### FW

#### I negate resolved

#### I value morality because a more desirable world is one that is more moral.

#### All people share an intrinsic value that comes from our humanity—each person has inalienable, equal human worth. Regardless of race, nationality, sexual orientation, or gender, each person is born with equal rights and opportunities. There is no reason to think one person should innately be granted more privileges than another.

#### Fixation on the motives of duty doesn’t make sense for governments. They must work with averages and aggregates meaning they have to use util.

Robert E. **Goodin 95** [professor of government at the University of Essex, and professor of philosophy and social and political theory at Australian National University], “Utilitarianism as a Public Philosophy”, Cambridge Studies in Philosophy and Public Policy, May 1995, BE

The great advantage of utilitarianism as a guide to public conduct is that it avoids gratuitous sacrifices, it ensures as best we are able to ensure in the uncertain world of public policy-making that policies are sensitive to people’s interests or desires or preferences. The great failing of more deontological theories, applied to those realms, is that they fixate upon duties done for the sake of duty rather than for the sake of any good that is done by doing one's duty. Perhaps it is per- missible (perhaps it is even proper) for private individuals in the course of their personal affairs to fetishize duties done for their own sake. It would be a mistake for public officials to do likewise, not least because it is impossible. The fixation on motives makes absolutely no sense in the public realm, and might make precious little sense in the private one even, as Chapter 3 shows. The reason public action is required at all arises from the inability of uncoordinated individual action to achieve certain morally desir- able ends. Individuals are rightly excused from pursuing those ends. The inability is real; the excuses, perfectly valid. But libertarians are right in their diagnosis, wrong in their prescription. That is the mes- sage of Chapter 2. The same thing that makes those excuses valid at the individual level - the same thing that relieves individuals of re- sponsibility - makes it morally incumbent upon individuals to organ- ize themselves into collective units that are capable of acting where they as isolated individuals are not. When they organize themselves into these collective units, those collective deliberations inevitably take place under very different cir- cumstances, and their conclusions inevitably take very different forms. Individuals are morally required to operate in that collective manner, in certain crucial respects. But they are practically circumscribed in how they can operate, in their collective mode. And those special con- straints characterizing the public sphere of decision-making give rise to the special circumstances that make utilitarianism peculiarly apt for public policy-making, in ways set out more fully in Chapter 4. Gov- ernment house utilitarianism thus understood is, I would argue, a uniquely defensible public philosophy.”

#### States not focusing on the consequences of their actions is merely avoiding responsibility.

David **Enoch 7** [The Faculty of Law, The Hebrew University, Mount Scopus Campus, Jerusalem], “INTENDING, FORESEEING, AND THE STATE,” Legal Theory, 13 (2007), 69–99, pg. 90-1, beckert

The general difficulty of the intending-foreseeing distinction here stemmed, you will recall, from the feeling that attempting to pick and choose among the foreseen consequences of one’s actions those one is more and those one is less responsible for looks more like the preparation of a defense than like a genuine attempt to determine what is to be done. Hiding behind the intending-foreseeing distinction seems like an attempt to evade responsibility, and so thinking about the distinction in terms of responsibility serves to reduce even further the plausibility of attributing to it intrinsic moral significance. This consideration—however weighty in general—seems to me very weighty when applied to state action and to the decisions of state officials. For perhaps it may be argued that individuals are not required to undertake a global perspective, one that equally takes into account all foreseen con- sequences of their actions. Perhaps, in other words, individuals are entitled to (roughly) settle for having a good will, and beyond that let chips fall where they may. But this is precisely what stateswomen and statesmen—and certainly states—are not entitled to settle for.44 In making policy decisions, it is precisely the global (or at least statewide, or nationwide, or something of this sort) perspective that must be undertaken. Perhaps, for instance, an individual doctor is entitled to give her patient a scarce drug without think- ing about tomorrow’s patients (I say “perhaps” because I am genuinely not sure about this), but surely when a state committee tries to formulate rules for the allocation of scarce medical drugs and treatments, it cannot hide behind the intending-foreseeing distinction, arguing that if it allows45 the doctor to give the drug to today’s patient, the death of tomorrow’s patient is merely foreseen and not intended. When making a policy-decision, this is clearly unacceptable. Or think about it this way (I follow Daryl Levinson here):46 perhaps restric- tions on the responsibility of individuals are justified because individuals are autonomous, because much of the value in their lives comes from personal pursuits and relationships that are possible only if their responsibility for what goes on in the (more impersonal) world is restricted. But none of this is true of states and governments. They have no special relationships and pursuits, no personal interests, no autonomous lives to lead in anything like the sense in which these ideas are plausible when applied to individuals persons. So there is no reason to restrict the responsibility of states in anything like the way the responsibility of individuals is arguably restricted.47 States and state officials have much more comprehensive responsibilities than individuals do. Hiding behind the intending-foreseeing distinction thus more clearly constitutes an evasion of responsibility in the case of the former. So the evading-responsibility worry has much more force against the intending-foreseeing distinction when applied to state action than elsewhere.

#### Therefore, the value criterion is maximizing expected well-being.

### Contention 1: Innovation

#### Private Sector space development leads to innovation that spills over into other areas.

**Hampson 17**, Joshua. [Security Studies Fellow at The Niskanen Center] “The Future of Space Commercialization.” *Niskansen Center*, 25 Jan. 2017, <https://republicans-science.house.gov/sites/republicans.science.house.gov/files/documents/TheFutureofSpaceCommercializationFinal.pdf>. [GHS-AA]

Innovation is generally hard to predict; some new technologies seem to come out of nowhere and others only take off when paired with a new application. It is difficult to predict the future, but it is reasonable to expect that a growing space economy would open opportunities for technological and organizational innovation. In terms of technology, the difficult environment of outer space helps incentivize progress along the margins. Because each object launched into orbit costs a significant amount of money—at the moment between $27,000 and $43,000 per pound, though that will likely drop in the future —each 19 reduction in payload size saves money or means more can be launched. At the same time, the ability to fit more capability into a smaller satellite opens outer space to actors that previously were priced out of the market. This is one of the reasons why small, affordable satellites are increasingly pursued by companies or organizations that cannot afford to launch larger traditional satellites. These small 20 satellites also provide non-traditional launchers, such as engineering students or prototypers, the opportunity to learn about satellite production and test new technologies before working on a full-sized satellite. That expansion of developers, experimenters, and testers cannot but help increase innovation opportunities. Technological developments from outer space have been applied to terrestrial life since the earliest days of space exploration. The National Aeronautics and Space Administration (NASA) maintains a website that lists technologies that have spun off from such research projects. Lightweight 21 nanotubes, useful in protecting astronauts during space exploration, are now being tested for applications in emergency response gear and electrical insulation. The need for certainty about the resiliency of materials used in space led to the development of an analytics tool useful across a range of industries. Temper foam, the material used in memory-foam pillows, was developed for NASA for seat covers. As more companies pursue their own space goals, more innovations will likely come from the commercial sector. Outer space is not just a catalyst for technological development. Satellite constellations and their unique line-of-sight vantage point can provide new perspectives to old industries. Deploying satellites into low-Earth orbit, as Facebook wants to do, can connect large, previously-unreached swathes of 22 humanity to the Internet. Remote sensing technology could change how whole industries operate, such as crop monitoring, herd management, crisis response, and land evaluation, among others. 23 While satellites cannot provide all essential information for some of these industries, they can fill in some useful gaps and work as part of a wider system of tools. Space infrastructure, in helping to change how people connect and perceive Earth, could help spark innovations on the ground as well. These innovations, changes to global networks, and new opportunities could lead to wider economic growth.

#### The private sector is key, because their incentivized by the need to make their products more marketable and beat their competition

**Castle 21**, Scott. [Scott Castle is an analytics infusion pioneer bringing over 25 years of software development, go to market strategy, product management and strategic partnership experience to his role as VP, Strategy at Sisense. Scott is passionate about turning data teams into superheroes that find unexpected insights in big data and disrupt traditional BI. Previously, Scott held technology positions at companies including Adobe, Electric Cloud and FileNet. Scott holds computer science degrees from the University of Massachusetts Amherst and UC Irvine.] “The New Space Race: A Breeding Ground for Great Innovation?” *AINews*, 22 Sept. 2021, <https://artificialintelligence-news.com/2021/09/22/the-new-space-race-breeding-ground-for-great-innovation/>. [GHS-AA]

The new space race is grabbing headlines and driving public interest in the potential of ‘extraterrestrial’ exploration. For tech innovators, it opens the doors to a world of exciting new possibilities. It has brought in a fast-moving, ‘Silicon Valley’ type innovative paradigm to a sector that was previously the government’s domain. Closer to home, the UK is about to get back into the space arena with UK Transport Secretary Grant Shapps announcing in May this year that rockets will be able to launch from the UK in 2022, with spaceports planned in Cornwall, Scotland and Wales. There are some big takeaways for product innovators and business leaders in this – pardon the pun – space. Investments galore! The advent of SpaceX, Blue Origin, and Virgin Galactic have generated a highly entrepreneurial, private sector-led new space technology ecosystem, with startups offering services and applications that are highly innovative and customer-focused. Morgan Stanley, which predicts the global space industry will generate revenue upwards of £730B in 2040, identifies this as a big investment opportunity for venture capital and private equity. In Q2 of 2021, new space exploration received an infusion of £3.3B, setting it on track to beat 2020’s total investment of £6.6B, reports Space Capital, a venture capital firm focused on the sector. The report estimates a total of £145B of equity investment across 1,533 companies in the new space ecosystem over the last decade. By factoring in the product innovations downstream that impact our daily life on Earth thanks to technology transfer, there is good reason for this optimism. Meanwhile, UK tech innovation continues to grow. In the Future UK Tech Built tech nation report 2021, UK tech VC investment is third in the world, hitting a record high of £10B in 2020 in the face of challenging conditions. UK deep tech investment also rose by 17% in 2020, the highest rate of growth globally. In the UK, the space industry is on an upward trajectory. Research findings from the latest ‘Size and Health of the UK Space Industry’ report, commissioned by the UK Space Agency shows the sector supports a highly skilled and productive workforce that’s growing across the country. The report shows in 2018/2019 income has risen from £14.8 billion to £16.4 billion, representing a growth of 5.7% (or 2.8% per annum) in real terms and employment is up by 3,200 from 41,900 to 45,100. In many ways, the new space ecosystem and its constellation of space tech startups and unicorns, ready to boldly go where no one has gone before, follow three of the ‘golden rules of product innovation’ in order to strive toward. Rule 1: Shoot for the moon and aim for radical changes SpaceX, Blue Origin, and Virgin Galactic have ushered in radical and disruptive innovation into the aerospace and space technology sector. SpaceX was listed as the top disrupter on the CNBC Disruptor 50 List in 2018, upending both aerospace leader Boeing and the rocket industry with its reusable rockets, becoming one of the most valuable companies in the world. Product leaders might typically be inclined to go for incremental innovation because it appears sustainable. However, your product could miss the mark, lose product/market fit, and eventually, customers if you don’t innovate quickly. During a crisis recovery period, this is of critical importance, reports McKinsey. Their recent survey of more than 200 executives revealed that over 85% think that the pandemic will have a lasting impact on customer needs over the next five years, but only 21% report they have the commitment and resources to face the challenge. By following agile, data-informed methods, product leaders can test and iterate while keeping management informed with a high-level road map. By moving fast, with analytics at speed and reduced time to insights, product leaders can innovate to stay ahead of the competition. Rule 2: Remove hurdles to allow space travel Virgin Galactic and Blue Origin have said they want to lower barriers to mass adoption of space travel. Space X has stated its single vision of reducing the cost to launch. While these sound like lofty aims, they follow the right questions and have an impact on technological progress on the ground. Cost of launch is the crucial barrier to product innovation in space technology, and reusable rockets pave the way for new space pioneers to experiment, test, iterate, and launch products and technology more frequently. Product leaders are equally focused on mass adoption of their products. A key “reduction of cost to launch” on that path is with the use of white-labelled embedded analytics. Think about how you can make it easier for your customers to interact with their data on your app. What if they could simply ask a question using plain language and have your app present analysed insights in a user-friendly format? That is now an attainable differentiator and value proposition for customers to keep returning to your product.

#### Innovation is key to solve climate change

**Atkinson 21**, Robert. [As founder and president of the Information Technology and Innovation Foundation (ITIF), recognized as the world’s top think tank for science and technology policy, Robert D. Atkinson leads a prolific team of policy analysts and fellows that is successfully shaping the debate and setting the agenda on a host of critical issues at the intersection of technological innovation and public policy. He is an internationally recognized scholar and a widely published author whom The New Republic has named one of the “three most important thinkers about innovation,” Washingtonian Magazine has called a “tech titan,” Government Technology Magazine has judged to be one of the 25 top “doers, dreamers and drivers of information technology,” and the Wharton Business School has given the “Wharton Infosys Business Transformation Award.”] “Growth Through Innovation Will Help Fight Climate Change.” *Information Technology & Innovation Foundation*, 11 Aug. 2021, <https://itif.org/publications/2021/08/11/growth-through-innovation-will-help-fight-climate-change>. [GHS-AA]

In the past decade a growing number of activists and pundits have argued that if we want to save the planet, particularly from global warming, the world can no longer afford growth. Many go further and call for degrowth: via shrinking the global gross domestic product (GDP). But, as Rob Atkinson explains in his column for The Korea Times, the notion of getting the poor to sacrifice to save the planet suffers from three main problems. First, few people are willing to consume less to save the planet, certainly not the 3 billion people who live on less than $2.50 per day. Second, even if the global GDP were cut in half―consigning billions of people to a much worse life―carbon emissions would be cut by only half at best, which is not enough to stop climate change. The only way to solve climate change is through cheap zero-carbon technologies, such as better batteries, cheaper renewables, carbon capture, nuclear power and more―all of which depend on technological progress, which in turn depends on investment in R&D, which depends on growth. In other words, growth powered by innovation is the solution to climate change, as it generates cleaner technologies and enables people with higher incomes to afford more expensive clean energy alternatives, such as electric cars or carbon capture systems. Third, when degrowth advocates claim that there are resource constraints to growth, they ignore innovation. If they point out that there are water shortages; I would counter that claim by saying that we have the oceans. Higher rates of growth, coupled with technological innovation, would enable widespread desalinization if it's needed. We are not running out of energy, and dirty energy can be produced if it is coupled with carbon capture and sequestration.

#### Solving warming is not all-or-nothing – every additional fraction of a degree is irreversible and costs millions of lives—prefer IPPC assessments that are the gold standard for warming consensus

David Wallace-Wells 19 [National Fellow at New America. He is deputy editor of New York Magazine, where he also writes frequently about climate and the near future of science and technology, including his widely read and debated 2017 cover story on worst-case scenarios for global warming], *The Uninhabitable Earth: A Story of the Future* (Kindle Edition: Allen Lane, 2019), pg. 8-30, beckert

* Every degree key – each bit 🡪 hundreds of millions of lives
* IPCC🡪best ev b/c conservative estimate + still really big impact
* Now key – not reversible, feedback loops 🡪 speeds up later

There is almost no chance we will avoid that scenario. The Kyoto Protocol achieved, practically, nothing; in the twenty years since, despite all of our climate advocacy and legislation and progress on green energy, we have produced more emissions than in the twenty years before. In 2016, the Paris accords established two degrees as a global goal, and, to read our newspapers, that level of warming remains something like the scariest scenario it is responsible to consider; just a few years later, with no single industrial nation on track to meet its Paris commitments, two degrees looks more like a best-case outcome, at present hard to credit, with an entire bell curve of more horrific possibilities extending beyond it and yet shrouded, delicately, from public view.28 For those telling stories about climate, such horrific possibilities—and the fact that we had squandered our chance of landing anywhere on the better half of that curve—had become somehow unseemly to consider. The reasons are almost too many to count, and so half-formed they might better be called impulses. We chose not to discuss a world warmed beyond two degrees out of decency, perhaps; or simple fear; or fear of fearmongering; or technocratic faith, which is really market faith; or deference to partisan debates or even partisan priorities; or skepticism about the environmental Left of the kind I’d always had; or disinterest in the fates of distant ecosystems like I’d also always had. We felt confusion about the science and its many technical terms and hard-to-parse numbers, or at least an intuition that others would be easily confused about the science and its many technical terms and hard-to-parse numbers. We suffered from slowness apprehending the speed of change, or semi-conspiratorial confidence in the responsibility of global elites and their institutions, or obeisance toward those elites and their institutions, whatever we thought of them. Perhaps we felt unable to really trust scarier projections because we’d only just heard about warming, we thought, and things couldn’t possibly have gotten that much worse just since the first Inconvenient Truth; or because we liked driving our cars and eating our beef and living as we did in every other way and didn’t want to think too hard about that; or because we felt so “postindustrial” we couldn’t believe we were still drawing material breaths from fossil fuel furnaces. Perhaps it was because we were so sociopathically good at collating bad news into a sickening evolving sense of what constituted “normal,” or because we looked outside and things seemed still okay. Because we were bored with writing, or reading, the same story again and again, because climate was so global and therefore nontribal it suggested only the corniest politics, because we didn’t yet appreciate how fully it would ravage our lives, and because, selfishly, we didn’t mind destroying the planet for others living elsewhere on it or those not yet born who would inherit it from us, outraged. Because we had too much faith in the teleological shape of history and the arrow of human progress to countenance the idea that the arc of history would bend toward anything but environmental justice, too. Because when we were being really honest with ourselves we already thought of the world as a zero-sum resource competition and believed that whatever happened we were probably going to continue to be the victors, relatively speaking anyway, advantages of class being what they are and our own luck in the natalist lottery being what it was. Perhaps we were too panicked about our own jobs and industries to fret about the future of jobs and industry; or perhaps we were also really afraid of robots or were too busy looking at our new phones; or perhaps, however easy we found the apocalypse reflex in our culture and the path of panic in our politics, we truly had a good-news bias when it came to the big picture; or, really, who knows why—there are so many aspects to the climate kaleidoscope that transforms our intuitions about environmental devastation into an uncanny complacency that it can be hard to pull the whole picture of climate distortion into focus. But we simply wouldn’t, or couldn’t, or anyway didn’t look squarely in the face ﻿of the science. This is not a book about the science of warming; it is about what warming means to the way we live on this planet. But what does that science say? It is complicated research, because it is built on two layers of uncertainty: what humans will do, mostly in terms of emitting greenhouse gases, and how the climate will respond, both through straightforward heating and a variety of more complicated, and sometimes contradictory, feedback loops. But even shaded by those uncertainty bars it is also very clear research, in fact terrifyingly clear. The United Nations’ Intergovernmental Panel on Climate Change (IPCC) offers the gold-standard assessments of the state of the planet and the likely trajectory for climate change—gold-standard, in part, because it is conservative, integrating only new research that passes the threshold of inarguability. A new report is expected in 2022, but the most recent one says that if we take action on emissions soon, instituting immediately all of the commitments made in the Paris accords but nowhere yet actually implemented, we are likely to get about 3.2 degrees of warming, or about three times as much warming as the planet has seen since the beginning of industrialization—bringing the unthinkable collapse of the planet’s ice sheets not just into the realm of the real but into the present.29, 30 That would eventually flood not just Miami and Dhaka but Shanghai and Hong Kong and a hundred other cities around the world.31 The tipping point for that collapse is said to be around two degrees; according to several recent studies, even a rapid cessation of carbon emissions could bring us that amount of warming by the end of the century.32 The assaults of climate change do not end at 2100 just because most modeling, by convention, sunsets at that point. This is why some studying global warming call the hundred years to follow the “century of hell.”33 Climate change is fast, much faster than it seems we have the capacity to recognize and acknowledge; but it is also long, almost longer than we can truly imagine. In reading about warming, you will often come across analogies from the planetary record: the last time the planet was this much warmer, the logic runs, sea levels were here. These conditions are not coincidences. The sea level was there largely because the planet was that much warmer, and the geologic record is the best model we have for understanding the very complicated climate system and gauging just how much damage will come from turning up the temperature by two or four or six degrees. Which is why it is especially concerning that recent research into the deep history of the planet suggests that our current climate models may be underestimating the amount of warming we are due for in 2100 by as much as half.34 In other words, temperatures could rise, ultimately, by as much as double what the IPCC predicts. Hit our Paris emissions targets and we may still get four degrees of warming, meaning a green Sahara and the planet’s tropical forests transformed into fire-dominated savanna.35 The authors of one recent paper suggested the warming could be more dramatic still—slashing our emissions could still bring us to four or five degrees Celsius, a scenario they said would pose severe risks to the habitability of the entire planet. “Hothouse Earth,” they called it.36 Because these numbers are so small, we tend to trivialize the differences between them—one, two, four, five. Human experience and memory offer no good analogy for how we should think of those thresholds, but, as with world wars or recurrences of cancer, you don’t want to see even one. At two degrees, the ice sheets will begin their collapse, 400 million more people will suffer from water scarcity, major cities in the equatorial band of the planet will become unlivable, and even in the northern latitudes heat waves will kill thousands each summer.37, 38 There would be thirty-two times as many extreme heat waves in India, and each would last five times as long, exposing ninety-three times more people.39 This is our best-case scenario. At three degrees, southern Europe would be in permanent drought, and the average drought in Central America would last nineteen months longer and in the Caribbean twenty-one months longer. In northern Africa, the figure is sixty months longer—five years. The areas burned each year by wildfires would double in the Mediterranean and sextuple, or more, in the United States. At four degrees, there would be eight million more cases of dengue fever each year in Latin America alone and close to annual global food crises.41 There could be 9 percent more heat-related deaths.40 Damages from river flooding would grow thirtyfold in Bangladesh, twentyfold in India, and as much as sixtyfold in the United Kingdom. In certain places, six climate-driven natural disasters could strike simultaneously, and, globally, damages could pass $600 trillion—more than twice the wealth as exists in the world today. Conflict and warfare could double. Even if we pull the planet up short of two degrees by 2100, we will be left with an atmosphere that contains 500 parts per million of carbon—perhaps more. The last time that was the case, sixteen million years ago, the planet was not two degrees warmer; it was somewhere between five and eight, giving the planet about 130 feet of sea-level rise, enough to draw a new American coastline as far west as I-95.42 Some of these processes take thousands of years to unfold, but they are also irreversible, and therefore effectively permanent. You might hope to simply reverse climate change; you can’t. It will outrun all of us. This is part of what makes climate change what the theorist Timothy Morton calls a “hyperobject”—a conceptual fact so large and complex that, like the internet, it can never be properly comprehended.43 There are many features of climate change—its size, its scope, its brutality—that, alone, satisfy this definition; together they might elevate it into a higher and more incomprehensible conceptual ﻿category yet. But time is perhaps the most mind-bending feature, the worst outcomes arriving so long from now that we reflexively discount their reality. Yet those outcomes promise to mock us and our own sense of the real in return. The ecological dramas we have unleashed through our land use and by burning fossil fuels—slowly for about a century and very rapidly for only a few decades—will play out over many millennia, in fact over a longer span of time than humans have even been around, performed in part by creatures and in environments we do not yet even know, ushered onto the world stage by the force of warming. And so, in a convenient cognitive bargain, we have chosen to consider climate change only as it will present itself this century. By 2100, the United Nations says, we are due for about 4.5 degrees of warming, following the path we are on today.44 That is, farther from the Paris track than the Paris track is from the two-degree threshold of catastrophe, which it more than doubles. As Naomi Oreskes has noted, there are far too many uncertainties in our models to take their predictions as gospel.45 Just running those models many times, as Gernot Wagner and Martin Weitzman do in their book Climate Shock, yields an 11 percent chance we overshoot six degrees.46 Recent work by the Nobel laureate William Nordhaus suggests that better-than-anticipated economic growth means better than one-in-three odds that our emissions will exceed the U.47N.’s worst-case “business as usual” scenario. In other words, a temperature rise of five degrees or possibly more. The upper end of the probability curve put forward by the U.N. to estimate the end-of-the-century, business-as-usual scenario—the worst-case outcome of a worst-case emissions path—puts us at eight degrees. At that temperature, humans at the equator and in the tropics would not be able to move around outside without dying.48 In that world, eight degrees warmer, direct heat effects would be the least of it: the oceans would eventually swell two hundred feet higher, flooding what are now two-thirds of the world’s major cities; hardly any land on the planet would be capable of efficiently producing any of the food we now eat; forests would be roiled by rolling storms of fire, and coasts would be punished by more and more intense hurricanes; the suffocating hood of tropical disease would reach northward to enclose parts of what we now call the Arctic; probably about a third of the planet would be made unlivable by direct heat; and what are today literally unprecedented and intolerable droughts and heat waves would be the quotidian condition of whatever human life was able to endure.49, 50, 51, 52 We will, almost certainly, avoid eight degrees of warming; in fact, several recent papers have suggested the climate is actually less sensitive to emissions than we’d thought, and that even the upper bound of a business-as-usual path would bring us to about five degrees, with a likely destination around four.53 But five degrees is nearly as unthinkable as eight, and four degrees not much better: the world in a permanent food deficit, the Alps as arid as the Atlas Mountains.54 Between that scenario and the world we live in now lies only the open question of human response. Some amount of further warming is already baked in, thanks to the protracted processes by which the planet adapts to greenhouse gas. But all of those paths projected from the present—to two degrees, to three, to four, five, or even eight—will be carved overwhelmingly by what we choose to do now. There is nothing stopping us from four degrees other than our own will to change course, which we have yet to display. Because the planet is as big as it is, and as ecologically diverse; because humans have proven themselves an adaptable species, and will likely continue to adapt to outmaneuver a lethal threat; and because the devastating effects of warming will soon become too extreme to ignore, or deny, if they haven’t already; because of all that, it is unlikely that climate change will render the planet truly uninhabitable. But if we do nothing about carbon emissions, if the next thirty years of industrial activity trace the same arc upward as the last thirty years have, whole regions will become unlivable by any standard we have today as soon as the end of this century. ﻿A few years ago, E. O. Wilson proposed a term, “Half-Earth,” to help us think through how we might adapt to the pressures of a changing climate, letting nature run its rehabilitative course on half the planet and sequestering humanity in the remaining, habitable half of the world.55 The fraction may be smaller than that, possibly considerably, and not by choice; the subtitle of his book was Our Planet’s Fight for Life. On longer timescales, the even-bleaker outcome is possible, too—the livable planet darkening as it approaches a human dusk. It would take a spectacular coincidence of bad choices and bad luck to make that kind of zero earth possible within our lifetime. But the fact that we have brought that nightmare eventuality into play at all is perhaps the overwhelming cultural and historical fact of the modern era—what historians of the future will likely study about us, and what we’d have hoped the generations before ours would have had the foresight to focus on, too. Whatever we do to stop warming, and however aggressively we act to protect ourselves from its ravages, we will have pulled the devastation of human life on Earth into view—close enough that we can see clearly what it would look like and know, with some degree of precision, how it will punish our children and grandchildren. Close enough, in fact, that we are already beginning to feel its effects ourselves, when we do not turn away. ﻿It is almost hard to believe just how much has happened and how quickly. In the late summer of 2017, three major hurricanes arose in the Atlantic at once, proceeding at first along the same route as though they were battalions of an army on the march.56 Hurricane Harvey, when it struck Houston, delivered such epic rainfall it was described in some areas as a “500,000-year event”—meaning that we should expect that amount of rain to hit that area once every five hundred millennia.57 Sophisticated consumers of environmental news have already learned how meaningless climate change has rendered such terms, which were meant to describe storms that had a 1-in-500,000 chance of striking in any given year. But the figures do help in this way: to remind us just how far global warming has already taken us from any natural-disaster benchmark our grandparents would have recognized. To dwell on the more common 500-year figure just for a moment, it would mean a storm that struck once during the entire history of the Roman Empire. Five hundred years ago, there were no English settlements across the Atlantic, so we are talking about a storm that should hit just once as Europeans arrived and established colonies, as colonists fought a revolution and Americans a civil war and two world wars, as their descendants established an empire of cotton on the backs of slaves, freed them, and then brutalized their descendants, industrialized and postindustrialized, triumphed in the Cold War, ushered in the “end of history,” and witnessed, just a decade later, its dramatic return. One storm in all that time, is what the meteorological record has taught us to expect. Just one. Harvey was the third such flood to hit Houston since 2015.58 And the storm struck, in places, with an intensity that was supposed to be a thousand times rarer still. That same season, an Atlantic hurricane hit Ireland, 45 million were flooded from their homes in South Asia, and unprecedented wildfires tilled much of California into ash.59, 60 And then there was the new category of quotidian nightmare, climate change inventing the once-unimaginable category of obscure natural disasters—crises so large they would once have been inscribed in folklore for centuries today passing across our horizons ignored, overlooked, or forgotten. In 2016, a “thousand-year flood” drowned small-town Ellicott City, Maryland, to take but one example almost at random; it was followed, two years later, in the same small town, by another.61 One week that summer of 2018, dozens of places all over the world were hit with record heat waves, from Denver to Burlington to Ottawa; from Glasgow to Shannon to Belfast; from Tbilisi, in Georgia, and Yerevan, in Armenia, to whole swaths of southern Russia.62 The previous month, the daytime temperature of one city in Oman reached above 121 degrees Fahrenheit, and did not drop below 108 all night, and in Quebec, Canada, fifty-four died from the heat.63 That same week, one hundred major wildfires burned in the American West, including one in California that grew 4,000 acres in one day, and another, in Colorado, that produced a volcano-like 300-foot eruption of flames, swallowing an entire subdivision and inventing a new term, “fire tsunami,” along the way.64, 65, 66 On the other side of the planet, biblical rains flooded Japan, where 1.2 million were evacuated from their homes.67 Later that summer, Typhoon Mangkhut forced the evacuation of 2.45 million from mainland China, the same week that Hurricane Florence struck the Carolinas, turning the port city of Wilmington briefly into an island and flooding large parts of the state with hog manure and coal ash.68, 69, 70 Along the way, the winds of Florence produced dozens of tornadoes across the region.71 The previous month, in India, the state of Kerala was hit with its worst floods in almost a hundred years.72 That October, a hurricane in the Pacific wiped Hawaii’s East Island entirely off the map.73 And in November, which has traditionally marked the beginning of the rainy season in California, the state was hit instead with the deadliest fire in its history—the Camp Fire, which scorched several hundred square miles outside of Chico, killing dozens and leaving many more missing in a place called, proverbially, Paradise.74 The devastation was so complete, you could almost forget the Woolsey Fire, closer to Los Angeles, which burned at the same time and forced the sudden evacuation of 170,000. It is tempting to look at these strings of disasters and think, Climate change is here. And one response to seeing things long predicted actually come to pass is to feel that we have settled into a new era, with everything transformed. In fact, that is how California governor Jerry Brown described the state of things in the midst of the state’s wildfire disaster: “a new normal.”75 The truth is actually much scarier. That is, the end of normal; never normal again. We have already exited the state of environmental conditions that allowed the human animal to evolve in the first place, in an unsure and unplanned bet on just what that animal can endure. The climate system that raised us, and raised everything we now know as human culture and civilization, is now, like a parent, dead. And the climate system we have been observing for the last several years, the one that has battered the planet again and again, is not our bleak future in preview. It would be more precise to say that it is a product of our recent climate past, already passing behind us into a dustbin of environmental nostalgia. There is no longer any such thing as a “natural disaster,” but not only will things get worse; technically speaking, they have already gotten worse. Even if, miraculously, humans immediately ceased emitting carbon, we’d still be due for some additional warming from just the stuff we’ve put into the air already. And of course, with global emissions still increasing, we’re very far from zeroing out on carbon, and therefore very far from stalling climate change. The devastation we are now seeing all around us is a beyond-best-case scenario for the future of warming and all the climate disasters it will bring. ﻿What that means is that we have not, at all, arrived at a new equilibrium. It is more like we’ve taken one step out on the plank off a pirate ship. Perhaps because of the exhausting false debate about whether climate change is “real,” too many of us have developed a misleading impression that its effects are binary. But global warming is not “yes” or “no,” nor is it “today’s weather forever” or “doomsday tomorrow.” It is a function that gets worse over time as long as we continue to produce greenhouse gas. And so the experience of life in a climate transformed by human activity is not just a matter of stepping from one stable ecosystem into another, somewhat worse one, no matter how degraded or destructive the transformed climate is. The effects will grow and build as the planet continues to warm: from 1 degree to 1.5 to almost certainly 2 degrees and beyond. The last few years of climate disasters may look like about as much as the planet can take. In fact, we are only just entering our brave new world, one that collapses below us as soon as we set foot on it. Many of these new disasters arrived accompanied by debate about their cause—about how much of what they have done to us comes from what we have done to the planet. For those hoping to better understand precisely how a monstrous hurricane arises out of a placid ocean, these inquiries are worthwhile, but for all practical purposes the debate yields no real meaning or insight. A particular hurricane may owe 40 percent of its force to anthropogenic global warming, the evolving models might suggest, and a particular drought may be half again as bad as it might have been in the seventeenth century. But climate change is not a discrete clue we can find at the scene of a local crime—one hurricane, one heat wave, one famine, one war. Global warming isn’t a perpetrator; it’s a conspiracy. We all live within climate and within all the changes we have produced in it, which enclose us all and everything we do. If hurricanes of a certain force are now five times as likely as in the pre-Columbian Caribbean, it is parsimonious to the point of triviality to argue over whether this one or that one was “climate-caused.” All hurricanes now unfold in the weather systems we have wrecked on their behalf, which is why there are more of them, and why they are stronger. The same is true for wildfires: this one or that one may be “caused” by a cookout or a downed power line, but each is burning faster, bigger, and longer because of global warming, which gives no reprieve to fire season. Climate change isn’t something happening here or there but everywhere, and all at once. And unless we choose to halt it, it will never stop. Over the past few decades, the term “Anthropocene” has climbed out of academic discourse and into the popular imagination—a name given to the geologic era we live in now, and a way to signal that it is a new era, defined on the wall chart of deep history by human intervention. One problem with the term is that it implies a conquest of nature, even echoing the biblical “dominion.” But however sanguine you might be about the proposition that we have already ravaged the natural world, which we surely have, it is another thing entirely to consider the possibility that we have only provoked it, engineering first in ignorance and then in denial a climate system that will now go to war with us for many centuries, perhaps until it destroys us. That is what Wally Broecker, the avuncular oceanographer, means when he calls the planet an “angry beast.”76 You could also go with “war machine.” Each day we arm it more. The assaults will not be discrete—this is another climate delusion. Instead, they will produce a new kind of cascading violence, waterfalls and avalanches of devastation, the planet pummeled again and again, with increasing intensity and in ways that build on each other and undermine our ability to respond, uprooting much of the landscape we have taken for granted, for centuries, as the stable foundation on which we walk, build homes and highways, shepherd our children through schools and into adulthood under the promise of safety—and subverting the promise that the world we have engineered and built for ourselves, out of nature, will also protect us against it, rather than conspiring with disaster against its makers. Consider those California wildfires. In March 2018, Santa Barbara County issued mandatory evacuation orders for those living in Montecito, Goleta, Santa Barbara, Summerland, and Carpinteria—where the previous December’s fires had hit hardest. It was the fourth evacuation order precipitated by a climate event in the county in just three months, but only the first had been for fire.77 The others were for mudslides ushered into possibility by that fire, one of the toniest communities in the most glamorous state of the world’s preeminently powerful country upended by fear that their toy vineyards and hobby stables, their world-class beaches and lavishly funded public schools, would be inundated by rivers of mud, the community as thoroughly ravaged as the sprawling camps of temporary shacks housing Rohingya refugees from Myanmar in the monsoon region of Bangladesh.78 It was. More than a dozen died, including a toddler swept away by mud and carried miles down the mountainslope to the sea; schools closed and highways flooded, foreclosing the routes of emergency vehicles and making the community an inland island, as if behind a blockade, choked off by a mud noose.79 Some climate cascades will unfold at the global level—cascades so large their effects will seem, by the curious legerdemain of environmental change, imperceptible. A warming planet leads to melting Arctic ice, which means less sunlight reflected back to the sun and more absorbed by a planet warming faster still, which means an ocean less able to absorb atmospheric carbon and so a planet warming faster still. A warming planet will also melt Arctic permafrost, which contains 1.8 trillion tons of carbon, more than twice as much as is currently suspended in the earth’s atmosphere, and some of which, when it thaws and is released, may evaporate as methane, which is thirty-four times as powerful a greenhouse-gas warming blanket as carbon dioxide when judged on the timescale of a century; when﻿ judged on the timescale of two decades, it is eighty-six times as powerful.80, 81 A hotter planet is, on net, bad for plant life, which means what is called “forest dieback”—the decline and retreat of jungle basins as big as countries and woods that sprawl for so many miles they used to contain whole folklores—which means a dramatic stripping-back of the planet’s natural ability to absorb carbon and turn it into oxygen, which means still hotter temperatures, which means more dieback, and so on. Higher temperatures means more forest fires means fewer trees means less carbon absorption, means more carbon in the atmosphere, means a hotter planet still—and so on. A warmer planet means more water vapor in the atmosphere, and, water vapor being a greenhouse gas, this brings higher temperatures still—and so on. Warmer oceans can absorb less heat, which means more stays in the air, and contain less oxygen, which is doom for phytoplankton—which does for the ocean what plants do on land, eating carbon and producing oxygen—which leaves us with more carbon, which heats the planet further. And so on. These are the systems climate scientists call “feedbacks”; there are more.82 Some work in the other direction, moderating climate change. But many more point toward an acceleration of warming, should we trigger them. And just how these complicated, countervailing systems will interact—what effects will be exaggerated and what undermined by feedbacks—is unknown, which pulls a dark cloud of uncertainty over any effort to plan ahead for the climate future. We know what a best-case outcome for climate change looks like, however unrealistic, because it quite closely resembles the world as we live on it today. But we have not yet begun to contemplate those cascades that may bring us to the infernal range of the bell curve. Other cascades are regional, collapsing on human communities and buckling them where they fall. These can be literal cascades—human-triggered avalanches are on the rise, with 50,000 people killed by avalanches globally between 2004 and 2016.83 In Switzerland, climate change has unleashed a whole new kind, thanks to what are called “rain-on-snow” events, which also caused the overflow of the Oroville Dam in Northern California and the 2013 flood of Alberta, Canada, with damages approaching $5 billion.84 But there are other kinds of cascade, too. Climate-driven water shortages or crop failures push climate refugees into nearby regions already struggling with resource scarcity. Sea-level rise inundates cropland with more and more saltwater flooding, transforming agricultural areas into brackish sponges no longer able to adequately feed those living off them; flooding power plants, knocking regions offline just as electricity may be needed most; and crippling chemical and nuclear plants, which, malfunctioning, breathe out their toxic plumes. The rains that followed the Camp Fire flooded the tent cities hastily assembled for the first disaster’s refugees. In the case of the Santa Barbara mudslides, drought produced a state full of dry brush ripe for a spark; then a year of anomalously monsoonish rain produced only more growth, and wildfires tore through the landscape, leaving a mountainside without much plant life to hold in place the millions of tons of loose earth that make up the towering coastal range where the clouds tend to gather and the rain first falls. Some of those watching from afar wondered, incredulously, how a mudslide could kill so many. The answer is, the same way as hurricanes or tornadoes—by weaponizing the environment, whether “man-made” or “natural.” Wind disasters do not kill by wind, however brutal it gets, but by tugging trees out of earth and transforming them into clubs, making power lines into loose whips and electrified nooses, collapsing homes on cowering residents, and turning cars into tumbling boulders. And they kill slowly, too, by cutting off food delivery and medical supplies, making roads impassable even to first responders, knocking out phone lines and cell towers so that the ill and elderly must suffer, and hope to endure, in silence and without aid. Most of the world is not Santa Barbara, with its Mission-style impasto of infinite-seeming wealth, and in the coming decades many of the most punishing climate horrors will indeed hit those least able to respond and recover. This is what is often called the problem of environmental justice; a sharper, less gauzy phrase would be “climate caste system.” The problem is acute within countries, even wealthy ones, where the poorest are those who live in the marshes, the swamps, the floodplains, the inadequately irrigated places with the most vulnerable infrastructure—altogether an unwitting environmental apartheid. Just in Texas, 500,000 poor Latinos live in shantytowns called “colonias” with no drainage systems to deal with increased flooding.85 The cleavage is even sharper globally, where the poorest countries will suffer more in our hot new world. In fact, with one exception—Australia—countries with lower GDPs will warm the most.86 That is notwithstanding the fact that much of the global south has not, to this point, defiled the atmosphere of the planet all that much. This is one of the many historical ironies of climate change that would better be called cruelties, so merciless is the suffering they will inflict. But disproportionately as it will fall on the world’s least, the devastation of global warming cannot be easily quarantined in the developing world, as much as those in the Northern Hemisphere would probably, and not to our credit, prefer it. Climate disaster is too indiscriminate for that. In fact, the belief that climate could be plausibly governed, or managed, by any institution or human instrument presently at hand is another wide-eyed climate delusion. The planet survived many millennia without anything approaching a world government, in fact endured nearly the entire span of human civilization that way, organized into competitive tribes and fiefdoms and kingdoms and nation-states, and only began to build something resembling a cooperative blueprint, very piecemeal, after brutal world wars—in the ﻿form of the League of Nations and United Nations and European Union and even the market fabric of globalization, whatever its flaws still a vision of cross-national participation, imbued with the neoliberal ethos that life on Earth was a positive-sum game. If you had to invent a threat grand enough, and global enough, to plausibly conjure into being a system of true international cooperation, climate change would be it—the threat everywhere, and overwhelming, and total. And yet now, just as the need for that kind of cooperation is paramount, indeed necessary for anything like the world we know to survive, we are only unbuilding those alliances—recoiling into nationalistic corners and retreating from collective responsibility and from each other. That collapse of trust is a cascade, too. ﻿Just how completely the world below our feet will become unknown to us is not yet clear, and how we register its transformation remains an open question. One legacy of the environmentalist creed that long prized the natural world as an otherworldly retreat is that we see its degradation as a sequestered story, unfolding separately from our own modern lives—so separately that the degradation acquires the comfortable contours of parable, like pages from Aesop, aestheticized even when we know the losses as tragedy. Climate change could soon mean that, in the fall, trees may simply turn brown, and so we will look differently at entire schools of painting, which stretched for generations, devoted to best capturing the oranges and reds we can no longer see ourselves out the windows of our cars as we drive along our highways.87 The coffee plants of Latin America will no longer produce fruit; beach homes will be built on higher and higher stilts and still be drowned.88 In many cases, it is better to use the present tense. In just the last forty years, according to the World Wildlife Fund, more than half of the world’s vertebrate animals have died; in just the last twenty-five, one study of German nature preserves found, the flying insect population declined by three-quarters.89, 90 The delicate dance of flowers and their pollinators has been disrupted, as have the migration patterns of cod, which have fled up the Eastern Seaboard toward the Arctic, evading the communities of fishermen that fed on them for centuries; as have the hibernation patterns of black bears, many of which now stay awake all winter.91, 92, 93 Species individuated over millions of years of evolution but forced together by climate change have begun to mate with one another for the first time, producing a whole new class of hybrid species: the pizzly bear, the coy-wolf.94 The zoos are already natural history museums, the children’s books already out of date. Older fables, too, will be remade: the story of Atlantis, having endured and enchanted for several millennia, will compete with the real-time sagas of the Marshall Islands and Miami Beach, each sinking over time into snorkelers’ paradises; the strange fantasy of Santa and his polar workshop will grow eerier still in an Arctic of ice-free summers; and there is a terrible poignancy in contemplating how desertification of the entire Mediterranean Basin will change our reading of the Odyssey, or how it will discolor the shine of Greek islands for dust from the Sahara to permanently blanket their skies, or how it will recast the meaning of the Pyramids for the Nile to be dramatically drained.95, 96, 97 We will think of the border with Mexico differently, presumably, when the Rio Grande is a line traced through a dry riverbed—the Rio Sand, it’s already been called.98 The imperious West has spent five centuries looking down its nose at the plight of those living within the pale of tropical disease, and one wonders how that will change when mosquitoes carrying malaria and dengue are flying through the streets of Copenhagen and Chicago, too. But we have for so long understood stories about nature as allegories that we seem unable to recognize that the meaning of climate change is not sequestered in parable. It encompasses us; in a very real way it governs us—our crop yields, our pandemics, our migration patterns and civil wars, crime waves and domestic assaults, hurricanes and heat waves and rain bombs and megadroughts, the shape of our economic growth and everything that flows downstream from it, which today means nearly everything. Eight hundred million in South Asia alone, the World Bank says, would see their living conditions sharply diminish by 2050 on the current emissions track, and perhaps a climate slowdown will even reveal the bounty of what Andreas Malm calls fossil capitalism to be an illusion, sustained over just a few centuries by the arithmetic of adding the energy value of burned fossil fuels to what had been, before wood and coal and oil, an eternal Malthusian trap.99, 100 In which case, we would have to retire the intuition that history will inevitably extract material progress from the planet, at least in any reliable or global pattern, and come to terms, somehow, with just how pervasively that intuition ruled even our inner lives, often tyrannically. Adaptation to climate change is often viewed in terms of market trade-offs, but in the coming decades the trade will work in the opposite direction, with relative prosperity a benefit of more aggressive action. Every degree of warming, it’s been estimated, costs a temperate country like the United States about one percentage point of GDP, and according to one recent paper, at 1.5 degrees the world would be $20 trillion richer than at 2 degrees.101, 102 Turn the dial up another degree or two, and the costs balloon—the compound interest of environmental catastrophe. 3.7 degrees of warming would produce $551 trillion in damages, research suggests; total worldwide wealth is today about $280 trillion.103, 104 Our current emissions trajectory takes us over 4 degrees by 2100; multiply that by that 1 percent of GDP and you have almost entirely wiped out the very possibility of economic growth, which has not topped 5 percent globally in over forty years.105 A fringe group of alarmed academics call this prospect “steady-state economics,” but it ultimately suggests a more ﻿complete retreat from economics as an orienting beacon, and from growth as the lingua franca through which modern life launders all of its aspirations.106 “Steady-state” also gives a name to the creeping panic that history may be less progressive, as we’ve come to believe really only over the last several centuries, than cyclical, as we were sure it was for the many millennia before. More than that: in the vision steady-state economics projects of a state-of-nature competitive scramble, everything from politics to trade and war seems brutally zero-sum. For centuries we have looked to nature as a mirror onto which to first project, then observe, ourselves. But what is the moral? There is nothing to learn from global warming, because we do not have the time, or the distance, to contemplate its lessons; we are after all not merely telling the story but living it. That is, trying to; the threat is immense. How immense? One 2018 paper sketches the math in horrifying detail. In the journal Nature Climate Change, a team led by Drew Shindell tried to quantify the suffering that would be avoided if warming was kept to 1.5 degrees, rather than 2 degrees—in other words, how much additional suffering would result from just that additional half-degree of warming. Their answer: 150 million more people would die from air pollution alone in a 2-degree warmer world than in a 1.1075-degree warmer one. Later that year, the IPCC raised the stakes further: in the gap between 1.1085 degrees and 2, it said, hundreds of millions of lives were at stake. Numbers that large can be hard to grasp, but 150 million is the equivalent of twenty-five Holocausts. It is three times the size of the death toll of the Great Leap Forward—the largest nonmilitary death toll humanity has ever produced. It is more than twice the greatest death toll of any kind, World War II. The numbers don’t begin to climb only when we hit 1.5 degrees, of course. As should not surprise you, they are already accumulating, at a rate of at least seven million deaths, from air pollution alone, each year—an annual Holocaust, pursued and prosecuted by what brand of nihilism? This is what is meant when climate change is called an “existential crisis”—a drama we are now haphazardly improvising between two hellish poles, in which our best-case outcome is death and suffering at the scale of twenty-five Holocausts, and the worst-case outcome puts us on the brink of extinction.109 Rhetoric often fails us on climate because the only factually appropriate language is of a kind we’ve been trained, by a buoyant culture of sunny-side-up optimism, to dismiss, categorically, as hyperbole. Here, the facts are hysterical, and the dimensions of the drama that will play out between those poles incomprehensibly large—large enough to enclose not just all of present-day humanity but all of our possible futures, as well. Global warming has improbably compressed into two generations the entire story of human civilization. First, the project of remaking the planet so that it is undeniably ours, a project whose exhaust, the poison of emissions, now casually works its way through millennia of ice so quickly you can see the melt with a naked eye, destroying the environmental conditions that have held stable and steadily governed for literally all of human history. That has been the work of a single generation. The second generation faces a very different task: the project of preserving our collective future, forestalling that devastation and engineering an alternate path. There is simply no analogy to draw on, outside of mythology and theology—and perhaps the Cold War prospect of mutually assured destruction. Few feel like gods in the face of warming, but that the totality of climate change should make us feel so passive—that is another of its delusions. In folklore and comic books and church pews and movie theaters, stories about the fate of the earth often perversely counsel passivity in their audiences, and perhaps it should not surprise us that the threat of climate change is no different. By the end of the Cold War, the prospect of nuclear winter had clouded every corner of our pop culture and psychology, a pervasive nightmare that the human experiment might be brought to an end by two jousting sets of proud, rivalrous tacticians, just a few sets of twitchy hands hovering over the planet’s self-destruct buttons. The threat of climate change is more dramatic still, and ultimately more democratic, with responsibility shared by each of us even as we shiver in fear of it; and yet we have processed that threat only in parts, typically not concretely or explicitly, displacing certain anxieties and inventing others, choosing to ignore the bleakest features of our possible future and letting our political fatalism and technological faith blur, as though we’d gone cross-eyed, into a remarkably familiar consumer fantasy: that someone else will fix the problem for us, at no cost. Those more panicked are often hardly less complacent, living instead through climate fatalism as though it were climate optimism. Over the last few years, as the planet’s own environmental rhythms have seemed to grow more fatalistic, skeptics have found themselves arguing not that climate change isn’t happening, since extreme weather has made that undeniable, but that its causes are unclear—suggesting that the changes we are seeing are the result of natural cycles rather than human activities and interventions. It is a very strange argument; if the planet is warming at a terrifying pace and on a horrifying scale, it should transparently concern us more, rather than less, that the warming is beyond our control, possibly even our comprehension. That we know global warming is our doing should be a comfort, not a cause for despair, however incomprehensively large and complicated we find the processes that have brought it into being; that we know we are, ourselves, responsible for all of its punishing effects ﻿should be empowering, and not just perversely. Global warming is, after all, a human invention. And the flip side of our real-time guilt is that we remain in command. No matter how out-of-control the climate system seems—with its roiling typhoons, unprecedented famines and heat waves, refugee crises and climate conflicts—we are all its authors. And still writing.

### Contention 2: Defense

#### Commercial space technology and satellite launches are key to US military power and primacy.

**Hampson 17**, Joshua. [Security Studies Fellow at The Niskanen Center] “The Future of Space Commercialization.” *Niskansen Center*, 25 Jan. 2017, <https://republicans-science.house.gov/sites/republicans.science.house.gov/files/documents/TheFutureofSpaceCommercializationFinal.pdf>. [GHS-AA]

Perhaps the most important legacy application of outer space for Americans is national security. The United States relies heavily on satellites for capabilities that make its global power projections and deterrence structures work. Satellites provide valuable real-time intelligence information, connect platforms and bases around the world, and provide the basis for highly accurate navigational systems on land, at sea, and in the air. It is not just that this space infrastructure is useful for American warfighters, but that it is essential. Elbridge Colby, a senior fellow at the Center for a New American Security (CNAS), wrote in his examination of recent changes to the space environment that space capabilities are “the stuff of which American global military primacy is made.” Military capabilities that the United States has 24 come to rely on, from remotely piloted drones to precision weaponry, all rely on satellites. To 25 manage this, The United States Space Command has 38,000 airmen based around the world working to secure access to national security space assets.26 It is not just the military that relies on satellites—the intelligence community does too. While the unclassified military space budget is around $10 billion on outer space a year, total national security 27 space spending may be over $25 billion annually. This reliance on outer space is not going to end any 28 time soon. At an event at the Center for Strategic and International Studies (CSIS) on October 24, 2016, Deputy Assistant Secretary of Defense for Space Policy Doug Loverro, spoke to the importance of leveraging space capabilities. Mr. Loverro highlighted that space is fundamental to everything the 29 United States does in conventional war, as well as nuclear deterrence, and disabused the notion that the country should pursue ways of fighting and projecting power without relying on outer space. Such an argument, he contends, is “not an attractive notion.” Going to war without space capabilities would put American soldiers at risk. Even so, managing the space environment is becoming more complex for the defense community. There is a growing perception that heavy reliance on satellites creates a soft spot in American defenses. America’s rivals have highlighted U.S. space capabilities as a possible vulnerability to 30 exploit. For some capabilities—particularly situational awareness, nuclear command and control, 31 and coordination among America’s widespread military and intelligence assets—satellites have become an almost “single point of failure.” This means that any one accident or disruption could 32 degrade or shut down a key tool. Concerns over this reliance have led to warnings of a “space Pearl Harbor” as defense analysts see American outer space assets as potentially ripe targets for 33 exploitation by international rivals.34 The United States is moving to mitigate some of these concerns by making more resilient and adding redundancy to the system. That way, if one satellite is damaged or degraded, the system as a whole still functions. The success or failure of these efforts may ultimately depend on commercial outer space. Building up U.S. space capabilities solely through government initiative could have both fiscal and operational problems—such a strategy would likely be expensive and spread unforeseen vulnerabilities across the entire American satellite fleet. Working with commercial companies for capabilities can reduce costs while providing strength through variation. Commercial satellites, for example, currently provide the military with 80 percent 35 of its satellite communications needs. Commercial providers also provide the vital launch services 36 that get the satellites into orbit. Today, these providers are the United Launch Alliance (ULA) and 37 Space Exploration Technologies (SpaceX). Without these companies, the United States government 38 would have to rebuild national launch capabilities. In the future, other commercial launch companies, such as Orbital ATK and Blue Origin, could also provide launch services for the military and 39 40 intelligence community. In short, **a more robust commercial space market is key to ensuring the resilience of American national security by assuring access to space.**

#### Military readiness and credible deterrence solves every threat---satellite and tech leadership sustain military overmatch, but decline emboldens rivals and causes miscalc and arms races that escalate.

Hal Brands 18. Henry A. Kissinger Distinguished Professor of Global Affairs at the Johns Hopkins University School of Advanced International Studies, Senior Fellow at the Center for Strategic and Budgetary Assessments and the Foreign Policy Research Institute, Ph.D. in history from Yale University. “Chapter 6: Does America Have Enough Hard Power?” American Grand Strategy in the Age of Trump; pp. 129-133.

Much contemporary commentary favors the first option—reducing commitments—and denounces the third as financially ruinous and perhaps impossible.5 Yet significantly expanding American capabilities would not be nearly as economically onerous as it may seem. Compared to the alternatives, in fact, this approach represents the best option for sustaining American primacy and preventing a slide into strategic bankruptcy that will eventually be punished. Since World War II, the United States has had a military second to none. Since the Cold War, America has committed to having overwhelming military primacy. The idea, as George W. Bush declared in 2002, that America must possess “strengths beyond challenge” has featured in every major U.S. strategy document for a quarter century; it has also been reflected in concrete terms.6 From the early 1990s, for example, the United States consistently accounted for around 35 to 45 percent of world defense spending and maintained peerless global power-projection capabilities.7 Perhaps more important, U.S. primacy was also unrivaled in key overseas strategic regions—Europe, East Asia, the Middle East. From thrashing Saddam Hussein’s million-man Iraqi military during Operation Desert Storm, to deploying—with impunity—two carrier strike groups off Taiwan during the China-Taiwan crisis of 1995– 96, Washington has been able to project military power superior to anything a regional rival could employ even on its own geopolitical doorstep. This military dominance has constituted the hard-power backbone of an ambitious global strategy. After the Cold War, U.S. policymakers committed to averting a return to the unstable multipolarity of earlier eras, and to perpetuating the more favorable unipolar order. They committed to building on the successes of the postwar era by further advancing liberal political values and an open international economy, and to suppressing international scourges such as rogue states, nuclear proliferation, and catastrophic terrorism. And because they recognized that military force remained the ultima ratio regum, they understood the centrality of military preponderance. Washington would need the military power necessary to underwrite worldwide alliance commitments. It would have to preserve substantial overmatch versus any potential great-power rival. It must be able to answer the sharpest challenges to the international system, such as Saddam’s invasion of Kuwait in 1990 or jihadist extremism after 9/11. Finally, because prevailing global norms generally reflect hard-power realities, America would need the superiority to assure that its own values remained ascendant. It was impolitic to say that U.S. strategy and the international order required “strengths beyond challenge,” but it was not at all inaccurate. American primacy, moreover, was eminently affordable. At the height of the Cold War, the United States spent over 12 percent of GDP on defense. Since the mid-1990s, the number has usually been between 3 and 4 percent.8 In a historically favorable international environment, Washington could enjoy primacy—and its geopolitical fruits—on the cheap. Yet U.S. strategy also heeded, at least until recently, the fact that there was a limit to how cheaply that primacy could be had. The American military did shrink significantly during the 1990s, but U.S. officials understood that if Washington cut back too far, its primacy would erode to a point where it ceased to deliver its geopolitical benefits. Alliances would lose credibility; the stability of key regions would be eroded; rivals would be emboldened; international crises would go unaddressed. American primacy was thus like a reasonably priced insurance policy. It required nontrivial expenditures, but protected against far costlier outcomes.9 Washington paid its insurance premiums for two decades after the Cold War. But more recently American primacy and strategic solvency have been imperiled. THE DARKENING HORIZON For most of the post–Cold War era, the international system was— by historical standards—remarkably benign. Dangers existed, and as the terrorist attacks of September 11, 2001, demonstrated, they could manifest with horrific effect. But for two decades after the Soviet collapse, the world was characterized by remarkably low levels of great-power competition, high levels of security in key theaters such as Europe and East Asia, and the comparative weakness of those “rogue” actors—Iran, Iraq, North Korea, al-Qaeda—who most aggressively challenged American power. During the 1990s, some observers even spoke of a “strategic pause,” the idea being that the end of the Cold War had afforded the United States a respite from normal levels of geopolitical danger and competition. Now, however, the strategic horizon is darkening, due to four factors. First, great-power military competition is back. The world’s two leading authoritarian powers—China and Russia—are seeking regional hegemony, contesting global norms such as nonaggression and freedom of navigation, and developing the military punch to underwrite these ambitions. Notwithstanding severe economic and demographic problems, Russia has conducted a major military modernization emphasizing nuclear weapons, high-end conventional capabilities, and rapid-deployment and special operations forces— and utilized many of these capabilities in conflicts in Ukraine and Syria.10 China, meanwhile, has carried out a buildup of historic proportions, with constant-dollar defense outlays rising from US$26 billion in 1995 to US$226 billion in 2016.11 Ominously, these expenditures have funded development of power-projection and antiaccess/area denial (A2/AD) tools necessary to threaten China’s neighbors and complicate U.S. intervention on their behalf. Washington has grown accustomed to having a generational military lead; Russian and Chinese modernization efforts are now creating a far more competitive environment. Second, the international outlaws are no longer so weak. North Korea’s conventional forces have atrophied, but it has amassed a growing nuclear arsenal and is developing an intercontinental delivery capability that will soon allow it to threaten not just America’s regional allies but also the continental United States.12 Iran remains a nuclear threshold state, one that continues to develop ballistic missiles and A2/AD capabilities while employing sectarian and proxy forces across the Middle East. The Islamic State, for its part, is headed for defeat, but has displayed military capabilities unprecedented for any terrorist group, and shown that counterterrorism will continue to place significant operational demands on U.S. forces whether in this context or in others. Rogue actors have long preoccupied American planners, but the rogues are now more capable than at any time in decades. Third, the democratization of technology has allowed more actors to contest American superiority in dangerous ways. The spread of antisatellite and cyberwarfare capabilities; the proliferation of man-portable air defense systems and ballistic missiles; the increasing availability of key elements of the precision-strike complex— these phenomena have had a military leveling effect by giving weaker actors capabilities which were formerly unique to technologically advanced states. As such technologies “proliferate worldwide,” Air Force Chief of Staff General David Goldfein commented in 2016, “the technology and capability gaps between America and our adversaries are closing dangerously fast.”13 Indeed, as these capabilities spread, fourth-generation systems (such as F-15s and F-16s) may provide decreasing utility against even non-great-power competitors, and far more fifth-generation capabilities may be needed to perpetuate American overmatch. Finally, the number of challenges has multiplied. During the 1990s and early 2000s, Washington faced rogue states and jihadist extremism—but not intense great-power rivalry. America faced conflicts in the Middle East—but East Asia and Europe were comparatively secure. Now, the old threats still exist—but the more permissive conditions have vanished. The United States confronts rogue states, lethal jihadist organizations, and great-power competition; there are severe challenges in all three Eurasian theaters. “I don’t recall a time when we have been confronted with a more diverse array of threats, whether it’s the nation state threats posed by Russia and China and particularly their substantial nuclear capabilities, or non-nation states of the likes of ISIL, Al Qaida, etc.,” Director of National Intelligence James Clapper commented in 2016. Trends in the strategic landscape constituted a veritable “litany of doom.”14 The United States thus faces not just more significant, but also more numerous, challenges to its military dominance than it has for at least a quarter century.

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#### 1] Even full-scale ASAT war can’t trigger Kessler – modelling

Drmola and Hubik 18 [Jakub Drmola, Division of Security and Strategic Studies, Department of Political Science at the Faculty of Social Sciences of Masaryk University. Tomas Hubik, Department of Theoretical Computer Science and Mathematical Logic, Faculty of Mathematics and Physics, Charles University. Kessler Syndrome: System Dynamics Model. Space Policy Volumes 44–45, August 2018, Pages 29-39. https://www.sciencedirect.com/science/article/pii/S0265964617300966?via%3Dihub]

The probabilities and rates of collisions of objects from different groups were calculated using a coefficient converting the rate of collisions between objects from one group to the rate of collisions between objects from another group. The initial base rate was estimated using iterative simulations and comparison of the resulting runs with real data and outputs from other models. Detailed model built by a group of researchers from the Lawrence Livermore National Laboratory was used as a base for the calibration [see 9]. As the major factor influencing collision probability is size, the probability increases with square of the diameter representing bigger area for possible impact. Speed would be another factor influencing the probability of impacts, but the speed depends on the distance from the Earth and is not influenced by debris size. It means that it will not vary between different debris groups and thus will not influence the collision probability conversion parameters in our model. One the most important limitations and simplifications of the model is the uncertainty of size, structure, and composition of the satellites—i.e. what debris the satellite will disintegrate into in case of a collision. Perhaps even more crucially, the rate of orbital decay changes significantly with the altitude and eccentricity of the trajectory. The lower the orbital altitude is or the more eccentric it is, the more drag the object experiences as it passes through the last vestiges of our atmosphere. Therefore, objects in the lower or more eccentric orbit will decay significantly faster. Thus, the actual lifetime of a piece of debris can easily vary from days to centuries. It also needs to be noted that while it may take many decades for a satellite to decay (especially from the popular orbits between 500 km and 800 km), we cannot assume the same about debris. That is because while satellite orbits typically have very low eccentricity, collisions result in fragments with velocities and trajectories that vary and differ from the original intact satellite (i.e. are more eccentric and decay faster). This makes estimating rate of orbital decay of debris quite difficult, especially when combined with the ongoing laudable efforts by Inter-Agency Space Debris Coordination Committee (IADC) to shorten the lifetime of satellites after they cease planned operations [14], [15]. Therefore, both the orbital and structural parameters used here are (and must be) overall averages designed to represent a “general LEO satellite” and are based on previous fragmentations, of which there are but few. Furthermore, this is getting increasingly more difficult as satellites are getting progressively more diverse, especially with the ongoing boom of the miniaturized CubeSats [16]. This leads to a relatively wide and heterogeneous population of real satellites being represented by a single, homogenized stock of simulated satellites in the model. It is also uncertain and difficult to predict how exactly is this going to evolve in the far future, what proportion of launched satellites will be of which size, and into which orbit they will be placed. Lacking precise information, we simply extrapolate current and expected trends. 5. Scenarios and simulation results 5.1. Business as usual and beyond The baseline scenario represents a continuation of the current trends, which are simply extended into the future. An average 1% growth rate of yearly launches of new satellites (starting at 89) is assumed, together with constant success rate in satellites’ ability to actively avoid collisions with debris and other satellites, constant lifetime, and failure rate. This basic model lacks any sudden events or major policy changes that would markedly influence the debris propagation. However, it serves both as a foundation for all the following scenarios and as a basis of comparison to see what the impact would be. Given high uncertainty regarding future state of the satellite industry (how many satellites will be launched per year, of what type and size, etc.), we elected to limit our simulations to 50 years. The model can certainly continue beyond this point, but the associated unknowns make the simulations progressively less useful. Running this model for its full 50 years (2016–2066) yields the expected result of perpetually growing amount of debris in the LEO. One can observe nearly 2-fold increase in the large debris (over 10 cm) and 3-fold increase in small debris (less than 1 cm) quantities (Fig. 5). The oscillations visible in the graph are caused by the aforementioned solar cycles which influence the rate of reentry for all simulated populations except the still active (i.e. powered) satellites. Also please note that throughout the article, the graphs use quite different scales for debris populations because of the considerable variations between scenarios. Using any single scale for all graphs would render some of them unintelligible. We can see that this increase in numbers still does not result in realization of the Kessler syndrome as most of the satellites being launched remain intact for their full expected service life. However, it comes with a considerable increase in risk to satellites, which is manifested by their higher yearly losses, making satellites operations riskier and more expensive for governments and private companies alike. This increased amount of debris in LEO combined with the larger number of active satellites makes it approximately twice as likely that an active satellite will suffer a disabling hit or a total disintegration during its lifetime. It should be noted that this risk might possibly be offset by future improvements in satellite reliability, debris tracking, and navigation [17]. This negative development of increasingly risky and costly operation of satellites can also be highlighted and visualized in a graph by comparing the number of satellites launched to the number of satellites lost (to collisions as well as malfunctions) in each given year (Fig. 6). This ratio shows diminishing efficiency of the system, where number of losses per launch increases. After fully acknowledging limitations stemming from inherent uncertainties, we can also try to “make things expectedly worse” by doubling the growth rate of yearly launches (to what it perhaps might end up being because of the boom in satellites industry because of increasing privatization of space, growing demand for communication satellites, etc.) and also extending the simulation timeframe to 200 years (Fig. 7). It must be stressed that the model was not designed with such long outlooks in mind, and many of the assumptions will certainly not hold over the next 200 years (such as static launch rate growth, size, and structure of the satellites, their lifetime, evasion rates, lack of mitigation, and many others). But in the overwhelmingly unlikely case that these assumptions stay true, the simulated outcome seems to suggest a collapse of sorts around the year 2163. However, it does not look like a suddenly triggered chain reaction leading to widespread fragmentation of the entire LEO but rather like a gradually reached point at which LEO is so full of debris, and the rate of active satellite fragmentation is so high (almost one every day) that the launches cannot keep up anymore. This is consistent with the findings reported by LaFleur and Finkelman, who found the debris system to be unconditionally stable [18], [19], [27]. 5.2. Antisatellite weapon system scenario Apart from the usual collisional risks that satellites face in the LEO, there has been growing concern regarding the development of antisatellite weapon systems (ASATs) by several world powers (namely China, Russian Federation, and the United States). These weapons are designed to intercept and destroy orbiting satellites and are, for the most part, descended from the antiballistic missile defense systems. While there are some alternative designs under development, the current generation mostly takes form of a boosted missile with a kinetic kill vehicle. This method of destruction (a collision of a missile with a satellite) leads to extensive fragmentation and creation of large debris clouds. A prime example of this was the Chinese 2007 ASAT test which destroyed China's own decommissioned weather satellite FengYun-1C. This hypervelocity collision created around 3000 pieces of medium to large debris and tens of thousands of smaller pieces, most of which will remain in orbit for decades, thus considerably contributing to overall risk of future orbital collisions [20]. As much as occasional tests of ASATs are increasing the amount of debris in the LEO, a greater danger by far is the possibility of a large-scale ASAT deployment during an armed conflict between two or more major, technologically advanced powers. Given the reliance of modern militaries on satellites for intelligence, communication, and navigation, it is generally presumed that the initial phase of any such conflict would involve mutual destruction of each other's satellites to blind the enemy and hinder their offensive operations [21], [22]. Such opening salvos could involve immediate destruction of dozens of satellites, thus creating massive clouds of debris threatening the remaining satellites and possibly leading to cascading disintegration across the entire orbit. This kind of hypothetical event is simulated in the second scenario, where an imaginary major military conflict erupts in the year 2040, during which roughly half of all military satellites are destroyed by intentional kinetic impacts using antisatellite weapons. With military and dual-use satellites generally representing a little over one-third of all satellites [23] (depending on criteria and the operating country), this results in some 200 satellites destroyed by ASATs in 2040 (Fig. 8). However, even this sudden event is not enough to trigger a chain reaction of satellites disintegrating in LEO, at least according to this model. Nevertheless, the number of collisions with active satellites ends up nearly twice as high at the end of the simulation (i.e. 25 years after the conflict and ASAT strikes) when compared to the previous run. This shows that the damage would be long-term and would negatively affect satellite operations (including commercial and scientific ones) for many years after any conflict involving ASATs.

#### 2] Kessler Syndrome is so unlikely, we don’t even need to remove debris

**Mosher ’19** [Dave; September 3rd; Journalist with more than a decade of experience reporting and writing stories about space, science, and technology; Business Insider, “Satellite collisions may trigger a space-junk disaster that could end human access to orbit. Here’s How,” <https://www.usafa.edu/app/uploads/Space_and_Defense_2_3.pdf>; GR]

The Kessler syndrome plays center-stage in the movie "Gravity," in which an accidental space collision endangers a crew aboard a large space station. But Gossner said that type of a runaway space-junk catastrophe is unlikely. "Right now I don't think we're close to that," he said. "I'm not saying we couldn't get there, and I'm not saying we don't need to be smart and manage the problem. But I don't see it ever becoming, anytime soon, an unmanageable problem." There is no current system to remove old satellites or sweep up bits of debris in order to prevent a Kessler event. Instead, space debris is monitored from Earth, and new rules require satellites in low-Earth orbit be deorbited after 25 years so they don't wind up adding more space junk. "Our current plan is to manage the problem and not let it get that far," Gossner said. "I don't think that we're even close to needing to actively remove stuff. There's lots of research being done on that, and maybe some day that will happen, but I think that — at this point, and in my humble opinion — an unnecessary expense." A major part of the effort to prevent a Kessler event is the Space Surveillance Network (SSN). The project, led by the US military, uses 30 different systems around the world to identify, track, and share information about objects in space. Many objects are tracked day and night via a networkof radar observatories around the globe. Optical telescopes on the ground also keep an eye out, but they aren't always run by the government. "The commercial sector is actually putting up lots and lots of telescopes," Gossner said. The government pays for their debris-tracking services. Gossner said one major debris-tracking company is called Exoanalytic. It uses about 150 small telescopes set up around the globe to detect, track, and report space debris to the SSN. Telescopes in space track debris, too. Far less is known about them because they're likely top-secret military satellites. Objects detected by the government and companies get added to a catalog of space debris and checked against the orbits of other known bits of space junk. New orbits are calculated with supercomputers to see if there's a chance of any collisions. Diana McKissock, a flight lead with the US Air Force's 18th Space Control Squadron, helps track space debris for the SSN. She said the surveillance network issues warnings to NASA, satellite companies, and other groups with spacecraft, based on two levels of emergency: basic and advanced. The SSN issues a basic emergency report to the public three days ahead of a 1-in-10,000 chance of a collision. It then provides multiple updates per day until the risk of a collision passes. To qualify for such reporting, a rogue object must come within a certain distance of another object. In low-Earth orbit, that distance must be less than 1 kilometer (0.62 mile); farther out in deep space, where the precision of orbits is less reliable, the distance is less than 5 kilometers (3.1 miles). Advanced emergency reports help satellite providers see possible collisions much more than three days ahead. "In 2017, we provided data for 308,984 events, of which only 655 were emergency-reportable," McKissock told Business Insider in an email. Of those, 579 events were in low-Earth orbit (where it's relatively crowded with satellites).

#### 3] No space war---attribution technology solves

Omar Lamrani 16, studied international relations at Clark University and holds a master's degree from the Diplomatic Academy of Vienna, where his thesis centered on Chinese military doctrine, 5/17/16, “Avoiding a War in Space”, https://worldview.stratfor.com/article/avoiding-war-space

If the United States wants to preserve its primacy in the face of increasing threats to its strength in space, Washington will need to invest in strategies to deter attacks on its orbital assets. The first step in strengthening space deterrence is to ensure proper attribution: The United States cannot hold its enemies accountable for attacks if it does not know who initiated them. But the vastness of space, along with the difficulty of obtaining physical evidence from attacked satellites, can make responsibility hard to prove.¶ To that end, the United States is investing in a second-generation surveillance system, known as Space Fence, to track satellites and orbital debris. Slated to begin operating in 2018, Space Fence uses ground-based radars that give it 10 times the detection capability of its predecessor, the Air Force Space Surveillance System.¶ In addition, the United States has been working with a classified satellite defense technology called the Self-Awareness Space Situational Awareness system, which reportedly will be able to pinpoint the source of a laser fired at a satellite.¶ Redundancy and shielding can also deter limited attacks against satellites. The innate redundancy of large satellite constellations could make attacking them too risky; such an assault would fail to significantly impair US space control while still inviting retaliation.¶ Meanwhile, more widespread use of resistant antenna designs, filters, surge arresters and fiber-optic components, which are less vulnerable to attack, is already being explored to further shield satellites from jamming, dazzling and blinding.

#### 4] Attribution - U.S. knows the difference between intentional indirect attacks and accidental collisions---no nation would try.

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Kinetic Attacks. Essentially, an adversary can choose between two types of noncyber antisatellite attacks: direct kinetic and indirect kinetic. While a direct kinetic antisatellite missile attack on a US satellite is possible, it would provide direct attribution to the attacker, thus leading to repercussions. The thruster and the heat from the missile would be identified and attributed to the country or vessel that launched the attack. A direct kinetic attack might be inviting, but the political price is high. Even though it would be inviting to attack satellites, an adversary would not be able to attack without leaving a trace of tangible evidence. Using an ASAT missile is a grave act of war and can only reasonably be used if the perpetrator anticipates and accepts a wartime response.

For a potential adversary, it can be far more advantageous to increase the amount of debris that clutters specific orbits, thus epitomizing the indirect attack. Increasing debris can be accomplished through actively adding debris to specific well-targeted orbits, systematic designer accidents, or collisions in space.

During the eighteenth century and until the Second World War, artillery units had a special round to be used if enemy infantry came uncomfortably close to the battery position—the case shot. The battery aimed toward the closing infantry and fired the case shots, which dispersed thousands of steel balls that created massive losses in the infantry ranks. Whether those steel balls hit an arm, a leg, the torso, or a hand did not matter; the infantry assault against the battery position lost momentum and ended. By applying the case shot idea to space, we can see an unsophisticated way to radically increase debris by using space boosters to reach lower Earth orbit (LEO) and then using kinetic energy to disperse hundreds of thousands of steel balls into a segment of space. Any obsolete or crude missile—exemplified by the Iranian Shahab or the North Korean Taepodong—could act as a space booster to take the payload to space. A salvo of 20 such crude space boosters delivering a significant amount of prefragmented shrapnel or steel balls could radically increase the amount of hypervelocity debris.

The probability for collision in space between a functional satellite and debris is a numbers game. Reduced to a simplified example, if the presence of 5,000 debris pieces at a specific altitude generates a risk of one satellite hit every 10 years—not taking into account additional debris generated from the impact—an additional 100,000 debris pieces would increase that risk drastically. To illustrate the principle, 20 space boosters can lift 30 metric tons of payload to LEO—roughly 400,000 steel balls—that would be spread at hypervelocity into the satellite orbits. The attack is kinetic but indirect, as the target satellites are not individually targeted but are instead approached by a swarm of hypervelocity debris that impacts the target satellites either by penetration or by destroying antennas, solar panels, or other equipment. This impact would initially generate more debris, although orbital decay would counterbalance some of it by moving it to a lower altitude; eventually it would disappear from space.

Either a direct or indirect kinetic attack would be an act of war and provide the necessary attribution to give the United States casus belli approved by at least a part of the international community. First, both the direct and indirect kinetic attack would be attributable to the nation that launched the attack, and observations from space-borne monitoring satellites would be accurate enough to give the United States a solid case. Second, creating unprecedented amounts of space debris would not only be hazardous to US satellites but also to those of other major powers. If rogue nation X launches an indirect kinetic attack, it would affect Russia’s, Europe’s, China’s, India’s, Pakistan’s, and other nations’ satellites. Depending on the dispersement of these debris objects, damage could be limited to small areas of space, but it would still be a space territory not used solely by the United States. Rogue nation X traditionally has avoided United Nations–supported repercussions from the international community when US interests have been damaged. Russia and/or China, in particular, are likely to veto any punitive actions proposed by the United States in the UN Security Council.20 In this scenario, rogue nation X cannot afford to lose that support by damaging Russian or Chinese space assets as collateral damage from its attack on US satellites. Chinese space assets are quite limited compared to Russian or US inventories; therefore, an indirect kinetic attack against US assets could result in severe damage to Chinese interests, as the Chinese lack space resilience. Neither direct nor indirect kinetic attacks are suitable or viable options for a rogue nation that intends to harm US satellites.

5] No space war – several **barriers to use of space weapons**

Bohumil **Doboš**, scholar at the Institute of Political Studies, Faculty of Social Sciences, Charles University in Prague, Czech Republic, and a coordinator of the Geopolitical Studies Research Centre, **’19**, Geopolitics of the Outer Space, Chapter 3: Outer Space as a Military-Diplomatic Field, Pgs. 48-49)

Despite the theorized potential for the achievement of the terrestrial dominance throughout the utilization of the ultimate high ground and the ease of destruction of space-based assets by the potential space weaponry, the utilization of space weapons is with current technology and no effective means to protect them far from fulfilling this potential (Steinberg 2012, p. 255). **In current global international political and technological setting, the utility of space weapons is very limited**, even if we accept that the ultimate high ground presents the potential to get a decisive tangible military advantage (which is unclear). This stands among the reasons for the lack of their utilization so far. Last but not the least, it must be pointed out that the states also develop passive defense systems designed to protect the satellites on orbit or critical capabilities they provide. These **further decrease the utility of space weapons**. These systems include larger maneuvering capacities, launching of decoys, preparation of spare satellites that are ready for launch in case of ASAT attack on its twin on orbit, or attempts to decrease the visibility of satellites using paint or materials less visible from radars (Moltz 2014, p. 31). Finally, we must look at the main obstacles of connection of the outer space and warfare. The first set of barriers is comprised of **physical obstructions**. As has been presented in the previous chapter, the outer space is very challenging domain to operate in. Environmental factors still present the largest threat to any space military capabilities if compared to any man-made threats (Rendleman 2013, p. 79). A following issue that hinders military operations in the outer space is the predictability of orbital movement. If the reconnaissance satellite's orbit is known, the terrestrial actor might attempt to hide some critical capabilities-an option that is countered by new surveillance techniques (spectrometers, etc.) (Norris 2010, p. 196)-but the hide-and-seek game is on. This same principle is, however, in place for any other space asset-any nation with basic tracking capabilities may quickly detect whether the military asset or weapon is located above its territory or on the other side of the planet and thus mitigate the possible strategic impact of space weapons not aiming at mass destruction. Another possibility is to attempt to destroy the weapon in orbit. Given the level of development for the ASAT technology, it seems that they will prevail over any possible weapon system for the time to come. Next issue, directly connected to the first one, is the utilization of weak physical protection of space objects that need to be as light as possible to reach the orbit and to be able to withstand harsh conditions of the domain. This means that their protection against ASAT weapons is very limited, and, whereas some avoidance techniques are being discussed, they are of limited use in case of ASAT attack. We can thus add to the issue of predictability also the issue of easy destructibility of space weapons and other military hardware (Dolman 2005, p. 40; Anantatmula 2013, p. 137; Steinberg 2012, p. 255). Even if the high ground was effectively achieved and other nations could not attack the space assets directly, there is still a need for communication with those assets from Earth. There are also ground facilities that support and control such weapons located on the surface. Electromagnetic communication with satellites might be jammed or hacked and the ground facilities infiltrated or destroyed thus rendering the possible space weapons useless (Klein 2006, p. 105; Rendleman 2013, p. 81). This issue might be overcome by the establishment of a base controlling these assets outside the Earth-on Moon or lunar orbit, at lunar L-points, etc.-but this perspective remains, for now, unrealistic. Furthermore, **no contemporary actor will risk full space weaponization in the face of possible competition and the possibility of rendering the outer space useless.** No actor is dominant enough to prevent others to challenge any possible attempts to dominate the domain by military means. To quote 2016 Stratfor analysis, "(a) war in space would be devastating to all, and preventing it, rather than finding ways to fight it, will likely remain the goal" (Larnrani 20 16). This stands true unless some space actor finds a utility in disrupting the arena for others.

#### 6] No miscalc or escalation

James Pavur 19, Professor of Computer Science Department of Computer Science at Oxford University and Ivan Martinovic, DPhil Researcher Cybersecurity Centre for Doctoral Training at Oxford University, “The Cyber-ASAT: On the Impact of Cyber Weapons in Outer Space”, 2019 11th International Conference on Cyber Conflict: Silent Battle T. Minárik, S. Alatalu, S. Biondi, M. Signoretti, I. Tolga, G. Visky (Eds.), <https://ccdcoe.org/uploads/2019/06/Art_12_The-Cyber-ASAT.pdf>

A. Limited Accessibility Space is difficult. Over 60 years have passed since the first Sputnik launch and only nine countries (ten including the EU) have orbital launch capabilities. Moreover, a launch programme alone does not guarantee the resources and precision required to operate a meaningful ASAT capability. Given this, one possible reason why space wars have not broken out is simply because only the US has ever had the ability to fight one [21, p. 402], [22, pp. 419–420]. Although launch technology may become cheaper and easier, it is unclear to what extent these advances will be distributed among presently non-spacefaring nations. Limited access to orbit necessarily reduces the scenarios which could plausibly escalate to ASAT usage. Only major conflicts between the handful of states with ‘space club’ membership could be considered possible flashpoints. Even then, the fragility of an attacker’s own space assets creates de-escalatory pressures due to the deterrent effect of retaliation. Since the earliest days of the space race, dominant powers have recognized this dynamic and demonstrated an inclination towards de-escalatory space strategies [23]. B. Attributable Norms There also exists a long-standing normative framework favouring the peaceful use of space. The effectiveness of this regime, centred around the Outer Space Treaty (OST), is highly contentious and many have pointed out its serious legal and political shortcomings [24]–[26]. Nevertheless, this status quo framework has somehow supported over six decades of relative peace in orbit. Over these six decades, norms have become deeply ingrained into the way states describe and perceive space weaponization. This de facto codification was dramatically demonstrated in 2005 when the US found itself on the short end of a 160-1 UN vote after opposing a non-binding resolution on space weaponization. Although states have occasionally pushed the boundaries of these norms, this has typically occurred through incremental legal re-interpretation rather than outright opposition [27]. Even the most notable incidents, such as the 2007-2008 US and Chinese ASAT demonstrations, were couched in rhetoric from both the norm violators and defenders, depicting space as a peaceful global commons [27, p. 56]. Altogether, this suggests that states perceive real costs to breaking this normative tradition and may even moderate their behaviours accordingly. One further factor supporting this norms regime is the high degree of attributability surrounding ASAT weapons. For kinetic ASAT technology, plausible deniability and stealth are essentially impossible. The literally explosive act of launching a rocket cannot evade detection and, if used offensively, retaliation. This imposes high diplomatic costs on ASAT usage and testing, particularly during peacetime. C. Environmental Interdependence A third stabilizing force relates to the orbital debris consequences of ASATs. China’s 2007 ASAT demonstration was the largest debris-generating event in history, as the targeted satellite dissipated into thousands of dangerous debris particles [28, p. 4]. Since debris particles are indiscriminate and unpredictable, they often threaten the attacker’s own space assets [22, p. 420]. This is compounded by Kessler syndrome, a phenomenon whereby orbital debris ‘breeds’ as large pieces of debris collide and disintegrate. As space debris remains in orbit for hundreds of years, the cascade effect of an ASAT attack can constrain the attacker’s long-term use of space [29, pp. 295– 296]. Any state with kinetic ASAT capabilities will likely also operate satellites of its own, and they are necessarily exposed to this collateral damage threat. Space debris thus acts as a strong strategic deterrent to ASAT usage.

### AT Satellite Collision

#### 1] No space war---attribution technology solves

Omar Lamrani 16, studied international relations at Clark University and holds a master's degree from the Diplomatic Academy of Vienna, where his thesis centered on Chinese military doctrine, 5/17/16, “Avoiding a War in Space”, https://worldview.stratfor.com/article/avoiding-war-space

If the United States wants to preserve its primacy in the face of increasing threats to its strength in space, Washington will need to invest in strategies to deter attacks on its orbital assets. The first step in strengthening space deterrence is to ensure proper attribution: The United States cannot hold its enemies accountable for attacks if it does not know who initiated them. But the vastness of space, along with the difficulty of obtaining physical evidence from attacked satellites, can make responsibility hard to prove.¶ To that end, the United States is investing in a second-generation surveillance system, known as Space Fence, to track satellites and orbital debris. Slated to begin operating in 2018, Space Fence uses ground-based radars that give it 10 times the detection capability of its predecessor, the Air Force Space Surveillance System.¶ In addition, the United States has been working with a classified satellite defense technology called the Self-Awareness Space Situational Awareness system, which reportedly will be able to pinpoint the source of a laser fired at a satellite.¶ Redundancy and shielding can also deter limited attacks against satellites. The innate redundancy of large satellite constellations could make attacking them too risky; such an assault would fail to significantly impair US space control while still inviting retaliation.¶ Meanwhile, more widespread use of resistant antenna designs, filters, surge arresters and fiber-optic components, which are less vulnerable to attack, is already being explored to further shield satellites from jamming, dazzling and blinding.

#### 2] Attribution - U.S. knows the difference between intentional indirect attacks and accidental collisions---no nation would try.

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Kinetic Attacks. Essentially, an adversary can choose between two types of noncyber antisatellite attacks: direct kinetic and indirect kinetic. While a direct kinetic antisatellite missile attack on a US satellite is possible, it would provide direct attribution to the attacker, thus leading to repercussions. The thruster and the heat from the missile would be identified and attributed to the country or vessel that launched the attack. A direct kinetic attack might be inviting, but the political price is high. Even though it would be inviting to attack satellites, an adversary would not be able to attack without leaving a trace of tangible evidence. Using an ASAT missile is a grave act of war and can only reasonably be used if the perpetrator anticipates and accepts a wartime response.

For a potential adversary, it can be far more advantageous to increase the amount of debris that clutters specific orbits, thus epitomizing the indirect attack. Increasing debris can be accomplished through actively adding debris to specific well-targeted orbits, systematic designer accidents, or collisions in space.

During the eighteenth century and until the Second World War, artillery units had a special round to be used if enemy infantry came uncomfortably close to the battery position—the case shot. The battery aimed toward the closing infantry and fired the case shots, which dispersed thousands of steel balls that created massive losses in the infantry ranks. Whether those steel balls hit an arm, a leg, the torso, or a hand did not matter; the infantry assault against the battery position lost momentum and ended. By applying the case shot idea to space, we can see an unsophisticated way to radically increase debris by using space boosters to reach lower Earth orbit (LEO) and then using kinetic energy to disperse hundreds of thousands of steel balls into a segment of space. Any obsolete or crude missile—exemplified by the Iranian Shahab or the North Korean Taepodong—could act as a space booster to take the payload to space. A salvo of 20 such crude space boosters delivering a significant amount of prefragmented shrapnel or steel balls could radically increase the amount of hypervelocity debris.

The probability for collision in space between a functional satellite and debris is a numbers game. Reduced to a simplified example, if the presence of 5,000 debris pieces at a specific altitude generates a risk of one satellite hit every 10 years—not taking into account additional debris generated from the impact—an additional 100,000 debris pieces would increase that risk drastically. To illustrate the principle, 20 space boosters can lift 30 metric tons of payload to LEO—roughly 400,000 steel balls—that would be spread at hypervelocity into the satellite orbits. The attack is kinetic but indirect, as the target satellites are not individually targeted but are instead approached by a swarm of hypervelocity debris that impacts the target satellites either by penetration or by destroying antennas, solar panels, or other equipment. This impact would initially generate more debris, although orbital decay would counterbalance some of it by moving it to a lower altitude; eventually it would disappear from space.

Either a direct or indirect kinetic attack would be an act of war and provide the necessary attribution to give the United States casus belli approved by at least a part of the international community. First, both the direct and indirect kinetic attack would be attributable to the nation that launched the attack, and observations from space-borne monitoring satellites would be accurate enough to give the United States a solid case. Second, creating unprecedented amounts of space debris would not only be hazardous to US satellites but also to those of other major powers. If rogue nation X launches an indirect kinetic attack, it would affect Russia’s, Europe’s, China’s, India’s, Pakistan’s, and other nations’ satellites. Depending on the dispersement of these debris objects, damage could be limited to small areas of space, but it would still be a space territory not used solely by the United States. Rogue nation X traditionally has avoided United Nations–supported repercussions from the international community when US interests have been damaged. Russia and/or China, in particular, are likely to veto any punitive actions proposed by the United States in the UN Security Council.20 In this scenario, rogue nation X cannot afford to lose that support by damaging Russian or Chinese space assets as collateral damage from its attack on US satellites. Chinese space assets are quite limited compared to Russian or US inventories; therefore, an indirect kinetic attack against US assets could result in severe damage to Chinese interests, as the Chinese lack space resilience. Neither direct nor indirect kinetic attacks are suitable or viable options for a rogue nation that intends to harm US satellites.

### AT Miscalc

#### 1] Space miscalc unlikely---hotlines and info sharing agreements avoids accidents and escalation

Chen Lan 16, an independent analyst and founder of the 'Go Taikonauts!', “Chinese Space Quarterly Report”, January 2016, http://www.go-taikonauts.com/images/newsletters\_PDF/GoTaikonauts18.pdf

During the IAC 2015, China re-iterated the wish for international participation and cooperation in its space station project including extending the station by modules provided by international partners. Twitter messages posted by a European journalist from the Congress, that is still to be confirmed, however, showed a different view from ESA. ESA’s new Director General JohannDietrich Wörner said he had told China that the world does not need two space stations and will likely persuade China to drop its space station in favour of joining the ISS. On the other side, during the traditional “Heads of Space Agencies Panel” in IAC 2015, NASA Administrator Charles Bolden expressed his belief that the current exclusion of China from the ISS will not last forever. Though Sino-U.S. cooperation on human spaceflight is still uncertain, a positive move between the two countries has been made, that is the establishment of a space hotline. Western media reported in November that the hotline has been setup between Washington and Beijing to allow easy sharing of technical information about their space operations, hopefully **avoiding any misunderstandings or accidents.** Russia’s space agency Roscosmos on 17 December signed a cooperation agreement with the China National Space Administration (CNSA). The document was signed at the 20th regular meeting of Russian and Chinese Heads of Government, during Russian Prime Minister Dmitry Medvedev’s three-day visit to Beijing. The two sides agreed to promote the use of “GLONASS” and “Beidou” and their augmentations in their own countries and around the world, expanding the market of navigation services provided by these systems. The two space agencies signed another agreement on the same day on cooperation in the field of space electronics. It was reported earlier that the two countries were discussing a barter deal that Russia will import Chinese space electronic components and will export rocket engines, presumably the RD-180, to China. However, an official statement about the agreement did not mention the engine. Also on the same day, Russian state-owned nanotechnology company RUSNANO and the China Aerospace Science and Industry Corporation (CASIC) signed a strategic partnership agreement. CNSA also signed an agreement with the Netherlands on 26 October, and a memorandum of understanding with the UAE (United Arab Emirates) on 15 December, on exploration and peaceful use of outer space. A year after India signed its first space cooperation agreement with China, scientists from ISRO and the Chinese space agency have decided on six major areas of interest, including the hosting of payloads on each other’s satellites and inter-planetary missions. The other areas of interest are Earth observation, disaster management, space science and navigation, as the Times of India reported on 5 October. The Brazilian Ministry of Science, Technology and Innovation announced on 30 December that the sixth CBERS (China-Brazil Earth Resources Satellite) satellite, CBERS-4A, is scheduled to be launched into space in December 2018. The Planetary Science Institute signed a cooperation agreement with the Qian Xuesen Laboratory of Space Technology (Qian Xuesen Lab), CAST, on 15 December to advance their mutual interests in facilitating the open-ended expansion of the exploration of the solar system and to use the knowledge thus gained in supporting the expansion of human activity beyond the Earth. Both institutions also wish to advance their common interest in communicating to the public the knowledge and benefits gained through robotic and human exploration of the solar system

### AT Kessler Syndrome

**1] The probability of collision is 0.1% Probability**

Alexander William **Salter**, **Economics Professor at Texas Tech**, **’16**, “SPACE DEBRIS: A LAW AND ECONOMICS ANALYSIS OF THE ORBITAL COMMONS” 19 STAN. TECH. L. REV. 221 \*numbers replaced with English words

The probability of a collision is currently **low**. Bradley and Wein estimate that the **maximum probability** in LEO of a collision over the lifetime of a spacecraft remains **below one in one thousand**, conditional on continued compliance with NASA’s deorbiting guidelines.3 However, the possibility of a future “snowballing” effect, whereby debris collides with other objects, further congesting orbit space, remains a significant concern.4 Levin and Carroll estimate the average immediate destruction of wealth created by a collision to be approximately $30 million, with an additional $200 million in damages to all currently existing space assets from the debris created by the initial collision.5 The expected value of destroyed wealth because of collisions, currently small because of the low probability of a collision, can quickly become significant if future collisions result in runaway debris growth.

#### 2] Even full-scale ASAT war can’t trigger Kessler – modelling

Drmola and Hubik 18 [Jakub Drmola, Division of Security and Strategic Studies, Department of Political Science at the Faculty of Social Sciences of Masaryk University. Tomas Hubik, Department of Theoretical Computer Science and Mathematical Logic, Faculty of Mathematics and Physics, Charles University. Kessler Syndrome: System Dynamics Model. Space Policy Volumes 44–45, August 2018, Pages 29-39. https://www.sciencedirect.com/science/article/pii/S0265964617300966?via%3Dihub]

The probabilities and rates of collisions of objects from different groups were calculated using a coefficient converting the rate of collisions between objects from one group to the rate of collisions between objects from another group. The initial base rate was estimated using iterative simulations and comparison of the resulting runs with real data and outputs from other models. Detailed model built by a group of researchers from the Lawrence Livermore National Laboratory was used as a base for the calibration [see 9]. As the major factor influencing collision probability is size, the probability increases with square of the diameter representing bigger area for possible impact. Speed would be another factor influencing the probability of impacts, but the speed depends on the distance from the Earth and is not influenced by debris size. It means that it will not vary between different debris groups and thus will not influence the collision probability conversion parameters in our model. One the most important limitations and simplifications of the model is the uncertainty of size, structure, and composition of the satellites—i.e. what debris the satellite will disintegrate into in case of a collision. Perhaps even more crucially, the rate of orbital decay changes significantly with the altitude and eccentricity of the trajectory. The lower the orbital altitude is or the more eccentric it is, the more drag the object experiences as it passes through the last vestiges of our atmosphere. Therefore, objects in the lower or more eccentric orbit will decay significantly faster. Thus, the actual lifetime of a piece of debris can easily vary from days to centuries. It also needs to be noted that while it may take many decades for a satellite to decay (especially from the popular orbits between 500 km and 800 km), we cannot assume the same about debris. That is because while satellite orbits typically have very low eccentricity, collisions result in fragments with velocities and trajectories that vary and differ from the original intact satellite (i.e. are more eccentric and decay faster). This makes estimating rate of orbital decay of debris quite difficult, especially when combined with the ongoing laudable efforts by Inter-Agency Space Debris Coordination Committee (IADC) to shorten the lifetime of satellites after they cease planned operations [14], [15]. Therefore, both the orbital and structural parameters used here are (and must be) overall averages designed to represent a “general LEO satellite” and are based on previous fragmentations, of which there are but few. Furthermore, this is getting increasingly more difficult as satellites are getting progressively more diverse, especially with the ongoing boom of the miniaturized CubeSats [16]. This leads to a relatively wide and heterogeneous population of real satellites being represented by a single, homogenized stock of simulated satellites in the model. It is also uncertain and difficult to predict how exactly is this going to evolve in the far future, what proportion of launched satellites will be of which size, and into which orbit they will be placed. Lacking precise information, we simply extrapolate current and expected trends. 5. Scenarios and simulation results 5.1. Business as usual and beyond The baseline scenario represents a continuation of the current trends, which are simply extended into the future. An average 1% growth rate of yearly launches of new satellites (starting at 89) is assumed, together with constant success rate in satellites’ ability to actively avoid collisions with debris and other satellites, constant lifetime, and failure rate. This basic model lacks any sudden events or major policy changes that would markedly influence the debris propagation. However, it serves both as a foundation for all the following scenarios and as a basis of comparison to see what the impact would be. Given high uncertainty regarding future state of the satellite industry (how many satellites will be launched per year, of what type and size, etc.), we elected to limit our simulations to 50 years. The model can certainly continue beyond this point, but the associated unknowns make the simulations progressively less useful. Running this model for its full 50 years (2016–2066) yields the expected result of perpetually growing amount of debris in the LEO. One can observe nearly 2-fold increase in the large debris (over 10 cm) and 3-fold increase in small debris (less than 1 cm) quantities (Fig. 5). The oscillations visible in the graph are caused by the aforementioned solar cycles which influence the rate of reentry for all simulated populations except the still active (i.e. powered) satellites. Also please note that throughout the article, the graphs use quite different scales for debris populations because of the considerable variations between scenarios. Using any single scale for all graphs would render some of them unintelligible. We can see that this increase in numbers still does not result in realization of the Kessler syndrome as most of the satellites being launched remain intact for their full expected service life. However, it comes with a considerable increase in risk to satellites, which is manifested by their higher yearly losses, making satellites operations riskier and more expensive for governments and private companies alike. This increased amount of debris in LEO combined with the larger number of active satellites makes it approximately twice as likely that an active satellite will suffer a disabling hit or a total disintegration during its lifetime. It should be noted that this risk might possibly be offset by future improvements in satellite reliability, debris tracking, and navigation [17]. This negative development of increasingly risky and costly operation of satellites can also be highlighted and visualized in a graph by comparing the number of satellites launched to the number of satellites lost (to collisions as well as malfunctions) in each given year (Fig. 6). This ratio shows diminishing efficiency of the system, where number of losses per launch increases. After fully acknowledging limitations stemming from inherent uncertainties, we can also try to “make things expectedly worse” by doubling the growth rate of yearly launches (to what it perhaps might end up being because of the boom in satellites industry because of increasing privatization of space, growing demand for communication satellites, etc.) and also extending the simulation timeframe to 200 years (Fig. 7). It must be stressed that the model was not designed with such long outlooks in mind, and many of the assumptions will certainly not hold over the next 200 years (such as static launch rate growth, size, and structure of the satellites, their lifetime, evasion rates, lack of mitigation, and many others). But in the overwhelmingly unlikely case that these assumptions stay true, the simulated outcome seems to suggest a collapse of sorts around the year 2163. However, it does not look like a suddenly triggered chain reaction leading to widespread fragmentation of the entire LEO but rather like a gradually reached point at which LEO is so full of debris, and the rate of active satellite fragmentation is so high (almost one every day) that the launches cannot keep up anymore. This is consistent with the findings reported by LaFleur and Finkelman, who found the debris system to be unconditionally stable [18], [19], [27]. 5.2. Antisatellite weapon system scenario Apart from the usual collisional risks that satellites face in the LEO, there has been growing concern regarding the development of antisatellite weapon systems (ASATs) by several world powers (namely China, Russian Federation, and the United States). These weapons are designed to intercept and destroy orbiting satellites and are, for the most part, descended from the antiballistic missile defense systems. While there are some alternative designs under development, the current generation mostly takes form of a boosted missile with a kinetic kill vehicle. This method of destruction (a collision of a missile with a satellite) leads to extensive fragmentation and creation of large debris clouds. A prime example of this was the Chinese 2007 ASAT test which destroyed China's own decommissioned weather satellite FengYun-1C. This hypervelocity collision created around 3000 pieces of medium to large debris and tens of thousands of smaller pieces, most of which will remain in orbit for decades, thus considerably contributing to overall risk of future orbital collisions [20]. As much as occasional tests of ASATs are increasing the amount of debris in the LEO, a greater danger by far is the possibility of a large-scale ASAT deployment during an armed conflict between two or more major, technologically advanced powers. Given the reliance of modern militaries on satellites for intelligence, communication, and navigation, it is generally presumed that the initial phase of any such conflict would involve mutual destruction of each other's satellites to blind the enemy and hinder their offensive operations [21], [22]. Such opening salvos could involve immediate destruction of dozens of satellites, thus creating massive clouds of debris threatening the remaining satellites and possibly leading to cascading disintegration across the entire orbit. This kind of hypothetical event is simulated in the second scenario, where an imaginary major military conflict erupts in the year 2040, during which roughly half of all military satellites are destroyed by intentional kinetic impacts using antisatellite weapons. With military and dual-use satellites generally representing a little over one-third of all satellites [23] (depending on criteria and the operating country), this results in some 200 satellites destroyed by ASATs in 2040 (Fig. 8). However, even this sudden event is not enough to trigger a chain reaction of satellites disintegrating in LEO, at least according to this model. Nevertheless, the number of collisions with active satellites ends up nearly twice as high at the end of the simulation (i.e. 25 years after the conflict and ASAT strikes) when compared to the previous run. This shows that the damage would be long-term and would negatively affect satellite operations (including commercial and scientific ones) for many years after any conflict involving ASATs.

#### 3] Kessler is so unlikely, we don’t even need to remove debris

**Mosher** **’19** [Dave; September 3rd; Journalist with more than a decade of experience reporting and writing stories about space, science, and technology; Business Insider, “Satellite collisions may trigger a space-junk disaster that could end human access to orbit. Here’s How,” <https://www.usafa.edu/app/uploads/Space_and_Defense_2_3.pdf>; GR]

The Kessler syndrome plays center-stage in the movie "Gravity," in which an accidental space collision endangers a crew aboard a large space station. But Gossner said that type of a runaway space-junk catastrophe is unlikely. "Right now I don't think we're close to that," he said. "I'm not saying we couldn't get there, and I'm not saying we don't need to be smart and manage the problem. But I don't see it ever becoming, anytime soon, an unmanageable problem." There is no current system to remove old satellites or sweep up bits of debris in order to prevent a Kessler event. Instead, space debris is monitored from Earth, and new rules require satellites in low-Earth orbit be deorbited after 25 years so they don't wind up adding more space junk. "Our current plan is to manage the problem and not let it get that far," Gossner said. "I don't think that we're even close to needing to actively remove stuff. There's lots of research being done on that, and maybe some day that will happen, but I think that — at this point, and in my humble opinion — an unnecessary expense." A major part of the effort to prevent a Kessler event is the Space Surveillance Network (SSN). The project, led by the US military, uses 30 different systems around the world to identify, track, and share information about objects in space. Many objects are tracked day and night via a networkof radar observatories around the globe. Optical telescopes on the ground also keep an eye out, but they aren't always run by the government. "The commercial sector is actually putting up lots and lots of telescopes," Gossner said. The government pays for their debris-tracking services. Gossner said one major debris-tracking company is called Exoanalytic. It uses about 150 small telescopes set up around the globe to detect, track, and report space debris to the SSN. Telescopes in space track debris, too. Far less is known about them because they're likely top-secret military satellites. Objects detected by the government and companies get added to a catalog of space debris and checked against the orbits of other known bits of space junk. New orbits are calculated with supercomputers to see if there's a chance of any collisions. Diana McKissock, a flight lead with the US Air Force's 18th Space Control Squadron, helps track space debris for the SSN. She said the surveillance network issues warnings to NASA, satellite companies, and other groups with spacecraft, based on two levels of emergency: basic and advanced. The SSN issues a basic emergency report to the public three days ahead of a 1-in-10,000 chance of a collision. It then provides multiple updates per day until the risk of a collision passes. To qualify for such reporting, a rogue object must come within a certain distance of another object. In low-Earth orbit, that distance must be less than 1 kilometer (0.62 mile); farther out in deep space, where the precision of orbits is less reliable, the distance is less than 5 kilometers (3.1 miles). Advanced emergency reports help satellite providers see possible collisions much more than three days ahead. "In 2017, we provided data for 308,984 events, of which only 655 were emergency-reportable," McKissock told Business Insider in an email. Of those, 579 events were in low-Earth orbit (where it's relatively crowded with satellites).

#### 4] There is no impact.

Von Fange **’**17 [Daniel Von Fange is a full stack developer that builds web platforms, with a particular interest in space applications. Kessler Syndrome is Over Hyped. May 21, 2017. braino.org/essays/kessler\_syndrome\_is\_over\_hyped/]

Kessler Syndrome is overhyped. A chorus of online commenters great any news of upcoming low earth orbit satellites with worry that humanity will to lose access to space. I now think they are wrong. What is Kessler Syndrome? Here’s the popular view on Kessler Syndrome. Every once in a while, a piece of junk in space hits a satellite. This single impact destroys the satellite, and breaks off several thousand additional pieces. These new pieces now fly around space looking for other satellites to hit, and so exponentially multiply themselves over time, like a nuclear reaction, until a sphere of man-made debris surrounds the earth, and humanity no longer has access to space nor the benefits of satellites. It is a dark picture. Is Kessler Syndrome likely to happen? I had to stop everything and spend an afternoon doing back-of-the-napkin math to know how big the threat is. To estimate, we need to know where the stuff in space is, how much mass is there, and how long it would take to deorbit. The orbital area around earth can be broken down into four regions. Low LEO - Up to about 400km. Things that orbit here burn up in the earth’s atmosphere quickly - between a few months to two years. The space station operates at the high end of this range. It loses about a kilometer of altitude a month and if not pushed higher every few months, would soon burn up. For all practical purposes, Low LEO doesn’t matter for Kessler Syndrome. If Low LEO was ever full of space junk, we’d just wait a year and a half, and the problem would be over. High LEO - 400km to 2000km. This where most heavy satellites and most space junk orbits. The air is thin enough here that satellites only go down slowly, and they have a much farther distance to fall. It can take 50 years for stuff here to get down. This is where Kessler Syndrome could be an issue. Mid Orbit - GPS satellites and other navigation satellites travel here in lonely, long lives. The volume of space is so huge, and the number of satellites so few, that we don’t need to worry about Kessler here. GEO - If you put a satellite far enough out from earth, the speed that the satellite travels around the earth will match the speed of the surface of the earth rotating under it. From the ground, the satellite will appear to hang motionless. Usually the geostationary orbit is used by big weather satellites and big TV broadcasting satellites. (This apparent motionlessness is why satellite TV dishes can be mounted pointing in a fixed direction. You can find approximate south just by looking around at the dishes in your northern hemisphere neighborhood.) For Kessler purposes, GEO orbit is roughly a ring 384,400 km around. However, all the satellites here are moving the same direction at the same speed - debris doesn’t get free velocity from the speed of the satellites. Also, it’s quite expensive to get a satellite here, and so there aren’t many, only about one satellite per 1000km of the ring. Kessler is not a problem here. How bad could Kessler Syndrome in High LEO be? Let’s imagine a worst case scenario. An evil alien intelligence chops up everything in High LEO, turning it into 1cm cubes of death orbiting at 1000km, spread as evenly across the surface of this sphere as orbital mechanics would allow. Is humanity cut off from space? I’m guessing the world has launched about 10,000 tons of satellites total. For guessing purposes, I’ll assume 2,500 tons of satellites and junk currently in High LEO. If satellites are made of aluminum, with a density of 2.70 g/cm3, then that’s 839,985,870 1cm cubes. A sphere for an orbit of 1,000km has a surface area of 682,752,000 square KM. So there would be one cube of junk per .81 square KM. If a rocket traveled through that, its odds of hitting that cube are tiny - less than 1 in 10,000. So even in the worst case, we don’t lose access to space. Now though you can travel through the debris, you couldn’t keep a satellite alive for long in this orbit of death. Kessler Syndrome at its worst just prevents us from putting satellites in certain orbits. In real life, there’s a lot of factors that make Kessler syndrome even less of a problem than our worst case though experiment. Debris would be spread over a volume of space, not a single orbital surface, making collisions orders of magnitudes less likely. Most impact debris will have a slower orbital velocity than either of its original pieces - this makes it deorbit much sooner. Any collision will create large and small objects. Small objects are much more affected by atmospheric drag and deorbit faster, even in a few months from high LEO. Larger objects can be tracked by earth based radar and avoided. The planned big new constellations are not in High LEO, but in Low LEO for faster communications with the earth. They aren’t an issue for Kessler. Most importantly, all new satellite launches since the 1990’s are required to include a plan to get rid of the satellite at the end of its useful life (usually by deorbiting) So the realistic worst case is that insurance premiums on satellites go up a bit. Given the current trend toward much smaller, cheaper micro satellites, this wouldn’t even have a huge effect. I’m removing Kessler Syndrome from my list of things to worry about.