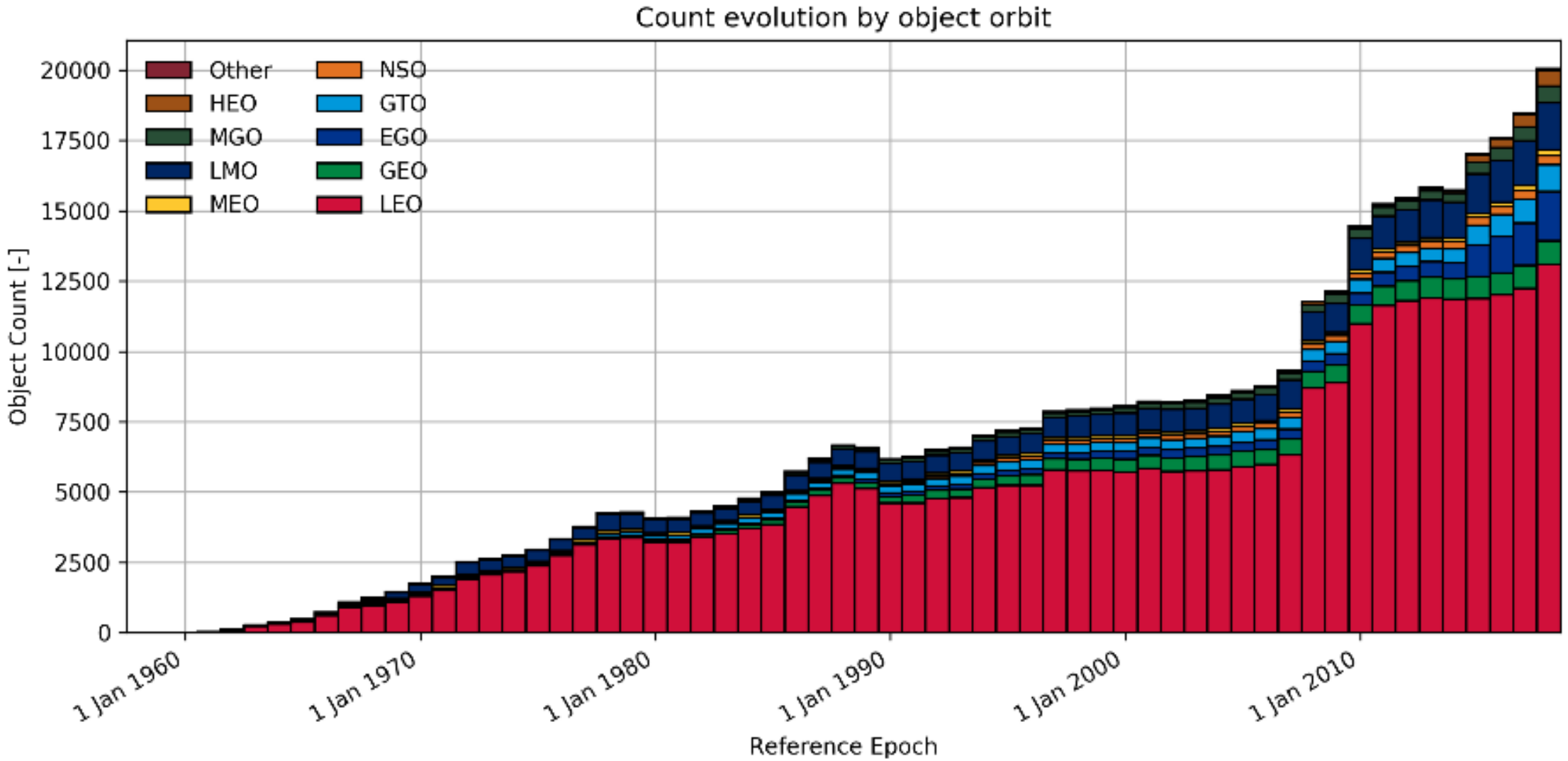
- Vanguard-I, launched in 1958 may be the first piece of debris in space (in MEO and expected to remain there for 200 more years)
- Humans created debris first time out the door – astronaut Ed White lost a glove on the first American EVA (Gemini 4, 1965)
- Since then…
  - ~300 in-orbit fragmentation events have been recorded since 1961
  - Few collisions - <10 accidental and intentional events
    - A privately owned American communication satellite, Iridium-33, and a Russian military satellite, Kosmos2251, collided at 11.7 km/s, both destroyed, and more than 2300 trackable fragments generated
  - Majority of the events were explosions of spacecraft and upper stages
    - US and Soviet Union ASATs (1968-1985)
    - Chinese FengYun-1C engagement in January 2007 alone created 3000 pieces of debris, and increased the trackable space object population by 25%.

Sources: History of Space Debris, Loretta Hall, ESA website: https://www.esa.int/Our_Activities/Operations/Space_Debris/About_space_debris

Other interesting debris events

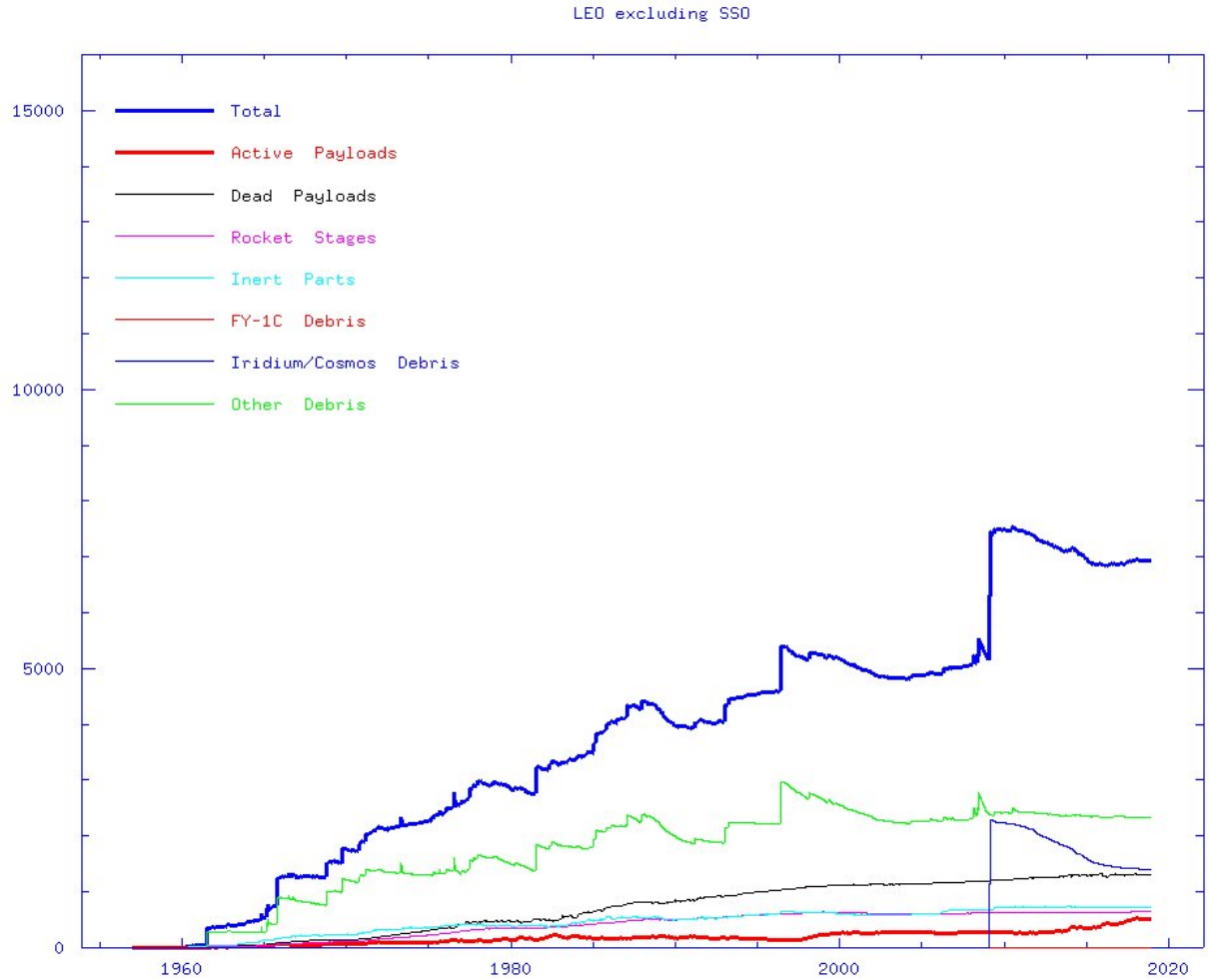
- Ejection of reactor cores from Buk reactors
  - 16 such ejection events
  - Droplets of reactor coolant liquid released into space
- Release of thin copper wires as part of a radio communication experiment (create a passive radio reflector) by MIT Lincoln Lab in the 1960s 1961 and 1963 to create an artificial ionosphere above the Earth – payload failed to disperse as planned, and 7 objects were catalogued as debris (still in orbit at 3,600 km)
- Most important non-fragmentation debris source: >2,400 solid rocket-motor firings, which have released Al_2O_3 in the form of micrometer--sized dust and mm- to cm-sized slag particles

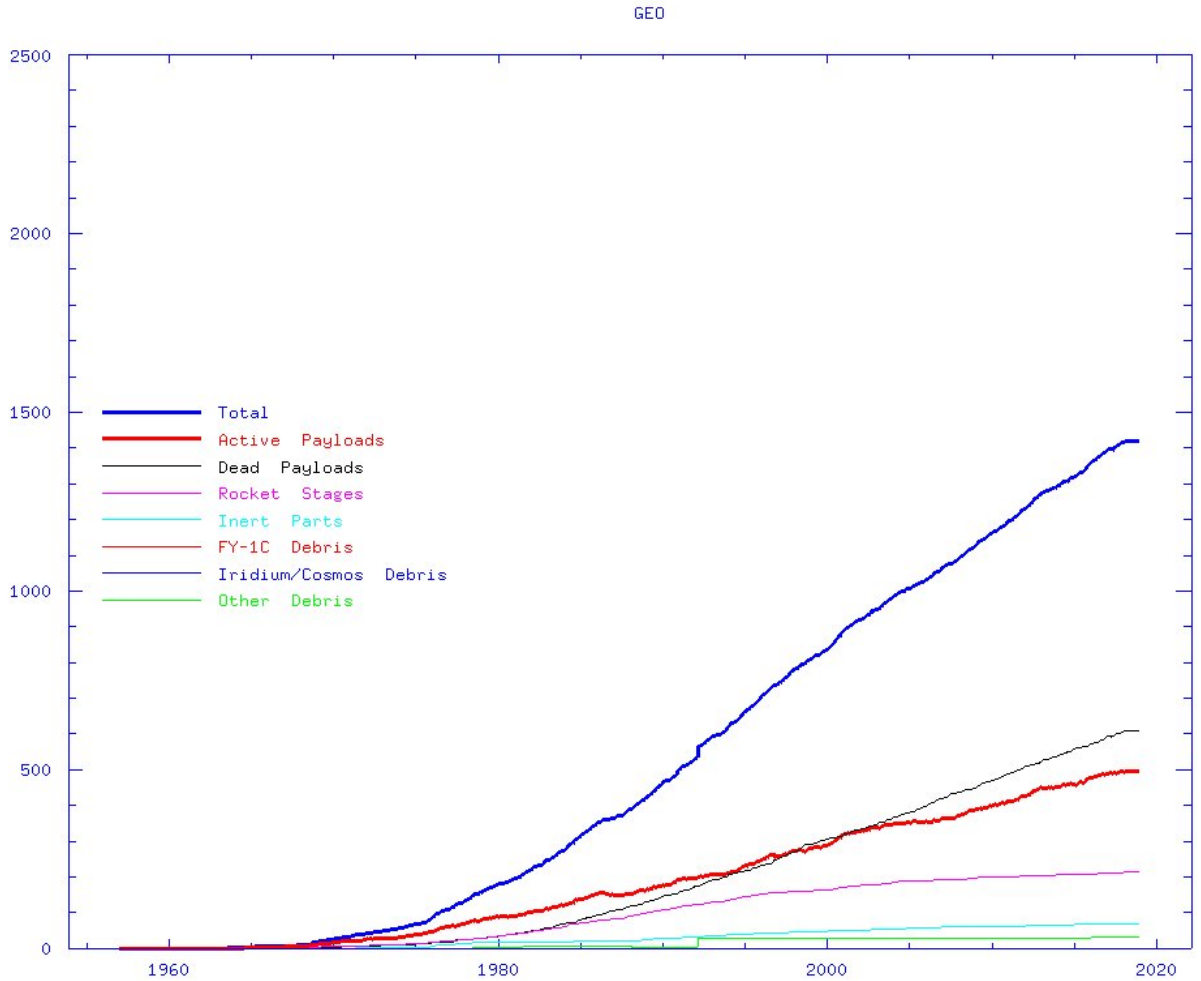
Where is the debris?



Source: https://www.esa.int/spaceinimages/Images/2017/04/Evolution_of_space_object_population

LEO and GEO have different types of debris

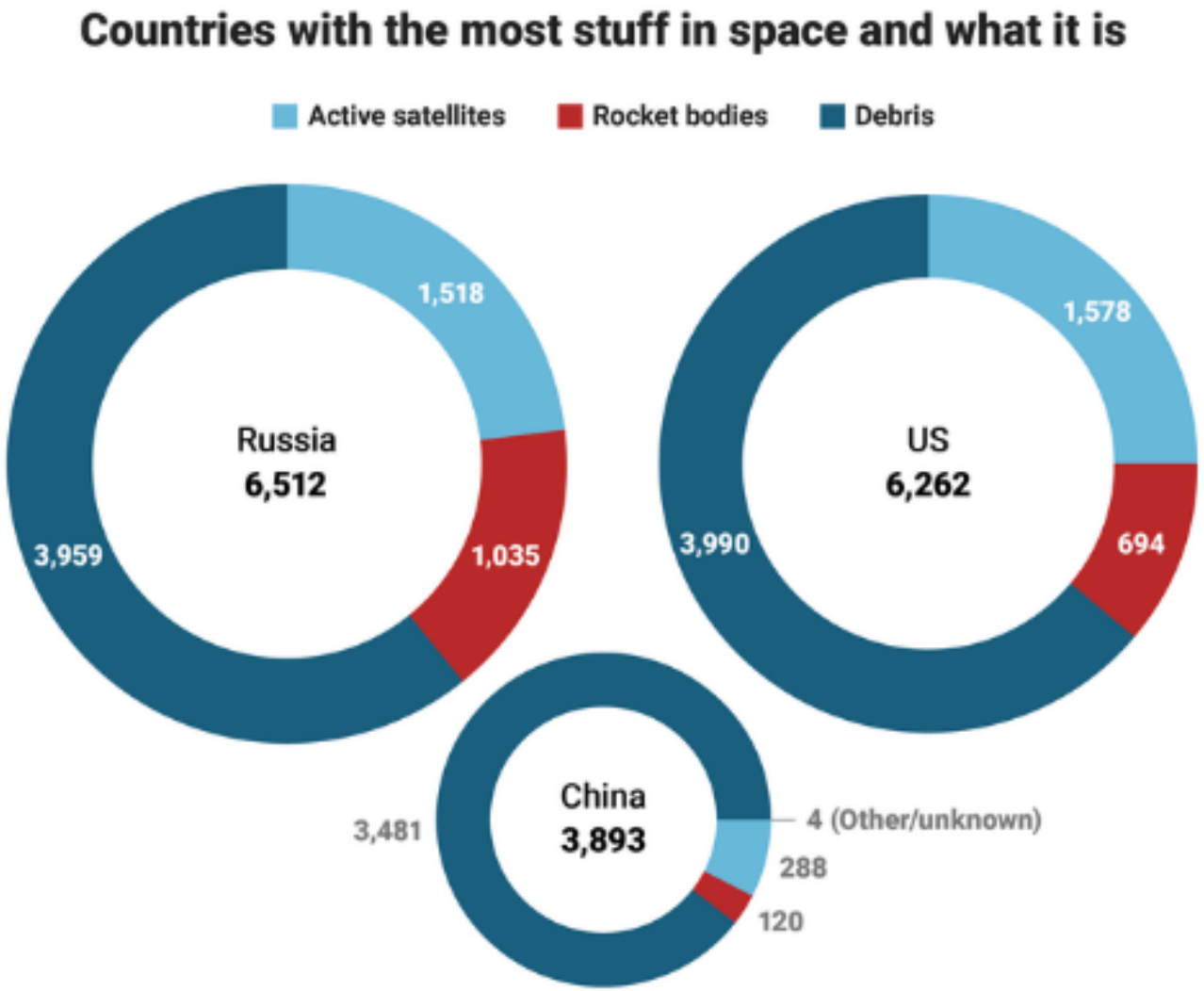


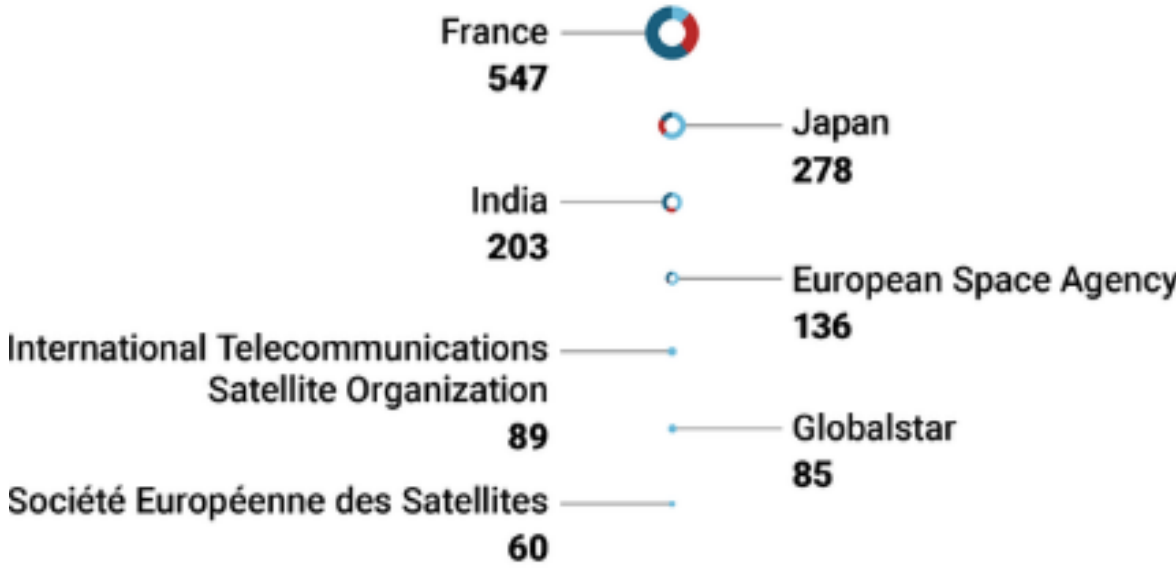


Source: J. McDowell, 2018.

Note: the Y axes for the figures are different

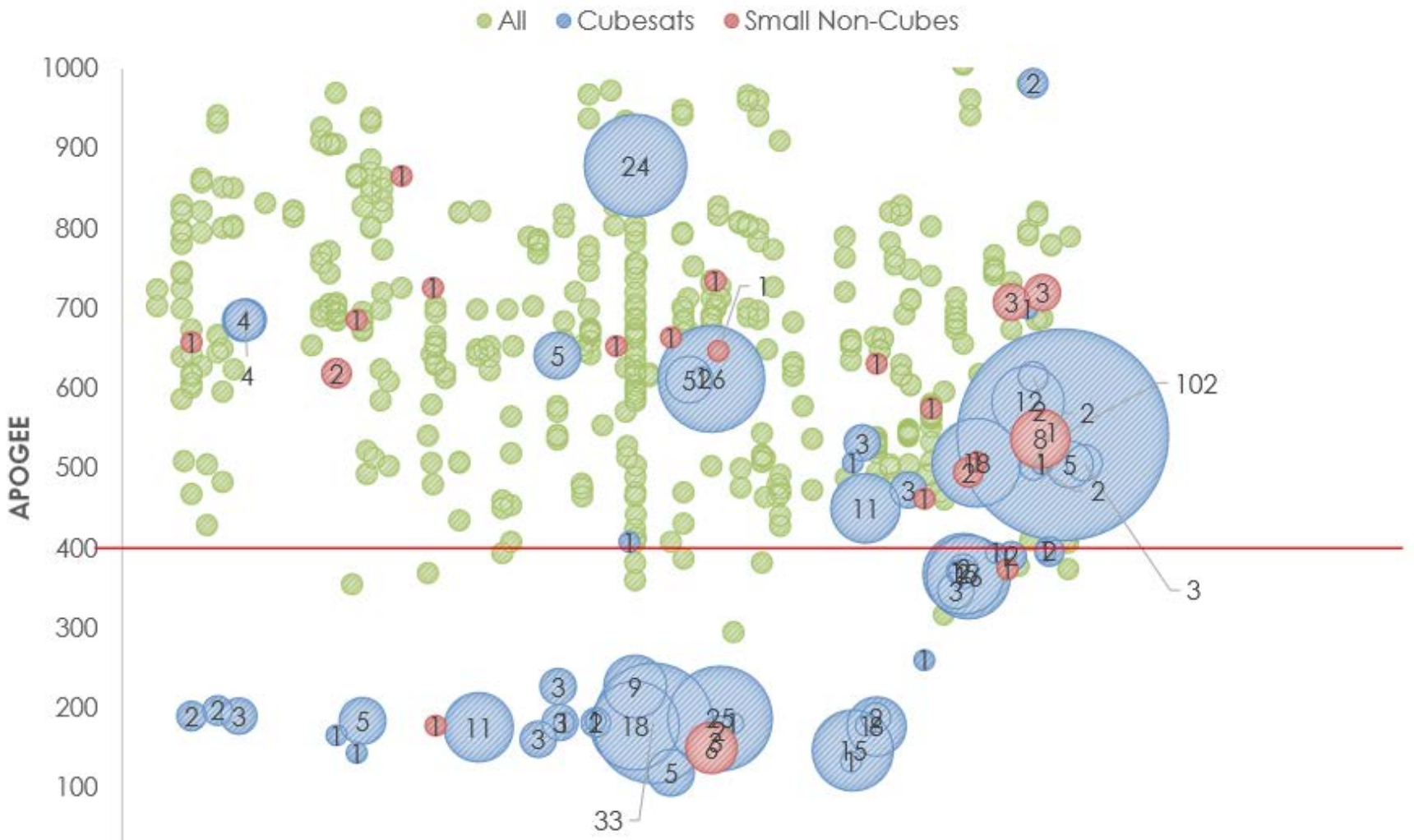
Who put it there?





Source: http://www.businessinsider.com/space-junk-debris-amount-statistics-countries-2018-3?r=UK&IR=T

Growing overlap of orbits



Source: Diana McKissock , May 2017

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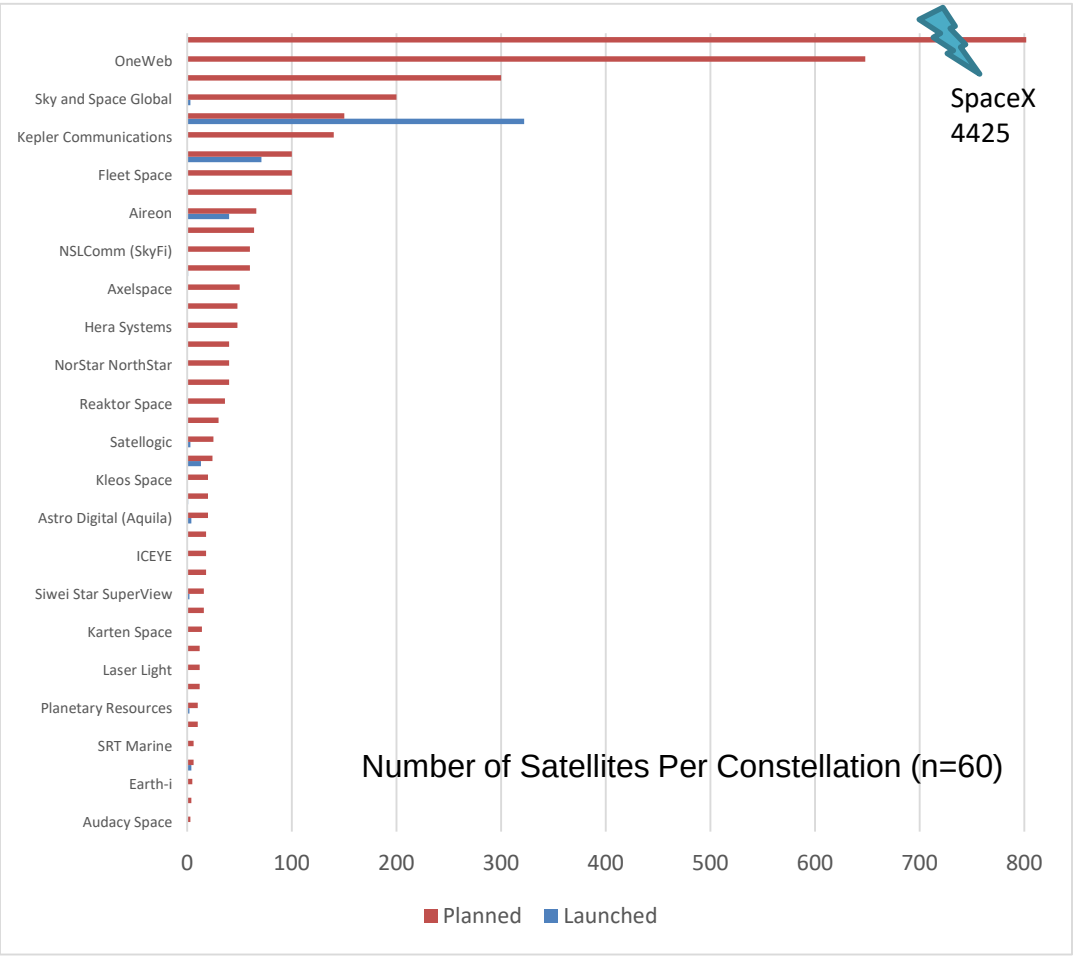
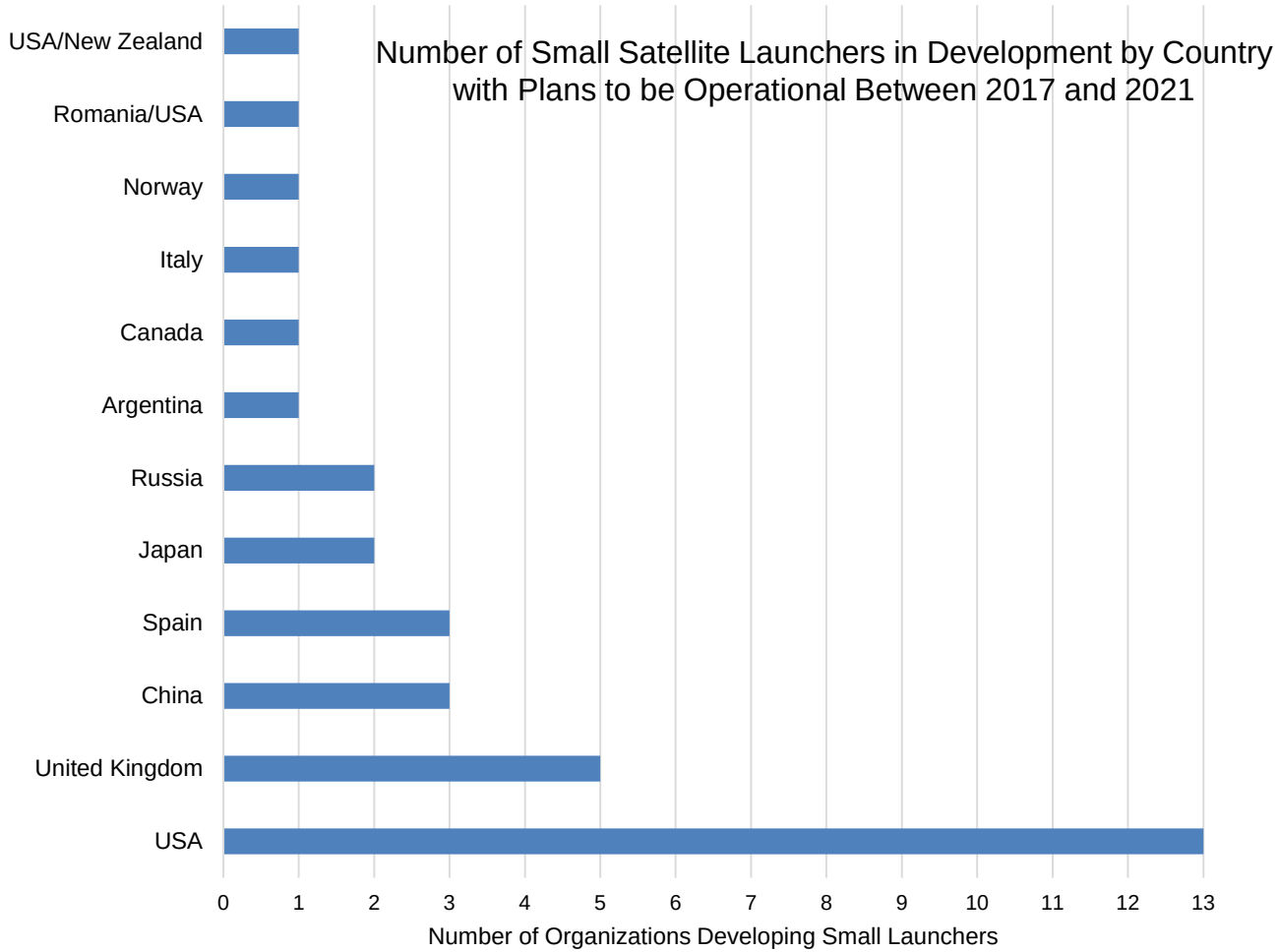
Future includes “mega” constellations and a large number of small satellites



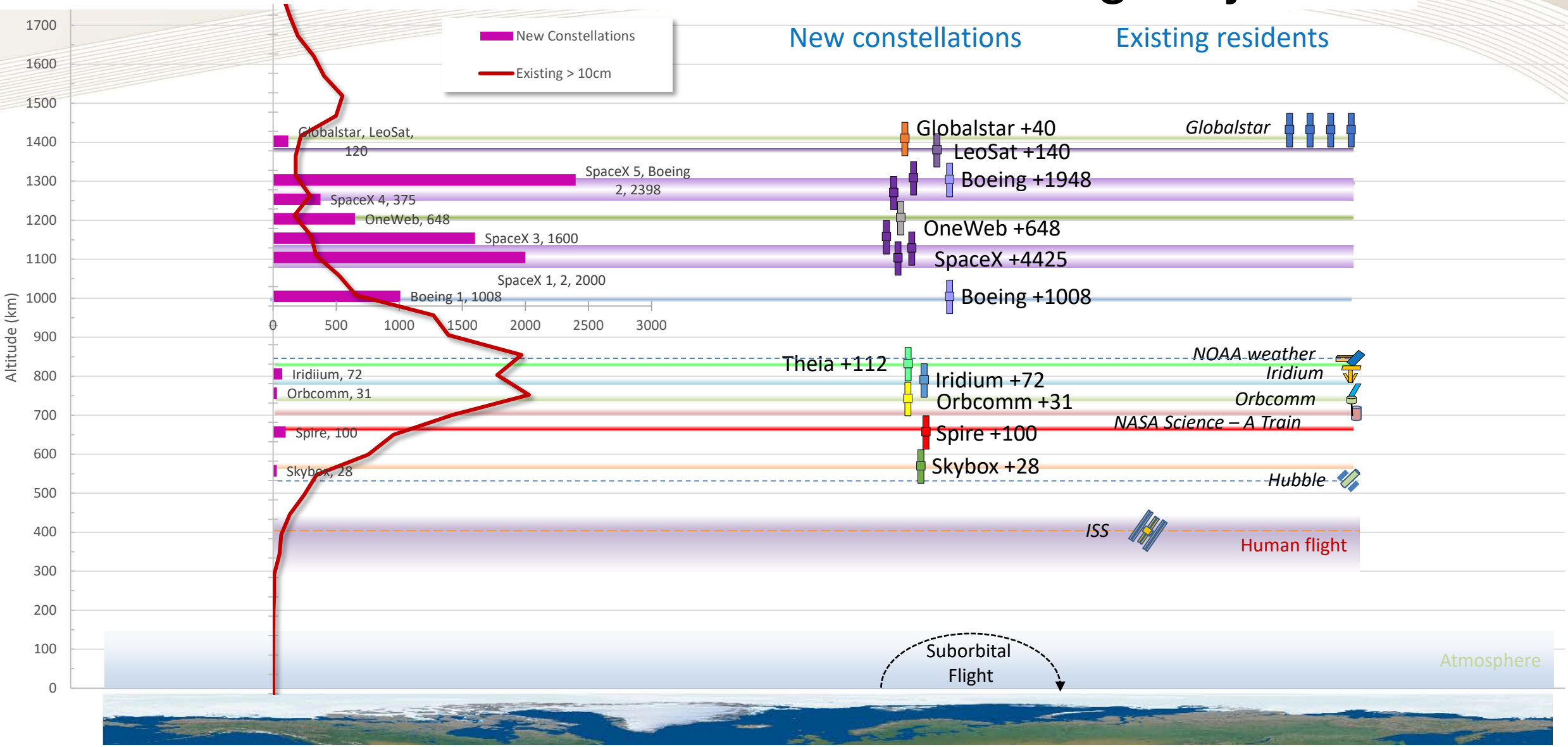
Source: http://www.newspace.im/, n.d.



Source: Lal, de la Rosa Blanco, Behrens et al., “Global Trends in Small Satellites.”

(Slide from Aerospace Corporation)

New Constellations can Exceed Existing Object Counts



Not a fun counting exercise!

- In 2017 alone, the US Air Force's 18th Space Control Squadron provided data for almost 310,000 close calls in space, and issued 655 "emergency-reportable" alerts to satellite operators.
- Of these, 579 were in LEO

Source: http://www.businessinsider.com/space-junk-collision-statistics-government-tracking-2017-2018-4

Goals for the afternoon

- J.-C. Liou, NASA
- Darren McKnight, Integrity Apps
- Dan Oltrogge, AGI
- Brian Weeden, Secure World Foundation

"Solve" the problem. What needs to be done? How should we do it? Who should do it? Who should pay for it? What happens if we do nothing?

Understand the problem. Why is this a hard problem? How did we get here?

Define the problem. What is the problem? *Why* is it a problem? (start with a definition)

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GY
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Questions for the Q-A Period

Big Picture Questions

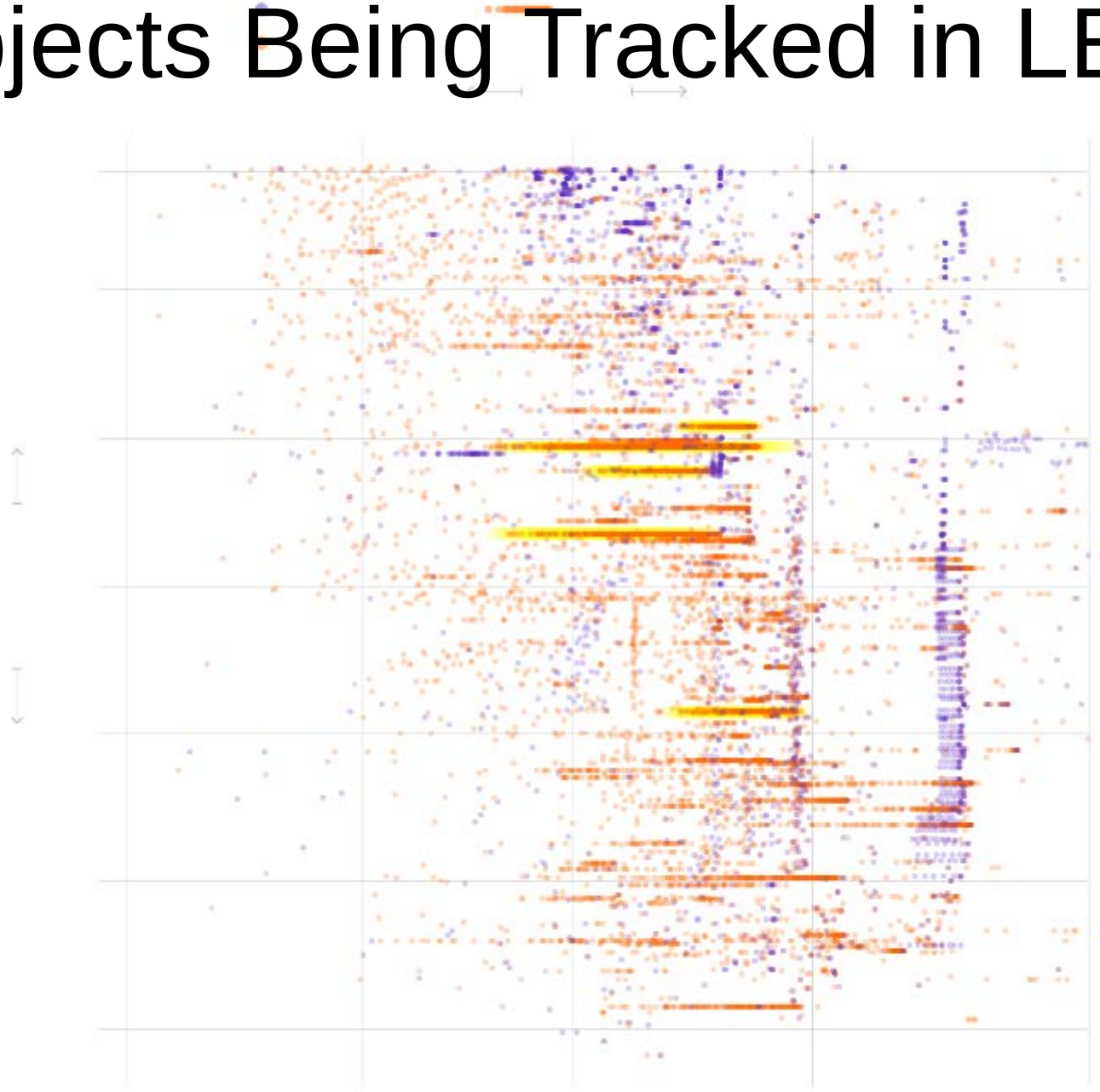
- Why haven’t we done anything yet?
- What do we not know yet?
- What are some near-term things we can start with?
- How can the National Academies help the orbital debris community?

Specific Questions (thanks to my colleague at STPI Ben Corbin)

- How much risk is added with a mega constellation of small satellites compared to existing spent upper stages?
- How much would we expect risk to rise as a result of a collision between two small satellites (maybe in comparison to the weather/Russian satellite collision)?
- Are there any promising technologies that might be more effective than docking with each individual piece of debris?
- Who is liable for debris cascades, when it's hard to tell which satellite a piece of debris came from but you do know which collision it came from?

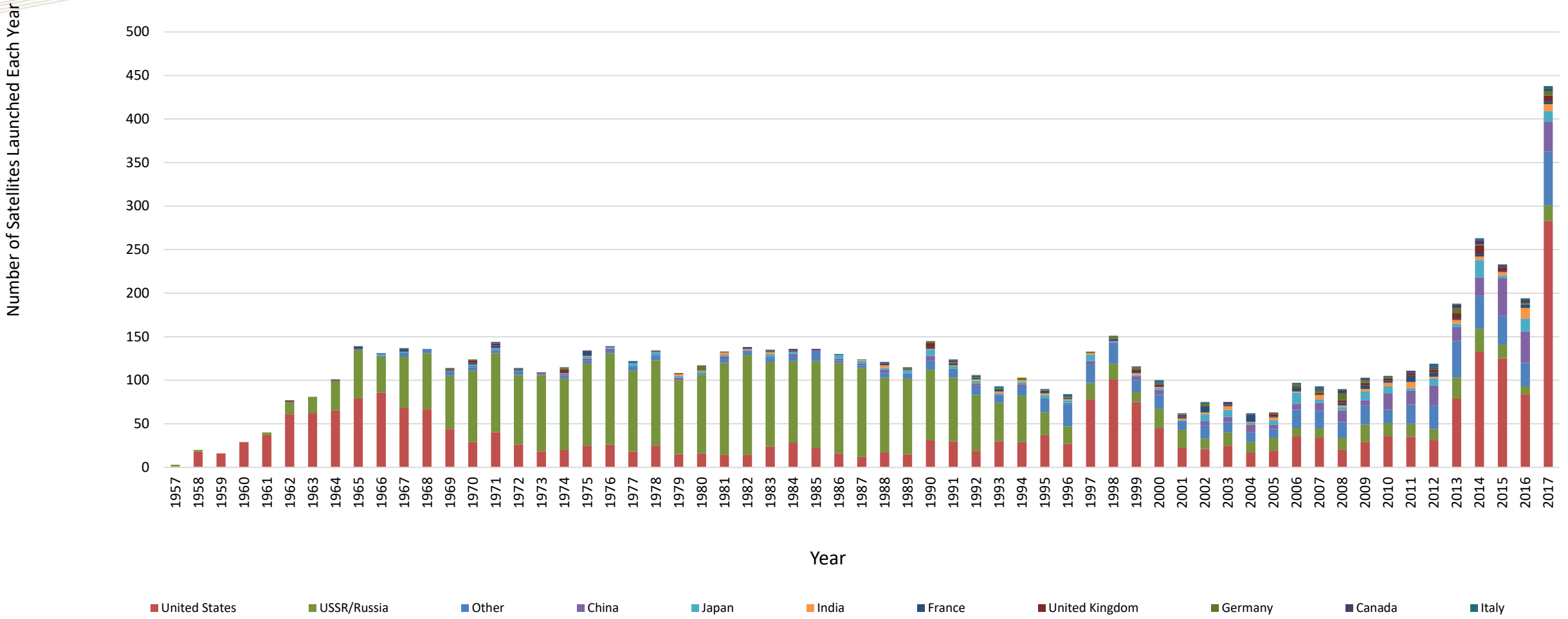
BACKUP SLIDES

Objects Being Tracked in LEO



Source: https://www.axios.com/yes-there-really-is-a-lot-of-space-junk-930b166d-68c4-4803-9bd6-9e23514eb942.html

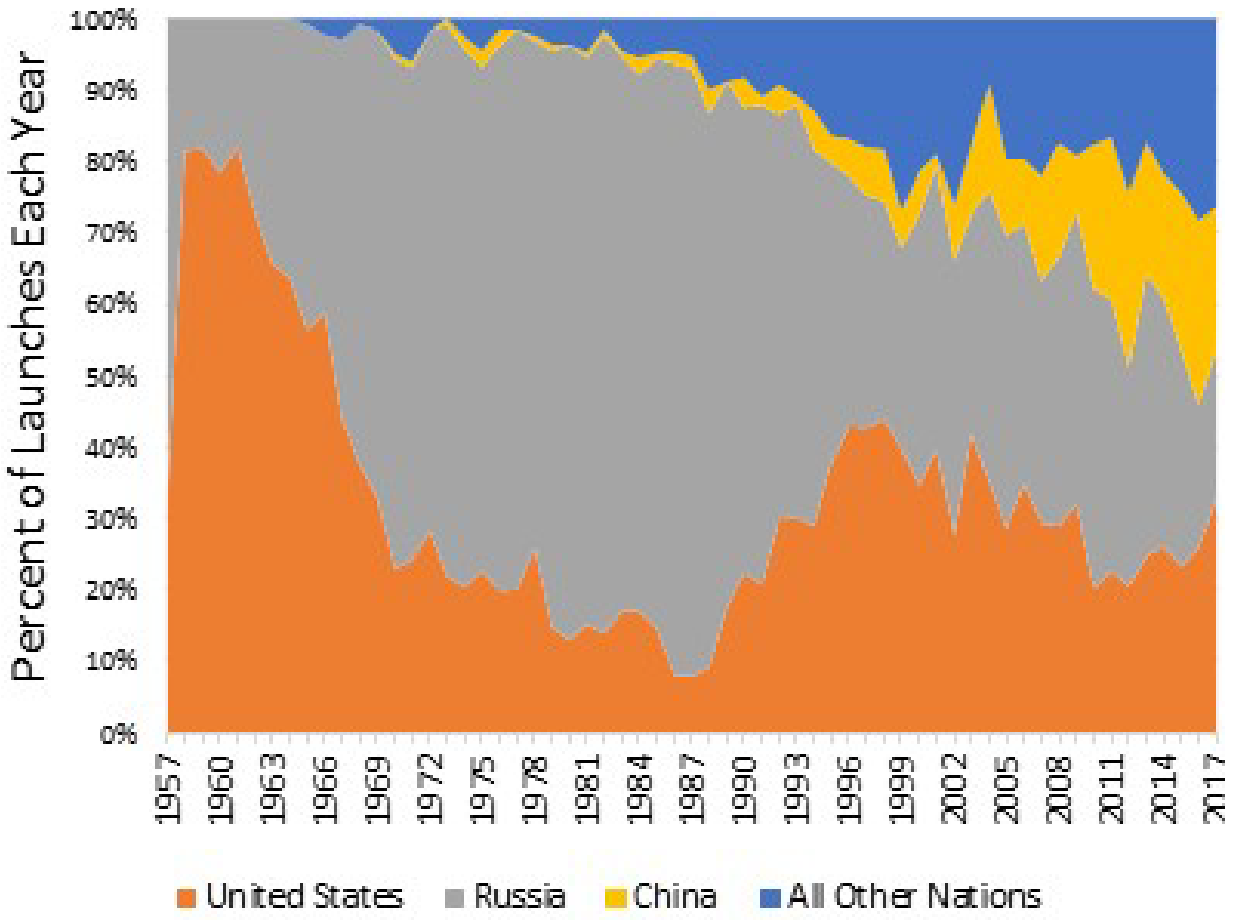
Total Number of Satellites Launched by Country

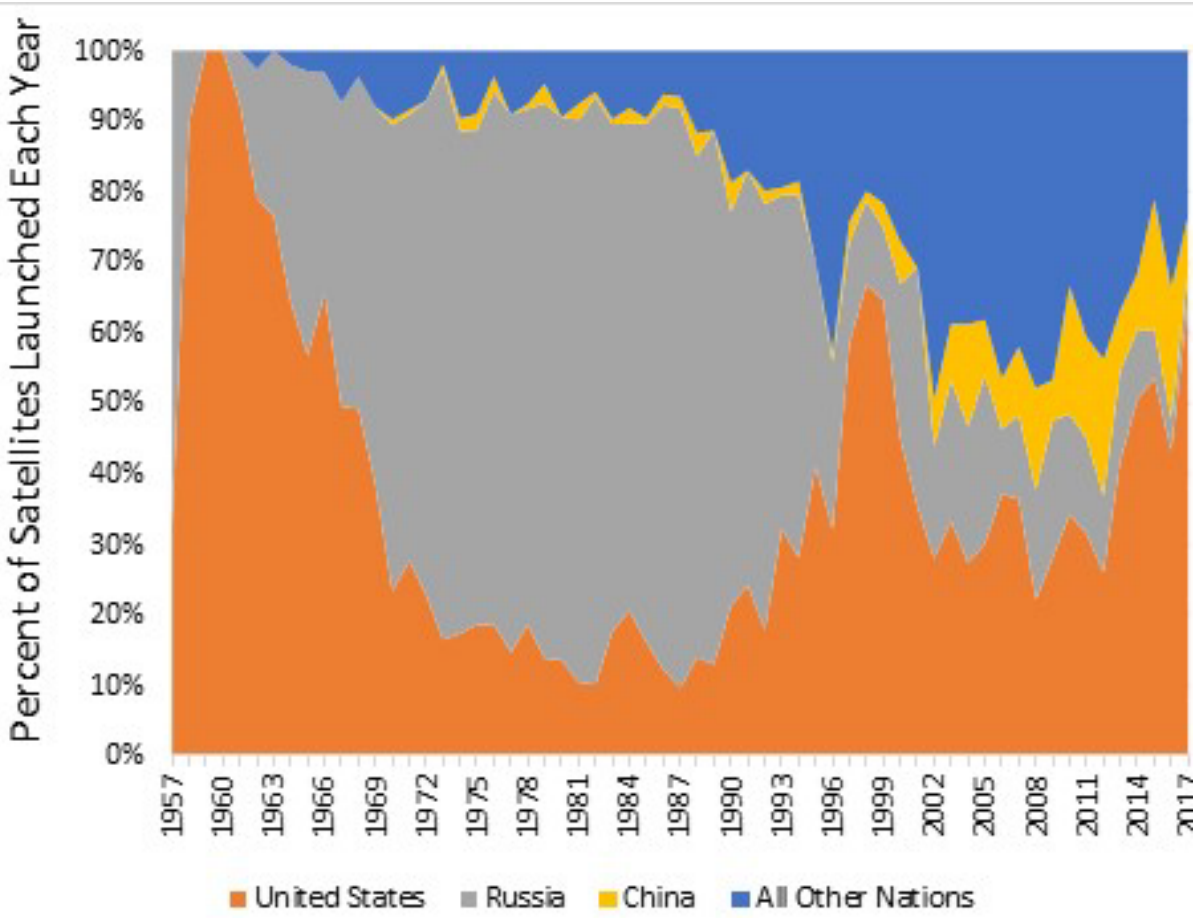


Source: J. McDowell, "Satellite Catalog," 2018 *CREDIT – Sara Carioscia*

Note: The numbers for the Soviet Union are added to the numbers for Russia. The high number of satellites in recent years is related to growing number of CubeSat launches.

Fraction of Launches and Satellites Launched, by Country





Source: J. McDowell, "Satellite Catalog," 2018 *CREDIT – Sara Carioscia*
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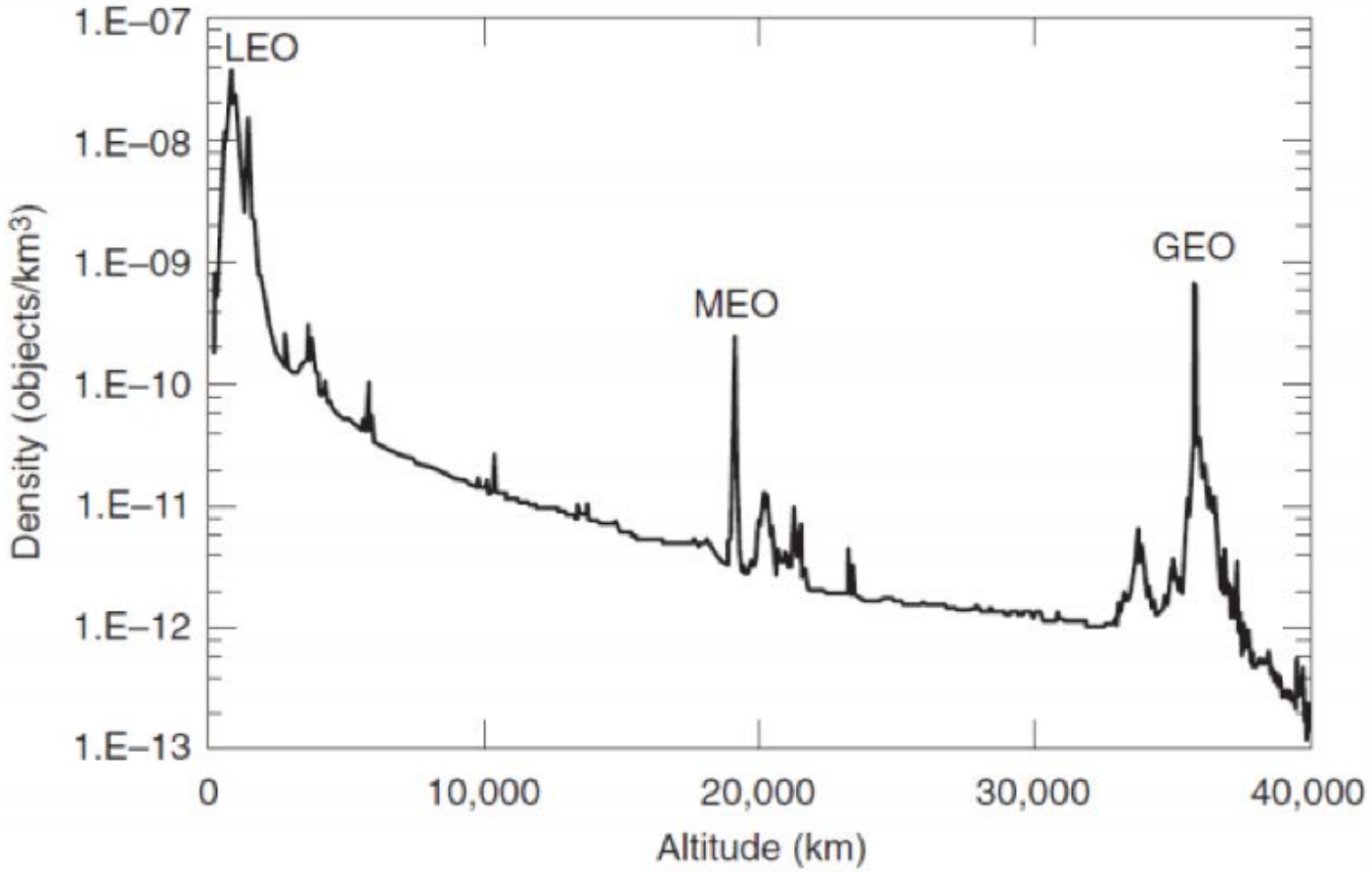
Altitude distribution of objects in the near-Earth region



https://www.nasa.gov/sites/default/files/atoms/files/niac_2016_phasei_janson_braneconcept_tagged.pdf