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Open comment on FAA proposed rule on "Mitigation Methods for Launch Vehicle Upper Stages on the Creation of Orbital Debris".

December 20, 2023

Dear Sir/Madam,

This comment on the Federal Aviation Administration (FAA) proposed rule on "Mitigation Methods for Launch Vehicle Upper Stages on the Creation of Orbital Debris (docket number FAA-2023-1858)" is provided by the Co-Directors and two Junior Fellows of the Outer Space Institute, a global network of space experts united in their commitment to highly innovative, transdisciplinary research that addresses grand challenges facing the continued and projected use and exploration of space.

The proposed rule will help to alleviate the space debris collision and re-entry risks that it sets out to mitigate, and is therefore commendable. However, making the rule simpler – by eliminating exceptions – would reduce these risks further and make the rule more effective.

Background

Since 2014, U.S. launches have resulted in 135 rocket bodies being abandoned in orbit. Sixty-four percent of those remain in orbit now. With an average mass of 2.6 tonnes, these large tanks and engines create a risk of collision with other space objects, including crewed space stations and active satellites. While in orbit, they are potential sources of substantial amounts of debris. They also contribute to orbital light pollution, with potentially serious consequences for astronomy, natural heritage, and cultural heritage. Eventually, many rocket bodies reenter Earth's atmosphere in an uncontrolled manner, creating a risk to people on the ground and in aircraft around the globe. These negative impacts and risks are unnecessary, since the technologies and mission designs required to conduct controlled reentries have existed for decades. However, space operators and their clients have so far accepted orbital pollution and safety risks as a cost of doing business. With the rising number of launches, this approach is unsustainable.

New rule

The proposed rule would give U.S. commercial operators five options for disposing of their rocket bodies:

- conduct a controlled reentry;
- move the upper stage to a less congested storage or graveyard orbit;
- send the upper stage on an Earth-escape orbit;
- retrieve the upper stage (called active debris removal) within five years; or
- perform an uncontrolled atmospheric disposal.

Sending the upper stage to an Earth-escape orbit is essential for interplanetary missions but impractical for Earth orbital missions. The other options merit further discussion.

Conduct a controlled reentry

Controlled reentries are the only option which truly mitigate the in-orbit and casualty risks. Upper stages can be removed from orbit within hours, and directed into a remote area of the ocean, away from people and aircraft.

In the new rule, any rocket body that would be left in an orbit passing through the low Earth orbit (LEO) region would have to perform a controlled reentry, subject to several caveats. As shown in Figure 1, had this requirement been in place for the last decade, it would have affected 69% of all rocket bodies abandoned after U.S. launches, leading to a safer and cleaner orbital environment today. But even then, the remaining 31% is not insignificant, especially with a recent growth in launches. For this reason, we recommend that the controlled reentry requirement be expanded in scope, to prevent any rocket bodies from being abandoned in orbit.

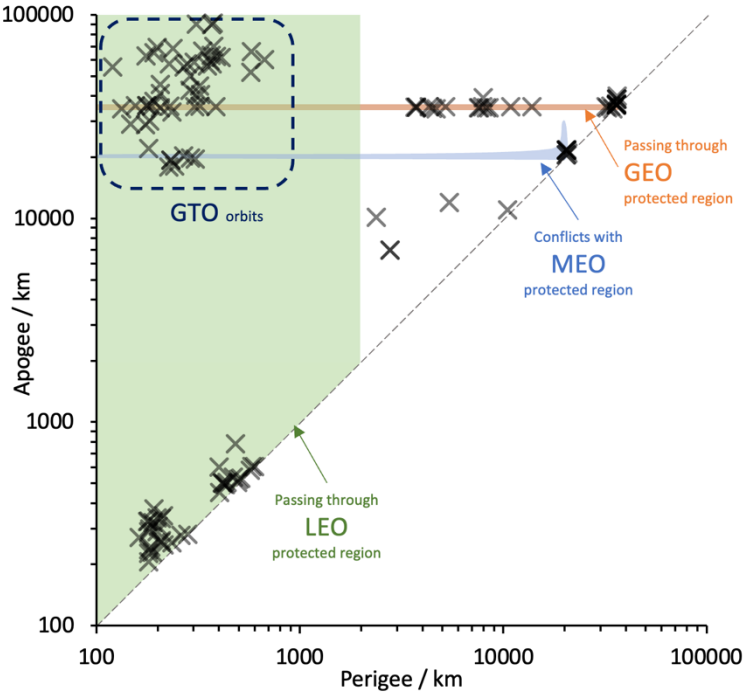

Figure 1. Post launch orbital position for 135 U.S. upper stages launched 2014-2023, excluding those that conducted controlled reentries. Orbits that infringe upon protected regions under the new rule are highlighted. If the proposed rule had been in place during these launches, those rocket bodies situated in a shaded area would have been non-compliant; for this reason, an alternative disposal method would have had to be used. The new rule does permit "passing through" the MEO protected region if less than 25 of 200 years are spent within it; this explains why the resulting non-compliant protected space has a complex shape. In contrast, no part of the orbit can remain in the LEO and GEO protected region. Data from GCAT.[1]

Move the upper stage to a less congested storage or graveyard orbit

About four U.S. launches per year leave a rocket body in an orbit entirely above LEO (see Figure 1). Some of these are left in so-called 'storage' or 'graveyard' orbits in medium Earth orbit (MEO) or above geostationary orbit (GEO). These rocket bodies are still abandoned, creating a risk of collision with other space debris or meteoroids.

[1] McDowell, J. (2023) General Catalogue of Artificial Space Objects (GCAT). Taken 13 November 2023.

There are certain mission designs (including direct-to-GEO launches, about one per year) for which abandoning a rocket body is the only practical option. However, these missions could be conducted in other ways, e.g., geostationary transfer launches, which could then use controlled reentries. It is noted in the proposal that 'Disposal orbits may become overly populated in the future which would preclude the future use of them for disposal'. Ultimately, rocket bodies should not be abandoned anywhere in the finite space of Earth orbit, and we therefore recommend that the option of a graveyard orbit be removed from the new rule.

Retrieve the upper stage (i.e., conduct "active debris removal") within five years

We encourage the development of active debris removal technologies able to remove upper stages from Earth orbit and send them into controlled reentries. This will be beneficial in mitigating the risk from some of the 2,300 abandoned rocket bodies currently orbiting Earth. However, there are some limitations with this approach that reduce the likelihood of it being used operationally, such as the risk of collision between the approaching spacecraft and the often-tumbling upper stage. We therefore recommend against relying on active debris removal for future launches, unless a controlled reentry effort fails.

Uncontrolled reentries

The proposed rule permits uncontrolled reentries up to 25 years after launch. Uncontrolled reentries are currently used for 35% of U.S. missions (62% if we exclude SpaceX). The new rule would require that the probability of a casualty from each uncontrolled reentry be less than 1 in 10,000, or a maximum casualty area (combined area of debris and people or vessels) of 7 m^2.

Applying these thresholds would permit uncontrolled reentries for rocket bodies smaller than approximately 700 kg, allowing "small launch" vehicles to use uncontrolled reentries (about 14 have done so in the last decade). However, for a 700 kg rocket stage, this means 70 to 280 kg of mass could survive reentry, using the common estimate of 10 to 40% of debris mass surviving reentry, creating a risk to people on the ground and in aircraft. This is unacceptable, for two reasons. First, the use of uncontrolled reentries is no longer necessary, thanks to already existing technologies and mission designs. Second, the 1 in 10,000 threshold was introduced in 1995, when there were less than half the number of space launches, half the number of annual flights and a world population 29% smaller than it is today. It is, quite simply, outdated. The new rule should prohibit all uncontrolled reentries.

Geostationary transfer orbits

All U.S. commercial launches would be required to adhere to the new disposal rules, including launches to Geostationary Transfer Orbit (GTO). Currently there are about two launches per year to GTO, and all of these abandon the upper stage in orbit. This is particularly troubling due to these rocket bodies crossing most of LEO, including the orbit of space stations and satellite megaconstellations.

Controlled reentries from GTO are possible and have been used by at least one U.S. operator in the past. Indeed, the technologies and mission designs required to conduct GTO controlled reentries are similar to those required for LEO controlled reentries. The proposed rule would require GTO launches to conduct controlled reentries, and we recommend that the FAA not make any exceptions for this launch type.

Waivers

Previous updates of orbital debris rules, such as the 2010 update of the Orbital Debris Mitigation Standard Practices (ODMSP) applied to NASA and DoD launches, allowed waivers to be granted for certain missions. Altogether, 44 waivers were granted, including for notably high-risk missions such

as a 2015 Atlas V launch with a 1 in 600 casualty risk. These waivers were granted until at least 2018 – almost a decade after the policy was implemented.[2]

We recommend that no waivers be allowed under the new rule. Many operators will already be capable of compliance, having adopted higher thresholds for NASA and DoD launches (e.g. SpaceX Falcon 9 upper stages can use controlled reentries), and using controlled reentries for commercial missions will therefore entail little, if any, extra cost. Newly emerging launch operators will be able to design their rockets to be compliant.

Conclusion

Controlled reentries are the only disposal option that truly minimise in-orbit and reentry risks. While active debris removal may help with clearing previously abandoned rocket bodies, it is a sub-optimal approach and unnecessary for new launches. Unless the abandonment of rocket bodies is generally prohibited, the space environment will continue to deteriorate, and people around the globe will be subject to growing and entirely preventable risks.

Yours sincerely,

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[2] Verspieren, Q., (2020) *The US Air Force compliance with the Orbital Debris Mitigation Standard Practices*. Advanced Maui Optical and Space Surveillance Technologies (AMOS) Conference. Link.