# 1AC – Plan

#### Plan: States ought to ban the appropriation of outer space through mega-constellations by private entities

## Adv. One: Russia

#### Tensions high between US and Russia – Putin looking for anyway to escalate

Knispel 4/19 Knispel, S., 2022. Putin ‘has his back up against the wall’ with Ukraine. [online] NewsCenter. Available at: <https://www.rochester.edu/newscenter/putin-ukraine-russian-invasion-escalation-519902/> [Accessed 22 April 2022]. Sarah Knispel is a student at the University of Rochester who interviewed Randall Stone who is a political science professor and the chair of the Department of Political Science at the University of Rochester and the director of the University’s Skalny Center for Polish and Central European Studies, is an expert on Russian-US relations, and Eastern and Central Europe.

An expert on Eastern and Central Europe discusses the direction of the war in Ukraine, including the likelihood of Russia’s using biological, chemical, or nuclear weapons. “It is crucial for American foreign policy not to escalate the situation in a way that puts the United States and Russia in direct conflict, ” Stone says. Vladimir Putin “made a tragic mistake,” by embarking on war with Ukraine, says [Randall Stone](http://www.sas.rochester.edu/psc/stone/), a political science professor and the chair of the [Department of Political Science](https://www.sas.rochester.edu/psc/) at the [University of Rochester](https://www.rochester.edu/). At the same time, Stone, an expert on Russian and Eastern European politics who serves as the director of the University’s [Skalny Center for Polish and Central European Studies](http://www.sas.rochester.edu/psc/CPCES/), stresses that the West must be careful to avoid escalation; in particular, NATO must not send air forces into Ukraine. “It appears credible that Putin would be willing to escalate,” he said in an interview in April. “Why? Because he was willing to take the risk of the invasion in the first place. He has chosen to put himself in a position where if we intervened, he loses, and probably loses everything, not just Ukraine, but his regime, maybe his life.” Q&A with Randall Stone Putin is shifting his military focus to eastern Ukraine. Why? Putin is looking for something that he can sell as a success as the war in Ukraine is not going the way he expected. Stone: Most observers agree that in order to end the conflict, Putin has to gain something that he can sell as a success at home. He no longer thinks Russia is going to take Kyiv, or any other major cities in Ukraine, but that he might be able to cut off a large portion of the Ukrainian army, which is currently arrayed in the East against the Donbas area. This could be a tactical victory that would allow him to enforce a territorial settlement, which would expand the breakaway regions of Donetsk and Luhansk—which Putin declared “independent” a few weeks ago—to include the entire administrative areas of Donbas and Luhansk. Perhaps that’s something that he could sell as a victory at home. While Ukraine’s President Volodymyr Zelensky has signaled willingness to compromise on NATO membership and possibly agree to Ukraine’s neutrality in return for a form of multilateral security guarantee, Zelensky has stood firm against demands to give up Ukrainian territory. I really think a decisive victory for Russia seems impossible at this point. Conversely, the eventual collapse of the Russian military seems possible amid signs of real structural weakness in the Russian army. And let’s not forget popular unrest in Russia, which could become another solution to the crisis. What are Putin’s biggest mistakes in this crisis? “What was supposed to be a relatively easy military operation for Russia has turned into a quagmire, which could lead to popular unrest that directly threatens Putin’s regime.” Stone: Until February 24 Putin seemed highly unlikely to be dislodged from power any time soon. He had solid control over all the ministries in Moscow, which were run by his former KGB cronies, and there was no strong opposition to his rule. Most Russians receive their news from Russian television, which has been under strict state control for years. In short, he was very politically secure, but this could all now change with a defeat in Ukraine. Already there are signs that many thousands of Russian troops have been killed and wounded in Ukraine. Credible estimates suggest that as many as 15,000 Russian soldiers may have died. All this adds up to a very different kind of war from what Putin anticipated when he invaded on February 24. What was supposed to be a relatively easy military operation for Russia has turned into a quagmire, which could lead to popular unrest that directly threatens Putin’s regime. How should the West respond? America must avoid escalating the situation in order to avoid a nuclear war. Stone: It is crucial for American foreign policy not to escalate the situation in a way that puts the United States and Russia in direct conflict, which would be extremely dangerous. We are dealing with a dictator who has his back up against the wall and who is going to be looking for any way out at this point. Turning this into a war with the West would be a way for Putin to shift the narrative away from the series of terrible mistakes that he has made. We must avoid giving him that opportunity and ensure that we don’t allow this war to become a nuclear exchange. Proposals to establish a [no-fly zone](https://www.cnn.com/videos/world/2022/03/29/no-fly-zone-meaning-ukraine-lon-orig.cnn) over Ukraine, which would involve US Air Force patrols in Ukrainian airspace, present a real danger of escalation that could lead to nuclear war. This is why the Biden administration has been careful to circumscribe US and NATO intervention in the conflict. How likely is Russia to use biological or chemical weapons? The use of biological and chemical weapons by Russia is unlikely. Stone: Chemical and biological weapons are really not useful as military weapons; they’re effective means of terrorizing civilians. I think it’s highly unlikely that they would be deployed and, of course, the United States would not respond with chemical or biological weapons. In the past, the US has shown that it’s not willing to intervene to prevent the use of chemical weapons against civilians—as seen either in Iraq or in Syria. What role does nuclear deterrence play here? Nuclear weapons are important but we need to distinguish between the functions of immediate versus extended deterrence. Nuclear weapons are important in this scenario because we’re in a situation of extended deterrence. International relations scholars distinguish between immediate deterrence and extended deterrence. Immediate deterrence essentially means that I will use nuclear weapons against you if you use them against me. Throughout the Cold War, both sides assumed a posture of mutually assured destruction, which meant that one could be fairly certain that nuclear weapons would not be used because a nuclear exchange would have been disastrous for both sides. “A decisive victory for Russia seems impossible at this point.” Extended deterrence is a bit more problematic. Extended deterrence means that I will use nuclear weapons to defend my ally, or to defend some specific objective. For example, Russia announced a strategy of extended nuclear deterrence to protect Cuba during the Cuban Missile Crisis, while the US threatened extended nuclear deterrence to defend Western Europe from a possible Soviet attack during the Cold War. The Soviet Union never really intended to attack Western Europe, but this was the centerpiece of US strategic doctrine for 45 years. Under what circumstances might Putin use nuclear weapons? If NATO partners were to send air forces into Ukraine, Putin might use nuclear weapons. Stone: Putin is using the idea of extended deterrence to prevent the US from intervening in a conventional war in Ukraine, and he has indicated that if NATO intervenes by sending its air force into Ukraine, the response would be a nuclear one. The NATO air force is so much more powerful than the Russian that NATO would quickly prevail and Russia would not have any chance of winning the war under those circumstances. This would be so disastrous for Putin that he likely would be willing to escalate to a nuclear war to prevent it. The response would probably take the form of nuclear attacks against NATO air bases in Poland and Romania, and perhaps in other European countries. This is why sending NATO planes has been off the table for NATO, because it appears credible that Putin would be willing to escalate. Why? Because he was willing to take the risk of the invasion in the first place. He has chosen to put himself in a position where if we intervened, he loses, and probably loses everything, not just Ukraine, but his regime, maybe his life. If Putin is willing to risk that much, it seems likely that he has already decided that he is willing to take the next logical step, which would be nuclear war. He probably calculates that such a war could be kept limited, but of course that is an experiment that no one wants to run.

#### Private mega-constellations ensure cascading debris

Boley and Byers 21. Aaron Boley is at the Department of Physics and Astronomy, The University of British Columbia, Vancouver, Canada and Michael Byers is at the Department of Physics and Astronomy, The University of British Columbia, Vancouver, Canada. 5/20/21. [Nature, “Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth,” <https://www.nature.com/articles/s41598-021-89909-7>]

Companies are placing satellites into orbit at an unprecedented frequency to build ‘mega-constellations’ of communications satellites in Low Earth Orbit (LEO). In two years, the number of active and defunct satellites in LEO has increased by over 50%, to about 5000 (as of 30 March 2021). SpaceX alone is on track to add 11,000 more as it builds its Starlink mega-constellation and has already filed for permission for another 30,000 satellites with the Federal Communications Commission (FCC)1 . Others have similar plans, including OneWeb, Amazon, Telesat, and GW, which is a Chinese state-owned company2 . Te current governance system for LEO, while slowly changing, is ill-equipped to handle large satellite systems. Here, we outline how applying the consumer electronic model to satellites could lead to multiple tragedies of the commons. Some of these are well known, such as impediments to astronomy and an increased risk of space debris, while others have received insufcient attention, including changes to the chemistry of Earth’s upper atmosphere and increased dangers on Earth’s surface from re-entered debris. The heavy use of certain orbital regions might also result in a de facto exclusion of other actors from them, violating the 1967 Outer Space Treaty. All of these challenges could be addressed in a coordinated manner through multilateral law-making, whether in the United Nations, the Inter-Agency Debris Committee (IADC), or an ad hoc process, rather than in an uncoordinated manner through diferent national laws. Regardless of the law-making forum, mega-constellations require a shift in perspectives and policies: from looking at single satellites, to evaluating systems of thousands of satellites, and doing so within an understanding of the limitations of Earth’s environment, including its orbits. Thousands of satellites and 1500 rocket bodies provide considerable mass in LEO, which can break into debris upon collisions, explosions, or degradation in the harsh space environment. Fragmentations increase the cross-section of orbiting material, and with it, the collision probability per time. Eventually, collisions could dominate on-orbit evolution, a situation called the Kessler Syndrome3 . There are already over 12,000 trackable debris pieces in LEO, with these being typically 10 cm in diameter or larger. Including sizes down to 1 cm, there are about a million inferred debris pieces, all of which threaten satellites, spacecraf and astronauts due to their orbits crisscrossing at high relative speeds. Simulations of the long-term evolution of debris suggest that LEO is already in the protracted initial stages of the Kessler Syndrome, but that this could be managed through active debris removal4 . The addition of satellite mega-constellations and the general proliferation of low-cost satellites in LEO stresses the environment further5–8 . [Omitted Figures 1 and 2] Results The overall setting. Te rapid development of the space environment through mega-constellations, predominately by the ongoing construction of Starlink, is shown by the cumulative payload distribution function (Fig. 1). From an environmental perspective, the slope change in the distribution function defnes NewSpace, an era of dominance by commercial actors. Before 2015, changes in the total on-orbit objects came principally from fragmentations, with efects of the 2007 Chinese anti-satellite test and the 2009 Kosmos-2251/Iridium-33 collisions being evident on the graph. Although the volume of space is large, individual satellites and satellite systems have specifc functions, with associated altitudes and inclinations (Fig. 2). Tis increases congestion and requires active management for station keeping and collision avoidance9 , with automatic collision-avoidance technology still under development. Improved space situational awareness is required, with data from operators as well as ground- and space-based sensors being widely and freely shared10. Improved communications between satellite operators are also necessary: in 2019, the European Space Agency moved an Earth observation satellite to avoid colliding with a Starlink satellite, afer failing to reach SpaceX by e-mail. Internationally adopted ‘right of way’ rules are needed10 to prevent games of ‘chicken’, as companies seek to preserve thruster fuel and avoid service interruptions. SpaceX and NASA recently announced11 a cooperative agreement to help reduce the risk of collisions, but this is only one operator and one agency When completed, Starlink will include about as many satellites as there are trackable debris pieces today, while its total mass will equal all the mass currently in LEO—over 3000 tonnes. Te satellites will be placed in narrow orbital shells, creating unprecedented congestion, with 1258 already in orbit (as of 30 March 2021). OneWeb has already placed an initial 146 satellites, and Amazon, Telesat, GW and other companies, operating under diferent national regulatory regimes, are soon likely to follow. Enhanced collision risk. Mega-constellations are composed of mass-produced satellites with few backup systems. Tis consumer electronic model allows for short upgrade cycles and rapid expansions of capabilities, but also considerable discarded equipment. SpaceX will actively de-orbit its satellites at the end of their 5–6-year operational lives. However, this process takes 6 months, so roughly 10% will be de-orbiting at any time. If other companies do likewise, thousands of de-orbiting satellites will be slowly passing through the same congested space, posing collision risks. Failures will increase these numbers, although the long-term failure rate is difcult to project. Figure 3 is similar to the righthand portion of Fig. 2 but includes the Starlink and OneWeb megaconstellations as fled (and amended) with the FCC (see “Methods”). Te large density spikes show that some shells will have satellite number densities in excess of n = 10−6 km−3 . Deorbiting satellites will be tracked and operational satellites can manoeuvre to avoid close conjunctions. However, this depends on ongoing communication and cooperation between operators, which at present is ad hoc and voluntary. A recent letter12 to the FCC from SpaceX suggests that some companies might be less-thanfully transparent about events13 in LEO. Despite the congestion and trafc management challenges, FCC flings by SpaceX suggest that collision avoidance manoeuvres can in fact maintain collision-free operations in orbital shells and that the probability of a collision between a non-responsive satellite and tracked debris is negligible. However, the flings do not account for untracked debris6 , including untracked debris decaying through the shells used by Starlink. Using simple estimates (see “Methods”), the probability that a single piece of untracked debris will hit any satellite in the Starlink 550 km shell is about 0.003 afer one year. Tus, if at any time there are 230 pieces of untracked debris decaying through the 550 km orbital shell, there is a 50% chance that there will be one or more collisions between satellites in the shell and the debris. As discussed further in “Methods”, such a situation is plausible. Depending on the balance between the de-orbit and the collision rates, if subsequent fragmentation events lead to similar amounts of debris within that orbital shell, a runaway cascade of collisions could occur. Fragmentation events are not confned to their local orbits, either. Te India 2019 ASAT test was conducted at an altitude below 300 km in an efort to minimize long-lived debris. Nevertheless, debris was placed on orbits with apogees in excess of 1000 km. As of 30 March 2021, three tracked debris pieces remain in orbit14. Such long-lived debris has high eccentricities, and thus can cross multiple orbital shells twice per orbit. A major fragmentation event from a single satellite could affect all operators in LEO. Even if debris collisions were avoidable, meteoroids are always a threat. The cumulative meteoroid flux15 for masses m > 10–2 g is about 1.2 × 10–4 meteoroids m−2 year−1 (see “Methods”). Such masses could cause non-negligible damage to satellites16. Assuming a Starlink constellation of 12,000 satellites (i.e. the initial phase), there is about a 50% chance of 15 or more meteoroid impacts per year at m > 10–2 g. Satellites will have shielding, but events that might be rare to a single satellite could become common across the constellation. One partial response to these congestion and collision concerns is for operators to construct mega-constellations out of a smaller number of satellites. But this does not, individually or collectively, eliminate the need for an all-of-LEO approach to evaluating the effects of the construction and maintenance of any one constellation. Surface impacts and atmospheric efects. Although failures do occur, frst stages of SpaceX rockets are usually landed and re-used, while second stages are usually controlled through re-entry and deposited in remote areas of ocean. Tis best practice might not be followed by others. For example, the frst stages of the Soyuz rockets employed by OneWeb are not reusable, nor are the second stage re-entries controllable. Te Long March rockets that will likely be employed by GW are similar. Uncontrolled re-entries do not always meet safety standards17, a situation that may be exacerbated by mega-constellations. Moreover, the cumulative impact of thousands of rocket stages on the ocean environment could be signifcant should those stages contain hazardous materials, such as unspent hydrazine fuels17–19. In the 1990s, Pacifc island countries opposed the Sea Launch project because of environmental concerns, including from discarded rocket stages20. In 2016, Inuit in the Canadian Arctic protested the Russian practice of disposing rocket stages in the North Water Polynya, a biologically rich area of year-round open water21. Te frst Starlink satellites contained some components that survive re-entry, with the highest human casualty risk for a single satellite calculated to be 1:17,40022, below NASA’s recommended 1:10,000 threshold. However, the initial approval process did not account for the cumulative casualty risk, and if all the then-planned 12,000 satellites had contained the same components, a continuous 5-year replacement cycle would have seen a 45% probability of one or more casualties per cycle. When the subsequent FCC petition process identifed the problem, SpaceX reportedly replaced some materials with a view to having all of the satellite components now demise in the atmosphere23. Other companies, based in other countries, might not follow this best practice or be required to do so. Te demise of satellite components during re-entry introduces a diferent problem, since none of that material actually disappears. Starlink satellites have a dry mass of about 260 kg; 12,000 satellites will total 3100 tonnes. A 5-year cycle would see on average almost 2 tonnes re-entering Earth’s atmosphere daily. While small compared to the 54 daily tonnes of meteoroid mass24, the satellites are mostly aluminum; most meteoroids, in contrast, contain less than 1% Al by mass25. Tus, depending on the atmospheric residence time of material from reentered satellites, each mega-constellation will produce fne particulates that could greatly exceed natural forms of high-altitude atmospheric aluminum deposition, particularly if the full numbers of envisaged satellites are launched. Anthropogenic deposition of aluminum in the atmosphere has long been proposed in the context of geoengineering as a way to alter Earth’s albedo26. Tese proposals have been scientifcally controversial and controlled experiments encountered substantial opposition27. Mega-constellations will begin this process as an uncontrolled experiment28. Rocket launches themselves afect the atmosphere. While cumulative CO2 emissions are small compared to other sources, CO2 is not the relevant metric. Black carbon produced by kerosene-fueled rockets such as SpaceX’s Falcon 9 and alumina particles produced by solid-fueled rockets lead to instantaneous radiative forcing. Modelling of the cumulative efect of emissions from 1000 annual launches of hydrocarbon-fuelled rockets found that, afer one decade, the black carbon would result in radiative forcing comparable to that resulting from sub-sonic aviation29. Although 1000 launches annually is 10 times the current rate, the construction and renewal of multiple mega-constellations will require dramatic increases in launches. Current launches likely cause non-negligible radiative forcing already30.

#### Competing orbits turn all potential good uses of satellites

Samson 1/17 – Victoria Samson is the Washington office director for the Secure World Foundation, an organization that focuses on space sustainability, and she has over 20 years of experience in military space and security issues. Previously, Ms. Samson was a senior analyst for the Center for Defense Information. She also was a senior policy associate at the Coalition to Reduce Nuclear Dangers, a consortium of arms control groups. Earlier, she was a researcher at Riverside Research Institute, where she worked on war-gaming scenarios for the Missile Defense Agency. 1/17/22. [Bulletin of the Atomic Scientists, “The complicating role of the private sector in space,” DOI: 10.1080/00963402.2021.2014229]

At this exact moment, we are seeing the increasing dominance of commercial actors in space – specifically the rise of mega-constellations, or large numbers of small satellites flying in formation to provide global coverage for a variety of governmental and commercial uses, including both communications and Earth observation. Consequently, the fundamental nature of space is changing, to one of a domain dominated by commercial actors. This change will have major consequences for international stability, both in terms of how it demonstrates that the old governance structure for space is being left behind – and how it highlights Russia’s declining rank in global space powers. Certain orbits may be effectively taken over by a handful of entities, and there will be competition for useful portions of the electromagnetic spectrum. With eyes on the sky everywhere, there will be little or no room for state secrets – for better or worse. This is happening at the same time that Russia’s space identity is floundering, which may further upset the stability of the domain of space. As of November 2021, there are roughly 4,800 active satellites in orbit around Earth, around 1,850 of which belong to just one entity: SpaceX’s Starlink mega-constellation (Thompson 2021). This change has happened very quickly, as Starlink satellites just began to be launched in May 2019 (O’Callaghan 2019). This is only the first wave of the megaconstellations as well. While it is hard to say exactly how many satellites will be launched as part of this new use of space, there are requests or plans for mega-constellations that could mean well over 100,000 new satellites could potentially be in low Earth orbit. While not all of these satellites will be launched, even a small fraction of that proposed number will fundamentally shift the situation so that the major actors in space will no longer be nation-states (as has been the case to date) but the private sector, changing the timbre of the space domain. This leads to challenges in discussing space security issues: Space is a shared, international domain; if we cannot include all the stakeholders in the discussions, we will not come to complete solutions to the problems. But first, some background. A little history The commercial sector is not new to space. Commercial entities have been active in space for decades now; in fact, it was a dispute over what should be the extent of their role in space that shaped part of the 1967 Outer Space Treaty. Article VI of that treaty notes: States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities . . .. The activities of nongovernmental entities in outer space, including the moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. (Outer Space Treaty 1967) This was a compromise between the United States and the USSR, in which the latter argued that there was no such thing as commercial space. Having language requiring state actors to carry out “authorization and continuing supervision” gave the United States the flexibility it wanted to develop a commercial space sector while ensuring that there would still be national oversight. A lack of coordination One way in which the rise of these mega-constellations may complicate international security in space is through concerns about these satellites hampering access to certain orbits. While slots in geosynchronous Earth orbit are set by the International Telecommunication Union, there is no international entity coordinating orbital slots at low Earth orbit. This means that, given the potentially tens of thousands of satellites that could be launched given company plans, certain orbits could be de facto ceded to a handful of entities – in defiance of Article II of the Outer Space Treaty, which says that space “is not subject to national appropriation.” Consequently, this could lead to strife or competition over certain orbits. It is possible that, given the number of satellites that companies are asking the United States’ Federal Communications Commission for broadcasting rights to, certain orbits may reach their carrying capacities – meaning that they are at the maximum number of satellites that can be operated, as defined by physical and radiofrequency interference aspects. This could lead to disputes over which country has the right to use certain orbits, or, alternatively, resentment when one country’s commercial sector essentially takes over a particular orbit Competition over parts of the electromagnetic spectrum is another possible path for international security issues to arise from mega-constellations. Satellites are only as good as their ability to receive and communicate information, which requires spectrum; if one or a few entities from one country use up all the readily accessible spectrum for specific capabilities at certain orbits, that could possibly lead to confrontation as well. For the most part, the companies launching mega-constellations are largely based in the West, which can shape the global perception of their effects and intent – although there have been some plans for at least one Chinese company to launch a mega-constellation of potentially 13,000 satellites, and the South Koreans have expressed interest in their own mega-constellation.

#### Debris pushes tensions over edge – risks nuclear war

Egeli 21 Sitki Egeli (2021) Space-to-Space Warfare and Proximity Operations: The Impact on Nuclear Command, Control, and Communications and Strategic Stability, Journal for Peace and Nuclear Disarmament, 4:1, 116-140, DOI: [10.1080/25751654.2021.1942681](https://doi.org/10.1080/25751654.2021.1942681) Sitki Egeli teaches at Turkey’s Izmir University of Economics. He was the foreign relations director of Turkey’s Undersecretariat for Defense Industries from 1991 to 1999, and afterwards served as vice president of Overseas Development Corporation, a multinational consulting firm specializing in the defense and aerospace industries. He holds a doctorate in international relations from Bilkent University and a master’s degree in the same field from the University of Chicago.

\*NC3 = nuclear command, control, and communication architecture

\*SSA = space situational awareness

Proximity Operations Pitted against NC3: Five scenarios NC3 capabilities and the proximity operations targeting them are technologically complex, multifaceted, and constantly evolving subjects. Analyzing the impact of proximity operations on NC3 and the ramifications for strategic stability is by no means easy or straightforward. To facilitate the task, we shall make use of five simplified scenarios. This clearly is not an exhaustive list of contingencies, and several equally plausible scenarios could be added. Scenario 1: What’s Wrong with Our Satellite? Amid increased tensions, perhaps even an imminent military confrontation between two nuclear-armed adversaries, a high-value (for example, early-warning or strategic communication) satellite stops functioning or communicating instantly and inexplicably. SSA sensors do not pick up any anomalies. This may be the outcome of a technical malfunction or a natural phenomenon, such as the impact of a collision with a meteoroid or piece of space debris small enough to have evaded detection. Alternatively, the satellite perhaps becomes the victim of a deliberate, undetected attack. Earth-to-space kinetic, electronic, or directed energy attacks would leave behind some trails. A cyberattack, which is harder to detect and attribute, is a strong possibility. So is a stealthy attack by hostile spacecraft. In fact, the adversary is known to have experimented with ominous small spacecraft that could easily conceal or disguise themselves until conducting a final maneuver to neutralize their targets. The victim would also be aware that, especially at distant GEO and HEO altitudes, SSA is not sufficiently comprehensive to detect and give warning of all suspicious or threatening movements as they happen. As suspicions abound, decision makers are faced with hard choices. Could this perhaps be the harbinger of a wider nuclear or nonnuclear first strike, along with which the attacker is seeking to eliminate the possibility of retaliation by degrading the defender’s capacity to command, control, and communicate with its forces? Should the defender react immediately before the remaining space-enabled NC3 elements are also compromised and its control over nuclear and nonnuclear forces degrades even further? In the absence of a clear-cut picture of what actually has happened, there is a risk that impending decisions will be made on the basis of insufficient and potentially erroneous information, and the climate will be ripe for unfounded presumptions and predispositions. The resulting ultimatums, responses, or counteractions could set off a dangerous cycle of escalation and tit-for-tat actions, whereby reactions and overreactions between adversaries lead to potentially catastrophic consequences. At a minimum, heightened tension in orbit would have the outcome of spilling down to Earth so as to further aggravate an already tense situation. Scenario 2: Unwelcome Guest The circumstances of the second scenario are very similar to the first, with the exception that when the satellite goes off, there is an RPO-capable vehicle, inspector satellite, or other unidentified object in its vicinity. But there is no evidence of hostile activity or interference. This is an increasingly plausible scenario because in recent years, suspicious, uncooperative spacecraft getting very close to strategic satellites of others and staying there for a while has become routine and customary. Whereas the dose of uncertainty over the real cause of loss of contact with satellite persists, the victim’s presumption that a proximity attack is to blame becomes much more intense. Thus, the considerations and processes are similar to those in the first scenario, but the potential for escalation is elevated exponentially. Scenario 3: To Preempt or Not to Preempt? The circumstances of the third scenario are similar to those of the second in that tensions are already high between nuclear-armed adversaries, but this time there is no loss of contact with a satellite. Instead, a suspicious spacecraft belonging to the adversary has positioned itself nearby or on the same orbital plane as a critical NC3 satellite. Even worse, there are indications that it may be undertaking additional maneuvering. The side whose satellite is being shadowed judges that a hostile action is imminent and that evasive, defensive, or preventive measures – or some combination of those – are warranted. Evasive maneuvering would take the targeted satellite out of its primary mission and achieve the same results the attacker was seeking. Alternatively, if appropriately equipped, the targeted satellite could resort to defensive measures such as emitting laser beams or HPMs to interfere with the sensors and electronics of the nearby attacker. The side believing its satellite is in imminent danger may decide to move in one of its small “defensive” spacecraft to fend off the “offensive” craft. However, the decision to actually engage the attacker will not be easy. Even when employed in a presumably preemptive and self-defense mode, the use of space-to-space weapons or a guardian spacecraft to inflict damage on the adversary would be tantamount to having the first shot of a military confrontation fired in space. Escalatory risks of launching the first strike in the space domain are evident (Bilsborough [2020](https://www.tandfonline.com/doi/full/10.1080/25751654.2021.1942681)Bilsborough, S. 2020. “More Space Wargames, Please.” War on the Rocks. 17 November 2020. <https://warontherocks.com/2020/11/more-space-wargames-please/> [[Google Scholar]](http://scholar.google.com/scholar_lookup?hl=en&publication_year=2020&author=S.+Bilsborough&title=More+Space+Wargames%2C+Please)). Scenario 4: Entanglement This scenario involves the opening or evolving phases of a nonnuclear confrontation between two nuclear-armed adversaries, with one or both of them attempting to disorient the other side’s conventional war effort by targeting its satellites. The motivation is simple and straightforward: all forms of modern warfare depend heavily on the services of satellites, and leaving one’s opponent devoid of those services reduces its operational efficacy. For satellites in LEO, a larger array of kinetic and non-kinetic anti-satellite options exist. For satellites in MEO and especially GEO altitudes, space-to-space and proximity operations stand out as the more viable option. However, there is one obvious danger: even when targeted as an extension of conventional skirmishes, most if not all military satellites are serving NC3 and nuclear forces as well. Consequently, their owners would likely become very sensitive to their loss. It is important to underline in this respect that there is no such thing anymore as strategic satellites dedicated exclusively to NC3 and nuclear forces (Acton [2018](https://www.tandfonline.com/doi/full/10.1080/25751654.2021.1942681)Acton, J. M. 2018. “Escalation through Entanglement.” International Security 43 (1): 56–99. <https://direct.mit.edu/isec/article/43/1/56/12199/Escalation-through-Entanglement-How-the>. [[Crossref]](https://www.tandfonline.com/servlet/linkout?suffix=cit0001&dbid=16&doi=10.1080%2F25751654.2021.1942681&key=10.1162%2Fisec_a_00320), [[Web of Science ®]](https://www.tandfonline.com/servlet/linkout?suffix=cit0001&dbid=128&doi=10.1080%2F25751654.2021.1942681&key=000441027400002), [[Google Scholar]](http://scholar.google.com/scholar_lookup?hl=en&volume=43&publication_year=2018&pages=56-99&issue=1&author=J.+M.+Acton&title=Escalation+through+Entanglement), 58). For example, early-warning satellites, originally developed to detect nuclear-tipped strategic missiles, are nowadays an indispensable part of active missile defenses aimed at intercepting shorter-range, nonnuclear missiles, which are frequently used in regional conflicts as well. Likewise, strategic communication and PNT satellites serve both tactical and strategic and both nuclear and nonnuclear forces. Therefore if high-value satellites also serving NC3 are targeted during a conventional confrontation, how quickly will their owners feel overly alarmed and cross the nuclear threshold in response? For example, the United States has already threatened to use nuclear weapons if its NC3 came under attack with nonnuclear weapons (Acton [2019](https://www.tandfonline.com/doi/full/10.1080/25751654.2021.1942681)Acton, J. M. 2019. “Why Is Nuclear Entanglement So Dangerous?.” Carnegie Q&A. 23 January 2019. <https://carnegieendowment.org/2019/01/23/why-is-nuclear-entanglement-so-dangerous-pub-78136> [[Google Scholar]](http://scholar.google.com/scholar_lookup?hl=en&publication_year=2019&author=J.+M.+Acton&title=Why+Is+Nuclear+Entanglement+So+Dangerous%3F)). Likewise, when faced with conventional attacks threatening the security of the state, Russia’s nuclear doctrine – described by some in the West as “escalate to de-escalate” – allows a limited nuclear strike to convince the adversaries to back down (Oliker [2018](https://www.tandfonline.com/doi/full/10.1080/25751654.2021.1942681)Oliker, O. 2018. “Moscow’s Nuclear Enigma.” Foreign Affairs. 15 October 2018. <https://www.foreignaffairs.com/articles/russian-federation/2018-10-15/moscows-nuclear-enigma> [[Google Scholar]](http://scholar.google.com/scholar_lookup?hl=en&publication_year=2018&author=O.+Oliker&title=Moscow%E2%80%99s+Nuclear+Enigma)). Even China’s strict “no first use” doctrine may be conducive to setting off preparations for a nuclear response in the face of high-tech conventional weapons used against China’s major strategic targets (Kulacki [2020](https://www.tandfonline.com/doi/full/10.1080/25751654.2021.1942681)Kulacki, G. 2020. “Would China Use Nuclear Weapons First in a War with the United States?” The Diplomat. 27 April 2020. <https://thediplomat.com/2020/04/would-china-use-nuclear-weapons-first-in-a-war-with-the-united-states/> [[Google Scholar]](http://scholar.google.com/scholar_lookup?hl=en&publication_year=2020&author=G.+Kulacki&title=Would+China+Use+Nuclear+Weapons+First+in+a+War+with+the+United+States%3F)). All told, the omens are not very comforting. Scenario 5: Accident In this scenario, a spacecraft capable of proximity operations conducts relatively benign activity, such as close inspection or eavesdropping, near its object of interest and ends up inadvertently harming it. This could be an accidental collision or perhaps unintended activation of its repertoire of kinetic and non-kinetic tools. That is not implausible, given the continuous presence of such vehicles nowadays in the immediate vicinity of others’ sensitive satellites. The trend toward embedding more autonomy and automation in spacecraft increases the probability of such accidents and the consequent rounds of uncontrolled events. In fact, even the debris resulting from in-orbit experiments at more distant orbits (such as the firing of high-speed projectiles) could find its way to a collision with a high-value satellite of an adversary. This may be a particularly discomforting possibility in the tightly populated GEO belt where the majority of NC3 satellites are located. If such inadvertent events were to take place during times of high tension between two adversaries, would the victim believe that the harm was unintended? Would forbearance and conciliation rule the day? Or would the responses be shaped by suspicion, worst-case assumptions and consequent reprisals, and thus escalation? There is little doubt that this scenario represents a set of dangerous uncertainties. These five scenarios provide a picture that differs from the previous section’s in some important ways. The earlier discussion of the characteristics and likely vulnerabilities of NC3 assets revealed significant backup capacity and thus considerable redundancy in the face of intrusions from space. The subsequent overview of a non-exhaustive list of scenarios points out that by threatening space-based elements of NC3, proximity operations could nonetheless create dangerous, potentially destabilizing, and escalatory pressures. It is true that the danger is not one of catastrophic collapse or complete paralysis of NC3 when its space-based elements come under attack. Rather, in circumstances comparable to those of a cyberattack, the real risks appear to emanate from ambiguities and uncertainties of timely and reliable detection and attribution of proximity attacks (Stoutland [2017](https://www.tandfonline.com/doi/full/10.1080/25751654.2021.1942681)Stoutland, P. 2017. “Growing Threat: Cyber and Nuclear Weapon Systems.” The Bulletin of the Atomic Scientists. 18 October 2017. <https://thebulletin.org/2017/10/growing-threat-cyber-and-nuclear-weapons-systems/> [[Google Scholar]](http://scholar.google.com/scholar_lookup?hl=en&publication_year=2017&author=P.+Stoutland&title=Growing+Threat%3A+Cyber+and+Nuclear+Weapon+Systems)). In the absence of complete, reliable, and timely information, decision makers would come under pressure to rapidly determine what they believe are the appropriate courses of action. Yet their decisions run a high risk of being erroneous and potentially catastrophic. This does not bode well for either crisis stability or escalation and crisis management. An equally important consideration is that when detection and attribution are problematic, effective defenses and retribution become untenable. And in the absence of both defenses and retaliation, deterrence may be doomed too. The consequences could be dire. A potential aggressor may be induced to place accurate or ill-founded confidence in its ability to degrade its opponent’s NC3. Or more plausibly, the victim of an actual or presumed space-to-space attack may become extremely worried about the cohesion of its NC3 and therefore resort to hurried, impulsive, and otherwise unthinkable courses of action. The consequence in both cases is the erosion of the long-held assumption that nuclear weapons are so destructive and retaliation so much assured that no sane leaders would risk igniting a general war against a nuclear-armed adversary (Krepinevich [2018](https://www.tandfonline.com/doi/full/10.1080/25751654.2021.1942681)Krepinevich, A. F., Jr. 2018. “The Eroding Balance of Terror.” Foreign Policy. 11 December 2018. <https://www.foreignaffairs.com/articles/2018-12-11/eroding-balance-terror> [[Google Scholar]](http://scholar.google.com/scholar_lookup?hl=en&publication_year=2018&author=A.+F.+Krepinevich&title=The+Eroding+Balance+of+Terror)). From this perspective, the worries about the destabilizing and escalatory properties of space-to-space warfare and proximity operations fit in with the heated debate since the Cold War period over the dangers of nuclear Sarajevos.

#### US-Russia nuclear conflict the most likely scenario for extinction

Farquhar et al., 17 (Sebastian Farquhar, John Halstead , Owen Cotton-Barratt, Stefan Schubert, Haydn Belfield, and Andrew Snyder-Beattie, \*DPhil student in Computer Science at the University of Oxford, \*\*Head of Applied Research at Founders Pledge, \*\*\*Research Fellow at the University of Southampton with DPhil in mathematics, \*\*\*\*researcher at the Social Behaviour and Ethics Lab at Oxford, \*\*\*\*\*Research Associate and Academic Project Manager at the University of Cambridge's Centre for the Study of Existential Risk, \*\*\*\*\*\*Director of Research at the Future of Humanity Institute at University of Oxford, 2017, accessed on 12-2-2020, The Future of Humanity Institute, "Existential Risk: Diplomacy and Governance", https://www.fhi.ox.ac.uk/xrisk-diplomacy/)

The bombings of Hiroshima and Nagasaki demonstrated the unprecedented destructive power of nuclear weapons. However, even in an all-out nuclear war between the United States and Russia, despite horrific casualties, neither country’s population is likely to be completely destroyed by the direct effects of the blast, fire, and radiation.8 The aftermath could be much worse: the burning of flammable materials could send massive amounts of smoke into the atmosphere, which would absorb sunlight and cause sustained global cooling, severe ozone loss, and agricultural disruption – a nuclear winter. According to one model 9 , an all-out exchange of 4,000 weapons could lead to a drop in global temperatures of around 8°C, making it impossible to grow food for 4 to 5 years. This could leave some survivors in parts of Australia and New Zealand, but they would be in a very precarious situation and the threat of extinction from other sources would be great. An exchange on this scale is only possible between the US and Russia who have more than 90% of the world’s nuclear weapons, with stockpiles of around 4,500 warheads each, although many are not operationally deployed.11 Some models suggest that even a small regional nuclear war involving 100 nuclear weapons would produce a nuclear winter serious enough to put two billion people at risk of starvation,12 though this estimate might be pessimistic.13 Wars on this scale are unlikely to lead to outright human extinction, but this does suggest that conflicts which are around an order of magnitude larger may be likely to threaten civilisation. It should be emphasised that there is very large uncertainty about the effects of a large nuclear war on global climate. This remains an area where increased academic research work, including more detailed climate modelling and a better understanding of how survivors might be able to cope and adapt, would have high returns. It is very difficult to precisely estimate the probability of existential risk from nuclear war over the next century, and existing attempts leave very large confidence intervals. According to many experts, the most likely nuclear war at present is between India and Pakistan.14 However, given the relatively modest size of their arsenals, the risk of human extinction is plausibly greater from a conflict between the United States and Russia. Tensions between these countries have increased in recent years and it seems unreasonable to rule out the possibility of them rising further in the future.

## Adv. 2 Ozone

#### Ozone hole healing – new destruction reverses progress

Stone 18 [Maddie Stone is a science journalist. “Our Best Evidence Yet That Humans Are Fixing the Ozone Hole.” January 5, 2018. https://gizmodo.com/our-best-evidence-yet-that-humans-are-fixing-the-ozone-1821808429]

The ozone hole feels like the quintessential ‘80s problem, but unlike car phones and mullets, it remains relevant in a number of ways. For starters, it’s still there, chilling over Antartica. More importantly, it’s slowly healing, and a new study offers some of the best evidence yet that sound environmental policy is responsible. It’s been nearly 30 years since the world adopted the Montreal Protocol, a landmark treaty banning the use of ozone-destroying chlorofluorocarbons (CFCs). But despite a firm scientific understanding of the link between CFCs and ozone depletion, it’s been tough to tell how much of a success the protocol was, because the ozone hole didn’t start showing signs of recovery until a few years back. Moreover, nobody had actually measured the chemistry of the hole to see if ozone-destroying compounds are declining as we’d expect due to the Montreal Protocol. A study published this week in Geophysical Research Letters addresses that knowledge gap. The authors, from NASA’s Goddard Spaceflight Center, made use of data collected by NASA’s Aura satellite, which measures a suite of trace atmospheric gases to understand changes to the ozone layer, Earth’s climate, and air pollution. “It kind of surprised me that no one had done this,” lead study author Susan Strahan told Earther. “The data is there if you’re careful about what data to use.” Strahan and her colleague Anne Douglass looked at changing ozone levels above Antarctica throughout the austral winter from 2005 to 2016, and found that ozone depletion had declined by about 20 percent. Then, they looked at levels of hydrochloric acid in the stratosphere at the end of winter, an indicator of how much ozone had been destroyed by CFCs. Sure enough, chlorine levels declined as well, at a rate of about 0.8 percent per year. That’s in line with model expectations of how much CFC levels should have declined over the same time period thanks to the Montreal Protocol’s ban. “This reaffirms our scientific understanding of what’s controlling ozone,” she said. Bill Randall, an atmospheric scientist at the University Corporation for Atmospheric Research who was not involved with the study, told Earther he thought the paper’s analysis was “very well done.” “They’re seeing net decreases in chlorine that are very consistent with the Montreal Protocol,” he said. “That’s a big take home message, that the Montreal Protocol is doing what we think it should be doing.”

#### Ozone Destruction – two warrants

#### Private launch industry decimates the ozone – profit pressures ensure toxic chemicals injected into the stratosphere

Ross and Vedda 18 Ross, Martin, and James Vedda. THE POLICY AND SCIENCE OF ROCKET EMISSIONS. The Aerospace Corporation, 2018, http://aerospace.wpengine.netdna-cdn.com/wp-content/uploads/2018/04/RocketEmissions.pdf, Accessed 21 Feb 2022. Dr. Martin Ross is senior project engineer for commercial launch projects. In that capacity, he leads research concerning the effects of space systems on the stratosphere—mainly, the impact of rocket-engine emissions on stratospheric ozone and climate forcing. Dr. James A. Vedda is senior policy analyst in the Center for Space Policy and Strategy.

Fool Me Twice, Shame on Me Concerns about atmospheric rocket emissions are analogous to early recognition of space debris, which continues to be a policy challenge today. Debris accumulation in valuable orbits is widely acknowledged to present an existential risk to continuing space operations and industry growth.1 Nevertheless, policy and practice to decisively deal with the problem are still in the formative stages, even as technology to reduce the risk via active disposal is on the horizon. If the potential magnitude of the space debris problem had been recognized early in the space age, and coordinated international actions had been taken at the time to address it, space debris may not have become the significant risk we face today. With hindsight, we can appreciate the formidable technical, geopolitical, and national security obstacles that prevented early resolution of the problem. Regardless of the cause of early inaction, space debris was not addressed and the situation evolved into a classic example of “the tragedy of the commons.” Half a century ago a potential problem presented itself, but a lack of urgency prevented good policy from being established when the problem was in its nascent stage. The result is that some regions of Earth’s orbital space present hazardous conditions due to debris accumulation. Today, launch vehicle emissions present a distinctive echo of the space debris problem. Rocket engine exhaust emitted into the stratosphere during ascent to orbit adversely impacts the global atmosphere. Rocket exhaust 3 has two main effects on the atmosphere. First, chemical reactions deplete the ozone layer.2 This has, historically, been the main concern about rocket emissions because solid rocket motors inject chlorine directly into the ozone layer and chlorine has been subject to international regulation since 1987.3 More recently, a second concern has come to light.4 Particles injected into the stratosphere absorb and reflect solar energy, changing the flow of radiation in the atmosphere, heating the stratosphere and cooling the surface, respectively. This radiative forcing has the effect of changing the Earth’s albedo and so the amount of solar energy injected into the atmosphere. These thermal changes also deplete the ozone layer.5 Rocket emissions have never been a priority for the scientific community. The literature is sparse and the present state of understanding of rocket emissions is weak. New fuels such as methane, about which no research has been done and which is a strong absorber of infrared radiation, will soon see wide use,6 further reducing the accuracy of estimates. Nevertheless, the meager amount of available research permits an assumption that present day ozone depletion and radiative forcing caused by launch emissions are likely small components of the sum of human influences on the atmosphere. Although rocket impacts to the global atmosphere are presently insignificant compared to other human activities,7 trends that include plans for airline-like operations, massive LEO communication satellite constellations, and space tourism indicate rocket impacts are likely to grow, possibly to the point of being considered significant. By most estimates and analyses from space planners, the pace and dimension of launches, and therefore emissions, will increase in coming years.8 The rate of orbital launches nearly doubled in the past decade, and may accelerate further. If we apply the lessons learned from space debris, now is the time to develop and implement policy to mitigate the risks to the natural and operational environments from rocket emissions. Like orbital debris, atmospheric rocket emissions have the long-term potential for risk to undermine efficient, routine space system operations if left to grow without attention. Regulation of launch vehicle emissions will not happen at current launch rates, but a confrontation between launch operations and international efforts to protect stratospheric ozone and manage atmospheric radiation is likely if the space industry expands as many space planners expect. This predicament was first pointed out in the context of the economics of launch vehicle reusability.9 The timing of this “tipping point” will be determined by the aggressiveness of international regulators as they react to increasing launch rates and greater visibility of the space industry. The next section briefly describes how rocket emissions affect the atmosphere and could attract the attention of regulators. This is followed by suggested actions to anticipate and mitigate this risk. Launch Vehicle Emissions and the Global Atmosphere Launch vehicle emissions disturb the atmosphere.4,10 Emissions into the troposphere (the layer nearest to the ground) are not important, aside from transient launch and landing site air quality concerns that local authorities already deal with. Emissions into the stratosphere are very different. The stratosphere is dynamically isolated from the troposphere beneath so that emissions in this layer can accumulate. Also, it contains the ozone layer so that the stratosphere has been the focus of strong international regulation since 1987 through the Montreal Protocol on Substances That Deplete the Ozone Layer.3 The stratosphere is a particularly sensitive region into which rockets directly inject combustion products— gases and particles—that will have impacts prompting the attention of policy-makers. The first suggestion that rocket emissions should be regulated appeared in 1994.11 The primary perturbations to the atmosphere from rocket emissions are stratospheric ozone depletion and a change in the atmosphere’s net radiative balance, a radiative forcing, that results in temperature changes throughout the atmosphere. Secondary changes include changes in the pattern of global circulation and cloudiness, including polar mesospheric clouds.12 While the magnitude and variety of rocket emission impacts are not well known, we can describe the overall picture across the various propellant combinations with some confidence. CO2 and H2 O emissions, which make up the main portion of all rocket exhaust, are unimportant, even at launch rates orders of magnitude greater than today. This is a key aspect of rocket emissions. Research has shown that a fleet of hydrogen-fueled launch vehicles, whose emissions are nearly entirely water vapor, could launch at any rate possible without risk of regulatory attention.13 Rocket CO2 and H2 O emissions are not of any concern with respect to atmospheric impacts.4 The important emissions of concern with respect to global impacts are chlorine and alumina particles from solid rocket motors (SRMs) and soot particles (hereafter, black carbon or BC), mainly, though not exclusively, from kerosene fueled engines. Chemical reactions involving chlorine and the surface of alumina particles cause ozone loss directly.14 Alumina and BC particles accumulate in the stratosphere in distinct layers and intercept incoming solar radiation.15 As the lifetime of small particles injected into the stratosphere is as long as four years, the steady state BC and alumina loading represents the contribution from all global launches during the past several years. These alumina and BC layers reflect and absorb a small portion of the downward solar flux, respectively.4,14 The energy from the intercepted solar flux warms the stratosphere, indirectly adding to ozone loss by accelerating ambient ozone-destroying reactions. Importantly, solar flux is reduced beneath the alumina and BC layers which act as a sort of “stratospheric umbrella” producing a negative radiative forcing that cools the Earth’s surface. Rocket emissions therefore act in the same manner as geoengineering schemes to counteract the warming from greenhouse gases. This equivalence may have policy implications. Within this picture, the actual magnitudes of ozone loss and stratospheric heating (as well as surface cooling) from space launch are poorly known. Application of sophisticated global atmosphere models to the problem of rocket emissions have been sparse and incomplete. The few models employed to date have been narrowly focused on unimportant emissions (for example, water vapor), have not applied a consistent methodology, and have not incorporated the complete canonical picture described above. The research done in the past two decades, while inadequate for detailed assessments, does allow for orderof-magnitude estimates for the ozone depletion and radiative forcing from the global launch fleet. Presentday global direct ozone loss from chlorine, reactive alumina surfaces, and from the BC accumulation is estimated to be greater than 0.01% and less than 0.1%.7 For comparison, the global ozone loss from long banned ozone depleting substances (ODSs) is about 3%.16 Clearly, if launch emissions were to increase by a factor of ten, the associated rocket ozone loss could be of an order comparable to ODS loss. Estimating the net radiative forcing from absorption and scattering of solar energy by the BC and alumina stratospheric accumulations is difficult; we have only one model of a specific case to deduce a more general understanding.14 We may use this paper, together with models of BC and alumina based geoengineering5 to estimate that rocket BC and alumina global radiative forcing equals on the order of negative 10 milliwatts per square meter. It is important to note the sign of the radiative forcing: rocket emissions cool the Earth’s surface. One model of future rocket BC emissions (larger than present day emission) predicts a surface cooling exceeding 1° C in a narrow latitude band directly beneath the BC accumulation.14 For comparison, the radiative forcing from global greenhouse gas (GHG) emissions is about positive 3 watts per square meter,17 several orders of magnitude greater than the estimated present day rocket forcing. This cursory description of the current level of understanding of rocket emissions and their global impacts makes clear how little is known about rocket emissions impacts; the accuracy of knowledge is an order of magnitude at best. We can more concisely describe the situation using specific terminology developed by climate scientists to express the confidence about facts and understanding.18 By this nomenclature, we have Low Confidence in the overall description of rocket impacts and Very Low Confidence in the numerical evaluation of present-day ozone depletion and radiative forcing. The Current Policy Environment What policies have addressed rocket emission impacts on the global atmosphere? Like space debris, the perceived “smallness” of the impacts and their unique character has left them in a policy void without consistent or directed attention. The following paragraphs briefly review these polices, with an eye towards anticipating and addressing future changes. National policy towards rocket emissions began with the National Environmental Protection Act (NEPA),19 established in 1974 to evaluate the impact of all new industrial activities. Under the NEPA process, any new 6 Federal activity must prepare an Environmental Impact Statement (EIS) that describes how the new system will affect the environment, including the atmosphere. Launch systems have gone through this process and many EIS documents have been assembled related to launch systems. The NEPA process does not formally have regulatory authority; it was developed mainly for informational purposes. The information contained in EIS documents is largely disconnected from the scientific community and is not subject to peer review. Importantly, NEPA does not require new scientific research be done. Thus, EIS documentation can be misleading, inaccurate, and overlook important information. Also, NEPA regards each system independently and only includes systems with Unites States origination. NEPA’s statutory requirements therefore provide little information on the global impact of rocket emissions. On the international stage, orbital launches were historically considered a national security matter and therefore beyond the scope of environmental regulation. The scientific community accordingly paid no attention to rockets even as significant research was being done to understand hypothetical supersonic transports. The introduction of the Space Shuttle changed this situation as it became the single largest rocket emission source by orders of magnitude. The Shuttle was too great of a stratospheric emission source to be ignored. The scientific community accordingly took policy cues from the Montreal Protocol to investigate SRM emissions. At first only SRM chlorine emissions were of interest. However, in 1997 laboratory experiments demonstrated how the surface of alumina particles emitted by SRMs can promote ozone-destroying chemical reactions.20 Subsequent models that included these heterogeneous reactions showed that alumina particles could indirectly cause more ozone loss than chlorine would directly. Based on questions expressed by the Montreal Protocol, the scientific community produced several models of the impact of Space Shuttle SRMs,13 but ignored other propellants. Research included direct sampling of SRM plumes, which indicated the alumina surface effect might be larger than expected. The uncertain microphysics of emitted alumina became the focus of limited research.21 However, by the turn of the century the Space Shuttle was not launching at the rate originally predicted and the global launch rate had declined during the 1990s. Rockets appeared to be a small and declining emission source. The policy cues transmitted to the scientific community had changed; rocket emissions were no longer of regulatory interest. As a result, research interest in rocket emissions waned and since the turn of the century, little research has been done. Focus on the Montreal Protocol is warranted because it is widely seen as the most successful international agreement of its kind and it directs, through various channels, research priorities. Despite changes in the political situations among the various party nations, the Montreal Protocol has remained a strong regulatory force since its inception in 1987. As evidence of its continuing strength, in 2017 the Montreal Protocol banned a class of compounds known as hydrofluorocarbons (HFCs).22 HFCs were not banned because of ozone depletion (they originated as CFC replacements) but rather due to their predicted future radiative impact. This is an important point: the Montreal Protocol regulates based on radiative forcing as well as ozone depletion. The Montreal Protocol does not specifically address emission sources such as rockets (and aircraft) that emit directly into the stratosphere. Compounds are identified for global phase-out based on a calculated Ozone Depletion Potential (ODP), a metric that compares a compound’s ozone depletion (per unit mass) to the ozone depletion caused by a standard compound. However, ODP is strictly defined only for gases released at the Earth’s surface, so rocket emissions cannot formally be assigned an ODP for assessment. For rocket emissions, the assessment therefore regresses to subjective descriptions. The impacts of rocket emissions The Montreal Protocol does not specifically address emission sources such as rockets that emit directly into the stratosphere.… 7 on stratospheric ozone are occasionally assessed in the Montreal Protocol’s Quadrennial Scientific Assessment of Ozone as “small” without a clear definition of “small” (or “large”) and without considering future launch rate growth. Coupling vague assessments such as “small” with Low or Very Low Confidence scientific understanding of rocket emissions leads to a policy gap that presents a risk for space launch. That is to say, rocket emissions impacts are ill-understood and the regulatory metric is ill-defined. This policy gap appears at a time when the Montreal Protocol remains an influential and active multilateral instrument, phasing out compounds based on their impact to global ozone and to climate forcing. And while the Montreal Protocol has successfully saved the ozone layer from severe degradation, the problem of ozone depletion is not fully solved. Ozone levels are still declining in some stratospheric regions.23 This suggests that the Montreal Protocol could be applied to poorly understood “small” impacts, such as launch emissions. These uncertainties, the lack of understanding of rocket emissions, the lack of formal metrics, and the growing influence of the Montreal Protocol present a clear risk of sudden and unanticipated change in the status of rocket emissions with respect to international regulatory attention. Finally, International Space Law, as promulgated through the Outer Space Treaty of 1967,24 has nothing to say about the atmospheric emissions problem. Article IX relates to activities in space that would “cause potentially harmful interference with exploration and use of space” and has been interpreted as the Treaty’s hook to orbital debris concerns. Article IX also could be linked to launch emissions and their potential for “harmful interference” with launch activities, but this would stretch Article IX beyond its original intent even farther than in the case of orbital debris. Rocket emissions from upper stages do add to the debris problem in low Earth orbit (mainly slag from SRMs), though this is a separate issue from stratospheric pollution. The relatively unconstrained atmospheric flight operations enjoyed by space launch providers since the beginning of the space age cannot be taken for granted as a permanent condition. This status is, to some extent, the result of policy neglect from the scientific and regulatory communities. Research has been minimal and inconsistent. The hint of regulation due to ozone depletion is faint but always present. The launch industry has benefitted so far from this policy vacuum. Situations of this kind are inherently unstable and prone to sudden change in status, thus posing a risk to space launch. The next section discusses developments that might precipitate such a change. Agents of Change If the current laissez-faire regime is unlikely to persist, the launch community will be compelled to formulate a strategy to deal with the possibility of a sudden change in regulatory attention. If the space industry does carry out the various ambitious plans for new space vehicles, it must be prepared for the “tipping point”25 wherein the scientific and regulatory communities (or perhaps environmental advocates) become aware that a large and growing launch industry has emerged. It is impossible to predict how or when a tipping point may occur. In the meantime, it is prudent to develop an understanding of the context and implications of such an occurrence. A. Perception A change in regulatory attention inevitably follows from a change in perception. It is often the case that, with regard to public policy, perception equals reality. The overall perception of space launch emissions today is best described as a relic of the historical “inconsequential and static” view. This perception is increasingly out of balance with actual developments in the space industry. In contrast to the “inconsequential and static” perception, the reality is one of global launch rate growth, introduction of new launch vehicles of all sizes, and the emergence of new launch sites (often referred to as “spaceports”) across the globe. Space launch, as a result of public interest in its futuristic nature, generates attention when growth and new developments take place. The launch industry has benefitted so far from this policy vacuum… 8 It is reasonable to expect that an adjustment in perception, possibly a paradigm shift, can occur as awareness increases. It is often the case that a new perception can be, at least initially, out of proportion to the actual situation; the new perception “overshoots” reality.23 This kind of tipping point for space launch would bring expanded, possibly undue, regulatory scrutiny to rocket emissions. B. Entanglement with Climate Intervention The atmospheric physics involved with the BC and alumina component of rocket emissions is directly related to the physics of attempts to mitigate climate change: so-called geoengineering or climate intervention. The goal of geoengineering is to add particles directly into the stratosphere in order to intercept a small portion of sunlight, preventing that energy from reaching the troposphere and so cooling the Earth’s surface. As noted above, BC and alumina emitted by rocket engines likely cool the Earth’s surface and so can be seen as a form of “weak” geoengineering. Indeed, BC and alumina have even been proposed in the scientific literature as geoengineering agents.26 The problem is that geoengineering is controversial and there is no formal policy regarding its deployment, of even in an experimental context. Policies and regulations to ban geoengineering have been proposed and the concept is widely condemned.27 A global ban on “… injection of particles into the stratosphere…”28 could present a problem for space launch, which currently injects approximately 10 gigagrams of BC and alumina particles into the stratosphere each year. Clearly, a ban on geoengineering would have to be formulated in a way that preserves the privilege of launch to emit potential geoengineering agents into the stratosphere. This would require strong policy engagement with the regulators which, in turn, requires that an understanding of rocket emissions with high scientific confidence be available. Progress in geoengineering, whether initial experiments or preventative regulation, could present a Tipping Point for rocket exhaust. C. New Propellants The global launch industry has used four propellant combinations (LOX/kerosene, LOX/hydrogen, SRM, and hypergolic) at various levels since the start of the space age. New propellants are being proposed and it appears that LOX/methane powered launch vehicles will enter the global fleet soon,6 possibly accounting for a significant portion of launches by 2030. The level of understanding LOX/methane engine emissions is evolving; this propellant combination has never been the focus of models of ozone depletion or changes in atmospheric radiation. Methane fueled engines can be expected to emit, uniquely, potentially significant amounts of hydrogen oxides (HOx) into the stratosphere. Hybrid propellant rocket engines that may see use in space tourism29 may result in significant nitrogen oxides (NOx) emissions. These could be important as HOx and NOx chemistry controls ozone concentrations in the stratosphere. In many situations, change ignites interest in existing configurations. From a policy perspective, scientific interest in methane fueled rocket engines could lead to questions regarding existing propellants, for which the current level of understanding has few answers. This could be the tipping point for engagement from the regulatory community. Preparedness: Filling the Blanks Any of these potential tipping points could be the specific factor that brings awareness of a dynamic and growing launch industry to the regulatory community. If “small and inconsequential” becomes “large and problematic,” the space launch community will need to be ready. History informs us that the best course of action in anticipation of a realignment in perception is to acknowledge the change and gather an increased level of understanding before the arrival of the tipping point. As pointed out above, early spacefaring nations missed the opportunity to deal with space debris before it became a problem, in part due to gaps in knowledge. Today we Geoengineering is controversial, and there is no formal policy regarding its deployment… 9 have an opportunity to prevent the same thing from happening with rocket emissions by filling in the blanks in our scientific understanding. Achieving an appropriate level of understanding of rocket emission effects on the global atmosphere requires collaboration across all stakeholders. The United States could take the lead by providing research funding and other incentives to its stakeholders and by inviting international participation in the research program. This should include agreement on the metrics regarding ozone depletion or radiative forcing that should be applied to launch vehicles. The research community that would perform the laboratory, in situ, and modelling experiments could be initiated through the national network of federal laboratories, universities, and corporate resources that currently performs atmospheric research. This community already has the instrumentation, models, and research aircraft needed for the research program. Indeed, the same scientific infrastructure that has investigated aircraft emissions could be applied to the rocket emission problem with only modest modification. A vigorous research program should incorporate global atmospheric models (e.g., for ozone loss, climate forcing, and pollutant interaction) and include the following components: • Stratospheric plume measurements using in situ and remote sensing instruments • Lab measurements to validate propellantspecific emissions and interactions • Engine test stand measurements to determine bulk properties and measure exit plane exhaust composition • Application of state of the art global chemistry and climate models using measured emissions and likely launch growth scenarios International guidance for space debris mitigation provides a precedent for how emissions guidelines could evolve on the global stage. In the late 1990s, DoD and NASA devised the national debris mitigations guidelines, which were subsequently proposed to the international community. By 2007, a modified version of the guidelines was adopted by the U.N. Committee on the Peaceful Uses of Outer Space, and ultimately by the U.N. General Assembly. At the appropriate time, rocket emissions guidelines could undertake a similar process, backed up by high-confidence research. A proactive United States could be a primary driver of this activity as it was for debris mitigation. The alternative—waiting for others to take the initiative—may not yield satisfactory results for U.S. interests. Conclusion Rocket emissions inherently impact the stratosphere in a way that no other industrial activity does. This is a fundamental aspect of placing payloads into space using chemical propulsion. The different types of propulsion systems affect the stratosphere in different ways. This means that the various global launch organizations, national or commercial, have different impacts on the global atmosphere. International concern for the global atmosphere is another fundamental fact. Many widely used industrial compounds have been eliminated by the most successful of the regulatory instruments, the Montreal Protocol, because they deplete ozone (e.g., CFCs) or they produce large climate forcing (e.g., HFCs). Rocket emissions, though they deplete ozone and cause climate forcing, so far have not been regulated due to the small number of launching states and annual Earth-to-orbit traffic consisting of about a hundred flights. But there is little doubt that these two fundamental realities, rocket emissions impacts and international stewardship, could come into conflict, given a sufficiently vigorous launch industry. It cannot be predicted when this conflict will emerge, but the present day launch industry outlook suggests that it is on the horizon. At the same time, entanglement with future geoengineering regulation could affect space launch as well. All of these potential future conflicts indicate that the launch community, in the U.S. and globally, should tackle the question of launch emissions while it is still manageable, and be prepared to respond to regulatory attention and inquiry. Experience with space debris mitigation strongly emphasizes this course of action: Act when concerns are small to prepare for a big future. In this case, that means initiating an aggressive scientific research program and being proactive in regulatory engagement.

#### 2) Megaconstellations destroy the ozone

Tereza 21 [Tereza; June 07, 2021; Bachelor's in Journalism and Master's in Cultural Anthropology from Prague's Charles University, Master's in Science from the International Space University. Space.com, “Air pollution from reentering megaconstellation satellites could cause ozone hole 2.0,” <https://www.space.com/starlink-satellite-reentry-ozone-depletion-atmosphere>]

Chemicals released as defunct satellites burn in the atmosphere could damage Earth’s protective ozone layer if plans to build megaconstellations of tens of thousands of satellites, such as SpaceX's Starlink, go ahead as foreseen, scientists warn. Researchers also caution that the poorly understood atmospheric processes triggered by those chemicals could lead to an uncontrolled geoengineering experiment, the consequences of which are unknown. For years, the space community was content with the fact that the amount of material that burns in the atmosphere as a result of Earth's encounters with meteoroids far exceeds the mass of defunct satellites meeting the same fate. Even the rise of megaconstellations won't change that. The problem, however, is in the different chemical composition of natural meteoroids compared to artificial satellites, according to Aaron Boley, an associate professor of astronomy and astrophysics at the University of British Columbia, Canada. "We have 54 tonnes (60 tons) of meteoroid material coming in every day," Boley, one of the authors of a paper published May 20 in the journal Scientific Reports, told Space.com. "With the first generation of Starlink, we can expect about 2 tonnes (2.2 tons) of dead satellites reentering Earth's atmosphere daily. But meteoroids are mostly rock, which is made of oxygen, magnesium and silicon. These satellites are mostly aluminum, which the meteoroids contain only in a very small amount, about 1%." Related: SpaceX's Starlink satellite megaconstellation launches in photos Uncontrolled geoengineering The scientists realised that megaconstellations have a significant potential to change the chemistry of the upper atmosphere compared to its natural state. But not only that. The burning of aluminum is known to produce aluminum oxide, also known as alumina, which can trigger further unexplored side effects. "Alumina reflects light at certain wavelengths and if you dump enough alumina into the atmosphere, you are going to create scattering and eventually change the albedo of the planet," Boley said. Albedo is the measure of the amount of light that is reflected by a material. In fact, increasing Earth's albedo by pumping certain types of chemicals into the higher layers of the atmosphere has been proposed as a possible geoengineering solution that could slow down global warming. However, Boley said, the scientific community has rejected such experiments because not enough is known about their possible side effects. "Now it looks like we are going to run this experiment without any oversight or regulation," Boley said. "We don't know what the thresholds are, and how that will change the upper atmosphere." The Cygnus re-supply vehicle, which delivers cargo to the International Space Station, burning up in the atmosphere during its reentry. (Image credit: ESA/Alexander Gerst) Ozone hole 2.0 The aluminum from re-entering satellites also has a potential to damage the ozone layer, a problem well known to humanity, which has been successfully solved by widespread bans on the use of chlorofluorocarbons, chemicals used in the past in aerosol sprays and refrigerators. In their paper, Boley and his colleague Michael Byers cite research by their counterparts from the Aerospace Corporation, a U.S. non-profit research organization, which identified local damage to the planet's ozone layer triggered by the passage of polluting rockets through the atmosphere. "We know that alumina does deplete ozone just from rocket launches themselves because a lot of solid-fuel rockets use, or have, alumina as a byproduct," Boley said. "That creates these little temporary holes in the stratospheric ozone layer. That's one of the biggest concerns about compositional changes to the atmosphere that spaceflight can cause." The ozone layer protects life on Earth from harmful UV radiation. The depletion of ozone in the stratosphere, the second lowest layer of the atmosphere extending between altitudes of approximately 7 to 40 miles (10 to 60 kilometers), led to an increased risk of cancer and eye damage for humans on Earth. Gerhard Drolshagen, of the University of Oldenburg, Germany, who has published papers about the effects of meteoroid material on Earth, told Space.com that reentering satellites usually evaporate at altitudes between 55 and 30 miles (90 and 50 km), just above the ozone-rich stratosphere. However, he added, the particles created as a result of the satellites' burning will eventually sink to the lower layers. Boley said that as the alumina sinks into the stratosphere, it will cause chemical reactions, which, based on existing knowledge, will likely trigger ozone destruction. Drolshagen, who wasn't involved in the recent study, agreed that because "satellites are mostly made of aluminum, the amount of aluminum deposited in the atmosphere will certainly increase." Concerns about the effects of aluminium oxides on the atmosphere have been cited by U.S. telecommunications operator Viasat in its request to the US Federal Communications Commision to suspend launches of SpaceX's Starlink megaconstellation until a proper environmental review of its possible impacts is conducted. Spectacular stratospheric clouds are linked to ozone destruction. (Image credit: NASA/Lamont Poole) Learning from past mistakes In their study, Boley and his colleagues looked only at the effects of the first generation of the Starlink megaconstellation, which is expected to consist of 12,000 satellites. More than 1,700 of these have already been launched. As a result of SpaceX's activities (and to a lesser extent those of other constellation operators), the number of active and defunct satellites in low Earth orbit, the region of space below the altitude of 620 miles (1,000 km), has increased by 50% over the past two years, according to the paper. "The problem is that there are now plans to launch about 55,000 satellites," Boley said. "Starlink second generation could consist of up to 30,000 satellites, then you have Starnet, which is China's response to Starlink, Amazon's Kuiper, OneWeb. That could lead to unprecedented changes to the Earth’s upper atmosphere." Megaconstellation operators, inspired by the consumer technology model, expect fast development of new satellites and frequent replacement, thus the high amount of satellites expected to be burning in the atmosphere on a daily basis.

#### Ozone depletion causes extinction – diseases, biodiversity loss, and food shortages

Bestill 16 Michele M. Betsill 16. Professor in Residence and Chair of Political Science department at Colorado State University, Ph.D in Environmental Politics and Policy, “Impacts Of Stratospheric Ozone Depletion” http://www.climate-policy-watcher.org/hydrology/impacts-of-stratospheric-ozone-depletion.html

Stratospheric ozone depletion was recognized as an environmental problem in need of international attention because it impacts both humans and the natural environment. When stratospheric ozone levels decrease, the amount of UV-B reaching Earth's surface increases (WMO, 1995). The changes in UV-B radiation are highest at high and midlatitudes in both hemispheres while the increases are fairly small in the tropics (UNEP, 1994). Increased levels of UV-B affect human health, the productivity of plant and animal species, as well as the composition of ecosystems. Impacts on Human Health Ultraviolet exposure does have some benefits for humans. For example, it initiates the production of vitamin D3, which is believed to inhibit the growth of tumor cells (UNEP, 1996). However, the balance of evidence indicates that the effects of stratospheric ozone depletion on human health are negative. The major risks include increased incidence of eye diseases, skin cancer, and infectious diseases. When UV-B levels increase, two main organ systems are exposed: the eyes and the skin. The impacts of ozone depletion are mediated through these two systems (Longstreth et al„ 1995; UNEP, 1998). Evidence suggests that increased UV-B radiation exposure may be associated with an increase in the incidence of cataracts, a clouding of the lens of the eye (Longstreth et al, 1995; UNEP, 1998). One review of research on this problem reported that a 1% increase in stratospheric ozone depletion would result in a 0.6 to 0.8% increase in the incidence of cataracts (UNEP, 1994; see also UNEP, 1998). The most widely known impact of increased UV-B radiation on human health is skin cancer. UV-B radiation damages deoxyribonucleic acid (DNA), which may cause gene mutations and the formation of cancer cells. Some studies estimate that a sustained 10% decrease in average stratospheric ozone concentrations would result in 250,000 new cases of nonmelanoma skin cancer. This is in addition to the 1.2 million cases already reported each year (Longstreth et al., 1995; UNEP, 1996). Many animal species, such as cows, goats, sheep, cats, and dogs, are also at increased risk of developing skin cancer as a result of increased exposure to UV-B radiation (UNEP, 1998). In an assessment of the effect of the Montreal Protocol and its amendments in protecting the ozone layer, Slaper and his colleagues (1996) concluded these efforts will substantially decrease the growth rate of the incidence of skin cancer over the next century. They found that under a scenario where there were no limits on the production and consumption of ozone-depleting substances, there would be a quadrupling in the incidence of skin cancer by the year 2100. Under the provisions of the Montreal Protocol (a 50% reduction in the production of CFCs by 1999), a doubling in the incidence of skin cancer could be expected in that same period. In contrast, they found the Copenhagen Amendments scenario (a complete phase-out in the production of 21 ozone-depleting substances by January 1, 1996) would result in a 10% increase in skin cancer incidence, peaking in the year 2060. This study lends support to the importance of international efforts to combat stratospheric ozone depletion. Researchers believe that skin exposure to increased levels of UV-B radiation is also linked to modifications in the human immune system. As a result, the ability of the immune system to respond to certain infectious diseases, such as tuberculosis, leprosy, and Lyme disease, is impaired (UNEP, 1998). Longstreth and her colleagues (1995) predict that higher levels of UV-B will result in increased severity and duration of diseases such as lupus rather than an increase in their incidence. Impacts on Aquatic Systems The balance of evidence indicates that increased UV-B radiation can have harmful effects on many species of aquatic organisms and the aquatic systems in which they live (SCOPE, 1993; UNEP, 1998). For example, studies in the Antarctic have linked increased UV-B levels to reduced phytoplankton productivity. Phytoplankton are the basis for the oceanic food chain. UV-B radiation affects the DNA, photosynthesis, enzyme activity, and nitrogen incorporation of phytoplankton. Reduced phytoplankton productivity will likely lead to reduced productivity further up the food chain. It has been estimated that a 16% reduction in stratospheric ozone could lead to a 5% loss of phytoplankton causing a loss of 7 million tons of fish worldwide per year (Hader et al., 1995; UNEP, 1994, 1996). Figure 1 illustrates the effects of UV-B radiation on phytoplankton. Researchers have also found that enhanced UV-B radiation disrupts the early development of several species of fish, shrimp, and crabs, ultimately affecting their motility (Hader et al., 1995). In damaging aquatic organisms, stratospheric Effects of enhanced solar UV-B irradiation on phytoplai Motility Vertical distribution In the water column Global consequences Reduced carbon dioxide sink? Effects of enhanced solar UV-B irradiation on phytoplai Motility Vertical distribution In the water column Reduced biomass production? Competition between species? Temperature increase? Food web in the ocean? Figure 1 Effects of UV-B radiation on phytoplankton (from Hader et al, 1995, p. 178). ozone depletion has serious implications for the world food supply. Globally, 30% of the animal protein consumed by humans comes from the oceans. The percentage is much higher in developing countries (UNEP, 1998). These impacts are particularly worrisome in light of the growing world population. Impacts on Terrestrial Plants and Ecosystems Scientific understanding of the impact of enhanced UV-B on terrestrial plants and ecosystems is incomplete. The majority of studies have been conducted in growth chambers and greenhouses under controlled conditions, conditions that are often quite different from those experienced in the field. Thus, researchers contend it is necessary to use caution in making generalizations about the impacts of enhanced UV-B on terrestrial plants. The results of existing studies need to be verified under field conditions (Caldwell et al., 1995). Keeping the limitations of existing research in mind, it is still possible to make some statements about the effect of enhanced UV-B on terrestrial plants. It appears that increased UV-B radiation may have both direct and indirect effects on plants. Some plant species exhibit a reduction in leaf area and/or stem growth when exposed to higher levels of UV-B. In addition, UV-B may also inhibit photosynthesis, damage plant DNA, and alter the time of flowering as well as the number of flowers in some species. The latter has implication for the availability of pollinators and thus the reproductive capacity of plants (Caldwell et al., 1995; UNEP, 1998). The effects of UV-B on plants are not always straightforward but rather depend on the species, the cultivar, and developmental stage of the plants as well as mineral nutrition in the soil, drought, and local air pollutants (Caldwell et al., 1995; UNEP, 1998). In affecting plants, enhanced UV-B radiation may ultimately lead to changes in entire ecosystems. In nonagricultural ecosystems (e.g., forests and grasslands), the balance of plants may change as some species are less able to respond to increases in UV-B radiation and their productivity declines. At the same time, the productivity of more responsive species will likely increase. The overall species composition of ecosystems will change, as will species interactions and ecosystem dynamics (Caldwell et al., 1995; UNEP, 1998).

#### Biodiversity loss causes extinction – threat multiplier that outweighs on timeframe

Torres 16 Phil Torres 4-11-2016 “Biodiversity loss: An existential risk comparable to climate change” thebulletin.org/biodiversity-loss-existential-risk-comparable-climate-change9329 (founder of the X-Risks Institute, an affiliate scholar at the Institute for Ethics and Emerging Technologies)

The sixth extinction. The repercussions of biodiversity loss are potentially as severe as those anticipated from climate change, or even a nuclear conflict. For example, according to a 2015 study published in Science Advances, the best available evidence reveals “an exceptionally rapid loss of biodiversity over the last few centuries, indicating that a sixth mass extinction is already under way.” This conclusion holds, even on the most optimistic assumptions about the background rate of species losses and the current rate of vertebrate extinctions. The group classified as “vertebrates” includes mammals, birds, reptiles, fish, and all other creatures with a backbone. The article argues that, using its conservative figures, the average loss of vertebrate species was 100 times higher in the past century relative to the background rate of extinction. (Other scientists have suggested that the current extinction rate could be as much as 10,000 times higher than normal.) As the authors write, “The evidence is incontrovertible that recent extinction rates are unprecedented in human history and highly unusual in Earth’s history.” Perhaps the term “Big Six” should enter the popular lexicon—to add the current extinction to the previous “Big Five,” the last of which wiped out the dinosaurs 66 million years ago. But the concept of biodiversity encompasses more than just the total number of species on the planet. It also refers to the size of different populations of species. With respect to this phenomenon, multiple studies have confirmed that wild populations around the world are dwindling and disappearing at an alarming rate. For example, the 2010 Global Biodiversity Outlook report found that the population of wild vertebrates living in the tropics dropped by 59 percent between 1970 and 2006. The report also found that the population of farmland birds in Europe has dropped by 50 percent since 1980; bird populations in the grasslands of North America declined by almost 40 percent between 1968 and 2003; and the population of birds in North American arid lands has fallen by almost 30 percent since the 1960s. Similarly, 42 percent of all amphibian species (a type of vertebrate that is sometimes called an “ecological indicator”) are undergoing population declines, and 23 percent of all plant species “are estimated to be threatened with extinction.” Other studies have found that some 20 percent of all reptile species, 48 percent of the world’s primates, and 50 percent of freshwater turtles are threatened. Underwater, about 10 percent of all coral reefs are now dead, and another 60 percent are in danger of dying. Consistent with these data, the 2014 Living Planet Report shows that the global population of wild vertebrates dropped by 52 percent in only four decades—from 1970 to 2010. While biologists often avoid projecting historical trends into the future because of the complexity of ecological systems, it’s tempting to extrapolate this figure to, say, the year 2050, which is four decades from 2010. As it happens, a 2006 study published in Science does precisely this: It projects past trends of marine biodiversity loss into the 21st century, concluding that, unless significant changes are made to patterns of human activity, there will be virtually no more wild-caught seafood by 2048. Catastrophic consequences for civilization. The consequences of this rapid pruning of the evolutionary tree of life extend beyond the obvious. There could be surprising effects of biodiversity loss that scientists are unable to fully anticipate in advance. For example, prior research has shown that localized ecosystems can undergo abrupt and irreversible shifts when they reach a tipping point. According to a 2012 paper published in Nature, there are reasons for thinking that we may be approaching a tipping point of this sort in the global ecosystem, beyond which the consequences could be catastrophic for civilization. As the authors write, a planetary-scale transition could precipitate “substantial losses of ecosystem services required to sustain the human population.” An ecosystem service is any ecological process that benefits humanity, such as food production and crop pollination. If the global ecosystem were to cross a tipping point and substantial ecosystem services were lost, the results could be “widespread social unrest, economic instability, and loss of human life.” According to Missouri Botanical Garden ecologist Adam Smith, one of the paper’s co-authors, this could occur in a matter of decades—far more quickly than most of the expected consequences of climate change, yet equally destructive. Biodiversity loss is a “threat multiplier” that, by pushing societies to the brink of collapse, will exacerbate existing conflicts and introduce entirely new struggles between state and non-state actors. Indeed, it could even fuel the rise of terrorism. (After all, climate change has been linked to the emergence of ISIS in Syria, and multiple high-ranking US officials, such as former US Defense Secretary Chuck Hagel and CIA director John Brennan, have affirmed that climate change and terrorism are connected.) The reality is that we are entering the sixth mass extinction in the 3.8-billion-year history of life on Earth, and the impact of this event could be felt by civilization “in as little as three human lifetimes,” as the aforementioned 2012 Nature paper notes. Furthermore, the widespread decline of biological populations could plausibly initiate a dramatic transformation of the global ecosystem on an even faster timescale: perhaps a single human lifetime. The unavoidable conclusion is that biodiversity loss constitutes an existential threat in its own right. As such, it ought to be considered alongside climate change and nuclear weapons as one of the most significant contemporary risks to human prosperity and survival.

#### Ozone depletion causes mutations that ensures existential pandemics

Supriya 21[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]

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.

## Framing

#### The standard is util. Prefer:

#### Death is the worse possible thing since it erases our very existence

Paterson 03, Craig [Department of Philosophy, Providence College, Rhode Island] 2003, “A Life Not Worth Living?”, Studies in Christian Ethics

Contrary to those accounts, I would argue that it is death per se that is really the objective evil for us, not because it deprives us of a prospective future of overall good judged better than the alter- native of non-being. It cannot be about harm to a former person who has ceased to exist, for no person actually suffers from the sub-sequent non-participation. Rather, death in itself is an evil to us because it ontologically destroys the current existent subject — it is the ultimate in metaphysical lightning strikes.80 The evil of death is truly an ontological evil borne by the person who already exists, independently of calculations about better or worse possible lives. Such an evil need not be consciously experienced in order to be an evil for the kind of being a human person is. Death is an evil because of the change in kind it brings about, a change that is destructive of the type of entity that we essentially are. Anything, whether caused naturally or caused by human intervention (intentional or unintentional) that drastically interferes in the process of maintaining the person in existence is an objective evil for the person. What is crucially at stake here, and is dialectically supportive of the self-evidency of the basic good of human life, is that death is a radical interference with the current life process of the kind of being that we are. In consequence, death itself can be credibly thought of as a ‘primitive evil’ for all persons, regardless of the extent to which they are currently or prospectively capable of participating in a full array of the goods of life.81  In conclusion, concerning willed human actions, it is justifiable to state that any intentional rejection of human life itself cannot therefore be warranted since it is an expression of an ultimate disvalue for the subject, namely, the destruction of the present person; a radical ontological good that we cannot begin to weigh objectively against the travails of life in a rational manner. To deal with the sources of disvalue (pain, suffering, etc.) we should not seek to irrationally destroy the person, the very source and condition of all human possibility.82

#### Requires the prevention of extinction which is a pre-req to all other frameworks.

GPP 17 Global Priorities Project, [Future of Humanity Institute at the University of Oxford, Ministry for Foreign Affairs of Finland] 2017, “Existential Risk: Diplomacy and Governance,” Global Priorities Project, <https://www.fhi.ox.ac.uk/wp-content/uploads/Existential-Risks-2017-01-23.pdf>

1.2. THE ETHICS OF EXISTENTIAL RISK In his book Reasons and Persons, Oxford philosopher Derek Parfit advanced an influential argument about the importance of avoiding extinction: I believe that if we destroy mankind, as we now can, this outcome will be much worse than most people think. Compare three outcomes: (1) Peace. (2) A nuclear war that kills 99% of the world’s existing population. (3) A nuclear war that kills 100%. (2) would be worse than (1), and (3) would be worse than (2). Which is the greater of these two differences? Most people believe that the greater difference is between (1) and (2). I believe that the difference between (2) and (3) is very much greater. ... The Earth will remain habitable for at least another billion years. Civilization began only a few thousand years ago. If we do not destroy mankind, these few thousand years may be only a tiny fraction of the whole of civilized human history. The difference between (2) and (3) may thus be the difference between this tiny fraction and all of the rest of this history. If we compare this possible history to a day, what has occurred so far is only a fraction of a second.65 In this argument, it seems that Parfit is assuming that the survivors of a nuclear war that kills 99% of the population would eventually be able to recover civilisation without long-term effect. As we have seen, this may not be a safe assumption – but for the purposes of this thought experiment, the point stands. What makes existential catastrophes especially bad is that they would “destroy the future,” as another Oxford philosopher, Nick Bostrom, puts it.66 This future could potentially be extremely long and full of flourishing, and would therefore have extremely large value. In standard risk analysis, when working out how to respond to risk, we work out the expected value of risk reduction, by weighing the probability that an action will prevent an adverse event against the severity of the event. Because the value of preventing existential catastrophe is so vast, even a tiny probability of prevention has huge expected value.67 Of course, there is persisting reasonable disagreement about ethics and there are a number of ways one might resist this conclusion.68 Therefore, it would be unjustified to be overconfident in Parfit and Bostrom’s argument. In some areas, government policy does give significant weight to future generations. For example, in assessing the risks of nuclear waste storage, governments have considered timeframes of thousands, hundreds of thousands, and even a million years.69 Justifications for this policy usually appeal to principles of intergenerational equity according to which future generations ought to get as much protection as current generations.70 Similarly, widely accepted norms of sustainable development require development that meets the needs of the current generation without compromising the ability of future generations to meet their own needs.71 However, when it comes to existential risk, it would seem that we fail to live up to principles of intergenerational equity. Existential catastrophe would not only give future generations less than the current generations; it would give them nothing. Indeed, reducing existential risk plausibly has a quite low cost for us in comparison with the huge expected value it has for future generations. In spite of this, relatively little is done to reduce existential risk. Unless we give up on norms of intergenerational equity, they give us a strong case for significantly increasing our efforts to reduce existential risks. 1.3. WHY EXISTENTIAL RISKS MAY BE SYSTEMATICALLY UNDERINVESTED IN, AND THE ROLE OF THE INTERNATIONAL COMMUNITY In spite of the importance of existential risk reduction, it probably receives less attention than is warranted. As a result, concerted international cooperation is required if we are to receive adequate protection from existential risks. 1.3.1. Why existential risks are likely to be underinvested in There are several reasons why existential risk reduction is likely to be underinvested in. Firstly, it is a global public good. Economic theory predicts that such goods tend to be underprovided. The benefits of existential risk reduction are widely and indivisibly dispersed around the globe from the countries responsible for taking action. Consequently, a country which reduces existential risk gains only a small portion of the benefits but bears the full brunt of the costs. Countries thus have strong incentives to free ride, receiving the benefits of risk reduction without contributing. As a result, too few do what is in the common interest. Secondly, as already suggested above, existential risk reduction is an intergenerational public good: most of the benefits are enjoyed by future generations who have no say in the political process. For these goods, the problem is temporal free riding: the current generation enjoys the benefits of inaction while future generations bear the costs. Thirdly, many existential risks, such as machine superintelligence, engineered pandemics, and solar geoengineering, pose an unprecedented and uncertain future threat. Consequently, it is hard to develop a satisfactory governance regime for them: there are few existing governance instruments which can be applied to these risks, and it is unclear what shape new instruments should take. In this way, our position with regard to these emerging risks is comparable to the one we faced when nuclear weapons first became available. Cognitive biases also lead people to underestimate existential risks. Since there have not been any catastrophes of this magnitude, these risks are not salient to politicians and the public.72 This is an example of the misapplication of the availability heuristic, a mental shortcut which assumes that something is important only if it can be readily recalled. Another cognitive bias affecting perceptions of existential risk is scope neglect. In a seminal 1992 study, three groups were asked how much they would be willing to pay to save 2,000, 20,000 or 200,000 birds from drowning in uncovered oil ponds. The groups answered $80, $78, and $88, respectively.73 In this case, the size of the benefits had little effect on the scale of the preferred response. People become numbed to the effect of saving lives when the numbers get too large.74 Scope neglect is a particularly acute problem for existential risk because the numbers at stake are so large. Due to scope neglect, decision-makers are prone to treat existential risks in a similar way to problems which are less severe by many orders of magnitude. A wide range of other cognitive biases are likely to affect the evaluation of existential risks.75

## Role of the Ballot

#### The role of the ballot is to vote for the most desirable world

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No question of values can be determined entirely true or false. This is why the resolution is desirable. Therefore neither debater should be held to a standard of absolute proof. No debater can realistically be expected to prove complete validity or invalidity of the resolution. The better debater is the one who, on the whole, proves his/her side of the resolution more valid as a general principle.2 And the truth-statement model of the resolution imposes an absolute burden of proof on the affirmative: if the resolution is a truth-claim, and the affirmative has the burden of proving that claim, in so far as intuitively we tend to disbelieve truthclaims until we are persuaded otherwise, the affirmative has the burden to prove that statement absolutely true. Indeed, one of the most common theory arguments in LD is conditionality, which argues it is inappropriate for the affirmative to claim only proving the truth of part of the resolution is sufficient to earn the ballot. Such a model of the resolution also gives the negative access to a range of strategies that many students, coaches, and judges find ridiculous or even irrelevant to evaluation of the resolution. If the negative need only prevent the affirmative from proving the truth of the resolution, it is logically sufficient to negate to deny our ability to make truth-statements or to prove normative morality does not exist or to deny the reliability of human senses or reason. Yet, even though most coaches appear to endorse the truth-statement model of the resolution, they complain about the use of such negative strategies, even though they are a necessary consequence of that model. And, moreover, such strategies seem fundamentally unfair, as they provide the negative with functionally infinite ground, as there are a nearly infinite variety of such skeptical objections to normative claims, while continuing to bind the affirmative to a much smaller range of options: advocacy of the resolution as a whole. Instead, it seems much more reasonable to treat the resolution as a way to equitably divide ground: the affirmative advocating the desirability of a world in which people adhere to the value judgment implied by the resolution and the negative advocating the desirability of a world in which people adhere to a value judgment mutually exclusive to that implied by the resolution. By making the issue one of desirability of competing world-views rather than of truth, the affirmative gains access to increased flexibility regarding how he or she chooses to defend that world, while the negative retains equal flexibility while being denied access to those skeptical arguments indicted above. Our ability to make normative claims is irrelevant to a discussion of the desirability of making two such claims. Unless there is some significant harm in making such statements, some offensive reason to reject making them that can be avoided by an advocacy mutually exclusive with that of the affirmative such objections are not a reason the negative world is more desirable, and therefore not a reason to negate. Note this is precisely how things have been done in policy debate for some time: a team that runs a kritik is expected to offer some impact of the mindset they are indicting and some alternative that would solve for that impact. A team that simply argued some universal, unavoidable, problem was bad and therefore a reason to negate would not be very successful. It is about time LD started treating such arguments the same way. Such a model of the resolution has additional benefits as well. First, it forces both debaters to offer offensive reasons to prefer their worldview, thereby further enforcing a parallel burden structure. This means debaters can no longer get away with arguing the resolution is by definition true of false. The “truth” of the particular vocabulary of the resolution is irrelevant to its desirability. Second, it is intuitive. When people evaluate the truth of ethical claims, they consider their implications in the real world. They ask themselves whether a world in which people live by that ethical rule is better than one in which they don’t. Such debates don’t happen solely in the abstract. We want to know how the various options affect us and the world we live in. This does not, however, mean this “worldview comparison” model would necessarily remove the ability of debaters to argue values or philosophy in the abstract. We have long recognized that purely deontological arguments have offensive impacts that can be compared against other such implications. This model would simply require debaters to more directly compare, for example, the importance of avoiding treating people as means to an end or protecting rights with the importance of saving lives or maximizing economic efficiency, for reasons I will explore shortly. Consequently, I believe worldview comparison better adheres to the NFL’s vision of the activity while providing better, more real-world, education about how to effectively and persuasively discuss the issues implicated by LD resolutions.