## Aff – Space Exploration

### Util

#### Pleasure and pain are intrinsically valuable. People consistently regard pleasure and pain as good reasons for action, despite the fact that pleasure doesn’t seem to be instrumentally valuable for anything.

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, <https://link.springer.com/article/10.1007/s10790-015-9506-9>] TDI

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.**

#### Moral uncertainty means preventing extinction should be our highest priority.

Bostrom 12 [(Nick Bostrom, Faculty of Philosophy & Oxford Martin School University of Oxford) “Existential Risk Prevention as Global Priority.” Global Policy, 2012] TDI

These reflections on moral uncertainty suggest an alternative, complementary way of looking at existential risk; they also suggest a new way of thinking about the ideal of sustainability. Let me elaborate.¶ Our present understanding of axiology might well be confused. We may not now know — at least not in concrete detail — what outcomes would count as a big win for humanity; we might not even yet be able to imagine the best ends of our journey. If we are indeed profoundly uncertain about our ultimate aims, then we should recognize that there is a great option value in preserving — and ideally improving — our ability to recognize value and to steer the future accordingly. Ensuring that there will be a future version of humanity with great powers and a propensity to use them wisely is plausibly the best way available to us to increase the probability that the future will contain a lot of value. To do this, we must prevent any existential catastrophe.

#### Actor specificity:

#### A] Governments must aggregate since every policy benefit some and harms others, which also means side constraints freeze action.

#### B] States lack wills or intentions since policies are collective actions.

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#### C] Actor-specificity comes first since different agents have different ethical standings.

#### Consequences first — anything else is irresponsible and escapes valuable discussions.

**Bracey 06** (Christopher A. Bracey 6, Associate Professor of Law, Associate Professor of African & African American Studies, Washington University in St. Louis, September, Southern California Law Review, 79 S. Cal. L. Rev. 1231, p. 1318)

Second, reducing conversation on race matters to an ideological contest allows opponents to elide inquiry into whether the results of a particular preference policy are desirable. Policy positions masquerading as principled ideological stances create the impression that a racial policy is not simply a choice among available alternatives, but the embodiment of some higher moral principle. Thus, the "principle" becomes an end in itself, without reference to outcomes. Consider the prevailing view of colorblindness in constitutional discourse. Colorblindness has come to be understood as the embodiment of what is morally just, independent of its actual effect upon the lives of racial minorities. This explains Justice Thomas's belief in the "moral and constitutional equivalence" between Jim Crow laws and race preferences, and his tragic assertion that "Government cannot make us equal [but] can only recognize, respect, and protect us as equal before the law." [281](http://web.lexis-nexis.com/universe/document?_m=cd9713b340d60abd42c2b34c36d8ef95&_docnum=9&wchp=dGLbVzz-zSkVA&_md5=9645fa92f5740655bdc1c9ae7c82b328) For Thomas, there is no meaningful difference between laws designed to entrench racial subordination and those designed to alleviate conditions of oppression. Critics may point out that colorblindness in practice has the effect of entrenching existing racial disparities in health, wealth, and society. But in framing the debate in purely ideological terms, opponents are able to avoid the contentious issue of outcomes and make viability determinations based exclusively on whether racially progressive measures exude fidelity to the ideological principle of colorblindness. Meaningful policy debate is replaced by ideological exchange, which further exacerbates hostilities and deepens the cycle of resentment.

### AC – Inherency

#### Currently, entrepreneurs are pushing for privatization of space travel with increasing success

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

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

### AC – Exploration Advantage

#### Space exploration is essential to the survival of humanity. Two impacts—

#### First, colonization—

#### It solves a litany of existential threats – don’t put all your eggs in one basket.

Fitzgerald 3/9 [(Shanon, Assistant Websites Editor at Liberty Fund), “Why Human Space Exploration Matters,” March 9 2021, https://www.econlib.org/why-human-space-exploration-matters/] TDI

While the yields to space exploration and the development of spaceflight technology may appear minimal in the immediate future, shifting our perspective to the longer term renders the human situation vis a viz space exploration extremely clear: if humans want to survive in perpetuity, we need to establish ourselves on other planets in addition to Earth. It is as simple as that. And yet we are not doing all that much to make that happen. To be clear, I’m long on Earth, too, and hope that technological improvements will continue to allow our species to get “more from less” right here on the third rock from the sun, enabling us to keep occupying the planet that saw us evolve into consciousness. I like to imagine that the distant future on Earth has the potential to be an extremely pleasant one, as advances in our scientific understanding and bio-technical praxis should hopefully allow our descendants to clean up any of the remaining messes previous generations will have left behind (e.g., nuclear and industrial waste, high amounts of atmospheric carbon, other lingering nasties) and stable-state free societies will hopefully allow all persons (or very nearly all persons) to live free and meaningful lives in productive community and exchange with their fellows. As the previous qualification highlights, the trickiest problems here on Earth and extending to wherever humans end up in the spacefaring age will still be social and political, and their successful resolution will depend more on the future state of our governing arts than our hard sciences. But regarding the negative events that could very well happen to Earth I think we all need to be equally clear: life might not make it here. There is no guarantee that it will, and in the very long run, with the expansion and subsequent death of our sun, we know with near certainty that it will not. Consider just a few possible extinction-level events that could strike even earlier: large meteors, supervolcanic eruptions, drastic climactic disruption of the “Snowball Earth” variety. As SpaceX founder and Tesla CEO Elon Musk recently observed on the Joe Rogan Experience podcast, “A species that does not become multiplanetary is simply waiting around until there is some extinction event, either self-inflicted or external.” This statement, applied to the human species, is obviously true on its face. As doomsday events go a giant asteroid might be more shocking, since we (people living today) have never experienced one before while concerned atomic scientists warn us about the nuclear bomb all the time, but the odds that we blow ourselves up are still there. Slim, but there. It’s more plausible that a severe nuclear war and the nuclear winter it would likely trigger would leave the human population greatly reduced as opposed to completely extinct, but then the question becomes: why is that a risk we would want to take? The bomb is here to stay for now, but there is no reason that 100% of known life in the universe needs to stay here on Earth to keep it company, waiting around for something even more destructive to show up. While we’re on that happy subject: Do you have any good intuitions about our collective chances against hostile, or simply arrogant or domineering, technologically-advanced extraterrestrial lifeforms, if and/or when they decide to pay us a visit on our home turf? These scary situation sketches will suffice. At bottom, the core reason I am a believer in the need to make life—and not just human life—multiplanetary is the same basic reason I would never counsel a friend to keep all their money and valuables in one place: diversification is good. Wisdom and experience suggest we store precious resources in multiple safe(ish) places. Diversification limits our exposure to risk, and increases our resilience when bad things do happen. One reserve gets hit, two or three others survive, and you probably feel that the effort to spread things out was worth it. What I’m saying here has strong undercurrents of common sense, yet our approach to the human population itself—the universal store and font of “human capital”—does not currently prioritize diversification to the degree our technological capabilities would allow. The distribution of the human population, and of almost all human knowledge and works, is overwhelmingly local. (Let us set to one side the possibility that aliens somewhere maintain an archive of captured human information.) Establishing outposts at least as large as those we maintain in Antarctica on the Moon and Mars, or other more suitable sites, by the end of this century would be a great first step toward genuinely diversifying the physical locations of the most precious resources known to us: human consciousness and creativity, human love and human soul, the great works in which all these things are displayed. Add also to this list repositories of scientific knowledge and knowhow, seed reserves, and certain materials necessary to re-start the manufacturing of fundamental technologies. Spreading these goods to a few additional locations within the solar system would be a major species-and-civilization-level accomplishment that all living at the time could feel satisfied by, and even take some pride in. And this is something that we seem to be just on the cusp of being able to do, given our recent and rapid technological advances in rocketry, computers, and materials science and engineering, among other important fields for space exploration and settlement. Quickly the uniplanetary human situation is becoming, if it is not already, one of pure choice.

#### Space col key to innovation,

West 20 Darrell M. West, 8-18-2020, "Five reasons to explore Mars," Brookings, <https://www.brookings.edu/blog/techtank/2020/08/18/five-reasons-to-explore-mars/> TDI

The recent launch of the Mars rover Perseverance is the latest U.S. space mission seeking to understand our solar system. Its [expected arrival at the Red Planet in mid-February](https://www.nytimes.com/2020/07/30/science/nasa-mars-launch.html) 2021 has a number of objectives linked to science and innovation. The rover is equipped with sophisticated instruments designed to search for the remains of ancient microbial life, take pictures and videos of rocks, drill for soil and rock samples, and use a small helicopter to fly around the [Jezero Crater landing spot](https://mars.nasa.gov/resources/22474/jezero-crater-mars-2020s-landing-site/). Mars is a valuable place for exploration because it can be reached in 6 ½ months, is a major opportunity for scientific exploration, and has been mapped and studied for several decades. The mission represents the first step in a long-term effort to bring Martian samples back to Earth, where they can be analyzed for residues of microbial life. Beyond the study of life itself, there are a number of different benefits of Mars exploration. UNDERSTAND THE ORIGINS AND UBIQUITY OF LIFE The site where Perseverance is expected to land is the place where experts believe 3.5 billion years ago held a lake filled with water and flowing rivers. It is an ideal place to search for the residues of microbial life, test new technologies, and lay the groundwork for human exploration down the road. The mission plans to investigate whether microbial life existed on Mars billions of years ago and therefore that life is not unique to Planet Earth. As noted by Chris McKay, a research scientist at NASA’s Ames Research Science Center, that would be an extraordinary discovery. “Right here in our solar system, [if life started twice](https://www.space.com/9329-earth-unique-life-common-universe.html), that tells us some amazing things about our universe,” he pointed out. “It means the universe is full of life. Life becomes a natural feature of the universe, not just a quirk of this odd little planet around this star.” The question of the origins of life and its ubiquity around the universe is central to science, religion, and philosophy. For much of our existence, humans have assumed that even primitive life was unique to Planet Earth and not present in the rest of the solar system, let alone the universe. We have constructed elaborate religious and philosophical narratives around this assumption and built our identity along the notion that life is unique to Earth. If, as many scientists expect, future space missions cast doubt on that assumption or outright disprove it by finding remnants of microbial life on other planets, it will be both invigorating and illusion-shattering. It will force humans to confront their own myths and consider alternative narratives about the universe and the place of Earth in the overall scheme of things. As noted in my Brookings book, [Megachange](https://www.brookings.edu/book/megachange-economic-disruption-political-upheaval-and-social-strife-in-the-21st-century/), given the centrality of these issues for fundamental questions about human existence and the meaning of life, it would represent a far-reaching shift in existing human paradigms. As argued by scientist McKay, discovering evidence of ancient microbial life on Mars would lead experts to conclude that life likely is ubiquitous around the universe and not limited to Planet Earth. Humans would have to construct new theories about ourselves and our place in the universe. DEVELOP NEW TECHNOLOGIES The U.S. space program has been an extraordinary [catalyst for technology innovation](https://www.jpl.nasa.gov/infographics/infographic.view.php?id=11358). Everything from Global Positioning Systems and medical diagnostic tools to wireless technology and camera phones owe at least part of their creation to the space program. Space exploration required the National Aeronautics and Space Administration to learn how to communicate across wide distances, develop precise navigational tools, store, transmit, and process large amounts of data, deal with health issues through digital imaging and telemedicine, and develop collaborative tools that link scientists around the world. The space program has pioneered the miniaturization of scientific equipment and helped engineers figure out how to land and maneuver a rover from millions of miles away. Going to Mars requires similar inventiveness. Scientists have had to figure out how to search for life in ancient rocks, drill for rock samples, take high resolution videos, develop flying machines in a place with gravity that is 40 percent lower than on Earth, send detailed information back to Earth in a timely manner, and take off from another planet. In the future, we should expect large payoffs in commercial developments from Mars exploration and advances that bring new conveniences and inventions to people. ENCOURAGE SPACE TOURISM In the not too distant future, wealthy tourists likely will take trips around the Earth, visit space stations, orbit the Moon, and perhaps even take trips around Mars. For a substantial fee, they can experience weightlessness, take in the views of the entire planet, see the stars from outside the Earth’s atmosphere, and witness the wonders of other celestial bodies. The Mars program will help with space tourism by improving engineering expertise with space docking, launches, and reentry and providing additional experience about the impact of space travel on the human body. Figuring out how weightlessness and low gravity situations alter human performance and how space radiation affects people represent just a couple areas where there are likely to be positive by-products for future travel. The advent of space tourism will [broaden human horizons](https://unitedearth.us/religion-and-spirituality/does-seeing-earth-from-space-alter-your-perspective/) in the same way international travel has exposed people to other lands and perspectives. It will show them that the Earth has a delicate ecosystem that deserves protecting and why it is important for people of differing countries to work together to solve global problems. Astronauts who have had this experience say it has altered their viewpoints and had a profound impact on their way of thinking. FACILITATE SPACE MINING Many objects around the solar system are made of similar minerals and chemical compounds that exist on Earth. That means that some asteroids, moons, and planets could be rich in minerals and rare elements. Figuring out how to [harvest those materials](https://www.sciencefocus.com/space/space-mining-the-new-goldrush/) in a safe and responsible manner and bring them back to Earth represents a possible benefit of space exploration. Elements that are rare on Earth may exist elsewhere, and that could open new avenues for manufacturing, product design, and resource distribution. This mission could help resource utilization through advances gained with its Mars Oxygen Experiment (MOXIE) equipment that converts Martian carbon dioxide into oxygen. If MOXIE works as intended, it would help humans live and work on the Red Planet. ADVANCE SCIENCE One of the most crucial features of humanity is our curiosity about the life, the universe, and how things operate. Exploring space provides a means to satisfy our thirst for knowledge and improve our understanding of ourselves and our place in the universe. Space travel already has exploded centuries-old myths and promises to continue to confront our long-held assumptions about who we are and where we come from. The next decade promises to be an exciting period as scientists mine new data from space telescopes, space travel, and robotic exploration. Ten or twenty years from now, we may have [answers to basic questions](https://www.brookings.edu/book/turning-point/) that have eluded humans for centuries, such as how ubiquitous life is outside of Earth, whether it is possible for humans to survive on other planets, and how planets evolve over time.

#### Nuke war causes extinction – it won’t stay limited

Edwards 17 [(Paul N. Edwards, CISAC’s William J. Perry Fellow in International Security at Stanford’s Freeman Spogli Institute for International Studies. Being interviewed by EarthSky/card is only parts of the interview directly from Paul Edwards.) “How nuclear war would affect Earth’s climate,” EarthSky, September 8, 2017, earthsky.org/human-world/how-nuclear-war-would-affect-earths-climate] TDI

We are not talking enough about the climatic effects of nuclear war. The “nuclear winter” theory of the mid-1980s played a significant role in the arms reductions of that period. But with the collapse of the Soviet Union and the reduction of U.S. and Russian nuclear arsenals, this aspect of nuclear war has faded from view. That’s not good. In the mid-2000s, climate scientists such as Alan Robock (Rutgers) took another look at nuclear winter theory. This time around, they used much-improved and much more detailed climate models than those available 20 years earlier. They also tested the potential effects of smaller nuclear exchanges. The result: an exchange involving just 50 nuclear weapons — the kind of thing we might see in an India-Pakistan war, for example — could loft 5 billion kilograms of smoke, soot and dust high into the stratosphere. That’s enough to cool the entire planet by about 2 degrees Fahrenheit (1.25 degrees Celsius) — about where we were during the Little Ice Age of the 17th century. Growing seasons could be shortened enough to create really significant food shortages. So the climatic effects of even a relatively small nuclear war would be planet-wide. What about a larger-scale conflict? A U.S.-Russia war currently seems unlikely, but if it were to occur, hundreds or even thousands of nuclear weapons might be launched. The climatic consequences would be catastrophic: global average temperatures would drop as much as 12 degrees Fahrenheit (7 degrees Celsius) for up to several years — temperatures last seen during the great ice ages. Meanwhile, smoke and dust circulating in the stratosphere would darken the atmosphere enough to inhibit photosynthesis, causing disastrous crop failures, widespread famine and massive ecological disruption. The effect would be similar to that of the giant meteor believed to be responsible for the extinction of the dinosaurs. This time, we would be the dinosaurs. Many people are concerned about North Korea’s advancing missile capabilities. Is nuclear war likely in your opinion? At this writing, I think we are closer to a nuclear war than we have been since the early 1960s. In the North Korea case, both Kim Jong-un and President Trump are bullies inclined to escalate confrontations. President Trump lacks impulse control, and there are precious few checks on his ability to initiate a nuclear strike. We have to hope that our generals, both inside and outside the White House, can rein him in. North Korea would most certainly “lose” a nuclear war with the United States. But many millions would die, including hundreds of thousands of Americans currently living in South Korea and Japan (probable North Korean targets). Such vast damage would be wrought in Korea, Japan and Pacific island territories (such as Guam) that any “victory” wouldn’t deserve the name. Not only would that region be left with horrible suffering amongst the survivors; it would also immediately face famine and rampant disease. Radioactive fallout from such a war would spread around the world, including to the U.S. It has been more than 70 years since the last time a nuclear bomb was used in warfare. What would be the effects on the environment and on human health today? To my knowledge, most of the changes in nuclear weapons technology since the 1950s have focused on making them smaller and lighter, and making delivery systems more accurate, rather than on changing their effects on the environment or on human health. So-called “battlefield” weapons with lower explosive yields are part of some arsenals now — but it’s quite unlikely that any exchange between two nuclear powers would stay limited to these smaller, less destructive bombs.

#### Privatization of space travel kills off public space exploration.

#### Space exploration must be public-sector – entrepreneurs purposely understate the barriers to colonization, yet exploit its potential for financial gain.

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

He opens the paper with a recognition that, at some point, if we stay on Earth, we will confront an eventual extinction event. “The alternative is to become a spacefaring civilization and a multi-planetary species.” He alights upon Mars as the obvious first option for establishing a “self-sustaining city — a city that is not merely an outpost, but which can become a planet in its own right.” He rejects Venus due to it being, as he correctly puts it, a super-high-pressure, hot acid bath. He rejects Mercury due to it being too close to the Sun, and the Moon for lack of atmosphere and its twenty-eight-day “day” (a Martian day, or “sol,” for comparison, is an Earthling-friendly 24.5 hours). And he rejects, at least for now, the moons of Jupiter or Saturn, as they are much harder to get to. Mars has more than its own share of habitability issues, but Musk does not mention them, other than to say that, while Mars is “a little cold” (in reality, -63ºC, or -81ºF, compared to Earth’s balmy 16ºC, or 57ºF), “we can warm it up.” The Martian atmosphere is “very helpful” because it’s primarily CO2, with some nitrogen and argon, meaning that “we can grow plants on Mars just by compressing the atmosphere.” Most cheery of all, Musk says it would be “quite fun” to be on Mars, because the gravity is about 38 percent that of Earth, making it easy to lift heavy things and “bound around.” Mars, as seen from space. (WikiImages via Pixabay) It’s all so simple. “We just need to change the populations because currently we have seven billion people on Earth and none on Mars.” And so the paper is primarily devoted to explaining how to solve that sole problem: how to lower the cost of a trip to Mars from the current roughly $10 billion per person down to the median cost of a house in the United States. By making rockets reusable, refilling in orbit, producing propellant on Mars, choosing the right propellant, and improving system design and performance, Musk reckons he can get the cost of a ticket down to $200,000, perhaps as little as $100,000. And Musk’s SpaceX has done a tremendous job so far of sharply reducing the cost of escaping Earth’s gravity well, primarily via deep vertical integration of the firm. It produces a whopping 70 percent of its components in-house, as opposed to the 1,200 different suppliers in the outsourced supply chain of its main competitor, the Boeing–Lockheed Martin partnership known as the United Space Alliance. Each of these suppliers extracts their own profit margin from every contract in the chain, jacking up the cost per launch to $460 million. SpaceX, by comparison, charges NASA and its other clients just $62 million per launch, and Musk says he has slashed the marginal cost of a reused Falcon 9 booster launch to a mere $15 million. Well done, Elon. Or, rather, well done to all the engineers, logistical experts, and other workers who have done most of the labor, allowing SpaceX to revolutionize the business model of getting to space. There is not really any mention of the enormous challenges of the atmosphere’s low pressure and toxic composition, the preponderance of deadly perchlorates in the soil, or the lack of magnetosphere to protect against solar and cosmic radiation. The current atmosphere of Mars is too thin to support most life: its pressure is only about 1 percent that of Earth. Only hypopiezotolerant microbes (those that live in low-pressure environments), such as ones that are lofted by winds into Earth’s stratosphere, would be able to survive. The atmosphere is also 95 percent carbon dioxide — fine for plants (if the pressure were able to be raised) but not for animals. Musk does say that once Mars is warmed up, “we would once again have a thick atmosphere and liquid oceans.” Bioremediation using bacteria to clean up perchlorates already occurs on Earth, but we are talking about an entire planet here. There is no discussion of how any of this might happen, over what time period, and who would pay for it. Same with the construction of an artificial magnetosphere. Dealing with the perchlorates alone would likely be profoundly more challenging and expensive than the relatively straightforward process of decarbonizing Earth’s economy. A 2018 NASA study found that there is insufficient CO2 and H2O from the Martian soil, polar ice caps, and minerals in the upper crust to get anywhere close to thickening the atmosphere and using it like a blanket to warm up the planet. All these sources combined would still only boost the pressure to about 7 percent of that of Earth. Carbon-bearing minerals deep in the crust might have enough CO2 to achieve the needed pressure, but nothing is known about their extent, and recovering them with current technology would be colossally energy intensive. Another idea is to direct comets or asteroids to crash into Mars and release their greenhouse gases that way. Again, these are fantastical ideas that will be impractical for many, many generations yet to come. NASA astronauts in space. (NASA) And there is likely no way of ever overcoming Mars’s low gravity. If you added all the mass of Venus to that of Mars, smashing the planets together, even then, you would still not quite achieve Earth’s gravity. It is true that we do not know what the physiological effects of 38 percent of Earth’s gravity are, either on humans or other life. We have two data points: Earth gravity, what we call 1G, and the 0G microgravity of the International Space Station (ISS). But from studies of astronauts who have spent extended periods aboard the ISS, we know that 0G is extremely bad for human health. Muscles atrophy. Tendons and ligaments begin to fail. Facial and finger muscles, which cannot be worked out via onboard gyms or treadmills, weaken. The spine lengthens, with astronauts gaining an inch or two in height and suffering from back pain. Bones demineralize, losing density at a rate of 1 percent per month. As Christopher Wanjek, a former NASA science writer and author of 2020 book Spacefarers — which is an optimistic volume on the viability of manned space travel — notes: “To visualize how bad that bone loss is, consider the fact that the major obstacle to fully recycling urine into drinking water on the ISS is that the filters get clogged daily with calcium deposits.” Wanjek writes how the rate of vision loss is such that a crew to Mars would need to pack eyeglasses with various prescriptions for “each phase of their gradual, inevitable, and permanent vision loss.” Kidneys get confused by blood not being where it’s supposed to be and think there is an excess, so they start to remove what they believe to be excess water. The blood thickens, driving a reduced production of red blood cells, which in turn drives anemia, shortness of breath, lethargy, and greater likelihood of infection. Perhaps worst of all, brain compression resulting from microgravity negatively impacts regions responsible for fine motor movement and executive function — deteriorations that could be permanent. A range of interventions, including exercise, drugs, and compression clothing can shave the sharp edges off some of these effects, but ultimately, the solution on a spacecraft is the simulation of gravity via centrifugal force — a spinning ship. This is not something that you can do with a whole planet. It is for this reason that Venus, with its gravity not too far off that of Earth, may actually be a better terraforming candidate than Mars — one day — despite its currently inhospitable atmosphere. The Real Business of SpaceX Isn’t Mars One has to suspect that Musk knows all this. We have a hint of this when, at one point in his paper, Musk concedes that it will be difficult to fund his vision just by slashing the cost of getting to space. He admits that SpaceX expects to generate substantial cash flow from launching lots of satellites and servicing the International Space Station for NASA. Additional help for bankrolling the Mars project might come from the emergence of a market for really fast transportation of things or people around the world by rocket: cargo could be transported anywhere on Earth in forty-five minutes, and a trip from New York to Tokyo could take a mere twenty-five minutes (so long as takeoff and landing takes place where the tremendous noise, as he puts it in hip-CEO-speak, “is not a super-big deal”). As a result, one gets the impression by reading between the lines that a self-sustaining Martian city is all just an impressive marketing maneuver taking advantage of most people’s sense of adventure and wonder; of our species’ ancient need to wander and explore. The real business of SpaceX was never a Martian colony but rather servicing a mature satellite market, stealing government space contracts from the likes of Boeing, and kicking off a terrestrial rocket transport sector. The dream of Mars is, in this case, not really any different from the adman’s fiction of romance and aspiration that sells a can of Pepsi or a Jeep. The dream of Mars is, in this case, not really any different from the adman’s fiction of romance and aspiration that sells a can of Pepsi or a Jeep. None of this is to suggest that establishing an outpost on Mars for the purposes of scientific exploration should not be attempted, even in the next couple of decades. But an outpost, as Musk himself makes clear, does not approach a self-sustaining city, and still less a multi-planetary species. Because humans do need to exit Earth at some point in order to maintain the species, if we are to establish genuinely self-sustaining colonies, then terraforming will likely be necessary one day, as well as interstellar generation ships that take us to habitable exoplanets far beyond the solar system. For all of this, we will have to figure out how to take our ecology with us. We are not really the collection of individuals we thought we were, but rather are deeply embedded within our ecosystems. Indeed, each of us is a microbial ecosystem whose edges are vague. Where does the bacterial, fungal, and viral multitude that is “me” stop and my equally microbiological environment begin? This does not mean that Earth will be the only home we ever have, but it does mean that the antiseptic, forestless, riverless Starship Enterprise would leave its inhabitants very sick before too long. How much of our ecology do we need to take with us, though? We just don’t know yet. The science of ecology is very much still a young discipline. This is where fantastical science-fiction conceptions of vast ships made from hollowed out asteroids and packed with different biomes fills the gap of what we do not know. Likewise for novels like Becky Chambers’s To be Taught, if Fortunate, in which, instead of terraforming other worlds, adapting them to our needs, we genetically alter our bodies via “somaforming” to adapt ourselves to their conditions. Plainly, then, there is no rush for any of this, even as there is a moral imperative for us, one day in the distant future, to permanently exit Earth. Our colonization of other worlds is akin to the building of the grandest cathedral we have ever envisaged: a project that will take centuries, or more likely millennia, many millennia. This is nothing that a private company can deliver. There is no near-term return on investment; indeed, there is no aim of profitability at all, but rather of our species’ survival through the eons.

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

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

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

#### Second, debris—

#### Commercial rocket launches produce space clutter—increased debris could reach a tipping point

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

“Physics tells us that two things can’t occupy the same space at the same time or else bad things happen,” Jah said dryly. Indeed, there’s already been one collision that produced sprawling orbital pollution. In 2009, a satellite owned by the U.S. firm Iridium slammed into a decommissioned Russian government satellite at more than 26,000 mph. The crash produced 2,300 pieces of debris, spraying off in all directions. And debris is a particularly gnarly problem in space, because when it’s traveling at thousands of miles an hour, even a marble-size chunk is like a bullet, capable of rendering a damaged satellite inoperable and unsteerable—the owner can no longer fire its boosters to guide it into a higher or lower orbit. There are currently an estimated 500,000 marble-size chunks up there. Decades of space travel by governments left plenty of refuse, ranging from parts of rocket boosters to stray bits of scientific experiments. One particularly grim vision of the future that haunts astronomers is the “Kessler syndrome,” proposed by the astrophysicist Donald Kessler in 1978. Kessler hypothesized that space clutter could reach a tipping point: One really bad collision could produce so much junk that it would trigger a chain reaction of collisions. This disaster scenario would leave hundreds of satellites eventually destroyed, and create a ring of debris that would make launching any new satellites impossible, forever. “Near space is finite—it’s a finite resource,” Jah said. “So now you have this growing trash problem that isn’t being remediated.... And if we exceed the capacity of the environment to carry all this traffic safely, then it becomes unusable.” That’s why a growing chorus of critics are already making the case that space is the next major environmental area to protect, after the oceans and land on Earth. “People seem to really treat resources in space as being infinite,” said Erika Nesvold, an astrophysicist who’s the cofounder of The JustSpace Alliance. “As we’ve seen, people don’t really intuitively understand exponential growth.” That’s the dilemma in a nutshell: The available room in the sky is limited, but the plans for growth are exponential. SpaceX isn’t the only New Space firm looking to toss up satellites. Satellite and rocket start-ups are now lining up en masse, atop new waves of investment. There are satellites geared up to connect to “the internet of things” so companies can communicate among proprietary networks of household devices. There are floating cameras pointing down—so as to gather “geospatial intelligence,” which is to say data streamed from “the vantage point you get from satellites looking down on Earth and giving us information about our planet,” as the venture capitalist Anderson told me. And new forms of satellite vision are emerging all the time, such as cameras that can see at night, or are specially designed to see agriculture. Experiments abound, and so satellite launches will inevitably multiply in their wake. Part of what makes near-Earth orbit so chaotic is that it is, at the moment, remarkably unregulated—not unlike the internet of the early ’90s. An American firm has to get permission from the Federal Communications Commission to launch a satellite, but once it’s in orbit, there’s no federal agency that can compel it to move out of the path of a collision. Satellite owners generally don’t like to move if they can avoid it, because their satellites have a limited amount of fuel; any movement decreases their usable lifespan. On top of that, there are dozens of nations shooting satellites into low-Earth orbit—but no international body coordinating their flight paths. Last fall, the European Space Agency realized one of SpaceX’s new Starlink satellites was on a dangerously close path to an ESA satellite. SpaceX said it had no plans to move the satellite; so the ESA decided to fire its thrusters and get clear. This high-stakes negotiation was conducted via email. What’s more, space debris is extremely hard to source. If a British satellite slams into yours, you can probably figure out who hit you. But if your satellite is wrecked by a random piece of junk, nobody has any clue where that debris came from. It is, in this way, a neat parallel to the problem of C02, where a ceaseless barrage of tiny commercial decisions creates a sprawling problem—one that’s all but designed to ensure that everyone who caused it can deny responsibility. And damage is asymmetric: A company with a small $60,000 satellite could smash into a wildly expensive one paid for by U.S. taxpayers. “A National Reconnaissance Office satellite is at least a billion dollars, if not more, so they have a lot more to lose if something hits a satellite,” Bhavya Lal, a researcher at the IDA Science and Technology Policy Institute, noted. “As more private activity starts to happen, there’s more chances of that loss of control, too.” One might dismiss all this anxiety as a sort of sci-fi version of hippie environmentalism—except that even the administrator of NASA is deeply worried about the chaos and destruction likely to be sown by commercial activity in near-Earth orbit. Jim Bridenstine, the Trump-appointed head of NASA, is as pro-market as one can be. He praises SpaceX every chance he gets; he talks about privatizing the space station. But when I asked him about the looming danger of space debris, during a press-conference call, he conceded that it’s a huge, unresolved issue.

#### Space dust wrecks satellites and debris exponentially spirals

Intagliata 17 [(Christopher Intagliata, MA Journalism from NYU, Editor for NPRs All Things Considered, Reporter/Host for Scientific American’s 60 Second Science) “The Sneaky Danger of Space Dust,” Scientific American, May 11, 2017, <https://www.scientificamerican.com/podcast/episode/the-sneaky-danger-of-space-dust/>] TDI

When tiny particles of space debris slam into satellites, the collision could cause the emission of hardware-frying radiation, Christopher Intagliata reports. Aside from all the satellites, and the space station orbiting the Earth, there's a lot of trash circling the planet, too. Twenty-one thousand [baseball-sized chunks](https://www.scientificamerican.com/article/orbital-debris-space-fence/) of debris, [according to NASA](https://www.orbitaldebris.jsc.nasa.gov/faq.html). But that number's dwarfed by the number of small particles. There's hundreds of millions of those. "And those smaller particles tend to be going fast. Think of picking up a grain of sand at the beach, and that would be on the large side. But they're going 60 kilometers per second." Sigrid Close, an applied physicist and astronautical engineer at Stanford University. Close says that whereas mechanical damage—like punctures—is the worry with the bigger chunks, the dust-sized stuff might leave more insidious, invisible marks on satellites—by causing electrical damage. "We also think this phenomenon can be attributed to some of the failures and anomalies we see on orbit, that right now are basically tagged as 'unknown cause.'" Close and her colleague Alex Fletcher modeled this phenomenon mathematically, based on plasma physics behavior. And here's what they think happens. First, the dust slams into the spacecraft. Incredibly fast. It vaporizes and ionizes a bit of the ship—and itself. Which generates a cloud of ions and electrons, traveling at different speeds. And then: "It's like a spring action, the electrons are pulled back to the ions, ions are being pushed ahead a little bit. And then the electrons overshoot the ions, so they oscillate, and then they go back out again.” That movement of electrons creates a pulse of electromagnetic radiation, which Close says could be the culprit for some of that electrical damage to satellites. The study is in the journal Physics of Plasmas. [Alex C. Fletcher and Sigrid Close, [Particle-in-cell simulations of an RF emission mechanism associated with hypervelocity impact plasmas](http://aip.scitation.org/doi/full/10.1063/1.4980833)]

#### Privatized space tourism increases collision risks due to orbital debris.

Tehrani 4/1 [(James, Editor in Chief of Spark Magazine) “Space Junk: A Safety and Sustainability Problem Moving at 18,000 MPH,” April 1, 2021, <https://sphera.com/spark/space-junk-a-safety-and-sustainability-problem-moving-at-18000-mph/>] TDI

Most of the current debris is found in the low Earth orbit (LEO), which is about 600 to 1,200 miles (1,000 to 2,000 kilometers) above the planet. NASA calls LEO an “orbital space junkyard.” The junk isn’t sitting idly in a landfill; it is moving around at speeds up to 18,000 mph (29,000 kph), or 23 times the speed of sound. While the Inter-Agency Space Debris Coordination Committee was designed to coordinate space debris efforts, there are currently no international laws in place regarding removing space debris. Since a single satellite can cost between $50 million and $400 million, the risk of damage from space debris to a satellite is clearly significant. And as more debris is left behind, there is obviously more risk of collisions, especially when space tourism picks up. The orbiting junk was explored in the 2013 film “Gravity,” starring George Clooney and Sandra Bullock; it’s known as the Kessler Effect. Don Kessler, the former NASA scientist who studied space debris even told the Guardian back in 2011 in regard to formulating a plan to deal with space junk: “The longer you wait to do this, the more expensive it’s going to be. … This scenario of increasing space debris will play out even if we don’t put anything else in orbit,” he said. On that point, the European Space Agency has contracted with a Swiss startup called ClearSpace that plans to launch its first mission to remove space debris in 2025. The Gravity of the Situation Without a doubt, space debris is an Operational Risk; even the International Space Station has to dodge space junk at times. Former NASA Administrator Jim Bridenstine even tweeted last September that the “Space Station has maneuvered 3 times in 2020 to avoid debris. In the last 2 weeks, there have been 3 high concern potential conjunctions. Debris is getting worse!” Some of the larger debris that doesn’t burn up re-entering the atmosphere (about one object per day) even crashes back on Earth. Since most of the Earth’s surface is covered in water, it’s not surprisingly that most of the junk winds up in oceans, so the risk to humans is statistically very low. That doesn’t mean nil though. For example, there is debris from Russian Proton rockets that has been found in Siberia, including that of old fuel tanks containing toxic fuel residue, which can be harmful to plants, animals and humans. The environmental risks of space junk need to be explored further. A piece of space junk floating through the ocean is certainly not nearly as concerning as our plastic problem, but it’s nothing to ignore either. LCA Leads the Way Just as more and more companies are assessing the Life Cycle Assessment (LCA) of their products and services from cradle to grave on Planet Earth, it stands to reason that LCA could be just as important in outer space. That’s especially true when you consider space tourism is poised to blast off to become a potential $1.5 billion industry by 2028. The more activity, the more debris.

#### Increased space debris makes future space exploration impossible

Webb 18 [(Amy Webb is a professor at the NYU Stern School of Business and is the chief executive of the Future Today Institute, a strategic foresight and research group in Washington, D.C.), “Space Oddities: We Need a Plan to Stop Polluting Space Before It’s Too Late” WIRED Science April 12, 2018 https://www.wired.com/story/we-need-a-plan-to-stop-polluting-space-before-its-too-late/] TDI

Space is our next dumping ground. As many as 170 million fragments of metal and astro debris necklace Earth. That includes 20,000 pieces larger than a softball, and 500,000 about the size of a marble, according to NASA. Old satellites, like Tiangong-1, are the biggest and highest-profile lumps of rubbish, but most of it comes from rocket parts and even lost astronaut tools. Size doesn’t always matter—a fleck of paint, orbiting at a high velocity, cracked the Space Shuttle's windshield. This debris will pose a navigation hazard for many centuries to come. At least 200 objects roar back into the atmosphere each year, including pieces of solar panels and antennas and fragments of metal. All of them pose dangers for future astronauts: One plum-sized piece of gnarled space trash traveling faster than a speeding bullet could rip a five-foot hole into a spacecraft. And that collision, then, would hatch its own spectacle of shrapnel, which would join the rushing river of junk already circling the planet. It’s not just Americans doing the dumping. China and Russia each have dozens of decommissioned satellites overhead, though the US certainly does it with style. Like everyone, I marveled at the successful launch of SpaceX’s Falcon Heavy rocket, whose cargo included Elon Musk’s Tesla Roaster and a mannequin driver named Starman. I’ll admit, I teared up listening to David Bowie as the rockets separated from the payload. It was an incredible technological achievement, one proving that the system could someday transport people and goods—perhaps real cars, and real people—into space. Now that Tesla and its driver are overhead, in America’s junkyard in the sky. To be sure, space is big. Really big. Most debris soars about 1,250 miles above the Earth’s surface, so you have better odds scoring a seat on Virgin Galactic’s maiden voyage than witnessing Starman crash into your next door neighbor’s house. But it’s our behavior back here on Earth—our insistence on sending things up, without really thinking how to safely contain or send them back down—that should concern you. We weren’t always so short-sighted. Ancient Native Americans lived by the Seventh Generation Principal, a way of long-term thinking that considered how every decision would affect their descendants seven generations into the future. In Japan, Buddhist monks devoted part of their daily rituals and work to ensuring the longevity of their communities, even planting and tending to bamboo forests, which would eventually be harvested, treated and used to repair temple roofs many decades hence. With each new generation, we live life faster than our ancestors. As a result, we spend less time thinking about the farther future of humanity. We now have our sights set on colonizing Mars, mining asteroids for research and commerce, and venturing out to the furthest reaches of our galaxy. Space is no longer the final frontier; we’re already exploring it. Our current approach is about getting there, rather than considering what “getting there” could mean for future generations of humans, not to mention other life in the universe. Where all that junk winds up isn’t something we can predict accurately. We could be unintentionally wreaking havoc on civilizations far away from Earth, catalyzing future intergalactic wars. Or, we might cause far less scintillating problems. Space junk could start to behave in unpredictable ways, reflecting sunlight the wrong direction, or changing our atmosphere, or impacting the universe in ways that don’t fit into our current understanding of physics. Last week—30 years after my friends and I created an imaginary net to capture space debris—SpaceX launched RemoveDEBRIS, its own prototype, an experimental net to collect junk in orbit. It’s a neat idea, but even as middle schoolers, we knew it was an impractical one. Individual nets can’t possibly scale to address the hundreds of millions of particles of debris already in orbit. The challenge is that all of our space agencies are inextricably tied to national governments and militaries. Seeking a global agreement on how to mitigate debris would involve each country divulging exactly what it was launching and when—an unlikely scenario. The private sector could collaborate to build grand-scale orbital cleaners, but their commercial interests are driven by immediate launches. Given all the planned launches in our near future, we don’t have much time to wait. We must learn to be better stewards of our own planet—and commit to very long-term thinking—before we try to colonize any others.

#### Early warning satellites going dark signals attacks – causes miscalc and goes nuclear

Orwig 16 [(Jessica, MS in science and tech journalism from Texas A&M, BS in astronomy and physics from Ohio State) “Russia says a growing problem in space could be enough to spark a war,” Insider,’ January 26, 2016, <https://www.businessinsider.com/russia-says-space-junk-could-spark-war-2016-1>] TDI

NASA has already warned that the large amount of space junk around our planet is growing beyond our control, but now a team of Russian scientists has cited another potentially unforeseen consequence of that debris: War. Scientists estimate that anywhere from 500,000 to 600,000 pieces of human-made space debris between 0.4 and 4 inches in size are currently orbiting the Earth and traveling at speeds over 17,000 miles per hour. If one of those pieces smashed into a military satellite it "may provoke political or even armed conflict between space-faring nations," Vitaly Adushkin, a researcher for the Institute of Geosphere Dynamics at the Russian Academy of Sciences, reported in a paper set to be published in the peer-reviewed journal Acta Astronautica, which is sponsored by the International Academy of Astronautics. Say, for example, that a satellite was destroyed or significantly damaged in orbit — something that a 4-inch hunk of space junk could easily do traveling at speeds of 17,500 miles per hour, Adushkin reported. (Even smaller pieces no bigger than size of a pea could cause enough damage to the satellite that it would no longer operate correctly, he notes.) It would be difficult for anyone to determine whether the event was accidental or deliberate. This lack of immediate proof could lead to false accusations, heated arguments and, eventually, war, according to Adushkin and his colleagues. A politically dangerous dilemma In the report, the Adushkin said that there have already been repeated "sudden failures" of military spacecraft in te last two decades that cannot be explained. "So, there are two possible explanations," he wrote. The first is "unregistered collisions with space objects." The second is "machinations" [deliberate action] of the space adversary. "This is a politically dangerous dilemma," he added. But these mysterious failures in the past aren't what concerns Adushkin most. It's a future threat of what experts call the cascade effect that has Adushkin and other scientists around the world extremely concerned. The Kessler Syndrome In 1978, American astrophysicist Donald Kessler predicted that the amount of space debris around Earth would begin to grow exponentially after the turn of the millennium. Kessler 's predictions rely on the fact that over time, space junk accumulates. We leave most of our defunct satellites in space, and when meteors and other man-made space debris slam into them, you get a cascade of debris. The cascade effect — also known as the Kessler Syndrome — refers to a critical point wherein the density of space junk grows so large that a single collision could set off a domino effect of increasingly more collisions. For Kessler, this is a problem because it would "create small debris faster than it can be removed," Kessler said last year. And this cloud of junk could eventually make missions to space too dangerous. For Adushkin, this would exacerbate the issue of identifying what, or who, could be behind broken satellites. The future So far, the US and Russian Space Surveillance Systems have catalogued 170,000 pieces of large space debris (between 4 and 8 inches wide) and are currently tracking them to prevent anymore dilemmas like the ones Adushkin and his colleagues cite in their paper. But it's not just the large objects that concern Adushkin, who reported that even small objects (less than 1/3 of an inch) could damage satellites to the point they can't function properly. Using mathematical models, Adushkin and his colleagues calculated what the situtation will be like in 200 years if we continue to leave satellites in space and make no effort to clean up the mess. They estimate we'll have: 1.5 times more fragments greater than 8 inches across 3.2 times more fragments between 4 and 8 inches across 13-20 times more smaller-sized fragments less than 4 inches across "The number of small-size, non-catalogued objects will grow exponentially in mutual collisions," the researchers reported.

#### We need to keep satellites to have a chance to stop warming

Alonso 18 [(Elisa Jiménez Alonso, communications consultant with Acclimatise, climate resilience organization) “Earth Observation of Increasing Importance for Climate Change Adaptation,” Acclimatise, May 2, 2018, <https://www.acclimatise.uk.com/2018/05/02/earth-observation-of-increasing-importance-for-climate-change-adaptation/>] TDI

Earth observation (EO) satellites are playing an increasingly important role in assessing climate change. By providing a constant and consistent stream of data about the state of the climate, EO is not just improving scientific outcomes but can also inform climate policy. Managing climate-related risks effectively requires accurate, robust, sustained, and wide-ranging climate information. Reliable observational climate data can help scientists test the accuracy of their models and improve the science of attributing certain events to climate change. Information based on projections from models and historic data can help decision makers plan and implement adaptation actions. Providing information in data-sparse regions Ground-based weather and climate monitoring systems only cover about 30% of the Earth’s surface. In many parts of the world such data is incomplete and patchy due to poorly maintained weather stations and a general lack of such facilities. EO satellites and rapidly improving satellite technology, especially data from open access programmes, offer a valuable source information for such data-sparse regions. This is especially important since countries and regions with a lack of climate data are often particularly vulnerable to climate change impacts. International efforts for systematic observation The importance of satellite-based observations is also recognised by the international community. Following the recommendations of the World Meteorological Organization’s (WMO) Global Climate Observing System (GCOS) programme, the UNFCCC strongly encourages countries that support space agencies with EO programmes to get involved in GCOS and support the programme’s implementation. The Paris Agreement highlights the need for and importance of effective and progressive responses to the threat of climate change based on the best available scientific knowledge. This implies that climate knowledge needs to be strengthened, which includes continuously improving systematic observations of the Earth’s climate. To meet the need of such systematic climate observations, GCOS developed the concept of the Essential Climate Variable, or ECV. According to WMO, an ECV “is a physical, chemical or biological variable or a group of linked variables that critically contributes to the characterization of Earth’ s climate.” In 2010, 50 ECVs which would help the work of the UNFCCC and IPCC were defined by GCOS. The ECVs, which can be seen below, were identified due to their relevance for characterising the climate system and its changes, the technical feasibility of observing or deriving them on a global scale, and their cost effectiveness. The 50 Essential Climate Variables as defined by GCOS. One effort supporting the systemic observation of the climate is the European Space Agency’s (ESA) Climate Change Initiative (CCI). The programme taps into its own and its member countries’ EO archives that have been established in the last three decades in order to provide a timely and adequate contribution to the ECV databases required by the UNFCCC. Robust evidence supporting climate risk management Earth observation satellites can observe the entire Earth on a daily basis (polar orbiting satellites) or continuously monitor the disk of Earth below them (geostationary satellites) maintaining a constant watch of the entire globe. Sensors can target any point on Earth even the most remote and inhospitable areas which helps monitor deforestation in vast tropical forests and the melting of the ice caps. Without insights offered by EO satellites there would not be enough evidence for decision makers to base their climate policies on, increasing the risk of maladaptation. Robust EO data is an invaluable resource for collecting climate information that can inform climate risk management and make it more effective.

#### Climate change causes extinction.

Specktor 19 [Brandon; writes about the science of everyday life for Live Science, and previously for Reader's Digest magazine, where he served as an editor for five years; "Human Civilization Will Crumble by 2050 If We Don't Stop Climate Change Now, New Paper Claims," livescience, 6/4/19; <https://www.livescience.com/65633-climate-change-dooms-humans-by-2050.html>]

The current climate crisis, they say, is larger and more complex than any humans have ever dealt with before. General climate models — like the one that the [United Nations' Panel on Climate Change](https://www.ipcc.ch/sr15/) (IPCC) used in 2018 to predict that a global temperature increase of 3.6 degrees Fahrenheit (2 degrees Celsius) could put hundreds of millions of people at risk — fail to account for the **sheer complexity of Earth's many interlinked geological processes**; as such, they fail to adequately predict the scale of the potential consequences. The truth, the authors wrote, is probably far worse than any models can fathom. How the world ends What might an accurate worst-case picture of the planet's climate-addled future actually look like, then? The authors provide one particularly grim scenario that begins with world governments "politely ignoring" the advice of scientists and the will of the public to decarbonize the economy (finding alternative energy sources), resulting in a global temperature increase 5.4 F (3 C) by the year 2050. At this point, the world's ice sheets vanish; brutal droughts kill many of the trees in the [Amazon rainforest](https://www.livescience.com/57266-amazon-river.html) (removing one of the world's largest carbon offsets); and the planet plunges into a feedback loop of ever-hotter, ever-deadlier conditions. "Thirty-five percent of the global land area, and **55 percent of the global population, are subject to more than 20 days a year of** [**lethal heat conditions**](https://www.livescience.com/55129-how-heat-waves-kill-so-quickly.html), beyond the threshold of human survivability," the authors hypothesized. Meanwhile, droughts, floods and wildfires regularly ravage the land. Nearly **one-third of the world's land surface turns to desert**. Entire **ecosystems collapse**, beginning with the **planet's coral reefs**, the **rainforest and the Arctic ice sheets.** The world's tropics are hit hardest by these new climate extremes, destroying the region's agriculture and turning more than 1 billion people into refugees. This mass movement of refugees — coupled with [shrinking coastlines](https://www.livescience.com/51990-sea-level-rise-unknowns.html) and severe drops in food and water availability — begin to **stress the fabric of the world's largest nations**, including the United States. Armed conflicts over resources, perhaps culminating in **nuclear war, are likely**. The result, according to the new paper, is "outright chaos" and perhaps "the end of human global civilization as we know it."

#### Independently, it shreds the ozone.

Josy **O’Donnell 18**, creator of Conservation Institute, “WHAT HAPPENS TO THE “SPACE JUNK” THAT FALLS BACK TO EARTH?,” https://ourplnt.com/space-junk-earth/#axzz5xRXia1uD

Second, as the orbits of man-made debris degrade, and they re-enter the earth’s atmosphere, **a shock wave occurs** in the upper reaches of the layer of ozone. This physical stress on the area can be damaging to the protective buffer. Researchers have discovered that the impact of objects entering the atmosphere at high speed can produce nitric oxide during the rapid cooling that follows the splitting of oxygen and nitrogen. **Nitric oxide is very destructive to the ozone layer**. Finally, though most of the debris that re-enters the earth’s atmosphere is vaporized due to the build- up of intense heat, the chemical residue of this material can also react with the ozone and deplete it. Some scientists fear that erosion of the ozone layer may cause global climate change. They predict that these altered weather patterns could transform fertile farmland into deserts and threaten human life on the planet. Thus, the environmental effect of space debris upon the ozone is of great concern to these experts.

#### Extinction

Sean **Martin 18**, express reporter, “Ozone layer DECAYING as scientists fear Earth 'heading towards MASS-EXTINCTION',” https://www.express.co.uk/news/science/916405/ozone-layer-destroyed-recovering-mass-extinction-dinosaurs

News in January broke that the ozone was on its way to recovering as Earth cuts down on CO2 emissions. However, on closer inspection, scientists now say the ozone layer – the part of the atmosphere which protects us from harmful radiation – **is continuing to deplete** over major cities, and is only really recovering over Antarctica. Chemicals known as CFCs, which are found in aerosols for example, have been destroying the ozone layer since the 1970s. The Montreal Protocol was agreed in 1987 to phase out CFCs, but researchers say it may be too late. Study co-author Professor Joanna Haigh, co-director of the Grantham Institute for Climate Change and the Environment at Imperial College London, said of the study published in Atmospheric Chemistry and Physics: "Ozone has been seriously declining globally since the 1980s, but while the banning of CFCs is leading to a recovery at the poles, the same does not appear to be true for the lower latitudes. "The potential for harm in lower latitudes may actually be worse than at the poles. The decreases in ozone are less than we saw at the poles before the Montreal Protocol was enacted, but UV radiation is more intense in these regions and more people live there.” In a separate study, researchers have found a thinning ozone layer could have **led to a mass extinction** 252 million years ago – meaning a depletion of the protective layer of the atmosphere could be more **catastrophic** than previously thought.

#### Debris increase causes premium spikes

Dr. Darren **McKnight 10**, received his Bachelor’s Degree from the United States Air Force Academy in Engineering Sciences, his Master’s Degree from the University of New Mexico in Mechanical Engineering, and his Doctorate from the University of Colorado in Aerospace Engineering Sciences, “Pay Me Now or Pay Me More Later: Start the Development of Active Orbital Debris Removal Now,” https://www.amostech.com/TechnicalPapers/2010/Posters/McKnight.pdf

Nominally, the bulk of the 10-15% average premium for a space mission covers the launch vehicle flight and the initial (first year) satellite operations while only a small portion of the total premium (i.e. about 1.5% of the satellite value per year) is for on-orbit operations after startup. [15] When the collision risk reaches a value of 1.5% per year, insurance **premiums will** likely **increase**. However, once a collision with an insured satellite occurs, the urgency for starting active debris removal options will also likely accelerate. While the probability of a single spacecraft being destroyed, or even just rendered non-operational, by a collision with a large trackable piece of debris is small, the probability that any large object will collide with another is quite a bit higher. The probability of collision for a specific satellite is proportional to the number of objects posing a collision hazard with it while the collision rate between objects is a function of the square of the number of objects present, assuming that the ratio of the large fragments to intact spacecraft is constant with time. [7] In this way, while a hypothetical 20% increase in the population would only produce a 20% increase in collision probability for a single large object, the probability that any two large objects colliding goes up by over 40%. This collision rate is only an approximation since as collisions occur between large objects the ratio of large fragments to intact spacecraft will change. However, early in this process (i.e. for several decades) this approximation introduces very little error. Eventually, this increased collision rate will result in a series of collisions between large objects and the total debris population will start to **increase rapidly**. In fact, before the 2007 Chinese ASAT event, the average annual increase to the cataloged population was around 250 objects per year. The Chinese test contributed over 2,700 trackable objects (while more than 3,000 have actually been identified) so, this single event contributed over ten years’ worth of population number growth. While this event was a purposeful collision, rather than accidental, the debris creation issue is still relevant. The accidental collision in February 2009 of the operational Iridium and defunct Russian communications satellites created more than 1,600 trackable objects (while over 2,000 objects have been identified), which is still over six years of “typical” growth. With a single event producing many years of “typical” **debris accumulation**, it is easy to see how quickly previous predictions of collision rates will have to be updated with new population levels. Work done in the 1970s by Don Kessler and Burton Cour-Palais hinted at the situation that is now becoming a reality: collisions between trackable objects are occurring with sufficient frequency such that these events are the main driver for future debris growth across all size ranges. [7] This is simple to understand since two colliding large trackable objects will create hundreds of trackable objects plus tens of thousands of lethal projectiles and so act as an accelerant to the growth of lethal (>1cm) debris fragments.

#### Turns the commercial sector

Pamela L. **Meredith 08**. Co-chair of the Zuckert Scoutt & Rasenberger, L.L.P., Space Law Practice Group and an adjunct professor of space law at American University's Washington College of Law. 2008. “Space Insurance Law-with a Special Focus on Satellite Launch and In-Orbit Policies.” The Air & Space Lawyer. Volume 21, No.4. pp 13-15. https://www.kmazuckert.com/publications/space/Commerical\_Space\_-\_Meredith\_-\_Space\_Insurance\_Law\_2008.pdf

Conclusion From the beginning of space insurance in 1965 until today, insurance has played a **critical role** in the development and sustained growth of the commercial satellite industry in the United States and **the world at large**. As with other high-risk enterprises involving high-value assets, financing for satellite ventures **may not have been possible** or **forthcoming** were it not for the **availability of finance**. **Insurance is a key condition in bond covenants** for satellite companies and in satellite asset-based transactions. Insurance provides the satellite owner and its financiers with the **peace of mind** that if the launch or satellite fails, the asset value is **protected** as provided in the insurance policy.

### AC – Solvency

#### Thus, States should end commercial space exploration and tourism by private entities

Cooper 8 [Cooper, Nikhil D. "Circumventing Non-Appropriation: Law and Development of United States Space Commerce." Hastings Const. LQ 36 (2008): 457.] TDI

The latest piece of congressional legislation regulating the commercial space industry was the Commercial Space Launch Act (CSLA) 77 that was spurred on in part by the host of new technologies capable of commercially exploiting space. 78 The CSLA streamlined the earlier space-launch bureaucracy and mandated the DOT to issue licenses for all commercial space launch programs, 79 regulate forms of space tourism8 and space advertising, 8 ' impose minimum liability insurance and financial responsibility requirements, and82 provide for administrative and judicial review of DOT Secretariat decisions.83 Il. A Legal System? The CSLA represents the most recent and comprehensive United States space commerce legislation; but, in the years since its passage, no one has seriously questioned its consistency with United States international obligations of "non-appropriation." The issue is especially apt now, however, because the current and future capacities of commercially exploiting space seem primed to challenge non-appropriation as the guiding theme in space commerce. Therefore, the question we must ask now is whether or not the United States is circumventing the intent of non-appropriation by encouraging and protecting private commercial expansion into space. A. Treaties Versus Congressional Acts Whether the regulatory regime outlined in the CSLA conflicts with the national non-appropriation principle, as outlined in the Outer Space Treaty of 1967 and in its succeeding treaties, is an issue that could be reviewed by the federal judiciary under its constitutional grant of subject-matter jurisdiction over cases "arising under" treaties.8 4 The judiciary's power to interpret treaties is a power distinct from the treaty-making authority delegated to the executive and legislative branches. Article II of the United States Constitution authorizes the president to ratify treaties with the consent of two-thirds membership of the Senate. 5 Treaties entered into in this manner are the supreme law of the United States and bind state constitutions, legislatures, and judiciaries.8 6 Generally, courts employ distinct methods of interpretation when called on to perform the separate but related tasks of interpreting treaties and resolving treaty-statutory disputes. As to the former, courts generally will liberally construct a treaty "to give effect to the purpose which animates it" and will prefer that liberal construction "[e]ven where a provision of a treaty fairly admits of two constructions, one restricting, the other enlarging [of] rights which may be claimed under it."87 A preference for broad construction, however, is not a license for courts to impose any interpretation they deem appropriate. For example, although courts have a greater ability to construct treaties more broadly than private contracts, they are still precluded from interpreting a treaty beyond the "apparent intent and purport" of its language.88 in this way, determining a treaty's "intent" delineates the boundaries of how broadly or narrowly the court may interpret a treaty's provision. Courts obviously have a much easier time determining a treaty's intent where the treaty language is unambiguous. In these instances, courts expressly forbid looking beyond the language of the treaty to supply the intent of the parties at the time the treaty was drawn.89 When the language of the treaty is ambiguous, however, the court will attempt to effectuate the drafter's intent through a broader inquiry into "the letter and spirit of the instrument," and may take into account "considerations deducible from the situation of the parties; and the reasonableness, justice, and nature of the thing, for which provision has been made." 90 The United States Supreme Court summarized its interpretive process in the case Eastern Airlines Inc., v. Floyd: When interpreting a treaty, [begin] "with the text of the treaty and the context in which the written words are used." 91 [When confronted with difficult or ambiguous passages, the Court provided that] [o]ther general rules of construction may be brought to bear[.] [And it finally noted that] treaties are construed more liberally than private agreements, and to ascertain their meaning we may look beyond the written words to the history of the treaty, the negotiations, and the practical construction adopted by the parties. 92 Treaty interpretation as described above is important when determining whether the treaty conflicts with an act of Congress. Each being the supreme law of the land, treaties and congressional acts are governed by the last-in-time rule: when they conflict, courts must privilege the last enacted treaty or congressional act over the other. 93 Still, federal courts often avoid finding such conflicts between congressional acts and treaty obligations. As Justice Marshall opined in 1804: [A]n act of Congress ought never to be construed to violate the law of nations if any other possible construction remains, and consequently can never be construed to violate neutral rights, or to affect neutral commerce, further than is warranted by the law of nations as understood in this country. 94 Supreme Court jurisprudence since has largely followed the same presumption and, therefore, courts are inclined to harmonize treaties and congressional legislation that are seemingly antithetical to one another. 95 In the event that a congressional act were to supplant United States treaty obligations, courts would look for unambiguous evidence appearing “clearly and distinctly" in the text of the statute or treaty provision. 96 In other words, repeals of prior statutes or treaty provision must likely be made express. In contrast, "repeals by implication" are generally disfavored "unless the last statute is so broad in its terms and so clear and explicit in its words as to show that it was intended to cover the whole subject, and, therefore, to displace the prior statute. 97 B. CSLA Versus the Outer Space Treaty Both being duly enacted, the CSLA and the Outer Space Treaty are considered the supreme law of the land. If there is a conflict between the United States space commerce provisions as outlined in the CSLA and the Outer Space Treaty, a reviewing court would first be called upon to interpret the intent of the treaty itself. Recall that in the context of treaty interpretation, a court would be at liberty to give the treaty a broad construction to effectuate its intent. The key provision of the Outer Space Treaty at issue would be the language of Article II which forecloses "national appropriation" of space by claims of sovereignty, means of use, occupation, or any other means.98 Black's Law Dictionary defines "appropriation" as "the exercise of control over property, a taking of possession." 99 If defined broadly enough, the joint enterprise nature of the United States space commerce, as implemented in the CSLA, might violate the "spirit" of non-appropriation as outlined in the Outer Space Treaty of 1967. The best argument one could make against the CSLA's provisions is to advocate the court to broadly interpret the "appropriation" principle of the Outer Space Treaty. The proponent of this argument would urge that in so doing, a court should look beyond the words of the treaty and examine the history, negotiations, and practical considerations at the time of the treaty's negotiation to determine its true intent. 100 One would also want to argue that the space commerce industry violates perhaps not the "letter" of the treaty, but circumvents entirely its "spirit" if a court were taking into account "considerations deducible from the situation of the parties; and the reasonableness, justice, and nature of the thing, for which provision has been made."' 01 One who attacked the CSLA's general legitimacy in this way could argue that the United States is effectively "appropriating" space through its protection and encouragement of private industry. Such an appropriation would take place not by realizing a "sovereign" right to space property or the uses of space as expressly proscribed in the Outer Space Treaty, but, instead, through the effective use of government power, services, and contracts to encourage and support the rapid development of the private space commerce industry in the United States. In essence, the result of such government encouragement might not amount to wholesale sovereign appropriation, but, at the very least, a kind of sovereign and private space activity that would cast doubt on whether the non-appropriation principle is actually being respected. Therefore, one arguing that such activities were tantamount to sovereign appropriation would highlight the interrelatedness of government and private industry and argue for a broad interpretation of "appropriation" that encompassed the practical effects of such a relationship. In addition to the regulatory interaction between the CSLA and private space commerce industries, the interrelatedness between government and private industry is clearly illustrated by the interaction between CSLA and the 1972 Liability Convention. Recall that the Outer Space Treaty and its progeny envision a "state-oriented" system of responsibility 10 2 where each member state is responsible for all actions in outer space undertaken by the state and its nationals. 10 3 The Liability Convention further binds member states by holding each strictly liable for its actions or the actions of its nationals within outer space and permits only member states to petition for remuneration under the terms of the treaty. 1 04 In its text, the CSLA cites to such international obligations,'0 5 while also mitigating the United States' liability under the Liability Convention. 0 6 The CSLA licensing program ensures overall safety of private space ventures, 0 7 raises the funds necessary to pay "potential treaty claims through its liability insurance requirement,' 10 8 and limits the United States' joint and several liability exposure through restricting private use of foreign launch and reentry facilities.'09 These provisions effectively allow the United States to pass on the financial cost and recover from their private entities the amount of damages for which they are internationally liable. 110 In this way, the government is limiting its international liability exposure by passing on the cost to the private sector. When highlighting the further interrelatedness between government and private industry, one could also note that the United States government holds something of a monopoly in launch services and currently requires that decisions regarding commercial space-launch must be approved through the CSLA. 1' In addition, one making this argument would want to highlight the highly interdependent nature of investment flowing from government to private space commerce: in a February 4, 2008 press release, NASA Deputy Administrator Shana Dale justified the agency's 2009 budget request of $17.6 billion by claiming that "[t]he development of space simply cannot be 'all government all the time[]' . . . . NASA's budget for [fiscal year] 2009 provides $173 million for entrepreneurs-from big companies or small ones-to develop commercial transport capabilities. . . [and] NASA is designating $500 million toward the development of this commercial space capability." 2

#### The aff solves orbital debris and decreases collision risks.

Budhiraia 20 [(Mili, LL.B. candidate 2022 at Faculty of Law, University of Delhi.) “The Menace of Space Debris,” August 30, 2020, https://www.jurist.org/commentary/2020/08/mili-budhiraja-space-debris-india/] TDI

For most of the time India has participated in the space industry, it has played with one hand firmly tied behind its back. But with the introduction of the Self-Reliant India Movement (Aatma Nirbhar Bharat Abhiyaan), private companies hold the baton along with the government organizations to operate in the entire range of space activities. The Indian space industry now has unrivaled possibilities in the sectorial dimensions that constitute the field of space research and exploration. This raises the question of how privatization in the new space economy has increased the threshold of accountability for state actors involved in the operations. As of now, there are 375 private companies all across the globe engaged in the space industry. The privatization of the space industry relies upon the premise that it would lead to the expansion of opportunities to utilize the space. When in the mid-twentieth century the concept of privatization rose to the fore, it was faced with a bitter backlash. The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, popularly known as the ‘Outer Space Treaty’, was made when the concept of involving commercial entities into the multitude of space operations was not favored. The United States Communication Satellite Act of 1962 provided foundational support to the launch of communication satellites by commercial enterprises, thereby setting the stage for the entry of private players into the industry. But with increasing access to space operations and a growing level of satellite population, the problem of space debris, and the pollution caused due to the congestion of satellites, witnessed a simultaneous growth reaction. Space debris ranges from defunct spacecraft to paint flecks chipped off from wear and tear. A small debris particle of a mere 1 millimeter has the potential to cause catastrophic collisions. Privatization can act as an inducement in a hyper-dependent society banking upon satellite supported technology to launch more satellites into space. The estimate hints upon a possible 1100 satellites launched by the space industry each year by 2025. While satellites provide a broad, interdisciplinary use including human space exploration, meteorology, and climate change to name a few, the situation has the potential to significantly increase space traffic. It calls for a higher level of safety in the orbiting region from the floating debris, which can cause collisions. Astrophysicist Donald J. Kessler predicted that the debris in the Lower Earth Orbit (LEO) would reach a breaking point with an increase in satellite traffic and would start a collision chain reaction. This phenomenon is known as Kessler Syndrome. As a corollary to this phenomenon runs the concept of “Tragedy of the Commons” introduced by Garrett Hardins. The tragedy of commons occurs in a shared-resource system where independent operations motivated by self-interests deplete the shared-resource through their collective action. The increase in space traffic, which subsequently leads to an increase in space debris, can render LEO economically unviable for other participants. The legal framework dealing with the issue of space contamination is insufficient to provide any recourse. The Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (2007) provides an international instrument of a persuasive nature and therefore, making it obligatory on the state parties is an onerous task. Article VI of the Outer Space Treaty imposes an international responsibility on the states, and Article VII renders a state party internationally liable to other states for any harm caused due to their operations. Though these provisions address the issues of responsibility in case of ruptures caused at an international level, they do not obligate states to take preventive actions or to remove the harmful agents from the outer space region. Moreover, Article IX of the Outer Space Treaty creates an obligation on the state parties to intimate with other members of the “potentially harmful activities”, but because the release of pollution is a recurrent phenomenon, the law cannot be put to good use. Article I of the Convention on International Liability for Damage Caused by Space Objects (Liability Convention) does not even cover environmental harm under the definition of damage. It exhibits the temperament of organizations on addressing the issues of environmental safety. The academic debate over the tackling of this issue has steered into the arena of taxation. A study has suggested that the problem of space debris can be controlled by levying “Orbit Tax”. The concept of Orbit Tax or Orbital Use Fees (OUF) stems from the Pigouvian Tax System proposed by the economist, Arthur Pigou. The Pigouvian tax was assessed on activities that adversely affect societal interests. The carbon tax which is assessed on the emission of greenhouse gasses illustrates the nature of this taxation system and the jurisprudence behind it. But as the question stands, is the employing of Orbit Tax an effective solution to curb the menace of space pollution? The answer cannot be in a binary nature. The implementation of the OUF requires global participation of the state actors who are involved in the space industry. Harmonious participation could only be ensured with the consensus reached among the state parties on the rate of taxation proposed, the criteria of assessing tax, etc. The Carbon Tax, a form of pollution tax, was implemented under the United Nations Framework Convention on Climate Change. It has witnessed significant participation and changes brought about in the municipal laws of many state members. But there has been a difference in the rate of taxation among the states which convolutes its implementation. Such disparities cannot be allowed to persist in the OUF model adopted for space debris taxation. Even if a presumption is accepted that Orbit Tax will be efficient in controlling the space debris release, the issue of the increased cost of operating satellites can result in a subsequent increase in the cost of providing satellite services. This can have an adverse impact on economically backward countries which are dependent on other state parties for launch and other satellite operations. Moreover, this does not provide an ultimate solution to eliminate the greater risk that debris causes. A better solution would be to motivate states to deploy efficient satellite infrastructure with a lower depletion rate. Instead of increasing the overall cost of a satellite through haphazard taxation measures, the satellite infrastructure shall be made more efficient. The goal should be of sustainable use of the resources. With the growing privatization of the Space Industry, the responsibility in outer space requires prompt actions. There is a need for international agreements of a binding nature to increase the threshold of accountability of member states to ensure a sustainable orbital domain. While increased participation of commercial enterprises is expounded as an economically growing feature of a country, the liability involved with the enlargement of the opportunity base cannot be side-lined. A legal framework has to be structured at both the international and national level to respond to the international responsibility laid down in Article VI of the Outer Space Treaty. Since the Outer Space Treaty is limited in its jurisdiction to state-sponsored activities, there is a need for an international instrument governing the operations of private players. The delay in employing environmental measures has significantly impacted the atmospheric make-up. The same temperament showcased for this issue could bring Kessler Syndrome to life.

#### A public-private partnership solves none of the aff – market dynamics and hiring competition mean the two sectors are zero sum.

Davenport 2/25 [(Christian, Reporter covering NASA and the space industry, Colby College, B.A., American Studies), “As private companies erode government’s hold on space travel, NASA looks to open a new frontier,” February 25, 2021, https://www.washingtonpost.com/technology/2021/02/25/nasa-space-future-private/] TDI

The four astronauts who will fly on a SpaceX mission by the end of the year will be a bunch of private citizens with no space experience. One’s a billionaire funding the mission; another is a health care provider. The third will be selected at random through a sweepstakes, and the last seat will go to the winner of a competition. In the new Space Age, you can buy a ticket to orbit — no need to have been a fighter pilot in the military or to compete against thousands of other overachievers for a coveted spot in NASA’s astronaut corps. In fact, for this mission, the first composed entirely of private citizens, NASA is little more than a bystander. It does not own or operate the rocket that will blast the astronauts into space or the capsule they will live in for the few days they are scheduled to circle Earth every 90 minutes. NASA has no say in selecting the astronauts, and it will not train or outfit them — that will all be done by Elon Musk’s SpaceX. The money to pay for the flight also will not come from NASA — or any other government account. The cost of the project is being borne by a billionaire, Jared Isaacman, who has set it up as a fundraiser for St. Jude’s Research Hospital and a promotional device for his business, Shift4Shop, which helps businesses set up websites and process payments. This is the new look of human space exploration as government’s long-held monopoly on space travel continues to erode, redefining not only who owns the vehicles that carry people to space, but also the very nature of what an astronaut is and who gets to be one. And it comes as NASA confronts some of the largest changes it has faced since it was founded in 1958 when the United States’ world standing was challenged by the Soviet Union’s surprise launch of the first Sputnik into orbit. Now it is NASA’s unrivaled primacy in human spaceflight that is under challenge. Thanks to NASA’s investments and guidance, the private space sector has grown tremendously — no entity more than SpaceX, which according to CNBC is now worth $74 billion. The commercial space industry is taking on ever more roles and responsibilities — flying not just cargo and supplies to the International Space Station, but even NASA’s astronauts there. The private sector will launch some of the major components of the space station NASA wants to build in orbit around the moon, and private companies are developing the spacecraft that will fly astronauts to and from the lunar surface. Space enthusiasts, including NASA, see enormous benefit in the shift — a new era of space exploration that will usher in a more capable and efficient space industry. But the changing dynamic also has left NASA, which for decades has set the pace for the American space project, with an uncertain role, a development NASA’s Safety Aerospace Safety Advisory Panel warns could have consequences for years to come. The growth of companies like SpaceX has "tremendous upside potential — and are accompanied by equally tremendous challenges for managing the risk of human space exploration,” it said in its annual report, released last month. “NASA leadership in human space exploration is still preeminent, but the agency’s role is evolving with critical implications for how risk and safety will be managed.” So far, NASA has done well “as it shifts from principally executing its programs and missions to commercially acquiring significant key elements and services,” it said. But as the agency continues to evolve, “NASA must make some strategically critical decisions, based on deliberate and thorough consideration, that are necessary because of their momentous consequences for the future of human space exploration and, in particular, for the management of the attendant risks.” In an interview, Steve Jurczyk, NASA’s acting administrator, said the agency is well aware of how its identity and role are changing, and he likened the agency’s role to how the U.S. government fostered the commercial aviation industry in the early 20th century. NASA’s predecessor, NACA, or the National Advisory Committee for Aeronautics, “did research, technology development to initially support defense … but also later on supporting a burgeoning commercial aircraft industry and aviation industry,” he said. “So that may be how we evolve, moving forward on the space side. We’re going to do the research and the technology development and be the enablers for continuing to support the commercial space sector.” NASA has not ceded all ground. It still leads major exploration and science programs that no company could match. Last week, for example, it landed a rover the size of a car on Mars, hitting a precise landing target after traveling nearly 300 million miles. Later this year, it is scheduled to launch the James Webb telescope, which is designed to look back in time to the origins of the universe. And it also recently snagged a sample of rocks and soil from an asteroid 200 million miles from Earth to return them to Earth for study. “NASA works," Rob Manning, the chief engineer at NASA’s Jet Propulsion Laboratory, said after the Perseverance landed safely on Mars. “When we put our arms together and our hands together and our brains together, we can succeed. This is what NASA does.” Those big, daring, push-the-envelope missions is where NASA’s future lies, agency and industry officials agree. Not in looking for financial gain, but blazing the trail and opening new frontiers, and then allowing private industry to take over in the way homesteaders expanded into the West. Within NASA, there is still some resistance to that paradigm shift. “NASA feels like that’s our domain,” said Phil McAlister, NASA’s director of commercial spaceflight. “And my response is, the solar system is a big place. We at NASA should always be doing the next thing, the thing where the profit motive is not as evident and where the barriers to entry are still too high for the private sector to really make a compelling business case.” Jan Worner, the outgoing general director of the European Space Agency, agrees. “I believe space agencies have to change,” he said in an interview. “If you are fixed permanently to the same thing that you did in the past, you will lose.” But NASA officials are concerned that much of the future workforce is going to be attracted to a growing number of commercial companies doing amazing things. There is Planet, for example, which is putting up constellations of small satellites that take an image of Earth every day. Or Relativity Space, which is 3-D printing entire rockets. Or Axiom Space, which is building a commercial space station. Or Astrobotic, which intends to land a spacecraft on the moon later this year. The question NASA faces, then, is an urgent one: “How do you maintain that NASA technical expertise?” Jurczyk said. The agency does not know. “It may mean people are hiring more midcareer from industry or having people come to NASA, then go to industry, and come back. Or a different model where maybe you’re not coming to NASA and staying for your 35-, 40-year career,” he said. “We’re still thinking through that.” The workforce predicament was not on NASA’s mind when it embarked on this road in 2006. That is when it awarded relatively small contracts to see whether the private sector could develop spacecraft capable of taking cargo to the International Space Station. At the time, SpaceX, which won an award, was largely unknown and on the verge of bankruptcy, with just one successful flight to orbit for its Falcon 1 rocket after three failures. Outside of what Musk once called “the weird rebels within NASA,” few thought the program would work. It was not taken seriously by the mainstream aerospace industry or even by NASA’s leadership. “Let’s just give these annoying commercial people enough money so that they can fail, and we can say, ‘That was dumb. We don’t have to do that again,'” Musk once told The Washington Post. But it did work. And now NASA is relying on the private sector not only to deliver supplies and science experiments to the surface of the moon, but also its most precious cargo — its astronauts — there. Turning over human spaceflight to the private sector was a line many thought NASA would never cross. But last year, SpaceX successfully flew two crewed missions to the space station, and Boeing, the other company with the human spaceflight contract, is hoping to fly its first later this year. NASA has been eager to build on that success and hire private-sector companies to build and operate the spacecraft that would take astronauts to and from the surface of the moon. And while NASA’s flagship rocket, the Space Launch System, would be used to fly astronauts to the moon and be the most powerful ever built, it has suffered all sorts of cost overruns and technical delays. A test of its engines that was supposed to last as long as eight minutes was cut short after just one because of a technical problem. And the redo of the test was recently postponed by NASA, which said it was looking into a problem with one of the valves. Recently, the NASA inspector general said the total cost of the rocket would reach $27 billion through 2025. That enormous cost has outraged critics of the space program, who have derided the effort as little more than a jobs program for select congressional districts and dubbed it the “Senate Launch System.” Recently, the Bloomberg editorial board called for the Biden administration to “scrap the Space Launch System,” asking, “Why is the U.S. government building a space rocket?” “No doubt, the era of government spacefaring had its glories,” the editorial read. “But space is now a $424 billion business, with U.S. companies at its forefront. The new administration should embrace this revolution — and bring the power of private enterprise to bear in crossing the next cosmic frontier.” Some high-level NASA officials, including former NASA Administrator Jim Bridenstine, have indicated that if the commercial sector can develop lower-cost alternatives, the space agency would have no choice but to consider those instead. NASA has already shifted one major mission from SLS — recently it announced that a commercial rocket, and not SLS, as Congress had mandated for years, would launch the Europa Clipper spacecraft that would study Jupiter’s moon. That alone would save NASA “over $1.5 billion compared to using an SLS rocket,” according to NASA’s fiscal year 2021 budget request. NASA has always relied on contractors to build its hardware — from the Apollo lunar module built by Grumman to the space shuttle, built largely by North American Rockwell. But NASA defined the precise requirements, took ownership of the spacecraft and operated them. That is not the case with many of its programs today. It works alongside the companies to validate their rockets and spacecraft and ensure they meet the agency’s safety standards. But the hardware and the launch procedures remain in private hands. The private astronaut mission, dubbed Inspiration4, marks the next iteration in this transition. Isaacman, the billionaire founder and chief executive of Shift4Shop, a payments technology company, paid an undisclosed sum for the SpaceX flight. Isaacman, an accomplished pilot, will occupy one of the four seats. Another will go to Hayley Arceneaux, a 29-year-old physician assistant at St. Jude Children’s Research Hospital. The third is to be raffled off as part of a fundraising effort for the hospital. And the fourth seat will go to the winner of a competition among entrepreneurs who use Shift4Shop’s platform. Isaacman has donated $100 million to St. Jude and hopes the fundraising effort will match that. “We will, of course, coordinate this with NASA,” Musk said on a call with reporters earlier this month to discuss the mission. “NASA has been briefed on this and is supportive.” But it will be SpaceX and the crew that will determine the flight parameters and training requirements, not NASA. “Wherever you want to go, we’ll take you there,” Musk said to Isaacman on the call. Meet the people paying $55 million each to fly to the space station That mission will be followed by a second flight made up entirely of civilians — three wealthy business executives, who are each paying $55 million, in addition to the commander, Michael Lopez-Alegria, a former NASA astronaut who now serves as a vice president at Axiom. Instead of spending a few days inside SpaceX’s Dragon spacecraft, which has about as much interior room as a large SUV, they will fly to the International Space Station. They will spend eight days there before flying back. Ultimately, Axiom’s goal is even bigger — to build a space station of its own. The ISS is getting old and will need to come down at some point. NASA has said that it would eventually get out of the space station business — and outsource that to the private sector as well. Axiom is one of the leading candidates to build the successor. If Axiom is successful, it could then proceed to its ultimate goal: charter missions of private citizens, flying on private rockets to a private space station with little to no involvement from NASA.

#### Colonies in space are sustainable and rely on planetary resources, NASA has a plan

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 of space exploration and technological achievement, one of the modern leaders in private spaceflight is still espousing an idea from the first days of space exploration.