AC

The value is justice. The word justice is present in the resolution so we should prefer it because the resolution is the stasis point of all debate. The value criterion is utilitarianism. Default to a util – Maximizing aggregate utility for the general population allows for policies that align with each actor's preference for equal material outcomes.

Allen 17 (Daneille Allen, Director of the Edmond J. Safra Center for Ethics at Harvard University and professor in Harvard's Department of Government and Graduate School of Education, political theorist who has published broadly in democratic theory, political sociology, and the history of political thought, "Political Equality and Empowering Economies-- Toward a New Political Economy" Page 2 – 7 http://henryfarrell.net/wp/wp-content/uploads/2017/04/Allen_equality.pdf, Rose)

We were of course surprised not just by Brexit and Trump but also by the recession of 2008. We have therefore been living in a state of intellectual surprise for almost a decade. Why is it that we have been so blind-sided? The answer lies, I suggest, in the dominant liberal policy-making paradigms. The dominant liberal policy paradigm, emerging from places like Harvard's Kennedy School of Government and operating in Washington think-tanks and policy making-spaces, fuses two things: utilitarian economic welfarism and Rawlsian welfarism. Let me explain**. On the utilitarian model the goal of policy is to maximize happiness or, better, utility, as the economists label it, for society. In its crudest forms, the effort to maximize aggregate utility relies on cost-benefit analyses, linked to preferences typically cast in terms of material goods.** Much modeling of utility maximization in relation to preferences has abstracted away from the contextual, social, psychological, and cultural particularities of individual economic actors. **The pursuit of utilitarian welfare maximization has typically focused on maximizing aggregate growth—in terms of income and wealth--and on using redistributive policies to spread the benefit of that growth**. John Rawls is a philosopher who in 1971 published an important book called Theory of Justice; and one of his main goals was to overturn utilitarianism. He sought to prioritize the right over the good, establishing as the purpose of political order the protection of a framework of right, not the pursuit of any particular good, even utility or happiness. Yet even as, philosophically, he sought to overturn utilitarianism, in many ways Rawlsianism has reinforced its practical applications. In the Rawlsian framework, the goal of a just society is to do two things. The first goal is to protect a set of basic liberties. Those basic liberties include things like the right of association, the right to free expression, and the right to participate politically. The second goal is to pursue social and economic structures, within the constraint of protecting those rights, that are to the benefit of the least well of in society ("the difference principle") and that secure fair equal opportunity throughout the society. Rawls' innovative and influential difference principle has anchored the major part of the reception of his work and led to a dominant focus, in philosophical discussions of justice, on the economic questions of distributive justice. These questions have gotten far more attention than his discussion of basic rights. Indeed, in the policy world, Rawlsianism has turned into a basic focus on redistributive taxation as the starting point for building a policy framework. Without intending to, Rawls reinforced the utilitarian paradigm precisely by hiving off consideration of basic rights from his treatment, via the difference principle, of social and economic spheres. **He provided support for the utilitarian focus on growth, so long as it was tethered to redistribution. In both utilitarian welfarism and Rawlsian welfarism, as expressed in the policy world, the core question for justice is one of material distribution**. **This is recognizable. When someone invokes the concept of "social justice," the first thing that comes to mind tends to be matters of economic distribution and welfarist social rights**. Similarly, when a speaker invokes the concept of inequality, the relevant kind of inequality the speaker has in mind is almost invariably economic inequality. That's what scholars and the general public know how to talk about, thanks to the intellectual support provided by policy paradigms coming out of utilitarian welfarism, on the one hand, and Rawlsian welfarism, on the other. Two features of this fused utilitarian-Rawlsian policy paradigm merit attention. The first is that both the utilitarian paradigm and the Rawlsian paradigm are universalizing. **That is, they both abstract away from the contextual specifics of any given society to develop their overarching policy guidelines (utility maximization, on the one hand; and the difference principle, on the other).** For instance, in Theory of Justice, Rawls seeks the definition of the right by asking us to imagine stepping behind "a veil of ignorance," where we no longer know anything about our own social situation; from that perspective in the imagination, we are to try to identify the principles that would constitute a just society, **one that we will consider just regardless of whether we turn out to be one of the just society's wealthier or poorer, male or female, black or white citizens and so forth.** The principles of justice are to be devised without taking into account any underlying demographic features of a society. Moreover, **they are understood to apply universally, to any social context.** In the context of utilitarianism, the move to abstract away from social particularity is less a matter of the intentional design of the theory and more a necessary consequence of its mathematization. In principle, utility is a concept that can embrace not only a given actors preferences for material outcomes but also his or her values and norms. But the project of "maximizing" utility requires that we convert preferences into something arithmetic, and so financial interests are conventionally used as a proxy for utility, thus flattening the particularities of preference that may in fact give meaning and shape to the life of any particular agent. As in the Rawlsian case, the move to treat material gain, money, as a proxy for utility permits universalization. Financial stakes can be translated into a currency and compared across countries and contexts without reference to the underlying demographic facts or situations on the ground in any given country. In other words, one of the things both of these intellectual paradigms do is turn our

attention away from the underlying demographic and institutionalarrangements of a society. Our minds are trained away from questions such as: Who has power and on account of what sorts of institutional structures and according to what sorts of allocations of resources and opportunities? We lose the habit of analyzing the demographic and political specificity of any given society to the degree that we embrace and reinforce the habits of using utilitarian and/or Rawlsian welfarism. To give you a concrete example of the kind of abstraction I am trying to pinpoint, think about how the World Bank historically operated throughout the late 20th century. A set of boilerplate requirements for economic liberalization were applied to developing economies as conditions for receiving loans from the bank. The fact the stability of these welfarist policy paradigms has taught us to overlook underlying social and political phenomena flows, I think, from a small philosophical mistake made in the early 19th century, and characterizing most variants of liberalism ever since. The mistake was to draw a distinction between two halves of that set of basic rights protected by liberalism. I introduced the concept of basic rights in describing Rawls' Theory of Justice, and provided as examples freedom of association, freedom of expression, and the right to participate in politics. With these three examples, I was limning the full spectrum of basic rights, including both halves as distinguished in the early 19th century. What does this mean exactly? An early 19th century French thinker named Benjamin Constant was the first to divide basic rights, basic human rights, into two categories. He called them the rights of the ancients and the rights of the moderns. The rights of the ancients comprised rights to participate in politics, in shaping the collective life of a society. We now call these positive liberties. The rights of the moderns, in contrast, comprise a right to property and the right to be left alone to take your property, which you have a right to, and to engage in commercial transactions in pursuit of your own wellbeing as you see fit. We call these negative liberties. The rights of the ancients were political rights, a right to be a part of a society that was working together to steer itself through collective decision making**. The rights of the moderns, forConstant, were about private autonomy, having the right to steer your own life, and being more or less left alone by any collective decision- making, to the maximum degree possible.** That distinction has worked its way into the philosophical tradition, and was extended by Isaiah Berlin in the early 20th century (who introduced the terms negative and positive liberties). Rawls, in Theory of Justice, argues that he's putting the two sets of rights back together again and that we need to protect the whole set of basic rights. In fact, however, the political rights become sacrifice-able in his argument, in various technical ways that I won't go into here (but do detail in Allen, "Difference without Domination"). Over the whole arc of Theory of Justice, we end up primarily focusing our thinking about politics on the conjunction of our private rights (the right to autonomy, property, association, expression, and so forth) with the economic questions associated with those rights-- the wealth associated with property and the need for redistribution that comes from the unequal flow of the gains of productivity across a population. In other words, when you lose sight of the political rights and focus primarily on the private rights or negative liberties, you can easily come to focus exclusively on economic questions and lose sight of political questions. That is what I see as having happened in the policy paradigms that dominated U.S. policy-making in the late 20th century. Another part of the story about the development of a truncated focus on economic questions— without reference to underlying political questions—relates to the transition over the course of the 20th century from the influence of law on public policy to the influence of economics. Sociologist Elizabeth Popp Berman (2014) has written well about the variety of factors— including new capacities for computation—that drove that change, and much more could be said about this transition. But the transition from law to economics also underscores the point I'm making. Legal thinking is fundamentally about the institutions of specific societies and about the consequences of particularities of those institutions for specific societies. Even sub-disciplines like comparative law that compare the legal systems in different places must begin by seeing the specificity of the legal institutions in each place under comparison. When law dominated the policy-making universe, universalizing policy approaches that abstracted from demographic and social specificity, were not broadly available. The abstracting, universalizing features of the fused utilitarian/Rawlsian welfarism that dominated policy making of the late 20th century seem to me to have produced the blindspots to society, politics, and political rights, that left us surprised not only by 2008 but also by Brexit and Trump.

1AC – Proliferated Constellations

I affirm, The Private Appropriation of outer space through the use of proliferated satellite constellations is unjust.

Mega constellations increase collision risk.

Boley & Byers 21 [Aaron C. Boley & Michael Byers, 5-20-2021, "Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth," Nature, https://www.nature.com/articles/s41598-021-89909-7, accessed 1-13-2022] BCortez

Although the volume of space is large, **individual satellites and satellite systems** have specific functions, with associated altitudes and inclinations (Fig. 2). This **increases congestion** and requires active management for station keeping and collision avoidance9, with automatic collision-avoidance technology **still under development.** Improved space situational awareness is required, with data from operators as well as ground- and space-based sensors being widely and freely shared10. Improved communications between satellite operators are also necessary: in 2019, the European Space Agency moved an Earth observation satellite to avoid colliding with a Starlink satellite, after failing to reach SpaceX by e-mail. Internationally adopted 'right of way' rules are needed10 to prevent games of 'chicken', as companies seek to preserve thruster fuel and avoid service interruptions. SpaceX and NASA recently announced11 a cooperative agreement to help reduce the risk of collisions, but this is only one operator and one agency.∂ When completed, Starlink will include about as many satellites as there are trackable debris pieces today, while its total mass will equal all the mass currently in LEO—over 3000 tonnes. The satellites will be placed in narrow orbital shells, creating unprecedented congestion, with 1258 already in orbit (as of 30 March 2021). OneWeb has already placed an initial 146 satellites, and Amazon, Telesat, GW and other companies, operating under different national regulatory regimes, are soon likely to follow. Deorbiting satellites will be tracked and operational satellites can manoeuvre to avoid close conjunctions. However, this depends on ongoing communication and cooperation between operators, which at present is ad hoc and voluntary. A recent letter12 to the FCC from SpaceX suggests that some companies might be less-than-fully transparent about events13 in LEO.∂ Despite the congestion and traffic management challenges, FCC filings by SpaceX suggest that collision avoidance manoeuvres can in fact maintain collision-free operations in orbital shells and that the probability of a collision between a non-responsive satellite and tracked debris is negligible. However, the **filings do not account for untracked debris**6, **including untracked debris decaying through the shells used by Starlink.** Using simple estimates (see "Methods"), the probability that a single piece of untracked debris will hit any satellite in the Starlink 550 km shell is about 0.003 after one year. Thus, if at any time there are 230 pieces of untracked debris decaying through the 550 km orbital shell, **there is a 50% chance that there will be one or more collisions between satellites in the shell and the debris.** As discussed further in "Methods", such a situation is plausible. Depending on the balance between the de-orbit and the collision rates, if subsequent fragmentation events lead to similar amounts of debris within that orbital shell, a runaway cascade of collisions could occur.∂ Fragmentation events are not confined to their local orbits, either. The India 2019 ASAT test was conducted at an altitude below 300 km in an effort to minimize long-lived debris. Nevertheless, debris was placed on orbits with apogees in excess of 1000 km. As of 30 March 2021, three tracked debris pieces remain in orbit14. Such long-lived debris has high eccentricities, and thus can cross multiple orbital shells twice per orbit. A major fragmentation event from a single satellite could affect all operators in LEO.∂ Even if debris collisions were avoidable, meteoroids are always a threat. The cumulative meteoroid flux15 for masses m > 10–2 g is about 1.2 × 10–4 meteoroids m−2 year−1 (see "Methods"). Such masses could cause non-negligible damage to satellites16. Assuming a Starlink constellation of 12,000 satellites (i.e. the initial phase), there is about a 50% chance of 15 or more meteoroid impacts per year at m > 10–2 g. Satellites will have shielding, but **events that might be rare to a single satellite could become common across the constellation.**

Mass de-orbiting increases risk of collision

Boley & Byers 21 [Aaron C. Boley & Michael Byers, 5-20-2021, "Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth," Nature, https://www.nature.com/articles/s41598-021-89909-7, accessed 1-13-2022] BCortez

Mega-constellations are composed of mass-produced satellites with few backup systems. This consumer electronic model allows for short upgrade cycles and rapid expansions of capabilities, but also **considerable discarded equipment**. SpaceX will actively de-orbit its satellites at the end of their 5–6-year operational lives. However, this process takes 6 months, so **roughly 10% will be de-orbiting at any time**. If other companies do likewise, **thousands of de-orbiting satellites will be slowly passing through the same congested space, posing collision risks.** Failures will increase these numbers, although the long-term failure rate is difficult to project. Figure 3 is similar to the righthand portion of Fig. 2 but includes the Starlink and OneWeb mega-constellations as filed (and amended) with the FCC (see "Methods"). The large density spikes show that some shells will have satellite number densities in excess of n=10−6 km−3n=10−6 km−3.

Current constellations are likely to collide – mitigation fails

May 18 [S.Le May, SERC Limited, Mount Stromlo, Canberra, Australia, 6-19-2018, "Space debris collision probability analysis for proposed global broadband constellations," No Publication, https://www.sciencedirect.com/science/article/abs/pii/S0094576518304375?via%3Dihub, accessed 1-13-2022] BCortez

The results of this study indicate a **high probability for the occurrence of at least one collision for both the proposed OneWeb and SpaceX constellations during an operational phase of 5 years**. It was found that the probability of there being at least one catastrophic collision involving a spacecraft within the OneWeb constellation is 5.0%, and for SpaceX much higher at 45.8%. It must be noted that the MASTER-2009 model does have limitations, including no quantified uncertainty associated with the flux output. The results of this study represent the mean collisional behaviour of the system, and are not strictly a prediction of the future. When the collision probability is derived from discrete random particles, the chance of having an accurate result increases with sample size and probability of collision. Both of these are higher for the SpaceX constellation compared with the OneWeb constellation. The differences observed between the results for the sphere and box-wing for the Total results for SpaceX thus have the highest chance of not being due to statistical noise. In statistics, the likelihood for the difference between two results being due to statistical noise is called statistical significance [28]. Similarly, for both constellations the results for N ( ) Total const and Nconst (Non Trackable −) may have greater statistical significance than Nconst (Catastrophic) and Nconst (, Catastrophic Non trackable −) as the flux is derived from a larger number of particles. Quantifying statistical significance in this context would require a more robust statistical analysis, recommended for future work. OneWeb's Orbital Debris Mitigation Plan reports that the probability of a OneWeb satellite becoming disabled as a result of collisions with small debris is 0.003, as computed using NASA's ORDEM3 model and taking the minimum hazardous debris size as 1 cm. In comparison, this study used ESA's MASTER model and a minimum size threshold of 3 mm to determine the probability of collision for a single OneWeb satellite. The resulting probability is around 0.008 (Table A.5), a value which aligns well with OneWeb's own study. In response to the FCC's request to provide an analysis of collision risk, SpaceX reported that there is "approximately a 1% chance per decade that any failed SpaceX satellite would collide with a piece of tracked debris". 3 Although this specific case wasn't explored in Section 4.4, our analysis for the probability of collision of one failed satellite with trackable debris (not shown here) agrees with this statement. However, **it does not take into account the collision probabilities associated with non-trackable objects, determined to be P≥1sat = 0.124 after 10 years using the sphere model.** The results of this study show that **implementation of the mitigation measures in MASTER did not significantly reduce the probability of at least one collision during the five year operational phase of either the OneWeb or SpaceX constellation**. The MASTER-2009 model's intermediate and full mitigation scenarios implement steady reductions of debris creation from 2020 onwards and therefore have very little impact on the first generation of the

OneWeb and SpaceX constellations which cease operation in 2023. Additional measures may be required to ensure the safe and sustainable operation of such constellations, including but not limited to reducing the size and number of satellites launched. Due to imminent launch dates and because of the potential value such constellations have for the global community, in particular developing economies, the question of how to ensure safe and sustainable operations alongside constellations of this scale still needs to be addressed.

Debris in space causes runaway collisions.

Mcdonald 21 [Bob Mcdonald, 5-21-2021, "Mega-satellite constellations could lead to chain-reaction spacecraft pile-ups in orbit," CBC, https://www.cbc.ca/radio/quirks/mega-satellite-constellations-could-lead-to-chain-reaction-spacecraft-pile-ups-in-orbit-1.6036322, accessed 1-13-2022] BCortez

But what Boley is concerned about is the possibility and implications of accidents. Random pieces of untracked space debris, or even meteors, could disable these satellites, disrupting their careful orbits and the deorbiting plans. The sheer number of these new satellites increases the risk. ∂And this could lead to a runaway disaster. Relative speeds are so fast in space that objects running into each other tend to be blown to bits, and those bits add to the problem. With every collision, more debris is added, increasing the risk even more in what could become a runaway cascade of collisions that could make the valuable real estate of low Earth orbit incredibly dangerous.

Collisions trigger miscalculated war --- early warning systems and communications for deterrence rely on satellites.

Anthony **Barrett 16**. Cofounder and director of research of the Global Catastrophic Risk Institute and senior risk analyst at ABS Consulting "False Alarms, True Dangers? Current and Future Risks of Inadvertent U.S.-Russian Nuclear War" https://www.semanticscholar.org/paper/False-Alarms%2C-True-Dangers-Current-and-Future-Risks-Barrett/dbc441aca0ddacb96598f78cfec7306ea85d1f71//

This scenario could take place over the next three years: Falling oil and gas prices make it difficult for Russia to maintain its early warning system components. One of the northern-facing Russian radars begins failing some of its reliability tests, and a month later the Russian early warning satellite constellation loses its only geostationary satellite. A combination of technical problems and budget pressures prevent either a radar overhaul or a launch of a replacement satellite for at least a year. Two months after the geostationary satellite loss, one of several remaining Russian early warning satellites in a highly elliptical Molniya orbit detects flares of some kind in the area of the ICBM fields in the northern United States. At that moment, **the satellite is the only component of the Russian early warning satellite constellation that is in an orbital position allowing it to see the** northern **U**nited **S**tates. The satellite cannot immediately determine whether the flares are due to launches at ICBM bases or to something else, such as fires at oil or gas facilities in the same region, or perhaps the reflection of sunlight off high-altitude clouds. The satellite is able to transmit its flare-detection signal to other parts of the Russian early warning system, alerting system operators in Russia. **However, the Russian satellite is then struck by orbital debris, and it instantly ceases communication with Russian**

early warning system operators. Russian early warning system operators must quickly decide what to tell their leaders. Did the satellite detect a launch of U.S. ICBMs? Was the loss of communications capabilities caused by sabotage? Could Russian radar systems rule out the possibility of incoming ICBMs? **These questions could be quite serious during a period of seeming calm** between the United States and Russia, **but they would be especially urgent during a period of heightened tension** or crisis. This Perspective represents the various pathways for a false alarm scenario for both nations in one fault tree (Figure 1), given the assumption that both Russia and the United States have similar procedures to respond to early warning alarms and use roughly analogous categories of low-, mid-, and high-level alarm events. **The outcome of concern here, of course, is the launch of nuclear missiles when one country mistakenly concludes that it is under attack by the other.** As shown in the second level of the tree, **a launch in response to a false alarm could occur either during a U.S.-Russian crisis or during a period of low tension**. The next layer in the tree shows that a launch in response to a false alarm could occur if a midlevel false alarm is promoted to a high level and involves senior national leadership who choose a launch response. Each of those steps in the decision process for false alarms has an associated node in the fault tree that is a key risk factor in the model. That all applies to both crisis and noncrisis periods. However, as is shown farther down the tree, during crisis conditions, the effective total rate of false alarms includes both midlevel false alarm events and any low-level events whose **resolution** (identification as a false alarm) **cannot be completed before the "use them or lose them" point where a launch response decision needs to be made by leaders**.1

It's the most likely scenario for conflict ---debris can't be distinguished from military attacks.

Peter **Dockrill 16**. Award-winning science & technology journalist. "Space Junk Accidents Could Trigger Armed Conflict, Study Finds." https://www.sciencealert.com/space-junk-accidents-could-trigger-armed-conflict-expert-warns.

The increasingly crowded space in Earth's low orbit could set the stage for an **international armed conflict**, says a new study. Researchers from the Russian Academy of Sciences warn that accidents stemming from the steady rise in space junk floating around the planet could incite **political rows** and even **warfare**, with nations potentially **mistaking debris**-caused incidents as the results of **intentional aggressive acts** by others. In a paper published in Acta Astronautica, the team suggests that space debris in the form of spent rocket parts and other fragments of hardware hurtling at high speed pose a "**special political danger**" that could **dangerously escalate** tensions between nations. According to the study, destructive impacts caused by random space junk cannot easily be told apart from military attacks. "The owner of the impacted and destroyed satellite can hardly quickly determine the real cause of the accident," the authors write. The risks of such an event occurring are compounded by the **sheer volume** of debris now orbiting Earth. Recent figures from NASA indicate that there are more than 500,000 pieces of space junk currently being tracked in orbit, travelling at speeds up to 28,160 km/h (17,500 mph). The majority of those objects are small – around the size of a marble – but some 20,000 of them are bigger than a

softball. In addition to these 500,000 or so fragments – which are big enough for scientists to know about them – NASA estimates that there are millions of undetectable pieces of debris in orbit that are too small to be monitored. But even extremely small fragments such as these pose a threat – in fact, they're considered a greater risk than trackable debris, as their **invisible status** means spacecraft and satellites can't do anything to avoid them **until it's too late.** As NASA observed in 2013: "Even tiny paint flecks can damage a spacecraft when travelling at these velocities. In fact a number of space shuttle windows have been replaced because of damage caused by material that was analysed and shown to be paint flecks… With so much orbital debris, there have been surprisingly few disastrous collisions." While we may have been lucky in the past, **we can't rely on that to continue**. The study by the Russian team cites the repeated sudden failures of defence satellites in past decades that were never explained. The researchers attribute two possible causes: either unrecorded collisions with space junk, or aggressive actions from adversaries. "This is a **politically dangerous dilemma**," the authors write.

It goes nuclear.

Les **Johnson 14**. Baen science fiction author, popular science writer, and NASA technologist. "Living without satellites". https://www.baen.com/living_without_satellites.

Satellite imagery is used by the military and our political leaders to maintain the peace. When your potential adversaries can't hide what they're doing, where their armies are moving and what they are doing with their civilian and military infrastructure, then the danger of surprise attack is diminished. In our nuclear age with instant death only minutes away by missile attack, the doctrine of Mutual Assured Destruction **(MAD) only works if both sides know whether or not they are being attacked.** The launch of missiles or a bomber fleet can easily be seen from space far in advance of either reaching their potential targets halfway around the globe. The danger of surprise attack is therefore small, making an **accidental war** far less likely. So what does all this mean? And what do we do about it? First of all, it means that the advocates of space development, exploration and commercialization have succeeded far beyond their initial expectations and dreams. The economies and **security of countries** in the developed world **are now dependent on space satellites**. We space advocates should celebrate our success and be terrified of it at the same time. Should we lose these fragile assets in space, our economy would experience a disruption like no other: ship, air and train travel would stop and only restart/operate in a much-reduced capacity for years (GPS loss). Many banking and retail transactions would cease (VSAT loss). Distribution of news and vital national information would be crippled (communications satellite loss). **Lives would be put at risk** and the productivity of our farming would dramatically decrease (weather satellite loss). The risk of war, including **nuclear war, would increase** (loss of spy satellites) and our military's ability to react to crises would be significantly reduced (loss of military logistics and intelligence gathering satellites).

Ozone Impact

Proliferated constellations massively increase both the scope and scale of space launches. Hallex and Cottom 20.

Matthew A. Hallex [Research Staff Member at Institute for Defense Analyses] and Travis S. Cottom [writer about Political Science & Defense]. "Proliferated Commercial Satellite Constellations Implications for National Security". 2nd Quarter 2020. Forum. <https://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-97/jfq-97_20-29_Hallex-Cottom.pdf?ver=2020-03-31-130614-940>

Spillover Effects: Satellite Manufacturing and Space Launch The **emergence of proliferated constellations** is reshaping other areas of the commercial space world by **driving expansion of satellite manufacturing and space launch capacity**. The **large numbers of satellites** that comprise proliferated constellations **require satellites to be mass-produced quickly and less expensively**—a **shift from the usual** paradigm **of uniquely designed, exquisite, and expensive space systems**. To produce the hundreds of satellites that will make up the OneWeb constellation, Airbus has opened a production line in Toulouse, France, and is planning an additional high-capacity satellite manufacturing plant in Florida.19 In August 2018, Boeing agreed to acquire Millennium Space Systems, which is building a manufacturing center in California that will annually produce hundreds of small satellites.20 Similarly, in 2018, Planet opened a facility in San Francisco that can produce 40 small imagery satellites each week.21 The **deployment of proliferated constellations will continue to drive demand for space launch capacity**. Small satellites have traditionally been launched as rideshare or secondary payloads, but the **demand for these opportunities exceeds the rate of large payload launches**. Rideshare opportunities also bound a satellite to the orbit of the primary satellite, which may not be the optimal inclination or orbit for smaller satellites. The l**ack of rideshare availability is driving the small launch vehicle market**; companies such as Vector Launch, Rocket Lab, Firefly Aerospace, and Virgin Orbit are developing new vehicles to capture part of this demand. China also has an active small launch program with three operational small launch vehicles.22 Demand is not confined to small launch vehicles. **Larger launch vehicles will permit proliferated constellations to be rapidly deployed by manifesting dozens to hundreds of small satellites in a single launch**. For instance, in February 2017, Planet launched 88 Dove satellites on a single Indian Polar Satellite Launch Vehicle.23 The relatively short planned lifespan of proliferated constellation satellites will also result in a continuous demand for launch services to replace satellites as they end their service lives, potentially resulting in larger economies of scale that reduce the cost of all launches.

That causes emissions which destroy the ozone layer

Larson 16 (Erik J L Larson (PhD in Atmospheric and Oceanic Studies, Postdoctoral fellow in Organismic and Evolutionary Biology at Harvard, Research Scientists at University of Colorado Boulder), Robert W Portmann (Researchers from Chemical Sciences Division at NOAA), Karen H Rosenlof (NOAA research scientist), David W. Fahey (Director of the Chemical Science Division at NOAA), John S Daniel (Chemical Sciences Division NOAA), and Martin N Ross (The Aerospace Corporation). "Global atmospheric response to emissions from a proposed reusable space launch system" Earth's Future. Volume 5. Issue 1. November 16, 2016. Accessed August 12, 2019.)

1 Introduction

It is often assumed that H2-fueled rocket engines have no impact on the global atmosphere since the only significant emission is H2O. However, in great enough quantities the emissions from these rockets can alter the stratosphere in many ways. H2O emissions can change stratospheric temperatures and alter the photochemistry controlling ozone (O3). Furthermore, rockets burning liquid H2 and oxygen (O2) use an H2-rich mixture rather than a stoichiometric ratio for enhanced thrust and emit H2 and HOX in the plume in addition to H2O. Enhancements in HOX can catalytically destroy O3

[Crutzen, 1969]. Superheated air in the engine and exhaust plume result in the production of NOx, which also catalytically destroys O_3 [Johnston, 1971; Ross et al., 2009; Lee et al., 2010]. NOx is also created in the mesosphere due to the heat produced during rocket reentry [Park, 1976]. Here we use the Whole Atmosphere Community Climate Model (WACCM) [Marsh et al., 2013] and the 2D National Oceanic and Atmospheric Administration/National Center for Atmospheric Research (NOCAR) model [Portmann and Solomon, 2007] to evaluate the potential effects of high Skylon launch rates on the climate and stratospheric O_3.

2 Calculating Emissions

Vertical profiles of NOX, H_2, and H_2O emitted during a Skylon rocket launch and reentry are estimated based on trajectory data from Reaction Engines Ltd. [http://www.reactionengines.co.uk/tech_docs.html]. Skylon rockets have two combustion phases as they ascend through the atmosphere. The first phase is air breathing from the surface to 28.5 km. During this phase the engines act as H_2 burning jet turbines, combusting H_2 with ambient air. The main exhaust is H_2O, which can be calculated directly from the amount of H_2 fuel consumed. During the second phase from 28 to 80 km the engines run in rocket mode, burning H_2 and liquid O_2. The H_2O produced in rocket mode is calculated from the mass of fuel used assuming a 6:1 mass ratio of oxygen to hydrogen; this assumption is made to be consistent with the fact that many rockets burn hydrogen-rich fuel for greater thrust (stoichiometric ratio for combustion is 8:1) [Colasurdo et al., 1998]. Although the excess H_2 likely oxidizes into H_2O in the plume due to high temperatures, H_2 emissions are also considered in our simulations as a bounding condition. The bounding cases assume either all or none of the excess H_2 is oxidized to H_2O in the plume. As discussed in the results, the intermediate combustion products HOX and H_2O_2 were tested with the NOCAR model and found not to be important contributors to O_3 destruction. Thus they are not included in WACCM simulations.

H_2 and H_2O emission profiles (kg/km/flight) are interpolated with 1-km vertical resolution (Figure 1a). The spike in emissions at 28 km is due to the spacecraft transition into rocket mode. The total amount of H_2O produced from a single flight is estimated to be 6 × 105 kg (assuming completely oxidized H_2) with about 4 × 105 kg emitted into the stratosphere (above 17 km). The projected 105 flights per year would deposit 4 × 1010 kg of H_2O in the stratosphere every year. To get a sense of how large a perturbation this represents, the yearly emissions are compared to the total amount of stratospheric water. Assuming a uniform mixing ratio of 4.5 parts per million by volume (ppmv) of H_2O above 100 hPa (17 km), there is 1.5 × 1012 kg of H_2O in the stratosphere. The projected 105 flights would emit approximately 3% of the current stratospheric H_2O burden every year. Assuming a constant flight frequency and a 3-year lifetime of the H_2O, when emitted above 100 hPa, this would increase globally averaged stratospheric H_2O by approximately 9%. The actual steady-state perturbation of H_2O due to these emissions in WACCM above 100 hPa is 10%; however, the local perturbation would be much larger and increase with height.

Estimating a NOX emission profile for the Skylon vehicle is problematic. Several flight phases must be considered: H_2 burned with air as a jet fuel, H_2 burned with liquid oxygen as a rocket fuel, and heating of air due to aerodynamic interactions. It is important to note that we consider the shock heating of air during reentry as an emission. When air is heated to temperatures exceeding 1800 K, as in a jet engine or behind the shock wave around a spacecraft during reentry, NOX is produced through the extended Zeldovich mechanism [Zeldovich et al., 1947]. This mechanism is exponentially dependent on temperature so that representative temperatures are required in order to calculate the thermally produced NOX. Detailed estimates of the NOX emissions have not yet been calculated by the rocket designers [R. Varvill, 2015, personal communication]. For this study, reliable estimates of NOX emissions from jet and rocket engines are scaled to the Skylon vehicle with the caveat that our estimates have high uncertainty. Lee et al. [2010], using the International Civil Aviation Organization (ICAO) emissions databank, estimated that 14 ± 3 g of NOX are produced for every kilogram of fuel combusted in jet engines. Emissions may be lower at supersonic speeds and are also a function of the temperature difference between high pressure (~100 atmospheres) liquid H_2 and jet fuel. Most of the engines in the ICAO databank use jet fuel with a 2:1 H:C ratio. The higher fuel density must be taken into consideration in the NOX estimates from H_2 combustion. For complete combustion in the jet engine air-burning phase, two hydrogen and one carbon atoms (14 g/mol) react with three oxygen atoms. For a pure H_2 fuel at complete combustion, three oxygen atoms will oxidize six hydrogen atoms (6 g/mol). Thus, from a stoichiometric perspective, burning 1 kg of jet fuel requires as much air as 6/14 kg of H_2 fuel. Thus 6/14 kg of H_2 fuel is assumed here to produce 14 g (11–17) of NOX during the air-burning phase. Alternatively, using the heat of combustion per fuel mass to scale the NOX production gives consistent results that are within the uncertainty range. The total production of NOX during the air-burning Skylon ascent is estimated to be 1400 ± 300 kg, although we acknowledge this range does not encompass all the uncertainties in the assumptions.

Zero NOX emission is assumed during the liquid oxygen burning phase of ascent. NOX would only be produced in H_2-fueled rocket engines in significant amounts (>0.01% of total flow) in afterburning reactions, which occur when ambient air is entrained into the hot underoxidized

plume [Brady et al., 1997]. Afterburning is generally not a significant factor for rocket engines above the tropopause. Therefore it is assumed that during this phase of flight, at altitudes greater than 28 km, significant NOX production is unlikely.

Finally, NOX is also produced in the shock wave during spacecraft reentry. Using analytic approximations and a numerical integration, Park [1976] calculated that the NOX produced during a Space Shuttle reentry is 4.5–9% of the mass of the spacecraft. Park and Rakich [1980] later updated this value to 17.5 ± 5.3% of the spacecraft mass, with a peak emission at 68 km. While the predicted Skylon mass is comparable to the Space Shuttle mass, the Skylon reentry flight path is different from that of the Shuttle, and this would affect NOX production. Skylon is expected to require more time above 5 km/s during reentry than the Shuttle did, which would tend to produce more NOX. However, these high speeds would occur at a higher altitude than for the Space Shuttle, which would tend to decrease NOX production [Park, 1976]. Given the compensating factors, and in the absence of actual flight data, Skylon is assumed to have the same vertical profile of reentry NOX emission as the Space Shuttle, with the total values scaled by vehicle mass. The estimated total amount of NOX produced during reentry is therefore 9880 ± 2760 kg per flight. This range does not encompass the uncertainty in all the assumptions made, and thus the stated value of NOX production is considered only representative. The estimated altitude profiles of NOX emissions from the ascent and reentry phases are shown in Figure 1b.

Park [1976] compared NOX formation between the Space Shuttle and meteorites based on the total mass entering the top of the atmosphere. Assuming the natural formation rate of upper atmospheric NOX is from 5.7 × 107 kg of meteorites producing their weight in NOX every year [Park, 1976], then 105 Skylon flight reentries would produce a factor of 20 more NOX than natural production from meteorites. Meteorites produce roughly 5× more NOX per mass than the Space Shuttle due to their much higher velocity when entering the atmosphere.

3 Model Descriptions

Table 1 summarizes the simulations that are run and includes the rocket emissions considered in each case. The Community Earth System Model (CESM v1.0.6) using the WACCM model [Marsh et al., 2013] is used to simulate these emissions. WACCM was chosen because the model domain extends higher than most climate models (140 km) and it can include interactive chemistry. Simulations are run with fixed sea surface temperatures and perpetual year 2000 anthropogenic emissions and CO2 concentrations at 1.9 × 2.5° resolution with 66 vertical levels using a hybrid sigma coordinate system. Cases with different emissions and flight frequency are compared to a zero-emission control case. Vertical emission profiles of H2O, H2, and NOX are included into two model horizontal grid cells spanning the equator. An equatorial launch is assumed because the energy required to put a rocket into orbit increases with launch latitude. Sensitivity tests are also run with the NOCAR model as these tests would be computationally expensive using WACCM. The NOCAR model is used to evaluate the sensitivity of our results to launch location, chlorine and greenhouse gas concentrations, emissions products, and number of launches per year. Including emissions into global model grid cells effectively dilutes the concentration of emissions compared to an actual rocket plume. The size of the equatorial grid cells is roughly 200 × 250 km2, which is about 1000 times larger in area than a rocket plume. The concentrations used in the model are thus 1000 times less than exist in the initial rocket plumes. Another assumption is that the emissions fill the grid cell before any chemical changes take place. Studies such as Lohn et al. [1999] and Ross et al. [1997] have looked into O3 depletion and other atmospheric effects inside rocket plumes. Lohn et al. [1999] found that solid rocket motor exhaust plumes from Titan class rockets destroy all of the O3 in the wake of the rocket. These predictions were verified by in situ plume measurements [Ross et al., 1997]. The ozone-depleted regions are several square kilometers in size and last about an hour before dissipating to background concentrations. It is expected that plume chemistry will affect the composition and abundance of the rocket emissions that exist at the grid scale after the plume disperses. However, for the Skylon emissions, the amount of excess H2 emitted during rocket mode that is oxidized in the plume versus the amount present at the grid scale is unknown. Thus, the limiting cases are explored, one in which all the excess H2 is immediately oxidized (simulation 4) and one in which it all persists to the grid scale (simulation 5). The sensitivity of two of our assumptions are tested with the NOCAR model; specifically that H2O and H2 are the only relevant HOY species emitted, and secondly, that year 2000 greenhouse gas and chlorine levels are appropriate choices for this study. Some hydrogen will be emitted as HOY species, although it is likely to be very small. Swain et al. [1990] measured H2O2 in hydrogen burning engine exhaust and found it to be undetectable under normal operating conditions and up to 1000 ppmv under extremely inefficient conditions when the fuel to air ratio was around 5. Despite this, we simulate some of the hydrogen emitted as HOX or H2O2 using the NOCAR model. Note that due to the family chemistry scheme in NOCAR, we cannot emit OH directly, but instead emitted an equivalent quantity as HOX, which should produce the same amount of ozone destruction. The H2O2 can be emitted directly because it is long lived. Table 2 displays the global mean total column ozone changes relative to simulation 7 (Table 1) with and without these emissions. Including these emissions, even at relatively high amounts (1% mole fraction), results in essentially no change in O3 loss. The global mean total column ozone loss in these simulations is within 0.05 Dobson Units (DU) of the base case (simulation 7). Thus, these species (OH and H2O2) are not important to include in the WACCM simulations. The WACCM simulations assume year 2000 conditions; however, we note that flights of the Skylon space plane, especially at rates assumed in this paper, are decades away at best. Future levels of greenhouse gases and chlorine are estimated to be much higher and lower, respectively, than in the year 2000 [IPCC, 2013]. Thus, we also test the sensitivity of ozone loss on greenhouse gas and chlorine levels with the NOCAR model. These results are shown in Table 3. Using year 2100 chlorine levels increases the global total column ozone loss by 6% compared to simulation 7. Under a lower chlorine concentration, NOX increases destroy more ozone due to reduced formation of chlorine nitrate. However, water vapor increases induce less ozone destruction from polar stratospheric cloud (PSC) increases due to decreased chlorine. The net effect is increased ozone losses from rocket emissions. Increasing greenhouse gas levels to year 2100 offsets some of this extra loss and the sign of the final change depends on the relative amounts of the three greenhouse gases in the scenario. CO2 increases cause the rocket-induced change to increase, while CH4 and N2O increases cause it to decrease. However, the changes are relatively small in all cases using the NOCAR model and we consider our WACCM simulations using year 2000 values as representative of any time between now and year 2100.

4 Stratospheric Ozone and Temperature Perturbations

Our base case scenario for 105 flights per year is simulation 7 in Table 1, which includes NOX, H2, and H2O emissions. The components of the emissions are modeled separately in simulations 1–6 to better understand the changes to O3. Plots of the O3 change due to the individual emission components can be found in the supplement. Preliminary WACCM simulations using a different emissions profile than Figure 1 and 104 flights per year did not produce any statistically significant global changes to the atmosphere. At 105 flights per year, as seen in simulation 7, stratospheric NOX concentrations increase by 0.3–3 parts per billion (ppb) and stratospheric H2O increases by 0–3 ppm. At this and higher flight frequencies significant changes occur in the stratosphere as shown in Figure 2.

At 105 flights per year O3 decreases significantly at all latitudes at altitudes above about 25 km and above 20 km at the poles as seen in simulation 7 (Figure 2a). The overlaid hatching (Figure 2a) indicates statistical significance from two different tests. As seen in Table 1, this depletion in O3 is predominantly due to catalytic destruction by NOX [Crutzen, 1970]. Our simulations with just NOX emissions (simulation 1) had almost the same amount of ozone destruction as the simulation with NOX, H2O, and H2 (simulation 7), and much more than simulations without NOX (simulations 4 and 5). Both sources of NOX, air-breathing ascent and reentry, contribute to the destruction of O3 as seen in simulations 2 and 3. However, the models disagree about the relative contribution from these two emission sources. The NOCAR model attributes more O3 loss than WACCM does to NOX created in the mesosphere during reentry (simulation 2). In addition, including H2 emissions may further reduce total O3 compared to H2O emissions alone in WACCM simulations. Note that including H2 emissions does not exacerbate O3 loss in the NOCAR runs; in fact O3 loss is lessened between simulations 4 and 5. Moreover, assuming H2O emissions alone seems to lead to an increase in O3 in WACCM; however these results are within the range of internal variability.

Below this region of destruction by NOX is a global layer of O3 enhancement between 18 and 24 km (Figure 2a), which can be explained through smog chemistry. The air-breathing ascent emits NOX throughout the troposphere and in the lower stratosphere at the equator. NOX emissions in the troposphere produce O3 through smog chemistry [Liu et al., 1980], which can also occur in the lowermost stratosphere. In addition ozone increases can occur from the "self-healing" effect (i.e., increased O3 production from increased UV penetration due to O3 losses above). O3 increases in the tropical tropopause region are not seen in the simulation with only reentry NOX (see Figure S2, Supporting Information). There are other competing processes due to the H2O emissions that affect O3 as well. The emitted H2O radiatively cools the stratosphere by a degree or less below 45 km and 1–3° above (Figure 2c and 2d). Although Figure 2 includes NOX and H2 emissions, similar cooling is present in simulations only considering H2O emissions (see Figure S4). Lower temperatures cause chemical reaction rates between O and O3 to become slower, thereby suppressing O3 loss and causing a positive anomaly below 40 km. Above about 40 km, this effect is more than offset by increased depletion of O3 due to an enhanced HOX catalytic cycle [Crutzen, 1969; Lary, 1997]. This is roughly consistent with modeling efforts of Evans et al. [1998], who found that increased CO2 and H2O in the upper atmosphere lead to net O3 loss above 50 km and production below. They also see some net loss around the tropopause, again roughly consistent with WACCM and the NOCAR model simulation 4, which only assumes H2O emissions (see Figure S4). Similarly, Tian et al. [2009] found that an increase of 2 ppm of H2O in the stratosphere affected O3 both chemically and radiatively. They found that an increased HOX cycle destroys stratospheric O3, while the radiative cooling from increased H2O increases stratospheric O3. However, when cooling exceeds 5 K in their model, the total column O3 at high latitudes decreases rather than increases. Furthermore, Stenke and Grewe [2005] also found that increased stratospheric H2O in their model increased HOX chemistry and destroyed O3; however the enhancement in OH decreased the efficiency of O3 destruction by the NOX cycle. The global total column O3 abundance in simulation 7 decreases by 1.4–1.5 DU (Table 1), with the highest O3 destruction occurring in the Antarctic (Figure 3a), although destruction in the tropics contributes more to the globally averaged total column O3 loss due to the larger area of the tropics. The polar regions are highly variable in WACCM as indicated by the gray shading. The red line in Figure 3 indicates results from the NOCAR model. The NOCAR model has more O3 loss than WACCM at the poles; however, the latitudinal dependencies are similar. NOCAR has annually repeating planetary and gravity wave fluxes in the troposphere, which limits the interannual variability, and thus we do not add uncertainty ranges due to variability. Simulation 8 (Figure 3b) has 3× higher flight frequency than simulation 7 and roughly 3× more O3 loss at most latitudes. However, in the Arctic, simulation 7 (Figure 3a) shows no ozone loss on average, while simulation 8 (Figure 3b) shows 7 DU of ozone loss. This difference is likely a consequence of cooler stratospheric temperatures having a nonlinear effect on O3 destruction [Tian et al., 2009]. Tian et al. [2009] found that chemical and radiative effects of a 2 ppmv increase of H2O lead to net increases in total column O3 in the Arctic. However, when the radiative cooling exceeded 4 K, they found that the total column O3 decreased. This is consistent with our findings from WACCM. Simulation 7 (Figure 3a) has no net O3 loss in the Arctic, however, simulation 8 (Figure 3b), which has a higher flight frequency and cooler stratospheric temperatures (see Figure S7), has significant net loss. The seasonal cycle of O3 destruction in WACCM (Figure 4a) due to constant rocket emissions throughout the year is shown along with the globally averaged O3 anomaly (Figure 4b). The largest O3 depletion occurs in austral spring in the Antarctic. WACCM (Figure 4a) has slight positive O3 anomalies for much of the year in the northern mid latitudes, in the Arctic, and in the Antarctic summer that are not seen in the NOCAR model (see Figure S8). However, the NOCAR global mean total column O3 anomaly is within the uncertainty of the WACCM simulation in all seasons (Figure 4b). Ozone loss in the polar regions has large variability in WACCM simulations (Figure 4c) which leads to the large uncertainty ranges near the poles, as seen in Figure 3.

The relationship between O3 column depletion and rocket launch frequency is quasilinear. Emissions from 105 flights per year decrease O3 by 1.4–1.5 DU, 3 × 105 flights per year decrease O3 by 3.5–3.9 DU, and 1 × 106 flights per year decrease O3 by 11 DU. Results from the NOCAR model agree well with the WACCM results. The NOCAR model also indicates that moving the launch location to any latitude outside the tropics produces similar globally averaged column O3 anomalies, although the maximum anomaly tends to be at the pole in the hemisphere of emissions (not shown). Emissions near the equator have similar maxima at the two poles in the NOCAR model.

Ozone depletion causes extinction – empirics

Martin 18 (a Science Reporter for Express.co.uk, Sean, "Ozone layer DECAYING as scientists fear Earth 'heading towards MASS-EXTINCTION'", via Express, Feb 8, https://www.express.co.uk/news/science/916405/ozone-layer-destroyed-recovering-mass-extinction-dinosaurs)

News in January broke that the ozone was on its way to recovering as Earth cuts down on CO2 emissions. However, on closer inspection, scientists now say the ozone layer – the part of the atmosphere which protects us from harmful radiation – is continuing to deplete over major cities, and is only really recovering over Antarctica. Chemicals known as CFCs, which are found in aerosols for example, have been destroying the ozone layer since the 1970s. The Montreal Protocol was agreed in 1987 to phase out CFCs, but researchers say it may be too late.Study co-author Professor Joanna Haigh, co-director of the Grantham Institute for Climate Change and the Environment at Imperial College London, said of the study published in Atmospheric Chemistry and Physics: "Ozone has been seriously declining globally since the 1980s, but while the banning of CFCs is leading to a recovery at the poles, the same does not appear to be true for the lower latitudes. "The potential for harm in lower latitudes may actually be worse than at the poles. "The decreases in ozone are less than we saw at the poles before the Montreal Protocol was enacted, but UV radiation is more intense in these regions and more people live there." In a separate study, researchers have found a thinning ozone layer could have led to a mass extinction 252 million years ago – meaning a depletion of the protective layer of the atmosphere could be more catastrophic than previously thought. During the Permian-Triassic extinction, 75 percent of land animals and 95 percent of marine life died. At the same time, there was a massive volcanic event occurring in a region known as the Siberian Traps. Scientists state the huge eruption, which lasted for a staggering one million years, virtually destroyed the ozone layer which allowed more UV radiation to pierce Earth. Graduate student Jeffrey Benca of the University of California, Berkeley, said of his research published in Science Advances: "During the end-Permian crisis, the forests may have disappeared in part or fully because of increased UV exposure. "With pulses of volcanic eruptions happening, we would expect pulsed ozone shield weakening, which may have led to forest declines previously observed in the fossil record. "If you disrupt some of the dominant plant lineages globally repeatedly, you could trigger trophic cascades by destabilising the food web base, which doesn't work out very well for land animals." As the ozone layer continues to be destroyed in modern times, scientists warn another catastrophic mass extinction could be on the cards. Co-author Cindy Looy of the Science Advances study said: "Palaeontologists have come up with various kill scenarios for mass extinctions, but plant life may not be affected by dying suddenly as much as through interrupting one part of the life cycle, such as reproduction, over a long period of time, causing the population to dwindle and potentially disappear."

Likely. Hallex and Cottom 20.

Matthew A. Hallex [Research Staff Member at Institute for Defense Analyses] and Travis S. Cottom [writer about Political Science & Defense]. "Proliferated Commercial Satellite Constellations Implications for National Security". 2nd Quarter 2020. Forum. <https://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-97/jfq-97_20-29_Hallex-Cottom.pdf?ver=2020-03-31-130614-940>

The OneWeb satellite constellation alone would increase the number of operational satellites by almost 50 percent compared to today, and the SpaceX constellation would triple the number of operational satellites compared to today.25 The **addition of hundreds or thousands of**

proliferated constellation satellites would increase congestion, stress existing U.S. space situational awareness (SSA) **and space traffic management capabilities, and could create a more dangerous debris environment**. **More satellites and associated debris would threaten orbital safety** and, at the very least, **increase the number of conjunction warnings**—notices of possible collisions between satellites and other objects in space—that the Combined Space Operations Center issues, distracting it from its national security mission. Proliferated constellation operators intend to address the risk of debris from their satellites by ensuring that they are disposed of through atmospheric re-entry at the end of their operating lives. A recent study by the National Aeronautics and Space Administration's Orbital Debris Program Office suggests that **a 99 percent end-of-life disposal rate may be necessary to maintain a sustainable orbital environment**.26 The **disposal level for LEO satellites, however, has not reached 20 percent in any of the last 25 years**.27 Unless proliferated constellations become far more reliable, they could pose a longterm threat to the ability of the United States and other space actors to operate safely in space. While potentially threatening the sustainability of safe orbital operations, new proliferated constellations also offer opportunities for the United States to increase the resilience of its national security space architectures. Increasing the resilience of U.S. national security space architectures has strategic implications beyond the space domain. **Adversaries such as China and Russia see U.S. dependence on space as a key vulnerability to exploit during a conflict**.