## 1

### PIC

#### Text: The appropriation of outer space by private entities is unjust, with the exception of the development and deployment of O’Neill Cylinders. States should divert additional funds to development of the O’Neill Cylinder.

#### O’Neill Cylinders are on the way, but funding and companies like SpaceX and Blue Origin are key because governments are insufficient.

Kanchwalla 11-13-21

Hussain Kanchwalla (scholar at the indian institute of technology), 11-13-2021, "What is an O’Neill Cylinder?," Science ABC, https://www.scienceabc.com/nature/universe/what-is-oneill-cylinder.html, // HW AW

Many people believe that the Earth will soon be in danger and the sprawling nature of humanity is the undeniable cause. With the rapid [technological progress](https://www.scienceabc.com/nature/universe/what-is-kardashev-scale.html) and advancement of the past few centuries, we’re quickly exhausting the resources from planet Earth in order to power our industrial needs and global commerce. Many futurists feel that we will be left with no option but to explore and colonize space if we intend to survive into a future when resources on Earth can no longer meet our requirements. [Overpopulation is an imminent challenge](https://www.scienceabc.com/humans/malthusian-catastrophe-shortage-of-food-sources-population-explosion.html) that makes the need for interstellar travel and colonization even more urgent. That being said, [**building a space habitat**](https://www.scienceabc.com/nature/universe/can-we-build-a-habitable-planet-from-scratch.html) **is no easy pursuit and is loaded with daunting challenges, such as the need for construction facilities in space, the recreation of livable communities in space, the recycling and processing of waste, the simulation of artificial gravity, and most importantly—convincing governments and global organizations that this venture is worth pursuing.** The prospect of space colonization paves the way for devising methods to extract energy from resources on other planets. On Earth, harnessing energy from the Sun using [solar panels](https://www.scienceabc.com/innovation/why-is-there-a-limit-to-the-efficiency-of-solar-panels.html) isn’t particularly efficient, and faces inevitable barriers caused by the atmosphere and the daily occurrence of darkness (e.g., nighttime). However, in space, solar constructs can perpetually harness energy from the Sun without interruption. Utilizing this copious amount of energy would permit us to travel throughout our solar system without worrying about energy expenditure. Moreover, chemical resources would be in great supply in our solar system. To begin with, NASA has recently embarked on a project to generate fuel, water, and oxygen from resources present on the Moon. Given these foundations for why organizations should foray into developing a space habitat, allow me to introduce the **O’Neill cylinder—a space settlement design consisting of two counter-rotating cylinders** proposed by renowned physicist Gerard O’Neill a few decades ago. Aside from being a physicist, O’Neill was also a professor at Princeton University and a space enthusiast. Although he is most widely acclaimed for his work in physics, where he developed new concepts to explore particle physics at higher energies, his work on space colonization turned out to be his truly long-lasting legacy. Origin of the Idea for the O’Neill Cylinder While teaching physics to his students at Princeton University, O’Neill assigned them the task of designing a megastructure in space in order to demonstrate that living and surviving in space is actually a possibility. His students came up with numerous designs to accommodate human habitation in space. After a long session of brainstorming, O’Neill boiled their theories down to the idea of a cylinder-like space settlement design. Later, additional details and the functioning of this design were published in Physics Today in 1974; the cylinder was aptly called the O’Neill cylinder. Design of the O’Neill Cylinder The O’Neill cylinder design consists of two cylinders rotating in opposite directions on a [bearing](https://www.scienceabc.com/eyeopeners/what-is-a-bearing.html) to mitigate the gyroscopic effect. Each cylinder was proposed to be 20 miles long and 5 miles in diameter, with 6 broad stripes along its length (3 habitable spaces and 3 windows). O’Neill envisioned industrial processes and recreational facilities to be located on the central axis in a virtually zero-gravity environment. Gravity Simulation One key difference between living on Earth and living in space (or on any other astronomical body) is the difference in gravity. [Artificial gravity](https://www.scienceabc.com/innovation/can-create-artificial-gravity.html) is needed for stability, and the O’Neill cylinder has a provision to achieve exactly that. As the two giant cylinders rotate on their axis, they would leverage the centripetal force of any object in the inner surface to create artificial gravity. Considering the cylinder’s dimensions, the acceleration equation: a=v²/r, and substituting the acceleration value of Earth (i.e., 9.81), we can deduce that the cylinder would need to rotate roughly 28 times per hour to simulate an appropriate gravitational force. Earthly Environment Simulation Maintaining an atmosphere with a constitution similar to that of Earth is the next challenge when building a space habitation. The O’Neill cylinder is prudently designed with a ratio of gases similar to what is found on Earth. However, there is a caveat; the pressure is half of that at sea level. This would not impact our breathing substantially, but this minor trade-off would translate into a handful of benefits, such as bringing down the need for gas and the construction of thick walls. The proposed O’Neill cylinder also has provisions wherein the habitat would be able to control its own micro-climate using an arrangement of mirrors and by altering the ratio of gases in the cylinder. Day and Night Simulation With the human habitat situated in a vacuum (space), the cylinder essentially turns into a huge thermos! The theoretical O’Neill cylinder tried to overcome this issue by using a series of mirrors hinged on each of the three windows. This way, direct sunlight could be directed into the cylinder to simulate day time. Similarly, by turning the mirror away, a night-like ambience could be created. This simulated ‘night’ would also permit the heat produced biologically to radiate out of the cylinder. **Despite the design of the O’Neill cylinder being technically sound, the idea is too sophisticated to be implemented with our present technology**. Thus far, its implementation has been confined to the realm of science fiction. However, **given the efforts of organizations like SpaceX and Mars One, perhaps some day O’Neill cylinders will actually help humanity settle in the great vastness of space!**

#### **This permanently solves extinction, which outweighs the affirmative.**

Haynes 19, 5/17, Korey "O’Neill colonies: A decades-long dream for settling space," Astronomy, https://astronomy.com/news/2019/05/oneill-colonies-a-decades-long-dream-for-settling-space Top of Form

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Last week, Amazon founder Jeff Bezos revealed his spaceship company’s new lunar lander, dubbed Blue Moon, and he spelled out a bold and broad vision for humanity’s future in space. Faced with the limits of resources here on Earth, most fundamentally energy, he pointed to life in space as a solution. “If we move out into the solar system, for all practical purposes, we have unlimited resources,” Bezos said. “We could have a trillion people out in the solar system.” And while colonies on other planets would be plagued by low gravity, long distances to Earth (leading to communication delays), and further limits down the road, those weaknesses are avoided if the colonies remain truly in space. To that end, Bezos instead suggested people consider taking up residence in O’Neill colonies, a futuristic concept for space settlements first dreamed up decades ago. “These are very large structures, miles on end, and they hold a million people or more each.” Gerard O’Neill was a physicist from Princeton University who teamed up with NASA in the 1970s on a series of workshops that explored efficient ways for humans to live off-world. Beyond influencing Bezos, his ideas have also deeply affected how many space experts and enthusiasts think about realistic ways of living in space. “What will space colonies be like?” O’Neill once asked the Space Science Institute he founded. “First of all, there’s no point in going out into space if the future that we see there is a sterile future of living in tin cans. We have to be able to recreate, in space, habitats which are as beautiful, as Earth-like, as the loveliest parts of planet Earth — and we can do that.” Of course, neither O’Neill nor anyone since has actually made such a habitat, but in many ways, the concepts he helped developed half a century ago remain some of the most practical options for large-scale and long-term space habitation. While NASA has mostly focused on exploring the moon and Mars in recent years, O’Neill colonies offer an option untethered to any planetary body. Instead, people would live in enormous circular structures in space that would be capable of hosting many thousands of people — or even millions according to Bezos — on a permanent basis. You may have seen these kinds of colonies in science fiction, from Star Trek, to the movie Interstellar. But in real life, researchers have thought up a a few variations: either a sphere, a cylinder, or a ring-shaped torus. All of these are designed to rotate and create a centrifugal force that mimics gravity for the inhabitants. While the sizes and specifications of the colonies vary, there are a few staples. In general, O’Neill colonies were designed to be permanent, self-sustaining structures. That means they would use solar power for electrical energy and for growing crops. The outer walls of an O’Neill colony are generally pictured as a transparent material, so that mirrors can aim sunlight through its walls as needed to provide light and energy – or to allow darkness, a feature humans also need, especially while we sleep. But building these colonies is a challenge beyond any humans have accomplished so far in space, and Bezos acknowledged that. He referred to two “gates” in his announcement, which he clarified as challenges that humans need to overcome. The first, which his company Blue Origin and other space entrepreneurs have been tackling, is to reduce the cost and difficulty of getting to space at all. But the second involves using resources from space, rather than hauling them from Earth. Bezos isn’t alone in such thinking. Most of NASA’s long-term plans for the Moon and Mars involve rely on harvesting materials and manufacturing products locally, using lunar and martian regolith to build and repair structures. And in the shorter term, three of the dozen experiments NASA selected as the first to fly as part of the new lunar program — possibly even by the end of the year — are what NASA terms “resource prospecting instruments.” That pairs well with O’Neill’s vision. These colonies are meant to use resources gathered from space, whether asteroids, the Moon, or even Mars. Doing so avoids the costly effort of heaving materials and goods out of Earth’s deep gravity well. That means they would be built using materials available cheaply in space. The humans and their attendant plants and animals would need to be carried from Earth. But raw materials like oxygen, nitrogen and aluminum are plentiful in the solar system, and mining for resources in space is a common theme across space settlement discussions. Because of their size, the colonies should be able to act as fully independent ecosystems, with plants to cycle air and water and resource cycles not so dissimilar from Earth. Humans are a long way from being able to launch anything like an O’Neill colony in the near future. But it’s somewhat telling that, after 50 years

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#### The United States federal government should propose to the Russian Federation and People’s Republic of China the establishment of:

#### - an international “debris credits” trading system that distributes tradeable quotas for debris production and rewards members of the international agreement with additional credits if they implement mitigation protocols.

#### -an international fund collected via a fee upon launch starting at 5% and moving upwards pending international agreement that functions as a partial rebate and victims restitution fund by providing partial compensation to countries who create “debris free” launches and implement post-mission disposal mechanisms as well as providing full compensation to countries in the events of collisions with orbital debris.

#### Debris credits solve the case without having to share SSA data.

Prasad and Lochan 7 [(M.Y.S. Prasad, Space Applications Centre, Indian Space Research Organisation, Ahmedabad, India, and Rajeev Lochan Indian Space Research Organisation, Bangalore, India,) “COMMON BUT DIFFERENTIATED RESPONSIBILITY - A PRINCIPLE TO MAINTAIN SPACE ENVIRONMENT WITH RESPECT TO SPACE DEBRIS” ISBN: 9781563479625, Proceedings of the Fiftieth colloquium on the Law of outer space : 24-28 September 2007, Hyderabad, India] TDI Re-Cut Ethan Yang

Space debris will be a concern for future for all the countries. Especially the developing countries which have limited Space assets will face serious consequences if any of their satellites is involved with incidents / accidents with Space debris. The manned missions of advanced countries requires absolutely high level of crew safety, and hence Space debris is a serious concern to them also. Even a close approach of the debris to the operational satellites may pose problems if the cloud of debris occupies larger volume. From these considerations, it is definitely essential to evolve strategies to limit the growth of Space debris, and also to evolve debris mitigation measures. However the analysis of the Space debris presented in section 4 clearly brought out that the debris population is proportional to the number of launches carried out by each country in the past. Hence larger responsibility lies with the countries which carried out a number of launches in the past. So the maintenance of Space environment from the Space debris point of view is a case well suited for “Common but differentiated responsibility” . In this context this principle means that all countries capable of taking actions are responsible to maintain the Space environment relatively clean with respect to Space debris. Also the countries, which are responsible for the present level of the debris population, should take higher responsibility in respect of limiting the future growth of Space debris, and also in providing knowledge and technology in the areas of Space debris monitoring and mitigation to all countries. In this context various measures can be contemplated for future. One of them had been achieved when UN-COPUOS adopted Space debris mitigation guidelines to be implemented by all countries on voluntary basis through national mechanisms. Different countries have evolved their own national Space debris mitigation standards and regulations to be implemented by the companies involved in aerospace activities in their countries. Still many countries feel that an appropriate legal regime at a global level is essential to tackle the Space debris issue. This is where the models evolved in the Kyoto Protocol can be considered to be tailored and used with appropriate modifications for Space debris legal regime. Some of the new mechanisms which can be derived from the principles of Kyoto Protocol are: • To limit the future Space debris generation, launch quota caps for each Space-faring country can be evolved linked to their past generation of the Space debris. • The countries can be rewarded with “debris credits” in case they implement Space debris mitigation measures in their missions. • Some advanced Space-faring nations may have pressing commitments to carry out larger number of launches. They can be enabled to carry out such missions through purchase of “debris credits” from the other countries, who have earned “debris credits” through application of Space debris mitigation measures. • The countries which do not have any Space activity for the present, but who have plans to develop either Space transportation or deploy satellites in orbit can be given fixed quota of “debris credits”. These credits can lapse after a certain period if they do not realize their Space missions. These countries can also be enabled to market their “debris credits” to the other countries, and benefit by acquiring Space technologies. • A Trust Fund can be created to compensate the victims involved in the accidents with Space debris, to which the contributions can be linked to the debris generated in the past by different countries. This can be a part of larger aspect of Space debris damage liability regime. • Special treatment can be considered for the countries willing to share their knowledge and technology in the area of Space debris with other countries, to take up the research and development to a higher level. Such cooperative ventures can be given special treatment as Joint Implementation Mechanisms to earn “Debris credits”. These are some of the ideas which are derived from the Kyoto Protocol with application to Space debris area. They are not exhaustive but only indicative for friture legal experts to examine while developing Space debris legal regime. 6. CONCLUSIONS This paper describes various multi-lateral initiatives in the area of analysis, and mitigation of Space debris. The specific features related to type of debris and the level of launches and other activities of Space-faring nations are detailed. The innovative mechanisms evolved in the Kyoto Protocol of UN FCCC are described and their applicability for Space debris case is argued. Possible measures which can be fashioned after the Kyoto Protocol are suggested to deal with the Space debris and maintenance of Outer Space environment. All the analysis is based on the conviction that ‘Common but Differentiated Responsibility’ is very well suited for the present Space debris scenario.

#### Global trust fund solves the aff and encourages companies to stay in countries party to the agreement

Pelton 13 [(Dr. Joseph N., Director of the Space and Advanced Communications Research Institute (SACRI) at George Washington University), Space debris and other threats from outer space. New York: Springer. 27-28, 2013] TDI Re-Cut Ethan Yang

The missing element in many of these discussions is how to create the economic wherewithal to address the debris problem and how to create financial incentives to correct the problem. In this section the analysis is directed toward the merits of establishing national, regional and in time perhaps universal agreements to establish economic funds—as well as incentives or penalties—to mitigate the problem. The purpose of such funds would be several fold: (i) to create a rebate system to reward “clean and debris free” launches; (ii) to award a further rebate to reward clean disposal of satellites at the end-of life. Under this approach there would now be clear incentives to get rid of space debris as opposed to the current disincentives and potential liabilities associated with bringing debris and satellites down or into graveyard orbits. The creation of a fund—or perhaps several funds that could grow into a global fund—would create incentives to develop the best technology rather than a single approach that might ultimately prove to be suboptimal. The 20-year sunset for the fund(s) would create a specific goal to complete the mission, and if success is achieved there would not be the additional issue of having to disband an international agency. The fund (or collection of national/regional funds) could be established over time in an “organic manner” with countries forming such a fund on a national basis, or perhaps Europe could form such a fund on a regional basis. This type of national, regional, and in time ultimately universal fund would be formed by space actors for the specific purpose of addressing the space debris issue. This approach would thus become a pro-active “forward looking” approach to financing a solution to the problem rather than seeking a “backwards-looking” approach to addressing space debris with no financing mechanism in place and nations being “coerced” into doing the “right thing”. The money to capitalize this type of space debris fund would be collected prior to all launches and would equivalent to perhaps 3-5 % of the total cost of various space-related missions. Under this approach LEO/polar orbit missions might be required to pay in 5 % of mission costs. MEO and GEO orbit and deep space missions might be asked to pay in a lower amount. This fund would be collected for a period of perhaps 20 years but would have a sunset provision on the premise that migitation of orbital debris could be successfully accomplished over this length of time. Thus there would need to be an active agreement to extend the fund or it would otherwise elapse. Such a fund (or network of funds) would be formed by means of a specific assessment paid into a designated bank account (or space insurance company) prior to launch. This fund would apply to all those deploying spacecraft into Earth orbit, or, if on a national or regional basis, would apply to all launches from that country or region. Organizations launching satellites beyond Earth orbit would also pay into the fund but a lower amount. After each launch there would be a partial rebate, assuming it was a certified as a clean “debris-free” launch as independently verified. When a spacecraft was de-orbited at end of life or successfully placed in a graveyard orbit there would be a further rebate. The size of the “clean launch” and “successful disposal” rebates would be specified at the time the fund(s) were established. Approximately half of the payments into the fund, however, would always be retained to compensate those entities involved in removing “officially designated” debris from orbit or moving defunct space objects to a graveyard orbit. The prime purpose of the national, regional or hopefully, global space debris fund would be to compensate those entities “licensed under an appropriate regulatory framework” to remove debris from Earth orbit or those that develop and operate systems to avoid collisions. This licensing process for entities designated to undertake orbit debris removal or collision avoidance activities might, for example, be formally assigned to the United Nations Office of Outer Space Affairs or in time spelled out in a new international space convention. Other entities might also be “licensed” by the U. N. Office of Outer Space Affairs to undertake activities associated with the prevention of space debris or space debris mediation or collision avoidance activities separate from the active removal of space debris from orbit. Such activities, however, would be limited to no more than a set percentage of the available funds. Payment into this fund would “seem and feel” to satellite operators and governmental space agencies conducting space operations very much like buying launch insurance for a spacecraft mission. Indeed the fund could possibly be administered by launch insurance companies. These payments would be different in that it would only represent about a third of the cost associated with purchasing launch insurance, and rebates would eventually return half of the money paid into the fund. Further, the projected end date for the fund would establish a very real goal for accomplishing “a largely space debris-free world”. The creation of this fund and the rebate payments would reverse the current incentives that actually “encourage” the increase of orbital debris. Under current space law the owners and operators of space objects not only lack an incentive to remove their space debris from orbit; they actually face substantial financial penalties if the removal process somehow adversely affects another space object and creates liabilities which they are compelled to pay. The payments into the fund are actually modest when compared to the damages that will ensue once we reach the Kessler syndrome stage and debris continues to cascade out of control on an exponentially increasing basis. Indeed payments for launch insurance operations over the last three decades have varied from a low of about 6 % of total mission costs to as much as 20 % of total costs. Today typically 15 % of mission costs is for launch insurance. If one considers this wide range of payments for launch insurance and the importance of the long term sustainability of space and safe space access one should consider a 5 % orbital debris fund as not being at all excessive or unreasonable, especially if half of the money is ultimately rebated in the advent of a “clean” launch with upper stage rocket motors and launcher fairings being removed from orbit and the satellite eventually disposed of as well. There would appear to be merit to a flexible “economic fund” approach as opposed to seeking to create a single international agency charged with space debris remediation that would likely focus on a preferred technology and a single approach to debris removal. Licensed international entities, under the fund approach, would not be restricted to a single country. Each country or region that acted first to create orbital debris funds could also give research grants to entities embarked on developing new technology to remove debris from orbit with the latest technology. In short it is believed that there would be “economic and political efficiency” in having a number of licensed commercial entities capable of developing a diversity of innovative technologies to carry out space debris removal. Overall it is believed that the “economic fund” mechanism could help to create all the right incentives: (a) to reward entities for a clean launch of the satellite and removal of upper stage rockets and protective fairing covers from orbit; (b) to reward operators for removing debris properly at end of life; (c) using the “sunset provision” to establish a specific goal to get the job done; (d) using the “fund approach” (or alternatively even a prize approach) that would allow the competitive development of the best and most cost efficient technology and (e) there would be no need to “dismantle” an international agency at the end of the process.

## 3

### DA

#### The US commercial space industry is booming – private space companies are driving innovation

**Lindzon 21** [(Jared Lindzon, A FREELANCE JOURNALIST AND PUBLIC SPEAKER BORN, RAISED AND BASED IN TORONTO, CANADA. LINDZON'S WRITING FOCUSES ON THE FUTURE OF WORK AND TALENT AS IT RELATES TO TECHNOLOGICAL INNOVATION) "How Jeff Bezos and Elon Musk are ushering in a new era of space startups," Fast Company, 2/23/21, https://www.fastcompany.com/90606811/jeff-bezos-blue-origin-elon-musk-spaces-space] TDI

In early February, Jeff Bezos, the founder of Amazon and one of the planet’s wealthiest entrepreneurs, dropped the bombshell announcement that he would be stepping down as CEO to free up more time for his other passions. Though Bezos listed a few targets for his creativity and energy—The Washington Post and philanthropy through the Bezos Earth Fund and Bezos Day One Fund—one of the highest-potential areas is his renewed commitment and focus on his suborbital spaceflight project, Blue Origin.

Before space became a frontier for innovation and development for privately held companies, opportunities were limited to nation states and the private defense contractors who supported them. In recent years, however, billionaires such as Bezos, Elon Musk, and Richard Branson have lowered the barrier to entry. Since the launch of its first rocket, Falcon 1, in September of 2008, Musk’s commercial space transportation company SpaceX has gradually but significantly reduced the cost and complexity of innovation beyond the Earth’s atmosphere. With Bezos’s announcement, many in the space sector are excited by the prospect of those barriers being lowered even further, creating a new wave of innovation in its wake.

“What I want to achieve with Blue Origin is to build the heavy-lifting infrastructure that allows for the kind of dynamic, entrepreneurial explosion of thousands of companies in space that I have witnessed over the last 21 years on the internet,” Bezos said during the Vanity Fair New Establishment Summit in 2016.

During the event, Bezos explained how the creation of Amazon was only possible thanks to the billions of dollars spent on critical infrastructure—such as the postal service, electronic payment systems, and the internet itself—in the decades prior.

“On the internet today, two kids in their dorm room can reinvent an industry, because the heavy-lifting infrastructure is in place for that,” he continued. “Two kids in their dorm room can’t do anything interesting in space. . . . I’m using my Amazon winnings to do a new piece of heavy-lifting infrastructure, which is low-cost access to space.”

In the less than 20 years since the launch of SpaceX’s first rocket, space has gone from a domain reserved for nation states and the world’s wealthiest individuals to everyday innovators and entrepreneurs. Today, building a space startup isn’t rocket science.

THE NEXT FRONTIER FOR ENTREPRENEURSHIP

According to the latest Space Investment Quarterly report published by Space Capital, the fourth quarter of 2020 saw a record $5.7 billion invested into 80 space-related companies, bringing the year’s total capital investments in space innovation to more than $25 billion. Overall, more than $177 billion of equity investments have been made in 1,343 individual companies in the space economy over the past 10 years.

“It’s kind of crazy how quickly things have picked up; 10 years ago when SpaceX launched their first customer they removed the barriers to entry, and we’ve seen all this innovation and capital flood in,” says Chad Anderson, the managing partner of Space Capital. “We’re on an exponential curve here. Every week that goes by we’re picking up the pace.”

#### The plan creates a restriction that encourages companies to move their operations to states with lower standards

Albert 14 [(Caley Albert, J.D. Loyola Marymount University) “Liability in International Law and the Ramifications on Commercial Space Launches and Space Tourism,” Loyola of Los Angeles International and Comparative Law Review, 11/1/14, <https://digitalcommons.lmu.edu/cgi/viewcontent.cgi?article=1708&context=ilr>] TDI

A parallel can be drawn here between the commercial space industry and the maritime law concept of the Flag of Convenience. The term has evolved over time, but in this day and age, it is commonly used to mean the owner of a vessel does not want to create an obligation with a country with stricter standards for registry; hence, the owner will register strictly for economic reasons with a country that has a more convenient registry.133 By flying a Flag of Convenience, ship owners are able to avoid taxation on earnings of ships registered under these flags, and in some cases, they can also receive relief from stricter crew standards and corresponding operating costs.134 A Flag of Convenience is flown by a vessel that is registered in one state, which the vessel has little if any connection to, when in reality the vessel is owned and operated from another state.135 This way the vessel avoids any unfavorable economic requirements from its true home state.136 In this sense, “flag shopping” is similar to “launch forum shopping,” similar in that Flags of Convenience are utilized for economic reasons, such as to avoid high taxes and compliance with certain restrictive international conventions, commercial space companies will forum shop when choosing which country to launch from. As of today, there has yet to be a catastrophic commercial launch incident, so for now commercial space companies do not have an incentive to forum shop, but if there is, the indemnification policies described above may lead companies to seek out countries that provide more coverage so they pay less in the event something goes wrong. This comparison to Flags of Convenience brings up two separate yet equally important issues. First, launch companies may try to follow the Flags of Convenience model and soon catch on to the wisdom of their maritime predecessors by “registering” in countries with more favorable conditions. Of course, in this case the concern is not with registration so much as launching. If launch companies follow the Flags of Convenience model, they will seek out the most convenient state for launch, most likely the state that provides the most liability coverage and has the least safety precautions. Launching from states with low safety standards increases the potential for catastrophic launch events. This, in turn, will place states that are potentially incapable of paying for damages from launch disasters in a position they would not normally assume if these commercial companies had not been drawn to their shores with the promise of more favorable regulations. Second, launch customers may also seek out companies located in states with lower cost liability regimes (lower insurance policy limits) since those companies will presumably charge less to launch their payloads. In this scenario, instead of the launch companies seeking out states with lower liability caps and softer regulations, the launch customers themselves will seek companies located in states with lowcost liability regimes. Here, the effect will be the same as above. Under the Liability Convention, the launching state will be liable for any damage caused by a vehicle launched from within its borders; hence, if customers start engaging in “launch forum shopping,” states will be incentivized to put in place low-cost liability regimes, which in turn will increase the states’ potential payout in the event of a catastrophic launch incident. Looking at the indemnification program the United States has in place in comparison to other countries, it is possible to see how either launch companies or launch customers could engage in “launch forum shopping” when a catastrophic launch incident ever occur. It is also important to keep in mind that various factors go into where a company or customer decides to launch from. A state’s indemnification program is just one factor in this decision. With this in mind, it is clear that if a launch incident did occur in the United States, the commercial launch company would be liable for much more than it would in another country. For instance, why would a commercial space company launch in the United States, where it would be liable up to $500 million and the additional costs that the government would not cover? The argument can be made that a catastrophic space incident has yet to occur, and even if it did, it is unlikely to cost above the $2.7 billion covered by the United States government. Other states like Russia or France, which has the two-tier liability system, would simply cover all claims above the initial insurance, which is much lower than the $500 million mark required by the United States. In that case, the commercial company would never have to pay more than the initial liability insurance. If there ever is a catastrophic commercial space incident in the future, it is easy to see why commercial companies or launch customers might be drawn to “launch forum shop” outside the United States.

#### Maintaining US space dominance requires a homegrown commercial space industry – private companies offshoring gives China the advantage they need

**Cahan and Sadat 21** [(Bruce Cahan, J.D) (Dr. Mir Sadat, ) "US Space Policies for the New Space Age: Competing on the Final Economic Frontier," based on Proceedings from State of the Space Industrial Base 2020 Sponsored by United States Space Force, Defense Innovation Unit, United States Air Force Research Laboratory, 1/6/21, https://www.politico.com/f/?id=00000177-9349-d713-a777-d7cfce4b0000] TDI

Today, China’s commercial space sector is in its infancy but is set to grow with continued national and provincial support, which have been rapidly increasing over the past three years.64 Since 2004, the United States and China accounted for 74% of the $135.2 billion venture capital (VC) invested in commercial space. 65 The early 2020s are pivotal, as it would be far cheaper for China and Chinese commercial space firms to acquire space technologies from the United States or allied nation companies seeking revenues or facing cashflow constraints, than to build the companies and their teams and technologies from scratch in China. The tight coupling of Chinese military goals and an economy organized to achieve those goals magnifies the economic threats and market disruptions that the United States must immediately address, in order for DoD and national security operations to rely on US commercial space capabilities.

3. ISSUES AND CHALLENGES

Peaceful Uses of Space and Space Exploration Space has been primarily a shared, not a warfighting, domain.67 With each passing second of Planck time,68 space enables a modern way of life, provides instantaneous global imagery, assures telecommunications, and captures humanity’s imagination for civil space exploration. As a result, space is a burgeoning marketplace and territory for commercial ventures and investors. Strengthening the US commercial space industrial base is vital to and beyond US national security. Civil space activities are a source of US “soft power” in global commerce, cooperation, and investment. 69 The civil space sector, led by NASA, is fundamental to America’s national security. 70 NASA is on an ambitious critical path to return to the Moon by 2024,71 along with developing the capabilities and infrastructure for a sustained lunar presence. NASA’s lunar plans provide a lunar staging area for missions to Mars and beyond. They offer a strategic and economic presence for the United States on the Moon. Congress, the White House, DoD, and NASA must recognize that economic and strategic dominance in service of national security requires catalyzing and accelerating growth of a vibrant, private US industrial and cultural expansion into the Solar System. Human visitation and eventual settlement beyond the Earth require sustaining visionary leaders, aided by, and aiding, US national security. A recurring theme in US policy is “maintaining and advancing United States dominance and strategic leadership in space” because US global competitors and adversaries are competent and capable of outpacing American space capabilities. 72 The stakes are high: At this historic moment, there is a real race for dominance over cislunar access and resources.   
Regulations Should Foster US Commercial Space as a National Asset   
Leveraging the reimagination and disruption of terrestrial industries, the US commercial space industry is pushing the frontiers of the United States and global space economics and capabilities. A pre-COVID19 assessment by the US Chamber of Commerce projected that the US space market will increase from approximately $385 billion in 2020, to at least $1.5 trillion by 2040. 73 This projection represents a seven percent (7%) annual compound average growth rate (CAGR), driven largely by expanded business opportunities in Low Earth Orbit (LEO). Total addressable market (TAM) for US commercial space companies could be far larger were they to have federal and financial support for initiating cislunar space operations and opportunities. Recent advancements in commercial space technologies and business models have driven down costs and unlocked new areas of economic growth and space capabilities that outpace and de-risk acquiring capabilities through traditional US government economic development, research and development (R&D), procurement and regulatory policies and processes. US regulations must ensure that US companies lead in commercial space. In specific, technological advances that lower access costs and expand space mission capabilities, content, continuity, and redundancies must be fully supported by or incorporated into US government programs, budgets, requirements, and acquisition processes. Until commercial space offerings are fully incorporated, and federal acquisition policies and personnel commit to innovation, US government fiscal buying power, intelligence and program support will lag and remain inadequate in comparison to US private sector companies and the nation’s global competitors and adversaries in space.

Addressing COVID-19’s Impact on US Commercial Space The COVID-19 pandemic damaged and still challenges the US space industrial base. US domestic investors’ funding of space R&D remains inconsistent across the lifecycle of New Space companies and the spectrum of technologies necessary to grow the space economy. To date, public R&D, government procurements and visionary space entrepreneurs have played a major role in establishing and funding the New Space industrial base. In the last five years, $11 billion of private capital has been invested.74 Traditional private investors may become reluctant to fund space technologies due to perceptions of higher risk over longer time horizons before receiving profitable returns on their capital. Institutional and long-horizon investors who manage patient capital have an appetite for illiquid, but higher yielding, terrestrial alternative asset investments such as commodities, private equity limited partnerships and real estate.75 The COVID-19 pandemic has created economic uncertainties making the New Space’s funding model unreliable. COVID-19 significantly impacted venture capital (VC)-backed companies: the pace of VC space investments fell 85% between April - June, as compared to January – March, in 2020. 76 Pre-COVID-19, the New Space industrial base confronted multiple challenges in raising later stages of venture capital such as (1) the lag between having an early-stage startup with an idea and commercializing a viable revenue-generating product, (2) the lack of market liquidity for founder and private equity space investments to attract and retain talented teams, and (3) the lack of a market to re-sell contracts for space goods and services when customers buy more capacity than needed. Even prior to the COVID-19 pandemic, federal financing of US R&D was at a historically minor level, as compared to businesses and universities.77 US government support for basic research has steadily declined as a percent of GDP. The federal government will experience near- to medium-term budget constraints.78 The vibrant venture community in the United States has taken up a portion of this slack by increasing R&D investment in later-stage and applied research. However, founding teams and VC financing rely on government to fund earlier R&D for basic science and engineering. Therefore, government must resume the sustainable and impactful past levels of support for basic research, an essential role in the space economy’s public-private partnership that ensures US leadership in space.

Space as Existential Terrain for National Security  
  
In this Digital Era, space integrates and drives all elements of US national security. The Cold War may be over, but since the early 2010s, a renewed era of great power competition has emerged across terrestrial land, air, sea, and cyber domains. This competition extends into space, where a great game ensues.79 Space is no longer an uncontested or sanctuary domain. Competent and capable global competitors and peer adversaries are challenging US military, commercial, and civil space interests. The United States, along with its allies and partners, has had to accept and anticipate that space may be a warfighting domain, as suggested primarily by Russian and Chinese counter-space capabilities, military operations, and declarative statements. On December 20, 2019, the bipartisan National Defense Authorization Act (NDAA) for Fiscal Year 202080 authorized the creation of the US Space Force, under the Department of the Air Force, to secure US national interests in an increasingly contested domain.81 Back in October 1775, the Continental Congress established the US Navy to ensure that commercial and government fleets could freely navigate the Atlantic coastline - today, that includes the South China Sea. Likewise, the USSF’s mission is to ensure unfettered access to and the freedom to operate in space. The 2017 National Security Strategy considers space to be a “priority domain.”82 Freedom of navigation is a sovereign right that nations have fought to achieve and defend. 83 The USSF’s main role is to organize, train and equip, as well as to protecting US space interests and supporting terrestrial and joint warfighters (e.g., US Space Command). Thus, USSF must secure US national interests in space, whether military, commercial, scientific, civil, or enhancing US competitiveness for cislunar leadership.

#### US space dominance prevents global war

**Zubrin 15** [(Robert Zubrin, president of Pioneer Energy, a senior fellow with the Center for Security Policy) “US Space Supremacy is Now Critical,” Space News, 1/22/15, <https://spacenews.com/op-ed-u-s-space-supremacy-now-critical/>] TDI

The United States needs a new national security policy. For the first time in more than 60 years, we face the real possibility of a large-scale conventional war, and we are woefully unprepared. Eastern and Central Europe is now so weakly defended as to virtually invite invasion. The United States is not about to go to nuclear war to defend any foreign country. So deterrence is dead, and, with the German army cut from 12 divisions to three, the British gone from the continent, and American forces down to a 30,000-troop tankless remnant, the only serious and committed ground force that stands between Russia and the Rhine is the Polish army. It’s not enough. Meanwhile, in Asia, the powerful growth of the Chinese economy promises that nation eventual overwhelming numerical force superiority in the region. How can we restore the balance, creating a sufficiently powerful conventional force to deter aggression? It won’t be by matching potential adversaries tank for tank, division for division, replacement for replacement. Rather, the United States must seek to totally outgun them by obtaining a radical technological advantage. This can be done by achieving space supremacy.To grasp the importance of space power, some historical perspective is required. Wars are fought for control of territory. Yet for thousands of years, victory on land has frequently been determined by dominance at sea. In the 20th century, victory on both land and sea almost invariably went to the power that controlled the air. In the 21st century, victory on land, sea or in the air will go to the power that controls space. The critical military importance of space has been obscured by the fact that in the period since the United States has had space assets, all of our wars have been fought against minor powers that we could have defeated without them. Desert Storm has been called the first space war, because the allied forces made extensive use of GPS navigation satellites. However, if they had no such technology at their disposal, the end result would have been just the same. This has given some the impression that space forces are just a frill to real military power — a useful and convenient frill perhaps, but a frill nevertheless. But consider how history might have changed had the Axis of World War II possessed reconnaissance satellites — merely one of many of today’s space-based assets — without the Allies having a matching capability. In that case, the Battle of the Atlantic would have gone to the U-boats, as they would have had infallible intelligence on the location of every convoy. Cut off from oil and other supplies, Britain would have fallen. On the Eastern front, every Soviet tank concentration would have been spotted in advance and wiped out by German air power, as would any surviving British ships or tanks in the Mediterranean and North Africa. In the Pacific, the battle of Midway would have gone very much the other way, as the Japanese would not have wasted their first deadly airstrike on the unsinkable island, but sunk the American carriers instead. With these gone, the remaining cruisers and destroyers in Adm. Frank Jack Fletcher’s fleet would have lacked air cover, and every one of them would have been hunted down and sunk by unopposed and omniscient Japanese air power. With the same certain fate awaiting any American ships that dared venture forth from the West Coast, Hawaii, Australia and New Zealand would then have fallen, and eventually China and India as well. With a monopoly of just one element of space power, the Axis would have won the war. But modern space power involves far more than just reconnaissance satellites. The use of space-based GPS can endow munitions with 100 times greater accuracy, while space-based communications provide an unmatched capability of command and control of forces. Knock out the enemy’s reconnaissance satellites and he is effectively blind. Knock out his comsats and he is deaf. Knock out his navsats and he loses his aim. In any serious future conventional conflict, even between opponents as mismatched as Japan was against the United States — or Poland (with 1,000 tanks) is currently against Russia (with 12,000) — it is space power that will prove decisive. Not only Europe, but the defense of the entire free world hangs upon this matter. For the past 70 years, U.S. Navy carrier task forces have controlled the world’s oceans, first making and then keeping the Pax Americana, which has done so much to secure and advance the human condition over the postwar period. But should there ever be another major conflict, an adversary possessing the ability to locate and target those carriers from space would be able to wipe them out with the push of a button. For this reason, it is imperative that the United States possess space capabilities that are so robust as to not only assure our own ability to operate in and through space, but also be able to comprehensively deny it to others. Space superiority means having better space assets than an opponent. Space supremacy means being able to assert a complete monopoly of such capabilities. The latter is what we must have. If the United States can gain space supremacy, then the capability of any American ally can be multiplied by orders of magnitude, and with the support of the similarly multiplied striking power of our own land- and sea-based air and missile forces be made so formidable as to render any conventional attack unthinkable. On the other hand, should we fail to do so, we will remain so vulnerable as to increasingly invite aggression by ever-more-emboldened revanchist powers. This battle for space supremacy is one we can win. Neither Russia nor China, nor any other potential adversary, can match us in this area if we put our minds to it. We can and must develop ever-more-advanced satellite systems, anti-satellite systems and truly robust space launch and logistics capabilities. Then the next time an aggressor commits an act of war against the United States or a country we are pledged to defend, instead of impotently threatening to limit his tourist visas, we can respond by taking out his satellites, effectively informing him in advance the certainty of defeat should he persist. If we desire peace on Earth, we need to prepare for war in space.

## 4

### DA

#### Mega-Constellations generates next-level weather forecasting.

Erwin 20 Sandra Erwin 10-14-2020 "SpaceX to explore ways to provide weather data to U.S. military" <https://spacenews.com/spacex-to-explore-ways-to-provide-weather-data-to-u-s-military/> (Sandra Erwin writes about military space programs, policy, technology and the industry that supports this sector. She has covered the military, the Pentagon, Congress and the defense industry for nearly two decades as editor of NDIA’s National Defense Magazine and Pentagon correspondent for Real Clear Defense.)//Elmer

The $2 million contract is to “assess the feasibility and long term viability of a ‘weather data as a service business model.” WASHINGTON — SpaceX is looking at ways it could provide weather data to the U.S. military. The company is working under a $2 million six-month study contract from the U.S. Space Force’s Space and Missile Systems Center. Charlotte Gerhart, chief of the Space and Missile Systems Center Production Corps Low Earth Orbit Division, said in a statement to SpaceNews that SpaceX received the contract in July from SMC’s Space Enterprise Consortium. The contract is to “assess the feasibility and long term viability of a ‘weather data as a service business model,’” said Gerhart. SpaceX did not respond to questions from SpaceNews on how the company would leverage the Starlink internet constellation to provide weather data. The contract awarded to SpaceX is part of a Space Force program called Electro Optical/Infrared Weather System (EO/IR EWS). The consortium in June awarded $309 million in contracts to Raytheon Technologies, General Atomics Electromagnetic Systems, and Atmospheric & Space Technology Research Associates to develop weather satellite prototypes and payloads. SpaceX won the portion of the EO/IR EWS program that is looking at how weather data could be purchased as a service from a commercial company. “The EWS program goal remains to provide a more resilient and higher refresh capability, enhancing global terrestrial weather capability,” said Gerhart. The SpEC consortium was created in 2017 to attract commercial space businesses to work with the military. The contracts awarded by SpEC are known as “other transaction authority” deals that are used for research projects and prototyping. The consortium on Oct. 8 informed its members that SpaceX had won the weather study contract. “The Air Force is pursuing a space-based environmental monitoring EO/IR system in a multi phased approach,” the SpEC said in an email to members. The EO/IR EWS program is looking at a future proliferated low-Earth orbit constellation to focus on cloud characterization and theater weather imagery that could be supplemented by commercial services. SpaceX’s contract is for the “weather data as a service system architecture exploration phase,” said SpEC. Industry sources speculated that SpaceX could provide weather data collected by sensors hosted on its own Starlink satellites, or it could team with a weather data services company and use Starlink to distribute the data to customers. One executive noted that both the U.S. military and the National Oceanic and Atmospheric Administration have growing demands for data that can be provided at relatively low cost from companies that operate proliferated LEO systems.

#### Solves climate change.

Taylor-Smith 21 Kerry Taylor-Smith 3-25-2021 "What Role can Advanced Weather Forecasting have in Providing Climate Crisis Solutions?" <https://www.azocleantech.com/article.aspx?ArticleID=1193> (Pursuing a passion for science, Kerry completed a degree in Natural Sciences at the University of Bath; where she studied a range of topics, including chemistry, biology, and environmental sciences. Her passion for writing grew as she worked on the university newspaper as a contributor, feature editor, and editor.)//Elmer

Humankind is in the midst of a climate crisis, battling to prevent global temperatures from rising while also keeping up with the energy demands of a growing population. Weather-related disasters cost billions of dollars each year, but it is not just the financial cost that should be considered – there is the loss of life, homes, wildlife, and infrastructure. There are several ways weather monitoring can help solve the climate crisis, from lowing transportation emissions to pinpointing extreme weather events such as wildfires and extraordinary variations in temperature. Tackling Emissions Global travel and shipping contribute significantly to global warming. Aircraft, ships, cars – nearly all modes of transportation emit harmful greenhouse gases, notably carbon dioxide, but also nitrous and sulfur oxides as well as particulates. These greenhouse gases trap heat in the Earth’s atmosphere, causing an overall warming effect and a negative impact on our climate. Aviation accounts for 2.4% of all anthropogenic carbon dioxide emissions, with international flights in 2019 producing 915 million tons of the gas. Weather forecasting technology providing accurate, real-time data on meteorological conditions can help airlines adjust routes to avoid headwinds or take advantage of favorable winds, both of which can help reduce fuel consumption and emissions. Shipping is one of the most fuel-efficient means of transport, but also one of the most polluting, contributing 3% of all greenhouse gas emissions - a figure expected to almost double by 2050. “Burning bunker fuel accounts for almost 90% of global sulfur emissions and the 15 largest ships in the world produce more sulfur each year than all cars put together,” states Renny Vandewege, Vice President of Weather Operations at DTN, a company providing decision support tools and forecast insights across many sectors. Shipping discharges a large and growing source of noxious gas but the sector has the potential to drastically cut emissions through fuel-saving techniques. Among the most promising is weather routing. “Using weather information and analytics can help mitigate risks today caused by climate change and can also reduce emissions further reducing future impacts”, explains Vandewege, a former director of the Broadcast Meteorology Program at Mississippi State University. Weather analytics can optimize routes and “reduce emissions up to 4% and reduce fuel consumption up to 10%, depending on the type of vessel, the season, and the conditions,” states Vandewege. “If there’s bad weather ahead, sophisticated algorithms that use information about the ship and its capabilities and the weather effects on that specific ship can make numerous calculations and provide optimal route alternatives for the mariner.” Extreme Weather Events Advanced weather forecasting alerts us to the probability of extreme meteorological events occurring. While these events are largely unpredictable, accurate meteorological data can identify hotspots where they are likely to occur. The better the data, the better prepared the general public and authorities can be. Wildfires have ravaged the US state of California and huge swathes of land in Australia. Climate change is responsible for the increasing intensity and occurrence of blazes, not just here, but worldwide. It has created the optimal conditions for wildfires to start, including warmer weather, less precipitation, dryer vegetation, and stronger winds. Advanced weather forecasting, such as DTN’s live Geographic Information System (GIS) can monitor atmospheric conditions to evaluate wildfire risk and predict areas where conditions are just right for a wildfire to ignite. “Fire weather forecasting uses atmospheric conditions to evaluate wildfire risk,” explains Vendewege. “Meteorologists can also use their tools and experience to identify the specific location of wildfires. Sophisticated imaging systems can show fire locations in real time, allowing for a live look at the conditions using a GIS layer service containing the latest fire hotspot data and also showing the likelihood of a fire.” Machine learning, a means of artificial intelligence, can also be used in conjunction with current forecasting methods to predicts heat waves or cold snaps. These extreme weather events are the result of unusual atmospheric patterns that researchers from Rice University realized could be taught to a pattern recognition program. The technology, designed to work with current analog forecasting systems rather than replace them, could predict events with 80% accuracy, five days before the event occurred. Although only proof-of-concept, the technology could provide an early warning about when and where an extreme weather event might occur. Conclusion Humans are heavily reliant on the weather; it has a role in every aspect of our lives, from feeding us to providing power for our ever-growing needs. Climate change has warmed the planet and altered our weather, making extreme weather events such as droughts and floods more likely. High-tech weather forecasting technology can help in the fight against climate change by monitoring meteorological conditions to aid decision making, whether that be in the aviation or shipping industry, or by helping us understand and predict natural hazards and disasters, allowing us to reduce the risk of adverse events – and the costs, environmental, economic or otherwise.

#### Climate change causes extinction.

Dr. Peter Kareiva 18 – Ph.D. in Ecology and Applied Mathematics from Cornell University, Director of the Institute of the Environment and Sustainability at UCLA, Pritzker Distinguished Professor in Environment & Sustainability at UCLA, et al., September 2018, “Existential Risk Due To Ecosystem Collapse: Nature Strikes Back”, Futures, Volume 102, p. 39-50

In summary, six of the nine proposed planetary boundaries (phosphorous, nitrogen, biodiversity, land use, atmospheric aerosol loading, and chemical pollution) are unlikely to be associated with existential risks. They all correspond to a degraded environment, but in our assessment do not represent existential risks. However, the three remaining boundaries (climate change, global freshwater cycle, and ocean acidification) do pose existential risks. This is because of intrinsic positive feedback loops, substantial lag times between system change and experiencing the consequences of that change, and the fact these different boundaries interact with one another in ways that yield surprises. In addition, climate, freshwater, and ocean acidification are all directly connected to the provision of food and water, and shortages of food and water can create conflict and social unrest.

Climate change has a long history of disrupting civilizations and sometimes precipitating the collapse of cultures or mass emigrations (McMichael, 2017). For example, the 12th century drought in the North American Southwest is held responsible for the collapse of the Anasazi pueblo culture. More recently, the infamous potato famine of 1846–1849 and the large migration of Irish to the U.S. can be traced to a combination of factors, one of which was climate. Specifically, 1846 was an unusually warm and moist year in Ireland, providing the climatic conditions favorable to the fungus that caused the potato blight. As is so often the case, poor government had a role as well—as the British government forbade the import of grains from outside Britain (imports that could have helped to redress the ravaged potato yields).

Climate change intersects with freshwater resources because it is expected to exacerbate drought and water scarcity, as well as flooding. Climate change can even impair water quality because it is associated with heavy rains that overwhelm sewage treatment facilities, or because it results in higher concentrations of pollutants in groundwater as a result of enhanced evaporation and reduced groundwater recharge. Ample clean water is not a luxury—it is essential for human survival. Consequently, cities, regions and nations that lack clean freshwater are vulnerable to social disruption and disease.

Finally, ocean acidification is linked to climate change because it is driven by CO2 emissions just as global warming is. With close to 20% of the world’s protein coming from oceans (FAO, 2016), the potential for severe impacts due to acidification is obvious. Less obvious, but perhaps more insidious, is the interaction between climate change and the loss of oyster and coral reefs due to acidification. Acidification is known to interfere with oyster reef building and coral reefs. Climate change also increases storm frequency and severity. Coral reefs and oyster reefs provide protection from storm surge because they reduce wave energy (Spalding et al., 2014). If these reefs are lost due to acidification at the same time as storms become more severe and sea level rises, coastal communities will be exposed to unprecedented storm surge—and may be ravaged by recurrent storms.

A key feature of the risk associated with climate change is that mean annual temperature and mean annual rainfall are not the variables of interest. Rather it is extreme episodic events that place nations and entire regions of the world at risk. These extreme events are by definition “rare” (once every hundred years), and changes in their likelihood are challenging to detect because of their rarity, but are exactly the manifestations of climate change that we must get better at anticipating (Diffenbaugh et al., 2017). Society will have a hard time responding to shorter intervals between rare extreme events because in the lifespan of an individual human, a person might experience as few as two or three extreme events. How likely is it that you would notice a change in the interval between events that are separated by decades, especially given that the interval is not regular but varies stochastically? A concrete example of this dilemma can be found in the past and expected future changes in storm-related flooding of New York City. The highly disruptive flooding of New York City associated with Hurricane Sandy represented a flood height that occurred once every 500 years in the 18th century, and that occurs now once every 25 years, but is expected to occur once every 5 years by 2050 (Garner et al., 2017). This change in frequency of extreme floods has profound implications for the measures New York City should take to protect its infrastructure and its population, yet because of the stochastic nature of such events, this shift in flood frequency is an elevated risk that will go unnoticed by most people.

4. The combination of positive feedback loops and societal inertia is fertile ground for global environmental catastrophes.

Humans are remarkably ingenious, and have adapted to crises throughout their history. Our doom has been repeatedly predicted, only to be averted by innovation (Ridley, 2011). However, the many stories of human ingenuity successfully addressing existential risks such as global famine or extreme air pollution represent environmental challenges that are largely linear, have immediate consequences, and operate without positive feedbacks. For example, the fact that food is in short supply does not increase the rate at which humans consume food—thereby increasing the shortage. Similarly, massive air pollution episodes such as the London fog of 1952 that killed 12,000 people did not make future air pollution events more likely. In fact it was just the opposite—the London fog sent such a clear message that Britain quickly enacted pollution control measures (Stradling, 2016). Food shortages, air pollution, water pollution, etc. send immediate signals to society of harm, which then trigger a negative feedback of society seeking to reduce the harm.

In contrast, today’s great environmental crisis of climate change may cause some harm but there are generally long time delays between rising CO2 concentrations and damage to humans. The consequence of these delays are an absence of urgency; thus although 70% of Americans believe global warming is happening, only 40% think it will harm them (http://climatecommunication.yale.edu/visualizations-data/ycom-us-2016/). Secondly, unlike past environmental challenges, the Earth’s climate system is rife with positive feedback loops. In particular, as CO2 increases and the climate warms, that very warming can cause more CO2 release which further increases global warming, and then more CO2, and so on. Table 2 summarizes the best documented positive feedback loops for the Earth’s climate system. These feedbacks can be neatly categorized into carbon cycle, biogeochemical, biogeophysical, cloud, ice-albedo, and water vapor feedbacks. As important as it is to understand these feedbacks individually, it is even more essential to study the interactive nature of these feedbacks. Modeling studies show that when interactions among feedback loops are included, uncertainty increases dramatically and there is a heightened potential for perturbations to be magnified (e.g., Cox, Betts, Jones, Spall, & Totterdell, 2000; Hajima, Tachiiri, Ito, & Kawamiya, 2014; Knutti & Rugenstein, 2015; Rosenfeld, Sherwood, Wood, & Donner, 2014). This produces a wide range of future scenarios.

Positive feedbacks in the carbon cycle involves the enhancement of future carbon contributions to the atmosphere due to some initial increase in atmospheric CO2. This happens because as CO2 accumulates, it reduces the efficiency in which oceans and terrestrial ecosystems sequester carbon, which in return feeds back to exacerbate climate change (Friedlingstein et al., 2001). Warming can also increase the rate at which organic matter decays and carbon is released into the atmosphere, thereby causing more warming (Melillo et al., 2017). Increases in food shortages and lack of water is also of major concern when biogeophysical feedback mechanisms perpetuate drought conditions. The underlying mechanism here is that losses in vegetation increases the surface albedo, which suppresses rainfall, and thus enhances future vegetation loss and more suppression of rainfall—thereby initiating or prolonging a drought (Chamey, Stone, & Quirk, 1975). To top it off, overgrazing depletes the soil, leading to augmented vegetation loss (Anderies, Janssen, & Walker, 2002).

Climate change often also increases the risk of forest fires, as a result of higher temperatures and persistent drought conditions. The expectation is that forest fires will become more frequent and severe with climate warming and drought (Scholze, Knorr, Arnell, & Prentice, 2006), a trend for which we have already seen evidence (Allen et al., 2010). Tragically, the increased severity and risk of Southern California wildfires recently predicted by climate scientists (Jin et al., 2015), was realized in December 2017, with the largest fire in the history of California (the “Thomas fire” that burned 282,000 acres, https://www.vox.com/2017/12/27/16822180/thomas-fire-california-largest-wildfire). This catastrophic fire embodies the sorts of positive feedbacks and interacting factors that could catch humanity off-guard and produce a true apocalyptic event. Record-breaking rains produced an extraordinary flush of new vegetation, that then dried out as record heat waves and dry conditions took hold, coupled with stronger than normal winds, and ignition. Of course the record-fire released CO2 into the atmosphere, thereby contributing to future warming.

Out of all types of feedbacks, water vapor and the ice-albedo feedbacks are the most clearly understood mechanisms. Losses in reflective snow and ice cover drive up surface temperatures, leading to even more melting of snow and ice cover—this is known as the ice-albedo feedback (Curry, Schramm, & Ebert, 1995). As snow and ice continue to melt at a more rapid pace, millions of people may be displaced by flooding risks as a consequence of sea level rise near coastal communities (Biermann & Boas, 2010; Myers, 2002; Nicholls et al., 2011). The water vapor feedback operates when warmer atmospheric conditions strengthen the saturation vapor pressure, which creates a warming effect given water vapor’s strong greenhouse gas properties (Manabe & Wetherald, 1967).

Global warming tends to increase cloud formation because warmer temperatures lead to more evaporation of water into the atmosphere, and warmer temperature also allows the atmosphere to hold more water. The key question is whether this increase in clouds associated with global warming will result in a positive feedback loop (more warming) or a negative feedback loop (less warming). For decades, scientists have sought to answer this question and understand the net role clouds play in future climate projections (Schneider et al., 2017). Clouds are complex because they both have a cooling (reflecting incoming solar radiation) and warming (absorbing incoming solar radiation) effect (Lashof, DeAngelo, Saleska, & Harte, 1997). The type of cloud, altitude, and optical properties combine to determine how these countervailing effects balance out. Although still under debate, it appears that in most circumstances the cloud feedback is likely positive (Boucher et al., 2013). For example, models and observations show that increasing greenhouse gas concentrations reduces the low-level cloud fraction in the Northeast Pacific at decadal time scales. This then has a positive feedback effect and enhances climate warming since less solar radiation is reflected by the atmosphere (Clement, Burgman, & Norris, 2009).

The key lesson from the long list of potentially positive feedbacks and their interactions is that runaway climate change, and runaway perturbations have to be taken as a serious possibility. Table 2 is just a snapshot of the type of feedbacks that have been identified (see Supplementary material for a more thorough explanation of positive feedback loops). However, this list is not exhaustive and the possibility of undiscovered positive feedbacks portends even greater existential risks. The many environmental crises humankind has previously averted (famine, ozone depletion, London fog, water pollution, etc.) were averted because of political will based on solid scientific understanding. We cannot count on complete scientific understanding when it comes to positive feedback loops and climate change.

## 5

### Fw

#### We concede util but death outweighs for 3 reasons –

#### 1] A] You don’t have any wellbeing if we’re all dead B] Reversibility - Someone who died can’t come alive again C] Objectivity- body count is the most objective way to calculate impacts because comparing suffering is unethical

#### Impact calc – extinction outweighs

#### Mathematics

MacAskill 14 [William, Oxford Philosopher and youngest tenured philosopher in the world, Normative Uncertainty, 2014]

The human race might go extinct from a number of causes: asteroids, supervolcanoes, runaway climate change, pandemics, nuclear war, and the development and use of dangerous new technologies such as synthetic biology, all pose risks (even if very small) to the continued survival of the human race.184 And different moral views give opposing answers to question of whether this would be a good or a bad thing. It might seem obvious that human extinction would be a very bad thing, both because of the loss of potential future lives, and because of the loss of the scientific and artistic progress that we would make in the future. But the issue is at least unclear. The continuation of the human race would be a mixed bag: inevitably, it would involve both upsides and downsides. And if one regards it as much more important to avoid bad things happening than to promote good things happening then one could plausibly regard human extinction as a good thing.For example, one might regard the prevention of bads as being in general more important that the promotion of goods, as defended historically by G. E. Moore,185 and more recently by Thomas Hurka.186 One could weight the prevention of suffering as being much more important that the promotion of happiness. Or one could weight the prevention of objective bads, such as war and genocide, as being much more important than the promotion of objective goods, such as scientific and artistic progress. If the human race continues its future will inevitably involve suffering as well as happiness, and objective bads as well as objective goods. So, if one weights the bads sufficiently heavily against the goods, or if one is sufficiently pessimistic about humanity’s ability to achieve good outcomes, then one will regard human extinction as a good thing.187 However, even if we believe in a moral view according to which human extinction would be a good thing, we still have strong reason to prevent near-term human extinction. To see this, we must note three points. First, we should note that the extinction of the human race is an extremely high stakes moral issue. Humanity could be around for a very long time: if humans survive as long as the median mammal species, we will last another two million years. On this estimate, the number of humans in existence in the The future, given that we don’t go extinct any time soon, would be 2×10^14. So if it is good to bring new people into existence, then it’s very good to prevent human extinction. Second, human extinction is by its nature an irreversible scenario. If we continue to exist, then we always have the option of letting ourselves go extinct in the future (or, perhaps more realistically, of considerably reducing population size). But if we go extinct, then we can’t magically bring ourselves back into existence at a later date. Third, we should expect ourselves to progress, morally, over the next few centuries, as we have progressed in the past. So we should expect that in a few centuries’ time we will have better evidence about how to evaluate human extinction than we currently have. Given these three factors, it would be better to prevent the near-term extinction of the human race, even if we thought that the extinction of the human race would actually be a very good thing. To make this concrete, I’ll give the following simple but illustrative model. Suppose that we have 0.8 credence that it is a bad thing to produce new people, and 0.2 certain that it’s a good thing to produce new people; and the degree to which it is good to produce new people, if it is good, is the same as the degree to which it is bad to produce new people, if it is bad. That is, I’m supposing, for simplicity, that we know that one new life has one unit of value; we just don’t know whether that unit is positive or negative. And let’s use our estimate of 2×10^14 people who would exist in the future, if we avoid near-term human extinction. Given our stipulated credences, the expected benefit of letting the human race go extinct now would be (.8-.2)×(2×10^14) = 1.2×(10^14). Suppose that, if we let the human race continue and did research for 300 years, we would know for certain whether or not additional people are of positive or negative value. If so, then with the credences above we should think it 80% likely that we will find out that it is a bad thing to produce new people, and 20% likely that we will find out that it’s a good thing to produce new people. So there’s an 80% chance of a loss of 3×(10^10) (because of the delay of letting the human race go extinct), the expected value of which is 2.4×(10^10). But there’s also a 20% chance of a gain of 2×(10^14), the expected value of which is 4×(10^13). That is, in expected value terms, the cost of waiting for a few hundred years is vanishingly small compared with the benefit of keeping one’s options open while one gains new information.

## Case

### AT: OST

There is a loophole in the ost rn that needs to be solved – it just says states must be responsible and that it should benefit everyone not that space appropriation is not allowed – space companies solve extinction so it’s the benefit of all and countries can be responsible

No impact – no card and also we outweigh because we solve extinction

### AT: War

We turn

Also companies don’t lead to tension they lead to competition

Without private appropriation we start a war due to lack of heg wich turns the case

### AT: Debris

#### Physics and math proofs prove no impact.

Cairncross 17 [Duncan Cairncross, Retired Planetary Science Engineer, BSc in Mechanical Engineering from the University of Glasgow, Diploma in Management DMS, Business Administration and Management, General from Teeside University, Former Asset Management Officer for the Gore District Council, “Is the Kessler Syndrome Disputed By Some Scientists?”, Quora, 10/25/2017, https://www.quora.com/Is-the-Kessler-Syndrome-disputed-by-some-scientists

Lets look at some numbers - we are talking LEO - so anything very small will de-orbit itself quite fast from atmospheric drag

These lumps are going the same direction - at similar speeds - as our satellites - so we are not talking about km/sec impacts - just rifle bullet speeds - 300 m/sec at maximum and the vast majority would have much much lower speeds

Everything is in a torus

Altitude 100 km to 300 km, - 1000 km North to 1000 km South - and about 40,000 km long

200 x 2000 x 40,000 = volume 16 billion cubic km -

18,000 Big bits - 100 mm - including 1,200 satellites

750,000 “bullets” - 10 mm

150 million bits 1 mm

Small bits we will ignore as they will not be going fast enough relative to our satellite to cause damage - and they will de-orbit quite fast

So one “bullet” for every 21,000 cubic km

That does not sound like too dangerous a neighborhood!

What happens if start some sort of cascade?

There is not much to cascade - 18,000 - “big bits” - if each of them became 1000 “bullets” then we would have 18 million “bullets” + the existing 750,000 bullets

And that is erring on the generous side - these bits are mostly metallic and metals don’t shatter into lots of 10 mm bits when hit by rifle bullets

That would be one “bullet” for every 853 cubic km AND most of the “bullets” will not actually be going very fast

Some time in the future when we have a lot mor,e as in a 100,000 times as much stuff in orbit then the Kessler Syndrome may be possible

If you are worried about communication satellites way up there in geostationary orbit then the situation is even better - there is a LOT more space up there and we have boosted a lot less junk up to those orbits

It is worth tracking the big bits and making sure that most satellites are safely de-orbited? - YES

But worrying about a Kessler Syndrome? - no not really

#### Long timeframe and squo solves

Kurt 15 [Joseph Kurt, JD- William & Mary School of Law, BA-Marquette University, NOTE: TRIUMPH OF THE SPACE COMMONS: ADDRESSING THE IMPENDING SPACE DEBRIS CRISIS WITHOUT AN INTERNATIONAL TREATY, 40 Wm. & Mary Envtl. L. & Pol'y Rev. 305 (2015)]

A. Practical Considerations: Feasible Solutions to the Space Debris Problem Are on Their Way

One key question in assessing whether an international treaty is a requisite for solving the space debris problem is just how difficult it will be to fashion a remedy. The more complex and costly are feasible solutions, the more likely it is that a comprehensive regime is necessary to bind the various actors together. 93Link to the text of the note

A good place to begin is to determine just how imminent is the onset of the cascade of exponentially more frequent debris-creating collisions, known as the Kessler Syndrome. 94Link to the text of the note To be certain, no one can be sure--this phenomenon being subject to highly complex probabilities. 95Link to the text of the note Indeed, experts' estimates of when such a cascade will become irreversible vary [\*316] widely. 96Link to the text of the note The National Research Council produced a report in 2011 that suggested that "space might be just 10 or 20 years away from severe problems." 97Link to the text of the note In fact, the cascading effect has already begun, albeit at a modest pace. 98Link to the text of the note However, Donald Kessler, who first described the eponymous effect in 1978, has significantly recalibrated his own outlook over the years. 99Link to the text of the note Originally, Kessler predicted that catastrophe would result by the year 2000. 100Link to the text of the note That date long passed, Kessler now speaks of a century-long process that "we have time to deal with." 101Link to the text of the note

Nevertheless, few would disagree with Cristophe Bonnal of the Centre National d'Études Spatiales ("CNES"), the French space agency, who says that it is "not yet clear" how much time we have to act. 102Link to the text of the note None of this is to say that interested parties should not act with great dispatch to address the space debris problem. Even if catastrophe is not on the immediate horizon--as some have suggested--Heiner Klinkrad, the European Space Agency's leading authority on space debris points out that "[t]he longer you wait, the more difficult and far more expensive" any solution will be. 103Link to the text of the note

The additional slack in plausible timelines is cause for optimism when one considers the progress being made towards remediating the problem of space debris. Such remediation entails a three-pronged approach: preventive measures to reduce the creation of new debris, 104Link to the text of the note space debris tracking technologies, 105Link to the text of the note and active debris removal ("ADR"). 106Link to the text of the note

In an effort to address the first prong, the United Nations General Assembly in 2007 endorsed the COPUOS Space Debris Mitigation Guidelines. 107Link to the text of the note The recommended measures include design changes which would [\*317] avoid the previously common practice of releasing debris during standard operations, refraining from intentional destruction of space objects, and limiting the risk of collisions through avoidance maneuvers and delaying launch times. 108Link to the text of the note As the COPUOS document points out, many of these practices had already been adopted by spacefaring nations. 109Link to the text of the note

Compliance with the COPUOS Mitigation Guidelines is voluntary and has not been universal; 110Link to the text of the note however, many nations do take steps beyond those called for in the Mitigation Guidelines, recognizing the importance of redressing the issue. 111Link to the text of the note That said, even if no nation ever again launched a single object into outer space, the operation of the Kessler Syndrome would ensure that, over time, continuing collisions amongst already present objects would result in Earth's orbit being rendered unusable. 112Link to the text of the note

Improvements in space debris tracking technology are another partial solution that promises to help actors avoid collisions by identifying orbital debris in the path of satellites or spacecraft. 113Link to the text of the note There are limits on the effectiveness of such tracking, however, including the inability of some optical systems to track objects at night. 114Link to the text of the note Moreover, commonly employed systems cannot continually track objects smaller than thirty centimeters in diameter. 115Link to the text of the note New systems are being developed, however, that will use lasers that can track the location of objects as small as a softball--sometimes to within one meter. 116Link to the text of the note Such technology is still at the planning stage for NASA, 117Link to the text of the note but Lockheed Martin is teaming up with an Australian-based company on a laser-tracking project already in the works. 118Link to the text of the note Another promising development comes from scientists at the Massachusetts Institute of Technology, who are working on soccer-ball-sized robots [\*318] designed to travel alongside the ISS, investigating potentially harmful space debris along the way. 119Link to the text of the note

But while tracking space debris can help avoid specific accidents, and thus slow the machinations of the Kessler Syndrome, only ADR can stabilize the space environment. 120Link to the text of the note

Fortunately, the targets for ADR that scientists believe will allow us to forestall an irreversible cascade of collisions are relatively modest. 121Link to the text of the note The most common estimate is that removing five to ten large pieces of debris per year is enough to keep the Kessler Syndrome at bay. 122Link to the text of the note And even more encouraging is that a broad array of national and private actors are exploring a plethora of ADR methods. 123Link to the text of the note For example, the Japanese hope to deploy, by 2019, a magnetic net that will draw pieces of space debris down to the Earth's atmosphere, where they will burn up. 124Link to the text of the note Such use of the atmosphere to incinerate debris is a common element of many ADR strategies, whether they employ nets, harpoons, tentacles, or ion thrusters to impact the debris. 125Link to the text of the note Meanwhile, a German Space Agency program is developing the means to robotically capture satellites. 126Link to the text of the note Other solutions include using enormous puffs of air, static electricity, or lasers to throw objects out of orbit. 127Link to the text of the note

Obviously, such projects carry a hefty price tag, but funding is coming in from a variety of sources. 128Link to the text of the note A laser-based project being developed by Australian National University, for example, received $ 20 million from the Australian government and an additional $ 130 million from NASA and other international public and private actors. 129Link to the text of the note But even these sums [\*319] are dwarfed by the $ 2 billion that Russia's leading space corporation, Energia, is investing in a nuclear-powered pod that it hopes to deploy by 2023. 130Link to the text of the note This pod will fly around space for fifteen years, knocking debris out of the atmosphere using an ion drive. 131Link to the text of the note

That substantial investments in ADR technologies have seemingly put us on the cusp of possessing the technology to stabilize the space environment significantly undermines claims that incentives to solve the orbital debris problem are lacking because of its nature as a "tragedy of the commons". 132Link to the text of the note Successful implementation of a solution is still years away--and can't be presumed. But taken together with the fact that we likely have a decades-long window to redress the problem, 133Link to the text of the note Col. Joseph Imburgia's 2011 warning that "a binding international agreement is needed to provide stability and order . . . and to preserve mankind's access to and through space" looks less and less prescient. 134Link to the text of the note

#### No impact:

#### They don’t care about a downed satellite

Bowen 18 [Bleddyn Bowen, Lecturer in International Relations at the University of Leicester. The Art of Space Deterrence. February 20, 2018. https://www.europeanleadershipnetwork.org/commentary/the-art-of-space-deterrence/]

Space is often an afterthought or a miscellaneous ancillary in the grand strategic views of top-level decision-makers. A president may not care that one satellite may be lost or go dark; it may cause panic and Twitter-based hysteria for the space community, of course. But the terrestrial context and consequences, as well as the political stakes and symbolism of any exchange of hostilities in space matters more. The political and media dimension can magnify or minimise the perceived consequences of losing specific satellites out of all proportion to their actual strategic effect.