CENTER FOR SPACE POLICY AND STRATEGY

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ORBITAL SLOTS FOR EVERYONE?

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Foreword

"New Space" entrepreneurs propose constellations that number in the thousands of satellites, and in the rapidly evolving space industry, they may very well succeed. But constellations of this size bring greater risk for collisions and the creation of debris, and no organization is responsible for assessing how they may impact the broader space community. In a future world of mega-constellations, is the unregulated status quo for orbit selection a sustainable path?

The History of Regulating Orbits

Geosynchronous Earth orbit (GEO) has long been recognized as prime—and scarce—real estate. Starting as a measure for spectrum management, the international community agreed in the 1960s to regulate the assignment of slots in the GEO belt through the International Telecommunications Union (ITU). Today, any company or nation planning to launch a satellite to GEO must apply to the ITU for an orbital slot, and popular regions over North America, Europe, and eastern Asia have become so congested that few or no slots are left for new entrants to the market.

With most of the regulatory focus on GEOs, orbital assignments for low Earth orbit (LEO), medium Earth orbit (MEO), and highly eccentric orbits (HEOs) have been left unregulated. In the United States, the Federal Communications Commission (FCC) requires any operator seeking a communications license also to submit a report verifying that a satellite satisfies internationally accepted debris-mitigation requirements, but the FCC is agnostic to the orbit itself. Spectrum management motivated some bilateral and trilateral coordination on navigation constellations in MEO (e.g., GPS vs. Russia's GLONASS vs. Europe's Galileo, all in the same orbit regime), but these interactions occurred at the nation-state level.

Imagine having a collision as disruptive as the 2009 Iridium-Cosmos collision every year…

With unfettered access to nearly any place in space, some orbits have become popular and crowded, such as sun-synchronous orbits in LEO, which provide a base for weather monitoring and Earth observation. Satellites in these orbits suffer from substantially more day-to-day collision risk, which also elevates the long-term risk to the overall space environment.

The Future Population in Space

The traditional space industry is growing at a sober pace, looking to loft one, two, or a handful of large, high-capacity satellites at a time. The operator of today's largest private constellation, Iridium Satellite Communications, looks only to replenish its current architecture, which numbers in the tens of satellites.

"New Space" entrepreneurs, however, are determined to disrupt the communications and imaging industries, setting their sights on offering continuous, ubiquitous space-based services, which demand massive constellations. Since late 2016, no fewer than five well-funded companies from the United States and abroad have proposed mega-constellations for global coverage: OneWeb plans to launch up to 1,320 satellites to LEO and 720 to MEO; Boeing proposes launching up to 2,956 satellites to LEO; SpaceX intends to provide broadband communications

with 4,425 satellites for Ka-band and another 7,518-satellite constellation for V-band; Telesat Canada seeks to field two constellations each of 117 satellites; and Planet—recently merged with Terra Bella—will have no fewer than 67 satellites in LEO to image the entire surface of the Earth every day.

By the mid-2020s, more than 15,000 new satellites could be in space, with their orbits selected myopically within the context of their own needs and with no consideration for the impact on the global space enterprise.

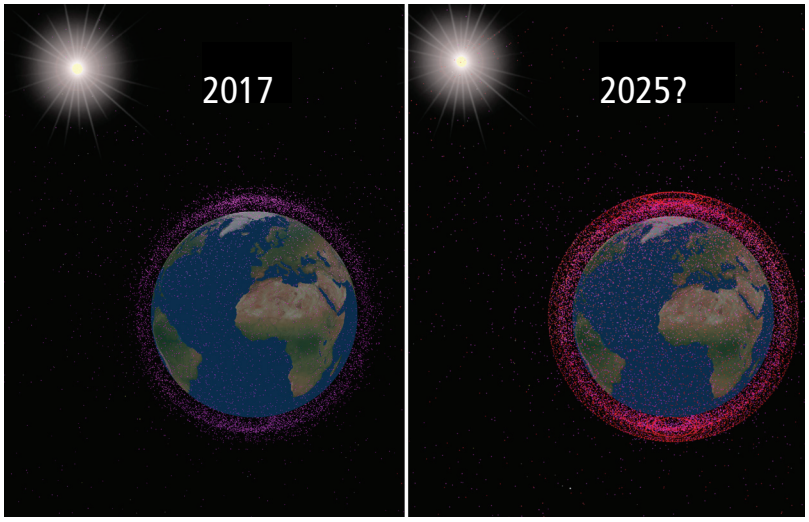

Figure 1: The crowded space environment today, showing all tracked objects, and what it may look like a decade from now, with proposed mega-constellations.

When the System Breaks

This unprecedented proliferation of satellites, particularly in LEO, will bring with it dramatic jumps in the risk of collision, debris generation and its cascading effects for future collisions, and the number of close-approach warnings for active satellites.

Aerospace recently performed an analysis[1] looking at the implications for the global debris environment if just a couple of these mega-constellations are realized. Its findings suggest that by the late 2020s and beyond, space could be far less hospitable than today:

- The number of collisions will increase tenfold or more, producing possibly one collision per year. Imagine having a collision as disruptive as the 2009 Iridium-Cosmos collision every year.
- Mega-constellations would increase the number of close-approach warnings by a factor of ten to one hundred. Using today's thresholds, more than 25,000 warnings would be issued each day, all of which must be adjudicated by the operators that receive them.
- After 200 years, the number of objects on orbit greater than 10 centimeters in size could exceed 500,000, a factor of five greater than without the mega-constellations.

What Can Be Done?

Decision makers have only a few years before the consequences of unregulated mega-constellations are upon us. In that time, there are three broad courses of action that could be followed:

- **Option 1: Do Nothing.** Although technical analysis paints a grim picture in terms of debris risk and collisions, the proposed mega-constellations are borne from a vibrant entrepreneurial spirit in the space industry that hasn't been seen since the dawn of the Space Age. Expanding the regulatory regime to all orbits could have a stifling effect on innovation or limit market access only to large entities that have the resources and connections to ensure a smooth regulatory process. By doing nothing, it is possible that the benefits of these mega-constellations and a booming new space industry would outweigh the costs on the global space enterprise, possibly even spurring new innovation into the development of robust, resilient satellites and architectures that can operate in the riskier space environment.
- **Option 2: Refine and Impose Stricter Disposal Requirements**. Satellites today are required to satisfy a set of disposal requirements that were drafted well before the age of CubeSats, microsatellites, and mega-constellations. In a world of mega-constellations, Aerospace analysis has shown that the current 25-year rule for natural disposal would lead to more than 100,000 baseball-sized objects in LEO by the year 2100, and 500,000 by the year 2200—and that's only from the constellations that would be launched in the 2020s. The current disposal requirements are clearly inadequate to prevent a tragedy of the commons overtaking all the space around Earth. New disposal requirements should be considered for promulgation both within the United States and

internationally, and enforced more assiduously than they are today. However, the analysis suggests that even reducing the on-orbit lifetime of these mega-constellations to only one year could still generate hundreds of thousands of baseball-sized objects over the next 200 years, largely due to the increased frequency of collisions while the constellations are active.

- **Option 3: Orbit Licensing.** Just as every operator in space must acquire a license for radio-frequency spectrum, regardless of orbit, it may be necessary to expand the licensing regime to the orbits themselves, whether in LEO, MEO, or GEO. Licensing for orbits, along with the aforementioned disposal requirements, would allow for an enterprise-level assessment of the impact of a proposed satellite or constellation, both on the debris environment as a whole and on the operations of satellites already in orbit. As with spectrum, orbits could be assigned or approved well in advance, and as with flight paths controlled by the FAA, orbits could be managed dynamically at the enterprise level. With active, cross-program flight-safety monitoring of this kind, secondary benefits such as reduced insurance rates may also follow. To make this regulatory regime a reality, the international community would have to come together again, as it did in the 1960s for GEO, and agree on who would manage this licensing, who would perform the enterprise-level analysis, and how it could be realized without strangling the free market. But coordination and management of who goes where in space with what and for how long may be the only sustainable option to ensure reliable access to space in the coming decades.

What Comes Next?

These three courses of action bring uncertainty and unknowns with them, and interdisciplinary analysis will be key to quantifying the benefits of each. Some of the questions that must be answered include:

- **Option 1, Do Nothing:** What is the cost versus benefit of letting the free market have its moment to shine? Can some technical challenges to surviving a hostile debris environment surely not be solved in the 2020s? Will this laissez-faire approach likely yield a net benefit or net loss for the space community? Who wins? Who loses?
- **Option 2, Disposal:** What should new disposal requirements be? Are they qualitatively different from how we view such requirements today? Who should enforce the requirements, and how? What should the consequences be for failing to meet them?
- **Option 3, Orbit Licensing:** Exactly how much licensing is necessary or optimal? Can some orbit regimes be left alone and unregulated for the foreseeable future? Do only certain aspects of the orbit need to be licensed? What are reasonable thresholds for risk that would drive licensing decisions? Who would manage the licensing process, including analysis and enforcement? What kind of resources and technical capabilities are needed to enable both prelaunch orbit licensing and dynamic orbit management?

There is still time to elect a policy response that both encourages innovation and preserves the habitability of space…

These three courses of action are a start along the path to creating a sustainable space environment, but much investigation and public debate remains before any irrevocable decisions should be made. Although the dangers posed by mega-constellations are manifest, there is still time to elect a policy response that both encourages innovation and preserves the habitability of space for future generations.

References

[1] Peterson, G., et al., "Implications of Proposed Small Satellite Constellations on Space Traffic Management and Long-Term Debris Growth in Near-Earth Environment," 67th International Astronautical Congress, Guadalajara, Mexico, 2016. Paper IAC-16-A6.7.8.