### Advantage: Debris

#### Privatization of space will increase space debris collisions.

**Muelhaupt 19** [Theodore J. Muelhaupt, June 2019, "Space traffic management in the new space era", [Journal of Space Safety Engineering](https://www.sciencedirect.com/science/journal/24688967), https://www.sciencedirect.com/science/article/pii/S246889671930045X?via%3Dihub, date accessed 1-23-2022] //Lex AT

The last decade has seen rapid growth and change in the space industry, and an explosion of commercial and private activity. Terms like NewSpace or democratized space are often used to describe this global trend to develop faster and cheaper access to space, distinct from more traditional government-driven activities focused on security, political, or scientific activities. The easier access to space has opened participation to many more participants than was historically possible. This new activity could profoundly worsen the space debris environment, particularly in low Earth orbit (LEO), but there are also signs of progress and the outlook is encouraging. Many NewSpace operators are actively working to mitigate their impact. Nevertheless, NewSpace represents a significant break with past experience and business as usual will not work in this changed environment. New standards, space policy, and licensing approaches are powerful levers that can shape the future of operations and the debris environment. 2. Characterizing NewSpace: a step change in the space environment In just the last few years, commercial companies have proposed, funded, and in a few cases begun deployment of very large constellations of small to medium-sized satellites. These constellations will add much more complexity to space operations. Table 1 shows some of the constellations that have been announced for launch in the next decade. Two dozen companies, when taken together, have proposed placing well over 20,000 satellites in orbit in the next 10 years. For perspective, fewer than 8100 payloads have been placed in Earth orbit in the entire history of the space age, only 4800 [1] remain in orbit and approximately 1950 [2] of those are still active. And it isn't simply numbers – the mass in orbit will increase substantially, and long-term debris generation is strongly correlated with mass. This table is in constant flux. It is based largely on U.S. filings with the Federal Communications Commission (FCC) and various press releases, but many of the companies here have already altered or abandoned their original plans, and new systems are no doubt in work. Although many of these large constellations may never be launched as listed, the traffic created if just half are successful would be more than double the number of payloads launched in the last 60 years and more than 6 times the number of currently active satellites. Current space safety, space surveillance, collision avoidance (COLA) and debris mitigation processes have been designed for and have evolved with the current population profile, launch rates and density of LEO space. By almost any metric used to measure activity in space, whether it is payloads in orbit, the size of constellations, the rate of launches, the economic stakes, the potential for debris creation, the number of conjunctions, NewSpace represents a fundamental change. 3. Compounding effects of better SSA, more satellites, and new operational concepts The changes in the space environment can be seen on this figurative map of low Earth orbit. Fig. 1 shows the LEO environment as a function of altitude. The number of objects found in each 10 km “bin” is plotted on the horizontal axis, while the altitude is plotted vertically. Objects in elliptical orbits are distributed between bins as partial objects proportional to the time spent in each bin. Some notable resident systems are indicated in blue text on the right to provide an altitude reference. The (dotted) red line shows the number of objects in the current catalog tracked by the U.S. Space Surveillance Network (SSN). All the COLA alerts and actions that must be taken by the residents are due to their neighbors in the nearby bins, so the currently visible risk is proportional to the red line. Fig 1 Download : Download full-size image Fig. 1. Objects in LEO orbit by altitude per 10 km altitude bin. Elliptical orbit objects distributed by portion spent in each bin. Some notable existing resident systems are listed on the right. New residents, including some replacement systems, are on the left. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.) The red line of the current catalog does not represent the complete risk; it indicates the risk we can track and perhaps avoid. A rule of thumb is that the current SSN LEO catalog contains objects about 10 cm or larger. It is generally accepted that an impact in LEO with an object 1 cm or larger will cause damage likely to be fatal to a satellite's mission. Therefore, there is a large latent risk from unobserved debris. While we cannot currently track and catalog much smaller than 10 cm, experiments have been performed to detect and sample much smaller objects and statistically model the population at this size [3]. The (solid) blue line represents the model of the 1 cm and larger debris that is likely mission-ending, usually called lethal but not trackable. If LEO operators avoid collisions with all the objects in the red line, they are nonetheless inherently accepting the risk from the blue line. This risk is already present. The (dashed) orange line is an estimate of the population at 5 cm and larger and is thus an estimate of what the catalog might conservatively be a few years after the Space Fence, a new radar system being built by the Air Force, comes on line (currently planned for 2019) [4]. Commercial companies offering space surveillance services, such as LeoLabs, ExoAnalytics, Analytic Graphics Inc., Lockheed, and Boeing, might also add to the number of objects currently tracked. Space Policy Directive 3 (SPD-3) [13] specifically seeks to expand the use of commercial SSA services. Existing operators can expect a sharp increase in the number of warnings and alerts they will receive because of the increase in the cataloged population. Almost all the increase will come from newly detected debris [5]. The pace of safety operations for each satellite on orbit will significantly change because of the increase in the catalog from the Space Fence. This effect is compounded because the NewSpace constellations described in Table 1 will drastically change the profile of satellites in LEO. The green bars in Fig. 1 represent the number of objects that will be added to the catalog (red or orange lines) from only the NewSpace large LEO constellations at their operational altitudes. This does not include the rocket stages that launch them, or satellites in the process of being phased into or removed from the operational orbits. Neighbors of one of these new constellations may face a radically different operations environment than their current practices were designed to address. Satellites in these large LEO constellations typically have planned operational lifetimes of 5–10 years. Some companies have proposed to dispose of their satellites using low thrust electric propulsion systems, which would spiral satellites down over a period of months or years from operating altitudes as high as 1500 km through lower orbits where the Hubble Space Telescope, the International Space Station, and other critical LEO satellites operate [6]. Similar propulsive techniques would raise replacement satellites from lower launch injection orbits to higher operational orbits. These disposal and replenishment activities will add thousands of satellites each year transiting through lower altitudes and posing a risk to all resident satellites in those lower orbits. More importantly, failures will occur both among transiting satellites and operational constellations, potentially leaving hundreds more stranded along the transit path. Aerospace studies [7–9] have shown that failed satellites, whether they fail during operations or fail during disposal, can pose as great or even greater risk than the many thousands of operational satellites (Fig. 2). Given the rapid flux in the proposed large LEO constellations (LLC), we created a Future Constellations Model (FCM) with elements that represented the characteristics of the different systems being proposed. In our models, almost all the collisions and the resulting debris from those collisions occur because of failed systems. Most large constellation operators intend to perform active collision avoidance for active systems, whether operational or in some stage of check-out or disposal, but failed satellites are assumed to be incapable of maneuver. Fig. 2 also shows that satellites in the disposal phase can contribute to collisions similarly to satellites in the operational phase. Fig 2 Download : Download full-size image Fig. 2. Collisions during operations and disposal over 10 years for various NewSpace Future Constellation Models (FCMs). 4. A notional illustration of workload The highest risk to operational satellites comes from the lethal but non-trackable debris that is depicted in the blue line in Fig. 2. However, operators perform collision avoidance only on the objects that can be tracked and cataloged. Advances in tracking and NewSpace launches will both act to increase this workload. A key element of the problem is that an increase in the LEO population will lead to an increase in close approaches to existing satellites [5], and the potential for accidental collisions. Conjunction prediction, collision probability (Pc), and maneuver planning for most existing satellite operators is a time- and personnel-intensive operation. Orbit analysts, and propulsion, navigation, and communications systems personnel are involved in evaluating and planning maneuvers over several days and must do so even if the ultimate decision is to “fly through” a close approach. Since most existing systems have small numbers of vehicles and the number of conjunctions any given operator experiences is relatively small, COLA remains a manual process. For systems not designed with automated maneuver planning, a COLA assessment that progresses all the way to a maneuver plan can consume considerable effort, whether or not the maneuver is executed. If a large constellation is deployed next to an existing resident system, the existing system may experience many conjunctions and alerts due to its close proximity of the dense new constellation. A sufficiently large constellation will, in effect, form a “shell” where frequent opportunities for conjunctions will be created. For example, Fig. 3 depicts a fictional scenario where 1225 “New” satellites are distributed in 35 planes in circular orbits at 1000 km altitude, at 98° inclination. These are placed near a hypothetical “Old” six-satellite constellation operating in a nearly circular orbit at the same altitude and 63° inclination. Following a common operations practice, we assume that the Old satellite operators flag a conjunction at Pc> 10−7, start COLA assessment with additional tracking at Pc> 10−6, and plan a COLA maneuver when the Pc> 10−5. A conjunction with Pc > 10−4 would typically be considered a significant risk leading most operators to maneuver. Fig 3 Download : Download full-size image Fig. 3. “New” large LEO constellation at same average altitude as “Old” existing constellation. Currently, the Old system in this example would typically see a warning (Pc > 10−6) a few times a month at this altitude, and of those, a few per year might cross the maneuver threshold. For the operations center, this would be multiplied by the number of satellites in the constellation. When the New system parks nearby, the number of COLA alerts jumps substantially. But the number of alerts depends entirely on the error bubble, (covariance) used. If the typical errors of the public external tracking data and the orbit propagation methods that are widely available (General Perturbations, or GP) are used for both constellations, over a 30-day period we see 129 conjunctions that cross the threshold for COLA assessment (Pc> 10−6), and 53 that cross the maneuver planning threshold (Pc> 10−5) (Fig. 4). This is nearly 2 per day. This could be an enormous workload for a manual process. If a high accuracy catalog (Special Perturbations, or “SP”) and a high-fidelity propagator with its typical covariances is used, the number of conjunctions goes from 129 to a more manageable 10. SP data is maintained by the Air Force, but it is not widely available. It is interesting to note that nine of those 10 crossed the maneuver-planning threshold, and of those, four crossed the Pc> 10−4 where many operators would choose to execute a maneuver. Compared to GP, the SP-quality data resulted in far fewer warnings and flagged four very close conjunctions. The operations center would have been able to concentrate on fewer “false alarms”. We also computed the case where GPS-quality owner-operator data was used for both systems, in which we assumed near-real-time owner-operator position data of very high quality was provided by both operators and used in the collision analysis. In this case, NONE of the conjunctions resulted in a warning and no COLA alerts were generated. The closest approach was 99 m, with a Pc of 3.7 × 10−7 using SP. But because of the quality of the GPS-based position data, this conjunction did not raise an alert because the fully-informed operators could be confident that a collision would not occur. Fig 4 Download : Download full-size image Fig. 4. Number of COLA alerts in 30 days for various qualities of position knowledge when a fictional new system is deployed near an existing one. In the example, an operations center for the Old constellation of six satellites could go from about one COLA assessment a week to nearly one per day per satellite, if only the published satellite catalog is available. If a new constellation operates too close to an existing system, the operator workload may become unreasonable using existing processes. But high accuracy data makes this manageable, and GPS-quality owner-operator data for both systems makes the problem vanish. Since these constellations are likely to be operated by different companies or governments, sharing high-quality position data would likely require an active space traffic management organization. Existing operators will not necessarily have large constellations parked nearby, but they will nonetheless be affected by the new activity. The new large constellations’ satellites typically will have relatively short lifetimes and will need frequent replenishment. The traffic transiting up and down will be substantial, and failures could leave stranded objects at intermediate altitudes, permanently increasing the collision risk. 5. Conjunction warning overload NewSpace operators will face a different challenge due to the vast increase in numbers of satellites. While there are likely as many operational plans as there are operators, a large constellation must consider close approaches with itself. Even if there are no neighboring systems, self-conjunctions can occur between two members of the same constellation. Depending on the configuration, a given operator could see hundreds to thousands of self-conjunctions that cross typical warning thresholds each day using current practices. This could be an issue for a space traffic management (STM) agency, even if it is not an issue for the operator. Aerospace models show that for one possible NewSpace constellation, more than 500,000 self-conjunctions each year could result that cross the typical Pc > 10−6 warning threshold. If no action were taken, we would expect 2–3 collisions per year. This is clearly unacceptable. Thus, current tracking accuracy and processes might produce millions of warnings per year for NewSpace operators to prevent half a dozen actual collisions. Under current practices operators would need to sort through an enormous haystack to find the needles, and because a handful of actual collisions will occur, the warnings cannot be ignored. Note that predictions such as the ones above are based on the current process of using non-cooperative external tracking and observation (i.e., skin tracking), and the resulting covariances. The number of warnings could be drastically reduced by using more accurate owner-operator information, but that is not currently universally done. The Space Data Association provides such a service, but only uses owner-operator data from members. In any case, current practices will need to change to avoid an unreasonable number of warnings. Recognizing this, many NewSpace operators are planning extensive automation to operate their constellations and mitigate the workload of manual COLA assessments, particularly for self-conjunctions. Most are also taking steps to obtain much higher quality position data than external observation permits. While automation may mitigate the COLA assessment workload for new operators, current operators may have to continue their labor-intensive assessments. The interaction between a NewSpace constellation and a nearby existing or a second large NewSpace constellation will create new challenges for operators. 6. The problem with maneuvers Recent years have seen a steady growth in the use of low-thrust propulsion via ion thrusters. These highly efficient systems have the feature of long, even continuous thrusting. A feature of the automation planned by some of the NewSpace operators is to make extensive use of low-thrust systems for both transit and station-keeping. One approach is to launch into low LEO orbit, transition to the higher LEO operational altitude via low-thrust, and at end-of-life, deorbit the same way. During automated operations, the individual vehicles may autonomously maneuver as needed. Orbit insertion at low LEO altitudes for functional check-out testing has the advantage of allowing early satellite failures to more safely occur in very low, “self-cleaning” orbits. But the slow spirals up to the operational altitude and down for disposal create numerous opportunities for conjunctions with all the resident satellites between the injection altitude and the operational altitude. Existing catalog and COLA processes have no effective way of dealing with frequent or continuous maneuvers, since they are based on predictions generated days in advance, with no assumption of maneuvers. If an existing constellation is operating in proximity to one of these automated constellations, its current COLA process breaks down. The automated maneuvers may move one vehicle in the constellation out of a conjunction, or it could create a new problematic conjunction. The existing practices have an inherent lag and data latency, and a small maneuver will at the very least add to the covariance error. The timelines of the current catalog process and automated maneuvers for a large constellation are fundamentally incompatible.

#### Kessler Syndrome destroys all satellites and traps us on earth.

**Ratner 18** [Paul Ratner, 8-29-2018, "How the Kessler Syndrome can end all space exploration and destroy modern life", Big Think, https://bigthink.com/surprising-science/how-the-kessler-syndrome-can-end-all-space-exploration-and-destroy-modern-life/, date accessed 1-23-2022] //Lex AT

What makes that situation possible is the fact that there are millions of micrometeoroids as well as man-made debris that is already orbiting Earth. The danger posed by even a small fragment that’s traveling at high speeds is easy to see. As [calculated by NASA](https://www.businessinsider.com/space-junk-kessler-syndrome-chain-reaction-prevention-2018-3), a 1-centimeter “paint fleck” traveling at 10km/s (22,000 mph) can cause the same damage as a 550-pound object traveling 60 miles per hour on Earth. If the size of the shard was increased to 10 centimeters, such a projectile would have the force of 7 kilograms of TNT. Now imagine thousands of such objects flying around at breakneck speeds and crashing into each other. If a chain reaction of exploding space junk did occur, filling the orbital area with such dangerous debris, the space program would indeed be in jeopardy. Travel that goes beyond the LEO, like the planned mission to Mars, would be made more challenging but still conceivably possible. What would, of course, be affected if the Kessler Syndrome’s worst predictions came to pass, are all the services that rely on satellites. Core aspects of our modern life—GPS, television, military and scientific research—all of that would be under threat. NASA experienced a small-scale Kessler Syndrome incident in the 1970s when Delta rockets that were left in orbit started to explode into shrapnel clouds. This inspired Kessler, an astrophysicist, to show that there is a point when the amount of debris in an orbit gets to critical mass. At that point, the collision cascading would start even if no more things are launched into space. And once the chain of explosions begins, it can keep going until the orbital space can no longer be used. In Kessler’s estimate, it would take 30 to 40 years to get to such a threshold. [NASA says](https://www.nasa.gov/centers/wstf/site_tour/remote_hypervelocity_test_laboratory/micrometeoroid_and_orbital_debris.html) that its experts caution that we are already at critical mass in the low-Earth orbit, which is about 560-620 miles (900 to 1,000 kilometers) out. According to NASA estimates, the Earth’s orbit currently has [500,000 pieces of space debris](http://orbitaldebris.jsc.nasa.gov/faqs.html#3) up to 10cm long, over 21,000 pieces of debris longer than 10cm, and more than 100 million pieces of space debris smaller than 1cm. A 2009 incident dubbed the [Cosmos-Iridium collision](http://www.spacesafetymagazine.com/space-debris/kessler-syndrome/iridium-33-cosmos-2251-years-later-learned-then/)featured a space collision between Russian and American communication satellites that provided a preview of potential attractions in the massive debris field it created. The accident resulted in more than 2,000 pieces of relatively large space junk.

#### Debris triggers nuclear miscalculation—uniquely likely in space.

**Blatt 20** [[Talia M. Blatt](https://hir.harvard.edu/author/talia/), May 26th, 2020, "Anti-Satellite Weapons and the Emerging Space Arms Race", Harvard International Review, https://hir.harvard.edu/anti-satellite-weapons-and-the-emerging-space-arms-race/, date accessed 1-23-2022] //Lex AT

Despite their deterrent functions, ASATs are more likely to provoke or exacerbate conflicts than dampen them, especially given the risk they [pose](https://thebulletin.org/2019/06/arms-control-in-outer-space-the-russian-angle-and-a-possible-way-forward/) to early warning satellites. These satellites are a crucial element of US ballistic missile defense, capable of [detecting missiles](https://www.globalsecurity.org/space/world/japan/warning.htm) immediately after launch and tracking their paths. Suppose a US early warning satellite goes dark, or is shut down. Going dark could signal a glitch, but in a world in which other countries have ASATs, it could also signal the beginning of an attack. Without early warning satellites, the United States is much more susceptible to nuclear missiles. Given the strategy of counterforcing—[targeting](https://www.belfercenter.org/sites/default/files/files/publication/isec_a_00273_LieberPress.pdf) nuclear silos rather than populous cities to prevent a nuclear counterattack—the Americans might believe their nuclear weapons are imminently at risk. It could be [twelve hours](https://books.google.com/books?id=ET8lDwAAQBAJ&pg=PA1&lpg=PA1&dq=%22Protecting+Space+Assets%22+johnson-freese&source=bl&ots=6Oq0IdeBjw&sig=ACfU3U1G6Hj8QdP4JlCRNxA6i5XplZwHyg&hl=en&sa=X&ved=2ahUKEwj1n-jT2YzpAhUugnIEHUuMCu4Q6AEwA3oECAkQAQ#v=onepage&q=%22Protecting%20Space%20Assets%22%20johnson-freese&f=false) before the United States regains satellite function, which is too long to wait to put together a nuclear counterattack. The United States, therefore, might move to mobilize a nuclear attack against Russia or China over what might just be a piece of debris shutting off a satellite. Additionally, accidental warfare, or strategic miscalculation, is uniquely likely in space. It is [much easier](https://books.google.com/books?id=VyXTDwAAQBAJ&pg=PA339&lpg=PA339&dq=space+offense+dominant&source=bl&ots=Mw0bgJ51qf&sig=ACfU3U3DeZiEHpr9nfszlCbJZIoyyssIpg&hl=en&sa=X&ved=2ahUKEwjrs-WD3IzpAhVulHIEHbL0AE4Q6AEwCXoECAoQAQ#v=onepage&q=space%20offense%20dominant&f=false) to hold an adversary’s space systems in jeopardy with destructive ASATs than it is to [sustainably defend](https://www.cnas.org/publications/commentary/the-us-military-should-not-be-doubling-down-on-space) a system, which is expensive and in some cases not technologically feasible because of limitations on satellite movement. Space is therefore [considered](https://books.google.com/books?id=VyXTDwAAQBAJ&pg=PA339&lpg=PA339&dq=space+offense+dominant&source=bl&ots=Mw0bgJ51qf&sig=ACfU3U3DeZiEHpr9nfszlCbJZIoyyssIpg&hl=en&sa=X&ved=2ahUKEwjrs-WD3IzpAhVulHIEHbL0AE4Q6AEwCXoECAoQAQ#v=onepage&q=space%20offense%20dominant&f=false) offense-dominant; offensive tactics like weapons development are prioritized over defensive measures, such as [improving GPS](https://www.politico.com/story/2018/04/06/outer-space-war-defense-russia-china-463067) or making satellites more resistant to jamming. As a result, countries are left with poorly defended space systems and rely on offensive posturing, which increases the risk that their actions are perceived as aggressive and incentivizes rapid, risky counterattacks because militaries cannot rely on their spaced-based systems after first strikes.

#### Extinction – nuke war fallout creates Ice Age and mass starvation

**Starr 15** (Steven Starr 15. “Nuclear War: An Unrecognized Mass Extinction Event Waiting To Happen.” Ratical. March 2015. <https://ratical.org/radiation/NuclearExtinction/StevenStarr022815.html> TG)

A war fought with 21st century strategic nuclear weapons would be more than just a great catastrophe in human history. If we allow it to happen, such a war would be a mass extinction event that [ends human history](https://ratical.org/radiation/NuclearExtinction/StarrNuclearWinterOct09.pdf). There is a profound difference between extinction and “an unprecedented disaster,” or even “the end of civilization,” because even after such an immense catastrophe, human life would go on.

But extinction, by definition, is an event of utter finality, and a nuclear war that could cause human extinction should really be considered as the ultimate criminal act. It certainly would be the crime to end all crimes.

The world’s leading climatologists now tell us that nuclear war threatens our continued existence as a species. Their studies predict that a large nuclear war, especially one fought with strategic nuclear weapons, would create a post-war environment in which for many years it would be too cold and dark to even grow food. Their findings make it clear that not only humans, but most large animals and many other forms of complex life would likely vanish forever in a nuclear darkness of our own making.

The environmental consequences of nuclear war would attack the ecological support systems of life at every level. Radioactive fallout produced not only by nuclear bombs, but also by the destruction of nuclear power plants and their spent fuel pools, would poison the biosphere. Millions of tons of smoke would act to [destroy Earth’s protective ozone layer](https://www2.ucar.edu/atmosnews/just-published/3995/nuclear-war-and-ultraviolet-radiation) and block most sunlight from reaching Earth’s surface, creating Ice Age weather conditions that would last for decades.

Yet the political and military leaders who control nuclear weapons strictly avoid any direct public discussion of the consequences of nuclear war. They do so by arguing that nuclear weapons are not intended to be used, but only to deter.

Remarkably, the leaders of the Nuclear Weapon States have chosen to ignore the authoritative, long-standing scientific research done by the climatologists, research that predicts virtually any nuclear war, fought with even a fraction of the operational and deployed nuclear arsenals, will leave the Earth essentially uninhabitable.

#### Public satellite data is key to biodiversity.

**Pennisi 21**[Elizabeth Pennisi, 18 NOV 2021, "Satellites offer new ways to study ecosystems—and maybe even save them", No Publication, https://www.science.org/content/article/satellites-offer-new-ways-study-ecosystems-maybe-even-save-them, date accessed 1-23-2022] //Lex AT

But such studies could only provide a snapshot of one forest at a time. To get the big picture of forests around the world, Cavender-Bares has sought a higher vantage. Now a plant ecologist at the University of Minnesota, Twin Cities, Cavender-Bares has devised ways to translate light measured by spectrometers flown over forests into insights about their health and resilience. She and others have [found this light](https://doi.org/10.1007/978-3-030-33157-3_1), captured from an airplane or satellite, holds clues to intimate details such as photosynthesis levels, the genetic diversity of the trees, and even the microbial inhabitants of the soil they grow in. Such remote sensing methods are not only revolutionizing how scientists such as Cavender-Bares study ecosystems, they’re also poised to become powerful new tools in the fight to protect them. Over the past year scientists have gathered to revise the most important international treaty aimed at conservation, the Convention on Biological Diversity (CBD). With the loss of plant and animal species accelerating, some researchers say conservation efforts should turn to remote sensing to monitor biodiversity in near–real time across wide swaths of the globe—and help policymakers prioritize the most critical areas. Historically, researchers had to venture out to jungles, deserts, and mountaintops to document the flora and fauna. But species distributions and abundances are changing faster than ground-based surveys can track, because of climate change, human activities, and other factors. Remote sensing offers the possibility of faster, more standardized monitoring across the entire globe. “In the past decade, there’s been a revolution in the technology available to characterize ecosystems from space,” says David Schimel, a research scientist at NASA’s Jet Propulsion Laboratory. Researchers are just beginning to figure out what remote sensing can and can’t do and how to incorporate it into global conservation efforts. But Schimel and others see great promise for supplementing ground-based measurements with a fuller picture of ecosystems’ health gleaned from aloft. “We want to transform the way biological research is done,” he says. CAVENDER-BARES FIRST learned that reflected or emitted light could help signal forest health during a graduate school visit to the Laboratory for the Use of ­Electromagnetic Radiation (LURE) at Paris-Sud University. In lab studies there almost 40 years ago, plant physiologist Jean-Marie Briantais and colleagues had shown they could measure photosynthetic activity by comparing how leaves fluoresce, or emit certain wavelengths of light, before and after being exposed to flashes of extremely bright white light. As the light displaces electrons inside chlorophyll, the intensity of red and infrared (IR) light emitted from the leaves varies, depending on how healthy the plant is. Later, Ismael Moya, a biophysicist at LURE, developed a sensor that required no extra light source, relying on sunlight instead. Moya went on to demonstrate that fluorescence could be detected from an airplane flying over crops, opening the way to surveying fields’ productivity remotely. “I just became fascinated with what we could learn from the interaction of plants with light and have been for 28 years,” Cavender-Bares says. In that time, researchers have mostly used methods based on reflected light, but fluorescence remains a valuable tool. By now, airplanes, drones, and towers all provide spectroscopic data on vegetation. So does NASA and the U.S. Geological Survey’s series of Landsat satellites, the first of which were launched in the 1970s. Initially, the agencies expected the satellites’ cameras to primarily capture images in visible light, but an experimental spectral sensor on board proved the value of recording more of the electromagnetic spectrum, such as near-IR light, and by 2013 the satellites were monitoring 11 portions of the spectrum. With these “multispectral” data, researchers can monitor how “green” or productive a vegetated landscape is. Spectroscopically detected dips in chlorophyll can also signal a forest that is suffering because of drought or insect invasion—or has been cleared for development.

#### Biodiversity loss causes extinction.

**Gallagher 21**[[Katherine Gallagher](https://inhabitat.com/author/katherinegallagher/), Apr 5, 2021, "“Extinction – The Facts” explores the global extinction crisis", Inhabitat - Green Design, Innovation, Architecture, Green Building | Green design &amp; innovation for a better world, https://inhabitat.com/extinction-the-facts-explores-the-global-extinction-crisis-and-its-consequences/, date accessed 1-19-2022] //Lex AT

Biodiversity loss [Biodiversity](https://inhabitat.com/tag/biodiversity/) refers to the variety of life found on Earth, including plants, animals and micro-organisms. Each of these species and organisms form unique communities and habitats, working together in various ecosystems to maintain balance. The United Nations brought 500 international scientists together in 2019 to investigate the current state of our natural world, only to find that the planet was losing biodiversity at a rate never seen before in the history of humanity. The results were unexpected and unprecedented; there were at least 1 million plant, animal and insect species threatened with extinction at a rate 100 times faster than their natural evolutionary rate. The numbers are nearly split, between about 500,000 insects and 500,000 plants and animals, with populations growing smaller by the day. “Extinction is a natural process,” explained professor Kathy Willis, a plant scientist at the University of Oxford. “Things come, they grow, their populations get huge and then they decline. But it’s the rate of extinction; that’s the problem.” When scientists look at previous groups in fossil records, extinction happens over millions of years. Today, we’re looking at tens of years. Since 1970, vertebrate animals — such as birds and reptiles — have declined by a total of 60%, while large animals have disappeared from three-quarters of their historic ranges. Professor Elizabeth Hadly, a biologist at Stanford University, said one of the most concerning aspects of this decline is that it’s happening simultaneously around the world. “In the Amazon, in Africa, in the [Arctic](https://inhabitat.com/tag/arctic); it’s happening not at one place and not with one group of organisms, but with all biodiversity, everywhere on the planet.” James Mwenda, a conservationist at Ol Pejeta Conservancy in Kenya, is the caretaker for the world’s last two living northern white rhinos, a [species](https://inhabitat.com/tag/species) that once numbered in the thousands throughout Central Africa. “Many people think of extinction being this imaginary tale told by conservationists, but I have lived it. I know what it is,” he said in the documentary. As a caretaker, Mwenda watched the northern white rhino population go from seven in 1990 to just two today, a mother and daughter named Najin and Fatu. A subspecies of the white rhinoceros, the northern white rhino was pushed to the critically endangered list due to hunting and habitat loss. “They’re here because we betrayed them,” he said sorrowfully. “And I think they feel it, this threatening tide of extinction that is pushing on them.” Losing entire portions of the planet’s individual species is tragic enough in itself, but the crisis encompasses much more than that. All of biodiversity is interlocked on a global scale, and the planet needs all parts of it to function properly. Humans are not outside of those ecological systems by any means. For example, a loss in insect species can put [pollination](https://inhabitat.com/tag/pollination/) at risk, which in turn puts food production at risk, affecting both humans and animals alike. Human influence The documentary also examines the ways that humans are driving biodiversity loss. Things like overfishing, deforestation and the illegal wildlife trade are the biggest contributors, but there are also less obvious threats like consumer-driven demand for products like clothes, which can cause pollution in their production. The [illegal wildlife trade](https://inhabitat.com/tag/illegal-wildlife-trade/) has become a multibillion dollar global industry over the last 20 years. Increased income in certain countries like China and Vietnam, where endangered animal parts may be seen as a status symbol or used for medicinal purposes, is one of the largest drivers. Pangolins, for instance, represent the most trafficked animals in the world, and the demand for their scales is directly responsible for their declining numbers. The scale of global [overfishing](https://inhabitat.com/tag/overfishing/) has dramatically increased as well. In some parts of the world, limits on ocean catch aren’t regulated. Scientists have seen declines in larger predator fish as their food supply dwindles due to overfishing, so the impact on marine ecosystems is widespread.

### Advantage 2: Cooperation

#### Entrepreneurs are pushing for privatization of space travel with increasing success.

Thompson 20 [(Clive, author of Coders: The Making of a New Tribe and the Remaking of the World, a columnist for Wired magazine, and a contributing writer to The New York Times Magazine) “Monetizing the Final Frontier The strange new push for space privatization,” December 3, 2020 <https://newrepublic.com/article/160303/monetizing-final-frontier>] TDI

For longtime enthusiasts of NASA’s human spacefaring, it was a singularly auspicious moment. Ever since NASA’s space shuttles were mothballed in 2011, the agency had no American-owned way of getting people into space. It had been paying the Russian government to fly U.S. astronauts up and back, on Russia’s Soyuz spacecraft. But this flight was different. It was the first time humans had flown in a rocket and a capsule made by a private-sector company: SpaceX, the creation of the billionaire Elon Musk. The launch was also a SpaceX branding bonanza. The astronauts rode up to the rocket in a Tesla, Musk’s fabled luxury electric car; when they’d reached orbit, they broadcast a live video in which they thanked SpaceX for making the flight happen, and showed off the sleek capsule—a genuine marvel of engineering, with huge touch screen control panels that looked rather like the ones inside a Tesla itself. Over the next few years, NASA will pay Musk and SpaceX $2.6 billion to ferry astronauts to and from the space station six times. For the feds, this price tag is remarkably cheaper than the space shuttle, which cost over $1 billion per flight. In his speech after the launch, Trump lauded the cost savings that SpaceX had realized on the government’s behalf. SpaceX, he announced, “embodies the American ethos of big thinking and risk-taking.... Congratulations, Elon.” For Musk, though, the launch was more than just a technical success, and is bigger even than the $2.6 billion contract. It cements him as a leading player in what might seem the unlikeliest stage of the final frontier’s exploration—the privatization of space. Private-sector activity in space travel is accelerating dramatically—rocketing, one might say. For decades, ever since people first headed for orbit in the 1960s, spaceflight had been mostly the preserve of governments. States were the only actors with the money and technical acumen to blast things into the vacuum and get them safely down again. The private sector didn’t have NASA’s know-how, nor—more important—a business plan that could rationalize the massive outlay of capital required to operate in space. In the last few years, that calculus has changed dramatically. A generation of “New Space” entrepreneurs has begun launching rockets and satellites. Some seek to flood the planet with fast, cheap mobile-phone signals; others want to manufacture new products in zero gravity, harnessing the novel physics of such conditions to engineer substances that can’t be made in Earth’s gravity. Further afield, they’re aiming to harvest water on the moon and even mine asteroids. Backing this burst of entrepreneurial fervor are many billionaires who made their money in the early Wild West of the internet, including Amazon’s Jeff Bezos, with dreams of building space colonies, and Musk, the former PayPal titan who hopes to personally make it to Mars.Barack Obama’s administration made the first major overtures to the space privatizers, signing legislation that paved the way for today’s space boom. But the real land rush has occurred under Trump, via a flurry of executive orders designed to give private firms greater access to “low-Earth orbit.” Trump officials have even touted the idea of privatizing the $100 billion space station itself—the last signature NASA-sponsored human spacecraft project still aloft. When Trump’s transition team in 2017 pondered the handoff of low-Earth orbit to the private sector, it concluded: “This may be the biggest and most public privatization effort America has ever conducted.” Or as Texas GOP Senator Ted Cruz—at the time the chairman of the Space, Science, and Competitiveness Subcommittee—put it in 2018: “I predict the first trillionaire will be made in space.” The burst of activity and high-tech acumen thrills many space fans. But it is making many others quite nervous. Opening up space to a frenzy of private actors could, they agree, produce measurable benefits back on planet Earth—making crucial scientific research, environmental monitoring, and everyday communication cheaper. But the critics are quick to note as well that the history of privatization is spotty at best, with plenty of civically brutal knock-on effects: concentrations of monopolistic power, enfeebled democratic control, and widespread environmental degradation. We’ve seen all those problems appear on Earth as all manner of traditional social goods, from education and housing to pension plans and mass transit, have been targeted for private-sector control. Next up, it seems, is the great beyond.

#### Deep space exploration is a shared goal that prevents escalation of US-Russia tensions. But privatization threatens it independent of our other internal links

CSIS 18 [(Center for Strategic and International Studies), “Why Human Space Exploration Matters,” August 21, 2018 https://www.csis.org/blogs/post-soviet-post/space-cooperation] TDI

U.S.-Russian space cooperation continues to be a stated mutual goal. In April 2018, President Putin said of space, “Thank God, this field of activity is not being influenced by problems in politics. Therefore, I hope that everything will develop, since it is in the interests of everyone…This is a sphere that unites people. I hope it will continue to be this way.” During his statement at a recent event at CSIS, NASA Administrator Jim Bridenstine said, “[space] is our best opportunity to dialogue when everything else falls apart. We’ve got American astronauts and Russian cosmonauts dependent on each other on the International Space Station, which enables us to ultimately maintain that dialogue.” The U.S. and Russia both benefit from the ISS partnership. Russia provides transportation to the ISS for U.S. astronauts, from which Russia receives an average of $81 million per seat on the Soyuz (and recognition of its status as a space power). The U.S. also benefits from Russia’s technical contributions to the ISS while Russia benefits The U.S. and Russia signed a joint statement in 2017 in support of the idea of collaborating on deep space exploration, including the construction of the Lunar Orbital Platform-Gateway, a research-focused space station orbiting the moon. Through agreements on civilian space exploration, such as the Lunar Orbital Platform-Gateway or future Mars projects, that have clear benefits to both sides, some degree of cooperation will remain in both countries’ interest. The high price tag for pursuing space exploration alone and opportunities for sharing and receiving technical expertise encourages international partnerships like the ISS. However, at least three factors, apart from the overall deterioration of U.S.-Russia relations, threaten this cooperation. First, growth of the private sector space industry may alter the economic arrangement between the U.S. and Russia, and ultimately lower the benefits of cooperation to both countries. The development of advanced technologies by private companies will give NASA new options to choose from and reduce the need to depend on (and negotiate with) Russia. If NASA and its Russian counterpart, Roskosmos, have no need to talk with one another, they probably won’t in the face of tense political relations. The U.S. intends to use Boeing and SpaceX capsules for human spaceflight beginning in 2020, and a Congressional plan in 2016 set a phase out date of Russian RD-180 rocket engines by 2022.

#### It’s make or break for the relationship—Ukraine, decline of US moral authority on international affairs puts us at the brink of the end of Russian diplomacy and even war

Weir 21 [(Fred Weir has been the Monitor's Moscow correspondent, covering Russia and the former Soviet Union, since 1998. He's traveled over much of that vast territory, reporting on stories ranging from Russia's financial crash to the war in Chechnya, creeping Islamization in central Asia, Russia's demographic crisis, the rise of Vladimir Putin and his repeated returns to the Kremlin, and the ups and downs of US-Russia relations). “Worse than the Cold War? US-Russia relations hit new low.“ Christian Science Monitor 4-20-2021 https://www.csmonitor.com/World/Europe/2021/0420/Worse-than-the-Cold-War-US-Russia-relations-hit-new-low] TDI

Russia’s relations with the West, and the United States in particular, appear to be plumbing depths of acrimony and mutual misunderstanding unseen even during the original Cold War.After years of deteriorating relations, sanctions, tit-for-tat diplomatic expulsions, and an escalating “information war,” some in Moscow are asking if there even is any point in seeking renewed dialogue with the U.S., if only out of concern that more talking might just make things worse. Events have cascaded over the past month. Russia’s treatment of imprisoned dissident Alexei Navalny, who has been sent to a prison hospital amid reports of failing health, underlines the sharp perceived differences between Russia and the West over matters of human rights. Meanwhile, a Russian military buildup near Ukraine has illustrated that the conflict in the Donbass region might explode at any time, possibly even dragging Russia and NATO into direct confrontation. With its relations with Washington at a nadir, Russia is eyeing a more pragmatic, if adversarial, relationship with the U.S. in the hopes of getting the respect it desires. President Joe Biden surprised the Kremlin by proposing a “personal summit” to discuss the growing list of U.S.-Russia disagreements in a phone conversation with Vladimir Putin last week. He later spoke of the need for “disengagement” in the escalating tensions around Ukraine, and postponed a planned visit of two U.S. warships to Russia-adjacent waters in the Black Sea. But days later he also imposed a package of tough sanctions against Russia, for its alleged SolarWinds hacking and interference in the 2020 U.S. presidential elections, infuriating Moscow and drawing threats of retaliation. Last month, after Mr. Biden agreed with a journalist’s intimation that Mr. Putin is a “killer,” the Kremlin ordered Russia’s ambassador to the U.S. to return home for intensive consultations, an almost unprecedented peacetime move. Over the weekend, Russian Foreign Minister Sergey Lavrov suggested that the acting U.S. ambassador to Moscow, John Sullivan, should likewise go back to Washington for a spell. On Tuesday, Mr. Sullivan announced he would do just that this week. And there is a growing sense in Moscow that the downward spiral of East-West ties has reached a point of no return, and that Russia should consider abandoning hopes of reconciliation with the West and seek permanent alternatives: perhaps in an intensified compact with China, and targeted relationships with countries of Europe and other regions that are willing to do business with Moscow. “Things are at rock bottom. This may not be structurally a cold war in the way the old one was, but mentally, in terms of atmosphere, it’s even worse,” says Fyodor Lukyanov, editor of Russia in Global Affairs, a Moscow-based foreign policy journal. “The fact that Biden offered a summit meeting would have sounded a hopeful note anytime in the past. Now, nobody can be sure of that. A hypothetical Putin-Biden meeting might not prove to be a path to better relations, but just the opposite. It could just become a shouting match that would bring a hardening of differences, and make relations look like even more of a dead end.” Room for discussion Foreign policy experts agree that there is a long list of practical issues that could benefit from purposeful high-level discussion. With the U.S. preparing to finally exit Afghanistan, some coordination with regional countries, including Russia and its Central Asian allies, might make the transition easier for everyone. One of Mr. Biden’s first acts in office was to extend the New START arms control agreement, which the Trump administration had been threatening to abandon, but the former paradigm of strategic stability remains in tatters and requires urgent attention, experts say. “If you are looking for opportunities to make the world a safer place through reason and compromise, there are quite a few,” says Andrey Kortunov, director of the Russian International Affairs Council, which is affiliated with the Foreign Ministry. “There are also some areas where the best we could do is agree to disagree, such as Ukraine and human rights issues.” The plight of Mr. Navalny, which has evoked so much outrage in the West, seems unlikely to provide leverage in dealing with the Kremlin because – as Western moral authority fades – Russian public opinion appears indifferent, or even in agreement with its government’s actions. Recent surveys by the Levada Center in Moscow, Russia’s only independent pollster, found that fewer than a fifth of Russians approve of Mr. Navalny’s activities, while well over half disapprove. An April poll found that while 29% of Russians consider Mr. Navalny’s imprisonment unfair, 48% think it is fair. Russian opposition figure Alexei Navalny, shown here during a hearing in the Babuskinsky District Court in Moscow Feb. 12, 2021, is in poor health amid his hunger strike while in prison in Russia. He was recently moved to a prison hospital. Tensions around the Russian-backed rebel republics in eastern Ukraine have been much severer than usual, with a spike in violent incidents on the front line, a demonstrative Russian military buildup near the borders, and strong U.S. and NATO affirmations of support for Kyiv. The Russian narrative claims that Ukrainian President Volodymyr Zelenskiy triggered the crisis a month ago by signing a decree that makes retaking the Russian-annexed territory of Crimea official Ukrainian state policy. Mr. Zelenskiy has also appealed to the U.S. and Europe to expedite Ukraine’s membership in NATO, which Russia has long described as a “red line” that would lead to war. But Russian leaders, who have been at pains to deny any direct involvement in Ukraine’s war for the past seven years, now say openly that they will fight to defend the two rebel republics. Top Kremlin official Dmitry Kozak even warned that if conflict erupts, it could be “the beginning of the end” for Ukraine. “This is a very desperate situation,” says Vadim Karasyov, director of the independent Institute of Global Strategies in Kyiv. “We know the West is not going to help Ukraine militarily if it comes to war. So we need to find some kind of workable compromises, not more pretexts for war.” Time to turn eastward? In this increasingly vexed atmosphere, the Russians appear to be saying there is no point in Mr. Putin and Mr. Biden meeting unless an agenda has been prepared well in advance, setting out a few achievable goals and leaving aside areas where there can be no agreement. “Russia isn’t going to take part in another circus like we had with Trump in Helsinki in 2018,” says Sergei Markedonov, an expert with MGIMO University in Moscow. “What is needed is a deeper dialogue. That could begin if we had a real old-fashioned summit between Biden and Putin, one that has been calculated to yield at least some positive results. We need to find a modus vivendi going forward, and the present course is not leading there.” Alternatively, Russia may turn away from any hopes of even pragmatic rapprochement with the West, experts warn. Mr. Lukyanov, who maintains close contact with his Chinese counterparts, says they felt blindsided at a summit with U.S. foreign policy chiefs in Alaska last month, when what they expected to be a practical discussion of how to overcome the acrimonious Trump-era legacy in their relations turned into what they saw as a U.S. lecture about how China needs to obey the “rules-based” international order. “It was the Chinese, in the past, who were very cautious about participating” in anything that looked like an anti-Western alliance, says Mr. Lukyanov. “We are hearing a new tone from them now. Now our growing relationship with China isn’t just about compensating for a lack of relations with the U.S. It’s about the need to build up a group of countries that will resist the U.S., aimed at containing U.S. activities and policies that are harmful to our two countries.”

#### Privatization of space travel makes it politically polarizing and drains public support.

Phillips 20 [(Leigh, science writer and EU affairs journalist, author of Austerity Ecology & the Collapse-Porn Addicts.) “We Don’t Need Elon Musk to Explore the Solar System,” May 8, 2021, https://jacobinmag.com/2021/05/elon-musk-space-exploration-mars-colonization] TDI

Elon Musk is right to dream of humanity’s future as a multi-planet species. However, the multigenerational, millennia-long project of space colonization will be a public-sector endeavor, or it will not happen. Elon Musk, the third-richest man in the world, CEO of SpaceX and Tesla (and dabbler in online edgelord provocation), issued a strange Twitter post last month in defense of his wealth. “I am accumulating resources to help make life multiplanetary & extend the light of consciousness to the stars,” he declared. And then, this week, the centibillionaire further provoked when he mentioned in an interview about Martian colonization that, while it would be a glorious experience, “a bunch of people will probably die in the beginning.” All this within days of NASA’s Perseverance Mars mission achieving the first helicopter flight on another planet and producing five grams of oxygen from the planet’s carbon dioxide–dominant atmosphere — two major milestones in space exploration. A reasonable critique of Musk’s SpaceX endeavors might begin by noting that, regardless of how noble an aim Musk may have for his centibillions, there simply should not be centibillionaires (or even regular millionaires and billionaires). One might also echo Neil Armstrong’s criticism of private space flight — a criticism that once made Elon cry when 60 Minutes asked him about his hero arguing against the privatization of space. We might note how space exploration during the Cold War, despite the militarist overtones of the Space Race, was explicitly intended to be for all mankind rather than in service of the jollies of ultrarich space tourists. A democratic and public redirection of Elon Musk’s billions might be spent differently. One might further assert that, given the non-identity of the set of all things that are beneficial and the set of all things that are profitable, space colonization will be a public-sector endeavor, or it will not happen — as such a private space travel has no near-term, medium-term, or even long-term prospect of any return on financial investment beyond servicing low-earth, medium-earth, or geostationary orbit. And, finally, we might denounce the union-busting at Musk’s factories or even argue that his “accumulation of resources” is less the product of his own efforts than it is primarily an upward redistribution of value created by his workers. That is to say that there are a raft of progressive critiques of Musk that could be made that nevertheless still value space exploration and, one day, human colonization of the cosmos. Indeed, if one values space exploration and looks forward to the time, as astronomer Carl Sagan put it, “when most human cultures will be engaged in an activity you might describe as a dandelion going to seed,” then a socialist critique is all the more necessary, given the irrational limitations markets impose on human endeavor. There are a raft of progressive critiques of Elon Musk that could be made that nevertheless still value space exploration and, one day, human colonization of the cosmos. But instead, there are thousands of snark-drenched tweets sneering at how crackpot, masculinist, and even childish Elon’s dream is. They argue that space travel is a waste of resources that would be better spent solving problems here on Earth, and that space colonization is a repetition of the colonization of the New World. Even Bernie Sanders responded to Musk by saying: “Space travel is an exciting idea, but right now we need to focus on Earth and create a progressive tax system so that children don’t go hungry, people are not homeless and all Americans have healthcare. The level of inequality in America is obscene and a threat to our democracy.” At the time of writing, the senator’s tweet had received some 95,000 likes. Bernie is, in this case, wrong. Space exploration, including space travel, is one of the grandest tasks humanity has ever set for itself. It is a false dichotomy — and an austerian one at that — to say that we do not have enough money for both a space program and social justice or environmental protection. We can more than afford to do both. NASA’s budget is but a fraction of the Pentagon’s. It should not be difficult to imagine a democratic socialist economy, or even just one a little less neoliberal, that permits much more space and much less war. We can have public health care and science. We can end homelessness and explore the cosmos. We can have unionized, family-supporting jobs for all and, one day, almost certainly some considerable time from now, colonies on other worlds. The Postcolonial Space Programs Let me offer a personal anecdote about how I came to change my mind about this. A few years ago, I was researching the space programs of developing nations in Sub-Saharan Africa and South America for a feature article for a science magazine. While I have always been a cheerleader for space science, I had heard that, in some cases, the states concerned did not really have the capacity for such activities and were doing little more than rebranding British or American satellites launched from Russian spaceports. I thought I would have a nice story of neoliberal regimes wasting what little money these countries had on vanity projects that were of dubious national provenance. So I got in touch with some of the British and American engineers that had worked on these projects and interviewed them off the record. To varying degrees, they conceded that this was more or less what was happening in some places, but not in others, where a country was more advanced and did have at least some of the capacity necessary. Off the record, they told stories of corruption and incompetence, delays and malfunctions. But they also said that there was a learning process and there absolutely was a transfer of skills and knowledge. It was a mixed bag, they said. It is a false dichotomy — and an austerian one at that — to say that we do not have enough money for both a space program and social justice or environmental protection. More than this, what told me that made me completely rethink my attitude toward developing world space programs. They said that, however much they might have questioned the priority given to a space program for a country without functioning roads or sewage systems, everywhere they went, when they said why they were in the country, ordinary people would respond by bursting with pride that their country, too, was going into space. For them, it symbolized that they were just as good as any developed nation, that modernity was coming, and that they, too, could be explorers and pioneers. I put away my story and never wrote it. Instead, I investigated the decline of mathematical training in Africa in the neoliberal era. During the postcolonial era, African socialist governments had been committed to developing a cadre of professionals schooled in advanced mathematics and science, sometimes with the assistance of the Soviet Union, sometimes with aid from the United States or France, depending on the contingencies of the Cold War. But the indifference that followed the end of the Cold War and the advent of neoliberalism had gutted such training, and now, in many countries, the aging, mathematically trained professionals were retiring or dying with no one to replace them. Such training is essential not just for scientific research but for civil engineering, national budgeting, and enterprise planning. Thankfully, a celebrated physicist, Neil Turok — also the son of the man who crafted the South African ANC’s armed struggle strategy, Ben Turok — had started a new institute expressly committed to reviving Africa’s mathematical capacity. I wrote about that instead. We can today spend on both space exploration and mathematics education — and we could have in the 1960s. We don’t only need charity, but we need vaulting ambition as well: not just social programs but science. Or, put another way: we want bread, but we want roses, too. How Venus Helped Us Understand Global Warming But even if Bernie made an unwittingly neoliberal argument by imagining there is not enough wealth in America to afford both an ambitious space program and luxuriant social programs, he did at least state that he thought space travel was exciting. It was a matter of prioritization rather than outright opposition. There were others, however, who attacked the very idea of going into space, not least at a time of climate emergency. We should focus on this living planet rather than unfathomably distant dead ones, they said. This is not a one-off; Left critics of space programs repeatedly issue calls for a focus on the environmental challenges Earth faces instead of going to space. But this is a second false dichotomy. Space science, in so many respects, is Earth science. NASA is perhaps the premier Earth science research agency in the world. Its Landsat program, originally named the Earth Resources Technology Satellite and dating back to 1972, is the longest running effort to deliver satellite imagery of the planet. Its latest iteration, Landsat 8, launched in 2013 and delivers millions of images free of charge to researchers or any member of the public, tracking forest loss and degrowth, glacier and icecap melt, land-use change and agricultural water use. Left critics of space programs repeatedly issue calls for a focus on the environmental challenges Earth faces instead of going to space. But space science, in so many respects, is Earth science. Then there is AIRS, the Atmospheric Infrared Sounder, on NASA’s Aqua satellite, which gathers infrared energy emitted from Earth’s surface and atmosphere and measurements of temperature and water vapor that are used to assess the accuracy of climate models, detect volcanic plumes, and forecast droughts. The Geostationary Carbon Observatory (GeoCarb), yet to launch, will monitor greenhouse gas emissions, and the Ice, Cloud and land Elevation Satellite-2 (ICESat-2) mission will measure ice-sheet elevation, sea-ice thickness, and tree-canopy height to track changes in Greenland and Antarctica ice and assess changes in the total mass of the world’s vegetation. As of 2021, there are some forty different current and soon-to-launch Earth science missions performed by NASA. When we send missions to other worlds, again, learning about them teaches us as much about Earth as they do about the Moon, Mars, Venus, Europa, Titan, or Enceladus. Let’s remember that climatologist James Hansen — whose 1988 congressional testimony on global warming was one of the main catalysts of early public and political awareness of the climate emergency — had his start studying the transfer of radiation through the Venusian atmosphere. It was his work investigating Venus — a planet with a runaway greenhouse effect — that led him to work on climate change on Earth. Indeed, the study of the atmospheres of both Venus and Mars is a key part of the story of how we discovered global warming. Robots vs. Humans One might respond that all of this is unmanned space exploration. Surely steady advances in robotics and miniaturization have weakened the case for manned spaceflight. Robots like the Perseverance rover (nicknamed Percy), which recently landed in Jezero Crater on Mars aiming, among other goals, to search for evidence of ancient microbial life, are much more able to access extreme environments inhospitable to humans and at a much lower cost. But while there are many things robots can do that humans cannot, there are also many things humans can do that robots cannot and will never be able to (at least until the advent of artificial general intelligence). As British planetary scientist Ian Crawford argues, humans have the advantage over robots with respect to on-the-spot decision-making and flexibility and thus increased probability of making serendipitous discoveries. There is also greater efficiency of sample collection and return with humans (382 kg of moon rocks returned by Apollo vs the 0.32 kg from the sample returns of the Soviet Union’s robotic Luna missions), and greater potential for large-scale exploratory activity, deployment, and maintenance of complex equipment. But it is the universal problem-solving capability of humans that is key. Crawford quotes Steve Squyres, the principal investigator for the Mars exploration rovers Spirit and Opportunity, who concluded in 2005: “The unfortunate truth is that most things our rovers can do in a perfect sol [a Martian day] a human explorer can do in less than a minute.” An artist’s rendering of the Perseverance rover on Mars. (Tim Tim / Wikimedia Commons) And we see this in the scientific literature. Comparing the number of refereed publications resulting from the Apollo moon missions (the only human exploration missions) with those from robotic missions to the Moon and Mars, Crawford finds the former has produced a much greater volume. Dividing the cumulative number of publications by days of fieldwork on the surface, Crawford gauges that the Apollo project was three orders of magnitude more efficient in producing scientific papers per day than its unmanned counterparts, while being about one or two orders of magnitude more expensive. He notes that the next most productive missions are the Luna sample return missions. This shows how important sample return is, and indeed, one of Percy’s goals is to collect rock and regolith (“soil”) samples that, at some point in the early 2030s, will be retrieved by a “fetch rover” mission and sent back to Earth via a Mars Ascent Vehicle, a miniature rocket whose design has yet to be agreed. One of the main reasons robotic missions have been cheaper is that they do not return. The return mission thus bumps up the cost. But the quantity and diversity of samples will not be as high as a human mission could deliver. He is keen to stress that none of this should downplay the importance of robotic Martian sample return, which is necessary until humans can safely be sent to Mars and back. The point is to correct the erroneous notion that manned space missions are merely white elephants servicing national pride in contests with geopolitical rivals such as the USSR or China but have no real scientific purpose. Even though the priority should be, and very much is, on robotic exploration, we will learn more if we do both over time than if we depend upon robotic exploration alone. Robots enhance rather than replace human exploration. The Prison of the Possible One might then argue, nevertheless, that, given the exorbitant cost of space travel, whether by human, robot, or satellite (a robot of a sort), we should still, as Bernie’s tweet stated, focus instead on hunger, homelessness, and health care on Earth. Prioritization of spending will always be necessary, but a strictly utilitarian approach that demands we cannot spend on large scientific endeavors until poverty and inequality are eradicated would likewise have to rule out other big-ticket but curiosity-driven science efforts such as the Large Hadron Collider. Indeed, it also follows that any scholarship that is not applied research with a demonstrably near-term human benefit should be halted until all other problems are solved, expensive or not. Of course, applied research would sooner or later come to a halt as well under such a utilitarian research regime as, by definition, applied research is an application of basic research. Those in the seventeenth century who thought, “Isn’t it kind of neat and weird that when I rub a piece of amber against a cat’s fur, the amber can pick up a feather? I wonder why this is,” had no notion that any investigation into the phenomenon of what we now call electricity would one day result in applications that power much of the world. And the demand that we only engage in activities with clear utility requires that all resources allocated to art and music be shifted elsewhere. How like the university administration philistines we see today slashing humanities funding to deliver more to STEM subjects, mothballing language courses and classics programs!

### Plan

#### Plan: The appropriation of outer space by private entities is unjust.

#### Enforcement is banning constellations in the LEO by claiming they violate Article II of the OST.

**Johnson 20** [Christopher D. Johnson, 2020, "The Legal Status of MegaLEO Constellations and Concerns About Appropriation of Large Swaths of Earth Orbit", Secure World Foundation, https://swfound.org/media/206951/johnson2020\_referenceworkentry\_thelegalstatusofmegaleoconstel.pdf, date accessed 1-23-2022] // Lex AT

Are Constellations Appropriation? The astronomy community has already voiced concerns about the impact that constellations will have on astronomy (AstronomyNow 2019). Constellations also bring potential risks from space debris and radiofrequency interference, both of which will have an effect on space sustainability. Starlink’s 1584 satellites in the 550 km region would effectively triple the number of satellites in the 400–600 km region, for example. Leaving these important concerns aside, constellations should also be considered in the context of their general legal status – and specifically whether large swaths of Low Earth Orbit are being impermissibly claimed and possessed by individual actors (whether the commercial actor itself, or by the authorizing national government). For example, and as mentioned above, the OneWeb constellation will be in 12 orbital planes at 1200 km. Phase 1 of the SpaceX Starlink constellations will fly 66 satellites in 24 orbital planes, for a total of 1584 satellites in its initial constellation. Do these megaconstellations constitute an impermissible appropriation (or ownership) of particular regions of outer space? Without offering a definitive conclusion, the following sections first argue why, and then why not, these large constellations in LEO constitute impermissible appropriations of sections of outer space. The reader can consider for themselves which of the following opposing arguments they find more convincing. Yes, This Is Impermissible Appropriation Article II of the Outer Space Treaty, discussed above, is clear on the point that the appropriation of outer space, including the appropriation of either void space or of celestial bodies, is an impermissible and prohibited action under international law. No means or methods of possession of outer space will legitimize the appropriation or ownership of outer space, or subsections thereof. Excludes Others The constellations above, because they seem to so overwhelmingly possess particular orbits through the use of multiple satellites to occupy orbital planes, and in a manner that precludes other actors from using those exact planes, constitute an appropriation of those orbits. While the access to outer space is nonrivalrous – in the sense that anyone with the technological capacity to launch space objects can therefore explore space – it is also true that orbits closer to Earth are unique, and when any actor utilizes that orbit to such an extent to these proposed constellations will, it means that other actors simply cannot go there. The Legal Status of MegaLEO Constellations and Concerns About Appropriation... 15 To allow SpaceX, for example, to so overwhelmingly occupy a number of altitudes with so many of their spacecraft, essentially means that SpaceX will henceforth be the sole owner and user of that orbit (at least until their satellites are removed). No other actors can realistically expect to operate there until that time. No other operator would dare run the risk of possible collision with so many other spacecraft in that orbit. Consequently, the sole occupant will be SpaceX, and if “possession is 9/10th of the law,” then SpaceX appears to be the owner of that orbit. Done Without Coordination Additionally, SpaceX and other operators of megaconstellations are doing so without any real international conversation or agreement, which is especially egregious and transgressive of the norms of outer space. Compared to the regime for GSO, as administered by the ITU and national frequency administrators, Low Earth Orbit is essentially ungoverned, and SpaceX and others are attempting to seize this lack of authority to claim entire portions of LEO for itself; and before any international agreement, consensus, or even discussion is had. They are operating on a purely “first come, first served” basis that smacks of unilateralism, if not colonialism. Governments Are Ultimately Implicated As we know, under international space law, what a nongovernmental entity does, a State is responsible for. Article VI of the Outer Space Treaty requires that at least one State authorize and supervise its nongovernmental entities and assure their continuing compliance with international law. As such, the prohibition on nonappropriation imposed upon States under Article II of the Outer Space Treaty applies equally to nongovernmental private entities such as SpaceX. Nevertheless, through the launching and bringing into use of the Starlink constellation, SpaceX will be the sole occupant, and thereby, possessor, both fact and in law, of 550 km, 1100 km, 1130 km, 1275 km, and 1325 km above our planet (or whatever orbits they finally come to occupy). The same is true for the other operators of these large constellations which will be solely occupying entire orbits.

### Framework

#### The value is morality.

#### The standard is maximized expected well-being.

#### 1] Policies can’t account for individual liberties - they must use util.

Goodin 90 Robert Goodin, fellow in philosophy, Australian National Defense University, THE UTILITARIAN RESPONSE, 1990, p. 141-2 // Lex CH

My larger argument turns on the proposition that there is something special about the situation of public officials that makes utilitarianism more probable for them than private individuals. Before proceeding with the large argument, I must therefore say what it is that makes it so special about public officials and their situations that make it both more necessary and more desirable for them to adopt a more credible form of utilitarianism. Consider, first, the argument from necessity. Public officials are obliged to make their choices under uncertainty, and uncertainty of a very special sort at that. All choices – public and private alike – are made under some degree of uncertainty, of course. But in the nature of things, private individuals will usually have more complete information on the peculiarities of their own circumstances and on the ramifications that alternative possible choices might have for them. **Public officials**, in contrast, [they] **are** relatively **poorly informed as to the effects that their choices will have on individuals**, one by one. **What they** typically do **know are** **generalities:** **averages and aggregates**. They know what will happen most often to most people as a result of their various possible choices, but that is all. **That is enough to allow**[s] public **policy-makers to use the utilitarian calculus** – assuming they want to use it at all – to chose general rules or conduct.

#### 2] Existential risk comes first under any framework.

**Ord 20** Toby Ord [Australian philosopher. He founded Giving What We Can, an international society whose members pledge to donate at least 10% of their income to effective charities], “The Precipice” Hachette Books, 2020 // Lex CH

But **an existential catastrophe is not** just **a catastrophe that destroys a particularly large number of lives. It destroys our potential**. My mentor, Derek Parfit, asked us to imagine a devastating nuclear war killing 99 percent of the world’s people.19 **A war that would leave behind a dark age lasting centuries, before the survivors could eventually rebuild civilization to its former heights; humbled, scarred—but undefeated. Now compare this with a war killing a full 100 percent of the world’s people. This second war would be worse, of course, but how much worse? Either war would be the worst catastrophe in history. Either would kill billions.** **The second war would involve tens of millions of additional deaths, and so would be worse for this reason**. But there is another, far more significant difference between the two wars. **Both wars kill billions of humans; but the second war kills humanity**. **Both wars destroy our present; but the second war destroys our future. It is this qualitative difference in what is lost with that last percent that makes existential catastrophes unique, and that makes reducing the risk of existential catastrophe uniquely important. 20 In expectation, almost all humans who will ever live have yet to be born.** Absent catastrophe, **most generations are future generations.** As the writer Jonathan Schell put it: The procession of generations that extends onwards from our present leads far, far beyond the line of our sight, and, compared with these stretches of human time, which exceed the whole history of the earth up to now, our brief civilized moment is almost infinitesimal. Yet we threaten, in the name of our transient aims and fallible convictions, to foreclose it all. **If our species does destroy itself, it will be a death in the cradle—a case of infant mortality**. 21 And because, in expectation, **almost all of humanity’s life lies in the future, almost everything of value lies in the future as well**: almost all the flourishing; almost all the beauty; our greatest achievements; our most just societies; our most profound discoveries. 22 We can continue our progress on prosperity, health, justice, freedom and moral thought. **We can create a world of wellbeing and flourishing that challenges our capacity to imagine. And if we protect that world from catastrophe, it could last millions of centuries**. This is our potential—what we could achieve if we pass the Precipice and **continue striving for a better world**. **It is this view of the future—the immense value of humanity’s potential —that most persuades me to focus my energies on reducing existential risk. When I think of the millions of future generations yet to come, the importance of protecting humanity’s future is clear to me**. **To risk destroying this future**, for the sake of some advantage limited only to the present, **seems** to me profoundly parochial and **dangerously short-sighted**. Such neglect privileges a tiny sliver of our story over the grand sweep of the whole; it privileges a tiny minority of humans over the overwhelming majority yet to be born; it privileges this particular century over the millions, or maybe billions, yet to come. 23 To see why this would be wrong, consider an analogy with distance. **A person does not matter less, the further away from you they are in space. It matters just as much if my wife gets sick while she is away at a conference in Kenya as if she gets sick while home with me in Oxford. And the welfare of strangers in Kenya matters just as much as the welfare of strangers in Oxford. Of course, we may have special duties to some individuals—to family; to members of the same community—but it is never spatial distance, in itself, that determines these differences in our obligations**. Recognizing that people matter equally, regardless of their geographic location, is a crucial form of moral progress, and one that we could do much more to integrate into our policies and our philanthropy. People matter equally regardless of their temporal location too. Our lives matter just as much as those lived thousands of years ago, or those a thousand years hence. 24 Just as it would be wrong to think that other people matter less the further they are from you in space, so it is to think they matter less the further away from you they are in time. The value of their happiness, and the horror of their suffering, is undiminished. Recognizing that people matter equally, wherever they are in time, is a crucial next step in the ongoing story of humanity’s moral progress. Many of us recognize this equality to some extent already. **We know it is wrong to make future generations worse off in order to secure lesser benefits for ourselves**. And if asked, we would agree that people now don’t objectively matter more than people in the future. But we assume that this leaves most of our priorities unaltered. For example, thinking that long-run effects of our choices quickly disappear; that they are so uncertain that the good cancels the bad; or that people in the future will be much better situated to help themselves.

### Extra Cards

#### Kessler syndrome ensures cascading impacts – turns every impact.

Dvorsky 15 (George Dvorsky 6-4-2015 “What Would Happen If All Our Satellites Were Suddenly Destroyed?” <https://io9.gizmodo.com/what-would-happen-if-all-our-satellites-were-suddenly-d-1709006681> (Senior staff reporter at Gizmodo specializing in astronomy, space exploration, SETI, archaeology, bioethics, animal intelligence, human enhancement, and risks posed by AI and other advanced tech.) //Elmer

Lastly, there’s the [Kessler Syndrome](http://www.spacesafetymagazine.com/space-debris/kessler-syndrome/) to consider. This scenario was portrayed in the 2013 film Gravity. In the movie, a Russian missile strike on a defunct satellite inadvertently causes a cascading chain reaction that formed an ever-growing cloud of orbiting space debris. Anything in the cloud’s wake — including satellites, space stations, and astronauts — gets annihilated. Disturbingly, the Kessler Syndrome is a very real possibility, and the likelihood of it happening [is steadily increasing as more stuff gets thrown into space](http://io9.com/how-to-clean-up-deadly-space-junk-before-disaster-strik-1443463338). Given these grim prospects, it’s fair to ask what might happen to our civilization if any of these things happened. At the risk of gross understatement, the complete loss of our satellite fleet would instigate a tremendous disruption to our current mode of technological existence — disruptions that would be experienced in the short, medium, and long term, and across multiple [domains](https://io9.gizmodo.com/what-would-happen-if-all-our-satellites-were-suddenly-d-1709006681). Compromised Communications Almost immediately we’d notice a dramatic reduction in our ability to communicate, share information, and conduct transactions. “If our communications satellites are lost, then bandwidth is also lost,” [Jonathan McDowell](http://planet4589.org/) tells io9. He’s an astrophysicists and Chandra Observatory scientist who works out of the [Harvard-Smithsonian Center for Astrophysics](http://planet4589.org/jcm/cfa-www.harvard.edu). McDowell says that, with telecommunication satellites wiped out, the burden of telecommunications would fall upon undersea cables and ground-based communication systems. But while many forms of communication would disappear in an [instant](https://io9.gizmodo.com/what-would-happen-if-all-our-satellites-were-suddenly-d-1709006681), others would remain. All international calls and data traffic would have to be re-routed, placing tremendous pressure on terrestrial and undersea lines. Oversaturation would stretch the capacity of these systems to the limit, preventing many calls from going through. Hundreds of millions of Internet connections would vanish, or be severely overloaded. A similar number of cell phones would be rendered useless. In remote areas, people dependent on satellite for television, Internet, and radio would practically lose all service. “Indeed, a lot of television would suddenly disappear,” says McDowell. “A sizable portion of TV comes from cable whose companies relay programming from satellites to their hubs.” It’s important to note that we actually have a precedent for a dramatic — albeit brief — disruption in com-sat capability. Back in 1998, [there was a day in which a single satellite failed and all the world’s pagers stopped working](http://articles.latimes.com/1998/may/21/news/mn-52190). Get Out Your Paper Maps We would also lose the Global Positioning System. In the years since its inception, GPS has become ubiquitous, and a surprising number of systems have become reliant on it. “Apart from the fact that everyone has forgotten to navigate without GPS in their cars, many airplanes use GPS as well,” says McDowell. Though backup systems exist, airlines use GPS to chart the most fuel-efficient and expeditious routes. Without GPS and telecomm-sats, aircraft controllers would have tremendous difficulty communicating with and routing airplanes. Airlines would have to fall back to legacy systems and procedures. Given the sheer volume of airline traffic today, accidents would be all but guaranteed. Other affected navigation systems would include those aboard cargo vessels, supply-chain management systems, and transportation hubs driven by GPS. But GPS does more than just provide positioning — it also provides for timing. Ground-based atomic clocks can perform the same function, but GPS is increasingly being used to distribute the universal time standard via satellites. Within hours of a terminated service, any distributing networks requiring tight synchronization would start to suffer from “clock drift,” leading to serious performance issues and outright service outages. Such disruptions could affect everything from the power grid through to the financial sector. In the report, “[A Day Without Space: Economic and National Security Ramifications](http://marshall.org/wp-content/uploads/2013/08/Day-without-Space-Oct-16-2008.pdf),” Ed Morris, the Executive Director of the Office of Space Commerce at the Department of Commerce, writes: If you think it is hard to get work done when your internet connection goes out at the office, imagine losing that plus your cell [phone](https://io9.gizmodo.com/what-would-happen-if-all-our-satellites-were-suddenly-d-1709006681), TV, radio, ATM access, [credit cards](https://io9.gizmodo.com/what-would-happen-if-all-our-satellites-were-suddenly-d-1709006681), and possibly even your electricity. [...] Wireless services, especially those built to [CDMA standard](http://www.protocols.com/pbook/cellular.htm), would fail to hand off calls from one cell to the next, leading to dropped connections. Computer networks would experience slowdowns as data is pushed through finite pipelines at reduced bit rates. The same would be true for major networks for communication and entertainment, since they are all IP-based today and require ultra-precise timing to ensure digital traffic reaches its destination. The lack of effective synch would hit especially hard in banking, where the timing of transactions needs to be recorded. Credit card payments and bank accounts would likely freeze, as billions of dollars could be sucked away from businesses. A financial crash is not out of the question. The Loss of Military Capability The sudden loss of satellite capability would have a profound effect on the military. The Marshall Institute puts it this way: “Space is a critical enabler to all U.S. warfare domains,” including intelligence, navigation, communications, weather prediction, and warfare. McDowell describes satellite capability as as the “backbone” of the U.S. military. And as 21st century warfare expert [Peter W. Singer](http://www.pwsinger.com/biography.html) from [New America Foundation](https://www.newamerica.org/) tells io9, “He who controls the heavens will control what happens in the battles of Earth.” Singer summarized the military consequences of losing satellites in an email to us: Today there are some 1,100 active satellites which act as the nervous system of not just our economy, but also our military. Everything from communications to GPS to intelligence all depend on it. Potential foes have noticed, which is why Russia and China have recently begun testing a new generation of anti-satellite weapons, which in turn has sparked the U.S. military to recently budget $5 billion for various space warfare systems. What would happen if we lost access to space? Well, the battles would, as one U.S. military officer put it, take us back to the “pre digital age.” Our drones, our missiles, even our ground units wouldn’t be able to operate the way we plan. It would force a rewrite of all our assumptions of 21st century high tech war. We might have a new generation of stealthy battleships...but the loss of space would mean naval battles would in many ways be like the game of Battleship, where the two sides would struggle to even find each other. Moreover, and as McDowell explains to io9, the loss of satellite capability would have a profound effect on arms control capabilities. Space systems can monitor compliance; without them, we’d be running blind. “The overarching consideration is that you wouldn’t really know what’s going on,” says McDowell. “Satellites provide for both global and local views of what’s happening. We would be less connected, less informed — and with considerably degraded situational awareness.” Compromised Weather Prediction and Climate Science One great thing satellites have done for us is improve our ability to forecast weather. Predicting a slight chance of cloudiness is all well and good, but some areas, like India, Pakistan, and Bangladesh, are dependent on such systems to predict potentially hazardous monsoons. And in the U.S., the NOAA has estimated that, during a typical hurricane season, weather satellites save as much as $3 billion in lives and property damage. There’s also the effect on science to consider. Much of what we know about climate change comes from satellites. As McDowell explains, the first couple of weeks without satellites wouldn’t make much of a difference. But over a ten-year span, the lack of satellites would preclude our ability to understand and monitor such things as the ozone layer, carbon dioxide levels, and the distribution of polar ice. Ground-based and balloon-driven systems would help, but much of the data we’re currently tracking would suddenly become much spottier. “We’re quite dependent on satellites for a global view of what’s happening on our planet — and at a time when we really, really need to know what’s happening,” says McDowell. It’s also worth pointing out that, without satellites, we also wouldn’t be able to monitor space weather, such as incoming space storms. Time to Recover With all the satellites gone, both governmental and private interests would work feverishly to restore space-based capabilities. Depending on the nature of the satellite-destroying event, it could take decades or more to get ourselves back to current operational standards. It would take a particularly long time to recover from a Carrington Event, which would zap many ground-based electronic systems as well. The U.S. military is already thinking along these lines, which is why it’s working on the ability to quickly send up emergency assets, such as small satellites parked in Low Earth Orbit (LEO). Cube satellites are increasingly favored, as an easy-to-launch, affordable, and effective solution — albeit a short-term one. The U.S. Operationally Responsive State Office is currently working on the concept of emergency replenishment and the ability to “rapidly deploy capabilities that are good enough to satisfy warfighter needs across the entire spectrum of operations, from peacetime through conflict.” As for getting full-sized, geostationary satellites back into orbit, that would prove to be a greater challenge. It can take years to built a new satellite, which typically requires a big, costly rocket to get it into space. Lastly, if a Kessler Syndrome wipes out the satellites, that would present an entirely different recovery scenario. According to McDowell, it would take a minimum of 11 years for LEO to clear itself of the debris cloud; any objects below 500 km (310 miles) would eventually fall back to Earth. Thus, we would only be able to start re-seeding LEO in a little over a decade following a Kessler event. Unfortunately, the area above 600 km (372 miles) would remain out of touch for a practically indefinite period of time; objects orbiting at that height tend to stay there for a long, long time. We’d probably lose this band for good — unless we manually removed the debris field, using clean-up satellites or other techniques. It’s worth noting that a single Kessler event could hit the LEO zone or the GEO zone (geosynchronous orbit) but realistically not both; LEO debris could never reach GEO, and vice versa — though a spent rocket in GTO (geosynchronous transfer orbit) or SSTO (supersynchronous transfer orbit) passes through or near both zones and could potentially affect either of them. The spent rockets in GTO do not stay too close to the GEO arc for long due to orbital perturbations, so a GEO Kessler event is very unlikely to be triggered by one of them. Suffice to say, we should probably take the prospect of a Kessler Syndrome more seriously, and be aware of what could happen if we’re no longer able to use these spaces.

#### Private entities are non-governmental.

Dunk 11 – Frans G. von der Dunk, 2011, [“The Origins of Authorisation: Article VI of the Outer Space Treaty and International Space Law,” University of Nebraska] Justin

4. Interpreting Article VI of the Outer Space Treaty One main novel feature of Article VI stood out with reference to the role of private enterprise in this context. Contrary to the version of the concept applicable under general international law, where “direct state responsibility” only pertained to acts somehow directly attributable to a state and states could only be addressed for acts by private actors under “indirect,” “due care”/“due diligence” responsibility,18 Article VI made no difference as to whether the activities at issue were the state’s own (“whether such activities are carried on by governmental agencies” . . .) or those of private actors (. . . “or by non-governmental entities”). The interests of the Soviet Union in ensuring that, whomever would actually conduct a certain space activity, some state or other could be held responsible for its compliance with applicable rules of space law to that extent had prevailed. However, the general acceptance of Article VI as cornerstone of the Outer Space Treaty unfortunately was far from the end of the story. Partly, this was the consequence of key principles being left undefined.

#### Outer space is

**Betz 21** [Eric Betz, 3-5-2021, "The Kármán Line: Where does space begin?", Astronomy, https://astronomy.com/news/2021/03/the-krmn-line-where-does-space-begin, date accessed 1-22-2022] //Lex AT

These days, spacecraft are venturing into the final frontier at a record pace. And a deluge of [paying space tourists](https://astronomy.com/news/2020/08/six-ways-to-buy-a-ticket-to-space-in-2021) should soon follow. But to earn their astronaut wings, high-flying civilians will have to make it past the so-called Kármán line. This boundary sits some 62 miles (100 kilometers) above Earth's surface, and it's generally accepted as the place where Earth ends and outer space begins. From a cosmic perspective, 100 km is a stone's throw; it's only one-sixth the driving distance between San Francisco and Los Angelas. It’s also well within the clutches of Earth's overpowering gravitational pull and expansive atmosphere. So, how did humans come to accept this relatively nearby location as the defining line between Earth and space? The answer is partly based on physical reality and partly based on an arbitrary human construct. That's why the exact altitude where space begins is something scientists have been debating since before we even sent the first spacecraft into orbit. What is the Kármán Line? [Experts have suggested](https://books.google.com/books/about/The_Never_Ending_Dispute.html?id=fG4_AQAAIAAJ) the actual boundary between Earth and space lies anywhere from a mere 18.5 miles (30km) above the surface to more than a million miles (1.6 million km) away. However, for well over half a century, most — including regulatory bodies — have accepted something close to our current definition of the Kármán Line. The Kármán line is based on physical reality in the sense that it roughly marks the altitude where traditional aircraft can no longer effectively fly. Anything traveling above the Kármán line needs a propulsion system that doesn’t rely on lift generated by Earth’s atmosphere — the air is simply too thin that high up. In other words, the Kármán line is where the physical laws governing a craft's ability to fly shift. However, the Kármán line is also where the human laws governing aircraft and spacecraft diverge. There are no national borders that extend to outer space; it’s governed more like international waters. So, settling on a boundary for space is about much more than the semantics of who gets to be called an astronaut. The United Nations has historically accepted the Kármán line as the boundary of space. And while the U.S. government has been reticent to agree to a specific height, people who fly above an altitude of 60 miles (100 km) typically earn astronaut wings from the Federal Aviation Administration. Even the Ansari X-prize chose the Kármán line as the benchmark height required to win its $10 million prize, which was claimed when Burt Rutan’s SpaceShipOne became the first privately-built spacecraft to carry a crew back in 2004.