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Responding to New Space Challenges: AAS Statements on Reentry Effects and Spaceflight Transparency

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and the AAS COMPASSE committee

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Humanity's increasing level of activity in outer space is starting to have an environmental impact, including effects of concern to astronomers.

In late 2024 the AAS issued two statements developed by the COMPASSE committee to highlight environmental concerns raised by increased space mission activity.

- a statement on the importance of considering the effects of increased numbers of reentries

- a statement on the importance of improving public transparency of activities beyond Earth orbit.

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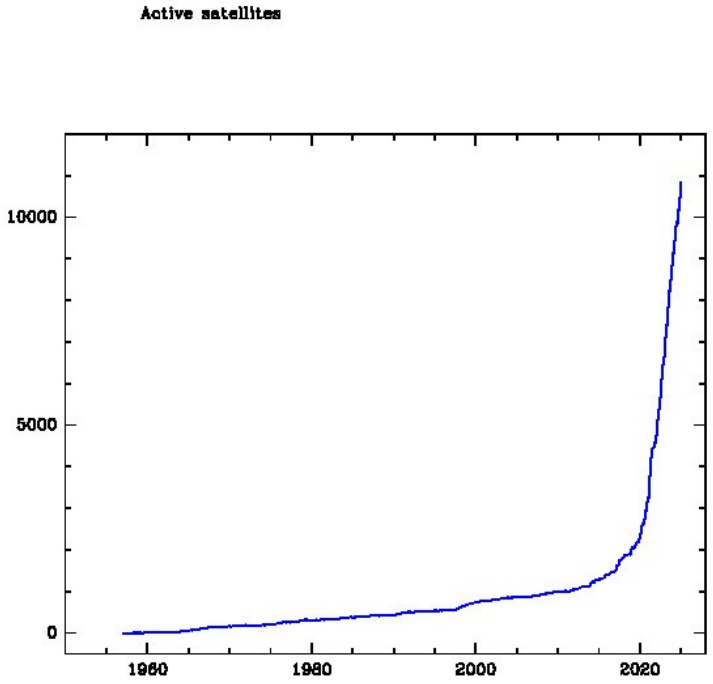
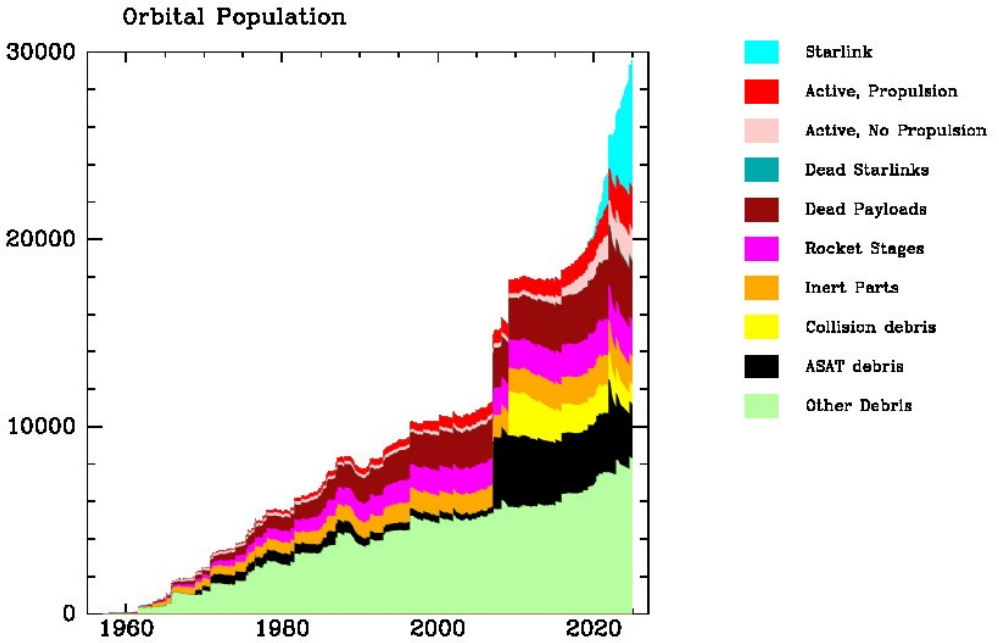
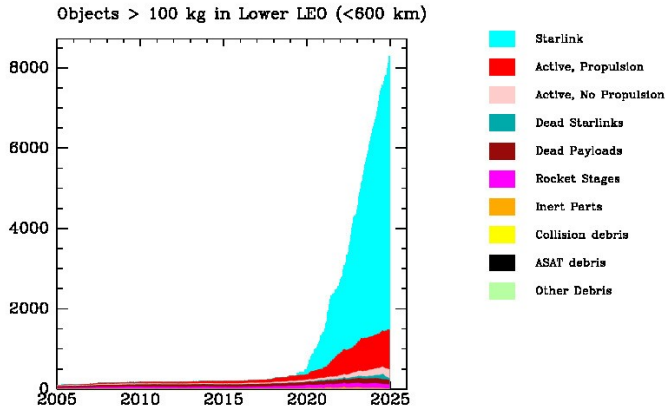




Unprecedented rise in number of active satellites in past few years

Tracked orbital debris population stable since 2010
~25000 objects tracked (> 10cm)
1 million estimated: 1- 10 cm
0.1-1 billion above 1 mm?



Starlink reentries will dump 8 tons of aluminum per day

- Starlink: 30,000 sats, each ~1000 kg
- Replaced every 5 years: **16 TONS** disposed per day

See also Schulz and Glassmeier 2021, Boley and Byers 2021

M. Kiczeski

Launches make ionospheric holes

Sometimes accompanied by red visible emission

Satellites

- Assume mostly aluminum alloy (assume 50% Al by mass)
- **8 tons of Al per day**

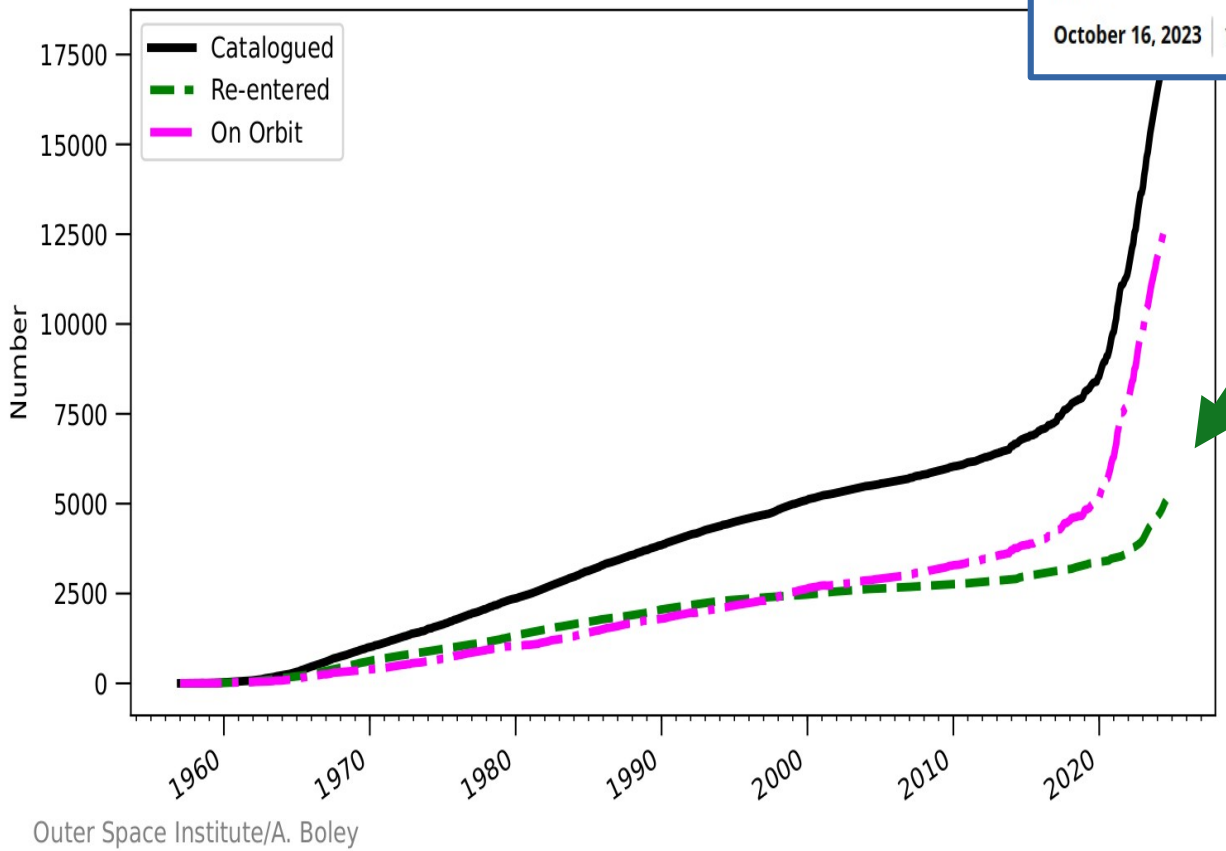
Meteoroids

- 15 tons/day of O
- 6 tons/day of Fe
- 4 tons/day of Si
- 3 tons/day of Mg
- 2 tons/day of S
- 0.4 tons/day of Ni
- **0.3 tons/day of Al**
- 0.2 tons/day of Na

Lodders 2010

Re-entry pollution is already measureable, NOW

A “hockey stick” occurred in the number of launched objects in ~2019. The “hockey stick” in re-entering objects is starting now.



RESEARCH ARTICLE | EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES

Metals from spacecraft reentry in stratospheric aerosol particles

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10% of stratospheric aerosols are **already** from satellite and rocket re-entry pollution

Re-entries from rockets are already dangerous, now


2020: dropped by China on Cote D'Ivoire


2021: dropped by USA (SpaceX) on Australia


2024: dropped by USA (SpaceX) on USA

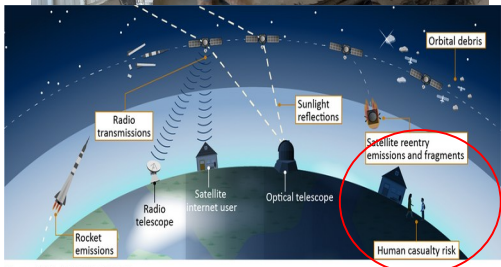

2022: dropped by China on Myanmar


2021: dropped by China on India


2024: dropped by USA (NASA) on USA


2024: dropped by USA (SpaceX) on Canada


2021: dropped by USA (SpaceX) on USA



Source: GAO. | GAO-22-105166
Note: Image not to scale.

The AAS is gravely concerned about the impacts of emissions and residual effects from extensive space launches and space object reentries upon Earth's sky and upper atmosphere [...]

[..] We call on policymakers to secure funding for scientific research on the aggregate effects of a growing number of launches and reentries on the Earth's climate and ozone layer, and on regulators to incorporate the results of such research into their licensing of space activities.

[with megaconstellations...] the steady state injection of metals into the atmosphere by vaporization of satellites would be at least 8000 tons/yr, exceeding natural injection of metals from meteoroids.

[...]
We recommend that regulators and policymakers [..] consider the issue [... fund research and act on results, which ..] could include setting a cap on the flux of reentry aerosols.

[...]
While such research is being carried out we strongly encourage abiding by the precautionary principle

Second statement - deep space transparency

Beyond Earth orbit, the only players used to be the US and Soviet governments

Now we have many developing countries (e.g. UAE, India)
and commercial players (e.g. SpaceX, iSpace, Astrobotic) operating beyond Earth orbit

But it's largely unregulated: no requirement to file a public 'flight plan', no equivalent of Earth orbit TLEs....

The AAS believes that spaceflight activities in cislunar and interplanetary space should be conducted in an open and transparent way [...]

[..] publicly report the trajectory of [cislunar , Lagrange, escape] objects

[..] deep space situational awareness be [done by] international coordination

[.. no] restricting publication of observations [beyond 100,000 km]

- Orbit data for deep space objects is not currently available the way it is for US Space Force tracking of Earth orbiting objects

- Multiple cases of newly-discovered "asteroids" turning out to be spacecraft after all
[Jan 3: 2018 CN41 removed from asteroid list, turns out to be Elon's Tesla]

- We don't like the planned 'secret asteroid mission' planned by an asteroid mining company who propose not to say which asteroid they are going to

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Summary:

In a new commercially dominated era of outer space, it is all the more important for civil society - including organizations like the AAS - to call out challenges to the sustainable, open and cooperative use of space, especially those that can interfere with astronomy.

Two examples of this are the effects arising from the huge increase in the number of spacecraft reentries, and the need for situational awareness as the entire inner solar system becomes criss-crossed with traffic from many countries and companies

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