# 1AC

#### I affirm resolved: the appropriation of outer space by private entities is unjust.

## Advantage 1 is Debris

#### Kessler syndrome is REAL and coming soon – space is unusable in practice long before it fully takes hold.

Kelvey 22 (Kelvey, Jon. “Kessler Syndrome: How Runaway Space Junk Could Trap Humans on Earth.” Inverse, Inverse, 3 Jan. 2022, https://www.inverse.com/science/what-is-kessler-syndrome. [Jon Kelvey is a science writer covering space, aerospace, and biosciences. His work has appeared in publications such as Air & Space Magazine, Earth and Space News, Slate, and Smithsonian in addition to Inverse. Kelvey studied cognitive neuroscience at UC Berkeley and prior to a career in journalism worked in the California wine industry, in construction as an electrician, and as a motel housekeeper.])//LK [Accessed 1/27/22]

When you’re screaming through the void faster than a speeding bullet, any traffic you encounter might as well be made of, well, speeding bullets. Defensive driving is recommended. Hazardous space debris has twice threatened the International Space Station recently. On or around November 12, a debris field generated by a Russian military anti-satellite missile, or ASAT test, sent ISS crew members — including Russian cosmonauts — to shelter in the station’s Dragon and Soyuz spacecraft in case they needed to evacuate, while on December 2, the station maneuvered around a chunk of a defunct American Pegasus rocket. No one was hurt in either case, and the risks were hardly novel — the ISS has maneuvered around space debris more than 30 times since 1999. But it’s also a problem that’s almost guaranteed to worsen given worrying trends in the militarization of space and the fact that all signs point to ever more objects being launched into space every year. Take into consideration mega-constellations like SpaceX’s Starlink, for which “the plan is to launch 100,000 active satellites in the next few years,” Jonathan McDowell, a Harvard astrophysicist who has been tracking satellites on the side for more than a decade, tells Inverse. “The collision rate grows as the square of the number of satellites. If you have 10 times as many satellites, you will have 100 times as many collisions.” And the thing is, space debris is not simply the detritus of old space missions. A satellite stricken by orbital debris becomes debris itself, which can then hit another satellite, creating debris that can strike another, and so on. It’s a chain reaction known as Kessler Syndrome, and while it doesn’t take place in the half-hour time frame as dramatized in the movie Gravity, the result may be the same: no more outer space for anybody. “At least some models suggest that, yeah, it's already underway,” McDowell says, “it's just going to take a century to play out.” Space Junk basics It’s a good thing the sky is so big, because humans have flung a lot of things up there. And every bit of it, from large spacecraft to tiny pieces of cloth, are careening around at 17,500 miles-per-hour or faster. At those speeds, even collisions between somewhat small objects can be catastrophic. “The unit I like to use is a megajoule, which is the kinetic energy of a one-ton truck hitting you at 100 miles an hour,” McDowell says. Collisions between small satellites can generate tens of thousands of megajoules of kinetic energy, while even tiny pieces of debris still pack enough of a punch to drill bullet holes in the ISS and other space assets. The Hubble Space Telescope carries a Whipple shield, for instance, a sort of bulletproof vest to absorb the energy of more minor debris impacts. hubble micrometeroid shield The radiator shield from Hubble’s Wide Field Planetary Camera II, as seen at the National Air and Space Museum. Each hole is where NASA drilled to find debris fragments. John Wenz It’s an imperfect solution, “smaller” being relative and “big” being game over. “If you get hit by a big enough piece of debris, [a Whipple shield] is not gonna be enough,” McDowell says. “And if something comes down the telescope aperture and hits the Hubble mirror, that’s also not good.” The good news is that organizations that track debris, such as the US Space Command, have a pretty good handle on the big stuff in orbit — anything from multi-ton dead satellites to debris 10 centimeters across. “The trackable debris we follow as individual objects, and we’re tracking about 40,000 objects, of which 5,000 or so are working satellites and the rest is junk,” McDowell says. “If you look at stuff down to just one centimeter, there’s probably a million of those. But we don’t really know because they’re too small.” There are two main sources of space debris at the moment, the primary being old rocket stages still in orbit decades after the delivery of their payload. “The fuel and the oxidizer get together because the seals fail,” McDowell says, “And they go bang.” The secondary source is military anti-satellite tests, he says, which generate debris clouds that can persist for decades. But if a Kessler Syndrome cascade is already underway, and continues apace unmitigated, eventually the most significant source of space debris will be the pulverized remains of satellites, spacecraft, and space stations dashed upon rocks of our own making. A history of space junking and space punking Putting aside the occasional meteor shower, space debris is an entirely human creation — satellites don’t launch themselves. But not all space debris is created equally. Many objects are merely byproducts of early space exploration, while the birth of others was more intentional. For example, while Russia has drawn international criticism for its ASAT test in November, in the early 1960s, it was the Soviet Union who accused the United States of purposefully polluting the spaceways. Between 1961 and 1963, the United States launched almost half a billion copper needles into low-Earth orbit, Caltech historian of technology Lisa Ruth Rand tells Inverse. Called Project West Ford, it was an attempt to create an artificial ionosphere for long-range radio communications in case a US-USSR nuclear war disrupted other means. The Soviets were not amused, and accused the US of “trying to destroy all space so that no one else could use it, out of spite,” Rand says. Both the Soviet Union and the United States developed and tested anti-satellite missile technologies in the 1970s and 80s, creating orbital debris and leading to a lull in ASAT tests until 2007, when China used an ASAT to destroy an old weather satellite. The US used an ASAT missile to destroy a spy satellite that failed after its launch in 2008, and India launched a small satellite in January of 2019 only to shoot it down with an ASAT in March 2019. The next and most recent ASAT test to actually destroy a satellite in space was the Russian test in November, and all four of the tests created debris, some of which will remain in orbit for years to come. “Most of the debris from the Russian ASAT will be down on a timescale of like five years, and the rest of it will be down on the timescale of 10 to 20 years, which, it’s still not good,” McDowell says. “For the Chinese ASAT, which was up at a higher altitude, more like 900 kilometers, some of that debris is likely going to be up there for many decades.” Such intentional creation of space debris seems irrational and irresponsible given how problematic incidental space debris already is. A 2009 collision between an Iridium communications satellite and a defunct Russian satellite over Siberia first turned Rand on to studying space debris as a research focus while in grad school, and for every impact, there are many more close calls. In 2012, for instance, a defunct Soviet Kosmos satellite threatened the Fermi Gamma-ray Space Telescope and presented its operators with a tough decision, Rand says. “Either light up thrusters that had been dormant for years, that were cold and could blow the whole works,” or hope the debris would pass further from Fermi than projected, such predictions always coming as probabilities rather than certainties. She says that the operators ultimately opted to risk using the thrusters, and the space telescope moved, and all was fine, but it was still a risky situation. And such situations are not always improved when all satellites involved are still live and operational. In September 2019, Rand says, a Starlink satellite and an ESA satellite almost collided when operators at SpaceX failed to check their email and missed some urgent missives from their counterparts at ESA. And over the summer of 2021, McDowell recently tweeted, the Chinese space station twice dodged Starlink satellites that may have passed within 1 kilometer of the station. “These are the kinds of close calls are happening a lot and increasingly more as the number of objects in outer space increases,” Rand says. “The number of functioning satellites in space is just exploding. It’s huge. It’s getting bigger and bigger every day.” What is Kessler Syndrome and why does it matter? In some ways, the Kessler Syndrome is like a slow-moving zombie apocalypse. (In George Romero’s classic Night of the Living Dead, Rand notes, it’s theorized a contaminated satellite returning from Venus triggers the zombie rise.) The space debris chain reaction converts otherwise operational space assets into further navigational hazards. “It’s an unwanted weaponizing of a valuable object into something that becomes dangerous,” Rand says. Had the Fermi telescope thrusters failed, “that would have been the loss of a major scientific instrument and cultural heritage artifact that had become a series of projectiles.” And the threat of losing space assets means the Kessler Syndrome has a costly impact long before the chain reaction has progressed enough to prevent access to space. More satellites in space mean more potential collisions, which means more satellites — and space stations — making more frequent evasive maneuvers to avoid further collisions, all of which can interrupt operations and cost operators money by decreasing the lifespan of their satellites. Every Starlink satellite has a limited amount of krypton propellant onboard for maneuvering around debris and Chinese space stations, for instance, and when the tank is near empty, it’s time for that satellite’s long fiery goodbye bow in the upper atmosphere — failure to do so just increases the problem by adding another dead satellite. “Space is big,” Rand says, “but once things start to collide, it becomes rapidly small.” Rapidly, but not linearly. Unfortunately, if the Kessler cascade is already underway, it will take years to reach a point where it’s happening in what humans perceive as “real-time.” By then, it may be too late. “On a timescale of decades, you’ll have to dodge more and more often, and eventually you won’t be able to dodge anymore because the traffic is so bad,” McDowell says. Adding the caveat that it’s just his back-of-the-envelope math, he says, “we are probably exceeding the carrying capacity of low Earth orbit right now.” The consequence of full bore Kessler syndrome allowed to run its course would be to negate the sci-fi ambitions of people like Elon Musk. To proscribe humans from the cosmos and limit our future to that of a one-planet species for many lifetimes — physically and intellectually. The space debris could ruin ground-based astronomy, too, hemming in our minds as well as our rockets. “It would mean to basically close ourselves off from the rest of the cosmos,” Rand says. “That the endgame of the space age is not so much humanity becoming cosmopolitan, becoming multi-planetary, becoming part of the universe, but instead making it so that we just can’t leave anymore.” What can we do about space debris? There is some good news when it comes to space debris, beginning with the fact that there are some natural processes that help to clear the space lanes of the dead and dying detritus of human space fairing. The Sun goes through an 11-year cycle of solar storms that, at its peak, makes the Earth’s atmosphere a little denser, generating more drag on any objects orbiting in lower orbits. “So there’s sort of a cleaning cycle every 11 years of the lower atmosphere, the lower part of [low-Earth orbit] goes through,” McDowell says. “But in the upper part of [low-Earth orbit] that change is not enough to make a difference, and the stuff keeps orbiting.” On average, objects orbiting around 200 kilometers altitude will re-enter Earth’s atmosphere within a week or two without active boosting, he says. In comparison, objects orbiting at around 400 kilometers will re-enter within a year or two. By 550 kilometers altitude, things take 25 years or more to re-enter the atmosphere, McDowell says, and “above about 600 kilometers, because the air density falls off so quickly, stuff up there will stay up for centuries, for millennia.” These physical realities of orbiting objects considered, there are two major paths to dealing with space debris, and we have to walk both of them. First, we need to safely rid space of the most problematic pieces of space debris. Second, we need to stop making more of it. As to the first, the technical challenges are not as awesome as you might assume, once you accept that you’ll never clear space of all small debris and focus only on the worst offenders. “The leading term in growing the Kessler cascade is the big things hitting each other because they create so much extra debris,” McDowell says. Get rid of the 100 biggest objects — late dead satellites, old rocket stages — and it would reduce the rate at which the runaway is happening. But it’s not yet clear who will do such work, who will pay for it, and if it’s even legal. Unlike ocean salvage, where the Law of the Sea allows third parties to extract resources from abandoned ships or wrecks, spacefaring nations retain responsibility and authority over all objects they have placed in space under the Outer Space Treaty of 1967. “If you want to remove an old Soviet abandoned rocket stage, without causing an international incident, you have to get Russia’s permission,” McDowell says. Since the technology you would use to remove an old satellite could be used to take out a new one, “it’s a bit of a sensitive issue.” So removal of old space debris may require a lot of international negotiation and new agreements, which is just as well, given the same is necessary to tamp down on the addition of new space debris. The United Nations may soon discuss new proposals to ban the test or use of ASAT weapons, and the proposal may have more lift under its wings given the wind condemnation of Russia’s missile test in November. “The bright side is that we are starting to restart discussions about what are the right rules of the road in space,” McDowell says. “Maybe if people get alarmed enough that something will actually be done.”

#### 2 internal links:

#### 1] 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.

#### Starlink is responsible for HALF of all dangerous space near-collisions – full megaconstellation can make collisions ten times more likely and debris avoidance software doesn’t check

Pultarova, 8/18/2021 – journalist, quoting Europe’s leading space debris expert

Tereza is a London-based science and technology journalist, aspiring fiction writer and amateur gymnast. Originally from Prague, the Czech Republic, she spent the first seven years of her career working as a reporter, script-writer and presenter for various TV programmes of the Czech Public Service Television. She later took a career break to pursue further education and added a Master's in Science from the International Space University, France, to her Bachelor's in Journalism and Master's in Cultural Anthropology from Prague's Charles University. She worked as a reporter at the Engineering and Technology magazine, freelanced for a range of publications including Live Science, Space.com, Professional Engineering, Via Satellite and Space News and served as a maternity cover science editor at the European Space Agency. “SpaceX Starlink satellites responsible for over half of close encounters in orbit, scientist says”, August 18, 2021, <https://www.space.com/spacex-starlink-satellite-collision-alerts-on-the-rise>, accessed 12/1/21, sb

Operators of satellite constellations are constantly forced to move their satellites because of encounters with other spacecraft and pieces of space junk. And, thanks to SpaceX's Starlink satellites, the number of such dangerous approaches will continue to grow, according to estimates based on available data. SpaceX's Starlink satellites alone are involved in about 1,600 close encounters between two spacecraft every week, that's about 50 % of all such incidents, according to Hugh Lewis, the head of the Astronautics Research Group at the University of Southampton, U.K. These encounters include situations when two spacecraft pass within a distance of 0.6 miles (1 kilometer) from each other. Lewis, Europe's leading expert on space debris, makes regular estimates of the situation in orbit based on data from the Socrates (Satellite Orbital Conjunction Reports Assessing Threatening Encounters in Space ) database. This tool, managed by Celestrack, provides information about satellite orbits and models their trajectories into the future to assess collision risk. Lewis publishes regular updates on Twitter and has seen a worrying trend in the data that reflects the fast deployment of the Starlink constellation. "I have looked at the data going back to May 2019 when Starlink was first launched to understand the burden of these megaconstellations," Lewis told Space.com. "Since then, the number of encounters picked up by the Socrates database has more than doubled and now we are in a situation where Starlink accounts for half of all encounters." The current 1,600 close passes include those between two Starlink satellites. Excluding these encounters, Starlink satellites approach other operators’ spacecraft 500 times every week. In comparison, Starlink's competitor OneWeb, currently flying over 250 satellites, is involved in 80 close passes with other operators' satellites every week, according to Lewis' data. And the situation is bound to get worse. Only 1,700 satellites of an expected constellation of tens of thousands have been placed into orbit so far. Once SpaceX launches all 12,000 satellites of its first generation constellation, Starlink satellites will be involved in 90% of all close approaches, Lewis’ calculations suggest. The risk of collision Siemak Hesar, CEO and co-founder of Boulder, Colorado, based Kayhan Space, confirms the trend. His company, which develops a commercial autonomous space traffic management system, estimates that on average, an operator managing about 50 satellites will receive up to 300 official conjunction alerts a week. These alerts include encounters with other satellites as well as pieces of debris. Out of these 300 alerts, up to ten might require operators to perform avoidance maneuvers, Hesar told Space.com. Kayhan Space bases their estimates on data provided by the U.S. Space Surveillance Network. This network of radars and telescopes, managed by the U.S. Space Force, closely monitors about 30,000 live and defunct satellites and pieces of debris down to the size of 4 inches (10 centimeters) and provides the most accurate location data of the orbiting objects. The size of this catalog is expected to increase ten times in the near future, Hesar added, partly due to the growth of megaconstellations, such as Starlink, and partly as sensors improve and enable detection of even smaller objects. The more objects in the catalog mean more dangerously close encounters. "This problem is really getting out of control," Hesar said. "The processes that are currently in place are very manual, not scalable, and there is not enough information sharing between parties that might be affected if a collision happens." Hesar compared the problem to driving on a highway and not knowing that there has been an accident a few miles ahead of you. If two spacecraft collide in orbit, the cloud of debris the crash generates would threaten other satellites travelling through the same area. "You want to have that situational awareness for the other actors that are flying in the neighbourhood," Hesar said. Bad decisions Despite the concerns, only three confirmed orbital collisions have happened so far. Earlier this week, astrophysicist and satellite tracker Jonathan McDowell, who's based at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, found evidence in Space-Track data that the Chinese meteorological satellite Yunhai 1-02, which disintegrated in March this year, was actually hit by a piece of space debris. The worst known space collision in history took place in February 2009 when the U.S. telecommunication satellite Iridium 33 and Russia's defunct military satellite Kosmos-2251 crashed at the altitude of 490 miles (789 kilometres). The incident spawned over 1,000 pieces of debris larger than 4 inches (10 cm). Many of these fragments were then involved in further orbital incidents. Lewis is concerned that with the number of close passes growing, the risk of operators at some point making a wrong decision will grow as well. Avoidance maneuvers cost fuel, time and effort. Operators, therefore, always carefully evaluate such risks. A decision not to make an avoidance maneuver following an alert, such as that made by Iridium in 2009, could, however, clutter the orbital environment for years and decades. "In a situation when you are receiving alerts on a daily basis, you can't maneuver for everything," Lewis said. "The maneuvers use propellant, the satellite cannot provide service. So there must be some threshold. But that means you are accepting a certain amount of risk. The problem is that at some point, you are likely to make a wrong decision." Hesar said that uncertainties in the positions of satellites and pieces of debris are still considerable. In case of operational satellites, the error could be up to 330 feet (100 meters) large. When it comes to a piece of debris, the uncertainty about its exact position might be in the order of a mile or more. "This object can be anywhere in this bubble of multiple kilometres," Hesar said. "At this point, and for the foreseeable future, avoidance is our best recourse. People that say 'I'm going to take the risk', in my humble opinion, that's an irresponsible thing to do." Starlink monopoly Lewis is concerned about the growing influence of a single actor — Starlink — on the safety of orbital operations. Especially, he says, as the spaceflight company has entered the satellite operations world only recently. "We place trust in a single company, to do the right thing," Lewis said. "We are in a situation where most of the maneuvers we see will involve Starlink. They were a launch provider before, now they are the world's biggest satellite operator, but they have only been doing that for two years so there is a certain amount of inexperience." SpaceX relies on an autonomous collision avoidance system to keep its fleet away from other spacecraft. That, however, could sometimes introduce further problems. The automatic orbital adjustments change the forecasted trajectory and therefore make collision predictions more complicated, according to Lewis. "Starlink doesn't publicize all the maneuvers that they're making, but it is believed that they are making a lot of small corrections and adjustments all the time," Lewis said. "But that causes problems for everybody else because no one knows where the satellite is going to be and what it is going to do in the next few days."

#### 2] Mining – masses of dust, sublimation, and other causes

Boley and Byers 20 (Arron, Department of Physics and Astronomy, University of British Columbia; Michael, Department of Political Science, University of British Columbia) U.S. policy puts the safe development of space at risk, SCIENCE, 9 Oct 2020, Vol 370, Issue 6513, pp. 174-175 <https://www.science.org/doi/full/10.1126/science.abd3402> EE

Mining can generate serious operational concerns. Lunar dust is a known challenge to operations on the Moon. Any surface activity could exacerbate lunar dust migration, including by lofting dust onto trajectories that cross lunar orbits, such as that of NASA's proposed Lunar Gateway (11). Moreover, without cooperation by all actors, the limited number of useful lunar orbits could quickly become filled with space debris.

On asteroids, low escape speeds will make it difficult to prevent the loss of surface material. Even if full enclosures are used, waste material may be purposefully jettisoned. Mining could also lead to uncontrolled outbursts of volatile sublimation after the removal of surface layers. Because the asteroids targeted for mining are likely to be those with small minimum orbit intersection distances, the resulting meteoroid debris streams could threaten lunar operations as well as satellites in Earth's orbit (12). In a worst-case scenario, a trajectory change resulting from mining could eventually lead to an Earth-impact emergency.

Space missions already provide some evidence of these risks. In 2019, during the course of Japan's Hayabusa2 mission, a small impactor was used to make a crater on (162173) Ryugu (13). Some of the resulting anthropogenic meteoroids could begin reaching Earth during the 2033 apparition. In 2022, NASA will test its ability to deflect an asteroid by striking (65803) Didymos B (Dimorphos) with the Double Asteroid Redirection Test spacecraft. This impact will produce anthropogenic meteoroids, with the possibility of immediate delivery to Earth (14). Although these risks are small, they demonstrate how easily human actions can change the near-Earth environment.

#### 2 impacts

#### 1] Access to LEOs through research satellites are uniquely key to fight climate change – monitoring, enforcement, and mitigation all require Satellite tech

Bender and Custodio 21 (Bender, Bryan, and Jonathan Custodio. “'It Is a Game Changer': Waging War on Climate Change from Space.” POLITICO, POLITICO, 4 Nov. 2021, [https://www.politico.com/news/2021/10/31/climate-change-space-satellites-517773. [Bryan Bender is a senior national correspondent for POLITICO, where he focuses on the Pentagon, NASA, and the defense and aerospace industries. He was previously the national security reporter for the Boston Globe, where he covered U.S. military operations in the Middle East, Asia, Latin America, and the Balkans. He also writes about terrorism and government secrecy. He is an adjunct professor at the Walter Cronkite School of Journalism at Arizona State University and the author of “You Are Not Forgotten,“ the story of an Iraq War veteran’s search for a missing World War II fighter pilot in the South Pacific. Jonathan Custodio is a POLITICO fellow currently reporting for the energy team. Past POLITICO experience includes a three-month rotation on World and National Security and an internship in the New York office, where he contributed regularly to New York Playbook and the New York Real Estate newsletter and covered city campaigns.])//LK](https://www.politico.com/news/2021/10/31/climate-change-space-satellites-517773.%20%5bBryan%20Bender%20is%20a%20senior%20national%20correspondent%20for%20POLITICO,%20where%20he%20focuses%20on%20the%20Pentagon,%20NASA,%20and%20the%20defense%20and%20aerospace%20industries.%20He%20was%20previously%20the%20national%20security%20reporter%20for%20the%20Boston%20Globe,%20where%20he%20covered%20U.S.%20military%20operations%20in%20the%20Middle%20East,%20Asia,%20Latin%20America,%20and%20the%20Balkans.%20He%20also%20writes%20about%20terrorism%20and%20government%20secrecy.%20He%20is%20an%20adjunct%20professor%20at%20the%20Walter%20Cronkite%20School%20of%20Journalism%20at%20Arizona%20State%20University%20and%20the%20author%20of%20) [Accessed 1/27/22]

The battle against climate change — and to mitigate some of its most deadly effects — is increasingly being waged from space. Satellites are measuring the rate of icebergs calving into the Arctic Ocean and outbreaks of phytoplankton from rising water temperatures and pollution. Soon, they will be used to “persistently pinpoint” the amount of methane and carbon dioxide spewing from factories and power plants most responsible for supercharging the planet. As President Joe Biden and other world leaders gather in Scotland this week for the United Nations’ annual climate change conference, the new space age has armed them with some of the best tools yet to diagnose climate change and gauge whether their policies to reverse it are working. “Satellites were absolutely key in understanding we had a climate crisis,” said Krystal Azelton, director of space applications programs at the Secure World Foundation, a nonprofit Washington, D.C., think tank. “We are seeing vast improvements … in data sharing and access” and “the push to have open access to government data around the world is huge.” The surge in new constellations of optical and radar satellites are also now making it possible to limit some of the damage of climate change — by predicting the trajectories of forest fires, measuring soil saturation to reduce flooding and detecting radio signals in remote regions to uncover illicit deforestation or mining. An aerial photograph shows flooding in Kentucky. Satellite images were used to help measure the extent of flooding in Stanton, Kentucky, last spring. | Courtesy of Planet An aerial photograph shows flooding in Kentucky. Satellite images were used to help measure the extent of flooding in Stanton, Kentucky, last spring. | Courtesy of Planet A top priority Biden, who arrives Monday in Glasgow, has made greater reliance on space technologies a major pillar of his ambitious agenda to tackle the climate crisis. One new effort is NASA’s Earth System Observatory program to “create a 3D, holistic view of Earth, from bedrock to atmosphere.” Biden’s first annual budget request for NASA also sought $24.8 billion, including a $2.25 billion for the Earth Science Division, a 12.5 percent boost. And he requested $6.98 billion, or a 22 percent increase, for the National Oceanic and Atmospheric Administration, which operates an extensive constellation of weather satellites. That includes a proposed 25 percent increase for NOAA’s National Environmental Satellite, Data, and Information Service. Biden’s budget proposals have been moving slowly through Congress since they were introduced in May. The NASA budget proposal has been approved by the House Science subcommittee and Senate appropriators, with increases of $240 million and $35.8 million, respectively. NOAA would get nearly $6.3 billion under the Senate appropriations bill and the House Appropriations committee approved a $6.46 billion budget. Rep. Eddie Bernice Johnson (D-Texas), chair of the House Science Committee, backed strong investments in space and Earth observation, while leaving the door open for federal government and private sector collaboration. “The challenge of the climate crisis certainly requires that we examine every opportunity to leverage capabilities and build or enhance partnerships across the government and private sectors,” Johnson said. “One area we are continuing to consider is how to ensure open public access for any commercially provided data by our federal science agencies.” Meanwhile, the National Space Council, the Cabinet-level body headed by Vice President Kamala Harris, has also made improving “our indications and warning of climate change” a priority for the nation’s space agenda. Using satellites to understand changes in the environment is not new; NASA’s first effort to gather facts about natural resources from orbit, as opposed to measuring the weather in the atmosphere, was the launch of the first Landsat satellite in 1972. Now, there are a variety of space-based means available on the commercial market to do it with far more accuracy and frequency. A climate census From September 2011 to August 2020, the number of commercial satellites designed to capture high-resolution images or detect heat or other invisible signatures jumped from 10 to 338, according to the Union of Concerned Scientists, which updates its list several times a year. POLITICO used the final update of each year for the tally. In the most recent update released in May, there were 450 commercial satellites used for earth observation. “The only way to really get a global view is from satellites,” said Walter Scott, chief technology officer at space technology company Maxar Technologies. “You need to be able to make observations over a longer period of time, to be able to see trends that are in fact climate as opposed to local variations in weather.” The tools now available, however, are akin to being able to analyze census data by neighborhood instead of just at the regional or national levels. One class of targets is what climate scientists call “heat islands,” or urbanized areas that experience higher temperatures than outlying areas, which can be better analyzed with higher resolution imaging. “There are things that are happening on very small scales, urban scales,” said Vernon Morris, an atmospheric and climate scientist at Arizona State University. “The ability to gather this granularity of data, so often, is probably the biggest difference,” agreed Matt Tirman, head of Satellogic North America, a division of the Argentine company founded in 2010 that operates a constellation of satellites that can also capture live-motion video. “I do think it is a game changer,” added Morris. An aerial photograph of a glacier in Alaska is shown. Satellite images show changes over time in the Columbia Glacier in Alaska. | Courtesy of Planet An aerial photograph of a glacier in Alaska is shown. Satellite images show changes over time in the Columbia Glacier in Alaska. | Courtesy of Planet Planet, an Earth observation company founded in 2010, recently partnered with NASA’s Jet Propulsion Lab, the state of California and a group of nonprofits to create the Carbon Mapper, which will use its satellites to scan the globe daily for emissions of damaging substances like methane — an invisible, odorless and powerful greenhouse gas. “It will be able to see that it's that building, and that oil pad, and that landfill that are responsible for methane leaks,” said Andrew Zolli, Planet’s chief impact officer. “This is the incredibly sensitive — what we call point source emissions detector.” Another similar effort is Climate TRACE, a collection of scientific institutions that is using Earth observation data to monitor coal-fired power plants. “They are looking at the coal plant and the coal that is flowing through the plant to determine if it is operating,” Zolli said. Another new set of tools is radar satellites that can monitor environmental changes in the Arctic or mountainous regions that are often obscured by clouds and darkness, major limitations for optical satellites. An aerial image shows a rockslide in New Zealand. A large rockslide on Mount Silberhorn in New Zealand is tracked from space. | Courtesy of Planet For instance, ICEYE, a Finnish company founded in 2014, is monitoring floating ice in the Nares Strait near Greenland and the Thwaites Glacier in Antarctica. The new tools are “of great importance especially for small-scale glacier monitoring,” said Eric Jensen, president of ICEYE US, its American subsidiary, Satellites outfitted with synthetic aperture and hyperspectral radars, meanwhile, have “an influence on our ability to better understand wildfires and what causes them and how they can be addressed,” said Azelton. Minimizing the damage Indeed, the growth of satellite imagery and data is providing new means to head off some of the more calamitous effects of climate change. “The ability to observe, which can ultimately lead to the ability to predict, is really what prepares us for hazards and helps us mitigate the disasters that they can lead to,” said Karen St. Germain, director of NASA’s Earth Science division. She noted that satellites can examine the trajectory of forest fires in real time and identify burn scars that cause landslides. “Vegetation is what holds the soil together,” she explained. “So, if the area’s burned and then the precipitation comes, that's when you can get landslides and cascading effects.” ICEYE’s radar satellites can also be used to quickly identify downed or damaged power lines, responsible for starting thousands of forest fires, so that crews can respond before it’s too late. Satellites are also assisting in the aftermath of climate-related natural disasters. Maxar aided several nongovernmental organizations in identifying safe sources of drinking water, accessible transportation routes, and even potentially trapped families after a destructive 2018 earthquake in Indonesia. An aerial photograph shows the Dixie Fire in California. California’s Dixie forest fire earlier this year burned across five counties and grew into the single largest forest fire in the state’s history. | Courtesy of Planet The satellite data of Spire Global, which describes itself as a “space-to-cloud data and analytics company,” boosted the accuracy of climate models and predicted a wildfire south of Lake Tahoe in Northern California 45 days before the inferno. It also forecast where winds would drive the flames. New satellites and sensors are also being used to track human activity that might be taking advantage of environmental calamity. One example is in the Arctic, where melting ice has led to a steady rise in commercial and military activity, particularly in the summer months. “It's really opened up that whole region,” said Adam Bennett, a senior director at HawkEye 360, which operates satellites that can detect radio frequency signals. “People don’t always know what's happening up there. So we did some sweeps and it was interesting to see here how we detected all kinds of additional RF activity in some cases in places we never would have expected.” “We were detecting things even all over the sea ice,” he added. “You know different concentrations of VHF communication. We saw a lot of additional maritime activity. You could even see vessels taking these pathways around the sea ice. You would not even know they were there.” Detections can also be made in real-time when responding to major disasters. Satellites from Maxar, NOAA and the Bureau of Ocean Energy Management were used to map the early October oil spill off California’s Pacific coast. A containment boom blocks oil-contaminated water. In an aerial view, a containment boom blocks oil-contaminated water in the area of the Talbert Marsh wetlands after a 126,000-gallon oil spill from an offshore oil platform on Oct. 4 in Huntington Beach, California. | Mario Tama/Getty Images Unleashing the potential There are, of course, limitations to space-based technology, most notably in ocean environments. Satellites can capture sea surface temperatures and measure coral reefs — and they can even gauge the thickness of the oil on the surface of the water to direct cleanup crews after a spill. But they can only see a few meters deep. According to NOAA’s National Ocean Service, more than 80 percent of the world’s oceans remain unmapped, unobserved and unexplored. “That's why we need to rely on ocean technologies and ocean exploration, and a lot of the marine sensor technologies that are coming online, to understand what's going on in the deeper ocean, both in terms of biodiversity, as well as energy changes,” Morris said. Yet, the game-changing potential of satellite data can make a huge difference if it is matched with the capacity on the ground to analyze, share and apply it. And large swaths of the globe where the effects of climate change are most pronounced are not connected. In West Africa, for example, “people don't know when the big flood is coming because there's no one to really take the satellite data and make it applicable on the ground,” said Gregory Jenkins, a professor of atmospheric science and African studies at Pennsylvania State University, noting that satellite data hasn’t even been fully integrated into weather forecasting on most of the continent. “We need to do much more in terms of assimilating satellite data into the weather forecast to improve them,” Jenkins said. “But we also need ground information to evaluate whatever the forecasts or the satellites are saying.” Finding more ways to share the data needs to be the priority of global leaders, numerous experts and executives say. Jasmine Sanders, a climate scientist and marine biologist who is executive director of climate youth advocacy organization Our Climate, said there remains too wide a gap between satellite companies and the advocacy groups, the scientific community and the government agencies who can make the most of it. “There's no one in between or no entity or organization that is showing how these groups could be connected,” she said. An oil spill is pictured. Multiple satellite images were used to assess the 2020 oil spill off the coast of Mauritania after the MV Wakashio, a Japanese oil tanker, went aground. | Courtesy of Planet Bureaucratic stumbling blocks in industrialized nations like the United States are also stymying efforts to share more climate data gleaned from satellites across government agencies, said Mark Mozena, senior director of government affairs at Planet. “Getting data should not be an issue when you're dealing with an emergency like a hurricane,” he said. “It should not be an issue when you're trying to prepare for next year's fires.” Johnson said one of her priorities is “how to ensure open public access for any commercially provided data by our federal science agencies.” But ultimately applying all this new, increasingly more detailed data is about far more than just diagnosing the extent of climate change and singling out the leading causes. “It's not just about naming and shaming,” said Zolli. “It's about creating the feedback loop so that we know whether we're making progress or not.”

#### Warming causes extinction

Klein 14[(Naomi Klein, award-winning journalist, syndicated columnist, former Miliband Fellow at the London School of Economics, member of the board of directors of 350.org), *This Changes Everything: Capitalism vs. the Climate*, pp. 12-14]

In a 2012 report, the World Bank laid out the gamble implied by that target. “As global warming approaches and exceeds 2-degrees Celsius, there is a risk of triggering nonlinear tipping elements. Examples include the disintegration of the West Antarctic ice sheet leading to more rapid sea-level rise, or large-scale Amazon dieback drastically affecting ecosystems, rivers, agriculture, energy production, and livelihoods. This would further add to 21st-century global warming and impact entire continents.” In other words, once we allow temperatures to climb past a certain point, where the mercury stops is not in our control.¶ But the bigger problem—and the reason Copenhagen caused such great despair—is that because governments did not agree to binding targets, they are free to pretty much ignore their commitments. Which is precisely what is happening. Indeed, emissions are rising so rapidly that unless something radical changes within our economic structure, 2 degrees now looks like a utopian dream. And it’s not just environmentalists who are raising the alarm. The World Bank also warned when it released its report that “we’re on track to a 4-C warmer world [by century’s end] marked by extreme heat waves, declining global food stocks, loss of ecosystems and biodiversity, and life-threatening sea level rise.” And the report cautioned that, “there is also no certainty that adaptation to a 4-C world is possible.” Kevin Anderson, former director (now deputy director) of the Tyndall Centre for Climate Change, which has quickly established itself as one of the U.K’s premier climate research institutions, is even blunter; he says 4 degrees Celsius warming—7.2 degrees Fahrenheit—is “incompatible with an organized, equitable, and civilized global community.”¶ We don’t know exactly what a 4 degree Celsius world would look like, but even the best-case scenario is likely to be calamitous. Four degrees of warming could raise global sea levels by 1 or possibly even 2 meters by 2100 (and would lock in at least a few additional meters over future centuries). This would drown some island nations such as the Maldives and Tuvalu, and inundate many coastal areas from Ecuador and Brazil to the Netherlands to much of California and the northeastern United States as well as huge swaths of South and Southeast Asia. Major cities likely in jeopardy include Boston, New York, greater Los Angeles, Vancouver, London, Mumbai, Hong Kong, and Shanghai.¶ Meanwhile, brutal heat waves that can kill tens of thousands of people, even in wealthy countries, would become entirely unremarkable summer events on every continent but Antarctica. The heat would also cause staple crops to suffer dramatic yield losses across the globe (it is possible that Indian wheat and U.S. could plummet by as much as 60 percent), this at a time when demand will be surging due to population growth and a growing demand for meat. And since crops will be facing not just heat stress but also extreme events such as wide-ranging droughts, flooding, or pest outbreaks, the losses could easily turn out to be more severe than the models have predicted. When you add ruinous hurricanes, raging wildfires, fisheries collapses, widespread disruptions to water supplies, extinctions, and globe-trotting diseases to the mix, it indeed becomes difficult to imagine that a peaceful, ordered society could be sustained (that is, where such a thing exists in the first place).¶ And keep in mind that these are the optimistic scenarios in which warming is more or less stabilized at 4 degrees Celsius and does not trigger tipping points beyond which runaway warming would occur. Based on the latest modeling, it is becoming safer to assume that 4 degrees could bring about a number of extremely dangerous feedback loops—an Arctic that is regularly ice-free in September, for instance, or, according to one recent study, global vegetation that is too saturated to act as a reliable “sink”, leading to more carbon being emitted rather than stored. Once this happens, any hope of predicting impacts pretty much goes out the window. And this process may be starting sooner than anyone predicted. In May 2014, NASA and the University of California, Irvine scientists revealed that glacier melt in a section of West Antarctica roughly the size of France now “appears unstoppable.” This likely spells down for the entire West Antarctic ice sheet, which according to lead study author Eric Rignot “comes with a sea level rise between three and five metres. Such an event will displace millions of people worldwide.” The disintegration, however, could unfold over centuries and there is still time for emission reductions to slow down the process and prevent the worst. ¶ Much more frightening than any of this is the fact that plenty of mainstream analysts think that on our current emissions trajectory, we are headed for even more than 4 degrees of warming. In 2011, the usually staid International Energy Agency (IEA) issued a report predicting that we are actually on track for 6 degrees Celsius—10.8 degrees Fahrenheit—of warming. And as the IEA’s chief economist put it: “Everybody, even the school children, knows that this will have catastrophic implications for all of us.” (The evidence indicates that 6 degrees of warming is likely to set in motion several major tipping points—not only slower ones such as the aforementioned breakdown of the West Antarctic ice sheet, but possibly more abrupt ones, like massive releases of methane from Arctic permafrost.) The accounting giant PricewaterhouseCoopers as also published a report warning businesses that we are headed for “4-C , or even 6-C” of warming.¶ These various projections are the equivalent of every alarm in your house going off simultaneously. And then every alarm on your street going off as well, one by one by one. They mean, quite simply, that climate change has become an existential crisis for the human species. The only historical precedent for a crisis of this depth and scale was the Cold War fear that we were headed toward nuclear holocaust, which would have made much of the planet uninhabitable. But that was (and remains) a threat; a slim possibility, should geopolitics spiral out of control. The vast majority of nuclear scientists never told us that we were almost certainly going to put our civilization in peril if we kept going about our daily lives as usual, doing exactly what we were already going, which is what climate scientists have been telling us for years. ¶ As the Ohio State University climatologist Lonnie G. Thompson, a world-renowned specialist on glacier melt, explained in 2010, “Climatologists, like other scientists, tend to be a stolid group. We are not given to theatrical rantings about falling skies. Most of us are far more comfortable in our laboratories or gathering data in the field than we are giving interviews to journalists or speaking before Congressional committees. When then are climatologists speaking out about the dangers of global warming? The answer is that virtually all of us are now convinced that global warming poses a clear and present danger to civilization.”

#### 2] Space junk guts astronomy – makes discoveries and detection impossible

Turner 21 (Turner, Ben. “Space Junk Is Blocking Our View of the Stars, Scientists Say.” LiveScience, Purch, 29 Apr. 2021, [https://www.livescience.com/space-junk-blocks-view-of-cosmos.html. [Ben Turner is a U.K. based staff writer at Live Science. He covers physics and astronomy, among other topics like weird animals and climate change. He graduated from University College London with a degree in particle physics before training as a journalist.])//LK](https://www.livescience.com/space-junk-blocks-view-of-cosmos.html.%20%5bBen%20Turner%20is%20a%20U.K.%20based%20staff%20writer%20at%20Live%20Science.%20He%20covers%20physics%20and%20astronomy,%20among%20other%20topics%20like%20weird%20animals%20and%20climate%20change.%20He%20graduated%20from%20University%20College%20London%20with%20a%20degree%20in%20particle%20physics%20before%20training%20as%20a%20journalist.%5d)//LK) [Accessed 1/27/22]

Long exposure star trail image taken at Hehuan Mountain, Taiwan. (Image credit: Shutterstock) The night sky is becoming increasingly filled with shiny satellites and space junk that pose a significant threat to our view of the cosmos, as well as astronomical research, a new study warns. The researchers found that the more than 9,300 tons (8,440 metric tons) of space objects orbiting Earth, including inoperative satellites and chunks of spent rocket stages, increase the overall brightness of the night sky by more than 10% over large parts of the planet. Such an increase would mean large swathes of the planet are considered light polluted, making it increasingly difficult for astronomers to take accurate measurements, and increasing the likelihood that they will miss significant discoveries altogether, the researchers said in the journal Monthly Notices of the Royal Astronomical Society. Related: Here's every spaceship that's ever carried an astronaut into orbit "We expected the sky brightness increase would be marginal, if any, but our first theoretical estimates have proved extremely surprising and thus encouraged us to report our results promptly," lead study author Miroslav Kocifaj, a senior researcher at the Slovak Academy of Sciences, said in a statement. The researchers calculated the change in brightness by developing a model that takes into account the average size and brightness of each piece of debris. CLOSE How Much Orbital Debris Has Grown Since 1960 Orbital debris has increased exponentially since 1960. Cataloged objects are shown for the last 50 years in this NASA animation. Credit: NASA ODPO 0 seconds of 49 secondsVolume 0% According to the researchers, satellites and space garbage ruin astronomical images by scattering reflected sunlight, producing bright streaks that are indistinguishable from — and often brighter than — objects of astrophysical interest, making it difficult if not impossible for them to get a clear picture. The researchers found that this effect is most pronounced when viewing the cosmos with low-resolution detectors, such as the human eye, resulting in a diffuse brightness across all of the night sky. Telescopes with high angular resolution and high sensitivity may also have part of their images ruined by the light pollution, although they can likely resolve the junk-reflected light into smears. Nevertheless, this could potentially obscure astronomical sights, such as the glowing clouds of stars along the disk of the Milky Way, wherever in the world star-gazers happen to be. "Unlike ground-based light pollution, this kind of artificial light in the night sky can be seen across a large part of the Earth's surface," study co-author John Barentine, director of public policy for the International Dark-Sky Association, said in the statement. "Astronomers build observatories far from city lights to seek dark skies, but this form of light pollution has a much larger geographical reach." And the night sky could get even junkier and brighter, especially with the ongoing installation of “mega-constellations,” — large arrays of commercial satellites that aim to provide global internet access. At least 12 operators, including Amazon, SpaceX and OneWeb, have plans to launch new mega-constellation satellites or expand existing networks. SpaceX's Starlink currently has 1,200 satellites in orbit, but the company intends to increase its fleet to 42,000 in the coming decades — roughly 14 times the number of operational satellites in orbit today. Bright streaks caused by SpaceX's Starlink constellation. Bright streaks caused by SpaceX's Starlink constellation. (Image credit: Andreas Möller) The increasingly crowded sky also ups the likelihood of satellites colliding with each other and other objects, creating more shiny debris. One solution to the problem, proposed by the European Space Agency (ESA) in December 2019, is the 2025 launch of a four-armed robot to grab individual items of space junk. ESA is hoping to use the mission as a test for a much wider-reaching operation by a fleet of robot cleaners. In the meantime, ESA's director general Johann-Dietrich Wörner has called for new rules to make companies and agencies that launch satellites responsible for tidying up their litter. A team of Australian scientists has even proposed blasting the junk from space with a laser, Live Science previously reported. The researchers hope that their paper will raise awareness of the detrimental effects of a trash-filled night sky. "Our results imply that many more people than just astronomers stand to lose access to pristine night skies," Barentine said. "This paper may really change the nature of that conversation." Originally published on Live Science Ben Turner is a U.K. based staff writer at Live Science. He covers physics and astronomy, among other topics like weird animals and climate change. He graduated from University College London with a degree in particle physics before training as a journalist. When he's not writing, Ben enjoys reading literature, playing the guitar and embarrassing himself with chess.

#### Asteroids cause extinction and without top-notch astronomical detection capabilities, a hit is inevitable

Dreier 21, Casey Dreier is Senior Space Policy Adviser for The Planetary Society, an independent nonprofit organization based in California. “Why an Asteroid Strike Is Like a Pandemic”, July 25, 2021, <https://www.scientificamerican.com/article/why-an-asteroid-strike-is-like-a-pandemic/>, accessed 12/3/21, sb

Imagine the following scenario. Scientists identify a potential global threat, but initial data are spotty—not enough to spur drastic action. Rapidly, relentlessly, the threat grows. What once was preventable becomes inevitable. The world has no choice but to endure the disaster at the cost of trillions of dollars and millions of lives. This is the story of COVID pandemic—but it could equally well be the story of a catastrophic strike by a large asteroid. As we emerge from the worst of COVID-19, we should heed this lesson: low-probability, high-impact events do occur; but they can be mitigated if we prepare and act early enough. Asteroids are like viruses in a sense: they number in the tens of millions but only a few types pose a threat to humans. For asteroids, it’s the “near-Earth” variety—those with orbits that come close to our own—that we must worry about. Also as with viral outbreaks, the likelihood of a catastrophe is unlikely in any given year, but almost inevitable over time. And just as we can in principle develop vaccines against emerging viruses before they cause too much damage, creating immunity without making people sick, we can similarly use modern technology to develop a level of global immune response to asteroid collisions. But this requires ongoing investments in research and preparedness—and while the U.S. spent more than $6.5 billion dollars on pandemic preparedness over the past decade (with admittedly mixed results), the nation spent less than a tenth of that on the work of asteroid detection and deflection. This is far too low. In fact, impacts from space happen all the time, but they are generally small and harmless. The Earth is peppered with meteors throughout the year that are mere inches across or less, which burn up as shooting stars when they enter our atmosphere. The threat comes from the bigger ones, which are house-sized or larger. These strike less frequently, but they do happen. In 2013, a 60-foot-diameter meteor exploded over the city of Chelyabinsk, injuring thousands of people. The really big ones—miles across—are even rarer, occurring every few hundred million years or so. But the damage they do can be catastrophic. Think of the mass extinction 65 million years ago that wiped out most of the dinosaurs. The good news is that we’ve found most of those and, fortunately for us, Earth is not in their crosshairs. But there is a middle ground that demands our attention: “city killer” asteroids that are about around the size of a football field and could unleash 10,000 times the energy of the atomic bomb that leveled Hiroshima. They seem to hit us every few thousand years, on average. There are likely many tens of thousands of them with orbits near Earth’s, yet we’ve only found about one third of these. And finding them is hard. Even the big ones are tiny, cosmically speaking, and are camouflaged against the blackness of space by their charcoal-like dark surfaces. Ground-based telescopes, which measure reflected light, struggle to see these small, dim objects. Only a few hundred are discovered each year. To significantly improve the rate of detection we need to move off the Earth, to the realm of the asteroids. We need a telescope in space. The Near-Earth Object (NEO) Surveyor is a modest space telescope currently under consideration by NASA. Instead of looking at reflected light, it would seek out heat signatures of asteroids, which glow with infrared radiation against the cold background of space. And in space, where there’s no bad weather and daytime that limit observations, the NEO Surveyor could find more city-killer asteroids in the next 10 years than have been discovered by all the telescopes on Earth over the past three decades. The mathematics of orbital mechanics that characterizes asteroids can be as heartless as the exponential growth that goes with viral outbreaks. And as with broad testing regimes that have been used during COVID, a dedicated effort to discover potentially hazardous asteroids will be the key to preventing disaster. It’s possible to alter an incoming asteroid’s orbit to protect the Earth, but that becomes increasingly more difficult depending on how close we are to impact. It is far easier to act years (if not decades) in advance. After more than a decade in bureaucratic purgatory, where the NEO Surveyor has struggled to gain approval, the project appears ready to move forward. The Biden administration recently proposed to fund this mission in its latest NASA budget; Congress should support this request. It will take years to build and launch, but as early as 2026 we may see the start of the first dedicated effort to understand the scope of the asteroid threat. We also need to invest in deflection technology, the “vaccine” of the asteroid response. Fortunately, NASA is close to launching a mission called the Double Asteroid Redirection Test (DART). In 2022, the spacecraft will ram into the tiny “moon” that orbits the near-Earth asteroid Didymos, slightly changing its orbit. Scientists will compare the exact degree of change to their predictions, which will help them understand how to alter asteroid orbits more effectively in the future. This is only a test, but it could serve the same function as the years of basic research into the field of mRNA vaccines that ultimately paid off when applied to COVID. We must also continue to support sky surveys by ground telescopes, which can support the work of space-based missions. The Vera Rubin Observatory, for example, now under construction in Chile and especially good at finding fast-moving objects in the solar system, will greatly assist in asteroid detection. (The proposed “megaconstellations” of Earth-orbiting satellites by Amazon, SpaceX, OneWeb, and others threaten to overwhelm our view of these dim objects and make asteroid detections more difficult. There is no easy solution to this, beyond further confirming the need for space-based detectors located in quieter regions of the solar system.) The coronavirus pandemic has many humbling lessons for humanity. But let this be one of them: low-probability, high-impact disasters do occur; and there is no higher impact disaster than a large asteroid collision with the Earth. We know that early awareness enables early action. Big problems later on can be prevented by small investments now. Let’s not be caught off-guard again.

## Advantage 2 is Space War

#### Disputes and misperceptions create cascading effects towards space weaponization and an arms race—an international framework solves BUT unilateral action causes escalating space wars

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The first concern is establishing clear regulations regarding asteroid mining. With an intent to establish clear regulations with respect to asteroid mining and to legalise material extraction from the moon and other celestial bodies by private companies in the US, the US government legalised space mining in 2015 by introducing the US Commercial Space Launch Competitiveness Act, 2015.[xxvii] This move was heartily welcomed by the private companies as it provided legitimacy to their planned activities. Subsequently in 2017, Luxembourg followed suit.[xxviii] While the US has been a spacefaring nation for many decades now, Luxembourg aspires to become a global leader in the nascent race to mine resources in outer space. In the 1980s the tiny European nation arose out of almost nowhere to become a leader in the satellite communications industry; today it is looking to the skies again, hoping to be the Silicon Valley of asteroid mining.[xxix] In the backdrop of a thriving steel industry that faced trade recession during the oil crisis of 1973, Luxembourg is trying to capitalise on the potential of space mining. As Prime Minister Xavier Bettel put it, “We realized it wouldn't be forever, the steel, so we decided to do other things.”[xxx] Similarly, looking beyond oil, the UAE is framing its policy approaches to make advances in two key areas: human space exploration, and commercial activities of resource extraction through mining.[xxxi] The two formal pieces of legislation (passed by the US and Luxembourg) provide an answer to the complex question of ownership in outer space; the two-word answer appears to be, “finders, keepers”. The US Commercial Space Launch Competitiveness Act, 2015 states: “A US citizen engaged in commercial recovery of an asteroid resource or a space resource shall be entitled to any asteroid resource or space resource obtained.”[xxxii] This legislation gives US space firms the right to own, keep, use, and sell the spoils of the cosmos as they deem fit. Luxembourg’s legislation is fairly analogous to the US Act, giving mining companies the right to keep their plunder. However, unlike the US law, Luxembourg’s does not require a company’s major stakeholders to be based in the country to enjoy its safeguards; the only requirement is for that company to have an office in the country.[xxxiii] In 2017, Japan entered into a five-year agreement with Luxembourg for mining operations in celestial bodies. Japan today appears a step closer to realising its objective of asteroid mining with two Japanese rovers, Minerva II-1, of JAXA landing on the surface of the asteroid named Ryugu in September 2018.[xxxiv] Earlier, Portugal and the UAE signed similar cooperation agreements with Luxembourg.[xxxv] Meanwhile, a few other countries—which have been critical of the US and Luxembourg, at the forefront of the space mining efforts—have also decided to join the field. The increasingly competitive and contested nature of outer space activities is spurring major spacefaring nations to push the boundaries in their space exploration. Asteroid mining could possibly become the next big thing and is already seeing a race among the space powers. The US and Luxembourg are at the forefront in space resource extraction in terms of the policy frameworks and funding.[xxxvi] Even as the US has clarified that the US Space Act 2015 is being misunderstood and that there is no change in the US policy towards national appropriation of space, the reality is that it has already spurred a major debate.[xxxvii] China and Russia are among those countries that are following on the path of the US and Luxembourg in undertaking mining missions in space. According to media reports, Ye Peijian, chief commander and designer of China’s lunar exploration programme has stated that China would send the first batch of asteroid exploration spacecraft around 2020.[xxxviii] Speaking to China’s Ministry of Science and Technology-run newspaper, Science and Technology Daily, Ye said that these asteroids have a high concentration of precious metals, which could rationalise the huge cost and risks involved in these activities as their economic value could run into the trillions of US dollars. Therefore, extraction, mining and transporting them back to Earth through robotic equipment will be a significant activity. Chinese scientists are working on missions to “bring back a whole asteroid weighing several hundred tonnes, which could turn asteroids with a potential threat to Earth into usable resources.”[xxxix] Ye was also quoted as saying that China has plans of “using an asteroid as the base for a permanent space station.”[xl] Helium mining on the moon is also part of China’s goals.[xli] Russia, for its part, is also responding to the space-mining developments of the last decade. For one, it plans to have a permanent lunar base somewhere between 2015 and 2020 for possible extraction of Helium.[xlii] Even as Russia’s official position on asteroid mining is that it is forbidden under the 1967 OST—which states that space is the “province of mankind”—the Russian industry players are of the view that they must follow the lead taken by the US and Luxembourg.[xliii] In early 2018, the director of the Scientific-Educational Center for Innovative Mining Technologies of the Moscow-based National University of Science and Technology MISIS (NUST MISIS), Pavel Ananyev, spoke about the Russian ambitions and proposed activities including space drilling rigs, water extraction on the Moon and 3D printers at space stations.[xliv] Russia’s private space companies including Dauria Aerospace, one of the first Russian private space companies, also hold the opinion that they must go forward in the same direction and call for a larger space to private sector to engage in extracting space resources.[xlv] Moscow may not have yet actively pursued space mining and resource extraction, but it is likely to pick up pace in the coming years alongside global efforts. Moscow clearly has a capacity gap in terms of funding because its earlier plans to have a permanent base in the Moon by 2015 is yet to happen. India, too, has ambitions in extraterrestrial resource extraction. In fact, a year after the US legislation, Prabhat Ranjan, executive director of Technology Information, Forecasting and Assessment Council (TIFAC), a policy organisation within the Department of Science and Technology, made a case for India to push ahead with lunar and asteroid mining. He said, “Moon is already being seen as a mineral wealth and further one can go up to the asteroids and start exploiting this. This can be a big game changer and if India doesn’t do this, we will lag behind.”[xlvi] More recently, Dr. K Sivan, Chairman of the country’s civil space organisation, Indian Space Research Organisation (ISRO), talked about ISRO’s plans for helium-3 extraction and said, “the countries which have the capacity to bring that source from the moon to Earth will dictate the process. I don’t want to be just a part of them, I want to lead them.”[xlvii] However, gaining proficiency in such missions is not easy – the NASA and ESA (the European Space Agency) have been discussing these possibilities for a longer time, albeit quietly. The ISRO Chairman’s response was characterised by an Indian commentator as “aspirational” and “emotional”, clearly conceding that the country’s technological wherewithal is yet to be adequate.[xlviii] Importantly, it is not clear how the legal and regulatory aspects of space mining operations are being dealt with. There was one instance, though, when Luxembourg and Japan in a joint press statement said, “The exchange of information may cover all the issues of the exploration and commercial utilization of space resources, including legal, regulatory, technological, economic, and other aspects.”[xlix] Whether such legalisation is truly legal is arguable. Space Mining: Legal or Not? The Outer Space Treaty (OST) of 1967, considered the global foundation of the outer space legal regime, along with the other four associated international instruments have provided the fundamental basis for outer space activities by prohibiting certain activities and emphasising aspects such as the “common heritage of mankind”. These agreements have been useful in highlighting the global common nature of outer space. At the same time, however, they have been insufficient and ambiguous in providing clear regulations to newer space activities such as asteroid mining. Based on the premise of ‘res communis’, the magna carta of space law, the OST, illustrates outer space as “the province of all mankind”.[l] Under Article I, States are free to explore and use outer space and to access all celestial bodies “on the basis of equality and in accordance with international law.”[li] Although the OST does not explicitly mention “mining” activities, under Article II, outer space including the Moon and other celestial bodies are “not subject to national appropriation by claim of sovereignty” through use, occupation or any other means.[lii] Furthermore, the Moon Agreement, 1979, not only defines outer space as “common heritage of mankind” but also proscribes commercial exploitation of planets and asteroids by States unless an international regime is established to govern such activities for “rational management,” “equitable sharing” and “expansion of opportunities” in the use of these resources.[liii] Slipping conveniently through the loophole in the OST, both the US and Luxembourg have authorised companies to claim exclusive ownership over extracted resources (but not of the asteroid itself). Proponents argue that since no sovereign nation is actually asserting rights over an area of outer space, instead, it is only a private unit claiming rights over singular resources, the treaty norm, “national appropriation by claim of sovereignty”, is not being violated. In the words of renowned space lawyer, Frans von der Dunk, “In terms of the law, yes it’s true that no country can claim any part of outer space as national territory — but that doesn’t mean private industry can’t mine resources.”[liv] Quoting reference from maritime law, Luxembourg regards space resources as appropriable akin to fish and shellfish, but celestial bodies and asteroids are not, just like the high sea. It is noteworthy that out of the only 18 nations that have ratified the Moon Agreement,[lv] none are major spacefaring nations, thereby giving themselves a convenient leeway to not abide by the same. These unilateral initiatives have set off a critical response from the international community. Applying literal interpretation of the OST, there is certainly room to construe that space mining may be legal, compared to the Moon Agreement whose prohibition is absolute. However, taking into consideration the letter and spirit of the OST, strengthened by the Moon Agreement, the argument that “national appropriation” only extends to appropriation of territory and not appropriation of resources is a far reach. That resource extraction is contemplated, albeit implicitly, in the OST, is nothing but logical. Not only have such claims of possessory rights not been recognised in the past, there is also global consensus regarding its illegality.[lvi] It therefore forms a part of customary international law, despite the Moon Agreement not having been widely ratified. In this light, the legalisation of space mining is a sheer violation of the elemental principles of international space law. Yet, there is no clarity on what activity is allowed and what is prohibited in outer space under the existing law.[lvii] There is ambiguity around most issues—from “who would license and regulate asteroid mining operations” to the legality of these activities as per the existing international space law.[lviii] When comparing it to the law of the seas, resource appropriation in the high seas and deep seabed is governed by the United Nations Convention on the Law of the Sea (UNCLOS), 1982, and that in Antarctica, as per the Protocol on Environmental Protection to the Antarctic Treaty, 1991. While the former is strictly regulated under Part XI of UNCLOS, the latter is completely forbidden but for scientific purposes. The law of the sea argument—“owning the fish, not the sea”—cannot be applied to outer space primarily because fish are living resources that can reproduce and therefore are renewable. Outer space resources, on the other hand, are depletable: once harvested, they cannot be replenished. The analogy with fish and seas, therefore, is not a fair one and its transposition to outer space and celestial bodies would be inaccurate. Perhaps a more comparable regime is the deep seabed, which contemplates property rights over mineral extraction. The utilisation and ownership of the deep seabed’s resources are exclusively structured around the International Seabed Authority (ISA), which is responsible for organising, carrying out and controlling all activities in the seabed.[lix] Not only must State parties seek sanction from the ISA before beginning resource exploitation, but the fiscal benefits from seabed mining must also be shared among all.[lx] Evidently, even the UNCLOS upholds State ownership and fair distribution over individual ownership and self-centred gains.[lxi] By allowing private ownership, the US and Luxembourg are once again in contravention of the very same law they are relying on. The touchstone principle, “province of all mankind” is also being defeated. Therefore, to even reap the limited benefits as under UNCLOS, at least the derivation must be made alike. This argument too falls flat. The Way Ahead Undoubtedly, growing technological adeptness has made space mining inevitable and, therefore, the question is no longer “if” but “when”. Nevertheless, a scenario where companies can, solely based on domestic laws, steadily exploit mineral resources in outer space, would be universally unacceptable. Minus regulations, the realisation of space exploitation will create great disparity between nations and disrupt dynamics of the world economy. Regulations are particularly important in the context of the space debris problem. We definitely do not wish for a future, befittingly described by renowned engineer and inventor Graham Hawkes, thus: “Space exploration promised us alien life, lucrative planetary mining, and fabulous lunar colonies. News flash, ladies and gents: Space is nearly empty. It’s a sterile vacuum, filled mostly with the junk we put up there.”[lxii] Therefore, it is extremely important that resource appropriation is carried out in an ethical manner, without interrupting safe and secure access to outer space, simultaneously allowing all countries a share in the proceeds. Technological advances and financial readiness are pushing both, states and non-state players towards new ventures in outer space. Yet, the rules of engagement especially dealing with the new commercial activities are far from ideal. There is a clear and urgent need to debate and come up with either a new regulation or accommodate the space mining activities within the existing international legal measures. Experts have articulated that these could possibly be addressed under the existing property law principles or old mining law principles.[lxiii] However, given the scale of activities that states and non-state parties will engage in, the ability of the existing regime to address space mining could be highly inadequate. The second option would be to develop a new instrument including an institutional architecture that would set out the parameters for activities related to resource extraction and space mining. Since there are a good number of commercial players playing a formidable role in asteroid mining, there has to be space for commercial players in the new gig, which might be a big departure from the earlier era institutions that saw states being the sole authority in regulating activities in outer space. A clear role for commercial players has been articulated for some time but the global space community has yet to reach a consensus in how they can be incorporated into the global governance debates. The apprehension on the part of a number of states is driven by the fact that private sector participation is still largely a western phenomenon. This trend may be undergoing change in other parts of the world but until there is a sizeable private sector community in other major spacefaring powers, there is a fear that the western bloc of countries may stand to gain from the industry being represented in the global governance debates. A third possible option is to get a larger global endorsement of the Moon Treaty, which highlights the common heritage of mankind. The Moon Treaty is important as it addresses a “loophole” of the OST “by banning any ownership of any extraterrestrial property by any organization or private person, unless that organization is international and governmental.”[lxiv] But the fact that it has been endorsed only by a handful of countries makes it a “failure” from the international law perspective.[lxv] Nevertheless, efforts must be made to strengthen the support base for the Moon Agreement given the potential pitfalls of resource extraction and space mining activities in outer space. Signatories to the Moon Treaty can take the lead within multilateral platforms such as the UN to debate the usefulness of the treaty in the changed context of technological advancements and new geopolitical dynamics, and potentially find compromises where there are disagreements. Pursuing a collective approach is ideal. An example is UNCLOS, which demonstrates that the international society possesses the capability of regulating mining quarters deemed to be the “province of mankind”. However, a sui generis legal framework must be crafted because the difference between the marines and outer space and their resources is wide, and the regulations are too region-specific to permit a superimposition of the oceanic regime to outer space. A sound legal environment will protect both the company performing operations and its beneficiaries, while ensuring even-handed resource allocation. In addition, regulations spelling out safety standards and identifying safety zones around mining operations could be useful in ensuring safe and secure operations in outer space. It would be wrong, however, to say that the international community has not debated over this. In fact, one of the main agenda points of the fifty-seventh session of UNCOPUS Legal Committee held in April 2018, was especially devoted to “general exchange of views on potential legal models for activities in the exploration, exploitation and utilization of space resources.”[lxvi] Upon evaluation, it is clear that countries are not against space mining as such; rather the contentious points are vis-à-vis authorisation, regulation, and where to place responsibility. There also appears to be concurrence regarding the need for international coordination efforts of some sort. Over the last two years, The Hague Space Resources Governance Working Group,[lxvii] established with the purpose of “assess[ing] the need for a regulatory framework for space resource activities, has identified 19 “building blocks”,[lxviii] encompassing subject matters that could be included in such a regulatory framework. Although this leaves a lot of hope for the legitimate mining of space resources, its status is still pending. Also, several questions need to be agreed upon by the global space policy community before the establishment of a framework. First, there must be an agreement among all the space powers on the need for a global governance framework for the use of space resources. This must be followed by detailed deliberations on the scope, mandate and objectives of such a framework. Can and should there be safety zones and exclusive rights be recognised under such a framework and how one can ensure equitable sharing of the resources, and lastly, the role of industries and how the interests of the industry as pioneers in this area can be secured. These are all pertinent questions that need to be considered and debated before an international regime for extraction and use of space resources can be established.[lxix] Even legal space mining activity could have serious impacts in two ways. For instance, any technological spinoffs that a country might have could add to the space weaponisation debate. Two, the erosion of norms with regard to space mining could have a cascading effect on other norms in the same issue area such as weaponisation of space. It is imperative for nations to actively combine their efforts to ensure that this activity transpires in the most globally acceptable manner and not one which stirs anarchism. The ancient Roman maxim, ‘Quod omnes tangit ab omnibus approbatur’ (What touches all must be approved by all) gains due traction in this kind of a scenario. Therefore, a universal activity like space exploration mandates an international guideline; or else, the first haul from mining, instead of earning admiration and exultation, will only be enmeshed in litigation.

#### Asteroid mining furthers tensions between the US, China and Russia and escalates

Jamasmie 21 Cecilia Jamasmie [Cecilia has covered mining for more than a decade. She is particularly interested in Corporate Social Responsibility (CSR), Diamonds and Latin America. Cecilia has been interviewed by BBC News and CBC among others and has been a guest speaker at mining conventions, including MINExpo 2016 and the World’s Copper Conference 2018. She is also member of the expert panel on Social License to Operate (SLO) at the European project MIREU (Mining and Metallurgic Regions EU). She holds a Master of Journalism from the University of British Columbia, and is based in Nova Scotia.], 2-2-2021, "Experts warn of brewing space mining war among US, China and Russia," MINING, <https://www.mining.com/experts-warn-of-brewing-space-mining-war-among-us-china-and-russia/> DD AG

A brewing war to set a mining base in space is likely to see China and Russia joining forces to keep the US increasing attempts to dominate extra-terrestrial commerce at bay, experts warn. The Trump Administration took an active interest in space, announcing that America would return astronauts to the moon by 2024 and creating the Space Force as the newest branch of the US military.It also proposed global legal framework for mining on the moon, called the Artemis Accords, encouraging citizens to mine the Earth’s natural satellite and other celestial bodies with commercial purposes. The directive classified outer space as a “legally and physically unique domain of human activity” instead of a “global commons,” paving the way for mining the moon without any sort of international treaty. Spearheaded by the US National Aeronautics and Space Administration (NASA), the Artemis Accords were signed in October by Australia, Canada, England, Japan, Luxembourg, Italy and the United Emirates “Unfortunately, the Trump Administration exacerbated a national security threat and risked the economic opportunity it hoped to secure in outer space by failing to engage Russia or China as potential partners,” says Elya Taichman, former legislative director for then-Republican Michelle Lujan Grisham. “Instead, the Artemis Accords have driven China and Russia toward increased cooperation in space out of fear and necessity,” he writes.Russia’s space agency Roscosmos was the first to speak up, likening the policy to colonialism. “There have already been examples in history when one country decided to start seizing territories in its interest — everyone remembers what came of it,” Roscosmos’ deputy general director for international cooperation, Sergey Saveliev, said at the time.China, which made history in 2019 by becoming the first country to land a probe on the far side of the Moon, chose a different approach. Since the Artemis Accords were first announced, Beijing has approached Russia to jointly build a lunar research base. President Xi Jinping has also he made sure China planted its flag on the Moon, which happened in December 2020, more than 50 years after the US reached the lunar surface.

#### US asteroid mining pushes Russia to do the same despite it violating international law- increases the likelihood for tensions to escalate.

Mallick and Rajagopalan 19 [Senjuti Mallick and Rajeswari Pillai Rajagopalan, If space is ‘the province of mankind’, who owns its resources?, 1-24-2019,ORF,https://www.orfonline.org/research/if-space-is-the-province-of-mankind-who-owns-its-resources-47561/, 12-16-2021 amrita]

Meanwhile, **a few other countries**—**which have been critical of the US and** Luxembourg, **at the forefront of** the **space mining** efforts—**have** also **decided to join** the field. **The increasingly competitive and contested nature** of outer space activities is spurring major spacefaring nations to **push the boundaries in** their **space exploration**. **Asteroid mining** could possibly become the next big thing and **is** already **seeing a race** among the space powers. The US and Luxembourg are at the forefront in space resource extraction in terms of the policy frameworks and funding.[xxxvi] **Even as the US has clarified that the** US Space **Act** 2015 **is** being **misunderstood** and that there is no change in the US policy towards national appropriation of space, **the reality** is that it has already **spurred a** major **debate**.[xxxvii] China and Russia are among those countries that are following on the path of the US and Luxembourg in undertaking mining missions in space. According to media reports, Ye Peijian, chief commander and designer of China’s lunar exploration programme has stated that China would send the first batch of asteroid exploration spacecraft around 2020.[xxxviii] Speaking to China’s Ministry of Science and Technology-run newspaper, Science and Technology Daily, Ye said that these asteroids have a high concentration of precious metals, which could rationalise the huge cost and risks involved in these activities as their economic value could run into the trillions of US dollars. Therefore, extraction, mining and transporting them back to Earth through robotic equipment will be a significant activity. Chinese scientists are working on missions to “bring back a whole asteroid weighing several hundred tonnes, which could turn asteroids with a potential threat to Earth into usable resources.”[xxxix] Ye was also quoted as saying that China has plans of “using an asteroid as the base for a permanent space station.”[xl] Helium mining on the moon is also part of China’s goals.[xli] **Russia,** for its part, **is** also **responding to the space-mining developments** of the last decade. For one, it plans to have a permanent lunar base somewhere between 2015 and 2020 for possible extraction of Helium.[xlii] **Even as** Russia’s **official position** on asteroid mining **is that it is forbidden** under the 1967 OST—which states that space is the “province of mankind”—the Russian **industry players** are of the view that they **must follow the** lead taken by the **US** and Luxembourg.[xliii] In early 2018, the director of the Scientific-Educational Center for Innovative Mining Technologies of the Moscow-based National University of Science and Technology MISIS (NUST MISIS), Pavel Ananyev, spoke about the Russian ambitions and proposed activities including space drilling rigs, water extraction on the Moon and 3D printers at space stations.[xliv] **Russia’s private space companies** including Dauria Aerospace, one of the first Russian private space companies, also **hold the opinion that they must go forward** in the same direction and call for a larger space to private sector to engage in extracting space resources.[xlv] **Moscow may not have** yet **actively pursued space mining** and resource extraction, **but it is likely to pick up pace** in the coming years alongside global efforts. Moscow clearly has a capacity gap in terms of funding because its earlier plans to have a permanent base in the Moon by 2015 is yet to happen.

#### Space wars go nuclear

Grego 18 – Laura, Senior Scientist in the Global Security Program at the Union of Concerned Scientists, Postdoctoral Researcher at the Harvard-Smithsonian Center for Astrophysics, PhD in Experimental Physics at the California Institute of Technology, Space and Crisis Stability, Union of Concerned Scientists, 3-19-18, <https://www.law.upenn.edu/live/files/7804-grego-space-and-crisis-stabilitypdf>

Why space is a particular problem for crisis stability For a number of reasons, space poses particular challenges in preventing a crisis from starting or from being managed well. Some of these are to do with the physical nature of space, such as the short timelines and difficulty of attribution inherent in space operations. Some are due to the way space is used, such as the entanglement of strategic and tactical missions and the prevalence of dual-use technologies. Some are due to the history of space, such the absence of a shared understanding of appropriate behaviors and consequences, and a dearth of stabilizing personal and institutional relationships. While some of these have terrestrial equivalents, taken together, they present a special challenge. The vulnerability of satellites and first strike incentives Satellites are inherently fragile and difficult to protect; in the language of strategic planners, space is an “offense-dominant” regime. This can lead to a number of pressures to strike first that don‘t exist for other, better-protected domains. Satellites travel on predictable orbits, and many pass repeatedly over all of the earth‘s nations. Low-earth orbiting satellites are reachable by missiles much less capable than those needed to launch satellites into orbit, as well as by directed energy which can interfere with sensors or with communications channels. Because launch mass is at a premium, satellite armor is impractical. Maneuvers on orbit need costly amounts of fuel, which has to be brought along on launch, limiting satellites‘ ability to move away from threats. And so, these very valuable satellites are also inherently vulnerable and may present as attractive targets. Thus, an actor with substantial dependence on space has an incentive to strike first if hostilities look probable, to ensure these valuable assets are not lost. Even if both (or all) sides in a conflict prefer not to engage in war, this weakness may provide an incentive to approach it closely anyway. A RAND Corporation monograph commissioned by the Air Force15 described the issue this way: First-strike stability is a concept that Glenn Kent and David Thaler developed in 1989 to examine the structural dynamics of mutual deterrence between two or more nuclear states.16 It is similar to crisis stability, which Charles Glaser described as ―a measure of the countries‘ incentives not to preempt in a crisis, that is, not to attack first in order to beat the attack of the enemy,‖17 except that it does not delve into the psychological factors present in specific crises. Rather, first strike stability focuses on each side‘s force posture and the balance of capabilities and vulnerabilities that could make a crisis unstable should a confrontation occur. For example, in the case of the United States, the fact that conventional weapons are so heavily dependent on vulnerable satellites may create incentives for the US to strike first terrestrially in the lead up to a confrontation, before its space-derived advantages are eroded by anti-satellite attacks.18 Indeed, any actor for which satellites or space-based weapons are an important part of its military posture, whether for support missions or on-orbit weapons, will feel “use it or lose it” pressure because of the inherent vulnerability of satellites. Short timelines and difficulty of attribution The compressed timelines characteristic of crises combine with these “use it or lose it” pressures to shrink timelines. This dynamic couples dangerously with the inherent difficulty of determining the causes of satellite degradation, whether malicious or from natural causes, in a timely way. Space is a difficult environment in which to operate. Satellites orbit amidst increasing amounts of debris. A collision with a debris object the size of a marble could be catastrophic for a satellite, but objects of that size cannot be reliably tracked. So a failure due to a collision with a small piece of untracked debris may be left open to other interpretations. Satellite electronics are also subject to high levels of damaging radiation. Because of their remoteness, satellites as a rule cannot be repaired or maintained. While on-board diagnostics and space surveillance can help the user understand what went wrong, it is difficult to have a complete picture on short timescales. Satellite failure on-orbit is a regular occurrence19 (indeed, many satellites are kept in service long past their intended lifetimes). In the past, when fewer actors had access to satellite-disrupting technologies, satellite failures were usually ascribed to “natural” causes. But increasingly, even during times of peace operators may assume malicious intent. More to the point, in a crisis when the costs of inaction may be perceived to be costly, there is an incentive to choose the worst-case interpretation of events even if the information is incomplete or inconclusive. Entanglement of strategic and tactical missions During the Cold War, nuclear and conventional arms were well separated, and escalation pathways were relatively clear. While space-based assets performed critical strategic missions, including early warning of ballistic missile launch and secure communications in a crisis, there was a relatively clear sense that these targets were off limits, as attacks could undermine nuclear deterrence. In the Strategic Arms Limitation Treaty, the US and Soviet Union pledged not to interfere with each other‘s ―national technical means‖ of verifying compliance with the agreement, yet another recognition that attacking strategically important satellites could be destabilizing.20 There was also restraint in building the hardware that could hold these assets at risk. However, where the lines between strategic satellite missions and other missions are blurred, these norms can be weakened. For example, the satellites that provide early warning of ballistic missile launch are associated with nuclear deterrent posture, but also are critical sensors for missile defenses. Strategic surveillance and missile warning satellites also support efforts to locate and destroy mobile conventional missile launchers. Interfering with an early warning sensor satellite might be intended to dissuade an adversary from using nuclear weapons first by degrading their missile defenses and thus hindering their first-strike posture. However, for a state that uses early warning satellites to enable a “hair trigger” or launch-on-attack posture, the interference with such a satellite might instead be interpreted as a precursor to a nuclear attack. It may accelerate the use of nuclear weapons rather than inhibit it. Misperception and dual-use technologies Some space technologies and activities can be used both for relatively benign purposes but also for hostile ones. It may be difficult for an actor to understand the intent behind the development, testing, use, and stockpiling of these technologies, and see threats where there are none. (Or miss a threat until it is too late.) This may start a cycle of action and reaction based on misperception. For example, relatively low-mass satellites can now maneuver autonomously and closely approach other satellites without their cooperation; this may be for peaceful purposes such as satellite maintenance or the building of complex space structures, or for more controversial reasons such as intelligence-gathering or anti-satellite attacks. Ground-based lasers can be used to dazzle the sensors of an adversary‘s remote sensing satellites, and with sufficient power, they may damage those sensors. The power needed to dazzle a satellite is low, achievable with commercially available lasers coupled to a mirror which can track the satellite. Laser ranging networks use low-powered lasers to track satellites and to monitor precisely the Earth‘s shape and gravitational field, and use similar technologies. 21 Higher-powered lasers coupled with satellite-tracking optics have fewer legitimate uses. Because midcourse missile defense systems are intended to destroy long-range ballistic missile warheads, which travel at speeds and altitudes comparable to those of satellites, such defense systems also have inherent ASAT capabilities. In fact, while the technologies being developed for long-range missile defenses might not prove very effective against ballistic missiles—for example, because of the countermeasure problems associated with midcourse missile defense— they could be far more effective against satellites. This capacity is not just theoretical. In 2007, China demonstrated a direct-ascent anti-satellite capability which could be used both in an ASAT and missile defense role, and in 2009, the United States used a ship-based missile defense interceptor to destroy a satellite, as well. US plans indicated a projected inventory of missile defense interceptors with capability to reach all low earth orbiting satellites in the dozens in the 2020s, and in the hundreds by 2030.22 Discrimination The consequences of interfering with a satellite may be vastly different depending on who is affected and how, and whether the satellite represents a legitimate military objective. However, it will not always be clear who the owners and operators of a satellite are, and users of a satellite‘s services may be numerous and not public. Registration of satellites is incomplete23 and current ownership is not necessarily updated in a readily available repository. The identification of a satellite as military or civilian may be deliberately obscured. Or its value as a military asset may change over time; for example, the share of capacity of a commercial satellite used by military customers may wax and wane. A potential adversary‘s satellite may have different or additional missions that are more vital to that adversary than an outsider may perceive. An ASAT attack that creates persistent debris could result in significant collateral damage to a wide range of other actors; unlike terrestrial attacks, these consequences are not limited geographically, and could harm other users unpredictably. In 2015, the Pentagon‘s annual wargame**,** or simulated conflict, involving space assets focused on a future regional conflict. The official report out24warnedthatit was hard to keep the conflict contained geographically when using anti-satellite weapons: As the wargame unfolded, a regional crisis quickly escalated, partly because of the interconnectedness of a multi-domain fight involving a capable adversary. The wargame participants emphasized the challenges in containing horizontal escalation once space control capabilities are employedto achieve limited national objectives. Lack of shared understanding of consequences/proportionalityStates havefairly similar understandings of the implications of military actions on the ground, in the air, and at sea,built over decades of experience. The United States and the Soviet Union/Russia have built some shared understanding of each other‘s strategic thinking on nuclear weapons, though this is less true for other states with nuclear weapons. But in the context of nuclear weapons, there is an arguable understanding about the crisis escalation based on the type of weapon (strategic or tactical) and the target (counterforce—against other nuclear targets, or countervalue—against civilian targets). Because of a lack of experience in hostilities that target space-based capabilities, it is not entirely clear what the proper response to a space activity is and where the escalation thresholds or “red lines” lie. Exacerbating this is the asymmetry in space investments; not all actors will assign the same value to a given target or same escalatory nature to different weapons.

#### Nuclear war causes extinction.

Starr ’17 (Steven; director of the University of Missouri’s Clinical Laboratory Science Program, senior scientist at the Physicians for Social Responsibility, Associate member of the Nuclear Age Peace Foundation, expert in the environmental consequences of nuclear war; 1/9/17; “Turning a Blind Eye Towards Armageddon — U.S. Leaders Reject Nuclear Winter Studies”; <https://fas.org/2017/01/turning-a-blind-eye-towards-armageddon-u-s-leaders-reject-nuclear-winter-studies/>; Federation of American Scientists; accessed 11/24/18; TV) [AV]

The detonation of an atomic bomb with this explosive power will **instantly ignite fires** over a surface area of three to five square miles. In the recent studies, the scientists calculated that the **blast**, **fire**, and **radiation** from a war fought with 100 atomic bombs could produce **direct fatalities** comparable to all of those worldwide in World War II, or to those once estimated for a “**counterforce**” **nuclear war** between the superpowers. However, the **long-term environmental effects** of the war **could** significantly disrupt the global weather for at least a decade, which would likely **result in** a vast **global famine**. The scientists predicted that **nuclear firestorms** in the burning cities would cause at least five million tons of **black carbon smoke** to quickly rise above cloud level into the stratosphere, where it could not be rained out. The smoke would circle the Earth in **less than two weeks** and would form **a** global **stratospheric smoke layer** that **would remain for** more than **a decade**. The smoke would absorb warming sunlight, which would **heat the smoke** to temperatures near the boiling point of water, producing **ozone losses of** 20 to **50 percent** over populated areas. This would almost double the amount of UV-B reaching the most populated regions of the mid-latitudes, and it would create UV-B indices unprecedented in human history. In North America and Central Europe, the time required to get a painful sunburn at mid-day in June could decrease to as little as six minutes for fair-skinned individuals. As the smoke layer blocked warming sunlight from reaching the Earth’s surface, it would produce the **coldest** average **surface temperatures** in the last 1,000 years. The scientists calculated that global **food production would decrease** by 20 to **40 percent** during a five-year period following such a war. Medical experts have predicted that the shortening of growing seasons and corresponding decreases in agricultural production could cause up to **two billion** people to perish from **famine**. The climatologists also investigated the effects of a nuclear war fought with the vastly more powerful modern **thermonuclear** weapons possessed by the United States, Russia, China, France, and England. Some of the thermonuclear weapons constructed during the 1950s and 1960s were 1,000 times more powerful than an atomic bomb. During the last 30 years, the average size of thermonuclear or “strategic” nuclear weapons has decreased. Yet today, each of the approximately 3,540 strategic weapons deployed by the United States and Russia is seven to **80 times** more powerful than the atomic bombs modeled in the India-Pakistan study. The smallest strategic nuclear weapon has an explosive power of **100,000 tons of TNT**, compared to an atomic bomb with an average explosive power of 15,000 tons of TNT. Strategic nuclear weapons produce much larger nuclear firestorms than do atomic bombs. For example, a standard Russian 800-kiloton warhead, on an average day, will ignite fires covering a surface area of 90 to 152 square miles. A **war** fought with hundreds or thousands of U.S. and Russian strategic nuclear weapons would **ignite immense** **nuclear firestorms** covering land surface areas of many thousands or **tens of thousands** of square miles. The scientists calculated that these fires would produce up to **180 million tons** of black carbon soot and **smoke**, which would form a dense, **global stratospheric smoke layer**. The smoke would remain in the stratosphere for 10 to **20 years**, and it **would block** as much as **70 percent of sunlight** from reaching the surface of the Northern Hemisphere and 35 percent from the Southern Hemisphere. So much sunlight would be blocked by the smoke that the noonday sun would resemble a full moon at midnight. Under such conditions, it would only require a matter of days or weeks for daily minimum **temperatures** to **fall below freezing** in the largest agricultural areas of the Northern Hemisphere, where freezing temperatures would occur every day for a period of between one to more than two years. Average surface temperatures would become colder than those experienced 18,000 years ago at the height of the last Ice Age, and the prolonged cold would cause average rainfall to decrease by up to 90%. Growing seasons would be completely eliminated for more than a decade; it would be **too cold and dark** to grow food crops, **which would doom the** majority of the **human population.** NUCLEAR WINTER IN BRIEF The profound cold and darkness following nuclear war became known as nuclear winter and was first predicted in 1983 by a group of NASA scientists led by Carl Sagan. During the mid-1980s, a large body of research was done by such groups as the Scientific Committee on Problems of the Environment (SCOPE), the World Meteorological Organization, and the U.S. National Research Council of the U.S. National Academy of Sciences; their work essentially supported the initial findings of the 1983 studies. The idea of nuclear winter, published and supported by prominent scientists, generated extensive public alarm and put political pressure on the United States and Soviet Union to reverse a runaway nuclear arms race, which, by 1986, had created a global nuclear arsenal of more than 65,000 nuclear weapons. Unfortunately, this created a backlash among many powerful military and industrial interests, who undertook an extensive media campaign to brand nuclear winter as “bad science” and the scientists who discovered it as “irresponsible.” Critics used various uncertainties in the studies and the first climate models (which are primitive by today’s standards) as a basis to criticize and reject the concept of nuclear winter. In 1986, the Council on Foreign Relations published an article by scientists from the National Center for Atmospheric Research, who predicted drops in global cooling about half as large as those first predicted by the 1983 studies and described this as a “nuclear autumn.”

## Framing – Short

#### The standard is maximizing expecting well being.

#### 1] Util is a lexical pre-requisite to any other framework: Threats to life preclude the ability for moral actors to effectively utilize and act upon other moral theories since they are in a constant state of crisis – that inhibits the ideal moral conditions which other theories presuppose.

#### 2] Extinction matters under any framework:

#### ---A] It precludes the possibility of any kind of moral value – we can’t confer value onto anything if we’re not alive.

#### ---B] Future generations means infinite magnitude – we have to look towards future lives too

#### ---C] Moral uncertainty means you should err towards preserving your ability to decide what is moral – that means preventing extinction

#### 3] Only pleasure and pain are intrinsically valuable – all other frameworks collapse.

Moen 16 [Ole Martin Moen, Research Fellow in Philosophy at University of Oslo “An Argument for Hedonism” Journal of Value Inquiry (Springer), 50 (2) 2016: 267–281]

Let us start by observing, empirically, that a widely shared judgment about intrinsic value and disvalue is that pleasure is intrinsically valuable and pain is intrinsically disvaluable. On virtually any proposed list of intrinsic values and disvalues (we will look at some of them below), pleasure is included among the intrinsic values and pain among the intrinsic disvalues. This inclusion makes intuitive sense, moreover, for there is something undeniably good about the way pleasure feels and something undeniably bad about the way pain feels, and neither the goodness of pleasure nor the badness of pain seems to be exhausted by the further effects that these experiences might have. “Pleasure” and “pain” are here understood inclusively, as encompassing anything hedonically positive and anything hedonically negative.2 The special value statuses of pleasure and pain are manifested in how we treat these experiences in our everyday reasoning about values. If you tell me that you are heading for the convenience store, I might ask: “What for?” This is a reasonable question, for when you go to the convenience store you usually do so, not merely for the sake of going to the convenience store, but for the sake of achieving something further that you deem to be valuable. You might answer, for example: “To buy soda.” This answer makes sense, for soda is a nice thing and you can get it at the convenience store. I might further inquire, however: “What is buying the soda good for?” This further question can also be a reasonable one, for it need not be obvious why you want the soda. You might answer: “Well, I want it for the pleasure of drinking it.” If I then proceed by asking “But what is the pleasure of drinking the soda good for?” the discussion is likely to reach an awkward end. The reason is that the pleasure is not good for anything further; it is simply that for which going to the convenience store and buying the soda is good.3 As Aristotle observes: “We never ask [a man] what his end is in being pleased, because we assume that pleasure is choice worthy in itself.”4 Presumably, a similar story can be told in the case of pains, for if someone says “This is painful!” we never respond by asking: “And why is that a problem?” We take for granted that if something is painful, we have a sufficient explanation of why it is bad. If we are onto something in our everyday reasoning about values, it seems that pleasure and pain are both places where we reach the end of the line in matters of value.