# 1AC – Cosmic Colonialism

## 1AC

### 1AC – Framing

#### Extinction first --- moral uncertainty.

**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**.

**Pleasure and pain are intrinsically valuable.**

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] 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.**

### 1AC – Cosmic Colonialism

#### Advantage 1 is Cosmic Colonialism.

#### Private appropriation of outer space expands corporate colonialism.

Shammas and Holen 19 [(Victor L, a sociologist working at the Department of Sociology and Human Geography, University of Oslo; Tomas B., independent scholar in Oslo, Norway) “One giant leap for capitalistkind: private enterprise in outer space,” 1-29-2019, pg. 3-5] TDI

The 2010s may very well be remembered as the ‘Age of NewSpace', the decade when outer space was turned into a capitalist space, when private corporations pushed the price of launches, satellites, and space infrastructure downwards, exerting what industry insiders call the ‘SpaceX effect' (Henry, 2018), centered on the technological achievement of ‘reusability', recovering used rocket boosters for additional launches, promising to drastically reduce the price of going to space (Morring, 2016). As one report observes, ‘Not only has the number of private companies engaged in space exploration grown remarkably in recent years, these companies are quickly besting their government-sponsored competitors' (Houser, 2017). What the rockets, shuttles, ships, and landing pods will carry beneath their payload fairing or in their cargo hold, however, along with supplies and satellites, is the capitalist worldview, a particular ideology—just as Robinson Crusoe, in Marx’s ironic retelling in Capital, ‘having saved a watch, ledger, ink and pen from the shipwreck… soon begins, like a good Englishman, to keep a set of books' (Marx, 1976, p. 170), brings with him English political economy—'Freedom, Equality, Property and Bentham', as Marx (1976, p. 280) says elsewhere— to his desert island.

In early 2018, astronomers across the world learned that a New Zealand start-up, Rocket Lab, which aimed to launch thousands of miniature satellites into orbit around Earth (so-called ‘smallsats'), had planned to launch a giant, shining ‘disco ball'—the ‘Humanity Star'—into orbit around Earth. It was an elaborate marketing stunt masked by humanistic idealism. ‘No matter where you are in the world, or what is happening in your life', said Rocket Lab CEO Peter Beck, ‘everyone will be able to see the Humanity Star in the night sky' (Amos, 2018). Many astronomers expressed outrage at these plans, fearing that the light from the Human Star would threaten their ability to carry out scientific observations. But while these astronomers were incensed by the idea of a bright geodesic object disrupting their ability to carry out observations, concerns with the effects of the arrival of capitalistkind on their ability to collect data were non-existent. The astronomical community was angered by the idea of a material, concrete, visible object polluting “pure” scientific data, but it paid less attention to the (invisible and abstract) recuperation of the night sky as it was brought into the fold of capitalism.

In an interview, Beck was quizzed about the Humanity Star and asked by a reporter about the difficulties of generating profits in space (Tucker, 2018). To this Beck replied, ‘It has always been a government domain, but we’re witnessing the democratization of it…[I]t [is] turning into a commercially dominated domain'. Beck established an equivalence established between the dissolution of space as the rightful domain of states and the advent of profitmaking ventures as signs of ‘democratization'. In space, according to Beck’s logic, democratization involves the disappearance of the state and the rise of capital. The argument, of course, is impeccably post-statist: on this account, states are monolithic, conservative Leviathans beyond the reach of popular control; corporations, on the other hand, are in principle representatives of the everyman: in the age of the start-up, any humble citizen could in theory become an agent of disruption, a force for change, an explorer of space, and a potential member of the cadre of capitalistkind. Following this logic, the question for the entrepreneurs of NewSpace is how to monetize outer space, which means turning space into a space for capital; their question is how they can deplanetarize capital and universalize it, literally speaking, that is, turn the Universe into a universe for capital. In this light, Peter Beck’s distortion of democratic ideals appears eminently sensible, equating democratization with monetization, that is, capital liberated from its earthly tethers.

Emblematic of this capitalist turn in space was the founding of Moon Express in 2011, composed of a ‘team of prominent Silicon Valley entrepreneurs…shooting for the moon with a new private venture aimed at scouring the lunar surface for precious metals and rare metallic elements' (Hennigan, 2011). Following Google’s Lunar XPRIZE—an intertwining of Silicon Valley and NewSpace’s capitalistkind—which promised a $20 million prize for the first private company to land a spacecraft on the Moon, travel 500 meters, and transmit high-definition images back to Earth, all by March 2018,9 Moon Express claimed that it would be capable of landing on the lunar surface and earn the cash prize. Their stated goal was twofold: first, to mine rare resource like Helium-3 (a steadily dwindling scarce resources on Earth), gold, platinum group metals, and water, and, second, to carry out scientific work that would ‘help researchers develop human space colonies for future generations' (Ioannou, 2017). The ordering is telling: first profits, then humanity. These were the hollow, insubstantial promises of a venture-capitalized NewSpace enterprise: in early 2018, Google announced that none of the five teams competing for the Lunar XPRIZE, including Moon Express, would reach their stated objectives by the 31 March deadline and they were taking their money back (Grush, 2018). In this sense, it was typical for NewSpace in its formative years: a corporate field populated by (overly exuberant) private enterprises who promised more than they could deliver. But the belief in NewSpace is real enough. In a tome bursting with the optimism of NewSpace, Wohlforth and Hendrix claim that ‘the commercial spaceflight industry is transforming our sense of possibility. Using Silicon Valley’s money and innovative confidence, it will soon bring mass space products to the market' (2016, p. 7).

The trope of humanity plays a key role in the rhetoric of the adherents of NewSpace. To fulfill the objectives of NewSpace, including profit maximization and the exploitation of celestial bodies, the symbolic figure of a shared humanity serves a useful purpose, camouflaging the conquest of space by capitalism with a dream of humanity boldly venturing forth into the dark unknown, thereby also providing the legitimacy and enthusiasm needed to support bolster the legitimacy of NewSpace. So long as the stargazers and SpaceX watchers are permitted their fill of ‘collective effervescence', to use Durkheim’s (1995, p. 228) concept, capitalist entrepreneurs will be able to pursue their business interests more or less as they please. The spectacle of outer space is crucial in this regard.

Crucially, however, and despite this spectacle, SpaceX’s technology might not necessarily be more sophisticated than its competitors or predecessors. Some industry insiders have rebuffed some of the more the spectacular claims of NewSpace’s proponents, arguing that launch vehicle reusability requires a (perhaps prohibitively) expensive refurbishing of the rocket engines involved in launches: ‘The economics will depend on how many times a booster can be flown, and how much the individual expense will be to refurbish the booster…each time' (Chang, 2017). Reusability may be a technological dead-end because of the inherently stressful effects of a rocket launch on the launch vehicle’s components, with extreme limitations on reusability beyond second-use as well as added risks of malfunctions that customers and insurers are likely to wish to avoid. Furthermore, the Falcon Heavy still has not matched the power and payload capacity of NASA’s Saturn V, a product of 1960s military-industrial engineering and Fordist state spending programs. What SpaceX and other NewSpace corporations do with great ingenuity, however, is to manage the spectacle of outer space, producing outpourings of public fervor, aided by a widespread adherence to the ‘Californian Ideology' (Barbrook and Cameron, 1996), or post-statist techno-utopianism, in many postindustrialized societies.

The very centrality of these maneuvers has initiated a new phase in the history of capitalist relations, that of ‘charismatic accumulation'—certainly not in the sense of any ‘objective' or inherent charismatic authority, but with a form of illusio, to speak with Bourdieu, vested in the members of capitalistkind by their uncanny ability to spin mythologizing self-narratives. This has always been part of the capitalist game, from Henry Ford and onwards, but the charismatic mission gains a special potency in the grandiose designs of NewSpace’s entrepreneurs. Every SpaceX launch is a quasi-religious spectacle, observed by millions capable of producing a real sense of wonder in a condition of (legitimizing) collective effervescence.

Outer space necessarily reduces inter-human difference to a common denominator or a shared species-being. An important leitmotiv in many Hollywood science fiction movies, including Arrival (2016), is that a first encounter with an alien species of intelligent beings tends to flatten all human difference (including ethnoracial and national categories), thereby restoring humankind to its proper universality (see also Novoa, 2016). Ambassadors of Earth as a whole, not representatives of particular nations, step forth to meet alien emissaries. But even in the absence of such an encounter, the search for habitable domains (or rather, profitable locales) beyond Earth will necessarily forge a shared conception of the human condition, initiated with the Pale Blue Dot photograph in 1990. Typical of this sentiment are the words of the astronomer Carl Sagan, who famously observed of this photograph: ‘On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives'.

This naïvely humanistic vision has been one of the dominant tropes in the discourse on space since the 1950s, and it remains strong today, as with the claims of the United Nations Office for Outer Space Affairs (UNOOSA) that their task is to ‘uphold the vision of a more equitable future for all humankind through shared achievements in space'. This representational tendency mobilizes humanism to generate enthusiasm about space-related activities. But such representations are increasingly being recuperated by capitalist enterprise, so that it is not humankind but its modulation by space capitalists that will launch into the dark unknown. It is not humankind but capitalistkind that ventures forth. In early 2018, NASA was set to request $150 million in its 2019 budget to ‘enable the development and maturation of commercial entities and capabilities which will ensure that commercial successors to the ISS…are operational when they are needed', only one of many signs that space is becoming a space for capitalism. According to one estimate, the value of just one single asteroid would be more than $20 trillion in rare earth and platinum-group metals (Lewis, 1996), a precious prize indeed for profit-hungry corporations.10 Even the UNOOSA spoke vociferously in favor of the commercialization of space, appealing variously to the ‘industry and private sector' and elevating the ‘space economy' to a central pillar in its Space2030 Agenda (including the ‘use of resources that create and provide value and benefits to the world population in the course of exploring, understanding and utilizing space'), even as the UN agency falls back on a humanistic, almost social-democratic vision of the equitable distribution of benefits (and profits) from space mining, exploration, and colonization (UNOOSA, 2018).

We find evidence of this strategic humanism in all manner of pronouncements from NewSpace entrepreneurs. To take but one example: Naveen Jain, the chairman and co-founder of MoonEx, a lunar commercialization firm, has claimed that ‘from an entrepreneur’s perspective, the moon has never truly been explored'. The moon, Jain has claimed, ‘could hold resources that benefit Earth and all humanity' (Hennigan, 2011). We should note the recourse to the trope of all of humanity by this NewSpace entrepreneur, mimicked in the 1979 Moon Agreement, a UN treaty, which also held that the Moon’s resources are ‘the common heritage of mankind' (Tronchetti, 2013, p. 13).11 In a purely factual sense, of course, Jain is wrong: Google Moon offers high-resolution images of the lunar surface,12 and the moon has already been explored, in the sense of being mapped, albeit rudimentarily and with room for further data collection. Crucially, however, these cartographic techniques have not been put to capitalist uses: mapping minerals, for instance, or producing detailed schemata that might one day turn the Moon into a ‘gas station' for commercial space ventures, as Wilbur Ross, Trump’s Secretary of Commerce, has proposed (Bryan, 2018). What is lacking, in short, are capitalist maps of the Moon, i.e., a cartography for capital. But as Klinger (2017: 199) notes, even though no one is ‘actively mining the Moon' at present, at least ‘six national space programs, fifty private firms, and one graduate engineering program, are intent on figuring out how to do so'; furthermore, Klinger draws attention to mapping efforts that have revealed high an abundance of rare earth metals, thorium, and iron in the Moon’s ‘Mare Procellarum KREEP' region (Klinger, 2017, p. 203).

We have already noted that it is not humanity, conceived as species-being, a Gattungswesen, that makes its way into space. The term Gattungswesen, of course, has a long intellectual pedigree, harking back to Hegel, Feuerbach, Marx, and others. The term can ‘be naturally applied both to the individual human being and to the common nature or essence which resides in every individual man and woman', Allan Wood (2004, p. 17) writes, as well as ‘to the entire human race, referring to humanity as a single collective entity or else to the essential property which characterizes this entity and makes it a single distinctive thing in its own right'. Significantly, the adherents of NewSpace often resort to the idea of humanity in its broad universality (e.g., Musk, 2017), but this denies and distorts the modulation of humanity by its imbrication with the project of global (and post-global, i.e., space-bound) capitalism. It is precisely the sort of false universality implied in the humanism of the supporters of NewSpace that Marx subjected to a scathing critique in the sixth of his Theses on Feuerbach. Here Marx noted that the human essence is not made up of some ‘abstraction inherent in each single individual' (1998, p. 570). Instead, humans are defined by the ‘ensemble of social relations' in which they are enmeshed. Under NewSpace, it is not humanity, plain and simple, that ventures forth, but a specific set of capitalist entrepreneurs, carrying a particular ideological payload, alongside their satellites, instruments, and supplies, a point noted by other sociologists of outer space, or ‘astrosociologists' (Dickens and Ormrod, 2007a, 2007b).

#### NewSpace actors engage in historical revisionism that moralistically justifies endless accumulation by displacing neoliberal guilt.

Johnson ‘20 (Johnson, Matthew Robert. "Mining the high frontier: sovereignty, property and humankind’s common heritage in outer space." PhD diss., University of Technology Sydney. Faculty of Arts and Social Sciences, 2020-08-26; JPark)

* This card basically says that, independent from the actual material expansion of capitalism/exploitation that occurs in space, NewSpace erases historical narratives on the violence of neoliberalism and colonization by promoting a new form of Manifest Destiny that is guilt-free – similar to a T&Y move to innocence

The trope of the frontier speaks to both violent appropriation and – as it appears in NewSpace discourse – redemption and freedom. Frontier mythology has a highly emotive resonance: it appeals to individual and collective psyches through the frontier’s promise of liberation, salvation and re-birth. As Blouet notes, “states are clever in promoting ambitions in the cloak of emotional appeals” (1994, p.285). The European colonial powers claimed theirs was a ‘civilising mission’ (Said 1995), a valorous project of “bringing light, faith and trade to ‘the dark places’ of the earth” as they murdered and subordinated indigenous populations on the imperial horizon (Lindqvist 2002, p.12). Ever since the Apollo program, outer space has held an important place in the emotional fabric of American national culture. What mythic elements can we discern in NewSpace cosmopolitics? What stories is NewSpace telling to render its colonial project as commensurate with the ‘benefit of all mankind’? Political mythologies are not opposed to political rationality – they permeate and are indissociable from them (Dean 2006). Political economist Mitchell Dean has illustrated that “mythic, poetic and symbolic elements” permeate spatial and cartographic notions of political order (2006, p.1). Deploying Connery’s term ‘geo-mythography’ (2001), he describes the mythic foundations of Schmitt’s conceptions of nomos. For instance, Schmitt begins The nomos of the earth by saying: “In mythical language, the earth became known as the mother of law...” (Schmitt 2003, p.42). Pagan concepts of the Earth Mother are evident in Schmitt’s account, which also drew on his conservative Catholicism in noting the herdsman or shepherd in the etymological roots of nomos (ibid, p.339-340). Indeed, Schmitt focuses on the nomos of medieval Europe’s respublica Christiania, an empire with Holy Rome at its centre acting as katcheon or ‘restrainer’ of the Antichrist (ibid, pp.58-62; Dean 2006). The contrasts that Schmitt makes between terra firma and mare libre arrive at a sort of telluric mythos, his genealogy of spatial law and order invoking the “consecrated sites” and “sacred orientations” of landed existence (Schmitt, in Dean 2006, p.10). The NewSpace imaginary of course involves a break from the ‘Earth Mother’ – a point Ormrod has argued while drawing on Freudian psychoanalytics (2007, pp.266-7) – but geo-myths are nonetheless an important part of their public justifications for space colonisation. ‘Manifest Destiny’ is a geopolitical discourse that emerged from Enlightenment progress ideology and is evident in many phases of American history and in the NewSpace vision (Parker 2009). Beginning with the 19th century impulse to “conquer and civilize the ‘empty continent’”, it was the United States’ destiny to continue expanding (Ó Tuathail 1994, p.159). Like lebensraum, which had been inspired by Friedrich Ratzel’s visit to frontier America, manifest destiny was a means of justifying imperial expansionism. This geo- mythography was wedded to American exceptionalism: if expansionism was America’s ‘destiny’, the violence of this expansionism was morally justifiable. The political geographer Gerard Ó Tuathail summarises Manifest Destiny with the following quote from founding father Thomas Paine: “The cause of America...is in great measure the cause of all mankind” (1994, p.159). The idea that humanity needs space to expand on the off-world frontier is a techno- utopian version of Manifest Destiny. In his essay ‘Capitalists in Space’ (2009), Parker has noted the parallels between off-world expansionism and westward frontiers in American culture. He draws attention to the US historian Frederick Jackson Turner (1893), who had argued that when the westward journey ended on the Pacific Coast and the American frontier was effectively closed, it “augured badly for the future of the USA. American character was defined by novelty, adaptation and growth, so without this imaginative geography of a frontier, there was a danger of atrophy” (Parker 2009, p.89). I am reminded here of Gerard 208 O’Neill’s remark that a steady state economy would allegedly produce a constriction of innovation and creativity that would be “abhorrent” (in Kilgore 2003, p.159). For NewSpace and neoliberalism, Property represents Progress. Yet the notion of private property as inherently virtuous rests upon unstable myths (Christman 2014). Like American exceptionalism, the **valorisation of private property rights in the NewSpace** and neoliberal **imaginary** requires **erasing** or simply forgetting the **violence of enclosure and colonialism**. Space writer and policy analyst Rand Simberg produced Homesteading the Final Frontier (2012) for the Atlas Network’s Competitive Enterprise Institute. He asserts that: “...under the view of the universe as a frontier full of potential, the resources that could be developed from it offer great opportunity for human flourishing. Centuries of history demonstrate that the best means of doing that is via the free exchange of goods and services, undergirded by legally enforceable private property rights” (Simberg 2012, p.4). In Simberg’s view, ‘centuries of history’ validate private property – and not common property – as the driver of human flourishing. With the ahistoricity characteristic of neoliberalism and neoclassical economics, Simberg sweeps aside centuries of appropriation, displacement and violence that followed in capitalism’s imperial wake. The history of private property is tainted with discrimination, coercion and the heavy hand of empire – this is inconsistent with the truth claims of universal beneficence inherent in NewSpace private property advocacy (**regardless** of how violent or peaceful space colonisation ends up being). In his Mythologies (1973), Roland Barthes looked to capitalist myths. His description of the ‘privation of history’ offers some insight into NewSpace’s erasure of property’s violent past. According to Barthes, the privation of history was a myth of estrangement that divorced objects from their history. “Myth deprives the object of which it speaks of all History. In it, history evaporates. It is a kind of ideal servant: it prepares all things, brings them, lays them out, the master arrives, it silently disappears: all that is left for one to do is enjoy this beautiful object without wondering where it came from” (1973, p.165). Severing an object from its history – this is clearly taking place in NewSpace’s revisionist history of private property. Consider the following remark from Moon Express’ Bob Richards: “As a country built on the foundations of Earth’s frontiers, the United States stands unique in all the world with the opportunity to focus the power of its entrepreneurial history and enterprising vision to open up the space frontier, and in so doing, create a peaceful, prosperous and boundless future for all humanity” (Richards 2017, p.1). The United States was actually built upon ‘foundations of the frontier’, but only because the expansion of Anglo-American sovereignty involved the imposition of European law upon the foundational nomoi of native American law. The (un)settling of the American frontier was ultimately not a ‘peaceful, prosperous and boundless’ process for all Americans. The privation of property history excises the violence, so that colonial power can be ascribed a **measure of ‘innocence’** (Whyte 2018, p.237), “as if one can take the good parts of a metaphor, setting the unseemly ones aside” (Messeri 2017). In NewSpace representations of property and discussions of space colonisation that appear in neoliberal advocacy (see also Singal 2018), the off-world frontier presents a zone of guilt-free appropriation, an opportunity to escape what Hegel described as the “slaughter- bench” of history (2001, p.35). Hegel’s Philosophy of History described how, in the name of progress, “the happiness of peoples, the wisdom of States, and the virtue of individuals have been victimized” (ibid, p.33). Hegel viewed the violence of western civilisation as ultimately worthwhile, if it meant the eventual realisation of Freedom – a teleological account of human history that NewSpace appears to share with Hegel, that “the History of the world is none other than the progress of the consciousness of Freedom” (2001, p.33). For NewSpace libertarians, off-world property represents a paradoxical freedom from the empire that is enabled by the empire. In their heroic colonisation of the off-world, they are relieved from repressing resistant ‘commoners’, from negotiating over prior land rights and from managing the ecological impacts of resource exploitation – all that needs to be done is undermine international treaty law (e.g. Gump 2018). Escaping history, the NewSpace salvationist narrative renders unilateral private property law as commensurate with “the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes” (Outer Space Treaty 1967, preamble).

#### The insistence on outer space as corporate capital’s spatial fix accelerates environmental degradation.

Shammas and Holen 19 [(Victor L, a sociologist working at the Department of Sociology and Human Geography, University of Oslo; Tomas B., independent scholar in Oslo, Norway) “One giant leap for capitalistkind: private enterprise in outer space,” 1-29-2019, pg. 6-8] julian

As Earth’s empty spaces are filled, as our planet comes to be shorn of blank places, capitalistkind emerges to rescue capitalism from its terrestrial limitations, launching space rockets, placing satellites into orbit, appropriating extraterrestrial resources, and, perhaps one day, building colonies on distant planets like Mars. But why limit ourselves to Mars? As of mid-2017, NASA’s Kepler observatory had discovered more than 5000 exoplanets—planets that seem like promising alternatives to Earth, located at an appropriate distance from their respective suns in the famed ‘Goldilocks zone'. These ‘planetary candidates', as they are known —that is, candidates for the replacement of Earth, capable of supporting human life with only minimal technological augmentation or cybernetic re-engineering—are above all viable candidates for selection by specific capitalists seeking to discover new profitable ventures beyond the limits of an Earth-bound capitalism. Space reveals the impotence of the neoliberal, postFordist state, its incapacity and unwillingness to embark on gigantic infrastructural projects, to project itself outwards, and to fire the imagination of (actual) humankind. Capitalistkind steps in to fill the vacuum left behind by a state that lacks what Mann (2012, p. 170) calls ‘infrastructural power'. The old question, the question of Old Space, was quite simply: is this planet a viable site for humankind, a suitable homeland for the reproduction of human life away from Earth? But the new question, the question for NewSpace, will be: can this celestial body support capitalistkind? Will it support the interests of capitalist entrepreneurs, answering to the capitalist desire for continued accumulation?

While some elements of the astrosociological community, such as the Astrosociology Research Institute (ARI),14 insist on elucidating the “human dimension” in outer space, Dickens and Ormrod recognize that this humanization-through-capitalism really involves the ‘commodification of the universe' (2007b, p. 2). While Dickens and Ormrod develop similar arguments to those sketched here—from their concept of an ‘outer spatial fix' to their argument about outer space becoming woven into circuits of capital accumulation—they were writing at a time when their remarks necessarily remained speculative: the commercialization of space was still in its infancy. In an inversion of Hegel’s owl of Minerva, reality has since largely confirmed their ideas and caught up with theory. Above all, when considering the various ventures ongoing in space today, it is not so much the universalizing human dimension as the specifically capitalist dimension that is striking. With the advent of NewSpace, outer space is becoming not the domain of a common humanity but of private capital.

The arguments laid out above mirror an ongoing turn in critical scholarship away from the notion of the Anthropocene towards a more rigorously political-economic concept of Capitalocene, premised on the ‘claim that capitalism is the pivot of today’s biospheric crisis' (Moore, 2016, p. xi). Just as the exponents of the concept of Capitalocene emphasize that it is capitalism, and not humanity as such, that is the driving force behind environmental transformation, so too does the notion of capitalistkind emphasize that it is not humankind tout court but rather a set of specific capitalist entrepreneurs who are acting as the central transformative agents of and in outer space, with the ‘ever-increasing infiltration of capital' into what was formerly the domain of the state (Dickens and Ormrod, 2007a, p. 6). We can also think about these issues in terms of what Philippopoulos-Mihalopoulos (2015) terms ‘spatial justice'. This concept captures the fact that struggles over justice are often struggles to occupy space, as the term is more conventionally understood, as with urban battles over the ‘right to the city' (Harvey, 2008), to provide just one example. But the same also holds true for outer space: there is an ongoing struggle over the right to take up space in outer space. So far, the capitalist side appears to be winning. As the proto-communism of the Cold War-era Outer Space Treaty is abandoned—in tandem with the increased technological feasibility of exploiting resources and accumulating profits in outer space—spatial justice in outer space increasingly comes to mean the ‘justice' of capital, capitalistkind taking the place of humankind. It is comparatively easy to declare that outer space is a commons, as the Outer Space Treaty did in the late 1960s, when that domain is, for all practical purposes, inaccessible to capital; with the heightened accessibility of outer space, however, it is unsurprising that central political agents, such as President Trump’s administration, should seek to dismantle this regulatory framework and ensure the smooth functioning of capital accumulation beyond the terrains of Earth.

What kind of capitalism is being projected into space? The complexity of state-market relations is sufficient to force us to hedge against a simplified reading of space commercialization: it is not a matter of states against markets, as if the two were mutually exclusive. Instead, as Bratton (2015) suggests, we are witnessing the emergence of a ‘stack', a complex intertwining of commercial, geopolitical, and technological concerns, which challenges previous notions of state sovereignty. This can be seen as a hybridized state-market form, with technology playing a central role in reciprocal processes of political and economic transformation. On the one hand, outer space was in some sense always already the domain of marketization, albeit to a limited extent, even during the Cold War, from the first commercial satellite launch in the early 1960s to President Ronald Reagan’s implementation of the Commercial Space Launch Act of 1984, which aimed to encourage private enterprise to take an interest in an emerging launch market. As Hermann Bondi, the head of the European Space Organization, wrote in the early 1970s, ‘It is clear…that there must be three partners in space, universities and research institutions on the one hand, the government on the second and industry on the third' (Bondi, 1971, p. 9).

On the other hand, outer space still remains firmly within the domain of the state and is likely to do so for the foreseeable future, with the likely continued importance of military uses of satellite technology and the weaponization of Earth’s orbit— crucially, the Outer Space Treaty only prohibits nuclear arms and other ‘weapons of mass destruction' in space, not conventional weapons, such as ballistic missiles. One novel element in this phase of capitalism-in-space is the interrelationship between Silicon Valley, NewSpace, and the state (see, e.g., Vance, 2015). Silicon Valley’s capitalist class, including Amazon’s Jeff Bezos, play an outsize role in NewSpace. Behind and around these figures, however, remains the state—through its weighty fiscal, regulatory, military, and symbolic investments.15 To take but one example: In June 2018, SpaceX won a $130 million contract with the U.S. Air Force to launch an ‘Air Force Space Command' satellite onboard a Falcon Heavy rocket (Erwin, 2018).

Fredric Jameson’s (2003, p. 76) oft-quoted observation that it is easier to imagine the end of humankind than the end of capitalism, is realized in the ideals and operations of capitalistkind. Elon Musk has observed that the goal of SpaceX is to establish humankind as a ‘multiplanetary species with a self-sustaining civilization on another planet' whose purpose is to counteract the possibility of a ‘worst-case scenario happening and extinguishing human consciousness' (Vance, 2015, p. 5). But couldn’t we view this idealistic assertion on behalf of humanity in another way? It is not human consciousness, over and against what the writer Kim Stanley Robinson (2017, p. 2) calls ‘mineral unconsciousness' (i.e., the mute, geological reality of the natural universe), so much as a specifically capitalist consciousness that is at stake. While the actions of capitalistkind may primarily be aimed at ensuring the future survival of the human species, an additional result is to ensure that the very idea of capitalism itself will outlive a (distantly) possible extinction event. Capitalism is a self-replicating system, pushing to expand ever outwards, using a territorializing strategy of survival. As David Harvey notes, ‘a steady rate of growth is essential for the health of a capitalist economic system, since it is only through growth that profits can be assured and the accumulation of capital be sustained' (1990, p. 180). In this respect, outer space is ideal: it is boundless and infinite. As Earth comes to be blanketed by capital, it is only to be expected that capital should set its sights on the stars above. The actions of capitalistkind serve to bolster the capitalist mode of production and accumulation: it is not only life but capital itself that must outlive Earth—even into the darkness of space.

#### Environmental degradation causes extinction.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

#### Corporate colonialism necessitates mass launch.

Shammas and Holen 19 [Victor L, a sociologist working at the Department of Sociology and Human Geography, University of Oslo; Tomas B., independent scholar in Oslo, Norway) “Capitalism and Outer Space: Replies to an Interlocutor” Dr. Victor Lund Shammas Blog, https://www.victorshammas.com/blog/2019/12/17/capitalism-and-outer-space, 12/18/2019] RM

When speaking of viability, one aspect that gets underplayed are the significant ecological effects of launching into space. For instance, SpaceX is developing the idea of Earth-to-Earth space flight, which might entail moving passengers from any point on Earth to any other point within, say, half an hour. What would be the ecological consequences of burning tremendous amounts of rocket fuel to escape Earth’s gravity well, just so that a London-based billionaire could get to Sydney in 30 minutes? There is something perverse about the idea that all the rest of us are being enjoined to cut back on flying, even as Musk and his cronies tinker away to make life easy for the hyper-rich.

Of course, this would be just one more step in a general tendency under capitalism that the geographer David Harvey calls time-space compression: The speed at which capital circulates increases and along with it life also accelerates. Both space and time are compressed by new technologies. One unfortunate consequence of Earth-to-Earth space flight, if it is ever realized, would be its damaging effects on our already CO2-saturated atmosphere. But perhaps more worrying, according to some rocket engineers, is the trail of soot and alumina left in the wake of rockets that could accumulate in the stratosphere and deplete our fragile ozone layer. The United Nations’ 2018 Quadrennial Global Ozone Assessment is the first annual UN report to take this threat seriously. Ironically, as Musk dreams of shuttling humans off Earth to Mars as a species-preserving measure, he could be co-responsible for accelerating the very destruction of Earth that he purportedly fears.

In a radically decarbonized future, heavy caps on emissions might be enough to shutter the space industry - or at least seriously rein it in. This might not be a bad thing, because as a report from the non-profit Aerospace Corporation recently noted, emissions from rockets “inherently impact the stratosphere in a way that no other industrial activity does.” Reaching space on a grand scale might entail tearing open and ripping apart our own atmosphere in the process. This is why we may need to rethink our future in space—perhaps even holding off from launching too many rockets into space—precisely in order to preserve life here on Earth.

#### That depletes the ozone layer, open the floodgates for existential UV floods, and leaves residual black carbon.

Grush 17 [Loren Grush, Loren Grush is a science reporter for The Verge, the technology and culture brand from Vox Media, where she specializes in all things space—from distant stars and planets to human space flight and the commercial space race. The daughter of two NASA engineers, she grew up surrounded by space shuttles and rocket scientists—literally. She is also the host of Space Craft, an original online video series that examines what it takes to send people to space. Before joining The Verge, Loren published stories in Popular Science, The New York Times, Nautilus Magazine, Digital Trends, Fox News, and ABC News.) “Why it’s time to study how rocket emissions change the atmosphere: Get the data now before the problem gets worse” The Verge, May 31, 2018] RM

Every time a rocket launches, it produces a plume of exhaust in its wake that leaves a mark on the environment. These plumes are filled with materials that can collect in the air over time, potentially altering the atmosphere in dangerous ways. It’s a phenomenon that’s not well-understood, and some scientists say we need to start studying these emissions now before the number of rocket launches increases significantly.

It’s not the gas in these plumes that’s most concerning. Some rockets do produce heat-trapping greenhouse gases, like carbon dioxide, but those emissions are negligible, according to experts. “The rocket business could grow by a factor of 1,000 and the carbon dioxide and water vapor emissions would still be small compared to other industrial sources,” Martin Ross, a senior project engineer at the Aerospace Corporation who studies the effects of rockets on the atmosphere, tells The Verge.

Instead, it’s tiny particles that are produced inside the trail that we need to watch out for, Ross says. Small pieces of soot and a chemical called alumina are created in the wakes of rocket launches. They then get injected into the stratosphere, the layer of Earth’s atmosphere that begins six miles up and ends around 32 miles high. Research shows that this material may build up in the stratosphere over time and slowly lead to the depletion of a layer of oxygen known as the ozone. The ozone acts like a big shield, protecting Earth against the Sun’s harmful ultraviolet radiation. However, the magnitude of this ozone depletion isn’t totally known, says Ross.

“IT’S A CALL FOR MORE RESEARCH IN THIS AREA TO KNOW EXACTLY WHAT WE’RE PUTTING INTO THE UPPER ATMOSPHERE AND IN WHAT QUANTITIES.”

That’s why he and others at the Aerospace Corporation, a nonprofit that provides research and guidance on space missions, are calling for more studies. They say it’s especially important now since the private space industry is at the early stages of a launch revolution. Currently, the number of launches each year is relatively small, around 80 to 90, so the aerospace industry’s impact on the atmosphere is not much of a concern. But in a new paper published in April, Ross and his colleague Jim Vedda argue that as launches increase, policymakers will eventually want to know what kind of damage these vehicles are causing to the environment and if regulations are necessary. When that time comes, it will be better to have as much data as possible to make the best decisions.

“It’s a call for more research in this area to know exactly what we’re putting into the upper atmosphere and in what quantities,” Vedda, a senior policy analyst at the Aerospace Corporation, tells The Verge. “So when the debates start, we have the good hard data that says, ‘Here’s a well-defined model of what’s actually happening.’”

So far, the research we have about these emissions mostly comes from lab experiments, modeling, and some direct detections of rocket plumes. At the turn of the century, a few high-altitude planes equipped with sensors flew through plumes created by the Space Shuttle and other vehicles to figure out what was inside.

It turns out that all kinds of rockets produce these emissions, but some types of vehicles produce more than others. Rockets that run on solid propellants produce a higher amount of alumina particles, a combination of aluminum and oxygen that is white and reflective. Most orbital rockets don’t run on solid propellants these days, though some launch companies like the United Launch Alliance do add solid rocket boosters to vehicles to give them extra thrust. Meanwhile, rockets that run on liquid kerosene, a type of refined oil, produce more of the dark soot particles, what is known as black carbon. Kerosene is used as a propellant for rockets such as ULA’s Atlas V and SpaceX’s Falcon 9.

ALL KINDS OF ROCKETS PRODUCE THESE EMISSIONS, BUT SOME TYPES OF VEHICLES PRODUCE MORE THAN OTHERS

Alumina and black carbon from rockets can stick around in the stratosphere for three to five years, according to Ross. As these materials collect high above the Earth, they can have interesting effects on the air. Black carbon forms a thin layer that intercepts and absorbs the sunlight that hits Earth. “It would act as a thin, black umbrella,” says Ross. That may help keep the lower atmosphere cool, but the intercepted energy from the Sun doesn’t just go away; it gets deposited into the stratosphere, warming it up. This warming ultimately causes chemical reactions that could lead to the depletion of the ozone layer.

The reflective alumina particles can also affect the ozone but in a different way. Whereas the soot acts like a black umbrella, the alumina acts like a white one, reflecting sunlight back into space. However, chemical reactions occur on the surface of these white particles, which, in turn, destroy the ozone layer, Ross says.

Black carbon and alumina have actually been proposed by scientists as possible geoengineering agents or tools for cooling down our warming climate. But while they may keep the lower atmosphere cool, geoengineering agents may have other unwanted side effects, too. They might interact with jet streams, causing droughts or more tropical storms. That’s why many scientists have criticized the idea of geoengineering to combat climate change.

However, rockets are putting these particles into the air no matter what, and this byproduct of ozone loss is particularly concerning for Ross and Vedda. As the ozone diminishes, more of the Sun’s harmful radiation could reach the ground. These UVB rays can cause skin cancer and cataracts. “That’s what we need to understand — the ozone depletion aspect of this because protection of the ozone layer is an international imperative,” says Ross. The 1987 Montreal Protocol, for example, is an international agreement to phase out materials that deplete the ozone.

Right now, Ross estimates that rocket launches around the world inject 10 gigagrams, or 11,000 tons, of soot and alumina particles into the atmosphere each year. But that number could be going up. SpaceX has vowed to increase the number of launches it does each year, and numerous other companies are going to start launching their own vehicles soon. What kind of impact that will have on the atmosphere is unclear. That’s why Ross and Vedda suggest the government and universities invest in a series of research programs, in which scientists collect more data on rocket particles from aircraft and satellites.

“WE WANT TO BE PROACTIVE BEFORE THIS TIPPING POINT OCCURS.”

#### **Ozone collapse causes extinction.**

Simmons 20 [Carla Simmons,, The Science Times, "A Repeat of One of the Biggest Extinctions Caused by Ozone Layer Erosion 359M Years Ago Possible, Warn Scientists | Science Times", May 27, 2020, https://www.sciencetimes.com/articles/25838/20200527/repeat-one-biggest-extinctions-caused-ozone-layer-erosion-359m-years.htm] BD

University of Southampton researchers have delved deeper into an extinction event that occurred about 360 million years ago. According to their research, the ozone layer's breakdown caused by ultraviolet (UV) radiation vanquished much of the Earth's marine life and greenery. Moreover, their discovery led to weighty indications for today's continually warming Earth.

Numerous episodes of mass extinction occurred in the geological past. One of the most notorious ones caused the extinction of dinosaurs about 66 million years ago. Their destruction was believed to have been caused by an asteroid hitting the Earth.

Additionally, two chapters were caused by large-scale volcanic eruptions that created the imbalance of oceans and atmospheres in the planets. Another one happened during the end of Permian Great Dying, which, according to Stanford, wiped out 96% of the Earth's aquatic species.

Scientists have discovered evidence pointing to high levels of UV radiation responsible for collapsing forest ecosystems and killing off water animal species during the Devonian geological period about 359 million years ago.

Their research revealed that warming temperatures after an intense ice age could have caused the ozone to collapse. The researchers suggest that the Earth might possibly reach comparable temperatures, thus might face the same consequences that occurred in the past.

The findings of their study are published in the journal Science Advances. Additionally, the research was partly funded by a grant from the National Geographic Society. It was also regulated in collaboration with The Sedgwick Museum of Earth Sciences at the University of Cambridge.

The team collected various rock samples during expeditions in locations in South America. They formed clues as to what was happening at the edge of the melting Devonian ice sheet, which allowed them to compare between the extinction event close to the pole and near the equator.

The rocks were then dissolved in hydrofluoric acid back in the laboratory. The dissolved rocks released microscopic plant spores, which were preserved for hundreds of millions of years. On microscopic examination, the scientists found many of the spores had bizarrely formed spines on their surface.

According to the researchers, the spikes were due to UV radiation damaging their DNA. Furthermore, they found that many spores had dark pigmented walls. These walls were thought to be a protective 'shield' against the increasing and damaging UV levels.

From their findings, the scientists have concluded that during a time of expeditious global warming, the ozone layer collapsed for a short while. Moreover, the ozone collapse exposed life on Earth to harmful UV radiation levels and, therefore, triggered a mass extinction event. This affected life on land and in shallow water at the Devonian-Carboniferous boundary.

From Climate Change to Climate Emergency

Professor John Marshall, the lead researcher from the University of Southampton's School of Ocean and Earth Science, said that our ozone layer is currently in a state of alteration. He adds that they have seen this pattern in the past, where a stimulant or impetus was unnecessary for the phenomenon to kick in.

He also says that current approximate calculations suggest that the Earth will reach similar global temperatures to those of 360 million years ago. Furthermore, they say it is possible that a similar collapse of the ozone layer could occur again, dangerously exposing surface and shallow sea life to harmful radiation.

#### UV floods supress immune responses and lead to radiation

Lucas et al 14 (R. M. Lucas (National Centre for Epidemiology and Population Health, The Australian National University, Canberra 2601, Australia, Telethon Kids Institute, University of Western Australia, Perth 6008, Australia), M. Norval (Biomedical Sciences, University of Edinburgh Medical School, Edinburgh EH8 9AG, Scotland, UK), R. E. Neale (QIMR Berghofer Medical Research Institute, Brisbane 4029, Australia), A. R. Young (King's College London (KCL), St John's Institute of Dermatology, London SE1 9RT, UK), F. R. de Gruijl (Department of Dermatology, Leiden University Medical Centre, P.O. Box 9600, NL-2300 RC Leiden, The Netherlands), Y. (Akita University Graduate School of Medicine, Akita-shi, Akita Prefecture, Japan, National Institute for Minamata Diseases, Minamata-sh, Kumamoto Prefecture, Japan) and J. C. van der Leun (iEcofys, Kanaalweg 16G, NL-3526 KL Utrecht, The Netherlands), “The consequences for human health of stratospheric ozone depletion in association with other environmental factors”, November 10th, 2014, <https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b>) CS

Effects of solar UV radiation on immune function and consequences for disease Mechanisms UV photons penetrate the epidermis and upper dermis162 and are absorbed by chromophores ([Table 2](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#tab2)), which then **initiate a cascade leading to changes in immune responses**. Table 2 Cutaneous chromophores involved in the initiation of UV-induced changes in immune function (reviewed in [ref. 163](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit163)While much of this information has been gathered from studies in vitro or in rodent models, less is known about humans. However, an action spectrum for the UV-induced suppression of the human immune response to a previously-encountered antigen (termed memory or recall immune responses) has been constructed: it has two peaks, one within the UV-B waveband at 300 nm and one at 370 nm in the UV-A waveband.[164,165](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit164) There is also evidence from studies in both humans and mice that interactive and additive effects between wavebands can occur.[166–168](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit166) Briefly, exposure to UV radiation causes up-regulation of some innate immune responses, **and down-regulation of** some acquired primary and memory **immune responses**, mainly through effects on T cell activity (reviewed in Gibbs & Norval,[163](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit163) Schwarz & Schwarz,[169](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit169) and Ullrich & Byrne[170](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit170)). The up-regulation includes the production of several antimicrobial peptides (AMPs) in the epidermis,[171,172](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit171) possibly through a vitamin D pathway (see below). The AMPs provide immediate protection against a variety of pathogens (bacteria, fungi, and viruses having a viral envelope) and they are also involved in the promotion of cell growth, healing, and angiogenesis. In contrast to these stimulatory functions, exposure to UV radiation induces T regulatory cells (Tregs) and other cell types which contribute to immunosuppression and help to restore cutaneous homeostasis.[172,173](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit172) Mediators such as platelet-activating factor, prostaglandin E2, histamine, and tumour necrosis factor-α are produced locally at the irradiated site. These alter the migration patterns and functions of various populations of immune cells. The end result is the generation of cell subsets with suppressive activity which are thought to remain for the life-time of the individual.[174,175](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit174) The UV-induced alterations in the normal immune response can be beneficial for some human diseases and detrimental for others. Vitamin D, synthesised following exposure of the skin to UV-B radiation, also has positive and negative effects on immune-related diseases. Indeed, it is difficult to distinguish between immunoregulation by vitamin D and other mediators induced by UV radiation,[176–180](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit176) since the downstream effects on immune parameters are similar. For clarity, the effects of UV radiation and those of vitamin D have been assessed separately in the sections below. We first focus on the effects of UV radiation on immunity, and address vitamin D-related effects on immune function in the section specifically on vitamin D. Polymorphic light eruption Polymorphic light eruption (PLE) is the commonest of the photodermatoses, with a prevalence of up to 20%.[181](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit181) PLE manifests as an intermittent itchy red skin eruption which resolves without scarring after a few days to weeks. It occurs 2–3 times more frequently in women than in men, with onset typically in the first three decades of life,[181](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit181) and is found predominantly in those with fair skin, although all skin types can be affected.[181](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit181) A recent study of Indian patients with dark skin phototypes (IV and V) who suffered from various photodermatoses revealed that PLE was the commonest of these, affecting 60% of the group.[182](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit182) The lesions occur most often in the spring and early summer or during a sunny holiday, following the first exposure to a large dose of sunlight. After repeated exposures, the lesions are less likely to occur. This process, called photohardening, is used therapeutically with good results. Recent investigations indicate that key events in photohardening include a decrease in the number of Langerhans cells in the epidermis and recruitment of mast cells into the dermis,[183](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit183) together with changes in systemic cytokine levels.[184](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit184) PLE is immunologically-mediated as a result of a failure to establish the normal suppression of immune responses following exposure to UV radiation. The antigen involved has not been identified but is likely to be novel, induced by the **DNA damaging properties of UV radiation**. Various abnormalities in the cutaneous immune response following UV radiation have been demonstrated in people with PLE compared with controls.[185,186](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit185) This disease therefore illustrates the positive evolutionary advantage of UV-induced immunosuppression in individuals who are not susceptible to PLE and what can happen if it is absent. Asthma **Asthma** comprises a group of diseases that evidence as wheeze, chest tightness, or shortness of breath, occurring as a result of obstruction of the airways and restriction of airflow that is usually reversible. The level of severity, frequency of symptoms, age of onset, main inflammatory phenotypes, and triggers and pathways are variable. This heterogeneity may explain the current lack of consistency in results from studies examining the relationship between UV radiation and the risk of asthma. There are anecdotal accounts that sunny holidays or living at high altitude decrease asthma symptoms. The prevalence of asthma was inversely associated with the intensity of UV radiation,[187](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit187) or past personal exposure to solar UV radiation.[188](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit188) However, in a study where different sub-types of asthma were considered, residence at latitudes closer to the equator (and with greater intensity of UV-B radiation) was associated with an increased risk of having asthma in atopic participants (with a history of allergic responses to specific antigens) but a decreased risk in those without atopy.[189](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit189) These findings highlight the importance of differentiating between subtypes of asthma in examining associations with exposure to UV radiation. Nevertheless, individual-level exposure to UV radiation was not measured (only latitude and ambient UV radiation), so the results could reflect exposure to other latitude-associated factors such as temperature and indoor heating. Infection and vaccination Studies over the past 20 years have shown that **exposure to solar UV radiation suppresses** microbe-specific acquired **immune responses in** animal models of **infection**. This modulation can lead to an **increased microbial load, reactivation from latency, and more severe symptoms, including death** (reviewed in Norval et al.[190](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit190)). A recent study showed that spending 8 or more hours outdoors per week when the UV Index was ≥4 was associated with an increased risk of ocular recurrence of herpes simplex virus (HSV) infection resulting in eruptive lesions.[191](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit191) **UV radiation prior to vaccination** causes a **less effective immune response** in several mouse models (reviewed in Norval & Woods[192](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit192)), but whether exposure to UV radiation adversely affects the course of infections and the efficacy of vaccination in humans remains an open question. Despite the paucity of new information, there remains the possibility that UV-induced immunosuppression could **convert an asymptomatic infection into a symptomatic one**, **reactivate** a range of **persistent infections**, increase the oncogenic potential of microbes, and **reduce the memory immune response,** for example after vaccination, so that it is no longer protective. Autoimmune diseases Many autoimmune diseases are considered to have both environmental and genetic risk factors. Evidence to support the importance of environmental exposures comes from geographical variation (changing incidence with changing latitude), temporal patterns (such as variations in incidence with season or season-of-birth) and results from observational epidemiological studies. Several studies show an inverse association between exposure to UV radiation and immune-mediated diseases, suggesting that the UV may be protective. In many cases, the assumed pathway has been through enhanced synthesis of vitamin D (see section on Vitamin D below). However, this evidence is now being re-evaluated in light of possible alternative pathways, including UV-induced immune modulation and altered susceptibility to relevant viral infections, and non-UV pathways such as changes in the secretion of melatonin (reviewed in Hart et al.[193](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit193)). While there have been suggestions that exposure to UV radiation may be important for conditions such as inflammatory bowel disease (for example, Nerich et al.[194](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit194)), type 1 diabetes,[195](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit195) and rheumatic diseases (including rheumatoid arthritis, systemic lupus erythematosus, dermatomyositis, and others),[196](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit196) the strongest evidence is for multiple sclerosis. Multiple sclerosis. Many studies (but not all) have shown that the prevalence, incidence, or mortality from multiple sclerosis (MS) increases with increasing latitude and decreasing altitude or intensity of ambient UV radiation, in predominantly fair-skinned populations (reviewed in Hewer et al.[197](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit197)). In the US Nurses Health Studies, a latitudinal gradient present in a cohort of female nurses born before 1946 was not apparent in a similar cohort born after 1946.[198](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit198) The findings reflected an increase in incidence in the south in the later cohort (rather than a decrease in the north). One explanation given to explain this change was that increasing sun-protective behaviours in the south had reduced the difference in personal dose of UV between the north and south.[199](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit199) Studies from the northern[200](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit200) and southern[201](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit201) hemispheres show that, compared to the general population, people with MS were more likely to have been born in late spring and less likely to have been born in late autumn. This timing would be consistent with a hypothesis that exposure of the mother to more UV radiation during the late first trimester, when the foetal nervous system is developing and maturing, is protective for the development of MS in later life.[201](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit201) Alternatively, it is also possible that exposures early in infancy, rather than in pregnancy, influence risk, or other factors that vary seasonally could be important. Animal studies suggest that UV-B irradiation can prevent the onset of experimental autoimmune encephalomyelitis, used as a model for MS,[202](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit202) and there is supportive evidence from recent studies in humans.[203,204](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit203) The role of UV-induced immune suppression in skin cancer Cutaneous malignant melanoma. Evidence that the immune response is important for the development of CMM is clearly shown by the increase in incidence following organ transplantation that requires ongoing treatment with immunosuppressive medications.[205](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit205) UV radiation, particularly UV-B, can cause suppression of many aspects of cell-mediated immunity but, until recently, how it influenced the initiation of CMM was unknown. In a transgenic mouse model, the recruitment of macrophages to the skin following UV-B irradiation and their subsequent proliferation were shown to be critical in the survival of melanocytes, including those with UV-induced DNA damage.[206–208](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit206) In addition, inflammation induced by UV radiation increased metastasis of melanoma, with neutrophils being the main drivers of the inflammatory process.[209](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit209) Consistent with these reports from animal models, in patients with metastatic melanoma there was a shorter survival time if metastases contained a high proportion of macrophages.[210](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit210) Non-melanoma skin cancer. Tumours induced by UV radiation are highly antigenic. UV-induced immune suppression plays a critical role in the development of NMSC as evidenced by the dramatically increased incidence in immunosuppressed people, for example, following organ transplantation.[211](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit211) This is especially shown for SCCs in organ transplant recipients receiving immunosuppressive drugs that suppress T cell activity, suggesting that effector T cells are of particular importance in the control of SCC.[212](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit212) Furthermore, Tregs induced by UV irradiation infiltrate SCCs and surround BCCs. Pharmacologically blocking steps in the pathway of UV-induced immunosuppression may be effective in preventing the development of skin cancers and actinic keratoses.[212–214](https://pubs.rsc.org/en/content/articlehtml/2015/pp/c4pp90033b#cit212)

#### Viruses to human bacterial genome to damage will ensure the next pandemic is existential

Supriya 4/19 [Lakshmi Supriya got her BSc in Industrial Chemistry from IIT Kharagpur (India) and a Ph.D. in Polymer Science and Engineering from Virginia Tech (USA). She has more than a decade of global industry experience working in the USA, Europe, and India. After her Ph.D., she worked as part of the R&D group in diverse industries starting with semiconductor packaging at Intel, Arizona, where she developed a new elastomeric thermal solution, which has now been commercialized and is used in the core i3 and i5 processors. From there she went on to work at two startups, one managing the microfluidics chip manufacturing lab at a biotechnology company and the other developing polymer formulations for oil extraction from oil sands. She also worked at Saint Gobain North America, developing various material solutions for photovoltaics and processing techniques and new applications for fluoropolymers. Most recently, she managed the Indian R&D team of Enthone (now part of MacDermid) developing electroplating technologies for precious metals.) “Humans versus viruses - Can we avoid extinction in near future?” News Medical Life Sciences, 4/19/21, https://www.news-medical.net/news/20210419/Humans-versus-viruses-Can-we-avoid-extinction-in-near-future.aspx] RM

Expert argues that human-caused changes to the environment can lead to the emergence of pathogens, not only from outside but also from our own microbiome, which can pave the way for large-scale destruction of humans and **even our extinction**.

Whenever there is a change in any system, it will cause other changes to reach a balance or equilibrium, generally at a point different from the original balance. Although this principle was originally posited by the French chemist Henry Le Chatelier for chemical reactions, this theory can be applied to almost anything else.

In an essay published on the online server Preprints\*, Eleftherios P. Diamandis of the University of Toronto and the Mount Sinai Hospital, Toronto, argues that changes caused by humans, to the climate, and everything around us will lead to changes that may have a dramatic impact on human life. Because our ecosystems are so complex, we don’t know how our actions will affect us in the long run, so humans generally disregard them.

Changing our environment

Everything around us is changing, from living organisms to the climate, water, and soil. Some estimates say about half the organisms that existed 50 years ago have already become extinct, and about 80% of the species may become extinct in the future.

As the debate on global warming continues, according to data, the last six years have been the warmest on record. Global warming is melting ice, and sea levels have been increasing. The changing climate is causing more and more wildfires, which are leading to other related damage. At the same time, increased flooding is causing large-scale devastation.

One question that arises is how much environmental damage have humans already done? A recent study compared the natural biomass on Earth to the mass produced by humans and found humans produce a mass equal to their weight every week. This human-made mass is mainly for buildings, roads, and plastic products.

In the early 1900s, human-made mass was about 3% of the global biomass. Today both are about equal. Projections say by 2040, the human-made mass will be triple that of Earth’s biomass. But, slowing down human activity that causes such production may be difficult, given it is considered part of our growth as a civilization.

Emerging pathogens

Although we are made up of human cells, we have almost ten times that of bacteria just in our guts and more on our skin. These microbes not only affect locally but also affect the entire body. There is a balance between the good and bad bacteria, and any change in the environment may cause this balance to shift, especially on the skin, the consequences of which are unknown.

Although most bacteria on and inside of us are harmless, gut bacteria can also have viruses. If viruses don’t kill the bacteria immediately, they can incorporate into the bacterial genome and stay latent for a long time until reactivation by environmental factors, when they can become pathogenic. They can also escape from the gut and enter other organs or the bloodstream. Bacteria can then use these viruses to kill other bacteria or help them evolve to more virulent strains.

An example of the evolution of pathogens is the cause of the current pandemic, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Several mutations are now known that make the virus more infectious and resistant to immune responses, and strengthening its to enter cells via surface receptors.

The brain

There is evidence that the SARS-CoV-2 can also affect the brain. The virus may enter the brain via the olfactory tract or through the angiotensin-converting enzyme 2 (ACE2) pathway. Viruses can also affect our senses, such as a loss of smell and taste, and there could be other so far unkown neurological effects. The loss of smell seen in COVID-19 could be a new viral syndrome specific to this disease.

Many books and movies have described pandemics caused by pathogens that wipe out large populations and cause severe diseases. In the essay, the author provides a hypothetical scenario where a gut bacteria suddenly starts producing viral proteins. Some virions spread through the body and get transmitted through the human population. After a few months, the virus started causing blindness, and within a year, large populations lost their vision.

Pandemics can cause other diseases that can threaten humanity’s entire existence. **The COVID-19 pandemic brought this possibility to the forefront**. If we continue disturbing the equilibrium between us and the environment, we don’t know what the consequences may be and **the next pandemic could lead us to extinction.**

### 1AC – Debris

#### Advantage 2 is Debris

#### Asteroid mining spikes the risk of satellite-dust collisions

Scoles 15 ~~[(Sarah Scoles, freelance science writer, contributor at Wired and Popular Science, author of the books Making Contact and They Are Already Here) "Dust from asteroid mining spells danger for satellites," New Scientist, May 27, 2015, <https://www.newscientist.com/article/mg22630235-100-dust-from-asteroid-mining-spells-danger-for-satellites/>~~] TDI

* Study this is citing – Javier Roa, Space Dynamic Group, Applied Physics Department, Technical University of Madrid. Casey J Handmer, Theoretical Astrophysics, California Institute of Technology. Both PhD Candidates. "Quantifying hazards: asteroid disruption in lunar distant retrograde orbits," arXiv, Cornell University, May 14, 2015, <https://arxiv.org/pdf/1505.03800.pdf>

NASA chose the second option for its [Asteroid Redirect Mission](http://www.nasa.gov/content/what-is-nasa-s-asteroid-redirect-mission/), which aims to [pluck a boulder from an asteroid’s surface](https://www.newscientist.com/article/dn27243-rock-grab-from-asteroid-will-aid-human-mission-to-mars) and relocate it to a stable orbit around the moon. But an asteroid’s gravity is so weak that it’s not hard for surface particles to escape into space. Now a new model warns that debris shed by such transplanted rocks could intrude where many defence and communication satellites live – in geosynchronous orbit.

According to [Casey Handmer](http://www.caseyhandmer.com/) of the California Institute of Technology in Pasadena and Javier Roa of the Technical University of Madrid in Spain, 5 per cent of the escaped debris will end up in regions traversed by satellites. Over 10 years, it would cross geosynchronous orbit 63 times on average. A satellite in the wrong spot at the wrong time will suffer a damaging high-speed collision with that dust.

The study also looks at the "catastrophic disruption" of an asteroid 5 metres across or bigger. Its total break-up into a pile of rubble would increase the risk to satellites by more than 30 per cent ([arxiv.org/abs/1505.03800](http://arxiv.org/abs/1505.03800)).

#### Commercial rocket launches produce space clutter—increased debris could reach a tipping point. AND private companies are impossible to control – only space decolonization solves

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.

“More satellites mean more risk,” he said. “And we as a nation have not yet caught up to the risk that currently exists in space.” In September, a few months after Bridenstine and I spoke, the space station had to fire its thrusters for 150 seconds to [move out of the way](https://blogs.nasa.gov/spacestation/2020/09/22/station-boosts-orbit-to-avoid-space-debris/) of dangerously approaching space junk, while the crew huddled in a Soyuz capsule in case the station’s hull was breached and they had to flee to Earth.

Apart from the fate of the station, one could ask who cares if a commercial stampede blights Earth’s orbit, and wrecks anyone’s ability to keep satellites aloft? Maybe it’ll just hurt a bunch of investors. And maybe we need less surveillance from deathless orbiting eyes, not more.

There are, though, plenty of civically significant reasons to keep low-Earth orbit usable. Satellite monitoring isn’t solely a spy activity—these days, it has become a powerful tool for climate scientists to figure out how the oceans are warming, and to puzzle out our adaptations to climate change. Other nonprofit concerns use satellites to monitor injustices on Earth: Global Forest Watch, for example, takes data from the 140-satellite array of the firm Planet and uses it to help [bust illegal deforestation](https://www.planet.com/pulse/planet-ksat-and-airbus-awarded-first-ever-global-contract-to-combat-deforestation/).

So it’d certainly be good to keep low-Earth orbit from becoming a junkyard. But there’s no ready consensus on how to do that. Some government regulation could help: Bridenstine wants Congress to pass a bill funding a department in charge of “compelling somebody to maneuver if it’s necessary.” Moriba Jah would like a federal law requiring space firms to openly publish the location of their satellites. (Some, like Planet, already do, but most, as Jah has found, make it very difficult for others to pin down the exact locations of their satellites.) “You can’t enforce anything unless you know what’s happening,” Jah said, and a name-and-shame system could help: “Once people can assign a first and last name, it’s like, OK, these assholes aren’t complying.” Better tech might also assist; the U.S. firm [LeoLabs](https://www.leolabs.space/) is building a radar-dish array that can track pieces of space junk as small as a few centimeters. Others are working on as-yet-untested ways of actually cleaning up orbital junk, possibly by pushing it down to burn up on reentry.

“Sometimes I think that we might need to have some terrible collision event happening for the world to kind of come together and take it seriously.”

New Space firms themselves, however, want to be left alone to deal with this problem. Most I spoke to argued—quite against the weight of industrial history—that the free market would self-regulate, since each firm wants orbits clean enough to make money in. But even some ardent champions of the new commercial boom worry things may get worse before anyone snaps to attention. “Sometimes I think that we might need to have some terrible collision event happening for the world to kind of come together and take it seriously,” Lal told me.

Satellites are the big commercial opportunity in space right now, though there are plenty of others in various states of gestation. Each one raises a handful of intriguing possibilities for a commercial boom, and its own blizzard of questions for earthbound society. One rough rule of thumb for sizing them up might go something like this: The farther out you go from Earth, the weirder the questions become.

The most proximal market, according to investors, is probably the development of [manufacturing in near-Earth orbit](https://www.space.com/40552-space-based-manufacturing-just-getting-started.html), on space stations. Microgravity, it turns out, makes it possible to create materials that can’t easily be pulled together on Earth. The range of product lines for off-planet factories runs from specially shaped contact lenses (designed to correct deep vision problems) to optical fibers capable of carrying more data than cables made on Earth. One firm, [Nanoracks](https://nanoracks.com/), currently contracts out room for commercial start-ups on the International Space Station. Its early client list boasts a diverse array of for-profit activities—everything from running science experiments to launching small, inexpensive “[Cubesats](https://www.nasa.gov/mission_pages/cubesats/overview)” that can fit in your hand and mostly do remote sensing (like monitoring the atmosphere) for research or industry. In the long run, Nanoracks aims to launch its own space station to offer complex manufacturing capabilities that wouldn’t currently fit in the International Space Station’s limited confines.

“There’s a lot of work you can do, a lot of research and a lot of exciting things when you’re not connected to a gigantic, humongous modular space station that has different gravity tensions, different forces acting on it, disturbing the microgravity,” Nanoracks CEO Jeffrey Manber noted.

The next generation of space stations will probably be built—like Manber’s hoped-for one—mostly by private interests. Such installations will continue to do plenty of work for governments. Manber would rather make a fully robotic space station—it’s far more profitable for New Space moguls not to shoulder the, ahem, astronomical costs of keeping people alive in outer space—but he anticipates that a major early customer would likely be NASA, and one of NASA’s main scientific areas of study is how humans react to living in space. Any for-profit space station NASA’s contracting agents would bring on would thus likely need to host a crew.

Beyond the space station beckons another old NASA stomping ground—the moon, which has become newly lucrative. After the last Apollo visit in 1972, NASA and Congress abandoned the moon; reaching it had been a quest to beat the Soviets, and, that race won, public support for the incredible expense evaporated. But over the last decade, moon activity has rebooted. Trump [announced](https://www.theatlantic.com/science/archive/2019/03/trump-nasa-moon-2024/585880/) the goal of returning NASA astronauts to the lunar surface; India [tried and failed](https://www.npr.org/2019/11/26/782890646/2-months-after-failed-moon-landing-india-admits-its-craft-crashed) to put a lander down; and last year, [China succeeded](https://www.space.com/42981-china-moon-far-side-panorama-chang-e-4.html). NASA is currently planning to build a lunar [Gateway](https://www.nasa.gov/gateway), a space station orbiting the moon, to assist in regular traffic back and forth; SpaceX has a $7 billion contract for launching its components.

What, exactly, made the moon sexy again? The [discovery of water](http://news.bbc.co.uk/2/hi/science/nature/8544635.stm). Beginning in the late aughts, moon probes have found that craters in the lunar poles contain water ice—some 600 million tons of it, according to one estimate. This instantly changed the moon’s geopolitical and economic import, because water is an enormously precious commodity in space. It’s crucial for life—not just as a fluid, but broken into its constituent molecular parts: oxygen that lets you breathe, and hydrogen for fuel. One scientist’s rough estimate found that the amount of water on the moon could power one space shuttle launch every day for 2,200 years. Several companies announced their eventual goal would be to create landing craft that could reach the moon and mine the water. One such concern, [the Moon Express](https://www.theverge.com/2017/7/12/15958164/moon-express-robot-landers-private-mining-outpost), pitches its mission in a heady compound of colonialist new frontier rhetoric—equal parts Star Trek and Rudyard Kipling: “The Moon is Earth’s 8th continent,” the firm announces on its website.

But even assuming the wet new lunar frontier can be tamed—for all the space-booster rhetoric, it’s still a very spec-ulative prospect, both logistically and economically—there’s a whole host of untested questions about property rights in the great beyond. Space law, it turns out, is very ambiguous about who’s empowered to exploit space resources, and to what geopolitical-cum-commercial ends. There’s an [Outer Space Treaty](https://2009-2017.state.gov/t/isn/5181.htm), signed in 1967 by most major industrial countries, which seeks to establish space as a shared resource for humanity. It lets corporations engage in commercial activities on other celestial bodies—but neither they nor countries can claim property rights; and whatever a corporation does in space, its host country is on the hook for. There is also a Moon Treaty, created in 1979, that bans property rights on the moon and requires equitable use of lunar resources by all nations. But the Moon Treaty is [mostly toothless](https://www.thespacereview.com/article/1954/1); no country that has launched humans into space ever signed it.

The force of those treaties was never certain. But now that there’s possible money at hand, individual countries are openly defying the treaties—writing laws under their own steam to allow property rights in the heavens. In 2015, Obama signed the [SPACE Act](https://psmag.com/social-justice/outer-space-treaties-didnt-anticipate-the-privatization-of-space-travel-can-they-be-enforced), which explicitly gives U.S. firms the rights to any resources they mine from a celestial body. The Trump administration is [actively pushing](https://www.theguardian.com/science/2020/may/05/trump-mining-moon-us-artemis-accords) for firms to mine the moon. Other countries courting New Space firms—[hello, Luxembourg](https://www.technologyreview.com/2019/11/26/131822/why-its-now-the-perfect-time-to-start-a-small-space-agency/)—are following suit.

History, of course, would suggest that treaties crumble when serious money comes into play. Western settlers signed treaties with indigenous people in the Americas, then ignored them, as Lucianne Walkowicz, an astronomer at the [Adler Planetarium](https://www.adlerplanetarium.org/) and another cofounder of the JustSpace Alliance, noted.

“In many cases,” she told me, “treaties are good until somebody discovers something that they want.” She’s a fan of the Outer Space Treaty, finding it “a very, like, hopeful, peaceful, almost Star Trek-esque view of what space is.” She hopes it proves stronger than it looks.

Historically, however, law tends to follow the facts on the ground rather than shape them. When a new geography for commerce opens, whoever shows up first to exploit the resources sets the norm—and then law is written to validate the first movers. “‘First come, first serve’ is essentially what’s going to happen when people start to do things on the moon,” Peter Ward, author of [The Consequential Frontier](https://www.penguinrandomhouse.com/books/610858/the-consequential-frontier-by-peter-ward/), said.

Yet before the great water rush on the moon starts in earnest, one key point is worth pausing over: The supply of ice on the moon is limited. The estimated water reserves up there may be eye-popping at first glance, but they’re not that big. They likely add up to “three to five cubic kilometers of water, based on the studies that have come up,” said James Schwartz, a philosopher who also studies the ethics of space exploration. “Not a lot of water compared to even moderate- or small-size lakes on Earth.” It wouldn’t be that hard for a concerted explosion of commercial activity to chew through it all.

That may sound far-fetched, but, as all these space ethicists note, to the eyes of nineteenth-century explorers and industrialists, our planet seemed limitless, too—and it only took another century-plus of rapid commercial activity to tear through a diminishing store of finite resources. The environmental implications of exhausting the moon seem ludicrously sci-fi and far-off right now, and they’ll remain so for a long time—until, abruptly, they’re not. As with low-Earth orbit, outer space becomes much smaller and more cramped when you start thinking at commercial scale.

In any event, the moon is chiefly envisioned as a way-station project among the most ambitious cohort of space privatizers. A settled moon colony would serve as the push-off point for the main event, commercially speaking, for New Space entrepreneurs: mining the asteroid belt.

Asteroids are almost comically rich in precious materials. The asteroid Ryugu, for example, has about $82 billion in nickel and iron, according to the “[Asterank](https://www.asterank.com/)” asteroid-value–ranking project. Another, Bennu, boasts a cool $669 million worth of iron and hydrogen. “You could totally collapse the gold and platinum market on Earth by mining asteroids,” joked Jacob Haqq Misra, a senior research investigator with the [Blue Marble Space Institute of Science](https://www.bmsis.org/), a nonprofit that encourages space exploration.

But there’s a hitch: Nobody has much of an idea how you’d actually mine an asteroid. Despite what you’ve seen in lumbering sci-fi epics like Armageddon, merely grabbing hold of a comparatively small, city-block–size object in microgravity is a forbidding physics puzzle—to say nothing of actually refining whatever you find.

One thing’s clear, however: In order to reach an asteroid, you’d need a lot of fuel for robotic probes. (Oxygen, too, if you’re bringing along a human crew.) This would likely be too expensive to do from Earth, given its gravity. The moon, on the other hand, is a sweet spot to base one’s commercial mining endeavors: enough gravity so humans can live in a base and assemble a rotating corps of mining robots, but sufficiently little gravity that launching mining probes at asteroids is easy.

“It takes so much energy to escape Earth’s orbit, by the time you do that, you’re basically halfway to anywhere in the universe,” Anderson said. “The moon as a launchpad—there’s a lot of commercial value there.”

Some New Space firms harbor still greater plans, in line with the classic “civilizing mission” that animated so many colonial land rushes in recent terrestrial history. Jeff Bezos wants to build space stations that rotate fast enough to simulate Earth gravity—and large enough to host entire cities full of residents. It’s a vision he built from a youth steeped in sci-fi. At Princeton, he took a class with Gerard O’Neill, a physicist who’d been [arguing since the 1960s](https://www.bloomberg.com/news/articles/2019-05-13/why-jeff-bezos-s-space-habitats-already-feel-stale) that humanity had to slip the surly bonds of Earth in order to survive over the long haul. O’Neill argued that living in space and mining asteroids represented the only path forward for the human race to continue growing and prospering without laying waste to planet Earth. He laid it out as a simple proposition of geology: If you were to mine the entire Earth down half a mile, leaving it a honeycombed crater, you’d still only get 1 percent of the metals and substances from the three biggest asteroids.

Bezos has eagerly endorsed the space-colony vision. In the short term, Bezos’s plans are the standard-issue vision for the New Space entrepreneur: building rockets and spacecraft that NASA will hire in order to resume landing astronauts on the moon. But in the long run—decades hence—building space colonies is, as he has argued, the only mission he can find big enough to devote his life and riches toward. “The only way that I can see to deploy this much financial resource,” Bezos [told Business Insider](https://www.businessinsider.com/jeff-bezos-interview-axel-springer-ceo-amazon-trump-blue-origin-family-regulation-washington-post-2018-4), “is by converting my Amazon winnings into space travel.”

The unexpected costs of Bezos-style space exploitation are, as yet, a little distant—decades, at least. But if there’s one thing we’ve learned from observing the human and environmental wreckage of the industrial era, it’s that history is like space travel: The path you set at the beginning is critical. Changing course later on is much harder. So it behooves us to plan now. Are there ways to avoid the worst possible outcomes in space? How is commercial life in space going to unfold?

The world’s small community of space ethicists has, in recent years, been increasingly pondering this, and they’ve come to some unsettling conclusions. First off, they note, the big winners in space will likely be ... the big winners on Earth. “I think it’s going to benefit the wealthy people that are running these mining firms,” Schwartz said bluntly. There are, as New Space investors today will tell you, winner-take-all dynamics. Bezos built a supply chain that is helping Amazon gradually dominate the world. Space will probably have room for only a few winners. So in order to envision the future contours of space conquest, it’s probably a safe bet to take all the harms of monopoly we see on this planet and project them on to a literally cosmic scale.

And that leads, in turn, to a corollary prophecy: Human rights in space are likely to be execrable, if they’re left up to the private sector.

Consider that anyone working in space will be reliant upon their employer for the most basic stuff of life. That’s not just food and water, but breathable oxygen, on a minute-by-minute basis. Plenty of science fiction has, over the years, war-gamed the bleak implications of these precarious situations. In Ridley Scott’s [Alien](https://www.imdb.com/title/tt0078748/) (1979), the employees of “The Company” are sent unwittingly to encounter a vicious alien life-form, with The Company hoping it would get a profitable specimen out of this. More recently, the TV show [The Expanse](https://www.imdb.com/title/tt3230854/) depicts the lives of asteroid miners as an outright form of slavery. One could, again, regard this as the typical pessimism of left-wing creative types—until one ponders workers’ rights on Earth as they exist now. Employees in Amazon’s warehouses are already [peeing into bottles](https://www.theverge.com/2018/4/16/17243026/amazon-warehouse-jobs-worker-conditions-bathroom-breaks) and [collapsing from heat exhaustion](https://www.businessinsider.com/amazon-warehouse-2011-9) in their attempt to satisfy their employer’s relentless work quotas; imagine if the company also controlled their breathable air.

Charles Cockell is a professor of astrobiology at the University of Edinburgh who’s written at length about the question of freedom in space settlements. He’s generally a libertarian, so he’s concerned about concentrations of power in both governments and private-sector firms in space.

“The controls on freedom of movement on the moon or Mars are worse than in North Korea,” he told me. “You can’t just walk out of a settlement.” Control of oxygen, he predicted, will empower the worst instincts of authoritarians of any stripe. “It will attract the coercively inclined and petty officialdom like all these things do…. It will attract people who crave power. You have to assume that that will lead to tyranny.”

These thought experiments don’t all conclude in grim dead-ends, however. There’s a whole arm of space ethics and philosophy devoted to asking the questions: Could the prospect of settling space positively serve society and justice? Could it offer up new ways of thinking about how we organize civic relations?

Coping with scarcity in space might impel settlers to reconsider some of the basic tent­poles of Western society. One is prison: On Mars, jailing someone would cost billions. A settlement would, as the astrophysicist and ethicist Nesvold noted, wonder, “Is it even worth it?” They’d be far more liable to consider styles of justice that don’t involve locking people up. The same goes for environmental thinking. Water and air will be so precious to space settlers that “the people who are living in space are going to be much more concerned about resource conservation,” Schwartz said. “It could be the attitudes that we get there are ones that are helpful to send back [to Earth].”

The idea of space as a fresh slate for political thinking is enticing. But it’s hemmed in by the very nature of the market forces currently reaching for the skies. Would any private-sector firms heading to space agree to limit their power when they’re beyond Earth’s grasp? Nesvold and Lucianne Walkowicz think it’s possible. There is, they believe, a window of opportunity right now, while commercial space activity is still ramping up, to convince everyone in New Space—from the firms to their early (and crucial) governmental clients—to take space ethics seriously. They’ve been pursuing two tracks of inquiry along these lines: first, talking directly to New Space companies about the political, social, and environmental aspects of space exploitation. (The smaller firms, Nesvold noted, are often eager to talk; the big ones—the SpaceXs and Blue Origins—not so much.) Walkowicz has also been holding public events to get everyday citizens to discuss, as she put it, “becoming interplanetary.”

“I think making the infrastructure of getting to spaceflight cheaper and more sustainable, reusable, all of that stuff is great—I love watching rocket launches as much as the next person,” Walkowicz told me. But she wants a much broader cross-section of the public to have a voice on how space is used. As she frames things, it’s a simple matter of public accountability: For all the self-mythologizing among New Space titans about the new, scrappy, and libertarian cast of modern space exploration, it’s still NASA—and by extension, the people’s treasury—that’s projected to supply the biggest revenue stream for much New Space activity today, and in the near future. In other words, we the people are paying for many of these rocket launches, and the huge outlays that will help bankroll the hard stuff, like future human colonies on the moon.

So the public ought to have more input on how the projected settlement and exploitation of outer space actually happens. Walkowicz and Nesvold want to create a bigger sample of people informed about the stakes in the new space race, people who’d lobby Congress to help lay down the new American road rules for space—from keeping orbits clean to the question of who gets to ride on those taxpayer-funded rockets in the first place.

Space, in other words, needs to be “decolonized.” That’s a coinage gaining currency among some space thinkers, including Lindy Elkins-Tanton. She’s a planetary scientist with one foot in the world of New Space, and another in the world of space ethics. She’s the head of the NASA [“Psyche” project](https://www.jpl.nasa.gov/missions/psyche/), which is launching a probe next year to explore the metallic asteroid Psyche. On the one hand, she is herself benefiting directly from the lower costs that New Space has created, so she’s generally a fan of commercial interests making space more viable. Her probe will launch on a SpaceX rocket, and it’s so much cheaper than NASA’s older launches that it makes her science far more affordable. (“I’m sure I’m not supposed to tell you, but I’ll tell you: It’s a lot of money,” she said.)

Yet as Elkins-Tanton noted, the story of new frontiers being settled is the history of colonization, fueled by moneyed interests. Whether it was Europeans heading to North America or Africa or parts of Asia, it was generally huge state interests putting up the money for risk-taking explorers—with the explorers getting rich, the states amassing power, the new frontiers becoming gradually stripped of resources, and their indigenous populations either killed or impoverished.

“Decolonization,” as she and other New Space ethicists put it, would be a different route. It’d be the act of exploring space with that history in mind, and working deliberately in concert to avoid its brutalities. What would that mean? Elkins-Tanton argued, like Walkowicz and Nesvold, that any voyages to space need to have much greater democratic participation. For years, she’s been organizing annual projects that bring together a disparate array of thinkers—astrophysicists, artists, indigenous scholars—to plan for things such as how a Mars colony might exist without becoming a human rights nightmare.

#### Private space companies vastly outpace the public sector and avoid regulation which makes it a uniquely dangerous industry

**Rauenzahn et al, 20** (The Regulatory Review, 6-6-2020, accessed on 1-14-2022, The Regulatory Review, "Regulating Commercial Space Activity | The Regulatory Review", https://www.theregreview.org/2020/06/06/saturday-seminar-regulating-commercial-space-activity/)azhang

Scholars address possible strategies to regulate an emerging commercial space industry. After much anticipation, the United States launched a manned rocket ship for the first time in almost a decade. The launch marked a new era of space travel as Elon Musk’s SpaceX became the first private company to transport astronauts to space. But the transformation of spaceflight from a public endeavor to a commercial industry raises questions about how to regulate the activities of private entities in space. In 2014, the National Aeronautics and Space Administration (NASA) outsourced the task of transporting its astronauts, granting billion-dollar contracts to SpaceX and Boeing in a program called Commercial Crew. NASA astronauts Doug Hurley and Bob Behnken became the first crew to enter space under this public-private program. Over the next few decades, NASA plans to rely on this commercial partnership to pursue even more ambitious goals: returning to the moon and sending astronauts to Mars. But private companies have their own aspirations for outer space. Musk hopes to use SpaceX to start a human colony on Mars. Amazon’s Jeff Bezos also has his sights set on space colonization, and firms such as Bigelow Aerospace and Axiom Space plan to develop their own space stations. Some investors see opportunities in space tourism and mining. But these for-profit goals raise serious concerns about who can claim ownership of space resources and what law will govern private activity in uncharted frontiers. International space law is governed by a 1967 agreement known as the Outer Space Treaty⁠. The treaty allows all nations to use and explore the moon and celestial bodies, prohibits claims of sovereignty, and it requires nations to oversee the activities of private space companies. But existing space law has not kept up with the growth in the private sector, and the United States lacks a comprehensive regulatory regime. In anticipation of a growing commercial space industry, some experts and scholars call for more robust regulation. This week’s Saturday Seminar focuses on possible legal frameworks for governing commercial activity in outer space.

#### 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)~~]

#### 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 the 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.

#### 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.

#### Satellite internet constellations accelerate collision risks – more close encounters and less transparency means bad decisions are inevitable.

Pultarova 21 “SpaceX Starlink satellites responsible for over half of close encounters in orbit, scientist says” Tereza Pultarova [Master's in Science from the International Space University, France, to her Bachelor's in Journalism and Master's in Cultural Anthropology from Prague's Charles University. She worked as a reporter at the Engineering and Technology magazine, freelanced for a range of publications including Live Science, Space.com, Professional Engineering, Via Satellite and Space News and served as a maternity cover science editor at the European Space Agency.], August 18, 2021 <https://www.space.com/spacex-starlink-satellite-collision-alerts-on-the-rise> SM

SpaceX Starlink satellites responsible for over half of close encounters in orbit, scientist says

Starlink satellites might soon be involved in 90% of close encounters between two spacecraft in low Earth orbit.

Operators of satellite constellations are constantly forced to move their satellites because of encounters with other spacecraft and pieces of space junk. And, thanks to SpaceX's Starlink satellites, the number of such dangerous approaches will continue to grow, according to estimates based on available data.

SpaceX's Starlink satellites alone are involved in about 1,600 close encounters between two spacecraft every week, that's about 50 % of all such incidents, according to Hugh Lewis, the head of the Astronautics Research Group at the University of Southampton, U.K. These encounters include situations when two spacecraft pass within a distance of 0.6 miles (1 kilometer) from each other.

Lewis, Europe's leading expert on space debris, makes regular estimates of the situation in orbit based on data from the Socrates (Satellite Orbital Conjunction Reports Assessing Threatening Encounters in Space ) database. This tool, managed by Celestrack, provides information about satellite orbits and models their trajectories into the future to assess collision risk.

Lewis publishes regular updates on Twitter and has seen a worrying trend in the data that reflects the fast deployment of the Starlink constellation.

"I have looked at the data going back to May 2019 when Starlink was first launched to understand the burden of these megaconstellations," Lewis told Space.com. "Since then, the number of encounters picked up by the Socrates database has more than doubled and now we are in a situation where Starlink accounts for half of all encounters."

The current 1,600 close passes include those between two Starlink satellites. Excluding these encounters, Starlink satellites approach other operators’ spacecraft 500 times every week.

In comparison, Starlink's competitor OneWeb, currently flying over 250 satellites, is involved in 80 close passes with other operators' satellites every week, according to Lewis' data.

And the situation is bound to get worse. Only 1,700 satellites of an expected constellation of tens of thousands have been placed into orbit so far. Once SpaceX launches all 12,000 satellites of its first generation constellation, Starlink satellites of all close approaches, Lewis’ calculations suggest.will be involved in 90%

**Chart, line chart

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A graph showing the number of close encounters between Starlink satellites and spacecraft of other operators plotted by Professor Hugh Lewis based on data from the Socrates database.A graph showing the number of close encounters between Starlink satellites and spacecraft of other operators plotted by Professor Hugh Lewis based on data from the Socrates database. (Image credit: Hugh Lewis)

The risk of collision

Siemak Hesar, CEO and co-founder of Boulder, Colorado, based Kayhan Space, confirms the trend. His company, which develops a commercial autonomous space traffic management system, estimates that on average, an operator managing about 50 satellites will receive up to 300 official conjunction alerts a week. These alerts include encounters with other satellites as well as pieces of debris. Out of these 300 alerts, up to ten might require operators to perform avoidance maneuvers, Hesar told Space.com.

Kayhan Space bases their estimates on data provided by the U.S. Space Surveillance Network. This network of radars and telescopes, managed by the U.S. Space Force, closely monitors about 30,000 live and defunct satellites and pieces of debris down to the size of 4 inches (10 centimeters) and provides the most accurate location data of the orbiting objects.

The size of this catalog is expected to increase ten times in the near future, Hesar added, partly due to the growth of megaconstellations, such as Starlink, and partly as sensors improve and enable detection of even smaller objects. The more objects in the catalog mean more dangerously close encounters.

"This problem is really getting out of control," Hesar said. "The processes that are currently in place are very manual, not scalable, and there is not enough information sharing between parties that might be affected if a collision happens."

Hesar compared the problem to driving on a highway and not knowing that there has been an accident a few miles ahead of you. If two spacecraft collide in orbit, the cloud of debris the crash generates would threaten other satellites travelling through the same area.

"You want to have that situational awareness for the other actors that are flying in the neighbourhood," Hesar said.

Bad decisions

Despite the concerns, only three confirmed orbital collisions have happened so far. Earlier this week, astrophysicist and satellite tracker Jonathan McDowell, who's based at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, found evidence in Space-Track data that the Chinese meteorological satellite Yunhai 1-02, which disintegrated in March this year, was actually hit by a piece of space debris.

The worst known space collision in history took place in February 2009 when the U.S. telecommunication satellite Iridium 33 and Russia's defunct military satellite Kosmos-2251 crashed at the altitude of 490 miles (789 kilometres). The incident spawned over 1,000 pieces of debris larger than 4 inches (10 cm). Many of these fragments were then involved in further orbital incidents.

Lewis is concerned that with the number of close passes growing, the risk of operators at some point making a wrong decision will grow as well. Avoidance maneuvers cost fuel, time and effort. Operators, therefore, always carefully evaluate such risks. A decision not to make an avoidance maneuver following an alert, such as that made by Iridium in 2009, could, however, clutter the orbital environment for years and decades.

"In a situation when you are receiving alerts on a daily basis, you can't maneuver for everything," Lewis said. "The maneuvers use propellant, the satellite cannot provide service. So there must be some threshold. But that means you are accepting a certain amount of risk. The problem is that at some point, you are likely to make a wrong decision."

Hesar said that uncertainties in the positions of satellites and pieces of debris are still considerable. In case of operational satellites, the error could be up to 330 feet (100 meters) large. When it comes to a piece of debris, the uncertainty about its exact position might be in the order of a mile or more.

"This object can be anywhere in this bubble of multiple kilometres," Hesar said. "At this point, and for the foreseeable future, avoidance is our best recourse. People that say 'I'm going to take the risk', in my humble opinion, that's an irresponsible thing to do."

Starlink monopoly

Lewis is concerned about the growing influence of a single actor — Starlink — on the safety of orbital operations. Especially, he says, as the spaceflight company has entered the satellite operations world only recently.

"We place trust in a single company, to do the right thing," Lewis said. "We are in a situation where most of the maneuvers we see will involve Starlink. They were a launch provider before, now they are the world's biggest satellite operator, but they have only been doing that for two years so there is a certain amount of inexperience."

SpaceX relies on an autonomous collision avoidance system to keep its fleet away from other spacecraft. That, however, could sometimes introduce further problems. The automatic orbital adjustments change the forecasted trajectory and therefore make collision predictions more complicated, according to Lewis.

"Starlink doesn't publicize all the maneuvers that they're making, but it is believed that they are making a lot of small corrections and adjustments all the time," Lewis said. "But that causes problems for everybody else because no one knows where the satellite is going to be and what it is going to do in the next few days."

#### LEO collisions due to constellations take out ISR and other military assets – debris cascades into different altitudes and triggers Kessler Syndrome.

Wong 19 “Congested Outer Space: Increased Deployment of Small Satellite Constellations Could Hamper Military Space Operations” 2019 Arthur Wong [Strategic Development of Forces Division, SHAPE. Prior to working at SHAPE he has worked at NATO HQ, within the Defence Investment Division on interoperability for NATO’s multinational battlegroups.] <https://www.japcc.org/congested-outer-space/> SM

Since the production of a large number of small satellites in a factory environment will lower the cost of the overall programme, companies such as SpaceX, Amazon and OneWeb have been creating a satellite constellation within the LEO and Medium Earth Orbit (MEO).8, 9 OneWeb is a new company which plans to create an initial constellation of 648 satellites to provide global satellite internet broadband services. Each satellite weighs approximately 150 kg and will be programmed to operate in 20 different orbital planes at an altitude of 1,200 km.10 Creating a large constellation within the LEO could mitigate transmission delays and latency due to their closer range to ground stations while allowing users to send and receive data in a timely manner. The first six of the 648 satellites were launched in early 2019 with more launches scheduled to occur throughout this year.

Both SpaceX and Amazon have also announced their intention of creating a separate constellation for internet communication systems. SpaceX satellite constellations, named Starlink, will be the largest constellation ever built when it is completed. The constellations consist of nearly 12,000 satellites in more than 20 different orbital planes.11 The altitude of Starlink will range between 550 km to 1,150 km. SpaceX aims to have a minimum of 2,200 satellites in the next five years and achieve initial commercial operation by 2020.12 Amazon’s version of constellation, named Kuiper, has also been seeking approval from the Federal Communications Commission (FCC) to launch more than 3,200 satellites between 590 km to 630 km in the LEO.13

Space Debris Threat Increases in the LEO

The usage of cube satellite has provided positive impacts in various fields, ranging from environmental studies to offering worldwide internet access in rural areas through communication constellations. However, the current space environment is becoming congested. Hundreds of satellites have already been scheduled to launch each year before the construction of the constellation programme by OneWeb, SpaceX and Amazon. To further worsen the space debris situation in the LEO, direct-ascent Anti-Satellite Testing (ASAT) was conducted in recent years and more debris will be created through such testing. During the Chinese ASAT in 2007, some debris from the collision was blasted outward away from the Earth, causing a potential threat to satellites above the altitude where the ASAT testing occurred.14 Nine years after the incident happened, there are still more than 3,000 traceable pieces in orbit.

In 2009, two satellites collided at a speed of 10 km/s at an altitude of 800 km. This was the first time a collision had happened between two satellites. The incident created more than 1,000 pieces of debris larger than 10 cm. Such activity could initiate a chain reaction, creating more collisions from the initial impact. This phenomenon is known as the Kessler Syndrome.15

From early 2019, there were approximately 34,000 pieces of debris larger than 10 cm (similar to the size of a cube satellite) and more than 900,000 pieces of debris ranging from one cm to 10 cm in size. Objects that are smaller than one cm in size are expected to be more than 100 million within the LEO.16 Despite the small size of the space debris, they are travelling at a speed of more than seven km/s. At this speed, tiny objects could harm any large satellite orbiting in the LEO. While satellites can increase their physical hardening to protect the on-board instruments from impact, some satellites cannot be hardened due to the size and dimensional constraints. Furthermore, hardened materials would also increase the overall cost of the satellite.

Constellation in the Making Could Impact Space-Based Military Assets

The previous examples revealed the congestion of the LEO. With companies continuing to launch thousands of small satellites, the chances of a collision in space will continue to increase. This will hinder space-based Intelligence, Surveillance and Reconnaissance (ISR) support to provide valuable information to military operations. A majority of the ISR assets are orbiting in the LEO. NATO relies on space-based assets to assist its operations. Increasing the number of spacecraft in the LEO could raise problems and threats to military assets as well as access to space assets to support operations. If the orbital path of these smaller objects were not tracked by the Space Operation Centre regularly, larger satellites or manned-space stations could be penetrated by the non-propulsion satellites, making them a potential kinetic kill vehicle.

Most satellites within the 600 km region of the LEO are affected by the atmospheric drag, which is helping to bring down some of the obsolete satellites. However, satellites orbiting above 800 km are less likely to be affected by the atmospheric drag, making cube satellites or small satellites without propulsion systems difficult to deorbit once they have reached the EOL.17, 18 The altitude for some of the OneWeb, Starlink and Kuiper constellations is planned to be above the atmospheric drag region. Despite this, Starlink satellites will have propulsion system for orbital manoeuvre and EOL deorbiting, tracking the full constellation with 12,000 satellites could be challenging for the company and the Combined Space Operations Center (CSpOC).19 Additionally, there is the possibility of losing contact with satellites before they reach their EOL. Envisat, an 8,210 kg satellite that is currently drifting at an altitude of 785 km, poses a collision threat with other satellites. Envisat was expected to decommission in 2014 but the European Space Agency (ESA) lost contact with the satellite in 2012.20 If no interaction will be made with the Envisat, it is expected to stay in orbit for the next 150 years.21

#### Collisions with early warning satellites causes miscalc and goes nuclear – magnified by the Kessler effect

Blatt 20 [Talia, joint concentration in Social Studies and Integrative Biology at Harvard, specialization in East Asian geopolitics and security issues] “Anti-Satellite Weapons and the Emerging Space Arms Race,” Harvard International Review, May 26, 2020, <https://hir.harvard.edu/anti-satellite-weapons-and-the-emerging-space-arms-race/> TG

Despite their deterrent functions, ASATs are more likely to provoke or exacerbate conflicts than dampen them, especially given the risk they [pose](https://thebulletin.org/2019/06/arms-control-in-outer-space-the-russian-angle-and-a-possible-way-forward/) to early warning satellites. These satellites are a crucial element of US ballistic missile defense, capable of [detecting missiles](https://www.globalsecurity.org/space/world/japan/warning.htm) immediately after launch and tracking their paths.

Suppose a US early warning satellite goes dark, or is shut down. Going dark could signal a glitch, but in a world in which other countries have ASATs, it could also signal the beginning of an attack. Without early warning satellites, the United States is much more susceptible to nuclear missiles. Given the strategy of counterforcing—[targeting](https://www.belfercenter.org/sites/default/files/files/publication/isec_a_00273_LieberPress.pdf) nuclear silos rather than populous cities to prevent a nuclear counterattack—the Americans might believe their nuclear weapons are imminently at risk. It could be [twelve hours](https://books.google.com/books?id=ET8lDwAAQBAJ&pg=PA1&lpg=PA1&dq=%22Protecting+Space+Assets%22+johnson-freese&source=bl&ots=6Oq0IdeBjw&sig=ACfU3U1G6Hj8QdP4JlCRNxA6i5XplZwHyg&hl=en&sa=X&ved=2ahUKEwj1n-jT2YzpAhUugnIEHUuMCu4Q6AEwA3oECAkQAQ#v=onepage&q=%22Protecting%20Space%20Assets%22%20johnson-freese&f=false) before the United States regains satellite function, which is too long to wait to put together a nuclear counterattack. The United States, therefore, might move to mobilize a nuclear attack against Russia or China over what might just be a piece of debris shutting off a satellite.

Additionally, accidental warfare, or strategic miscalculation, is uniquely likely in space. It is [much easier](https://books.google.com/books?id=VyXTDwAAQBAJ&pg=PA339&lpg=PA339&dq=space+offense+dominant&source=bl&ots=Mw0bgJ51qf&sig=ACfU3U3DeZiEHpr9nfszlCbJZIoyyssIpg&hl=en&sa=X&ved=2ahUKEwjrs-WD3IzpAhVulHIEHbL0AE4Q6AEwCXoECAoQAQ#v=onepage&q=space%20offense%20dominant&f=false) to hold an adversary’s space systems in jeopardy with destructive ASATs than it is to [sustainably defend](https://www.cnas.org/publications/commentary/the-us-military-should-not-be-doubling-down-on-space) a system, which is expensive and in some cases not technologically feasible because of limitations on satellite movement. Space is therefore [considered](https://books.google.com/books?id=VyXTDwAAQBAJ&pg=PA339&lpg=PA339&dq=space+offense+dominant&source=bl&ots=Mw0bgJ51qf&sig=ACfU3U3DeZiEHpr9nfszlCbJZIoyyssIpg&hl=en&sa=X&ved=2ahUKEwjrs-WD3IzpAhVulHIEHbL0AE4Q6AEwCXoECAoQAQ#v=onepage&q=space%20offense%20dominant&f=false) offense-dominant; offensive tactics like weapons development are prioritized over defensive measures, such as [improving GPS](https://www.politico.com/story/2018/04/06/outer-space-war-defense-russia-china-463067) or making satellites more resistant to jamming.

As a result, countries are left with poorly defended space systems and rely on offensive posturing, which increases the risk that their actions are perceived as aggressive and incentivizes rapid, risky counterattacks because militaries cannot rely on their spaced-based systems after first strikes.

There are several hotspots in which ASATs and offensive-dominant systems are particularly relevant. Early warning satellites [play](https://www.politico.com/story/2018/04/06/outer-space-war-defense-russia-china-463067) a central role in US readiness in the event of a conflict involving North Korea. News of North Korean missile launches comes from these satellites. Given North Korea’s [history](https://www.bbc.com/news/world-asia-pacific-11813699) of nuclear provocations, unflinchingly hostile rhetoric towards the United States and South Korea, and diplomatic opacity, North Korea is always a threatening, unknowable adversary, but recent developments have magnified the risk. With the health of Kim Jong-un [potentially in jeopardy](https://apnews.com/f5d302ae65b03838173e40848223b771), a succession battle or even civil war on the peninsula [raises the chances](https://www.express.co.uk/news/world/1273890/Kim-Jong-un-dead-North-Korea-nuclear-weapon-news-latest-death-US) of loose nukes. If the regime is terminal, traditional MAD risk calculus will become moot; with nothing to lose, North Korea would have no reason to hold back its nuclear arsenal. Or China [might decide](https://foreignpolicy.com/2020/04/28/kim-jong-un-china-north-korea/) to seize military assets and infrastructure of the regime. If the US does not have its early warning satellites because they have been taken out in an ASAT attack, the US, South Korea, and Japan are all in imminent nuclear peril, while China could be in a position to fundamentally reshape East Asian geopolitics.

The South China Sea is another hotspot in which ASATs could risk escalation. China [is developing](https://missiledefenseadvocacy.org/missile-threat-and-proliferation/todays-missile-threat/china-anti-access-area-denial-coming-soon/) Anti-Access Area Denial (A2/AD) in the South China Sea, a combination of long range radar with air and maritime defense meant to deny US freedom of navigation in the region. Given the disputed nature of territory in the South China Sea, the United States and its allies do not want China to successfully close off the region.

#### Independently causes cyberwar and satellite hacking which escalates.

Falco 19 “Opinion: Our satellites are prime targets for a cyberattack. And things could get worse.” Gregory Falco [Gregory Falco is a cyber research fellow at Harvard University’s Belfer Center and a postdoctoral security researcher at the Massachusetts Institute of Technology’s Computer Science and Artificial Intelligence Laboratory. He is the founder and chief executive of NeuroMesh, a tech security company.] May 7, 2019 <https://www.washingtonpost.com/opinions/our-satellites-are-prime-targets-for-a-cyberattack-and-things-could-get-worse/2019/05/07/31c85438-7041-11e9-8be0-ca575670e91c_story.html> SM

One minute. That’s how long it took me last month to demonstrate to a major broadcasting company and production team how to access and restart a leading satellite Internet provider’s control system. Five minutes is how long it took me to demonstrate how to gain full control of it.

Hackers are always improving their ability to break into our digital infrastructure. Yet the computer systems running our satellites haven’t kept up, making them prime targets for an attack. This makes our space assets a massive vulnerability — and it could get much worse if we’re not careful.

This past weekend, SpaceX won approval from the Federal Communications Commission to increase the number of low-flying satellites as part of its Starlink project so that they can provide faster Internet access to the world. Unfortunately, access will be faster for both legitimate users and hackers alike. The FCC does not require applicants to publicly demonstrate how they will secure these satellites or the Internet they plan to provide. SpaceX, like other private space companies, has shared virtually no information about its cybersecurity efforts or plans.

This is extremely disconcerting, considering the potential ramifications of a satellite being hacked. The most mundane outcome is that the satellite will no longer function, but the other extreme is for an attacker to break into a satellite and take over any thrusters (which SpaceX has insisted its satellites will have) and then propel the satellite into critical infrastructure and military satellites in other orbits. In other words, attackers could possibly use the hacked satellite as a kinetic weapon.

There has long been a void of attention to securing space infrastructure, ranging from space-faring rovers to satellite ground-control systems that manage all the space-based assets. Virtually no policy or oversight agency exists concerning securing space assets — something I’ve discussed with government leadership to little avail. While the FCC regulates communications, it should not necessarily be responsible for all things space security. Perhaps the new Space Development Agency could be.

This leaves space security in the hands of the private sector, which is exploiting the recent ease of access to space. The advent of small satellites known as CubeSats offers the chance to launch a satellite into orbit for as little as $30,000 . And because the government wants to encourage economic activity in this area, requirements to do so are extremely light. This leaves those who are creating the satellites responsible for the cybersecurity of their assets, which is not usually part of the rocket scientist’s traditional skill set.

As a space cybersecurity researcher, I am excited about the renewed interest in space from both the commercial and exploratory perspectives. But we need to be strategic about the security of these space systems. Unlike “Internet of things” devices such as baby monitors, which we purchase for less than $100 and discard or sell once a new model comes out, satellites often remain in orbit for much longer and are less dispensable. So if we don’t consider the cybersecurity of the space asset now, we’ll likely be dealing with the ramifications of that for several years to come. The lack of government intervention in satellite security does not mean that we can ignore cybersecurity as an issue.

Private space companies such as SpaceX, OneWeb and Blue Origin need to join the conversation about cybersecurity and help consumers understand that they are taking it seriously (if they are). (Blue Origin’s founder and owner, Jeff Bezos, also owns The Post.) Right now, there are several job openings for information security analysts at private space companies, indicating that they are likely hurting for talent and are behind in figuring out their security. This isn’t surprising given that space is hard, and traditional IT experts don’t have the right skill sets for a space cybersecurity job. Space systems have unique requirements that are more akin to an industrial control system, such as an energy smart meter, than to an email server.

Private space companies need to start a dialogue with the security research community about their particular challenges so that we can help. They should also be transparent with the FCC that they need help in securing their infrastructure. The last thing we need is for China or Russia to take over SpaceX’s satellites and wreak havoc on our space assets.

#### Empirics prove it’s possible and likely by state and nonstate actors – especially true given private sector cost cutting.

Akoto 20 “Hackers could shut down satellites -- or turn them into weapons” February 13, 2020 William Akoto [a postdoctoral research fellow at the University of Denver.] <https://www.upi.com/Top_News/Voices/2020/02/13/Hackers-could-shut-down-satellites-or-turn-them-into-weapons/4091581597502/> SM

Feb. 13 (UPI) -- Last month, SpaceX became the operator of the world's largest active satellite constellation. As of the end of January, the company had 242 satellites orbiting the planet with plans to launch 42,000 over the next decade. This is part of its ambitious project to provide Internet access across the globe. The race to put satellites in space is on, with Amazon, U.K.-based OneWeb and other companies chomping at the bit to place thousands of satellites in orbit in the coming months.

These new satellites have the potential to revolutionize many aspects of everyday life -- from bringing Internet access to remote corners of the globe to monitoring the environment and improving global navigation systems. Amid all the fanfare, a critical danger has flown under the radar: the lack of cybersecurity standards and regulations for commercial satellites, in the United States and internationally. As a scholar who studies cyber conflict, I'm keenly aware that this, coupled with satellites' complex supply chains and layers of stakeholders, leaves them highly vulnerable to cyberattacks.

If hackers were to take control of these satellites, the consequences could be dire. On the mundane end of scale, hackers could simply shut down satellites, denying access to their services. Hackers could also jam or spoof the signals from satellites, creating havoc for critical infrastructure. This includes electric grids, water networks and transportation systems.

Some of these new satellites have thrusters that allow them to speed up, slow down and change direction in space. If hackers took control of these steerable satellites, the consequences could be catastrophic. Hackers could alter the satellites' orbits and crash them into other satellites or even the International Space Station.

Commodity parts

Makers of these satellites, particularly small CubeSats, use off-the-shelf technology to keep costs low. The wide availability of these components means hackers can analyze them for vulnerabilities. In addition, many of the components draw on open-source technology. The danger here is that hackers could insert back doors and other vulnerabilities into satellites' software.

The highly technical nature of these satellites also means multiple manufacturers are involved in building the various components. The process of getting these satellites into space is also complicated, involving multiple companies. Even once they are in space, the organizations that own the satellites often outsource their day-to-day management to other companies. With each additional vendor, the vulnerabilities increase as hackers have multiple opportunities to infiltrate the system.

Hacking some of these CubeSats may be as simple as waiting for one of them to pass overhead and then sending malicious commands using specialized ground antennas. Hacking more sophisticated satellites might not be that hard either.

Satellites are typically controlled from ground stations. These stations run computers with software vulnerabilities that can be exploited by hackers. If hackers were to infiltrate these computers, they could send malicious commands to the satellites.

History of hacks

This scenario played out in 1998 when hackers took control of the U.S.-German ROSAT X-Ray satellite. They did it by hacking into computers at the Goddard Space Flight Center in Maryland. The hackers then instructed the satellite to aim its solar panels directly at the sun. This effectively fried its batteries and rendered the satellite useless. The defunct satellite eventually crashed back to Earth in 2011. Hackers could also hold satellites for ransom, as happened in 1999 when hackers took control of the U.K.'s SkyNet satellites.

Over the years, the threat of cyberattacks on satellites has gotten more dire. In 2008, hackers, possibly from China, reportedly took full control of two NASA satellites, one for about two minutes and the other for about nine minutes. In 2018, another group of Chinese state-backed hackers reportedly launched a sophisticated hacking campaign aimed at satellite operators and defense contractors. Iranian hacking groups have also attempted similar attacks.

Although the U.S. Department of Defense and National Security Agency have made some efforts to address space cybersecurity, the pace has been slow. There are no cybersecurity standards for satellites and no governing body to regulate and ensure their cybersecurity. Even if common standards could be developed, there are no mechanisms in place to enforce them. This means responsibility for satellite cybersecurity falls to the individual companies that build and operate them.

As they compete to be the dominant satellite operator, SpaceX and rival companies are under increasing pressure to cut costs. There is also pressure to speed up development and production. This makes it tempting for the companies to cut corners in areas like cybersecurity that are secondary to actually getting these satellites in space.

### 1AC – Advocacy

#### Thus, resolved: The appropriation of outer space by private entities is unjust.