#### Interpretation- The affirmative may only defend the removal of space assets that require appropriation.

#### “Appropriation” means to take as property

**Leon 18** (Amanda M., Associate, Caplin & Drysdale, JD UVA Law) "Mining for Meaning: An Examination of the Legality of Property Rights in Space Resources." Virginia Law Review, vol. 104, no. 3, May 2018, p. 497-547. HeinOnline.

**Appropriation**. The term "appropriation" also remains ambiguous. **Webster's defines** the verb "**appropriate**" **as** "**to take to oneself in exclusion of others**; **to** claim or **use as by an exclusive or pre-eminent right**; as, let no man appropriate a common benefit."16 5 Similarly, **Black's** Law Dictionary **describes "appropriate" as an act "[t]o make a thing one's own; to make a thing the subject of property**; to exercise dominion over an object to the extent, and for the purpose, of making it subserve one's own proper use or pleasure."166 Oftentimes, **appropriation refers to the setting aside of government funds, the taking of land for public purposes, or a tort of wrongfully taking another's property as one's own**. The term appropriation is often used not only with respect to real property but also with water. According to U.S. case law, a person completes an appropriation of water by diversion of the water and an application of the water to beneficial use.167 This **common use** of the term "appropriation" with respect to water **illustrates** two key points: (1) **the term applies to natural resources-e.g., water or minerals-not just real property**, **and** (2) **mining space resources and putting them to beneficial use**-e.g., selling or manufacturing the mined resources **could reasonably be interpreted as an "appropriation" of outer space**. While **the ordinary meaning of "appropriation"** reasonably **includes the taking of natural resources as well as land**, whether the drafters and parties to the OST envisioned such a broad meaning of the term remains difficult to determine with any certainty. **The prohibition against appropriation "by any other means" supports such a reading**, though**, by expanding the prohibition to other types not explicitly described**.168

#### ‘Of’ implies we should consider appropriation as a whole

#### Violation- Satellites do not Prefer our application. Legal precedent has an intent to define a distinction between exclusive use and Appropriation. Satellites are not

UCOSTA 86 (U.S. Congress, Office of Technology Assessment “Space Stations and the Law: Selected Legal Issues -- Background Paper” (1986). Documents on Outer Space Law. 12)

The Legal Character of Outer Space. **Outer space is considered** by most jurists **to be res communis**; that is, a place that is owned by no one but is **free for** use by **everyone**. Article II of the 1967 Outer Space Treaty states: "outer space, including the Moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means." **Although space may not be "appropriated**," it is "free for exploration and use by all States. ,,11 In some circumstances this "**use" may** even be **exclusive**. For example, a **country that places a broadcasting satellite in geostationary orbit**12 **prevents other countries from placing broadcasting satellites in that identical position** in that orbit. **Such exclusive use** is allowed because it **constitutes neither a permanent "appropriation" nor an attempt to extend state sovereignty.**13 A similar situation exists in maritime law. Nations may not claim sovereignty over portions of the high seas; however, when conducting activities such as naval maneuvers, satellite launch or recovery at sea, or missile tests, nations have in the past exercised temporary control over portions of the high seas. 14 In both maritime law and space law, temporary exclusive use is allowed as long as it is accomplished with "due regard" for the corresponding interests of other states. 15

#### Standards

#### 1] Limits – they can spec infinite different types of appropriation like space mining, satellite orbit types, colonization, etc. This takes out functional limits – it’s impossible for me to research every possible combination of entities, governments, and appropriation.

#### 2] TVA solves – just read your aff as an advantage to a whole rez aff – we don’t stop them from reading new FWs, mechanisms or advantages. PICs aren’t aff offense – a] it’s ridiculous to say that neg potential abuse justifies the aff being non-T b] There’s only a small number of pics on this topic c] PICs incentivize them to write better affs that can generate solvency deficits to PICs

#### D] Voter:

#### Fairness and education are voters – debate’s a game that needs rules to evaluate it and education gives us portable skills for life like research and thinking.

#### Precision o/w – anything else justifies the aff arbitrarily jettisoning words in the resolution at their whim which decks negative ground and preparation because the aff is no longer bounded by the resolution.

#### Drop the debater – a) they have a 7-6 rebuttal advantage and the 2ar to make args I can’t respond to, b) it deters future abuse and sets a positive norm.

#### Use competing interps – a) reasonability invites arbitrary judge intervention since we don’t know your bs meter, b) collapses to competing interps – we justify 2 brightlines under an offense defense paradigm just like 2 interps.

#### No RVIs – a) illogical – you shouldn’t win for being fair – it’s a litmus test for engaging in substance, b) norming – I can’t concede the counterinterp if I realize I’m wrong which forces me to argue for bad norms, c) chilling effect – forces you to split your 2AR so you can’t collapse and misconstrue the 2NR, d) topic ed – prevents 1AR blipstorm scripts and allows us to get back to substance after resolving theory

#### Evaluate T before 1AR theory – a) norms – we only have a couple months to set T norms but can set 1AR theory norms anytime, b) magnitude – T affects a larger portion of the debate since the aff advocacy determines every speech after it

#### No impact turns to T—T is a procedural that determines case’s validity and every argument says the aff is bad

### 2-

#### Cyber-attacks on critical infrastructure are coming now.

Underwood 20 [Kimberly Underwood, 6-24-2020, "China is Retooling, and Russia Seeks Harm to Critical Infrastructure," SIGNAL Magazine, <https://www.afcea.org/content/china-retooling-and-russia-seeks-harm-critical-infrastructure>] [pT]

Intelligence leader warns of the mounting threats of cyber espionage, digital attacks and influence operations from adversaries.

U.S. adversaries are trying to take control of cyberspace as a medium, resulting in implications to our freedom of maneuver and access in cyberspace, says Brig. Gen. Gregory Gagnon, USAF, director of Intelligence (A2), Headquarters Air Combat Command (ACC), Joint Base Langley-Eustis. Increasing cyberspace activity is coming from China, Russia, Iran and North Korea.

“We are seeing it not just in volume, but we are seeing an expansion in the ways that they use cyberspace, whether it is to steal information, whether it is to directly influence our citizens or whether it is to disrupt critical infrastructure,” Gen. Gagnon reports. The general spoke at the AFCEA Tidewater chapter’s recent monthly virtual luncheon.

China and Russia continue to pose the greatest espionage and cyber attack threats to the United States, but the intelligence leader anticipates that other adversaries and strategic competitors will also build and integrate cyber espionage, cyber attacks and influence operations into how they conduct business.

“Our strategic competitors will increasingly use cyber space capabilities including cyber espionage, cyber attack and continued influence operations to seek political, economic and military advantage over the United States, our allies and our partners,” he said. “This is not an ‘if,’ it is a yes. They are doing it and they will continue.”

Gen. Gagnon warned that China in particular is using cyber espionage to collect intelligence, target critical infrastructure and steal intellectual property. It is all part of China’s plan to move from being a regional actor to being seen as a global power. The shift also means a greater role for the adversary’s military. The Chinese military is in the process of transitioning from a defensive, inflexible ground-based force charged with domestic and peripheral security to a joint, highly agile, expeditionary and power projecting arm of Chinese foreign policy, he noted.

“What is going on in China is a dynamic revectoring of the objectives and goals of the People's Liberation Army,” Gen. Gagnon said. “This is not a small change. This is a major change in course and direction. They're doing it to be a power projection arm of a Chinese foreign policy that engages both in military diplomacy and operations around the globe, but also in predatory economic activity.”

Moreover, China’s military spending in 2018 exceeded $200 billion, an increase of about 300% since 2002, the general stated. And while it is not the $750 billion that the United States government spends every year on military defense, the Chinese funding does not reflect the same level of investment in manpower or healthcare.

A good portion of their $200 billion directly funds technology and capabilities. “A big chunk of our budget is not buying kit,” Gen. Gagnon explained. “If you're the CCP [Chinese Communist Party], you don't have the same extensive retirement programs that you have to pay for,” he said. “You don't have this extensive healthcare which you have to provide. So, when you think about $200 billion, think about that buying kit and buying operations. That is significant.”

#### Mega constellations function as critical infrastructure that increase resiliency and protect against cyberattacks.

Hallex and Cottom 20 [Matthew A. Hallex is a Research Staff Member at the Institute for Defense Analyses. Travis S. Cottom is a Research Associate at the Institute for Defense Analyses. “Proliferated Commercial Satellite Constellations: Implications for National Security.” 2020. <https://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-97/jfq-97_20-29_Hallex-Cottom.pdf?ver=2020-03-31-130614-940>] [pT]

While potentially threatening the sustainability of safe orbital operations, new proliferated constellations also offer opportunities for the United States to increase the resilience of its national security space architectures. Increasing the resilience of U.S. national security space architectures has strategic implications beyond the space domain. Adversaries such as China and Russia see U.S. dependence on space as a key vulnerability to exploit during a conflict. Resilient, proliferated satellite constellations support deterrence by denying adversaries the space superiority they believe is necessary to initiate and win a war against the United States.28 Should deterrence fail, these constellations could provide assured space support to U.S. forces in the face of adversary counterspace threats while imposing costs on competitors by rendering their investments in counterspace systems irrelevant. Proliferated constellations can support these goals in four main ways.

First, the extreme degree of disaggregation inherent in government and commercial proliferated constellations could make them more resilient to attacks by many adversary counterspace systems. A constellation composed of hundreds or thousands of satellites could withstand losing a relatively large number of them before losing significant capability. Conducting such an attack with kinetic antisatellite weapons—like those China and Russia are developing—would require hundreds of costly weapons to destroy satellites that would be relatively inexpensive to replace.

Second, proliferated constellations would be more resilient to adversary electronic warfare. Satellites in LEO can emit signals 1,280 times more powerful than signals from satellites in GEO.29 They also are faster in the sky than satellites in more distant orbits, which, combined with the planned use of small spot beams for communications proliferated constellations, would shrink the geographic area in which an adversary ground-based jammer could effectively operate, making jammers less effective and easier to geolocate and eliminate.30

Third, even if the United States chooses not to deploy national security proliferated constellations during peacetime, industrial capacity for mass-producing proliferated constellation satellites could be repurposed during a conflict. Just as Ford production lines shifted from automobiles to tanks and aircraft during World War II, one can easily imagine commercial satellite factories building military reconnaissance or communications satellites during a conflict.

Fourth, deploying and maintaining constellations of hundreds or thousands of satellites will drive the development of low-cost launches to a much higher rate than is available today. Inexpensive, high-cadence space launch could provide a commercial solution to operationally responsive launch needs of the U.S. Government. In a future where space launches occur weekly or less, the launch capacity needed to augment national security space systems during a crisis or to replace systems lost during a conflict in space would be readily available.31

#### Cyberattacks cause extinction – false warnings, stealing nukes, and introducing vulnerability.

**Moniz et al. 18** [Ernest J. Moniz, Sam Nunn, and Des Browne, September 2018, “Nuclear Weapons in the New Cyber Age,” <https://media.nti.org/documents/Cyber_report_finalsmall.pdf>] [pT]

Cyber-based threats target all sectors of society—from the financial sector to the entertainment industry, from department stores to insurance companies. Governments face an even more critical challenge when it comes to cyberattacks on their most critical systems. Attacks on critical infrastructure could have extraordinary consequences, but a successful cyberattack3 on a nuclear weapon or related system—a nuclear weapon, a delivery system, or the related Nuclear Command, Control, and Communications (NC3) systems—could have existential consequences. Cyberattacks could lead to false warnings of attack, interrupt critical communications or access to information, compromise nuclear planning or delivery systems, or even allow an adversary to take control of a nuclear weapon.

Given the level of digitization of U.S. systems and the pace of the evolving cyber threat, one cannot assume that systems with digital components—including nuclear weapons systems—are not or will not be compromised. Among the reasons: nuclear weapons and delivery systems are periodically upgraded, which may include the incorporation of new digital systems or components. Malware could be introduced into digital systems during fabrication, much of which is not performed in secure foundries. In addition, there are a range of external dependencies, such as connections to the electric grid, that are outside the control of defense officials but directly affect nuclear systems. Finally, the possibility always exists that an insider, either purposefully or accidentally, could enable a cybersecurity lapse by introducing malware into a critical system.

Increased use of digital systems may also adversely affect the survivability of nuclear systems. New technologies can enhance reliability and performance, but they can also lead to new vulnerabilities in traditionally survivable systems, such as submarines or mobile missile launchers.4

### 3-

#### Space colonization only happens because of market demand from Starship – and our ev indicates the field is booming but on the brink

Maidenberg, 21, 12/28/21, WSJ, “SpaceX’s Future Depends on a Gigantic Rocket and 42,000 Internet Satellites”, He reports on longtime and newer space companies, as well as issues tied to the safe operation of commercial planes and other aircraft. As part of his work, he focuses on government agencies such as the National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA). Prior to his current role, Micah worked as a breaking news reporter for the Journal and the Dow Jones Newswires. He began writing about business and economic issues for Crain’s Chicago Business, where he reported on real estate, manufacturing and transportation beats. He also completed an investigative-reporting fellowship at the Columbia University School of Journalism, where he earned a Master's degree. URL: <https://www.wsj.com/articles/spacexs-future-depends-on-a-gigantic-rocket-and-42-000-internet-satellites-11640687404>, KR

SpaceX wants to use its Starship rocket for the kind of voyages to Mars and beyond that Elon Musk has long dreamed of pursuing.

Starship also forms an important foundation of the future business strategy at his space company, which wants to use the vehicle in part to build out Starlink, the satellite-internet service many investors believe could eventually form the bulk of the company’s revenue.

Space Exploration Technologies Corp., the formal name for the company Mr. Musk founded almost two decades ago, faces steep challenges in engineering Starship into a reusable rocket that would sharply drive down launch costs. Mr. Musk recently said the ship takes up more of his time than any other single initiative, and warned the vehicle, along with the internet service, are creating significant challenges for the company.

“Starship is a hard, hard, hard, hard project,” he said at a December event hosted by The Wall Street Journal. “This is the biggest rocket ever made.”

Starship, which would be blasted to orbit on a booster dubbed Super Heavy, stands 160 feet tall and has a diameter of 30 feet, creating room to send hundreds of Starlink satellites to orbit at once, more than the several dozen it is able to deploy right now on one of its Falcon 9 rockets. More than half of the launches tracked by U.S. flight-safety regulators that the company has conducted the past two years have been Starlink deployments. The company plans to rapidly boost the pace of satellite launches in the years ahead. SpaceX, in a July presentation to the Federal Communications Commission, said it had so far launched around 1,800 Starlink satellites and was active in more than 20 countries. The FCC has authorized SpaceX to launch around 12,000 satellites, but the company wants to add at least around 30,000 more, according to commission filings. Mr. Musk said at an industry conference this summer that SpaceX is likely to invest at least $5 billion and perhaps as much as $10 billion in Starlink before it fully starts generating cash, with ongoing investments after that. In a November tweet, Mr. Musk said if severe global recession cut into the availability of capital and liquidity while SpaceX was losing billions on Starship and Starlink, then bankruptcy “while still unlikely, is not impossible.” Over the past two years, the company began equity sales that raised at least $3.8 billion, according to filings that some private companies like SpaceX may have to disclose under Securities and Exchange Commission rules. SpaceX doesn’t release financial statements. A spokesman for the company pointed to a recent statement posted to SpaceX’s website that said in part the company’s year ahead would include a potential first orbital mission for Starship and expanding Starlink. Mr. Musk unveiled Starlink in 2015, aiming to develop a network of smaller satellites in a low orbit around Earth that could provide high-speed internet access around the world. SpaceX set out aggressive targets for Starlink, projecting that year more than 40 million subscribers by 2025, The Wall Street Journal previously reported. SpaceX said this summer that it had around 140,000 Starlink customers. Starlink lists costs for the service at $99 a month, with a $499 charge for an internet terminal—or roughly half the amount it costs the company to make it, Mr. Musk said over the summer. Other companies, such as London-based OneWeb, are also creating networks of internet satellites, and an Amazon.com Inc. unit plans to do so in the future. Around 3.7 billion people globally remain unconnected to the internet, according to a recent report from two agencies at the United Nations, while U.S. officials have worked for years to improve access to high-speed internet in underserved areas. “There’s a need for connectivity in places that don’t have it right now,” or where connections are very limited or expensive, Mr. Musk said this summer. In addition to consumers, Mr. Musk has indicated Starlink could offer services to other businesses, recently saying in a tweet that fliers should ask airlines for Starlink.

The internet service creates a source of demand for Starship, said Matt Weinzierl, a Harvard Business School professor who has studied the space economy.

Historically, those behind big rockets without a clear use for them have faced challenges: “If we don’t know why we built them, it can be a real losing proposition,” Mr. Weinzierl said, adding he thinks the company will identify other uses for the rocket.

Starship, meanwhile, has at least one confirmed customer in place: the National Aeronautics and Space Administration, which in April awarded SpaceX a $2.9 billion contract to develop a Starship to take astronauts back to the surface of the moon.

As it works to develop Starship and Starlink, SpaceX has built out a business based on government customers such as NASA and on commercial-satellite operators.

The value of its contracts with public-sector clients amounted to $2.2 billion for the federal government’s 2021 fiscal year, up from $195 million a decade earlier, according to a contracts database. SpaceX typically charges private clients $60 million to $65 million for Falcon 9 launches, according to people familiar with the matter.

The company’s valuation has soared as it proved its spacecraft like Falcon 9 could work as intended and as it started constructing its fleet of Starlink satellites. SpaceX was valued at $100 billion in October, more than double its valuation in the summer of 2020, according to PitchBook. The latest figure rests heavily on prospects for Starlink because the potential demand for the high-speed internet service globally is much larger than the size of the launch market, investors say.

#### Specifically, Starship from spaceX is the most prominent solution

O’Callaghan, 21, 12/7/21, MIT Review, “How SpaceX’s massive Starship rocket might unlock the solar system—and beyond”, Jonathan O'Callaghan is a freelance space journalist based in London, UK who covers commercial spaceflight, astrophysics, and space exploration. URL: <https://www.technologyreview.com/2021/12/07/1041420/spacex-starship-rocket-solar-system-exploration/>, KR

Much has already been made of Starship’s human spaceflight capabilities. But the rocket could also revolutionize what we know about our neighboring planets and moons. “Starship would totally change the way that we can do solar system exploration,” says Ali Bramson, a planetary scientist from Purdue University. “Planetary science will just explode.”

If it lives up to its billing, scientists are already talking about sending missions to Neptune and its largest moon in the outer solar system, bringing back huge quantities of space rock from Earth’s moon and Mars, and even developing innovative ways to protect Earth from incoming asteroids.

Starship—which is being built at a Texas site dubbed “Starbase”—consists of a giant spaceship on top of a large booster, known as Super Heavy. Both can land back on Earth so they can be reused, reducing costs. The entire vehicle will be capable of lifting 100 metric tons (220,000 pounds) of cargo and people into space on regular low-cost missions. The volume of usable space within Starship is a whopping 1,000 cubic meters—big enough to fit the entire Eiffel Tower, disassembled. And that’s got scientists excited.

“Starship is, like, wow,” says James Head, a planetary scientist from Brown University.

In mid-November, speaking in a publicly accessible virtual meeting about Starship hosted by the US National Academies of Sciences, Engineering, and Medicine, Musk discussed the project’s scientific potential. “It’s extremely important that we try to become a multiplanet species as quickly as possible,” he said. “Along the way, we will learn a great deal about the nature of the universe.” Starship could carry “a lot of scientific instrumentation” on flights, said Musk—far more than is currently possible. “We’d learn a tremendous amount, compared to having to send fairly small vehicles with limited scientific instrumentation, which is what we currently do,” he said.

“You could get a 100-ton object to the surface of Europa,” said Musk.

Cheap and reusable

Central to many of these ideas is that Starship is designed to be not just large but cheap to launch. Whereas agencies like NASA and ESA must carefully choose a smattering of missions to fund, with launch costs in the tens or hundreds of millions of dollars, Starship’s affordability could open the door to many more. “The low cost of access has the potential to really change the game for science research,” says Andrew Westphal, a lecturer in physics at the University of California, Berkeley, with flights potentially as low as $2 million per launch. “You can imagine privately financed missions and consortia of citizens who get together to fly things.”

NASA has selected SpaceX’s Starship as the lander to take astronauts to the moon

When the first astronauts in over 50 years set foot on the moon, they’ll be riding to the surface aboard Starship.

What’s more, Starship has a key advantage over other super-heavy-lift rockets in development, such as NASA’s much-delayed Space Launch System and Blue Origin’s New Glenn rocket. The upper half of the rocket is designed to be refueled in Earth orbit by other Starships, so more of its lifting capability can be handed over to scientific equipment rather than fuel. Taking humans to the moon, for example, might require eight separate launches, with each consecutive “tanker Starship” bringing up fuel to the “lunar Starship” that then makes its way to the moon with scientific equipment and crew.

Scientists are now starting to dream of what Starship might let them do. Earlier this year, a paper published by Jennifer Heldmann of NASA Ames Research Center explored some of the scientific opportunities that might be opened by Starship missions to the moon and Mars. One great benefit is that Starship could carry full-sized equipment from Earth—no need to miniaturize it to fit in a smaller vehicle, as was required for the Apollo missions to the moon. For example, “you could bring a drilling rig,” says Heldmann. “You could drill down a kilometer, like we do on Earth.” That would afford unprecedented access to the interior of the moon and Mars, where ice and other useful resources are thought to be present. Before, such an idea have been “a little bit insane,” says Heldmann. But with Starship, “you could do it, and still have room to spare,” she adds. “What else do you want to bring?”

Because Starship can land back on Earth, it will also—theoretically—be able to bring back vast amounts of samples. The sheer volume that could be returned, from a variety of different locations, would give scientists on Earth unprecedented access to extraterrestrial material. That could shed light on a myriad of mysteries, such as the volcanic history of the moon or “the question of life and astrobiology” on Mars, says Heldmann.

Starship could also enable more extravagant missions to other locations, either via a direct launch from Earth or perhaps by using the moon and Mars as refueling stations, an ambitious future envisioned by Musk.

#### Space exploration solves extinction and endless resource wars.

Collins 10 [Patrick Collins, professor of economics at Azabu University in Japan, and a Collaborating Researcher with the Institute for Space & Astronautical Science, as well as adviser to a number of companies, Adriano V. Autino is President of the Space Renaissance International; Manager, CEO/CTO, Systems Engineering Consultant / Trainer at Andromeda Systems Engineering LLC; and Supplier of methodological tools and consultancy at Intermarine S.p.A, Acta Astronautica, Volume 66, Issues 11–12, June–July 2010, “What the growth of a space tourism industry could contribute to employment, economic growth, environmental protection, education, culture and world peace”, Pages 1553–1562]

7. World peace and preservation of human civilisation

The major source of social friction, including international friction, has surely always been unequal access to resources. People fight to control the valuable resources on and under the land, and in and under the sea. The natural resources of Earth are limited in quantity, and economically accessible resources even more so. As the population grows, and demand grows for a higher material standard of living, industrial activity grows exponentially. The threat of resources becoming scarce has led to the concept of “Resource Wars”. Having begun long ago with wars to control the gold and diamonds of Africa and South America, and oil in the Middle East, the current phase is at centre stage of world events today [37]. A particular danger of “resource wars” is that, if the general public can be persuaded to support them, they may become impossible to stop as resources become increasingly scarce. Many commentators have noted the similarity of the language of US and UK government advocates of “war on terror” to the language of the novel “1984” which describes a dystopian future of endless, fraudulent war in which citizens are reduced to slaves.

7.1. Expansion into near-Earth space is the only alternative to endless “resource wars”

As an alternative to the “resource wars” already devastating many countries today, opening access to the unlimited resources of near-Earth space could clearly facilitate world peace and security. The US National Security Space Office, at the start of its report on the potential of space-based solar power (SSP) published in early 2007, stated: “Expanding human populations and declining natural resources are potential sources of local and strategic conflict in the 21st Century, and many see energy as the foremost threat to national security” [38]. The report ended by encouraging urgent research on the feasibility of SSP: “Considering the timescales that are involved, and the exponential growth of population and resource pressures within that same strategic period, it is imperative that this work for “drilling up” vs. drilling down for energy security begins immediately” [38].

Although the use of extra-terrestrial resources on a substantial scale may still be some decades away, it is important to recognise that simply acknowledging its feasibility using known technology is the surest way of ending the threat of resource wars. That is, if it is assumed that the resources available for human use are limited to those on Earth, then it can be argued that resource wars are inescapable [22] and [37]. If, by contrast, it is assumed that the resources of space are economically accessible, this not only eliminates the need for resource wars, it can also preserve the benefits of civilisation which are being eroded today by “resource war-mongers”, most notably the governments of the “Anglo-Saxon” countries and their “neo-con” advisers. It is also worth noting that the $1 trillion that these have already committed to wars in the Middle-East in the 21st century is orders of magnitude more than the public investment needed to aid companies sufficiently to start the commercial use of space resources.

Industrial and financial groups which profit from monopolistic control of terrestrial supplies of various natural resources, like those which profit from wars, have an economic interest in protecting their profitable situation. However, these groups’ continuing profits are justified neither by capitalism nor by democracy: they could be preserved only by maintaining the pretence that use of space resources is not feasible, and by preventing the development of low-cost space travel. Once the feasibility of low-cost space travel is understood, “resource wars” are clearly foolish as well as tragic. A visiting extra-terrestrial would be pityingly amused at the foolish antics of homo sapiens using long-range rockets to fight each other over dwindling terrestrial resources—rather than using the same rockets to travel in space and have the use of all the resources they need!

7.2. High return in safety from extra-terrestrial settlement

Investment in low-cost orbital access and other space infrastructure will facilitate the establishment of settlements on the Moon, Mars, asteroids and in man[/woman]-made space structures. In the first phase, development of new regulatory infrastructure in various Earth orbits, including property/usufruct rights, real estate, mortgage financing and insurance, traffic management, pilotage, policing and other services will enable the population living in Earth orbits to grow very large. Such activities aimed at making near-Earth space habitable are the logical extension of humans’ historical spread over the surface of the Earth. As trade spreads through near-Earth space, settlements are likely to follow, of which the inhabitants will add to the wealth of different cultures which humans have created in the many different environments in which they live.

Success of such extra-terrestrial settlements will have the additional benefit of reducing the danger of human extinction due to planet-wide or cosmic accidents [27]. These horrors include both man-made disasters such as nuclear war, plagues or growing pollution, and natural disasters such as super-volcanoes or asteroid impact. It is hard to think of any objective that is more important than preserving peace. Weapons developed in recent decades are so destructive, and have such horrific, long-term side-effects that their use should be discouraged as strongly as possible by the international community. Hence, reducing the incentive to use these weapons by rapidly developing the ability to use space-based resources on a large scale is surely equally important [11] and [16]. The achievement of this depends on low space travel costs which, at the present time, appear to be achievable only through the development of a vigorous space tourism industry.

#### Case Plan Flaw: They can’t solve any of their stuff. Companies can incorporate and reincorporate. Starlink can be housed in another division of space X or reincorporated somewhere else so the plan cant solve.

### Case

#### Climate change makes Ozone depletion inevitable.

**Ward 21** (Cassidy Ward is an award-winning journalist for SyFy Wire. “COULD A SOLAR FLARE DESTROY HUMANITY, LIKE IN 'FINCH'? THE SCIENCE BEHIND THE FICTION”. NOVEMBER 10, 2021.)

A solar event in 2000 knocked out about 1 percent of the total ozone layer, most of it in the upper atmosphere, according to satellite data. **The greater threat to the ozone layer is anthropogenic climate change.** To date, **our use of CFCs has caused the ozone layer** **to deplete** by roughly 5 to 6 percent and it could have been much worse. Earlier projections showed an estimated 17 percent depletion by 2020 had we kept emitting CFCs and similar compounds as we had been before regulations limited and finally ended their use. These numbers far outstrip the impact of solar storms. Moreover, climate change has caused the radical depletion of the ozone layer at least once before on our planet, causing widespread devastation. **Rapid warming at the end of the Devonian period, 359 million years ago, caused ozone collapse** allowing harmful radiation to reach the surface. The ensuing extinction event **killed off three quarters of life** on Earth. **Another extinction level event involving the loss of the ozone layer** is not outside the realm of possibility, but the cause likely **won't come from space**. When it comes to risk of climate disaster, the call is coming from inside the house.

#### Their Delbert evidence says rockets are an alt cause they can’t solve.

Delbert, 2021

Caroline Delbert is a writer, book editor, researcher, and avid reader. “All the Satellites in Space Could Crack Open the Ozone Layer”, https://www.popularmechanics.com/space/satellites/a36651845/satellite-pollution-starlink-ozone/, JUN 17, 2021, accessed 12/1/21, sb

The hole in the ozone layer, Earth’s protective chemical shield that absorbs most of the sun’s ultraviolet rays, has slowly healed over the last few decades since the global ban of chlorofluorocarbons (CFCs). But scientists are now raising the alarm about puncturing a new hole in the ozone layer—this time without any noticeable CGCs in sight. Instead, the surprising cause is deterioration of the aluminum in megaconstellation satellites like SpaceX’s Starlink network. For our purposes, a satellite is a human-made object put into low-Earth orbit (LEO) for a planned lifespan. There are about 5,000 active and defunct satellite sin LEO, with over 40,000 Starlink sats planned in the future, plus satellite projects from national space agencies and private companies around the world, researchers from the University of British Columbia say in their new Scientific Reports study. The human-made distinction may seem obvious, but it hasn’t always been. That’s because, as Space.com reports, scientists spent decades favorably comparing satellite “junk” to the amount of material deposited and burned up in our atmosphere by meteorites. As long as meteorites were so much more of the material by volume while doing almost no harm to the planet, how bad could human-made satellites be? Well, as it turns out, it’s a matter of quality rather than quantity. That’s because meteorites are made of a different constellation of minerals and elements than our custom-manufactured sky robots. “We have 54 tonnes (60 tons) of meteoroid material coming in every day,” lead study author Aaron Boley told Space.com. “With the first generation of Starlink, we can expect about 2 tonnes (2.2 tons) of dead satellites reentering Earth’s atmosphere daily. But meteoroids are mostly rock, which is made of oxygen, magnesium and silicon. These satellites are mostly aluminum, which the meteoroids contain only in a very small amount, about 1 [percent].” Aluminum is key to everything at stake here. First, it burns into reflective aluminum oxide, or alumina, which could turn into an unwitting geoengineering experiment that could alter Earth’s climate. And second, aluminum oxide could damage and even rip a new hole in the ozone layer. Let’s look at each threat separately and try to figure it out. Misadventures in Geoengineering Geoengineering is the umbrella term for technologies that seek to alter the climate or other physical realities about the planet. The major meaning that most people associate with the word is solar geoengineering, an experimental idea to fight climate change. Yes, this includes launching reflective aerosols that will “block the sun” back into space and ostensibly cool the planet, which is what Bill Gates eventually wants to try. But we just don’t know how large-scale geoengineering could affect the planet’s climate. (In the sci-fi flick Snowpiercer, geoengineering has turned Earth into a lifeless iceball whose only survivors must crowd aboard an unceasing train. That’s probably our worst-case scenario.) Aluminum oxide scatters more light than glass, with a refractive index of about 1.76 compared with just 1.52 for glass and about 1.37 for plain aluminum. The researchers write: “Anthropogenic deposition of aluminum in the atmosphere has long been proposed in the context of geoengineering as a way to alter Earth’s albedo. These proposals have been scientifically controversial and controlled experiments encountered substantial opposition. Mega-constellations [of satellites] will begin this process as an uncontrolled experiment.” Another Hole in the Ozone? What, then, of the ozone layer? Once again, aluminum oxide comes to the forefront. As aluminum burns, it can chemically react with ozone in the air to form aluminum oxide, thereby depleting the naturally protective supply of ozone in the atmosphere. The atmosphere can absorb a small amount of these chemicals without ill effect, but with tens of thousands of satellites in play, the quantities will naturally go up. That’s in addition to the ozone damage done by each rocket launch to put satellites into LEO. “Rockets threaten the ozone layer by depositing radicals directly into the stratosphere, with solid-fueled rockets causing the most damage because of the hydrogen chloride and alumina they contain,” the researchers write. While satellites typically dissolve above the stratosphere where most ozone is contained, the particulate can drift down into the stratosphere in order to react there with ozone, scientist Gerhard Drolshagen, an expert on meteoroid material, told Space.com. Aluminum oxide will sink to that level and subsequently cause losses.

#### Impact is awful- says if ozone is SUDDENLY stripped away, not if there are new holes

#### Voosen, 2020

Paul Voosen is a staff writer who covers Earth and planetary science. “No asteroids needed: ancient mass extinction tied to ozone loss, warming climate”, 27 MAY 2020, <https://www.science.org/content/article/no-asteroids-or-volcanoes-needed-ancient-mass-extinction-tied-ozone-loss-warming>, accessed 12/5/21, sb

The end of the Devonian period, 359 million years ago, was an eventful time: Fish were inching out of the ocean, and fernlike forests were advancing on land. The world was recovering from a mass extinction 12 million years earlier, but the climate was still chaotic, swinging between hothouse conditions and freezes so deep that glaciers formed in the tropics. And then, just as the planet was warming from one of these ice ages, another extinction struck, seemingly without reason. Now, spores from fernlike plants, preserved in ancient lake sediments from eastern Greenland, suggest a culprit: The planet's protective ozone layer was suddenly stripped away, exposing surface life to a blast of mutation-causing ultraviolet (UV) radiation. Just as the extinction set in, the spores became misshapen and dark, indicating DNA damage, John Marshall, a palynologist at the University of Southampton, and his co-authors say in a paper published today in Science Advances. It's evidence, he says, that "all of the ozone protection is gone." Scientists have long believed—at least before humanity became a force for extinction—that there were just two ways to wipe out life on Earth: an asteroid strike or massive volcanic eruptions. But 2 years ago, researchers found evidence that in Earth's worst extinction—the end-Permian, 252 million years ago—volcanoes lofted Siberian salt deposits into the stratosphere, where they might have fed chemical reactions that obliterated the ozone layer and sterilized whole forests. Now, spores from the end-Devonian make a compelling case that, even without eruptions, a warming climate can deplete the ozone layer, says Lauren Sallan, a paleobiologist at the University of Pennsylvania. "Because the evidence is so strong, it will make people rethink other mass extinction events." The end-Devonian die-off has long sat in the shadow of the Late Devonian extinction 12 million years earlier, one of the planet's largest. Likely driven by volcanoes that emitted gases that drastically cooled and warmed the planet, it killed most corals and many shelled sea creatures. But 10 years ago, work by Sallan and others revealed the end-Devonian was mighty in its own right, wiping out many plants and vertebrates, including most tetrapods, the four-limbed fish that had begun to evolve fingers and toes. Only the five-toed tetrapods survived. "It resets our own evolution," Marshall says. "All these archaic lineages, it kicked them out of the frame." What the end-Devonian lacked was a cause. There was no evidence for volcanism or a giant impact, but one alluring clue was seen in the rapid formation and disappearance of rock deposits associated with glaciers, Sallan says. "Something was really screwed up with climate at that time." Over the past 3 decades, Marshall has explored rocks surviving from this time in eastern Greenland. At the time, this terrain lay far from the arctic, at lower latitudes, locked in the arid interior of a landmass called the Old Red Sandstone Continent. As the climate warmed after the Devonian's last ice age, lakes formed and filled with sediment that slowly turned to mudstone, recording conditions before and during the extinction. In 2017, Marshall exhumed the perfect mudstone in a 6-meter-long drilled core. It captures a startling transformation: Healthy fossilized spores, coated in distinctive symmetrical spikes, suddenly grow misshapen, their spikes dilapidated and uneven. Spores are a common fossil because of their armored coat, but they are vulnerable to UV radiation, much like humans; spores can even develop a "tan" in response to UV. The damage Marshall saw is consistent with such exposure, says Jeffrey Benca, an experimental paleobotanist who has linked such damage to the end-Permian extinction. "What they propose seems quite plausible," he says. Marshall argues that the warming climate drove more powerful summer thunderstorms, which could have injected an ozone-depleting mix of water and salts into the stratosphere. As UV rays killed off forests, nutrient runoff into the sea could have caused blooms of plankton and algae, which would have produced more ozone-destroying salts in a runaway feedback. "It looks like it might be a perfect storm," he says. Marshall's scenario could explain not just the extinction, but also the many natural gas deposits dating from the period, says Sarah Carmichael, a geochemist at Appalachian State University. They formed from decaying organic matter, but no one has explained the needed surge in plankton growth. Nutrient runoff from dead forests could have fertilized the marine life.

**Time frame – Kessler effect 200 years away**

**Stubbe 17** [(Peter, PhD in law @ Johann Wolfgang Goethe University Frankfurt) “State Accountability for Space Debris: A Legal Study of Responsibility for Polluting the Space Environment and Liability for Damage Caused by Space Debris,” Koninklijke Brill Publishing, ISBN 978-90-04-31407-8, p. 27-31] TDI

The prediction of possible scenarios of the future evolution of the debris p o p ulation involves many uncertainties. Long-term forecasting means the prediction of the evolution of the future debris environment in time periods of decades or even centuries. Predictions are based on models84 that work with certain assumptions, and altering these parameters significantly influences the outcomes of the predictions. Assumptions on the future space traffic and on the initial object environment are particularly critical to the results of modeling efforts.85 A well-known pattern for the evolution of the debris population is the so-called Kessler effect’, which assumes that there is a certain collision probability among space objects because many satellites operate in similar orbital regions. These collisions create fragments, and thus additional objects in the respective orbits, which in turn enhances the risk of further collisions. Consequently, the num ber of objects and collisions increases exponentially and eventually results in the formation of a self-sustaining debris belt aroundthe Earth. While it has long been assumed that such a process of collisional cascading is likely to occur only in a very long-term perspective (meaning a time 1 n of several hundred years),87 a consensus has evolved in recent years that an uncontrolled growth of the debris population in certain altitudes could become reality much sooner.88 In fact, a recent cooperative study undertaken by various space agencies in the scope of i a d c shows that the current l e o debris population is unstable, even if current mitigation measures are applied. The study concludes:

Even with a 90% implementation of the commonly-adopted mitigation measures [...] the l e o debris population is expected to increase by an average of 30% in the next 200 years. The population growth is primarily driven by catastrophic collisions between 700 and 1000 km altitudes and such collisions are likely to occur every 5 to 9 years.89

**1] Probability – 0.1% chance of a collision.**

**Salter 16** [(Alexander William, Economics Professor at Texas Tech) “SPACE DEBRIS: A LAW AND ECONOMICS ANALYSIS OF THE ORBITAL COMMONS” 19 STAN. TECH. L. REV. 221 \*numbers replaced with English words] TDI

The probability of a collision is currently low. Bradley and Wein estimate that the maximum probability in LEO of a collision over the lifetime of a spacecraft remains below one in one thousand, conditional on continued compliance with NASA’s deorbiting guidelines.3 However, the possibility of a future “snowballing” effect, whereby debris collides with other objects, further congesting orbit space, remains a significant concern.4 Levin and Carroll estimate the average immediate destruction of wealth created by a collision to be approximately $30 million, with an additional $200 million in damages to all currently existing space assets from the debris created by the initial collision.5 The expected value of destroyed wealth because of collisions, currently small because of the low probability of a collision, can quickly become significant if future collisions result in runaway debris growth.

## Debris removal

ESA 19, European Space Agency, “ESA commissions world’s first space debris removal” The European Space Agency (ESA) is Europe’s gateway to space. Its mission is to shape the development of Europe’s space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world. <https://www.esa.int/Safety_Security/Clean_Space/ESA_commissions_world_s_first_space_debris_removal> Livingston RB

ClearSpace-1 will be the first space mission to remove an item of debris from orbit, planned for launch in 2025. The mission is being procured as a service contract with a startup-led commercial consortium, to help establish a new market for in-orbit servicing, as well as debris removal. Following a competitive process, a consortium led by Swiss startup [ClearSpace](https://clearspace.today/) – a spin-off company established by an experienced team of space debris researchers based at Ecole Polytechnique Fédérale de Lausanne ([EPFL](https://www.epfl.ch/en/)) research institute – will be invited to submit their final proposal, before starting the project next March. “This is the right time for such a mission,” says Luc Piguet, founder and CEO of ClearSpace. “The space debris issue is more pressing than ever before. Today we have nearly 2000 live satellites in space and more than 3000 failed ones. “And in the coming years the number of satellites will increase by an order of magnitude, with multiple mega-constellations made up of hundreds or even thousands of satellites planned for low Earth orbit to deliver wide-coverage, low-latency telecommunications and monitoring services. The need is clear for a ‘tow truck’ to remove failed satellites from this highly trafficked region.” At [Space19+](http://www.esa.int/About_Us/Corporate_news/ESA_ministers_commit_to_biggest_ever_budget), ESA’s Ministerial Council, which took place in Seville, Spain, at the end of November, ministers agreed to place a service contract with a commercial provider for the safe removal of an inactive ESA-owned object from low-Earth orbit. Supported within ESA’s new Space Safety programme, the aim is to contribute actively to cleaning up space, while also demonstrating the technologies needed for debris removal. “Imagine how dangerous sailing the high seas would be if all the ships ever lost in history were still drifting on top of the water,” says ESA Director General Jan Wörner. “That is the current situation in orbit, and it cannot be allowed to continue. ESA’s Member States have given their strong support to this new mission, which also points the way forward to essential new commercial services in the future.” “Even if all space launches were halted tomorrow, projections show that the overall orbital debris population will continue to grow, as collisions between items generate fresh debris in a cascade effect,” says Luisa Innocenti, heading ESA’s [Clean Space](http://blogs.esa.int/cleanspace/) initiative. “We need to develop technologies to avoid creating new debris and removing the debris already up there.  “NASA and ESA studies show that the only way to stabilise the orbital environment is to actively remove large debris items. Accordingly we will be continuing our development of essential guidance, navigation and control technologies and rendezvous and capture methods through a new project called Active Debris Removal/ In-Orbit Servicing – ADRIOS. The results will be applied to ClearSpace-1. This new mission, implemented by an ESA project team, will allow us to demonstrate these technologies, achieving a world first in the process.” The ClearSpace-1 mission will target the Vespa (Vega Secondary Payload Adapter) upper stage left in an approximately 800 km by 660 km altitude orbit after the second flight of ESA’s Vega launcher back in 2013. With a mass of 100 kg, the Vespa is close in size to a small satellite, while its relatively simple shape and sturdy construction make it a suitable first goal, before progressing to larger, more challenging captures by follow-up missions – eventually including multi-object capture.

#### Even stopping new launches doesn’t solve, but a small reduction every year does

**ESA no date**, European Space Agency, “Active debris removal” The European Space Agency (ESA) is Europe’s gateway to space. Its mission is to shape the development of Europe’s space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world. <https://www.esa.int/Safety_Security/Space_Debris/Active_debris_removal> Livingston RB

Limiting launch rates neither feasible nor helpful Therefore, limiting the launch rate or a further reduction of the allowed lifetime in orbit after the end of the mission (which would be two options to reduce the overall number of intact objects in space) do not seem feasible, because they cannot be mandated. For all new objects, strong compliance with post-mission mitigation measures would allow maintaining the number of intact objects at a level similar to the current one, and avoid having to deal with more objects in addition to those already in orbit. Therefore, in order to reduce the number of big objects in LEO, the only option is to actively remove large objects now in orbit and having a long remaining lifetime in space. This would provide several benefits: The most critical objects (those that would generate the most fragments in case of any collision, and that have a higher collision risk) could be removed from the environment first; Decommissioned objects could also be removed; A controlled deorbit could be performed (as large removal targets typically are also most critical in terms of on-­ground risk). Studies at ESA and NASA show that with a removal sequence planned according to a target selection based on mass, area, or cumulative collision risk, the environment can be stabilised when on the order of 5–10 objects are removed from LEO per year (although the effectiveness of each removal decreases as more objects are removed).

#### The Kessler syndrome is starting now but private megaconstellations make management impossible

Boley/Byers, 5/20/2021 – University of British Columbia Professors

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Aaron C. Boley & Michael Byers, “Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth”, Scientific Reports volume 11, Article number: 10642 (2021), 20 May 2021, <https://www.nature.com/articles/s41598-021-89909-7.pdf>, accessed 12/1/21, sb

Thousands of satellites and 1500 rocket bodies provide considerable mass in LEO, which can break into debris upon collisions, explosions, or degradation in the harsh space environment. Fragmentations increase the cross-section of orbiting material, and with it, the collision probability per time. Eventually, collisions could dominate on-orbit evolution, a situation called the Kessler Syndrome3. There are already over 12,000 trackable debris pieces in LEO, with these being typically 10 cm in diameter or larger. Including sizes down to 1 cm, there are about a million inferred debris pieces, all of which threaten satellites, spacecraft and astronauts due to their orbits crisscrossing at high relative speeds. Simulations of the long-term evolution of debris suggest that LEO is already in the protracted initial stages of the Kessler Syndrome, but that this could be managed through active debris removal4. The addition of satellite mega-constellations and the general proliferation of low-cost satellites in LEO stresses the environment further5,6,7,8. Results The overall setting The rapid development of the space environment through mega-constellations, predominately by the ongoing construction of Starlink, is shown by the cumulative payload distribution function (Fig. 1). From an environmental perspective, the slope change in the distribution function defines NewSpace, an era of dominance by commercial actors. Before 2015, changes in the total on-orbit objects came principally from fragmentations, with effects of the 2007 Chinese anti-satellite test and the 2009 Kosmos-2251/Iridium-33 collisions being evident on the graph. Although the volume of space is large, individual satellites and satellite systems have specific functions, with associated altitudes and inclinations (Fig. 2). This increases congestion and requires active management for station keeping and collision avoidance9, with automatic collision-avoidance technology still under development. Improved space situational awareness is required, with data from operators as well as ground- and space-based sensors being widely and freely shared10. Improved communications between satellite operators are also necessary: in 2019, the European Space Agency moved an Earth observation satellite to avoid colliding with a Starlink satellite, after failing to reach SpaceX by e-mail. Internationally adopted ‘right of way’ rules are needed10 to prevent games of ‘chicken’, as companies seek to preserve thruster fuel and avoid service interruptions. SpaceX and NASA recently announced11 a cooperative agreement to help reduce the risk of collisions, but this is only one operator and one agency. When completed, Starlink will include about as many satellites as there are trackable debris pieces today, while its total mass will equal all the mass currently in LEO—over 3000 tonnes. The satellites will be placed in narrow orbital shells, creating unprecedented congestion, with 1258 already in orbit (as of 30 March 2021). OneWeb has already placed an initial 146 satellites, and Amazon, Telesat, GW and other companies, operating under different national regulatory regimes, are soon likely to follow. Enhanced collision risk Mega-constellations are composed of mass-produced satellites with few backup systems. This consumer electronic model allows for short upgrade cycles and rapid expansions of capabilities, but also considerable discarded equipment. SpaceX will actively de-orbit its satellites at the end of their 5–6-year operational lives. However, this process takes 6 months, so roughly 10% will be de-orbiting at any time. If other companies do likewise, thousands of de-orbiting satellites will be slowly passing through the same congested space, posing collision risks. Failures will increase these numbers, although the long-term failure rate is difficult to project. Figure 3 is similar to the righthand portion of Fig. 2 but includes the Starlink and OneWeb mega-constellations as filed (and amended) with the FCC (see “Methods”). The large density spikes show that some shells will have satellite number densities in excess of n=10−6 km−3. Deorbiting satellites will be tracked and operational satellites can manoeuvre to avoid close conjunctions. However, this depends on ongoing communication and cooperation between operators, which at present is ad hoc and voluntary. A recent letter12 to the FCC from SpaceX suggests that some companies might be less-than-fully transparent about events13 in LEO. Despite the congestion and traffic management challenges, FCC filings by SpaceX suggest that collision avoidance manoeuvres can in fact maintain collision-free operations in orbital shells and that the probability of a collision between a non-responsive satellite and tracked debris is negligible. However, the filings do not account for untracked debris6, including untracked debris decaying through the shells used by Starlink. Using simple estimates (see “Methods”), the probability that a single piece of untracked debris will hit any satellite in the Starlink 550 km shell is about 0.003 after one year. Thus, if at any time there are 230 pieces of untracked debris decaying through the 550 km orbital shell, there is a 50% chance that there will be one or more collisions between satellites in the shell and the debris. As discussed further in “Methods”, such a situation is plausible. Depending on the balance between the de-orbit and the collision rates, if subsequent fragmentation events lead to similar amounts of debris within that orbital shell, a runaway cascade of collisions could occur. Fragmentation events are not confined to their local orbits, either. The India 2019 ASAT test was conducted at an altitude below 300 km in an effort to minimize long-lived debris. Nevertheless, debris was placed on orbits with apogees in excess of 1000 km. As of 30 March 2021, three tracked debris pieces remain in orbit14. Such long-lived debris has high eccentricities, and thus can cross multiple orbital shells twice per orbit. A major fragmentation event from a single satellite could affect all operators in LEO. Even if debris collisions were avoidable, meteoroids are always a threat. The cumulative meteoroid flux15 for masses m > 10–2 g is about 1.2 × 10–4 meteoroids m−2 year−1 (see “Methods”). Such masses could cause non-negligible damage to satellites16. Assuming a Starlink constellation of 12,000 satellites (i.e. the initial phase), there is about a 50% chance of 15 or more meteoroid impacts per year at m > 10–2 g. Satellites will have shielding, but events that might be rare to a single satellite could become common across the constellation. One partial response to these congestion and collision concerns is for operators to construct mega-constellations out of a smaller number of satellites. But this does not, individually or collectively, eliminate the need for an all-of-LEO approach to evaluating the effects of the construction and maintenance of any one constellation.