### 1

#### Interpretation: LEO ends before outer space begins according to science and the Karman line is not an objective way to measure the beginning of outer space.

Sabine **Stanley, 20** - ("Low Earth Orbit: Troposphere and Stratosphere," Great Courses Daily, 7-9-2020, 1-16-2022https://www.thegreatcoursesdaily.com/low-earth-orbit-troposphere-and-stratosphere/)//AW

Even though low earth orbit includes all layers of the atmosphere, most of what people know from the atmosphere happens in the first two layers. Troposphere and stratosphere are the closest layers with the major amount of atmospheric mass. Low earth orbit somehow marks the beginning of outer space. The Karman line was a governmental attempt to mark the boundary between Earth and outer space, but they could not agree on an altitude. Thus, it ranges from 80 to 100 kilometers. What everyone agrees on are the layers of the atmosphere and their altitudes. The first layer is the troposphere. Learn more about how plate tectonics sets up life. What Is the Troposphere? The lowest layer of atmosphere is called the troposphere, with an average thickness of 10 kilometers, spread above the Earth’s surface. Everything known as ‘weather’ happens in this layer, namely, winds, thunderstorms, tornadoes, hurricanes, blizzards, and cloud formation. The troposphere is the lowest layer of the atmosphere, where weather happens, and 80% of the atmosphere’s mass is concentrated. (Image: BlueRingMedia/Shutterstock) The convective overturning of air results in all the weather phenomena. Besides, water goes through all its phases in the troposphere: vapor, rain, and snow. The ‘overturning’ is reflected in the name of this thin but dense layer: tropos is Greek for ‘turn’, referring to the overturning of air. Now, why does air overturn here? This is a transcript from the video series A Field Guide to the Planets. Watch it now, on Wondrium. Overturning in the Troposphere The overturning – vertical mixing – happens since the highest temperature of the troposphere is at the bottom. The average temperature on the surface is about 60°F, and it decreases down to an average of −75°F at the top. About 80% of the atmosphere’s mass is concentrated here. The troposphere ends with a boundary called the tropopause, where the next layer begins. Learn more about near-Earth asteroids and the asteroid belt. What is the Stratosphere? The stratosphere is the second-lowest layer of Earth’s atmosphere, starting at 10 kilometers above the surface. Unlike the troposphere, the temperature in the stratosphere increases with altitude. At the top, the temperature is around 32°F – almost 100 degrees higher than the bottom. However, the pressure decreases to one millibar, i.e., 1000 times less than the Earth’s surface pressure. The stratosphere ends at the stratopause. Does the higher temperature mean the stratopause is warm? Is the Stratosphere Warm? The higher temperature in the troposphere is the result of the Sun’s ultraviolet (or UV) radiation, trapped by ozone particles (O3). The famous ozone layer, where UV is absorbed, is located here. The highest concentration of ozone is at the lowest part of the stratosphere, but O3 can also be found up to the middle of the layer. Most of the radiated UV is absorbed by O3, breaking it into O2 and atomic oxygen (O). Next, O and O2 combine again and recreate O3. However, the absorbed energy does not create a warm environment, since the molecules are so far away from each other that collisions rarely happen. Hence, airplanes flying around this altitude need to create pressure inside the cabin and regulate the temperature. Learn more about Venus, the veiled greenhouse planet. Airplanes in the Stratosphere The cruising altitude for most commercial flights is around 39,000 feet or 12 kilometers above the surface. This means that airplanes fly in the lowest part of the stratosphere, above the weather and the turbulence it causes. The boundary of the two layers can be seen from the plane, as clouds do not enter the stratosphere. The air is too thin here, so airplane cabins are pressurized. Stratosphere is where most commercial planes fly, as the pressure is ideal for flying. (Image: Kost9/Shutterstock) Besides the commercial planes, NASA’s SOFIA also flies in the lower stratosphere. SOFIA: Stratospheric Observatory for Infrared Astronomy SOFIA is a Boeing 747 with a 100-inch telescope attached. It flies at 12 kilometers, above 99% of Earth’s atmosphere, and studies the solar system in the infrared part of the light spectrum. Transient phenomena, such as eclipses and occultations, are also studied best with SOFIA. Pluto and Saturn’s moon, Titan, was also studied by SOFIA from the stratosphere. Higher in the stratosphere, the air pressure is too low for typical airplanes to fly. Military jets and other planes that do fly at higher altitudes use their engine power to conduct the flight. However, scientific balloons are launched to collect data. The best location to do so is McMurdo Station in Antarctica, as the South Pole vortex keeps the balloons contained in a small area and does not let them fly away into the distance. It can be concluded that the first two layers of the atmosphere in the low Earth orbit are the ones humans make the most use of. Common Questions about Low Earth Orbit Q: Is low Earth orbit considered space? Low Earth orbit is the ‘circle’ around Earth’s atmosphere up to 2000 kilometers above the surface. The satellites and other human-made space objects also orbit in the low earth orbit. **The end of the orbit is the beginning of space**, where solar winds start, and the Earth’s atmosphere is too thin to be considered gas. Q: What does low Earth orbit mean? Low earth orbit extends up to 2000 kilometers above the surface. All the atmosphere layers reside in this area, with almost 80% of the mass concentrated in the lowest layer, the troposphere. The weather, winds and tornados, plane flights, and satellite orbits all occur in this 2000-kilometer-high zone before space characteristics dominate the environment.

#### Vote neg – two impacts:

#### They massively expand topic limits by allowing an aff that takes place anywhere in Earth’s atmosphere. That means that affs about weather balloons, missiles, school rocket projects, or airspace owned by governments could all be potential affs. Don’t let them say that they only expand it by a few thousand kilometers- our atmosphere is where most testing and air activities happen. There are more launches within our atmosphere than outside of it, so they more than double the topic prep burden.

#### Topic literature- our evidence is from a scientific source meant to clarify specifically whether or not the LEO is space from a scientific basis. Prefer it to semantic. It’s better for education because it forces the debaters to look at the substance behind the topic .

#### Drop the debater to preserve fairness and education – use competing interps – reasonability invites arbitrary judge intervention and a race to the bottom of questionable argumentation. No RVIs – they don’t get to win for following the rules, RVIs encourage abuse, and a good theory debater will just dump on the RVI in the 2AR which crowds out substance. T is higher than 1AR theory because it skews the round from the start

### 2

#### TEXT: The Outer Space Treaty ought to be amended to establish an international legal trust system governing outer space.

Finoa 21 [Ivan Finoa (Department of Law University of Turin), “Building a New Legal Model for Settlements on Mars,” A. Froehlich (ed.), Assessing a Mars Agreement Including Human Settlements, Studies in Space Policy 30, 2021. <https://doi.org/10.1007/978-3-030-65013-1_7>]CT

7.5 A Proposal for an International Legal Trust System

Since several legal and policy issues may arise from the actual legal framework, a new international legal regime for outer space shall: (a) Provide for property rights or a lease allocation system, both incentivising investments in the space sector. The system would be supervised and led by the United Nations (UN) through the United Nations Office for Outer Space Affairs (UNOOSA). (b) Establish the rule of law in outer space. A laissez faire system could turn into anarchy whereby countries and companies could race to grab as many resources as possible bringing considerable potential conflict. (c) Recognise outer space as common heritage of mankind, instead of res communis.24 (d) Provide a sustainable exploitation of celestial bodies, to avoid the uncontrolled production of space debris or to prevent the complete exhaustion of the celestial bodies’ masses or their natural orbits.25 The United Nations should manage the ordered and sustainable economic development in outer space for the present and future generations. (e) Prevent the militarisation of outer space and favours the international collaboration, which are the same aims of the Outer Space Treaty’ drafters. (f) Consider the weak points of the Moon Agreement which led to nations’ refusal to sign. Only a widely accepted agreement would have the power of law in the international context.

The abovementioned requirements could be met by establishing an international Legal Trust System (ILTS). A trust is an arrangement that assigns assets to one or more trustees that will manage them in the interest of one or more beneficiaries. The latter may include the trustee or the settlor.26 Translated in the ILTS, mankind would assume the role of settlor and beneficiary of the outer space resources. The UNOOSA would act as main trustee of outer space resources and trading property rights and leases to companies and countries. The rights over the celestial bodies or over its resources would depend on the nature of the celestial body itself. For example, property rights are preferable to a lease over asteroids, as they could just disappear after the exploitation. Both leases and property rights can be provided over lands and mining sites on Mars. Leases or defeasible titles are preferable for some land mass on those celestial bodies which could hypothetically be used by humankind pending an Earth disaster. In the case of lucrative activities, such as mining, companies will choose whether to get the exclusive use over the resource through payment of the lease or through annual payment linked to net proceeds or to production charges.

7.6 The Functioning of the International Legal Trust System

When a company is interested in leasing or buying an outer space resource, before starting any operations, it must send a plan of work to the United Nations. The plan of work shall include all the details of the activity that would be carried out; it shall be consistent with pre-established parameters of sustainability and shall not interfere with other space activities. If the UN approves the company plan of work, the country of the company assumes the role of co-trustee for the specific resource. Thus, as a cotrustee, countries must investigate whether all activities of their national companies are consistent with the plan of work authorised by the UN. These supervisory duties would be added to the responsibility of nations for all space objects that are launched within their territory.27 The UN, as main trustee, would oversee that countries are performing their duties. This model would be the ordinary one. There would be also an extraordinary model, in which the UN would be the only trustee. This model would be possible in two instances: when the country of the applicant for a private company is not technologically able to act as a trustee or when the applicant of the activity is a country itself. Furthermore, as stated previously, the beneficiaries of this trust are the countries of the world and their citizens; hence all mankind would take concrete profit from lease transactions and benefit sharing. The income from the sales, leases and benefit sharing can be distributed to mankind by financing international global goals, following a similar model of the 17 Sustainable Development Goals adopted by the United Nations in 2015, which addressed poverty, inequality, climate change, environmental degradation, and peace and justice. Finally, the International Legal Trust System would meet acceptance because every country would obtain benefit sharing to improve its living standard and space faring nations would rely on property rights.

#### The legal trust would incentivize investment in space while preventing conflict and ensuring sustainable development and the equitable distributions of resources.

Finoa ’20 – Ivan Finoa [Department of Law, University of Turin], “An international legal trust system to deal with the new space era,” 71st International Astronautical Congress (IAC) – The CyberSpace Edition, (12-14 October 2020). <<https://d1wqtxts1xzle7.cloudfront.net/66728932/_IAC_20_E7.VP.8.x58518_An_international_legal_trust_system_to_deal_with_the_new_space_era_BY_IVAN_FINO-with-cover-page-v2.pdf?Expires=1642044926&Signature=asvt6StaK5n9UnpXuJIlo4ziI839WzFYjDZy37bm70ObGy3vFJyHwWNGxhn2beze4QzYDPPX0pVEXAwYvDaINVNxN01Ify8YwG5loNRddlat-grf3iawic7KvwqPowxFe2GuemVvbB-KW8ZVBxigwS-gelSKIVy4KYR9UgiDrM6e6deEBnUTcULSwmsH-JdHNg13ytZ3vNVMMlxZW2MPOCRuB2WlOHdCLoC86VqafSoMwuec-d~Aisbgyt5F2vO-GjvI60bR7h2MSp0iT6P7apIDUUpHUsDGbvcdxp22HSxXdlvr7lSqtLnL5rKxujGDYq~R9B~WuGiorVL2hn74UQ__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA>>CT

Considering the worsening climate change, in the future outer space might be our last Noah’s Ark. Now, humans must look to space as an opportunity to support growing resource requirements. Asteroids are rich in metals, which could be transported back to Earth. Unfortunately, the existing international legal framework discourages investments in the space economy. Once an enterprise invests billions of dollars in discovering and developing a mining site, it cannot claim any ownership because of the non-appropriation principle stipulated in Article 2 of the Outer Space Treaty (OST). Thus, other entities could legally access and exploit the same resource without any participation in the initial financial investment, increasing the risk of potential conflict. Bearing this in mind, the question arises, which legal regime could ensure effective allocation of resources, avoiding a chaotic space race to acquire valuable assets? The aim of this research is to argue that the first two articles of OST should be amended, to set up an international legal trust system which would guarantee different kinds of rights, dependently on the nature of the celestial body. E.g., property rights could be preferable to a lease over asteroids, as they could be exploited to their disappearance. This proposed system would be led by the United Nations Office for Outer Space Affairs (UNOOSA), as the main trustee. The co-trustees would be the nations of the world. Prior to initiating any space activity, every entity would send a request to their national government. If all the legal parameters are respected, the nation would forward the operational request to the UNOOSA. In the case of acceptance, UNOOSA would record the permit on an international public registry. The country in which the company has been registered would investigate whether the activities of its national company are consistent with the permit. This would be the ordinary model. The extraordinary model would be when the applicant for the space activity is a state, then the trustee would be the UN. All lucrative activities would be subject to benefit-sharing. Finally, this research will demonstrate the valuable outcome of the International Legal Trust System and its advantages for all humankind. Private companies would rely on property rights, while the benefit-sharing could be used to finance the 17 Sustainable Development Goals adopted by the UN in 2015, which address peace, climate change, inequalities and poverty.

### 3

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

Underwood 20 [Kimberly Underwood is a reporter on emerging communication technologies, cyberwarfare, the intelligence community, military command operations and weaponry research. “China is Retooling, and Russia Seeks Harm to Critical Infrastructure.” June 24, 2020. https://www.afcea.org/content/china-retooling-and-russia-seeks-harm-critical-infrastructure]

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.” To the industry, Gen. Gagnon warned companies that Beijing will authorize Chinese espionage against key U.S technologies. “Many of your corporations hold this technology,” he stressed. “They are trying to undercut your ability to be profitable by developing those same technologies in China. They are competing against us in the international market. I will tell you that China's persistent cyber espionage threat and their growing tech threat to our core military and critical infrastructure will continue to be persistent. China remains the most active strategic competitor responsible for cyber espionage against corporations and allies.” China, like Russia, is also increasing its information warfare against the United States. “They are becoming more adept at using social media to deliver messages directly to the U.S. population that alter the way we think, the way we behave and the way we decide,” the general observed. The improvement of their cyber attack capabilities and ways to alter information online is intended to shape views inside China, shift the mindset of Chinese people around the world, as well as to try to shape the world’s view, not just of China, but also of the United States. “You are seeing that play out in the pandemic, how people view us around the world,” he offered. “We're also concerned about Chinese intelligence and security services,” the A2 continued. “They use Chinese information technology firms as routine and systemic espionage platforms against the United States and against our allies. Many of you are tracking what is in the news about 5G and Huawei, and that's what we're talking about.” As for Russia, their highly capable operations of cyber espionage, influence and cyber attacks continue to target the United States and its allies. In particular, Russia’s form of integrating cyber espionage attacks and influence operations, or information confrontation, is very effective, Gen. Gagnon emphasized. “If you think about it, they’re generally playing with the weaker hand, so they have been rather brilliant on the international stage in achieving their foreign policy objectives,” he said. In addition, Moscow is staging cyberattack assets to disrupt or damage U.S. military or civilian information systems during the COVID-19 pandemic. “There is activity that they undertake on a day-to-day basis to try to gain a decisive military intelligence,” he stated. “Their security services continue to target our systems, both for U.S. information systems and critical infrastructure, as well as the networks of our NATO and Five-Eye partners. They do it for positional advantage in cyberspace to be able to do the five Ds: deceive, deny, disrupt, degrade and destroy our assets, but also to gain intelligence on how systems are established and set up so that they can maintain attack vectors.” Russia also is targeting U.S. critical infrastructure, the general cautioned. “Russia has the ability to execute cyber attacks in the United States that can generate localized temporary disruptive effects on critical infrastructure, such as disrupting electric distribution networks for at least a few hours.” In fact, he warned, Moscow is mapping out critical infrastructure with the long-term goal of being able to cause “substantial damage.”

#### Megaconstellations 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]

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 JFQ 97, 2nd Quarter 2020 Hallex and Cottom 25 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

Ernest J. Moniz et al. 18, Ernest J. Moniz is the CEO of the Nuclear Threat Initiative, served as the thirteenth United States Secretary of Energy from 2013 to January 2017. Sam Nunn, and Des Browne, September 2018, “Nuclear Weapons in the New Cyber Age,” https://media.nti.org/documents/Cyber\_report\_finalsmall.pdf

The Cyber Threat to Nuclear Weapons and Related Systems

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

### 4

#### Starlink is key to global internet access.

John Koetsier {journalist, analyst, author, and speaker}, 20 - ("Elon Musk’s 42,000 StarLink Satellites Could Just Save The World," Forbes, 1-9-2020, https://www.forbes.com/sites/johnkoetsier/2020/01/09/elon-musks-42000-starlink-satellites-could-just-save-the-world/?sh=85866264c2cd)//marlborough-wr/

Elon Musk’s other company, SpaceX, is building Starlink, a global communications constellation that could approach a [staggering 42,000 satellites](https://www.forbes.com/sites/johnkoetsier/2019/12/20/apple-building-satellite-to-iphone-tech-spacex-launching-42000-satellites-2--2--/#5d1ee85668a7). And it could be all that stands between us and a fragmented world living in virtually — and actually — different realities. How? World War II can tell us the answer. In the early 1940s a tyrannical power using fake news, hate speech, military might and hegemonic power controlled most of Europe: the Nazis. They controlled public life, news and local economies. Resistance groups dotted the European mainland, with one lifeline for non-official communication from free countries: radio. As such, radios were [contraband](https://www.theholocaustexplained.org/life-in-nazi-occupied-europe/occupation-case-studies/) and confiscated. One of the activities the allies undertook to support resistance fighters was shipping in radios for communication and outside news. Today, radios aren’t at risk of being confiscated. And as a cloud-delivered service, hijacking the internet happens largely out of public sight, in servers and routers that enable services like Netflix and the BBC and Facebook and Google. It’s called [splinternet](https://en.wikipedia.org/wiki/Splinternet), and it’s the ongoing division of a worldwide interconnected internet into separate and isolatable fiefdoms, each of which can be controlled and managed so that governing powers can control what their populations see. The Great Firewall of China is the most well-known example, but Iran, Syria and Vietnam also control significant portions of the internet for their populations. Russia just [completed technology](https://www.pcmag.com/news/371347/russia-is-about-to-disconnect-from-the-internet-what-that-m) to wall off its internal networks, servers and internet users from the wider internet. And India, in its attempt to control unrest following its anti-Muslim citizenship law, has employed a particularly heavy-handed approach: simply [blocking](https://www.tellerreport.com/news/2019-12-27---india--new-internet-outages--protesters-back-on-the-street-.ryrh4IhQyI.html) the internet entirely. (One unintended result: contractors in India can’t reach their employers in the U.S.) Another country, United Arab Emirates, took a different approach: outlawing all messengers [except one that it built a digital backdoor into: Totok](https://www.forbes.com/sites/johnkoetsier/2019/12/23/top-50-social-app-in-usa-outed-as-spying-tool-for-united-arab-emirates-apple-and-google-delete-it/#5790934b7291). However it happens, it allows governments to control what people see, read and hear from outside sources — and censor what their own people say. Starlink can change all of that. Elon Musk recently revealed [details](https://twitter.com/elonmusk/status/1214548764054216704?ref_src=twsrc%5Etfw%7Ctwcamp%5Etweetembed%7Ctwterm%5E1214548764054216704&ref_url=https%3A%2F%2Fwww.digitaltrends.com%2Fcool-tech%2Felon-musk-reveals-what-youll-need-to-connect-to-his-internet-satellites%2F) about how people will access StarLink. It will be incredibly simple, and it will enable access to the relatively free global internet from anywhere on the planet. What that means is that anyone can access the internet from anywhere. Chinese citizens will be able to access Google and information about Tiananmen Square. Russian citizens will be able to see external analysis of Putin’s financial dealings if even Russia blocks outside sources. Indian protesters can’t be cut off from the internet. Of course, governments will make the Starlink Terminal illegal. But that in itself will be a victory. Censorship works best when it is invisible: when people don’t even know that there is alternate information, other understandings of reality. (Chinese teenage exchange students at a relative’s house last year, for example, had never heard of Tiananmen Square, and refused to believe stories that, they felt, painted China in a negative light.) But when a device to connect to the outside world becomes contraband, the glass walls become opaque. People realize that walls have been erected to prevent them from seeing other opinions. And that is at least one step to maintaining a free, open and accessible internet globally, which should help combat fake news, propaganda and information deprivation aimed at controlling populations. And it’s a step towards making the splinternet harder to achieve. 1,000 satellites will be enough to enable basic service, Musk has said. SpaceX just [launched](https://www.digitaltrends.com/cool-tech/spacex-launches-60-more-starlink-satellites-amid-astronomer-concerns/) a third batch of 60 satellites, and is expected to continue launching that many [every two weeks](https://www.spaceitbridge.com/spacex-starlink-launch-targeted-for-november-11-will-questions-be-answered.htm) through the rest of 2020.

#### Free internet is crucial to the promotion of democracy. Pirannejad 17:

Ali Pirannejad {Department of Public Administration, University of Tehran, Tehran, Iran; Faculty of Technology, Policy and Management, Delft University of Technology, Delft, Netherlands, }, 17 - ("Can the internet promote democracy? A cross-country study based on dynamic panel data models," Taylor &amp; Francis, 4-1-2017, <https://www.tandfonline.com/doi/abs/10.1080/02681102.2017.1289889?journalCode=titd20)//marlborough-wr/>

In the age of information revolution, information and communication technologies are penetrating all levels of societies and are also influencing the political aspect of each country by providing some facilities such as the Internet and web technologies. Democracy, as a universal value and a political system, is also well known and has an important role in the sublimation of the human societies. This study attempts to examine the effect of Internet extension on democracy promotion by using a panel consisting of 122 countries covering the period from the year 2000 to 2014. In order to estimate the effect, and also to deal with the endogeneity and autocorrelation problems, the dynamic panel data models are employed in the study. The results of estimation models indicate that Internet extension has a significantly positive effect on democracy promotion during the period. In the end, some ideas for further research are presented.

#### Democracy Promotion is key to prevent great power war – we’re on the brink.

Gat 11 (Azar- the Ezer Weizman Professor of National Security at Tel Aviv University, 2011, “The Changing Character of War,” in The Changing Character of War, ed. Hew Strachan and Sibylle Scheipers, p. 30-32)

Since 1945, the decline of major great power war has deepened further. Nuclear weapons have concentrated the minds of all concerned wonderfully, but no less important have been the institutionalization of free trade and the closely related process of rapid and sustained economic growth throughout the capitalist world. The communist bloc did not participate in the system of free trade, but at least initially it too experienced substantial growth, and, unlike Germany and Japan, it was always sufﬁciently large and rich in natural resources to maintain an autarky of sorts. With the Soviet collapse and with the integration of the former communist powers into the global capitalist economy, the prospect of a major war within the developed world seems to have become very remote indeed. This is one of the main sources for the feeling that war has been transformed: its geopolitical centre of gravity has shifted radically. The modernized, economically developed parts of the world constitute a ‘zone of peace’. War now seems to be conﬁned to the less-developed parts of the globe, the world’s ‘zone of war’, where countries that have so far failed to embrace modernization and its pacifying spin-off effects continue to be engaged in wars among themselves, as well as with developed countries.¶ While the trend is very real, one wonders if the near disappearance of armed conﬂict within the developed world is likely to remain as stark as it has been since the collapse of communism. The post-Cold War moment may turn out to be a ﬂeeting one. The probability of major wars within the developed world remains low—because of the factors already mentioned: increasing wealth, economic openness and interdependence, and nuclear deterrence. But the deep sense of change prevailing since 1989 has been based on the far more radical notion that the triumph of capitalism also spelled the irresistible ultimate victory of democracy; and that in an afﬂuent and democratic world, major conﬂict no longer needs to be feared or seriously prepared for. This notion, however, is fast eroding with the return of capitalist non-democratic great powers that have been absent from the international system since 1945. Above all, there is the formerly communist and fast industrializing authoritarian-capitalist China, whose massive growth represents the greatest change in the global balance of power. Russia, too, is retreating from its postcommunist liberalism and assuming an increasingly authoritarian character.¶ Authoritarian capitalism may be more viable than people tend to assume. 8 The communist great powers failed even though they were potentially larger than the democracies, because their economic systems failed them. By contrast, the capitalist authoritarian/totalitarian powers during the ﬁrst half of the twentieth century, Germany and Japan, particularly the former, were as efﬁcient economically as, and if anything more successful militarily than, their democratic counterparts. They were defeated in war mainly because they were too small and ultimately succumbed to the exceptional continental size of the United States (in alliance with the communist Soviet Union during the Second World War). However, the new non-democratic powers are both large and capitalist. China in particular is the largest player in the international system in terms of population and is showing spectacular economic growth that within a generation or two is likely to make it a true non-democratic superpower.¶ Although the return of capitalist non-democratic great powers does not necessarily imply open conﬂict or war, it might indicate that the democratic hegemony since the Soviet Union’s collapse could be short-lived and that a universal ‘democratic peace’ may still be far off. The new capitalist authoritarian powers are deeply integrated into the world economy. They partake of the development-open-trade-capitalist cause of peace, but not of the liberal democratic cause. Thus, it is crucially important that any protectionist turn in the system is avoided so as to prevent a grab for markets and raw materials such as that which followed the disastrous slide into imperial protectionism and conﬂict during the ﬁrst part of the twentieth century. Of course, the openness of the world economy does not depend exclusively on the democracies. In time, China itself might become more protectionist, as it grows wealthier, its labour costs rise, and its current competitive edge diminishes.¶ With the possible exception of the sore Taiwan problem, China is likely to be less restless and revisionist than the territorially conﬁned Germany and Japan were. Russia, which is still reeling from having lost an empire, may be more problematic. However, as China grows in power, it is likely to become more assertive, ﬂex its muscles, and behave like a superpower, even if it does not become particularly aggressive. The democratic and non-democratic powers may coexist more or less peacefully, albeit warily, side by side, armed because of mutual fear and suspicion, as a result of the so-called ‘security dilemma’, and against worst-case scenarios. But there is also the prospect of more antagonistic relations, accentuated ideological rivalry, potential and actual conﬂict, intensiﬁed arms races, and even new cold wars, with spheres of inﬂuence and opposing coalitions. Although great power relations will probably vary from those that prevailed during any of the great twentieth-century conﬂicts, as conditions are never quite the same, they may vary less than seemed likely only a short while ago.

# CASE

### Debris

#### Turn: Starlink is key to rural broadband. Cross-apply their own Tompkins card on how the modern food system relies on satellites.

Weinschenk 2/25 [(Carl, IT and telecom journalist for Telecompetitor, Teleco Transformation, and IT Business Edge) “Report: Starlink Looks Very Promising for Rural Broadband,” Telecompetitor, 2/25/2021] JL

SpaceX’s Starlink satellite broadband service has the potential to be a game changer for rural broadband, according to an analysis by PCMag of Starlink speeds. The analysis is based on beta tester data exclusively provided to it by Ookla Speedtest.

The site looked at data from rural, suburban and urban areas. Among its more than 10,000 users in its semi-public beta were “a perplexing” number in urban and suburban areas where a variety of high-speed options already are available. The story cites Chicago, Seattle and Minneapolis as places where there were testers, despite readily available alternatives.

The site compared download speeds against other fixed service providers in 30 counties with at least 30 samples in any month from December 30 to February 24. The counties in which the fixed providers had the biggest speed advantage over Spacelink were urban or suburban: Los Angeles and Santa Clara counties, CA; Cook County, IL; King County, WA and Washington County, MN.

It is in rural areas that Starlink shines, according to the research. The five counties in which Starlink had the biggest download speed advantage over the fixed group were rural: Vilas County, WI; Ravali County, MT; Waldo County, ME; Okanogan County, WA and Lamoile County, VT.

The number of counties in which Starlink beat the fixed providers and those in which the fixed providers beat Starlink appeared to be about equal, as was the speed differential.

“Our own analysis shows that Starlink will make the biggest difference in rural, low-density, low-population counties with few options other than lower-quality satellite services,” wrote Sascha Segan, author of the PCMag article about Startlink rural speeds.

1. **Space debris is hype---there are thousands of satellites and only 15 debris collisions ever**

Mark **Albrecht 16**, Chairman of the board of USSpace LLC & fmr. head of the National Space Council, “Congested space is a serious problem solved by hard work, not hysteria, 5/9/16, https://spacenews.com/op-ed-congested-space-is-a-serious-problem-solved-by-hard-work-not-hysteria/

There are over a half million pieces of human-made material in orbit around our planet. Some are the size of school buses, some the size of BB gun pellets. They all had a function at some point, but now most are simply space debris littered from 100 to 22,000 miles above the Earth. Yet, all behave perfectly according to the laws of physics. Many in the space community have called the collision hazard caused by space debris a crisis.

Popular culture has embraced the risks of collisions in space in films like Gravity. Some participants have dramatized the issue by producing graphics of Earth and its satellites, which make our planet look like a fuzzy marble, almost obscured by a dense cloud of white pellets meant to conceptualize space congestion.

Unfortunately, for the sake of a good visual, satellites are depicted as if they were hundreds of miles wide, like the state of Pennsylvania (for the record, there are no space objects the size of Pennsylvania in orbit). Unfortunately, this is the rule, not the exception, and almost all of these articles, movies, graphics, and simulations are **exaggerated and misleading**. Space debris and collision risk is real, but it **certainly** is **not a crisis.**

So what are the facts?

On the positive side, space is **empty** and it is **vast**. At the altitude of the International Space Station, **one half a degree** of Earth longitude is almost **40 miles long**. That same one half a degree at geostationary orbit, some 22,000 miles up is over 230 miles long. Generally, we don’t intentionally put satellites closer together than one-half degree. That means at geostationary orbit, they are no closer than 11 times as far as the eye can see on flat ground or on the sea: That’s the horizon over the horizon 10 times over. In addition, other than minute forces like solar winds and sparse bits of atmosphere that still exist 500 miles up, **nothing gets in the way of orbiting objects** and **they behave quite predictably**. The location of the smallest spacecraft can be predicated within a 1,000 feet, 24 hours in advance.

Since we first started placing objects into space there have been 11 known low Earth orbit collisions, and three known collisions at geostationary orbit. Think of it: 135 space shuttle flights, all of the Apollo, Gemini and Mercury flights, **hundreds** of telecommunications satellites, **1,300 functioning satellites** on orbit today, **half a million** total objects in space larger than a marble, and **fewer than 15 known collisions**. **Why** do people **worry?**

#### Early warning’s in GEO – no LEO escalation

Von Fange 17 [Daniel Von Fange is a full stack developer that builds web platforms and engineer, with a particular interest in space applications. Kessler Syndrome is Over Hyped. May 21, 2017. braino.org/essays/kessler\_syndrome\_is\_over\_hyped/]

GEO - If you put a satellite far enough out from earth, the speed that the satellite travels around the earth will match the speed of the surface of the earth rotating under it. From the ground, the satellite will appear to hang motionless. Usually the geostationary orbit is used by big weather satellites and big TV broadcasting satellites. (This apparent motionlessness is why satellite TV dishes can be mounted pointing in a fixed direction. You can find approximate south just by looking around at the dishes in your northern hemisphere neighborhood.) For Kessler purposes, GEO orbit is roughly a ring 384,400 km around. However, all the satellites here are moving the same direction at the same speed - debris doesn’t get free velocity from the speed of the satellites. Also, it’s quite expensive to get a satellite here, and so there aren’t many, only about one satellite per 1000km of the ring. Kessler is not a problem here.

#### Space commercialization is a strong constraint on conflict – solves space war

Wendy N. Whitman **Cobb 20**, is currently an associate professor of strategy and security studies at the US Air Force's School of Advanced Air and Space Studies, 7-21-2020, "Privatizing Peace: How Commerce Can Reduce Conflict in Space," Routledge & CRC Press, <https://www.routledge.com/Privatizing-Peace-How-Commerce-Can-Reduce-Conflict-in-Space/Cobb/p/book/9780367337834> // AAli

By the end of the twentieth century, scholars zeroed in on the democratic peace theory which attempts to explain why democracies do not go to war with other democracies and why, in some analyses, they seem to be more prone to peace in general than non-democracies. Similar to the golden arches, what is it about democracy that seems to induce such peacefulness? Academics have proposed everything from the nature of mediating institutions to the restraint of public opinion, to trade relations. While these variations will be explored further in Chapter 3, of interest here are the versions that focus explicitly on trade, commercial ties, and capitalism. Along these lines, Erik Gartzke argues, "peace ensues when states lack differences worthy of costly conflict."31 If the costs of conflict are too high, then states should be more unlikely to engage in it. To this end, economic globalization can provide the means through which costs are raised. “The integration of world markets not only facilitates commerce, but also creates new interests inimical to war. Financial interdependence ensures that damage inflicted on one economy travels through the global system, afflicting even aggressors."32 Focusing his analysis primarily on the influence of capitalism, Gartzke's findings suggest that states with markets more closely tied to the global economy are far less likely to experience a militarized dispute.

In thinking about the space environment today, there are obvious principles of capitalism at work. However, China, a major spacefaring state that has been making capitalist reforms, arguably remains far from a true capitalist country. This is especially true in their space industry which is heavily subsidized by the state and almost wholly integrated with China's military.34 Many other states continue to subsidize space activities heavily as well. A better approach through which to examine conflict in space is presented by an offshoot of the capitalist peace which is termed the commercial peace. The commercial peace thesis emphasizes the role of trade and the connections made through it to explain a lack of conflict. Han Dorussen and Hugh Ward write:

Trade is important not only because it creates an economic interest in peace but also because trade generates 'connections' between people that promote communication and understanding.... Based on these ideas, the flow of goods between countries creates a network of ties and communication links. If two countries are more embedded in this network, their relations should be more

peaceful 35

Given the interconnectedness of the global economy to space-based assets, a version of the commercial peace thesis can be used to argue that the chance of conflict in space is less than is commonly understood or recognized precisely because of the extent to which the global economy has become dependent on space-based assets.

To understand this argument, consider a scenario in which Russia, in preparation for a new assault on Eastern Europe, attacks a key US military satellite with the purpose of disrupting and disabling military communications in Europe. This action would conceivably enable the Russians to undertake their attack under more favorable conditions and prevent a quicker response from America and its allies. However, if the satellite was attacked via an ASAT that kinetically destroyed the US satellite, the debris cloud created from the attack could have disastrous consequences beyond military communications Much like the movie Gravity, the debris cloud could cause a chain reaction, hitting and ~~disabling~~ dismantling other satellites that would in turn disrupt civilian communications, business transactions, and perhaps even Russian military satellites. The economic effects of lost satellites would not be restricted to one country alone; the global economic consequences in terms of lost property (satellites), lost transactions, and financial havoc would echo throughout the world, including in Russia itself. Finally, the attack on one satellite could even ultimately endanger the ISS and its inhabitants, several of which are Russians. Destruction of the ISS would negate billions of dollars in investment from not just Russia, but other countries that have participated in it including Japan, Italy, and Canada. Therefore, an attack on a US military satellite would not just be an attack on one but an attack on all.

While the previous scenario highlights several reasons why it would not be in Russia's best interest to attack a US satellite, this book argues that the economic argument is both the strongest and the most restraining especially as space becomes more congested, competitive, contested, and commercialized. The emergence of private space companies enhances this argument. "In the commercial sector, companies need reliability and legal enforcement mechanisms if they are going to operate profitably in a shared environment."36 In order to foster the growing area of space commercialization, companies must be assured that the activities they undertake in space will be protected in some way or, at a minimum, allowed to proceed to the extent where they can reap the profit. This could be done through international organizations that would provide some sort of space traffic control, but the likelihood of a major international breakthrough on rules regarding space is unlikely in the near term. Therefore, actors must rely on the protections afforded them by an increasingly globalized economy that is ever more dependent on space-based assets.

#### 5. No Escalation

#### a) Military Precedent

Zarybnisky 18, Eric J. Celestial Deterrence: Deterring Aggression in the Global Commons of Space. Naval War College Newport United States, 2018. (Senior Materiel Leader at United States Air Force)//Elmer

PREVENTING AGGRESSION IN SPACE While deterrence and the Cold War are strongly linked in the public’s mind through the nuclear standoff between the United States and the Soviet Union, the fundamentals of deterrence date back millennia and deterrence remains relevant. Thucydides alludes to the concept of deterrence in his telling of the Peloponnesian War when he describes rivals seeking advantages, such as recruiting allies, to dissuade an adversary from starting or expanding a conflict.6F 6 Aggression in space was successfully avoided during the Cold War because both sides viewed an attack on military satellites as highly escalatory, and such an action would likely result in general nuclear war.7F 7 In today’s more nuanced world, attacking satellites, including military satellites, does not necessarily result in nuclear war. For instance, foreign countries have used highpowered lasers against American intelligence-gathering satellites8F 8 and the United States has been reluctant to respond, let alone retaliate with nuclear weapons. This shift in policy is a result of the broader use of gray zone operations, to which countries struggle to respond while limiting escalation. Beginning with the fundamentals of deterrence illuminates how it applies to prevention of aggression in space.

#### b) Deterrence

**Pavur and Martinovic 19** [James Pavur and Ivan Martinovic, May 2019, "The Cyber-ASAT: On the Impact of Cyber Weapons in Outer Space," ResearchGate, 11th International Conference on Cyber Conflict: Silent Battle [https://www.researchgate.net/publication/334422193\_The\_Cyber-ASAT\_On\_the\_Impact\_of\_Cyber\_Weapons\_in\_Outer\_Space accessed 12/10/21](https://www.researchgate.net/publication/334422193_The_Cyber-ASAT_On_the_Impact_of_Cyber_Weapons_in_Outer_Space%20accessed%2012/10/21)]Adam

A. Limited Accessibility

Space is difficult. Over 60 years have passed since the first Sputnik launch and only nine countries (ten including the EU) have orbital launch capabilities. Moreover, a launch programme alone does not guarantee the resources and precision required to operate a meaningful ASAT capability. Given this, one possible reason why space wars have not broken out is simply because only the US has ever had the ability to fight one [21, p. 402], [22, pp. 419–420].

Although launch technology may become cheaper and easier, it is unclear to what extent these advances will be distributed among presently non-spacefaring nations. Limited access to orbit necessarily reduces the scenarios which could plausibly escalate to ASAT usage. Only major conflicts between the handful of states with ‘space club’ membership could be considered possible flashpoints. Even then, the fragility of an attacker’s own space assets creates de-escalatory pressures due to the deterrent effect of retaliation. Since the earliest days of the space race, dominant powers have recognized this dynamic and demonstrated an inclination towards de-escalatory space strategies [23].

B. Attributable Norms

There also exists a long-standing normative framework favouring the peaceful use of space. The effectiveness of this regime, centred around the Outer Space Treaty (OST), is highly contentious and many have pointed out its serious legal and political shortcomings [24]–[26]. Nevertheless, this status quo framework has somehow supported over six decades of relative peace in orbit.

Over these six decades, norms have become deeply ingrained into the way states describe and perceive space weaponization. This de facto codification was dramatically demonstrated in 2005 when the US found itself on the short end of a 160-1 UN vote after opposing a non-binding resolution on space weaponization. Although states have occasionally pushed the boundaries of these norms, this has typically occurred through incremental legal re-interpretation rather than outright opposition [27]. Even the most notable incidents, such as the 2007-2008 US and Chinese ASAT demonstrations, were couched in rhetoric from both the norm violators and defenders, depicting space as a peaceful global commons [27, p. 56]. Altogether, this suggests that states perceive real costs to breaking this normative tradition and may even moderate their behaviours accordingly.

One further factor supporting this norms regime is the high degree of attributability surrounding ASAT weapons. For kinetic ASAT technology, plausible deniability and stealth are essentially impossible. The literally explosive act of launching a rocket cannot evade detection and, if used offensively, retaliation. This imposes high diplomatic costs on ASAT usage and testing, particularly during peacetime.

C. Environmental Interdependence

A third stabilizing force relates to the orbital debris consequences of ASATs. China’s 2007 ASAT demonstration was the largest debris-generating event in history, as the targeted satellite dissipated into thousands of dangerous debris particles [28, p. 4]. Since debris particles are indiscriminate and unpredictable, they often threaten the attacker’s own space assets [22, p. 420]. This is compounded by Kessler syndrome, a phenomenon whereby orbital debris ‘breeds’ as large pieces of debris collide and disintegrate. As space debris remains in orbit for hundreds of years, the cascade effect of an ASAT attack can constrain the attacker’s long-term use of space [29, pp. 295– 296]. Any state with kinetic ASAT capabilities will likely also operate satellites of its own, and they are necessarily exposed to this collateral damage threat. Space debris thus acts as a strong strategic deterrent to ASAT usage.

### Ozone

#### Nonunique—governments can still send satellites to space

#### Self-regulation/standards solves.

Jennifer **Friedberg, 13** - (" Bracing for the Impending Rocket Revolution," Colorado University, 2013, 1-6-2022https://www.colorado.edu/law/sites/default/files/Friedberg%2011713.pdf)//AW

High-tech industries often adopt voluntary standards rather than be vulnerable to legal action or constrained by governmental regulations they did not help develop. The possibility of legal action in an international court and over-regulation by governments often encourages industries to adopt voluntary standards and to self-regulate.170 Like the locomotive, automotive, and aviation industries, the commercial space industry is highly technical, has the potential to adversely affect the environment, and benefits from being perceived as safe by the public.171 Over the years, such high-tech transportation industries have tended to self-regulate to avoid “command and control” measures from state governments and, conversely, to encourage those governments to adopt the guidelines suggested by the industry.172 Although the word “standards” often refers to technical specifications, it can also refer to an allowable emissions threshold, like in the aviation and automotive industries. Technical standards can be tied to environmental standards; standardized catalytic converters all remove the same amount of toxins from car exhausts. By adopting standards and producing consistent results, high-tech transportation industries can build public trust in certain companies and trade associations. “[W]here reliance on a particular standard or seal is significant, noncompliance becomes so competitively disadvantageous from the point of view of producers that voluntary standards become mandatory.”173 Under the threat of legal liability or government over-regulation, high-tech industries often self-regulate.174

#### Continued private space development and megaconstellations are the only way to solve the ozone layer – empirics prove. Autry 19:

Greg Autry {the director of the Southern California Commercial Spaceflight Initiative at the University of Southern California, vice president at the National Space Society, and chair of the International Space Development Conference, }, 19 - ("Space Research Can Save the Planet—Again," Foreign Policy, 7-20-2019, <https://foreignpolicy.com/2019/07/20/space-research-can-save-the-planet-again-climate-change-environment/)//marlborough-wr/>

Today conservationists and other critics are more likely to see space programs as militaristic splurges that squander billions of dollars better applied to solving problems on Earth. These well-meaning complaints are misguided, however. Earth’s problems—most urgently, climate change—can be solved only from space. That’s where the tools and data already being used to tackle these issues were forged and where the solutions of the future will be too. Space research has already been critical in averting one major environmental disaster. It was NASA satellite data that revealed a frightening and growing hole in the ozone layer over the South Pole, galvanizing public concern that, in 1987, produced the Montreal Protocol: the first international agreement addressing a global environmental problem. Since then, thanks to worldwide restrictions on damaging chlorofluorocarbons, the ozone situation has stabilized, and a full planetary recovery is expected. As this case showed, space can provide the vital information needed to understand a problem—and a surprising range of ways to solve it. Climate change is a poster child for the critical role of space data. Trekking across the globe to measure ice sheets with drills and gauge sea temperatures from the sides of ships is an expensive, slow, and insufficient way to assay the state of the planet. Satellites operated by NASA, the U.S. National Oceanic and Atmospheric Administration, and an increasing number of commercial firms provide a plethora of multispectral imaging and radar measurements of developments such as coral reef degradation, harmful plankton blooms, and polar bears negotiating thinning ice. Much of the technology involved in observing the Earth today was initially developed for probes sent to explore other planets in our solar system. Indeed, understanding the evolution of other planets’ climates is essential for modeling possible outcomes on Earth. NASA probes revealed how, roughly 4 billion years ago, a runaway greenhouse gas syndrome turned Venus into a hot, hellish, and uninhabitable planet of acid rain. Orbiters, landers, and rovers continue to unravel the processes that transformed a once warm and wet Mars into a frigid, dry dust ball—and scientists even to conceive of future scenarios that might terraform it back into a livable planet. Discovering other worlds’ history and imagining their future offers important visions for climate change mitigation strategies on Earth, such as mining helium from the moon itself for future clean energy. Spinoff technologies from space research, from GPS to semiconductor solar cells, are already helping to reduce emissions; the efficiency gains of GPS-guided navigation shrink fuel expenditures on sea, land, and air by between 15 and 21 percent—a greater reduction than better engines or fuel changes have so far provided. Modern solar photovoltaic power also owes its existence to space. The first real customer for solar energy was the U.S. space program; applications such as the giant solar wings that power the International Space Station have continually driven improvements in solar cell performance, and NASA first demonstrated the value of the sun for powering communities on Earth by using solar in its own facilities. Promisingly, space-based solar power stations could overcome the inconvenient truth that wind and solar will never get us anywhere near zero emissions because their output is inherently intermittent and there is, so far, no environmentally acceptable way to store their power at a global scale, even for one night. Orbital solar power stations, on the other hand, would continually face the sun, beaming clean power back through targeted radiation to Earth day or night, regardless of weather. They would also be free from clouds and atmospheric interference and therefore operate with many times the efficiency of current solar technology. Moving solar power generation away from Earth—already possible but held back by the current steep costs of lifting the materials into space—would preserve land and cultural resources from the blight of huge panel farms and save landfills from the growing problem of discarded old solar panels. Sustainable energy advocates in the U.S. military and the Chinese government are actively pursuing space-based solar power, but just making solar cells damages the environment due to the caustic chemicals employed. Space technology offers the possibility of freeing the Earth’s fragile biosphere and culturally important sites from the otherwise unavoidable damage caused by manufacturing and mining. The U.S. start-up Made in Space is currently taking the first steps toward manufacturing in orbit. The company’s fiber-optic cable, produced by machinery on the International Space Station, is orders of magnitude more efficient than anything made on Earth, where the heavy gravity creates tiny flaws in the material. Made in Space and others are eventually planning to build large structures, such as solar power stations, in space. As these technologies develop, they will augment each other, bringing costs down dramatically; space manufacturing, for instance, slashes the cost of solar installations in space. Eventually, firms will be able to supply endeavors in space with materials from the moon and asteroids, avoiding the cost and environmental impact of lifting them into orbit. Mining the solar system comes with its own potential impacts, but extracting resources from distant and lifeless worlds is clearly preferable to the continued degradation of the Earth.