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Earth & Space

How to stop a tragedy of the space commons

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Earth's orbits are filling with satellites and space junk. Left unchecked, collisions between space junk could propagate out of control, and humanity will lose access to a valuable resource. Just as we pay to maintain parks and nature reserves, we need to start charging orbit users for using orbital space. Orbital-use fees will preserve orbital space and make the space industry more profitable.

Image credits: European Space Agency (ESA)

Satellites are an integral part of our lives. They guide us to our destinations; they connect people around the world; and they help us respond to natural disasters. Yet even as our reliance on orbital satellites grows, so too does the risk of ruining our orbits with debris and causing a collision.

Since the dawn of the space age, we've been filling the orbital space around the Earth with junk. Old satellites that are no longer functional, rocket bodies that have fulfilled their purpose, even nuts, bolts, and bits of propellant fuel clutter Earth's orbits. Objects in orbit move fast—on the order of kilometers per second—and collisions between these objects can create many more hazardous space junk fragments. The worst-case scenario, though uncertain and occurring over a long time, is for the collisions to propagate until they become constant and self-sustaining—a tipping point known in the space community as Kessler Syndrome.

My coauthors and I are environmental economists. When we see problems like this our first thought is "Whose incentives are driving the problem, and how can those incentives be redirected?" We've studied similar issues in fisheries and road traffic, air pollution and climate change. While the specifics vary, one thing is common: some users don't have the right incentives to clean up their mess or to prevent it in the first place. As we learned more about the space junk problem, we realized insights from environmental economics could be helpful in developing effective long-run solutions to orbital traffic management. So, we set to develop a model to explain how incentives could be driving the space junk problem, and how they might be adjusted to fix it. Our model needed to combine the physical

dynamics of orbital mechanics with the economic dynamics of investing in assets over time.

While collision risk is costly and orbit users have an incentive to manage their risk exposure, international space law gives them few incentives to manage the risks they impose on others. Anyone who can access an orbit can use it, creating an "open access" regime. Prospective orbit users face a choice between launching profitable satellites, thereby imposing current and future collision risk on others, or not launching and leaving those profits to competitors. This is a classic "externality" problem: my actions impose costs on others, which I don't internalize.

Once we understood this, we started to think of an incentive to keep orbits clean. The answer turned out to be a surprisingly simple: charge orbit users annual fees for orbit use. The key is to charge users the precise amount of the cost they impose on others. If my satellites create a 0.05% annual risk of collision for others in nearby regimes, I pay an annual fee which reflects the cost of that additional collision risk. Making orbit users account for the costs they impose on others has three effects over time: (1) some satellites, which provide less in benefits than they cost society in collision risks, won't get launched, keeping orbits cleaner; (2) satellite operators will face a strong financial incentive to safely dispose of their satellites as soon as they're no longer profitable, helping to clean up orbits; (3) national entities can raise funds to support useful causes, such as debris removal technology development.

Our model predicts that an internationally-standardized fee beginning at roughly $14,900 per satellite/year in 2020, and escalating at roughly 14% per year to around $235,000 per satellite-year in 2040, would stabilize orbital collision risk at a lower level than it is now while also increasing the long-run value of the satellite industry more than four-fold. This is driven by a simple fact: when the orbital environment is cleaner, fewer satellites need to be replaced, making it more profitable to operate a satellite.

This result is significant in part because it shows how a well-studied solution for environmental management on Earth could help a burgeoning industry prevent an environmental catastrophe in a novel resource. But it's also significant because it shows how preserving the resource could be in everyone's interest—society continues to get the benefits of satellites, and satellite operators get to enjoy greater profits. In most contexts, addressing these problems is a game of catchup, where we start after ecological collapse has already begun. While we need to act quickly to preserve our orbits, the problem is still in its infancy and we have a win-win option on the table. We should not let this opportunity pass us by.