## \*\*1NC- Off Case\*\*

### 1NC – Mining DA

#### The space-for-space economy is beginning to develop now because of private enterprise in space, but the affirmative prevents this development.

Weinzierl and Sarang 21 (Matt, PhD in Economics Harvard University, Joseph and Jacqueline Elbling Professor of Business Administration at HBS and a Research Associate at the National Bureau of Economic Research, and Mehak, Research Associate at Harvard Business School and the Lunar Exploration Projects Lead for the MIT Space Exploration Initiative, Harvard Business Review, "The Commercial Space Age is Here," 2/12, <https://hbr.org/2021/02/the-commercial-space-age-is-here>)

In 2019, 95% of the estimated $366 billion in revenue earned in the space sector was from the space-for-earth economy: that is, goods or services produced in space for use on earth. The space-for-earth economy includes telecommunications and internet infrastructure, earth observation capabilities, national security satellites, and more. This economy is booming, and though research shows that it faces the challenges of overcrowding and monopolization that tend to arise whenever companies compete for a scarce natural resource, projections for its future are optimistic. Decreasing costs for launch and space hardware in general have enticed new entrants into this market, and companies in a variety of industries have already begun leveraging satellite technology and access to space to drive innovation and efficiency in their earthbound products and services. In contrast, the space-for-space economy — that is, goods and services produced in space for use in space, such as mining the Moon or asteroids for material with which to construct in-space habitats or supply refueling depots — has struggled to get off the ground. As far back as the 1970s, research commissioned by NASA predicted the rise of a space-based economy that would supply the demands of hundreds, thousands, even millions of humans living in space, dwarfing the space-for-earth economy (and, eventually, the entire terrestrial economy as well). The realization of such a vision would change how all of us do business, live our lives, and govern our societies — but to date, we’ve never even had more than 13 people in space at one time, leaving that dream as little more than science fiction. Today, however, there is reason to think that we may finally be reaching the first stages of a true space-for-space economy. SpaceX’s recent achievements (in cooperation with NASA), as well as upcoming efforts by Boeing, Blue Origin, and Virgin Galactic to put people in space sustainably and at scale, mark the opening of a new chapter of spaceflight led by private firms. These firms have both the intention and capability to bring private citizens to space as passengers, tourists, and — eventually — settlers, opening the door for businesses to start meeting the demand those people create over the next several decades with an array of space-for-space goods and services.

#### Space-for-space is key for continued space-for-earth developments like asteroid mining

Weinzierl and Sarang 21 (Matt, PhD in Economics Harvard University, Joseph and Jacqueline Elbling Professor of Business Administration at HBS and a Research Associate at the National Bureau of Economic Research, and Mehak, Research Associate at Harvard Business School and the Lunar Exploration Projects Lead for the MIT Space Exploration Initiative, Harvard Business Review, "The Commercial Space Age is Here," 2/12, <https://hbr.org/2021/02/the-commercial-space-age-is-here>)

To be sure, people have dreamt of using the vacuum and weightlessness of space to source or make things that cannot be made on earth for half a century, and time and again the business case has failed to pan out. Skepticism is natural. Those failures, however, have been in space-for-earth applications. For example, two startups of the 2010s, Planetary Resources, Inc. and Deep Space Industries, recognized the potential of space mining early on. For both companies, however, the lack of a space-for-space economy meant that their near-term survival depended on selling mined material — precious metals or rare elements — to earthbound customers. When it became clear that demand was insufficient to justify the high costs, funding dried up, and both companies pivoted to other ventures. These were failures of space-for-earth business models — but the demand for in-space mining of raw building material, metals, and water will be enormous once humans are living in space (and are therefore far cheaper to supply). In other words, when people are living and working in space, we are likely to look back on these early asteroid mining companies less as failures and more as simply ahead of their time.

#### Mining solves extinction from scarcity.

Pelton 17—(Director Emeritus of the Space and Advanced Communications Research Institute at George Washington University, PHD in IR from Georgetown).. Pelton, Joseph N. 2017. The New Gold Rush: The Riches of Space Beckon! Springer. Accessed 8/30/19.

Are We Humans Doomed to Extinction? What will we do when Earth’s resources are used up by humanity? The world is now hugely over populated, with billions and billions crammed into our overcrowded cities. By 2050, we may be 9 billion strong, and by 2100 well over 11 billion people on Planet Earth. Some at the United Nations say we might even be an amazing 12 billion crawling around this small globe. And over 80 % of us will be living in congested cities. These cities will be ever more vulnerable to terrorist attack, natural disaster, and other plights that come with overcrowding and a dearth of jobs that will be fueled by rapid automation and the rise of artifi cial intelligence across the global economy. We are already rapidly running out of water and minerals. Climate change is threatening our very existence. Political leaders and even the Pope have cautioned us against inaction. Perhaps the naysayers are right. All humanity is at tremendous risk. Is there no hope for the future? This book is about hope. We think that there is literally heavenly hope for humanity. But we are not talking here about divine intervention. We are envisioning a new space economy that recognizes that there is more water in the skies that all our oceans. Th ere is a new wealth of natural resources and clean energy in the reaches of outer space—more than most of us could ever dream possible. There are those that say why waste money on outer space when we have severe problems here at home? Going into space is not a waste of money. It is our future. It is our hope for new jobs and resources. The great challenge of our times is to reverse public thinking to see space not as a resource drain but as the doorway to opportunity. The new space frontier can literally open up a “gold rush in the skies.” In brief, we think there is new hope for humanity. We see a new a pathway to the future via new ventures in space. For too long, space programs have been seen as a money pit. In the process, we have overlooked the great abundance available to us in the skies above. It is important to recognize there is already the beginning of a new gold rush in space—a pathway to astral abundance. “New Space” is a term increasingly used to describe radical new commercial space initiatives—many of which have come from Silicon Valley and often with backing from the group of entrepreneurs known popularly as the “space billionaires.” New space is revolutionizing the space industry with lower cost space transportation and space systems that represent significant cost savings and new technological breakthroughs. “New Commercial Space” and the “New Space Economy” represent more than a new way of looking at outer space. These new pathways to the stars could prove vital to human survival. If one does not believe in spending money to probe the mysteries of the universe then perhaps we can try what might be called “calibrated greed” on for size. One only needs to go to a cubesat workshop, or to Silicon Valley or one of many conferences like the “Disrupt Space” event in Bremen, Germany, held in April 2016 to recognize that entrepreneurial New Space initiatives are changing everything [ 1 ]. In fact, the very nature and dimensions of what outer space activities are today have changed forever. It is no longer your grandfather’s concept of outer space that was once dominated by the big national space agencies. The entrepreneurs are taking over. The hopeful statements in this book and the hard economic and technical data that backs them up are more than a minority opinion. It is a topic of growing interest at the World Economic Forum, where business and political heavyweights meet in Davos, Switzerland, to discuss how to stimulate new patterns of global economic growth. It is even the growing view of a group that call themselves “space ethicists.” Here is how Christopher J. Newman, at the University of Sunderland in the United Kingdom has put it: Space ethicists have offered the view that space exploration is not only desirable; it is a duty that we, as a species, must undertake in order to secure the survival of humanity over the longer term. Expanding both the resource base and, eventually, the habitats available for humanity means that any expenditure on space exploration, far from being viewed as frivolous, can legitimately be rationalized as an ethical investment choice. (Newman) On the other hand there are space ethicists and space exobiologists who argue that humans have created ecological ruin on the planet—and now space debris is starting to pollute space. Th ese countervailing thoughts by the “no growth” camp of space ethicists say we have no right to colonize other planets or to mine the Moon and asteroids—or at least no right to do so until we can prove we can sustain life here on Earth for the longer term. However, for most who are planning for the new space economy the opinion of space philosophers doesn’t really fl oat their boat. Legislators, bankers, and aspiring space entrepreneurs are far more interested in the views of the super-rich capitalists called the space billionaires. A number of these billionaires and space executives have already put some very serious money into enterprises intent on creating a new pathway to the stars. No less than five billionaires with established space ventures—Elon Musk, Paul Allen, Jeff Bezos, Sir Richard Branson, and Robert Bigelow—have invested millions if not billions of dollars into commercializing space. They are developing new technologies and establishing space enterprises that can bring the wealth of outer space down to Earth. This is not a pipe dream, but will increasingly be the economic reality of the 2020s. These wealthy space entrepreneurs see major new economic opportunities. To them space represents the last great frontier for enterprising pioneers. Th us they see an ever-expanding space frontier that offers opportunities in low-cost space transportation, satellite solar power satellites to produce clean energy 24h a day, space mining, space manufacturing and production, and eventually space habitats and colonies as a trajectory to a better human future. Some even more visionary thinkers envision the possibility of terraforming Mars, or creating new structures in space to protect our planet from cosmic hazards and even raising Earth’s orbit to escape the rising heat levels of the Sun in millennia to come. Some, of course, will say this is sci-fi hogwash. It can’t be done. We say that this is what people would have said in 1900 about airplanes, rocket ships, cell phones and nuclear devices. The skeptics laughed at Columbus and his plan to sail across the oceans to discover new worlds. When Thomas Jefferson bought the Louisiana Purchase from France or Seward bought Alaska, there were plenty of naysayers that said such investment in the unknown was an extravagant waste of money. A healthy skepticism is useful and can play a role in economic and business success. Before one dismisses the idea of an impending major new space economy and a new gold rush, it might useful to see what has already transpired in space development in just the past five decades. The world’s first geosynchronous communications satellite had a throughput capability of about 500 kb / s. In contrast, today’s state of the art Viasat 2 —a half century later— has an impressive throughput of some 140 Gb/s. Th is means that the relative throughput is nearly 300,000 greater, while its lifetime is some ten times longer (Figs. 1.1 and 1.2 ). Each new generation of communications satellite has had more power, better antenna systems, improved pointing and stabilization, and an extended lifetime. And the capabilities represented by remote sensing satellites , meteorological satellites , and navigation and timing satellites have also expanded their capabilities and performance in an impressive manner. When satellite applications first started, the market was measured in millions of dollars. Today commercial satellite services exceed a quarter of a billion dollars. Vital services such as the Internet, aircraft traffi c control and management, international banking, search and rescue and much, much more depend on application satellites. Th ose that would doubt the importance of satellites to the global economy might wish to view on You Tube the video “If Th ere Were a Day Without Satellites?” [ 2 ]. Let’s check in on what some of those very rich and smart guys think about the new space economy and its potential. (We are sorry to say that so far there are no female space billionaires, but surely this, too, will come someday soon.) Of course this twenty-fi rst century breakthrough that we call the New Space economy will not come just from new space commerce. It will also come from the amazing new technologies here on Earth. Vital new terrestrial technologies will accompany this cosmic journey into tomorrow. Information technology, robotics, artificial intelligence and commercial space travel systems have now set us on a course to allow us humans to harvest the amazing riches in the skies—new natural resources, new energy, and even totally new ways of looking at the purpose of human existence. If we pursue this course steadfastly, it can be the beginning of a New Space renaissance. But if we don’t seek to realize our ultimate destiny in space, Homo sapiens can end up in the dustbin of history—just like literally millions of already failed species. In each and every one of the five mass extinction events that have occurred over the last 1.5 billion years on Earth, some 50–80 % of all species have gone the way of the T. Rex, the woolly mammoth, and the Dodo bird along with extinct ferns, grasses and cacti. On the other hand, the best days of the human race could be just beginning. If we are smart about how we go about discovering and using these riches in the skies and applying the best of our new technologies, it could be the start of a new beginning for humanity. Konstantin Tsiokovsky, the Russian astronautics pioneer, who fi rst conceived of practical designs for spaceships, famously said: “A planet is the cradle of mankind, but one cannot live in a cradle forever.” Well before Tsiokovsky another genius, Leonardo da Vinci, said, quite poetically: “Once you have tasted flight, you will forever walk the earth with your eyes turned skyward, for there you have been, and there you will always long to return.” The founder of the X-Prize and of Planetary Resources, Inc., Dr. Peter Diamandis, has much more brashly said much the same thing in quite diff erent words when he said: “The meek shall inherit the Earth. The rest of us will go to Mars.” The New Space Billionaires Peter Diamandis is not alone in his thinking. From the list of “visionaries” quoted earlier, Elon Musk, the founder of SpaceX; Sir Richard Branson, the founder of Virgin Galactic; and Paul Allen, the co-founder of Microsoft and the man who financed SpaceShipOne, the world’s first successful spaceplane have all said the future will include a vibrant new space economy. Th ey, and others, have said that we can, we should and we soon shall go into space and realize the bounty that it can offer to us. Th e New Space enterprise is today indeed being led by those so-called space billionaires , who have an exciting vision of the future. They and others in the commercial space economy believe that the exploitation of outer space may open up a new golden age of astral abundance. They see outer space as a new frontier that can be a great source of new materials, energy and various forms of new wealth that might even save us from excesses of the past. Th is gold rush in the skies represents a new beginning. We are not talking about expensive new space ventures funded by NASA or other space agencies in Europe, Japan, China or India. No, these eff orts which we and others call New Space are today being forged by imaginative and resourceful commercial entrepreneurs. Th ese twenty-fi rst century visionaries have the fortitude and zeal to look to the abundance above. New breakthroughs in technology and New Space enterprises may be able to create an “astral life raft” for humanity. Just as Columbus and the Vikings had the imaginative drive that led them to discover the riches of a new world, we now have a cadre of space billionaires that are now leading us into this New Space era of tomorrow. These bold leaders, such as Paul Allen and Sir Richard Branson, plus other space entrepreneurs including Jeff Bezos of Amazon and Blue Origin, and Robert Bigelow, Chairman of Budget Suites and Bigelow Aerospace, not only dream of their future in the space industry but also have billions of dollars in assets. These are the bright stars of an entirely new industry that are leading us into the age of New Space commerce. These space billionaires, each in their own way, are proponents of a new age of astral abundance. Each of them is launching new commercial space industries. They are literally transforming our vision of tomorrow. These new types of entrepreneurial aerospace companies—the New Space enterprises—give new hope and new promise of transforming our world as we know it today. The New Space Frontier What happens in space in the next few decades, plus corresponding new information technologies and advanced robotics, will change our world forever. These changes will redefi ne wealth, change our views of work and employment and upend almost everything we think we know about economics, wealth, jobs, and politics. Th ese changes are about truly disruptive technologies of the most fundamental kinds. If you thought the Internet, smart phones, and spandex were disruptive technologies, just hang on. You have not seen anything yet. In short, if you want to understand a transition more fundamental than the changes brought to the twentieth century world by computers, communications and the Internet, then read this book. There are truly riches in the skies. Near-Earth asteroids largely composed of platinum and rare earth metals have an incredible value. Helium-3 isotopes accessible in outer space could provide clean and abundant energy. There is far more water in outer space than is in our oceans. In the pages that follow we will explain the potential for a cosmic shift in our global economy, our ecology, and our commercial and legal systems. These can take place by the end of this century. And if these changes do not take place we will be in trouble. Our conventional petro-chemical energy systems will fail us economically and eventually blanket us with a hydrocarbon haze of smog that will threaten our health and our very survival. Our rare precious metals that we need for modern electronic appliances will skyrocket in price, and the struggle between “haves” and “have nots” will grow increasingly ugly. A lack of affordable and readily available water, natural resources, food, health care and medical supplies, plus systematic threats to urban security and systemic warfare are the alternatives to astral abundance. The choices between astral abundance and a downward spiral in global standards of living are stark. Within the next few decades these problems will be increasingly real. By then the world may almost be begging for new, out of- the-box thinking. International peace and security will be an indispensable prerequisite for exploitation of astral abundance, as will good government for all. No one nation can be rich and secure when everyone else is poor and insecure. In short, global space security and strategic space defense, mediated by global space agreements, are part of this new pathway to the future.

### 1NC – SBSP DA

#### The space-for-space economy is beginning to develop now because of private enterprise in space, but the affirmative prevents this development

Weinzierl and Sarang 21 (Matt, PhD in Economics Harvard University, Joseph and Jacqueline Elbling Professor of Business Administration at HBS and a Research Associate at the National Bureau of Economic Research, and Mehak, Research Associate at Harvard Business School and the Lunar Exploration Projects Lead for the MIT Space Exploration Initiative, Harvard Business Review, "The Commercial Space Age is Here," 2/12, <https://hbr.org/2021/02/the-commercial-space-age-is-here>)

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#### That’s key to satellite monitoring, resource management, agriculture, climate change monitoring, and space-based solar power development

Sommariva 20 (Andrea, Italian Institute for International Political Studies, "The Evolution of Space Economy: The Role of the Private Sector and the Challenges for Europe," 12/11, <https://www.ispionline.it/en/pubblicazione/evolution-space-economy-role-private-sector-and-challenges-europe-28604>)

The second factor focuses on spacecraft and space-access costs. NASA has moved from a government-run International Space Station access system to one where the transportation of goods and people relies on private companies, obviously under contract and control of NASA, thus eliminating the monopoly of Lockheed Martin and Boeing. As a result, significant progress has been made in the design and development of cost-effective launch vehicles. Currently, SpaceX has developed a system to reuse the first stage of rockets, which serves to give the initial thrust necessary to overcome Earth's atmosphere. Normally, after doing its job, the first stage came off and fell into the ocean as waste. SpaceX has successfully developed the recovery and reuse of the first stages of rockets, reducing the cost per kilogram of payload by more than 50 percent. These developments provide access to space for many small and medium-sized companies, as well as educational and research institutions. In the near future, the development of the satellite Internet will allow people and companies to connect wherever they are - an effective alternative when terrestrial networks are absent or of poor quality. In addition, satellite technology gives rise to a growing stream of uses, including transportation and logistics efficiency, natural resource management, precision agriculture, environment and climate change monitoring, and makes it a potential source of economic growth, social well-being, and sustainable development. As for the exploration programs, the return to the Moon is now days on the agendas of the major space agencies, such as NASA and ESA. Over the next ten to fifteen years, the use of space resources will be crucial for the success of expeditions to the Moon and other planets. The Moon's resources provide propellant for the in-orbit refueling of spacecraft, reducing their costs[1], and oxygen and water for support systems of the future space station around the Moon (the Gateway project). A new form of public-private partnership is rising, a partnership in which governments will provide initial support in the exploration and the advancement of critical technologies (telecommunications and Moon-Earth navigation), and in the construction of space infrastructure. NASA plans a first exploration mission at the South Pole of the Moon in 2024. The private sector would then take the lead in creating new markets and expanding the presence of humanity in space. SpaceX is developing a vehicle, Starship, for missions to the Moon and beyond. The Starship is a fully reusable launch vehicle. It consists of two stages, the booster and the spacecraft, which in November 2018 Elon Musk renamed Super Heavy and Starship respectively. The overall vehicle architecture includes both the launcher and the vehicle, as well as the infrastructure for the first and subsequent launches, and zero-gravity propellant transfer’s technology. The spacecraft alone is designed to be used, in a first phase, without a booster for both freight and passenger transport. In April 2020, NASA selected a modified version of the Starship as one of three landing systems for the Artemis Program. Moon mining will present also an opportunity to make space based solar power (SBSP) economically feasible. SBSP has been studied for decades. However, the costs of launching such large infrastructure from Earth to geosynchronous orbit (GEO) make these projects economically not feasible. At the SEE Lab-SDA Bocconi, we have initiated a study where the basic idea is to build the SBSP satellite with material from the Moon and to transfer the components to GEO where they would be assembled. Its costs are comparable to a large-scale nuclear power plant. If preliminary results are confirmed by the completion of the study, space based solar power can transform the energy markets of Earth[2], and can give an important contribution to the climate change’s mitigation.

#### SBSP is necessary to reduce emissions and solve climate change

Shtivelman 12 - J.D., Boston University School of Law [Aleksey, 2012, *B. U. J. SCI. & TECH. L. Vol. 18:435*, “SOLAR POWER SATELLITES: THE RIGHT TO A SPOT IN THE WORLD'S HIGHEST PARKING LOT”, Hein Online]

\*\*\*edited for gendered language

Rather than spending millions on land-based solar power projects, it would be much more profitable if these nations invested in SBSP satellites for two reasons. First, although SBSP satellites are much more expensive at the outset, the cost of initial investment is returned in a period of time comparable to what it would take to recoup the investment cost of a land-based solar farm. 113 Second, SBSP satellites generate about eight to ten times as much power as land-based solar farms."l 4 This means that after one and a half years, SBSP satellites would generate eight to ten times the revenue of a land-based solar farm. As a result, countries that currently rely on coal, nuclear or other types of non-clean, non-renewable energy may look to SBSP for their energy needs, and consequently generate a significant spike in demand for orbital locations on the GSO. This increased demand will raise two issues: (1) whether a GSO orbital slot can be owned, and, (2) if not, whether there is a way to allocate the right to access GSO orbital slots for a period of time. A viable legal framework could address both of these issues in a clear and precise manner. The ITU currently allocates slots for telecommunications satellites, but the increased demand for slots in GSO for SBSP satellites may force countries to reevaluate ITU's authority to regulate SBSP satellites.

1. An unsuccessful attempt to appropriate GSO slots

The ITU allocation is one way to solve the problem, but given the physical limitations of the GSO, there is an underlying conflict between the goals of fair and equitable access on one side and the GSO's efficient use on the other.' 5 The conflict arises when developed countries receive priority to access the GSO because they have the demand, infrastructure, and funding to put satellites into orbit, while developing countries without viable satellites also want access the GSO. 116 This a posteriori approach to GSO property rights favors those who are first to apply for frequency and orbital slots and protects those applicants from interference by later users."17 At the same time, developing countries do not favor such a "free-market-approach" to GSO access; on the contrary, they would like a multilateral approach that distributes access to the GSO equitably among all nations. 118 "As feared by the developing States, this a posteriori system [has] provided a few industrialized and rich States with the opportunity of temporarily unlimited use of registered frequencies and orbit positions."' "19 Developing countries feel that they should have equal access to these frequencies and orbital slots. 120

These countries have tried to gain leverage over the GSO resource by advocating for the creation of an administrative agency that would allocate a part of the GSO to each country. In 1976, eight developing countries above the equator claimed sovereign right over the parts of the GSO lying over their territories and called for the administration of the rest of the GSO. 12 ' The Declaration of the First Meeting of Equatorial Countries (the "Bogota Declaration") asserted that these countries had the right to parts of the GSO because the orbit should be considered part of the earth and not outer space. 22 These countries argued that the gravitational force that produces the GSO was defived from their land.' 23 Both developed and developing countries rejected the Bogota Declaration's arguments because its claims were weak: the gravity that produces the orbit (1) is produced by the entire earth, not just these eight nations, and (2) produces all orbits, not just the GSO.124

Another of the arguments in the Bogota Declaration was that there is no legally defined boundary as to where an atmosphere ends and space begins. 125 Furthermore, the Bogota Declaration declared that even the Outer Space Treaty, which provides the basic outline for the peaceful exploration and use of outer space, does not address the issue. 126 While there is no definition that all countries in the world accept regarding the boundary of space, the International Aeronautic Federation recognizes the Karman Line as the edge of the atmosphere and the beginning of space.' 27 The International Aeronautic Federation is a non-governmental organization founded in 1905, for the purpose of encouraging aeronautical and astronautical activities worldwide. 28 It has 100 member countries, including the United States, United Kingdom, Spain, Sweden, South Africa, Mongolia, Korea, Israel, Iran, as well as many others.1 29 For the preceding reasons, the International Aeronautic Federation portrays a widely held view concerning the definition of space. The Karman line is one hundred kilometers above sea level, and that is where the atmosphere becomes so thin that an airplane cannot fly and a spaceship is needed for flight.' 30 The GSO lies more than 35,000 kilometers above sea level, which is approximately 34,900 kilometers higher than the Karman line. Therefore, GSO is well above the demarcation of space that is internationally recognized. For this reason and others, most countries did not accept the Bogota Declaration. Accordingly, the Bogota Declaration was an unsuccessful attempt to appropriate GSO slots.

1. Space law must allow appropriation of space for the good of everyone

The Bogota Declaration was ultimately a failure because it violated internationally accepted principles. According to the Outer Space Treaty of 1967, GSO orbital positions and frequencies cannot be appropriated because no country can appropriate or own space. 31 Ninety-one states have signed this treaty, including the United States, the United Kingdom, Ukraine, Japan, Greece, Denmark, Spain, Uganda, Afghanistan, Iraq and many others. 32 The treaty specifies that outer space is the "province of mankind" and that all activity should be done for the benefit of all of humanity. 133 It would then seem that no country could have exclusive ownership over an orbital position in the GSO or any orbit. 134

Even if the Outer Space Treaty of 1967 prohibits countries from owning orbital slots in the GSO, the slots should still be allocated to countries that will use them, on a first-come, first-served basis. SBSP has so much potential to benefit all of [hu]mankind that if even a single country uses a GSO slot to gather power, the advantage of developing the technology of SBSP may outweigh the argument that all nations should have equal access to space.'3 5 Countries like Tonga that have no capability of sending satellites into orbit should not be able to claim GSO slots because this would prohibit developed countries from placing satellites into orbit that can benefit the whole world.136

The Outer Space Treaty of 1967 likely permits the allocation of GSO slots to individual countries on the condition that the slots are used for SBSP satellites that benefit all mankind.

Countries with orbiting SBSP satellites could meet such conditional requirements in three ways. First, they could be required to provide power to less developed countries. Second, launching countries can help decrease global warming because SBSP satellites provide clean energy. Third, launching countries can lower the cost of solar power systems as they become cheaper and more affordable with time so that many less developed countries around the world will be able to access solar power from space. By satisfying any of these conditions, deployment of SBSP satellites would qualify under the treaty as "use of outer space ... carried out for the benefit and in the interests of all countries."'137 The universal benefits provided by SBSP satellites would therefore be consistent with the treaty's requirement that the use of outer space "shall be the province of all mankind." 138 Thus, while the Outer Space Treaty of 1967 may prohibit ownership of GSO slots, the temporary allocation of GSO slots for the use of SBSP satellites would be compatible with the goals of the treaty. ."

As a result of the need to allow SBSP to have access to the GSO, there will need to be some sort of regulatory structure to GSO slot allocation. If a regulatory organization, such as the ITU, allows licensees to use a particular GSO position and microwave frequency, for a limited period of time, this would appear to satisfy the current international regime under the Outer Space Treaty of 1967. In order to comply with the treaty, countries would not have to surrender their slot or frequency, as they could simply allow other countries to lease the power satellites from them for a period of time. SBSP satellites in GSO would fall within the "province of mankind" requirement of the Outer Space Treaty of 1967 because SBSP can decrease global warming and help less developed countries by providing them with electricity in areas lacking infrastructure. Furthermore, SBSP satellites in GSO would satisfy the "peaceful purposes" requirement of the Outer Space Treaty of 1967 because the satellites are used for commercial power production and cannot be converted into weapons. 139

#### Climate change causes a litany of impacts---food wars, fish wars, oxygen depletion, disease, and it’s a threat multiplier---tech is key to solve!

Wallace-Wells 17 – Deputy Editor NY Magazine, National Fellow New America [David, July 10, *New York Magazine*, “The Uninhabitable Earth, Annotated Edition”, <http://nymag.com/intelligencer/2017/07/climate-change-earth-too-hot-for-humans-annotated.html?gtm=bottom&gtm=top>, accessed 2/1/19]

We published “The Uninhabitable Earth” on Sunday night, and the response since has been extraordinary — both in volume (it is already the most-read article in New York Magazine’s history) and in kind. Within hours, the article spawned a fleet of commentary across newspapers, magazines, blogs, and Twitter, much of which came from climate scientists and the journalists who cover them. Some of this conversation has been about the factual basis for various claims that appear in the article. To address those questions, and to give all readers more context for how the article was reported and what further reading is available, we are publishing here a version of the article filled with research annotations. They include quotations from scientists I spoke with throughout the reporting process; citations to scientific papers, articles, and books I drew from; additional research provided by my colleague Julia Mead; and context surrounding some of the more contested claims. Since the article was published, we have made four corrections and adjustments, which are noted in the annotations (as well as at the end of the original version). They are all minor, and none affects the central project of the story: to apply the best science we have today to the median and high-end “business-as-usual” warming projections produced by the U.N.’s “gold standard” Intergovernmental Panel on Climate Change. But the debate this article has kicked up is less about specific facts than the article’s overarching conceit. Is it helpful, or journalistically ethical, to explore the worst-case scenarios of climate change, however unlikely they are? How much should a writer contextualize scary possibilities with information about how probable those outcomes are, however speculative those probabilities may be? What are the risks of terrifying or depressing readers so much they disengage from the issue, and what should a journalist make of those risks? I hope, in the annotations and commentary below, I have added some context. But I also believe very firmly in the set of propositions that animated the project from the start: that the public does not appreciate the scale of climate risk; that this is in part because we have not spent enough time contemplating the scarier half of the distribution curve of possibilities, especially its brutal long tail, or the risks beyond sea-level rise; that there is journalistic and public-interest value in spreading the news from the scientific community, no matter how unnerving it may be; and that, when it comes to the challenge of climate change, public complacency is a far, far bigger problem than widespread fatalism — that many, many more people are not scared enough than are already “too scared.” In fact, I don’t even understand what “too scared” would mean. The science says climate change threatens nearly every aspect of human life on this planet, and that inaction will hasten the problems. In that context, I don’t think it’s a slur to call an article, or its writer, alarmist. I’ll accept that characterization. We should be alarmed.

I. ‘Doomsday’ Peering beyond scientific reticence. It is, I promise, worse than you think. If your anxiety about global warming is dominated by fears of sea-level rise, you are barely scratching the surface of what terrors are possible, even within the lifetime of a teenager today. And yet the swelling seas — and the cities they will drown — have so dominated the picture of global warming, and so overwhelmed our capacity for climate panic, that they have occluded our perception of other threats, many much closer at hand. Rising oceans are bad, in fact very bad; but fleeing the coastline will not be enough. Indeed, absent a significant adjustment to how billions of humans conduct their lives, parts of the Earth will likely become close to uninhabitable, and other parts horrifically inhospitable, as soon as the end of this century. The most credible prediction of the effects of climate change comes from the U.N.’s Intergovernmental Panel on Climate Change, which issues regular reports synthesizing the latest science. The IPCC’s median business-as-usual projection for warming by 2100 is about four degrees, which would expose half the world’s population to unprecedented heat stress, according to Steven C. Sherwood and Matthew Huber’s landmark study on the subject. “I haven’t learned anything since publishing that paper,” Sherwood, a professor at UNSW Sydney, Kensington, told me. “It looks to me that at that those numbers — four to six degrees — you’d start to see the tropics evacuating, because people wouldn’t be able to live there. It might be less than four degrees. But around four degrees or five degrees, would be the point where people would be finding it unbearable.” It wouldn’t just be heat stress driving people away, he said. “A combination of heat stress and other things. I think you’d start to see crop failures, damage to the biosphere. Keep in mind, in the tropics, two or three degrees takes the environment outside the range of natural variability.” As Richard Alley of Pennsylvania State University told me, “under rapid emissions, by the end of the century, 40 percent of the ability of people to work outside would be lost.” How likely is this median, “business-as-usual” outcome? It’s difficult to say, unfortunately, given how many and how variable the inputs would be for any projections: emissions rates, the pace of technological change, cultural changes, and public policy, all on top of what is already a quite complicated (and not entirely understood) natural system that delivers both amplifying and moderating feedbacks to human-produced greenhouse-gas effects. In some ways, it is easiest to talk about that business-as-usual model, because it holds so many of those variables constant. But, since a number of readers have wondered about those probabilities, I’ll mention a couple of estimates that seemed helpful, to me, in establishing the general lay of the land. In my interview with Michael Oppenheimer, of Princeton, he told me that he’d estimate our chances of staying below the Paris accord’s goal of two-degrees warming at 10 percent. In my interview with Wallace Smith Broecker, of Columbia, he mentioned some research he’d followed whereby researchers ran a single model many, many times to generate a range of probabilities; “The mean was about 3.5 degrees Celsius of warming,” he told me. “But it showed there was something like 15 percent probability that it’d be more than four degrees, just on these model runs.” And in their book Climate Shock: The Economic Consequences of a Hotter Planet, Gernot Wagner and Martin Weitzman estimate a 15 percent chance that we overshoot six degrees. These models make a variety of assumptions, both about natural systems and manmade response, but collectively they do suggest, to me at least, that we have been far too focused on the optimistic possibilities (which bring us to 2100 at or under two degrees warming) and not nearly focused enough on the more dire ones. As Joseph Romm wrote in Climate Change: What Everyone Needs to Know, “Any time this book or any news report cites an IPCC projection of future warming or future climate impacts, it is almost certain that projection represents an underestimate of what is to come.” Even when we train our eyes on climate change, we are unable to comprehend its scope. This past winter, a string of days 60 and 70 degrees warmer than normal baked the North Pole,“This is a little bit shocking,” Ketil Isaksen of the Norwegian Meteorological Institute said of the temperatures. melting the permafrost “When we built the seed vault, there was not even discussion of the permafrost,” Hege Njaa Aschim, the press representative of the organization that oversees the project, told me. But the weather last winter, she said, was “like a Norwegian summer.” “We didn’t come up with the term doomsday vault,” Cary Fowler, the mastermind of the seed vault, told me. “The idea there was to provide an insurance policy, so if anything were to happen to those other facilities, it wouldn’t be an extinction event.” that encased Norway’s Svalbard seed vault — a global food bank nicknamed “Doomsday,” designed to ensure that our agriculture survives any catastrophe, and which appeared to have been flooded by climate change less than ten years after being built. The Doomsday vault is fine, for now: The structure has been secured and the seeds are safe.Fowler was emphatic on this point to me — there had been a wave of press coverage that presented the flooding as something catastrophic, rather than a breach that let meltwater in just 15 or 20 meters down a much-longer tunnel that leads from the exterior of the mountain into the seed vault’s “cathedral” room, from which the storage facilities fan. But treating the episode as a parable of impending flooding missed the more important news. Until recently, permafrost was not a major concern of climate scientists, because, as the name suggests, it was soil that stayed permanently frozen. But Arctic permafrost contains 1.8 trillion tons of carbon,In this paper, it’s calculated by petagrams; 1,672 petagrams is about 1.8 trillion tons. more than twice as muchThis is from Joseph Romm’s Climate Change, page 81 (in the paperback edition). The book was an invaluable resource in researching this article, and I highly recommend it to anyone interested in picking up where this piece leaves off. as is currently suspended in the Earth’s atmosphere. When it thaws and is released, that carbon may evaporate as methane, which is 34 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 86 times as powerful.This is also from Romm, also page 81. You can read more about methane’s greenhouse effects here. In other words, we have, trapped in Arctic permafrost, twice as much carbon as is currently wrecking the atmosphere of the planet, all of it scheduled to be released at a date that keeps getting moved up, partially in the form of a gas that multiplies its warming power 86 times over.There has been a fair amount of criticism of my use of this material. Michael Mann in particular has faulted me for it; in his initial Facebook post about the story, he wrote that “the science doesn’t support the notion of a game-changing, planet-melting methane bomb.” At Climate Feedback, several other scientists took issue with various aspects of my characterization as well. ¶ There is little doubt that this permafrost is melting quickly. According to the IPCC’s Fifth Assessment, by 2100, “it is virtually certain that near-surface permafrost extent at high northern latitudes will be reduced as global mean surface temperature increases, with the area of permafrost near the surface (upper 3.5 m) projected to decrease by 37% (RCP2.6) to 81% (RCP8.5) for the multi-model average.” But there is some important context I did not include here: Few scientists believe there is a substantial risk of methane release from permafrost happening suddenly, or all at once. Also, most of the carbon will likely escape as C02, not methane. In retrospect, I sympathize with those who find misleading the phrase “all of it scheduled to be released at a date that keeps getting moved up.” The schedule I was referring to was the melting, which will take decades; the thawing is a process, not an event. ¶ I believe that my original description of the possibility of the methane release lacked some relevant (reassuring) context. But I do not believe the science was fundamentally misrepresented here: There is that much carbon in the permafrost; the permafrost is melting at accelerating rates; some of the carbon will be released as methane; and methane is a stronger greenhouse gas than carbon dioxide. ¶ My intention in referencing the permafrost was to illustrate, for readers unfamiliar with the particulars of projection models, how many uncertain factors were at play — how many forces we don’t understand, and how possibly significant those forces could be in the warming of the planet. As Joseph Romm writes, “The thawing tundra or permafrost may well be the single most important amplifying carbon-cycle feedback. Yet, none of the Intergovernmental Panel on Climate Change’s climate models include carbon dioxide or methane emissions from warming tundra as a feedback.” He also writes, “A 2011 study by the U.S. National Oceanic and Atmospheric Administration and the National Snow and Ice Data Center found that thawing permafrost will turn the Arctic from a place that stores carbon (a sink) to a place that generates carbon (a source) in the 2020s—and release a hundred billion tons of carbon by 2100.” That study, he says, assumes none of the carbon will be released as methane, and yet still predicts a release “equivalent to half the amount of carbon that has been released into the atmosphere since the dawn of the industrial age.” ¶ To be additionally clear, none of the warming scenarios described in the remainder of this article are built on the premise of a methane release from permafrost. They all extrapolate from the median and high-end IPCC projections for business-as-usual warming. Even if you take issue with my characterization of the threat from permafrost melt, it does not affect my discussion of any of the risks that follow. The permafrost melt is a wild card which could add to those IPCC projections. (Romm calculates it could add a degree of warming by 2100 all on its own.) ¶ For those who are really interested in reading about methane, there are also the clathrates to consider — bubbles of methane at the bottom of the ocean, which many energy companies are now hoping to mine. Speaking about those with me, Lee Kump, a Penn State geoscientist, had this to say: “We haven’t really anticipated these positive feedbacks — for instance, these pockets of methane. That methane starts bubbling out, that’s a potent greenhouse gas. As that spreads throughout the globe, there’s a tremendous potential there for methane hydrates release.” He went on: “As you move towards the poles, we’re already seeing the consequences of warming there in terms of methane release.” Maybe you know that already — there are alarming stories in the news every day, like those, last month, that seemed to suggest satellite data showed the globe warming since 1998 more than twice as fast as scientists had thought (in fact, the underlying story was considerably less alarming than the headlines).This reference to recent, alarming news generated a fair amount of pushback among scientists. We’ve adjusted the text to make clear that, while many outlets did describe the study in these terms — in the Washington Post, for instance: “Satellite temperature data, leaned on sharply by climate change doubters, revised sharply upward”) — the actual news was much less dramatic. There was satellite data that was revised upward, but it was data that had been previously interpreted to be below estimates and adjacent data sets, and was revised to bring it more or less into line with those estimates and data sets (that is, it did not change the big-picture assessment of how fast the planet was warming). In general, I agree with this characterization, by Carl Mears, who wrote the study: “This sentence is true for RSS data,” he told Climate Feedback. “But it’s somewhat misleading due to lack of context.” The paper on which the news was based can be found here. Or the news from Antarctica this past May, when a crack in an ice shelf grew 11 miles in six days, then kept going; the break now has just three miles to go — by the time you read this, it may already have met the open water, where it will drop into the sea one of the biggest icebergs ever, a process known poetically as “calving.”As readers have pointed out, there is a debate within the scientific community about whether this calving is a natural process or the result of climate change. In either case, it is alarming news, given that the ice now loosed into the ocean will melt faster. And, of course, the calving has since occurred. But no matter how well-informed you are, you are surely not alarmed enough. Over the past decades, our culture has gone apocalyptic with zombie movies and Mad Max dystopias, perhaps the collective result of displaced climate anxiety, and yet when it comes to contemplating real-world warming dangers, we suffer from an incredible failure of imagination. The reasons for that are many: the timid language of scientific probabilities, which the climatologist James Hansen once called “scientific reticence”. That paper can be found here. Hansen spoke about this with me: “You’re rewarded in science for not stepping out too rapidly,” he said. in a paper chastising scientists for editing their own observations so conscientiously that they failed to communicate how dire the threat really was; the fact that the country is dominated by a group of technocrats who believe any problem can be solved and an opposing culture that doesn’t even see warming as a problem worth addressing; the way that climate denialism has made scientists even more cautious in offering speculative warnings; the simple speed of change and, also, its slowness, such that we are only seeing effects now of warming from decades pastHansen also spoke about this with me: “The fundamental difficulty is the delayed response — the inertia of the climate system. The ocean is deep and the ice sheets are three kilometers thick, and they don’t respond quickly to what is really a weak forcing. And so the system has only partially responded to the forcing we’ve put up already. There’s more in the pipeline. You’re talking about a system that responds on the timescale of decades to centuries — that’s a different time constant than the political constant.” ; our uncertainty about uncertainty, which the climate writer Naomi Oreskes in particular has suggested stops us from preparing as though anything worse than a median outcome were even possibleOne especially good paper by Oreskes can be found here. ; the way we assume climate change will hit hardest elsewhere, not everywhere; the smallness (two degreesThis is the warming target, in Celsius, of the Paris climate accord agreement. ) and largeness (1.8 trillion tonsThis is the amount of carbon in the permafrost (see note No. 8). ) and abstractness (400 parts per millionThis is the current concentration of CO2 in the atmosphere. ) of the numbers; the discomfort of considering a problem that is very difficult, if not impossible, to solve; the altogether incomprehensible scale of that problem, which amounts to the prospect of our own annihilation; simple fear. But aversion arising from fear is a form of denial, too. In between scientific reticence and science fiction is science itself. This article is the result of dozens of interviews and exchanges with climatologists and researchers in related fields and reflects hundreds of scientific papers on the subject of climate change. What follows is not a series of predictions of what will happen — that will be determined in large part by the much-less-certain science of human response. Instead, it is a portrait of our best understanding of where the planet is heading absent aggressive action. It is unlikely that all of these warming scenarios will be fully realized, largely because the devastation along the way will shake our complacency. But those scenarios, and not the present climate, are the baseline. In fact, they are our schedule.These five sentences were the focal point of much of the debate among scientists surrounding this piece: Were they explicit enough to explain to readers that this article would be a tour of worst-case scenarios, and was not intended to be read as a prediction of likely outcomes? And furthermore, was such a worst-case-scenario tour irresponsible, given that they are not the most likely scenarios? For some of the most thoughtful commentary on all sides of the debate, I recommend reading the essays by Susan Matthews, David Roberts, and Robinson Meyer. The present tense of climate change — the destruction we’ve already baked into our future — is horrifying enough.Joseph Romm, in Climate Change: “Many cornerstone elements of our climate began changing far faster than most scientists had projected. The Arctic began losing sea ice several decades ahead of every single climate model used by the IPCC, which in turn means the Arctic region warmed up even faster than scientists expected. At the same time, the great ice sheets of Greenland and Antarctica, which contain enough water to raise sea levels ultimately 25–80 meters (80–260 feet), have begun disintegrating ‘a century ahead of schedule,’ as Richard Alley, a leading climatologist put it in 2005. In 2014 and 2015, we learned that both ice sheets are far less stable than we realized, and they are dangerously close to tipping points that would lead to irreversible collapse and dramatic rates of sea level rise.” Most people talk as if Miami and Bangladesh still have a chance of surviving; most of the scientists I spoke with assume we’ll lose them within the century, even if we stop burning fossil fuel in the next decade.Peter Ward told me Bangladesh is “doomed”: “The worst place on earth has to be Bangladesh, because it’s not just the covering, it’s the sideways salt problem that will doom them.The scary thing is that, the direct cover is what people cite, but they ignore, to date, the sideways infiltration of salt. And this, again, just a slight rise in sea level causes a huge problem. And, as you know, as the sea level rises, it’s like a diving board for storm surge. You’re causing storm surge to jump ever further inland, and that in itself means huge inundation — it doesn’t have to be the rise to destroy the crops. It’s just a bad, bad situation. Bangladesh — you cover it up, where are those people going to go?” ¶ In Bangladesh, 40 percent of land is projected to be lost with just 65 centimeters (just over two feet) sea-level rise. Could some of this flooding be avoided if the world zeroed out emissions immediately and entirely (if the Paris accords legislated 100 percent carbon-neutral energy and industry and land use)? Some, possibly. But one 2012 study by Climate Analytics suggested that even if the planet eliminated emissions entirely by 2016 a best-possible-case outcome would be sea-level rise of 59 centimeters by 2100 — just about exactly that two feet of rise that would cover 40 percent of the country. ¶ A few of the other scientists I spoke with weren’t quite as definitive as Ward, but in general agreed that no plausible emissions-reduction regime could stop the planet from reaching about 1.5 degrees warming by the end of the century, which will produce some quite problematic sea-level effect. “Forty or 50 years from now we’ll be at doubled carbon dioxide,” Wallace Smith Broecker told me. “And that will be away above — we may not be above two degrees at that point, because the ocean is sucking up a lot of heat, and we have to heat up the ocean. And that’s one thing — the melting of the ice. Of course that involves almost all the major cities in the world, which are on the ocean. Bangladesh and Florida and so forth.” That same two-foot sea-level rise would increase flooding in Miami Beach and other Miami barrier islands about a hundredfold, according to Doug Marcy of the NOAA, working from data centered on nearby Virginia Key. Here is one good report on the threat to Miami and South Florida generally. Two degrees of warming used to be considered the threshold of catastrophe: tens of millions of climate refugees unleashed upon an unprepared world.James Hansen has been especially vocal about the risks of a two-degrees-warmer world. Now two degrees is our goal, per the Paris climate accords, and experts give us only slim odds of hitting it.For instance, this expert. The U.N. Intergovernmental Panel on Climate Change issues serial reports, often called the “gold standard” of climate research; the most recent one projects us to hit four degrees of warming by the beginning of the next century, should we stay the present course. But that’s just a median projection. The upper end of the probability curve runs as high as eight degreesSee the U.N,’s Summary for Policymakers. — and the authors still haven’t figured out how to deal with that permafrost melt. The IPCC reports also don’t fully account for the albedo effect (less ice means less reflected and more absorbed sunlight, hence more warming); more cloud cover (which traps heat)At Climate Feedback, Ted Letcher calls this a “gross oversimplification.” However, he goes on to say that, “The IPCC report does generally show a net positive cloud feedback, indicating global cloud feedbacks will lead to additional warming.” ; or the dieback of forests and other flora (which extract carbon from the atmosphere).Some of these effects are included in the IPCC reports, but this assessment of how fully they’ve been incorporated comes from a fact-checking conversation with Michael Oppenheimer (separate from the original reporting interview). Oppenheimer is not only one of the world’s leading authorities on climate change, he has also been closely involved through the years with the IPCC project. Some scientists have argued that the IPCC has modeled some of these effects, and they are correct in the sense that the reports include many, many divergent models, emphasized to different degrees and given different amounts of prominence in their reports. But on the question of just how fully those reports account for these effects, I’m with Oppenheimer. Each of these promises to accelerate warming,As some scientists have pointed out, there are also feedback loops that work in the opposite direction, though they are generally considered to be less powerful, so that the net effect remains “positive” (that is, amplifying warming). As Joseph Romm points out, “In 2011, Science published a major review, ‘Lessons from Earth’s Past,’ which suggested that carbon dioxide ‘may have at least twice the effect on global temperatures than currently projected by computer models.’” and the history of the planet shows that temperature can shift as much as five degrees Celsius within thirteen years.This phrase has been updated to more accurately reflect the rate of warming during the Paleocene–Eocene Thermal Maximum. The last time the planet was even four degrees warmer, Peter Brannen points out in The Ends of the World, his new history of the planet’s major extinction events,Brannen’s book is a very engaging way into the history of mass extinctions (and he was a very helpful interview, too). This sentence was updated to correct a reference to Brannen’s book. the oceans were hundreds of feet higher.\* The Earth has experienced five mass extinctionsHere is an even shorter way into the history. before the one we are living through now,In their book Dire Predictions, Michael Mann and Lee Kump estimate that four degrees of warming would eliminate between 40 and 70 percent of the world’s species. At 2.2 degrees, we’d lose between 15 and 37 percent. each so complete a slate-wiping of the evolutionary record it functioned as a resetting of the planetary clock,“To me, the mass extinctions were really interesting in terms of what happens after them — we have this dead period, and the recovery fauna is totally different,” Peter Ward told me. “And that leads to the idea of, Gee, how much longer will the recovery be if we have an extinction now?” and many climate scientists will tell you they are the best analog for the ecological future we are diving headlong into.“To find analogue worlds for the future, we have to go way back in Earth’s history,” Lee Kump told me. “Each of these events, including the modern situation, starts with a trigger. In the past it’s been a volcanic eruption, now it’s fossil-fuel burning, but it’s a very analogous perturbation to the system. But then it’s amplified by hidden feedbacks that get activated from the initial warming, and bring that warming even further.” Unless you are a teenager, you probably read in your high-school textbooks that these extinctions were the result of asteroids. In fact, all but the one that killed the dinosaurs were caused by climate change produced by greenhouse gas.“Impact was key, and king, for the 1980s and 1990s — every one of the big extinctions was attributed to impact,” Peter Ward told me. “But it became clear that, in fact, no, these were not impact extinctions. We had to invent a new term. I don’t know who came up with it first, but I was in there pretty early calling them greenhouse extinctions. And this new paradigm started coming into play. We’re even starting to see that K–T [the extinction that killed off the dinosaurs] also has a greenhouse component — because there was warming right at the impact.” The most notorious was 252 million years ago; it began when carbon warmed the planet by five degrees, accelerated when that warming triggered the release of methane in the Arctic, and ended with 97 percent of all life on Earth dead.For more about the end-Permian mass extinction, see this National Geographic article, this article from Phys.org, and my interview with Peter Ward. In Climate Feedback’s scientist survey, Lee Kump took issue with my description of the role of methane in the end-Permian extinction: “Whether methane was released remains speculative, although not unlikely.” Speaking about the same extinction event to me, he was much less equivocal: “That was triggered by volcanic eruption — in this case in Siberia, one of the biggest volcanic events of all time. And that had the predictable effects — release of CO2, methane, and ultimately mass extinctions.” We are currently adding carbon to the atmosphere at a considerably faster rate; by most estimates, at least ten times faster.“Maximum rates of carbon emissions for both the PETM and the end-Permian is about 1 billion tons of carbon, and right now we’re at 10 billion tons of carbon,” Lee Kump told me. “The duration of both of those events was much longer than fossil-fuel burning will go on, and so the total amount is lower — but not by a factor of ten. By a factor of two or three.” According to the World Bank, “The present CO2 concentration is higher than paleoclimatic and geologic evidence indicates has occurred at any time in the last 15 million years.” The rate is accelerating.“It’s going completely in the wrong direction, with no sign that the planet as a whole has the problem under control,” Kevin Trenberth, a senior scientist at the National Center for Atmospheric Research, told Inside Climate News. As Joseph Romm puts it, “The current rate of increase in global warming is roughly the same as detonating 400,000 Hiroshima bombs per day, 365 days per year.” This is what Stephen Hawking had in mind when he said, this spring, that the species needs to colonize other planets in the next century to survive, and what drove Elon Musk, last month, to unveil his plans to build a Mars habitat in 40 to 100 years. These are nonspecialists, of course, and probably as inclined to irrational panic as you or I. But the many sober-minded scientists I interviewed over the past several months — the most credentialed and tenured in the field, few of them inclined to alarmism and many advisers to the IPCC who nevertheless criticize its conservatism — have quietly reached an apocalyptic conclusion, too: No plausible program of emissions reductions alone can prevent climate disaster.See, for instance, my interviews with James Hansen and Wallace Smith Broecker. 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 (and even echoes the biblical “dominion”). And 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 Wallace Smith Broecker, the avuncular oceanographer who coined the term “global warming,” means when he calls the planet an “angry beast.”“The climate system is an angry beast and we are poking it with sticks.” You could also go with “war machine.” Each day we arm it more.

II. Heat Death

The bahraining of New York. In the sugar­cane region of El Salvador, as much as one-fifth of the population has chronic kidney disease, the presumed result of dehydration from working the fields they were able to comfortably harvest as recently as two decades ago. Photo: Heartless Machine Humans, like all mammals, are heat engines; surviving means having to continually cool off, like panting dogs. For that, the temperature needs to be low enough for the air to act as a kind of refrigerant, drawing heat off the skin so the engine can keep pumping. At seven degrees of warming, that would become impossible for large portions of the planet’s equatorial band, and especially the tropics, where humidity adds to the problemThis is from the landmark paper on the subject, by Steven C. Sherwood and Matthew Huber. ; in the jungles of Costa Rica, for instance, where humidity routinely tops 90 percent, simply moving around outside when it’s over 105 degrees Fahrenheit would be lethal. You can use this rough wet-bulb-temperature calculator to explore other circumstances. And the effect would be fast: Within a few hours, a human body would be cooked to death from both inside and out. This is based on research by Sherwood, which can be found here. Climate-change skeptics point out that the planet has warmed and cooled many times before, but the climate window that has allowed for human life is very narrow, even by the standards of planetary history. At 11 or 12 degrees of warming, more than half the world’s population, as distributed today, would die of direct heat.Sherwood and Huber again. Things almost certainly won’t get that hot this century, though models of unabated emissions do bring us that far eventually.“One of the problems in the IPCC is that they only want to focus on what happens in the year 2100. If you go out to 2300, it’s not hard to get past six degrees — half the models do that,” Sherwood told me by phone. Later, by email, he added: “Several of the models run for the last IPCC report eventually reach more than 10C of warming under a no-mitigation scenario (though not until the next century or the one after). You could say it is unlikely. Most models eventually exceed 6C though, so this is actually unlikely \*not\* to happen without mitigation!” This century, and especially in the tropics, the pain points will pinch much more quickly even than an increase of seven degrees. The key factor is something called wet-bulb temperature, which is a term of measurement as home-laboratory-kit as it sounds: the heat registered on a thermometer wrapped in a damp sock as it’s swung around in the air (since the moisture evaporates from a sock more quickly in dry air, this single number reflects both heat and humidity). At present, most regions reach a wet-bulb maximum of 26 or 27 degrees Celsius; the true red line for habitability is 35 degrees. What is called heat stress comes much sooner.Sherwood and Huber again. Actually, we’re about there already. Since 1980, the planet has experienced a 50-fold increase in the number of places experiencing dangerous or extreme heatThe original paper is by James Hansen, though for this and much of my account of extreme heat events I relied on Joseph Romm’s Climate Change. ; a bigger increase is to come. The five warmest summers in Europe since 1500 have all occurred since 2002,This is from the World Bank’s very helpful 2012 report Turn Down the Heat, on life in a world four degrees warmer. and soon, the IPCC warns, simply being outdoors that time of year will be unhealthy for much of the globe.The warning appears on page 15 of the Fifth Assessment’s Synthesis Report. As some readers have pointed out, these effects will come about gradually, beginning with the rare unusually hot day; those unusually hot days will gradually become more frequent in number. As with all of the climate effects in this article, it’s important to remember that heat stress is not a binary matter: It’s not that there are two options, lethal heat waves and normal, comfortable temperatures, but that global warming will gradually bring about more and more heat stress. The same is true, of course, for effects on agriculture, economics, conflict, and other areas. As Richard Alley told me, “We’ve warmed the world one degree. The general impression is that each degree is more costly, more damaging, than the previous one. The first degree — most estimates are that the first degree was almost free. But we can see a dotted line into Syria. The second degree will cost more than the first degree. You might say it costs the square of the warming.” Even if we meet the Paris goals of two degrees warming, cities like Karachi and Kolkata will become close to uninhabitable, annually encountering deadly heat waves like those that crippled them in 2015.“Even if such aspirations are realized, large increases in the frequency of deadly heat should be expected, with more than 350 million more megacity inhabitants afflicted by midcentury,” this paper warns. At four degrees, the deadly European heat wave of 2003, which killed as many as 2,000 people a day, will be a normal summer. Also from Turn Down the Heat. At six, according to an assessment focused only on effects within the U.S. from the National Oceanic and Atmospheric Administration, summer labor of any kind would become impossible in the lower Mississippi Valley, and everybody in the country east of the Rockies would be under more heat stress than anyone, anywhere, in the world today.The report can be found here. As Joseph Romm has put it in his authoritative primer Climate Change: What Everyone Needs to Know, heat stress in New York City would exceed that of present-day Bahrain, one of the planet’s hottest spots, and the temperature in Bahrain “would induce hyperthermia in even sleeping humans.”This is from page 138, though it refers to the same NOAA study mentioned above. The high-end IPCC estimate, remember, is two degrees warmer still. By the end of the century, the World Bank has estimated, the coolest months in tropical South America, Africa, and the Pacific are likely to be warmer than the warmest months at the end of the 20th century.See Turn Down the Heat. Air-conditioning can help but will ultimately only add to the carbon problem; plus, the climate-controlled malls of the Arab emirates aside, it is not remotely plausible to wholesale air-condition all the hottest parts of the world, many of them also the poorest.The air-conditioning/carbon trade-off is especially acute in developing countries. And indeed, the crisis will be most dramatic across the Middle East and Persian Gulf, where in 2015 the heat index registered temperatures as high as 163 degrees Fahrenheit.This was in Iran. As soon as several decades from now, the hajj will become physically impossible for the 2 million Muslims who make the pilgrimage each year.This study, by Jeremy S. Pal and Elfatih A. B. Eltahir, was also written about in the New York Times. It is not just the hajj, and it is not just Mecca; heat is already killing us. In the sugarcane region of El Salvador, as much as one-fifth of the population has chronic kidney disease, including over a quarter of the men, the presumed result of dehydration from working the fields they were able to comfortably harvest as recently as two decades ago.A good account of this phenomenon appeared in Australia’s The Age (flagged for me by Steven Sherwood). With dialysis, which is expensive, those with kidney failure can expect to live five years; without it, life expectancy is in the weeks.“Average life expectancy on dialysis is 5–10 years,” the National Kidney Foundation estimates. Of course, heat stress promises to pummel us in places other than our kidneys, too. As I type that sentence, in the California desert in mid-June, it is 121 degrees outside my door.This was in Palm Springs. It is not a record high.But close.

III. The End of Food

Praying for cornfields in the tundra. Climates differ and plants vary, but the basic rule for staple cereal crops grown at optimal temperature is that for every degree of warming, yields decline by 10 percent.The major paper on this subject is by David S. Battisti and Rosamond L. Naylor. Some estimates run as high as 15 or even 17 percent.“Under optimal conditions — these are controlled plots, where they have irrigation and pesticides — you get this kind of typical, between 10 percent and 17 percent decline for every degree Celsius of increase,” David Battisti told me. “But people will say, ‘What about the carbon fertilization?’” That has been thought to aid plant growth, a kind of airborne fertilizer. “Everything I’ve seen about CO2 fertilization — none of it is helpful for grains. It might be helpful for biomass, but it’s not helpful for grains. And so, yeah, if you want to eat the leaves of the wheat plant, it might be okay. But if you want to eat the wheat, it’s not necessarily good.” Which means that if the planet is five degrees warmer at the end of the century, we may have as many as 50 percent more people to feed and 50 percent less grain to give them.In my interview with Battisti, I suggested this arithmetic: four or five degrees warming means 50 or 60 percent drop in yields, for a population that will be 50 to 75 percent higher. “That’s right, that’s right,” he said. “Yup, yup. And there are some things you could do. You could have some of these countries develop and not turn to a meat diet, which would help a little bit. Obviously, when people get wealthier their diet shifts more to a meat diet, which means you need grain to feed cows and pigs and chickens. And every country — even India is shifting to be more meat consumption per person, though it’s a small shift because of religious reasons, but every other country lies on the same curve. As the income goes up, the consumption of meat goes up. Which means the demand for grains will go through the roof.” And proteins are worse: It takes 16 calories of grain to produce just a single calorie of hamburger meat,Battisti: “There are these seed-conversion rates that range from a factor of— very low is three, three kilograms of protein that you feed a fish for one kilogram you get out of it. For beef, it’s ten. And, you end up with massive amounts of grain to feed pigs and chickens.” butchered from a cow that spent its life polluting the climate with methane farts.Cows both burp and fart methane, although the burps are actually worse; National Geographic recently wrote that cow burps are responsible for 26 percent of U.S. methane release. Pollyannaish plant physiologists will point out that the cereal-crop math applies only to those regions already at peak growing temperature, and they are right — theoretically, a warmer climate will make it easier to grow corn in Greenland. But as the pathbreaking work by Rosamond Naylor and David Battisti has shown, the tropics are already too hot to efficiently grow grain, and those places where grain is produced today are already at optimal growing temperature — which means even a small warming will push them down the slope of declining productivity.“If you’re beyond the optimal temperature, as in the tropics, as you increase temperature, yields decline,” Battisti said. “In the mid-latitudes, people haven’t worried so much, because we live near the optimal temperature for growing grains. But the thing is, there’s a lot of natural variability in growing-season temperature in the mid-latitudes, compared to the tropics. Tropics are steady. So you have this same wobbling around of temperatures, but I’ve warmed enough so I’m now on the downside of that optimal slope, than it means you’re wobbling all over the slope, anything from perfectly warm conditions, like we have today, to way too warm, as we have today in the tropics. So the volatility in the yield will go through the roof. And our calculations show that. By 2050, under a typical middle-of-the-road emissions scenario, you’re looking at a doubling of the volatility for grains in the mid-latitudes. In places like China, the U.S., Europe, Ukraine — the breadbasket countries of the world — the volatility from year to year just from natural climate variability at a higher temperature is going to much higher. The impact on the crops is going to be greater and greater.” And you can’t easily move croplands north a few hundred miles, because yields in places like remote Canada and Russia are limited by the quality of soil there; it takes many centuries for the planet to produce optimally fertile dirt.“Pretty much all the arable land worth farming is already being farmed, so I’m not sure you can say where to go,” Battisti told me. So warming couldn’t help production at higher latitudes? I asked. “No, no. You’d really have no change in higher latitudes, simply because it takes a long time for soil to be prepared to grow grain. A lot of places, you go north in Canada, you run out of soil. You run out of conditions to grow. Part of it is climate, and part of it is grow quality. There was a pretty big piece of ice up there not so long ago, and there’s not enough topsoil to grow grains.” According to the U.N.’s Food and Agriculture Organization, it takes about 1,000 years for three centimeters of topsoil to form. Drought might be an even bigger problem than heat, with some of the world’s most arable land turning quickly to desert.“As much as one third of the Earth’s currently habited and arable land faces a near permanent drying this century,” Joseph Romm writes in Climate Change. Precipitation is notoriously hard to model, yet predictions for later this century are basically unanimous: unprecedented droughts nearly everywhere food is today produced.Peter Brannen, in Ends of the World: “By the year 2050, according to a 2014 MIT study, there will also be 5 billion people living in water-stressed areas.” By 2080, without dramatic reductions in emissions, southern Europe will be in permanent extreme drought, much worse than the American dust bowl ever was.See “Global warming and 21st century drying,” a 2014 study led by Benjamin I. Cook. The same will be true in Iraq and Syria and much of the rest of the Middle East; some of the most densely populated parts of Australia, Africa, and South America; and the breadbasket regions of China.This is from Romm, page 99. None of these places, which today supply much of the world’s food, will be reliable sources of any. As for the original dust bowl: The droughts in the American plains and Southwest would not just be worse than in the 1930s, a 2015 NASA study predicted, but worse than any droughts in a thousand years — and that includes those that struck between 1100 and 1300, which “dried up all the rivers East of the Sierra Nevada mountains” and may have been responsible for the death of the Anasazi civilization.The quote is Romm, working off this study, summarized here. Remember, we do not live in a world without hunger as it is. Far from it: Most estimates put the number of undernourished at 800 million globally.Technically, the World Hunger Organization puts the number at 795 million. In case you haven’t heard, this spring has already brought an unprecedented quadruple famine to Africa and the Middle East; the U.N. has warned that separate starvation events in Somalia, South Sudan, Nigeria, and Yemen could kill 20 million this year alone.Read about it from the U.N. here.

IV. Climate Plagues

What happens when the bubonic ice melts? Rock, in the right spot, is a record of planetary history, eras as long as millions of years flattened by the forces of geological time into strata with amplitudes of just inches, or just an inch, or even less. Ice works that way, too, as a climate ledger, but it is also frozen history, some of which can be reanimated when unfrozen. There are now, trapped in Arctic ice, diseases that have not circulated in the air for millions of years — in some cases, since before humans were around to encounter them.The BBC recently covered this well. Which means our immune systems would have no idea how to fight back when those prehistoric plagues emerge from the ice. The Arctic also stores terrifying bugs from more recent times. In Alaska, already, researchers have discovered remnants of the 1918 flu They actually extracted it from the cadaver of a frozen woman. that infected as many as 500 million and killed as many as 100 million — about 5 percent of the world’s population and almost six times as many as had died in the world war for which the pandemic served as a kind of gruesome capstone. As the BBC reported in May, scientists suspect smallpox and the bubonic plague are trapped in Siberian ice, too — an abridged history of devastating human sickness, left out like egg salad in the Arctic sun. Experts caution that many of these organisms won’t actually survive the thaw and point to the fastidious lab conditions under which they have already reanimated several of them — the 32,000-year-old “extremophile” bacteria revived in 2005,This one came immediately back to life. an 8 million-year-old bug brought back to life in 2007,This one grew very slowly when revived. the 3.5 million–year–old one a Russian scientist self-injected just out of curiosity“Just to see what would happen,” as Vice wrote in their profile of the scientist. Watch him on YouTube, here. — to suggest that those are necessary conditions for the return of such ancient plagues.Jean-Michel Claverie and colleagues, for instance, have published on this debate. But already last year, a boy was killed and 20 others infected by anthrax released when retreating permafrost exposed the frozen carcass of a reindeer killed by the bacteria at least 75 years earlier; 2,000 present-day reindeer were infected, too, carrying and spreading the disease beyond the tundra.The Guardian had a good news story about this episode; anthrax had not previously been seen in the region since 1941. What concerns epidemiologists more than ancient diseases are existing scourges relocated, rewired, or even re-evolved by warming. The first effect is geographical. Before the early-modern period, when adventuring sailboats accelerated the mixing of peoples and their bugs, human provinciality was a guard against pandemic. Today, even with globalization and the enormous intermingling of human populations, our ecosystems are mostly stable, and this functions as another limit, but global warming will scramble those ecosystems and help disease trespass those limits as surely as Cortés did. You don’t worry much about dengue or malaria if you are living in Maine or France. But as the tropics creep northward and mosquitoes migrate with them, you will. You didn’t much worry about Zika a couple of years ago, either. As it happens, Zika may also be a good model of the second worrying effect — disease mutation. One reason you hadn’t heard about Zika until recently is that it had been trapped in Uganda; another is that it did not, until recently, appear to cause birth defects. Scientists still don’t entirely understand what happened, or what they missed.One of the major problems here is that scientists lack much data about how Zika has affected humans in the past. For some hypotheses about this mystery, see this reporting by Time. But there are things we do know for sure about how climate affects some diseases: Malaria, for instance, thrives in hotter regions not just because the mosquitoes that carry it do, too, but because for every degree increase in temperature, the parasite reproduces ten times faster.The effect varies based on latitude, humidity, and other factors, but this research is a good place to start reading. Which is one reason that the World Bank estimates that by 2050, 5.2 billion people will be reckoning with it.“The total population at risk in 2050 is projected to be about 5.2 billion if only climate impacts are considered,” the World Bank says in Turn Down the Heat. To be clear, “reckoning” does not mean that 5.2 billion people will be infected with malaria, but that that many people will live in conditions where they could potentially be infected.

V. Unbreathable Air

A rolling death smog that suffocates millions. Our lungs need oxygen, but that is only a fraction of what we breathe. The fraction of carbon dioxide is growing: It just crossed 400 parts per million, and high-end estimates extrapolating from current trends suggest it will hit 1,000 ppm by 2100. At that concentration, compared to the air we breathe now, human cognitive ability declines by 21 percent. The science on this subject is young, but here are two studies. There is also a good summary of the research and its limitations in Joseph Romm’s Climate Change, pages 112–118. Other stuff in the hotter air is even scarier, with small increases in pollution capable of shortening life spans by ten years.“An increase in pollution particles in the air of 10 micrograms per cubic meter cuts victims’ life expectancy by 9-11 years,” one recent study showed. The warmer the planet gets, the more ozone forms, and by mid-century, Americans will likely suffer a 70 percent increase in unhealthy ozone smog, the National Center for Atmospheric Research has projected.That study is from 2014, and can be found here. By 2090, as many as 2 billion people globally will be breathing air above the WHO “safe” levelFrom Joseph Romm, summarizing a report from the U.K.’s Met Office Hadley Centre. ; one paper last month showed that, among other effects, a pregnant mother’s exposure to ozone raises the child’s risk of autism (as much as tenfold, combined with other environmental factors).This study was published only last month; it considers a number of factors, including exposure to ozone, that in combination increase a child’s risk of autism. Which does make you think again about the autism epidemic in West Hollywood.The cause is as yet unclear, but Los Angeles’s West Hollywood neighborhood has had about three times as many autism diagnoses as would be expected. Already, more than 10,000 people die each day from the small particles emitted from fossil-fuel burning“More than 10,000 people are dying each day from the small particles coming out from fossil-fuel burning,” James Hansen told me, “which is more than have been killed in history from the radiation from nuclear-power plants. It’s an irrational fear of low-level radiation. You have to avoid high levels of radiation, but we know ways to do nuclear which are much safer — that will not explode, that won’t produce a meltdown.” ; each year, 339,000 people die from wildfire smoke, in part because climate change has extended forest-fireThis data is a decade old, and would likely be even higher now. season (in the U.S., it’s increased by 78 days since 1970See here. ). By 2050, according to the U.S. Forest Service, wildfires will be twice as destructive as they are today; in some places, the area burned could grow fivefold.For further reading, see this Forest Service material about the longer fire season. What worries people even more is the effect that would have on emissions, especially when the fires ravage forests arising out of peat. Peatland fires in Indonesia in 1997, for instance, added to the global CO2 release by up to 40 percent,The fires continued into 1998, but the carbon quantification is limited to the previous year; that suggests the estimate is likely too low. and more burning only means more warming only means more burning. There is also the terrifying possibility that rain forests like the Amazon, which in 2010 suffered its second “hundred-year drought” in the space of five years,Obviously, droughts of this scale should no longer, technically, be considered “hundred-year” events. could dry out enough to become vulnerable to these kinds of devastating, rolling forest fires — which would not only expel enormous amounts of carbon into the atmosphere but also shrink the size of the forest. That is especially bad because the Amazon alone provides 20 percent of our oxygen. Not that we’re really at risk of running out of oxygen, even with a significantly diminished Amazon. Then there are the more familiar forms of pollution. In 2013, melting Arctic ice remodeled Asian weather patterns, depriving industrial China of the natural ventilation systems it had come to depend on, which blanketed much of the country’s north in an unbreathable smog.“Today, Shanghai air really has a layered taste,” chef Alan Yu said in 2013. “At first, it tastes slightly astringent with some smokiness. Upon full contact with your palate, the aftertaste has some earthy bitterness, and upon careful distinguishing you can even feel some dust-like particulate matter.” Literally unbreathable.This difficulty was widely reported, but recently China has taken action to reduce its dependence on coal-generated electricity, which will likely help the smog buildup. A metric called the Air Quality Index categorizes the risks and tops out at the 301-to-500 range, warning of “serious aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly” and, for all others, “serious risk of respiratory effects”; at that level, “everyone should avoid all outdoor exertion.”For more information on the Air Quality Index and what it measures, see here and here. The Chinese “airpocalypse” of 2013 peaked at what would have been an Air Quality Index of over 800.Some of these measures vary a bit. That year, smog was responsible for a third of all deaths in the country.In many cases, the smog exacerbated other medical conditions.

VI. Perpetual War

The violence baked into heat. Climatologists are very careful when talking about Syria.“There’s a lot of qualitative narrative evidence linking climate to the Syrian civil conflict,” Marshall Burke of Stanford’s Earth System Science Center told me. “I think some of that’s compelling. But it’s hard to make a quantitative case for any particular conflict that climate was the cause, right? We don’t observe the Syrian civil war in the absence of the drought that happened in 2007, so we don’t have a good experiment.” Michael Mann, director of Pennsylvania State University’s Earth System Science Center, told me this: “The Syrian uprising was driven by another drought that was the worst drought on record — the paleo record suggests the worst in 900 years. Drought is a big one, it’s behind a lot of the conflict that we see.” They want you to know that while climate change did produce a drought that contributed to civil war, it is not exactly fair to say that the conflict is the result of warming; next door, for instance, Lebanon suffered the same crop failures. Of course there are many negative shocks short of civil war. “In 2012,” Peter Brannen writes in Ends of the World, “when the monsoon failed in India (as it’s expected to do in a warmer world), 670 million people — that is, 10 percent of the global population — lost access to power when the grid was crippled by unusually high demand from farmers struggling to irrigate their fields, while the high temperatures sent many Indians seeking kilowatt-chugging air conditioning.” But researchers like Marshall Burke and Solomon Hsiang have managed to quantify some of the non-obvious relationships between temperature and violence“A lot of folks have looked at these relationships, and they’ve been sort of hypothesized for a long time,” Burke told me. “You can find it as far back as Shakespeare and probably even earlier than that — mentions of linkages between climate and human violence. So there’s this nice part in Romeo and Juliet where the good guys are out in the streets — it’s like Benvolio and Mercutio or something — and they’re talking and one of them says to the other, ‘We should go inside. It’s hot out. We’re gonna get pissed off and things are gonna go badly.’ And then all hell breaks loose. That’s how I start every talk on conflict now. ‘This is the Shakespeare reference.’” He continued: “It’s sort of remarkable how clear and replicable the results have been, when you look over the last 20 or 30 years, periods over which we have sort of better conflict data around the world and can do a good job of sort of understanding statistically what the linkages have been. We can look at different types of conflict, and, depending on where you are, there are certain types of conflict and there aren’t certain types of conflict. The iconic civil-war picture people have in their mind, those unfortunately still occur and tend to occur mostly in places like sub-Saharan Africa. So that’s where a lot of the research there is focused. Of course in the U.S., we don’t have civil wars, or at least not for the last 150 years. But we have other types of human violence, and those are pretty well measured in data and we can study those. And across all these different types of violence, again, we see this strong positive relationship between warmer-than-average temperatures and increasing conflict.” : For every half-degree of warming, they say, societies will see between a 10 and 20 percent increase in the likelihood of armed conflict.“When you increase temperature by half a degree, on average you see something like a 10 to 20 percent increase in the risk of conflict,” Burke told me. “Now, that, of course, does not mean that every conflict has something to do with the climate system. We’re not claiming that every conflict has a climate root. But on average climate has worked, as the CIA says, as a threat multiplier for conflict around the world. This just shows up so strongly in the data that we just can’t ignore it, right? We can’t turn away from this historical fact in the data. Do we fully understand that fact? I don’t think so. There are a lot of different potential mechanisms that could link climate to conflict. But it is in the data. So now I think it’s our job as researchers to better understand what are the exact mechanisms that link these two things. And there are a lot of folks working on that. Our team’s working on it. Other folks are. And we have some ideas. But I wouldn’t say there’s a smoking gun in terms of perfectly understanding the linkage. But to ignore the linkage in the data, to me, would be insane. It’s so strongly there, and comes through in so many settings, that it’s just a statistical fact.” In climate science, nothing is simple, but the arithmetic is harrowing: A planet five degrees warmer would have at least half again as many wars as we do today. Overall, social conflict could more than double this century.To read more of Burke and Hsiang’s work on the relationship between climate and conflict, I recommend these two papers. This is one reason that, as nearly every climate scientist I spoke to pointed out, the U.S. military is obsessed with climate changeIn 2015, the Department of Defense released this major report on the impacts of climate change on national security. : The drowning of all American Navy bases by sea-level rise is trouble enough, but being the world’s policeman is quite a bit harder when the crime rate doubles. Of course, it’s not just Syria where climate has contributed to conflict. Some speculate that the elevated level of strife across the Middle East over the past generation reflects the pressures of global warming“The Middle East, where we’ve also seen a lot of this conflict — I don’t think we can rule out potential effects there, either now or in the future,” Burke told me. — a hypothesis all the more cruel considering that warming began accelerating when the industrialized world extracted and then burned the region’s oil. What accounts for the relationship between climate and conflict? Some of it comes down to agriculture and economics “Hot temperatures reduce agricultural productivity, lower crop yields, and, at the margin for farmers who are close to subsistence, this could alter their incentives to start or join a conflict,” Burke told me. “They need resources. They need to put food on the table. And joining a conflict is one way to do that, as I think a long literature has shown. And, again, it’s not like hot temperature is needed to turn everyone into a civil-war insurgent. These civil wars are often started with very small numbers of people. So you only need to affect the decisions of literally handfuls of individuals to get some of these conflicts.” ; a lot has to do with forced migration, already at a record high, with at least 65 million displaced people wandering the planet right now.See here. But there is also the simple fact of individual irritability. “People are more pissed off on Twitter when it’s hot,” Burke told me. “They use frowny face emoticons more often. People commit aggravated assault and homicide more often when it’s hot in the U.S. This has been show pretty clearly. We have new work showing that people commit violence on themselves more often when it’s hot. So you see rates of suicide go up when temperatures are hot. All sorts of human violence — from an individual scale all the way up to a group-level scale — show an increase when you crank up the temperature. The agricultural stuff I think is a plausible explanation for group-scale violence. It is a less plausible explanation for the individual-level stuff.” Heat increases municipal crime rates, and swearing on social media, and the likelihood that a major-league pitcher, coming to the mound after his teammate has been hit by a pitch, will hit an opposing batter in retaliation.The study on baseball retaliation can be found here, and further interesting research between heat and crime here. And the arrival of air-conditioning in the developed world, in the middle of the past century, did little to solve the problem of the summer crime wave.

VII. Permanent Economic Collapse

Dismal capitalism in a half-poorer world. The murmuring mantra of global neoliberalism, which prevailed between the end of the Cold War and the onset of the Great Recession, is that economic growth would save us from anything and everything. But in the aftermath of the 2008 crash, a growing number of historians studying what they call “fossil capitalism”Andreas Malm’s Fossil Capital is the touchstone. have begun to suggest that the entire history of swift economic growth, which began somewhat suddenly in the 18th century, is not the result of innovation or trade or the dynamics of global capitalism but simply our discovery of fossil fuels and all their raw power — a onetime injection of new “value” into a system that had previously been characterized by global subsistence living. Before fossil fuels, nobody lived better than their parents or grandparents or ancestors from 500 years before, except in the immediate aftermath of a great plague like the Black Death, which allowed the lucky survivors to gobble up the resources liberated by mass graves. After we’ve burned all the fossil fuels, these scholars suggest, perhaps we will return to a “steady state” global economy. Of course, that onetime injection has a devastating long-term cost: climate change. The most exciting research on the economics of warming has also come from Hsiang and his colleagues, who are not historians of fossil capitalism but who offer some very bleak analysis of their ownThey’ve also put together a helpful website exploring and illustrating their findings. : Every degree Celsius of warming costs, on average, 1.2 percent of GDP“You see huge responses in GDP to fluctuations in temperature,” Burke told me. “So in hot countries if you crank up the temperature one degree Celsius you lose about one percentage point GDP growth in that year. Instead of growing at 2 percent a year you’re growing at 1 percent a year. So there’s a huge effect.” The precise 1.2 percentage point estimate for GDP loss is for the United States. (an enormous number, considering we count growth in the low single digits as “strong”“It turns out, historically the optimum temperature for producing things is about 13 degrees Celsius,” Burke told me. “That’s what we see in the historical data. And a couple of the largest economies in the world, coincidentally or not, are right at 13 degrees Celsius. So the annual average temperature in the U.S. is right above. It’s 13-point-something, 13.4 degrees Celsius, which is sort of funny to think about. I live out here in the Bay Area and the annual average temperature in Palo Alto, California, is 13 degrees Celsius. Silicon Valley is at the optimum temperature for producing things as measured historically.” ). This is the sterling work in the field, and their median projection is for a 23 percent loss in per capita earning globally by the end of this century (resulting from changes in agriculture, crime, storms, energy, mortality, and labor).That paper is found here. Tracing the shape of the probability curve is even scarier: There is a 12 percent chance that climate change will reduce global output by more than 50 percent by 2100, they say, and a 51 percent chance that it lowers per capita GDP by 20 percent or more by then, unless emissions decline. By comparison, the Great Recession lowered global GDP by about 6 percent, in a onetime shock; Hsiang and his colleagues estimate a one-in-eight chance of an ongoing and irreversible effect by the end of the century that is eight times worse.You can explore this material more here. The scale of that economic devastation is hard to comprehend, but you can start by imagining what the world would look like today with an economy half as big, which would produce only half as much value, generating only half as much to offer the workers of the world. It makes the grounding of flights out of heat-stricken Phoenix last monthThe science of this is fascinating. A crude summary: Hotter air is less dense, which means less lift for planes trying to take off. (Also interestingly, some models are more effective at higher temperatures than others.) seem like pathetically small economic potatoes. And, among other things, it makes the idea of postponing government action on reducing emissions and relying solely on growth and technology to solve the problem an absurd business calculation. Every round-trip ticket on flights from New York to London, keep in mind, costs the Arctic three more square meters of ice.Which does suggest the wisdom of a carbon tax.

VIII. Poisoned Oceans

Sulfide burps off the skeleton coast. That the sea will become a killer is a given.“People are expecting, depending on what we do, maybe two or three feet in the next hundred years,” Richard Alley told me. “But there’s some chance of 15. If you put that in, that’s one that’s clearly concerning. The worst case you can think of is, you build the levees, you tell people it’s safe, West Antarctic collapses, and the levees fail. There’s a bit of worry about the predictability. If it goes fast — and fast would be decades or less, rather than centuries or more — it will probably involve a lot of breakage, a lot of icebergs breaking off. Fracture mechanics is pretty well understood, but the predictability of it … Just think of all the times in your life that you’ve seen somebody drop a ceramic coffee cup on the floor. Do we understand fracture? Sure. Can you accurately predict what one coffee cup will do when you drop it on the floor? Maybe not.” Barring a radical reduction of emissions, we will see at least four feet of sea-level rise and possibly ten by the end of the century.Ten feet is the upper estimate. A third of the world’s major cities are on the coast,See this paper from Gordon McGranahan, Deborah Balk, and Bridget Anderson. When looking just at extremely large cities — those with populations above 5 million — nearly two-thirds are on the coast. not to mention its power plants, ports, navy bases, farmlands, fisheries, river deltas, marshlands, and rice-paddy empires, and even those above ten feet will flood much more easily, and much more regularly, if the water gets that high.“As the sea level rises, it’s like a diving board for storm surge,” Peter Ward told me. “You’re causing storm surge to jump ever farther inland.” At least 600 million people live within ten meters of sea level today.See, again, the paper from McGranahan, Balk, and Anderson. But the drowning of those homelands is just the start. At present, more than a third of the world’s carbon is sucked up by the oceansEstimates vary from about a quarter to about half; this paper suggests 40 percent of all carbon since the beginning of the industrial era has gone into the ocean. Lee Kump’s estimate is higher: “Half of the fossil fuels we’ve burned have gone into the ocean, which has mitigated the warming,” he told me. Then added: “What are the limits to the Earth’s ability to do that? — thank God, or else we’d have that much more warming already. But the result is what’s called “ocean acidification,” which, on its own, may add a half a degree to warming this century.See here. It is also already burning through the planet’s water basins — you may remember these as the place where life arose in the first place. You have probably heard of “coral bleaching” — that is, coral dyingIn fairness, coral bleaching is not quite a true euphemism for coral dying; when corals are stressed, they expel algae, which turns them white. The corals can recover but often do not. — which is very bad news, because reefs support as much as a quarter of all marine life and supply food for half a billion people.Although some scientists believe there is hope for the reefs. Ocean acidification will fry fish populations directly, too, though scientists aren’t yet sure how to predict the effects on the stuff we haul out of the ocean to eatIf you think about the plankton floating around the ocean, they’re at the base of the food chain,” Lee Kump told me. “There’s a cascade of effects up the food chain that can have impacts on food supply for humans especially — that’s associated with coastal fisheries, that sort of thing.” ; they do know that in acid waters, oysters and mussels will struggle to grow their shells,See here. and that when the pH of human blood drops as much as the oceans’ pH has over the past generation, it induces seizures, comas, and sudden death.This is obviously a very loose analogy, but it’s based on material from the Smithsonian. It’s also not an uncommon one; Lee Kump, too, resorted to the analogy of the human body when explaining to me the principle of ocean homeostasis, and what its disruption might mean. “An underlying theoretical framework for that arises from human homeostatic mechanisms,” he said. “We have homeostatic mechanisms for stabilizing body temperature and all different parts of our physiology.” That isn’t all that ocean acidification can do. Carbon absorption can initiate a feedback loop in which underoxygenated waters breed different kinds of microbes that turn the water still more “anoxic,” first in deep ocean “dead zones,” then gradually up toward the surface.“The other thing we should be watching very closely,” Lee Kump told me, “is the expansion of low-oxygen waters — the so-called dead zones in the coastal ocean, where the drop of oxygen is the combined effect of the warming, because the water can just take up less oxygen.” There, the small fish die out, unable to breathe, which means oxygen-eating bacteria thrive, and the feedback loop doubles back.Research on climate change and dead zones can be found here, and is synthesized here. That paper notes: “Given the variety and strength of the mechanisms by which climate change exacerbates hypoxia” — that’s lack of oxygen — “and the rates at which climate is changing, we posit that climate change variables are contributing to the dead zone epidemic.” This process, in which dead zones grow like cancers, choking off marine life and wiping out fisheries, is already quite advanced in parts of the Gulf of Mexico and just off Namibia, where hydrogen sulfide is bubbling out of the sea along a thousand-mile stretch of land known as the “Skeleton Coast.”Read NASA on hydrogen sulfide and the Skeleton Coast. The name originally referred to the detritus of the whaling industry, but today it’s more apt than ever. Hydrogen sulfide is so toxic that evolution has trained us to recognize the tiniest, safest traces of it, which is why our noses are so exquisitely skilled at registering flatulence. Hydrogen sulfide is also the thing that finally did us in that time 97 percent of all life on Earth died, once all the feedback loops had been triggered and the circulating jet streams of a warmed ocean ground to a haltSee this summary of findings by Lee Kump. — it’s the planet’s preferred gas for a natural holocaust. Gradually, the ocean’s dead zones spread, killing off marine species that had dominated the oceans for hundreds of millions of years, and the gas the inert waters gave off into the atmosphere poisoned everything on land. Plants, too. It was millions of years before the oceans recovered.

IX. The Great Filter

Our present eeriness cannot last. So why can’t we see it? In his recent book-length essay The Great Derangement, the Indian novelist Amitav Ghosh wonders why global warming and natural disaster haven’t become major subjects of contemporary fiction — why we don’t seem able to imagine climate catastrophe, and why we haven’t yet had a spate of novels in the genre he basically imagines into half-existence and names “the environmental uncanny.” “Consider, for example, the stories that congeal around questions like, ‘Where were you when the Berlin Wall fell?’ or ‘Where were you on 9/11?’ ” he writes. “Will it ever be possible to ask, in the same vein, ‘Where were you at 400 ppm?’ or ‘Where were you when the Larsen B ice shelf broke up?’ ” His answer: Probably not, because the dilemmas and dramas of climate change are simply incompatible with the kinds of stories we tell ourselves about ourselves, especially in novels, which tend to emphasize the journey of an individual conscience rather than the poisonous miasma of social fate.In general, I’d say Ghosh is more or less accurate in describing the state of the “climate novel,” though there has been a recent rise in disaster fiction. But he is less on point when talking more generally about our narrative culture; our movies and television, for instance, have been littered lately with apocalypse scenarios, not all climate-related but which can probably be understood as in some ways inflected by climate anxiety. Perhaps a more interesting question is not why we have failed to imagine these scenarios, but why we have quarantined them, culturally, as something like parables, rather than stories that impress on us the real-world urgency of climate change. Surely this blindness will not last — the world we are about to inhabit will not permit it. In a six-degree-warmer world, the Earth’s ecosystem will boil with so many natural disasters that we will just start calling them “weather”: a constant swarm of out-of-control typhoons and tornadoes and floods and droughts, the planet assaulted regularly with climate events that not so long ago destroyed whole civilizations. The strongest hurricanes will come more often, and we’ll have to invent new categories with which to describe them; tornadoes will grow longer and wider“In particular, the trail of destruction from tornadoes may be getting longer and wider,” Joseph Romm writes in Climate Change, summarizing the work of James Elsner. and strike much more frequently,The reaction of tornadoes to climate change is not fully understood, but Michael Tippett of Columbia explains that a warming climate will make the circumstances necessary for tornado formation much more common. In Climate Change, Romm quotes Tom Karl, director of NOAA’s National Climatic Data Center saying “What we can say with confidence is that heavy and extreme precipitation events often associated with thunderstorms and convection are increasing and have been linked to human-induced changes in atmospheric composition.” and hail rocks will quadruple in size.Tippett has published dozens of papers on this subject. Also, see this paper by John T. Allen in Nature on the potential of hail increasing in size and frequency due to climate change. Humans used to watch the weather to prophesy the future; going forward, we will see in its wrath the vengeance of the past. Early naturalists talked often about “deep time” — the perception they had, contemplating the grandeur of this valley or that rock basin, of the profound slowness of nature. What lies in store for us is more like what the Victorian anthropologists identified as “dreamtime,” or “everywhen”: the semi-mythical experience, described by Aboriginal Australians, of encountering, in the present moment, an out-of-time past, when ancestors, heroes, and demigods crowded an epic stage. You can find it already watching footage of an iceberg collapsing into the sea — a feeling of history happening all at once. It is. Many people perceive climate change as a sort of moral and economic debt, accumulated since the beginning of the Industrial Revolution and now come due after several centuries — a helpful perspective, in a way, since it is the carbon-burning processes that began in 18th-century England that lit the fuse of everything that followed. But more than half of the carbon humanity has exhaled into the atmosphere in its entire history has been emitted in just the past three decades; since the end of World War II, the figure is 85 percent.The graph of emissions over time is very vivid. Which means that, in the length of a single generation, global warming has brought us to the brink of planetary catastrophe, and that the story of the industrial world’s kamikaze mission is also the story of a single lifetime. My father’s, for instance: born in 1938, among his first memories the news of Pearl Harbor and the mythic Air Force of the propaganda films that followed, films that doubled as advertisements for imperial-American industrial might; and among his last memories the coverage of the desperate signing of the Paris climate accords on cable news, ten weeks before he died of lung cancer last July. Or my mother’s: born in 1945, to German Jews fleeing the smokestacks through which their relatives were incinerated, now enjoying her 72nd year in an American commodity paradise, a paradise supported by the supply chains of an industrialized developing world. She has been smoking for 57 of those years, unfiltered. Or the scientists’. Some of the men who first identified a changing climate (and given the generation, those who became famous were men) are still alive; a few are even still working. Wally Broecker is 84 years old and drives to work at the Lamont-Doherty Earth Observatory across the Hudson every day from the Upper West Side. Like most of those who first raised the alarm, he believes that no amount of emissions reduction alone can meaningfully help avoid disaster. Instead, he puts his faith in carbon capture — untested technology to extract carbon dioxide from the atmosphere, which Broecker estimates will cost at least several trillion dollars — and various forms of “geoengineering,” the catchall name for a variety of moon-shot technologies far-fetched enough that many climate scientists prefer to regard them as dreams, or nightmares, from science fiction.My full interview with Broecker is here. Among the scientists I interviewed for this story, David Battisti was among the most outspoken about the risks of geoengineering of this kind. “It’s really stupid as an insurance policy — to think it’s anything but a Hail Mary pass,” he said. “This is so obvious to us. I’ve worked on it in the past — you don’t have to do very much to show that it’s dangerous. I’d rather see the world go to four degrees warmer than do geoengineering.” He is especially focused on what’s called the aerosol approachScientists at Harvard have recently launched a new research effort into aerosol injection. — dispersing so much sulfur dioxide into the atmosphere that when it converts to sulfuric acid, it will cloud a fifth of the horizon and reflect back 2 percent of the sun’s rays, buying the planet at least a little wiggle room, heat-wise. “Of course, that would make our sunsets very red, would bleach the sky, would make more acid rain,” he says. “But you have to look at the magnitude of the problem. You got to watch that you don’t say the giant problem shouldn’t be solved because the solution causes some smaller problems.” He won’t be around to see that, he told me. “But in your lifetime …” Jim Hansen is another member of this godfather generation. Born in 1941, he became a climatologist at the University of Iowa, developed the groundbreaking “Zero Model” for projecting climate change, and later became the head of climate research at NASA, only to leave under pressure when, while still a federal employee, he filed a lawsuit against the federal government charging inaction on warming (along the way he got arrested a few times for protesting, too).Including for protesting the Keystone XL pipeline. The lawsuit, which is brought by a collective called Our Children’s Trust and is often described as “kids versus climate change,” is built on an appeal to the equal-protection clause, namely, that in failing to take action on warming, the government is violating it by imposing massive costs on future generations; it is scheduled to be heard this winter in Oregon district court.Go here for more information on the case; it could be hugely significant. Hansen has recently given up on solving the climate problem with a carbon tax alone,The word “alone” has been added to to make clear that James Hansen still supports a carbon-tax-based approach to emissions, even though he no longer believes it will be sufficient. which had been his preferred approach, and has set about calculating the total cost of the additional measure of extracting carbon from the atmosphere. Hansen began his career studying Venus, which was once a very Earth-like planet with plenty of life-supporting water before runaway climate change rapidly transformed it into an arid and uninhabitable sphere enveloped in an unbreathable gas; he switched to studying our planet by 30, wondering why he should be squinting across the solar system to explore rapid environmental change when he could see it all around him on the planet he was standing on. “When we wrote our first paper on this, in 1981,” he told me, “I remember saying to one of my co-authors, ‘This is going to be very interesting. Sometime during our careers, we’re going to see these things beginning to happen.’ ” Several of the scientists I spoke with proposed global warming as the solution to Fermi’s famous paradox, which asks, If the universe is so big, then why haven’t we encountered any other intelligent life in it? The answer, they suggested, is that the natural life span of a civilization may be only several thousand years, and the life span of an industrial civilization perhaps only several hundred. In a universe that is many billions of years old, with star systems separated as much by time as by space, civilizations might emerge and develop and burn themselves up simply too fast to ever find one another.In their paper “Anthropic Shadow,” Nick Bostrom and his colleagues explored our difficulty understanding truly existential risks. Because, by definition, human life has evolved to where it is today in the absence of a species-extinguishing event, we present-day human historians are endowed with enormous, accidental overconfidence in our capacity to endure, they suggest. This is another corollary of the anthropic principle: We take the human experience as our only model of evolution, discounting entirely the infinite number of evolutionary branches cut dead at the nub elsewhere in the universe. “As a consequence,” Bostrom and his colleagues write, “we should have no confidence in historically based probability estimates for events that would certainly extinguish humanity.” Peter Ward, a charismatic paleontologist among those responsible for discovering that the planet’s mass extinctions were caused by greenhouse gas, calls this the “Great Filter”: “Civilizations rise, but there’s an environmental filter that causes them to die off again and disappear fairly quickly,” he told me. “If you look at planet Earth, the filtering we’ve had in the past has been in these mass extinctions.”My full interview with Ward ends with his saying, “Go get ’em, man. We need people out there like you. I mean it. Though you’re not going to get thanked for it, you know.” The mass extinction we are now living through has only just begun; so much more dying is coming. And yet, improbably, Ward is an optimist. So are Broecker and Hansen and many of the other scientists I spoke to. We have not developed much of a religion of meaning around climate change that might comfort us, or give us purpose, in the face of possible annihilation. But climate scientists have a strange kind of faith: We will find a way to forestall radical warming, they say, because we must. It is not easy to know how much to be reassured by that bleak certainty, and how much to wonder whether it is another form of delusion; for global warming to work as parable, of course, someone needs to survive to tell the story. The scientists know that to even meet the Paris goals, by 2050, carbon emissions from energy and industry, which are still rising, will have to fall by half each decade; emissions from land use (deforestation, cow farts, etc.) will have to zero out; and we will need to have invented technologies to extract, annually, twice as much carbon from the atmosphere as the entire planet’s plants now do.This road map was laid out in Science and neatly summarized in Vox. Nevertheless, by and large, the scientists have an enormous confidence in the ingenuity of humans — a confidence perhaps bolstered by their appreciation for climate change, which is, after all, a human invention, too. They point to the Apollo project, the hole in the ozone we patched in the 1980s,The Montreal Protocol, which was finalized in 1987, regulated the use of ozone-depleting substances such as CFCs. Its effects in shrinking the ozone hole began to be measurable in 2000. the passing of the fear of mutually assured destruction. Now we’ve found a way to engineer our own doomsday, and surely we will find a way to engineer our way out of it, one way or another. The planet is not used to being provoked like this, and climate systems designed to give feedback over centuries or millennia prevent us — even those who may be watching closely — from fully imagining the damage done already to the planet. But when we do truly see the world we’ve made, they say, we will also find a way to make it livable. For them, the alternative is simply unimaginable.

### 1NC – Primacy DA

#### American space innovation is high and on the rise- but innovation could tank in the absence of private companies

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After publicly stalling out due to cost concerns circa 2011, America’s space race is quickly heating up again. Only instead of NASA, this time it’s being spearheaded through private space exploration by three billionaire investors and the companies that mirror these entrepreneurs’ out-of-this-world ambitions: Richard Branson (Virgin Galactic), Elon Musk (SpaceX) and Jeff Bezos (Blue Origin). Expected to be a $1.4 trillion market by 2030, according to analysts at Bank of America, private space exploration and tourism are already ushering in a host of new innovations outside of traditional aerospace and defense realms. For example: Morgan Stanley suggests that the business world’s growing rush to reach orbit may also help sate the world’s ever-growing appetite for high-speed satellite broadband technology and data, kick-start rocket-fueled delivery services and even enable asteroid mining in years to come. Here, we take a closer look at the field’s three front-runners, how each is pioneering new scientific advancements, and various trickle-down innovations that private space exploration may soon bring back to dozens of industries on planet Earth. Virgin Galactic On July 11—just 17 years after announcing the company—Virgin Group founder Richard Branson took his inaugural trip 53 miles above the Earth’s surface in Virgin Galactic’s suborbital, rocket-powered space plane VSS Unity. Capable of holding six passengers and two pilots, the craft isn’t likely to be earthbound for very long; the company has already sold around 600 tickets for flights at the princely sum of $200,000 to $250,000 apiece. As of early August, more tickets were available starting at $450,000 each. The increasing desire for private space exploration points to companies’ growing desire to more cost-efficiently use resources, leverage emerging or preexisting technology in new ways, optimize processes and workflows, and pioneer new markets by democratizing access to resources and equipment. The first of the billionaire space company founders to reach the edge of space (depending on the definition), Branson did so thanks to myriad scientific and business innovations made by his firm. Advancements not only include a new high-speed aircraft design that leverages modular technology to improve flight rate and maintenance access. They also incorporate a livery design built from a mirrorlike material that provides heightened thermal protection and color-changing potential, a spectacular display of the plane’s advanced capabilities in keeping with Branson’s notoriously flashy brand of showmanship. These upgrades have helped power Virgin Galactic’s ongoing push to capture public and media attention, enticing armchair astronauts to fulfill childhood dreams and fueling a booming business in space tourism. Moreover, unlike traditional crewed rockets, which launch from ground-based locales, Virgin’s ships lift off from bigger planes that drop them off in midair. It’s a highly efficient technique that consumes less fuel and reduces the need for custom launch pad infrastructure. Passengers, who can enjoy three to five minutes of weightlessness, will soon include scientists who can run experiments midflight, as opposed to primarily using traditional suborbital space testing methods—i.e., spacecraft without a crew. SpaceX Tesla founder Elon Musk’s SpaceX is an all-purpose space technology firm that designs and manufactures myriad cutting-edge rockets and spacecraft. Case in point: Its Dragon capsule has already proved it can cost-efficiently carry crew and cargo to the International Space Station. The company’s Starship large-scale rocket and spacecraft system is also designed to carry massive payloads into orbit—and, thanks to NASA’s support, is expected soon to land the first astronauts on the moon since the Apollo program. Not yet 20 years old, SpaceX is additionally focused on introducing more dependable equipment at a fraction of standard production and operating costs. Other innovations include the Falcon 9, a reusable two-stage rocket for repeatedly transporting people and equipment into space, and Falcon Heavy, the world’s most powerful rocket today, which can carry twice as much weight as its closest competitor. SpaceX’s ambitions even extend to commercial space flight and ride-sharing if you or your company’s inventory need to catch a quick lift into the atmosphere. Almost as curious as the company’s public-facing creations are those powering its operations behind the scenes, including a fleet of autonomous drone ships that catch rockets as they hurtle back to earth, landing in the ocean. SpaceX is also heavily investing in building out Starlink, a broadband internet service powered by thousands of satellites that has the potential to bring high-speed connectivity to remote and rural areas around the globe. In short, by leveraging a host of leading-edge technical advancements to power practical innovations in communications, transport and aerospace operations, SpaceX aims to privatize the field of space flight as a whole. No wonder NASA ranks among the company’s biggest customers. Blue Origin The brainchild of Amazon founder Jeff Bezos, Blue Origin was founded in 2000 with the mission of expanding humanity’s reach into space, fueling interstellar exploration, and powering the search for new material and energy resources. It hopes to do so by delivering low-cost, fully or partly reusable orbital launch vehicles that can serve the needs of businesses and individuals alike. One person recently paid an astounding $28 million for a ticket. Unlike Virgin Galactic, Blue Origin makes spacecraft that are able to cross the Kármán line—the 62-mile-high measurement that most countries consider to be the boundary of outer space. (The U.S. uses 50 miles as a benchmark instead.) The company’s mantra is “Launch, Land, Repeat,” a testimonial to its commitment to drastically lower expenses associated with space travel, and to the built-in vertical takeoff and landing technology that allows used vehicles to be quickly refurbished and once again take flight. Note that Blue Origin is also experimenting with oversized lunar landers designed to ferry astronauts and equipment affordably to and from the moon. Investment Opportunities and New Innovations The increasing desire for private space exploration points to companies’ growing desire to more cost-efficiently use resources, leverage emerging or preexisting technology in new ways, optimize processes and workflows, and pioneer new markets by democratizing access to resources and equipment. Each of the big three players has sought to tap into a mix of proprietary and community knowledge bases, leverage new high-tech and engineering advancements to lower overhead and operating costs, and boost the accessibility of space travel. Likewise, all have looked to raise public awareness, amortize their investments in new innovations and extend potential revenue streams by finding new business applications for their proprietary solutions at every turn. To read more about the commercialization of space, read “Commercial Space Is Becoming Big Business.” Virgin Galactic is publicly traded, Blue Origin and SpaceX are not. However, more than 10,000 companies (42% of which are American), worth upward of $4 trillion in total, are now pioneering space-based business solutions. In addition, many of these firms—which are looking to make plays in many fields, like telecom, tourism, artificial intelligence and robotics—are investor-friendly startups helping to further capitalize or expand upon the innovations that the big three players are ushering in. Key areas of growth going forward for space-based business are expected to include navigation and mapping, satellite communications, cloud-based applications, manufacturing, and health care/medicine. And that’s before you factor in potential research and scientific applications. Example: the University of Florida researching plants’ changing gene activity in weightless environments via experiments conducted in partnership with Virgin Galactic. It’s yet to be determined whether billionaire-funded private space exploration spaceflight firms will successfully deliver on their aim to democratize space travel, or such trips will remain a prohibitively pricey luxury for most aspiring voyagers. Regardless of whether casual flights into space and stargazing business or research contracts become more commonplace, it’s clear that this nascent field has a promising future. While a Jetsons-style culture of weekend jaunts into orbit is still the stuff of science fiction for now, don’t forget: Succeed or fail, to their credit, all of these firms are helping expand businesses’ ambitions to the stars and beyond and helping illustrate a multitude of potential new uses for aerospace solutions.

#### US space firms are competitive and key to drive innovation

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On 11 July UK billionaire businessman Richard Branson travelled to the edge of space in a spaceplane developed by his company, Virgin Galactic. On Tuesday this week, the billionaire founder of Amazon, Jeff Bezos, will take a similar trip to space aboard the New Shepherd rocket built by his Blue Origin company. Elon Musk’s SpaceX will soon begin sending paying civilians into Earth orbit with the company’s Falcon 9 rocket. The ability of such billionaires to afford private spaceflight trips or invest in heavy-lift rockets, while paying a smaller fraction of income in tax than the average American, reflects inequality in America. This inequality has been made especially stark during the COVID-19 pandemic with billionaires’ wealth increasing while many others experienced financial hardships. Increasing wealth and reaching for space has not purchased popularity for these billionaires. Ahead of Bezos’ upcoming suborbital flight, a petition to “not allow Bezos to return to Earth” gained more than 160,000 signatures. Richard Branson has been criticized for using his wealth to go to space rather than addressing more terrestrial problems like climate change. But after half a century of government-led exploration beyond earth, why are billionaires now at the forefront of our minds when we think about space travel, and what do they mean for how we go to space? The private sector has always had a close involvement with space Billionaire interest in space is not new. Historically, science research funding for observatories in the 19th and 20th centuries was typically provided through endowments from wealthy individuals. Institutions such as the Smithsonian and the Guggenheim family were the early donors of Robert Goddard’s ambitious projects to develop rockets and space technology. Following 1980s initiatives like MirCorp’s plan to provide privately owned space stations, the 1990s and 2000s saw commercial space efforts like Peter Diamandis’ introduction of the Ansari X Prize (1996), the US government’s Alternate Access to [the International Space] Station Program (2000-2002), and the founding of Mojave Aerospace Ventures (2004). Between 2001 and 2009 seven wealthy people went to space as paying customers on Russian Soyuz rockets including Dennis Tito, Iranian American businesswoman Anousheh Ansari and Cirque du Soleil founder Guy Laliberte. More recently, aside from Jeff Bezos and Richard Branson, other billionaires have also planned trips to space, including Jared Isaacman and Yusaku Maezawa. The wave of billionaires now seemingly interested in space exploration is a return to a past trend. Space exploration is expensive Private actors and the government think differently when it comes to what type of space programs to prioritize. The government prioritizes aspects of a space program that are in the public-interest such as national security and Earth sciences, while wealthy individuals that enter the space sector are interested in personal and financial endeavors that involve space exploration, such as making life multiplanetary for Elon Musk and space tourism for Richard Branson and Dennis Tito. The Apollo program which ultimately sent astronauts to the moon in 1969 is thought of as the height of US government leadership in space. But the massive investment which made the first moon landing possible was an anomaly that had been driven by political necessity given the climate of the Cold War. As Figures 1 and 2 show, by 1965, the US government had begun to cut NASA’s budget to the point that by the 1970s it made up only about 0.5-1 percent of the total federal budget. According to Dr. John Logsdon of George Washington University’s Space Policy Institute: “From 1970 onward, NASA has not had a budget adequate to support a robust program of human exploration.” Figure 1 – NASA’s budget from 1959 – 2025 Source: The Space Report Figure 2 – NASA’ share of US federal Budget 1959-2018 Source: The Space Report The lackluster interest in space exploration by the US government since the 1970s sits alongside with a similar lack of enthusiasm by the American public. In a 2018 survey conducted by Pew Research Center, a majority of American adults believed that that monitoring Earth’s climate system should be the highest priority and sending astronauts to Mars and the Moon the lowest (Figure 3). Figure 3 – Americans’ views on policy priorities Source: Pew Research Center, 2018 Re-emergence of commercial space At the same time, many wealthy individuals have been dissatisfied with the lack of public enthusiasm and the lack of progress in recent years due to the government’s traditional view of space operations, and failures of the Space Shuttle. Wealthy individuals like Musk believed that they could spur a robust marketplace for providing access to space which could work alongside and provide services for government space agencies by leveraging reusable technologies, lean manufacturing, and vertically integrated production to enable cheap space access. Because typical debt and equity investors are unwilling to finance the risks of space exploration and the government is unable or uninterested in large up-front investments, it is natural for private space exploration to be funded out of billionaire’s own wealth initially, with government support through development contracts. Government support and US Commercial Space Policy Without the government, the private sector cannot thrive in space. The government supports the private sector by adopting regulatory reforms or creating contracts and awards. Early attempts to invigorate the commercial space industry include the 1984 Commercial Space Launch Act, which was unsuccessful as US launch firms were unable to compete against NASA’s Space Shuttle. President Reagan’s 1986 US Space Launch Strategy reduced NASA’s ability to provide commercial launches, which led to the re-emergence of commercial space activities. The limitations provided by the 1986 policy led to the first commercial space launch by Space Services, Inc. in 1989. The US government under the Obama administration made policy reforms such as introducing fixed price contracting to support development of commercial services. An example of this was a request for over $6 billion to subsidize commercial crew vehicles to visit the International Space Station for the Commercial Crew Resupply (CRS) program. Congressional appropriators in the Senate created a “Dual-track” approach, exemplified by the 2010 NASA Authorization Act, which calls for commercial cargo development. The bill shows that policymakers were willing to compromise on certain aspects of the space program such as CRS to support private space launch companies. By 2010, commercialization was well underway with Obama’s National Space Policy that emphasized supporting a “competitive US commercial space sector.” As of 2011, NASA had paid SpaceX $181 million for 14 Commercial Resupply Missions and $298 million under the Commercial Orbital Transportation Services Demonstration Agreement. The Trump Administration increased public investment in private space actors further and established a series of Space Policy Directives that were meant to bolster the commercial sector. Government support to the private sector further comes in the form of NASA- approved loans, loan guarantees, and tax credits. Firms can also receive tax exemptions through facility constructions, discounted loans, and environmental credits. It is estimated that all of Musk’s ventures, not limited to SpaceX, received at least $4.9 billion in government support through tax breaks, factory construction, discounted loans, environmental credits, facility loans, and rebates to product buyers. Photo by SpaceX on Unsplash How billionaires support the space industry Private investment in space has created competition and reduced space launch costs. New space actors began to challenge the government-created monopoly, United Launch Alliance (ULA), for contracts, creating competition and introducing a market for small-medium class reusable launch. SpaceX’s Falcon 9’s average cost is $62 million, while ULA’s Atlas V starts at $110 million per launch. Commercial actors enable the government to have multiple competitive proposals to select from during project development. NASA would pay less money upfront for a service, while private companies can operate and have autonomy over their final product. The government can act as a buyer of commercial services, which allows NASA to be more efficient and cost-effective, as the agency can cut costs by only developing projects it has expertise and funding for. Such competition has dramatically changed space technology. New players that enter the space industry are able to embark on ambitious projects at a greater scale and faster pace. Innovative concepts such as reusable rocket stages has shifted the launch industry into integrating reusability into vehicle design and the proliferation of ridesharing missions has decreased the costs of space launch. This has lowered barriers to enter the space industry, making small satellites rideshare as low as $1 million per mission. Innovations in space launch have further changed the policy environment and streamlined launch and reentry regulations. Billionaires in space are here to stay Investment from wealthy individuals in recent decades have stimulated private markets and paved the way for many startups to enter the industry. As more new players join the commercial space industry, access to space becomes cheaper, resulting in an explosion of proposed satellite constellations and small launch vehicle concepts. Wealthy entrepreneurs have seen an opportunity to take advantage of a lack of government interest in space exploration funding. The high-risk nature of space exploration requires substantial upfront investment that only wealthy individuals can provide before any pay-off. Private investments in space promote competition and innovation. Billionaires providing upfront investments has stimulated the space market and made space more accessible – and profitable.

#### Innovation from commercial firms ensures economic dominance and US primacy

Beames 21 Charles Beames is executive chairman and chief strategy officer of Colorado-based York Space Systems and chairman of the SmallSat Alliance.“Opinion: The Innovation That Will Ensure U.S. Security in Space | Aviation Week Network.” Aviationweek.com, 1/28/2021. https://aviationweek.com/aerospace/commercial-space/opinion-innovation-will-ensure-us-security-space. //WL

During the Cold War, it was not the U.S.’ superior weapons or soldiers that ultimately led to the Soviet Union’s capitulation. Historians record that the relative economic might of the U.S. ultimately brought the Cold War to a peaceful and conclusive end. Three decades later, the U.S. again finds itself at the dawn of what many have dubbed the “Second Space Race,” for which the U.S. ought to remain mindful of this lesson, lest it be used against us. The West is once again threatened by a hegemonic national security rival. This time, America’s archnemesis is characterized by planning for a long contest that will feature fast-forward economics, global diplomacy, military muscle and information manipulation: China, it appears, is preparing to use its economic power to win. While maintaining its deep belief in Marx’s communist vision, the Chinese one-party government has fashioned a national economy that learned from the Soviet Union’s mistakes. Through friendly engagement with Western economies, China strengthens its own economy and weakens the West’s, nudging the world toward the worldview of the Chinese Communist Party. What then, are the best avenues for the U.S. to win this new near-peer space competition? They are the same ones that delivered victory in the last century: free markets, real economic growth and the productivity that often follows. This time, however, we must keep in mind that our rival is a keen student that has learned from our earlier successes—and Soviet failures. The American response must not repeat the Cold War strategy of outspending our rival in government programs. Instead, the U.S. long game must put the commercial industry first: deliberately buy goods and services from our commercial domestic market, only providing government solutions when the commercial market cannot meet requirements. Unlike other military services, there are no real “weapons” in space. Much of what the government is developing for civil and national security space needs also exists as products or services in the commercial market. By encouraging the commercial industry to grow and not competing against it, the U.S. will secure a long-term strategy leading to unrivaled space leadership. The U.S. economy has generated growth and prosperity unmatched in human history, with billions of dollars being invested every year into profitable commercial space companies. To outpace China militarily and economically, the new administration must double down on space privatization projects like NASA’s Commercial Crew and Commercial Resupply Programs started under the Obama administration. The Trump administration correctly reprioritized the importance of space for national security, but it directed too much government spending to legacy space projects and fell short in encouraging the next generation of commercial space companies. An American “commercial first” policy for space technologies can solve government needs at the federal and state levels, which account for about half of commercial space company revenue. By prioritizing the highly competitive commercial sector, the government will bolster U.S. competitiveness without illegally subsidizing it. More important, it would reinforce the American values of free markets and open competition. As the new administration settles in, national security political insiders are already hedging their bets on who and what will be the winners and losers of the new political cycle. This is especially true for the space sector, not only because it was an area of significant emphasis during the last administration but also because there continues to be significant private investment and anticipated growth in the area. The unrelenting march of the knowledge economy and remarkable utility of the commercial space industry is limited only to our imaginations. The new U.S. Space Force and other civil space agencies will be better positioned if they leverage the burgeoning industry and do not overshadow it with government alternatives. If, however, the government decides to compete against the private sector with its top-down directed design methods and protocols, our commercial industry will be lost to China, much like the drone market was just a decade ago. Economic dominance in the space industry, not space weapons, will ultimately decide which side defines the 21st-century space domain and the national security implications that come with it. America must strategically rethink policies that will take advantage of, rather than compete against, its blossoming commercial space industry. Getting space policy right—commercial industry first and using government solutions only when necessary—will lead to explosive growth. Getting policy wrong? Well, just ask the Soviets.

#### US hegemony solves arms races, land grabs, and great power war – reject old defense that ignores emerging instability and compounding risk from other powers’ spheres of influence

Brands 20 Hal Brands is Henry A. Kissinger Distinguished Professor of Global Affairs at the Johns Hopkins School of Advanced International Studies (SAIS), a resident scholar at the American Enterprise Institute, and a Bloomberg Opinion columnist. Brands, Hal. “Don’t Let Great Powers Carve up the World.” Foreign Affairs, April 27, 2020. [https://www.foreignaffairs.com/articles/china/2020-04-20/dont-let-great-powers-carve-world .//WL](https://www.foreignaffairs.com/articles/china/2020-04-20/dont-let-great-powers-carve-world%20.//WL)

What a difference two decades make. In the early years of this century, the world appeared to be moving toward a single, seamless order under U.S. leadership. Today the world is fragmenting, and authoritarian challengers, led by China and Russia, are chipping away at American influence in East Asia, eastern Europe, and the Middle East. In its 2002 National Security Strategy, the George W. Bush administration envisioned the end of great-power rivalries. In 2020, the question is how great powers can navigate their rivalries without stumbling into war. Writing in Foreign Affairs (“The New Spheres of Influence,” March/April 2020), Graham Allison offers a road map for this new environment: the United States should accept the return of “spheres of influence” and effectively let China and Russia dominate swaths of their respective geopolitical neighborhoods. Doing so, Allison contends, is actually in keeping with the United States’ best diplomatic traditions, considering that Washington tolerated a Soviet sphere of influence in eastern Europe during the Cold War. Reviving that tradition is necessary, simply because the United States no longer has the military and economic dominance to deny China and Russia their geopolitical due. And it is desirable, because mutually accepted spheres of influence can promote stability and peace in a more rivalrous world. Allison’s argument is alluring but wrong. In truth, the United States has resisted the creation of rival spheres of influence for most of its history, even as it has worked assiduously to build its own. Ceding ground to China and Russia today would be not a recipe for stability but a blueprint for coercion and conflict, and it would weaken the United States’ geopolitical hand vis-à-vis its rivals. Nor is a return to spheres of influence foreordained—Washington still has the power to prevent Beijing and Moscow from dominating their regions, so long as it rejects Allison’s advice to cut loose its vulnerable frontline allies. A tougher, more competitive world is unavoidable. A far more dangerous world, divided into competing superpower fiefdoms, is not. AN AMERICAN TRADITION Spheres of influence have been common throughout history, but Americans have never been quite comfortable with them. In fact, much of U.S. foreign policy dating back to independence has consisted of efforts to prevent rival powers from establishing such domains. In the nineteenth century, U.S. leaders rejected the idea that any European power should have a sphere of influence in North America or the Western Hemisphere at large. They maneuvered—often quite ruthlessly—to evict European powers from these areas. At the turn of the twentieth century, the United States took this regional policy global. The so-called Open Door policy aimed to dissuade foreign powers from carving up China, and later all of East Asia, into exclusive spheres. Washington joined World War I in part to prevent Germany from becoming the dominant European power. A generation later, the United States fought to deny Japan a sphere of influence in the Pacific and prevent Hitler from establishing primacy over the entire Old World. During and after World War II, Washington also engaged in quieter diplomatic and economic efforts to accelerate the dissolution of the British Empire. Opposition to spheres of influence is a part of U.S. diplomatic DNA. Even during the Cold War, Americans never fully accepted Soviet control over eastern Europe. The Truman and Eisenhower administrations sought to roll back the Iron Curtain through ideological warfare and covert action; later administrations expanded trade and diplomatic ties with Warsaw Pact states as a subtler way of undermining Kremlin control. The Reagan administration overtly and covertly supported political movements that were challenging the Kremlin’s authority from within. And when Washington had a chance to peacefully destroy the Soviet sphere of influence after the fall of the Berlin Wall, it did, supporting German unification and the expansion of NATO. Opposition to spheres of influence, in other words, is a part of U.S. diplomatic DNA. The reason for this, Charles Edel and I argued in 2018, is that spheres of influence clash with fundamental tenets of U.S. foreign policy. Among them is the United States’ approach to security, which holds that safeguarding the country’s vital interests and physical well-being requires preventing rival powers from establishing a foothold in the Western Hemisphere or dominating strategically important regions overseas. Likewise, the United States’ emphasis on promoting liberty and free trade translates to a concern that spheres of influence—particularly those dominated by authoritarian powers—would impede the spread of U.S. values and allow hostile powers to block American trade and investment. Finally, spheres of influence do not mesh well with American exceptionalism—the notion that the United States should transcend the old, corrupt ways of balance-of-power diplomacy and establish a more humane, democratic system of international relations. Of course, that intellectual tradition did not stop the United States from building its own sphere of influence in Latin America from the early nineteenth century onward, nor did it prevent it from drawing large chunks of Europe, East Asia, and the Middle East into a global sphere of influence after World War II. Yet the same tradition has led the United States to run its sphere of influence far more progressively than past great powers, which is why far more countries have sought to join that sphere than to leave it. And since hypocrisy is another venerable tradition in global affairs, it is not surprising that Americans would establish their own, relatively enlightened sphere of influence while denying the legitimacy of everyone else’s. That endeavor reached its zenith in the post–Cold War era, when the collapse of the Soviet bloc made it possible to envision a world in which Washington’s sphere of influence—also known as the liberal international order—was the only game in town. The United States maintained a world-beating military that could intervene around the globe; preserved and expanded a global alliance structure as a check on aggression; and sought to integrate potential challengers, namely Beijing and Moscow, into a U.S.-led system. It was a remarkably ambitious project, as Allison rightly notes, but it was the culmination of, rather than a departure from, a diplomatic tradition reaching back two centuries. GIVE THEM AN INCH… The post–Cold War moment is over, and the prospect of a divided world has returned. Russia is projecting power in the Middle East and staking a claim to dominance in its “near abroad.” China is seeking primacy in the western Pacific and Southeast Asia and using its diplomatic and economic influence to draw countries around the world more tightly into its orbit. Both have developed the tools needed to coerce their neighbors and keep U.S. forces at bay. Allison is one of several analysts who have recently advanced the argument that the United States should make a virtue of necessity—that it should accept Russian and Chinese spheres of influence, encompassing some portion of eastern Europe and the western Pacific, as the price of stability and peace. The logic is twofold: first, to create a cleaner separation between contending parties by clearly marking where one’s influence ends and the other’s begins; and second, to reduce the chances of conflict by giving rising or resurgent powers a safe zone along their borders. In theory, this seems like a reasonable way of preventing competition from turning into outright conflict, especially given that countries such as Taiwan and the Baltic states lie thousands of miles from the United States but on the doorsteps of its rivals. Yet in reality, a spheres-of-influence world would bring more peril than safety. Russia’s and China’s spheres of influence would inevitably be domains of coercion and authoritarianism. Both countries are run by illiberal, autocratic regimes; their leaders see democratic values as profoundly threatening to their political survival. If Moscow and Beijing dominated their respective neighborhoods, they would naturally seek to undermine democratic governments that resist their control—as China is already doing in Taiwan and as Russia is doing in Ukraine—or that challenge, through their very existence, the legitimacy of authoritarian rule. The practical consequence of acceding to authoritarian spheres of influence would be to intensify the crisis of democracy that afflicts the world today. The United States would suffer economically, too. China, in particular, is a mercantilist power already working to turn Asian economies toward Beijing and could one day put the United States at a severe disadvantage on the world’s most economically dynamic continent. Washington should not concede a Chinese sphere of influence unless it is also willing to compromise the “Open Door” principles that have animated its statecraft for over a century. Spheres of influence are not a recipe for stability but a blueprint for coercion and conflict. Such costs might be acceptable in exchange for peace and security. But spheres of influence during the Cold War did not prevent the Soviets from repeatedly testing American redlines in Berlin, causing high-stakes crises in which nuclear war was a real possibility. Nor did those spheres prevent the two sides from competing sharply, and sometimes violently, throughout the “Third World.” Throughout history, spheres-of-influence settlements, from the Thirty Years’ Peace between Athens and Sparta to the Peace of Amiens between the United Kingdom and Napoleonic France have often ended, sooner or later, in war. The idea that spheres of influence are a formula for peace rests on assumptions that often go unexamined: that revisionist powers are driven primarily by insecurity, that their grievances are limited and can be easily satisfied, that the truly vital interests of competing powers do not conflict, and that creative statecraft can therefore fashion an enduring, mutually acceptable equilibrium. The trouble is that these premises don’t always hold. Ideology and the quest for greatness—not simply insecurity—often drive great powers. Rising states are continually tempted to renegotiate previous bargains once they have the power to do so. Offering concessions to a revisionist state may simply convince it that the existing order is fragile and can be tested further. Conceding a sphere of influence to a great-power challenger might not produce stability but simply give that challenger a better position from which to realize its ambitions. Consider the situation in the western Pacific. The most minimal Chinese sphere of influence would surely include Taiwan. Yet if Taiwan became a platform for Chinese military capabilities, the defense of other U.S. allies in the region, such as Japan and the Philippines, would become vastly more difficult. Nor would such a concession likely satisfy Chinese ambitions. A growing body of literature by scholars such as Toshi Yoshihara, James Holmes, Liza Tobin, and Elizabeth Economy suggests that China desires at the very least to push the United States beyond the chain of islands running from Japan to Taiwan to the Philippines. Even a limited Chinese sphere in the western Pacific would serve as a springboard to this larger objective. Meanwhile, the United States will have sacrificed a number of critical advantages by pulling out. A free Taiwan offers proof that Chinese culture and democracy are not incompatible; subjugating Taiwan would also allow Beijing to remove this ideological threat. Worse still, the United States would lose the edge that comes from being the only great power without significant security hazards near its borders. It was only after the United States achieved dominance in the Western Hemisphere that it could project power globally. Russia and China, by contrast, still have to deal with U.S. allies, partners, and military presences in their own backyards—a circumstance that diverts resources they might otherwise use to pursue more distant ambitions and compete with the United States at a truly global scale. MEASURES OF POWER Fortunately, new spheres of influence are avoidable. Russia is a formidable player because of its willingness to take risks and pursue asymmetric strategies; but Moscow will not rebuild a meaningful sphere of influence so long as the United States opposes that ambition. In Europe, Russia is still dramatically outmatched. Admittedly, on NATO’s eastern flank, geography and the local balance of power favor Moscow; but even there, the alliance has been strengthening its capabilities for several years. Studies by the RAND Corporation show that with the right troop deployments, NATO could establish a credible—and affordable—deterrent to Russian aggression without posing any offensive threat. Russia, meanwhile, has struggled even to pull Ukraine back into its orbit: although Russian-backed separatists are waging a bloody war in the eastern part of the country, and Moscow has annexed Crimea, western Ukraine has gravitated toward Europe and the United States since 2014. And although Russia can wield some influence in the Middle East, it can emerge as the region’s primary outside power only if the United States abandons its role there. Rising states are continually tempted to renegotiate previous bargains once they have the power to do so. The extent of China’s power makes the situation in the western Pacific more difficult. Yet Beijing will have trouble dominating the region in the same way that the United States came to dominate the Caribbean. China’s neighbors are not pushovers. Many have the diplomatic and military support of the United States, and some, such as Japan, are major powers in their own right. What is more, China must project military power across large bodies of water if it is to establish authority in the region, and to do so is inherently difficult. It will be all the more difficult if U.S. regional allies invest in the capabilities needed to inflict high costs on any assault and if Washington refines its capabilities and concepts for countering Chinese aggression. The regional military balance will not ever revert to what it was in 1996, when Washington could face down Beijing’s attempts to intimidate Taiwan by sailing two carrier strike groups into the waters off China’s coast; but with the right investments and strategies, the United States and its allies can lengthen the odds of Chinese regional dominance. Perhaps in recognition of this fact, China is also using information operations, economic blandishments, and other forms of political meddling to weaken the region’s resistance to its power. Yet some countries are already working to reduce their vulnerability to economic and political coercion. Australia has undertaken a major campaign to highlight malign Chinese influence; Japan is actively seeking to limit its dependence on supply chains that run through China. Washington may have done more by itself than China has done to undermine U.S. economic power in the region, through its withdrawal from the Trans-Pacific Partnership trade agreement and its tardiness in developing alternatives, together with its allies, to Chinese technology, investment, and lending. These policy errors are damaging, but they are still within the United States’ power to correct. DON'T GIVE UP YET The prospects for maintaining favorable regional balances of power are far better than the skeptics assume. What is essential, however, is that Washington not erode those balances by severing ties with vulnerable allies and partners on the frontlines. Allison suggests that doing so might be necessary to bring U.S. capabilities in line with commitments and reduce friction with rising powers. Yet the effect of abandoning the Baltic allies or breaking the ambiguous commitment to Taiwan would be to make it impossible for those countries to ward off Chinese or Russian influence and to demoralize other U.S. allies around them. Washington would be paving the way for just the authoritarian spheres of influence it should—and can—avoid. The United States has a distinguished record of breaking down authoritarian spheres of influence, first in its own hemisphere and then beyond. It should not now make the historic blunder of throwing that achievement away for an illusory promise of stability or as a premature concession to a darker future that need not come to pass.

### 1NC- Cylinder PIC

#### Text: The appropriation of outer space by private entities is unjust, with the exception of the development and deployment of O’Neill Cylinders. States should divert additional funds to development of the O’Neill Cylinder.

#### We solve for the entirety of the affirmative’s case. This is mutually exclusive with the aff’s plan because they get rid of ALL private space appropriation, but our counterplan does LESS than the affirmative.

#### O’Neill Cylinders are on the way, but funding and companies like SpaceX and Blue Origin are key because governments are insufficient.

Kanchwalla 11-13-21

Hussain Kanchwalla (scholar at the indian institute of technology), 11-13-2021, "What is an O’Neill Cylinder?," Science ABC, https://www.scienceabc.com/nature/universe/what-is-oneill-cylinder.html, // HW AW

Many people believe that the Earth will soon be in danger and the sprawling nature of humanity is the undeniable cause. With the rapid [technological progress](https://www.scienceabc.com/nature/universe/what-is-kardashev-scale.html) and advancement of the past few centuries, we’re quickly exhausting the resources from planet Earth in order to power our industrial needs and global commerce. Many futurists feel that we will be left with no option but to explore and colonize space if we intend to survive into a future when resources on Earth can no longer meet our requirements. [Overpopulation is an imminent challenge](https://www.scienceabc.com/humans/malthusian-catastrophe-shortage-of-food-sources-population-explosion.html) that makes the need for interstellar travel and colonization even more urgent. That being said, [**building a space habitat**](https://www.scienceabc.com/nature/universe/can-we-build-a-habitable-planet-from-scratch.html) **is no easy pursuit and is loaded with daunting challenges, such as the need for construction facilities in space, the recreation of livable communities in space, the recycling and processing of waste, the simulation of artificial gravity, and most importantly—convincing governments and global organizations that this venture is worth pursuing.** The prospect of space colonization paves the way for devising methods to extract energy from resources on other planets. On Earth, harnessing energy from the Sun using [solar panels](https://www.scienceabc.com/innovation/why-is-there-a-limit-to-the-efficiency-of-solar-panels.html) isn’t particularly efficient, and faces inevitable barriers caused by the atmosphere and the daily occurrence of darkness (e.g., nighttime). However, in space, solar constructs can perpetually harness energy from the Sun without interruption. Utilizing this copious amount of energy would permit us to travel throughout our solar system without worrying about energy expenditure. Moreover, chemical resources would be in great supply in our solar system. To begin with, NASA has recently embarked on a project to generate fuel, water, and oxygen from resources present on the Moon. Given these foundations for why organizations should foray into developing a space habitat, allow me to introduce the **O’Neill cylinder—a space settlement design consisting of two counter-rotating cylinders** proposed by renowned physicist Gerard O’Neill a few decades ago. Aside from being a physicist, O’Neill was also a professor at Princeton University and a space enthusiast. Although he is most widely acclaimed for his work in physics, where he developed new concepts to explore particle physics at higher energies, his work on space colonization turned out to be his truly long-lasting legacy. Origin of the Idea for the O’Neill Cylinder While teaching physics to his students at Princeton University, O’Neill assigned them the task of designing a megastructure in space in order to demonstrate that living and surviving in space is actually a possibility. His students came up with numerous designs to accommodate human habitation in space. After a long session of brainstorming, O’Neill boiled their theories down to the idea of a cylinder-like space settlement design. Later, additional details and the functioning of this design were published in Physics Today in 1974; the cylinder was aptly called the O’Neill cylinder. Design of the O’Neill Cylinder The O’Neill cylinder design consists of two cylinders rotating in opposite directions on a [bearing](https://www.scienceabc.com/eyeopeners/what-is-a-bearing.html) to mitigate the gyroscopic effect. Each cylinder was proposed to be 20 miles long and 5 miles in diameter, with 6 broad stripes along its length (3 habitable spaces and 3 windows). O’Neill envisioned industrial processes and recreational facilities to be located on the central axis in a virtually zero-gravity environment. Gravity Simulation One key difference between living on Earth and living in space (or on any other astronomical body) is the difference in gravity. [Artificial gravity](https://www.scienceabc.com/innovation/can-create-artificial-gravity.html) is needed for stability, and the O’Neill cylinder has a provision to achieve exactly that. As the two giant cylinders rotate on their axis, they would leverage the centripetal force of any object in the inner surface to create artificial gravity. Considering the cylinder’s dimensions, the acceleration equation: a=v²/r, and substituting the acceleration value of Earth (i.e., 9.81), we can deduce that the cylinder would need to rotate roughly 28 times per hour to simulate an appropriate gravitational force. Earthly Environment Simulation Maintaining an atmosphere with a constitution similar to that of Earth is the next challenge when building a space habitation. The O’Neill cylinder is prudently designed with a ratio of gases similar to what is found on Earth. However, there is a caveat; the pressure is half of that at sea level. This would not impact our breathing substantially, but this minor trade-off would translate into a handful of benefits, such as bringing down the need for gas and the construction of thick walls. The proposed O’Neill cylinder also has provisions wherein the habitat would be able to control its own micro-climate using an arrangement of mirrors and by altering the ratio of gases in the cylinder. Day and Night Simulation With the human habitat situated in a vacuum (space), the cylinder essentially turns into a huge thermos! The theoretical O’Neill cylinder tried to overcome this issue by using a series of mirrors hinged on each of the three windows. This way, direct sunlight could be directed into the cylinder to simulate day time. Similarly, by turning the mirror away, a night-like ambience could be created. This simulated ‘night’ would also permit the heat produced biologically to radiate out of the cylinder. **Despite the design of the O’Neill cylinder being technically sound, the idea is too sophisticated to be implemented with our present technology**. Thus far, its implementation has been confined to the realm of science fiction. However, **given the efforts of organizations like SpaceX and Mars One, perhaps some day O’Neill cylinders will actually help humanity settle in the great vastness of space!**

#### **This permanently solves extinction, which outweighs the affirmative.**

Haynes 19, 5/17, Korey "O’Neill colonies: A decades-long dream for settling space," Astronomy, https://astronomy.com/news/2019/05/oneill-colonies-a-decades-long-dream-for-settling-space Top of Form

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Last week, Amazon founder Jeff Bezos revealed his spaceship company’s new lunar lander, dubbed Blue Moon, and he spelled out a bold and broad vision for humanity’s future in space. Faced with the limits of resources here on Earth, most fundamentally energy, he pointed to life in space as a solution. “If we move out into the solar system, for all practical purposes, we have unlimited resources,” Bezos said. “We could have a trillion people out in the solar system.” And while colonies on other planets would be plagued by low gravity, long distances to Earth (leading to communication delays), and further limits down the road, those weaknesses are avoided if the colonies remain truly in space. To that end, Bezos instead suggested people consider taking up residence in O’Neill colonies, a futuristic concept for space settlements first dreamed up decades ago. “These are very large structures, miles on end, and they hold a million people or more each.” Gerard O’Neill was a physicist from Princeton University who teamed up with NASA in the 1970s on a series of workshops that explored efficient ways for humans to live off-world. Beyond influencing Bezos, his ideas have also deeply affected how many space experts and enthusiasts think about realistic ways of living in space. “What will space colonies be like?” O’Neill once asked the Space Science Institute he founded. “First of all, there’s no point in going out into space if the future that we see there is a sterile future of living in tin cans. We have to be able to recreate, in space, habitats which are as beautiful, as Earth-like, as the loveliest parts of planet Earth — and we can do that.” Of course, neither O’Neill nor anyone since has actually made such a habitat, but in many ways, the concepts he helped developed half a century ago remain some of the most practical options for large-scale and long-term space habitation. While NASA has mostly focused on exploring the moon and Mars in recent years, O’Neill colonies offer an option untethered to any planetary body. Instead, people would live in enormous circular structures in space that would be capable of hosting many thousands of people — or even millions according to Bezos — on a permanent basis. You may have seen these kinds of colonies in science fiction, from Star Trek, to the movie Interstellar. But in real life, researchers have thought up a a few variations: either a sphere, a cylinder, or a ring-shaped torus. All of these are designed to rotate and create a centrifugal force that mimics gravity for the inhabitants. While the sizes and specifications of the colonies vary, there are a few staples. In general, O’Neill colonies were designed to be permanent, self-sustaining structures. That means they would use solar power for electrical energy and for growing crops. The outer walls of an O’Neill colony are generally pictured as a transparent material, so that mirrors can aim sunlight through its walls as needed to provide light and energy – or to allow darkness, a feature humans also need, especially while we sleep. But building these colonies is a challenge beyond any humans have accomplished so far in space, and Bezos acknowledged that. He referred to two “gates” in his announcement, which he clarified as challenges that humans need to overcome. The first, which his company Blue Origin and other space entrepreneurs have been tackling, is to reduce the cost and difficulty of getting to space at all. But the second involves using resources from space, rather than hauling them from Earth. Bezos isn’t alone in such thinking. Most of NASA’s long-term plans for the Moon and Mars involve rely on harvesting materials and manufacturing products locally, using lunar and martian regolith to build and repair structures. And in the shorter term, three of the dozen experiments NASA selected as the first to fly as part of the new lunar program — possibly even by the end of the year — are what NASA terms “resource prospecting instruments.” That pairs well with O’Neill’s vision. These colonies are meant to use resources gathered from space, whether asteroids, the Moon, or even Mars. Doing so avoids the costly effort of heaving materials and goods out of Earth’s deep gravity well. That means they would be built using materials available cheaply in space. The humans and their attendant plants and animals would need to be carried from Earth. But raw materials like oxygen, nitrogen and aluminum are plentiful in the solar system, and mining for resources in space is a common theme across space settlement discussions. Because of their size, the colonies should be able to act as fully independent ecosystems, with plants to cycle air and water and resource cycles not so dissimilar from Earth. Humans are a long way from being able to launch anything like an O’Neill colony in the near future. But it’s somewhat telling that, after 50 years

## \*\*1NC- On Case\*\*

### Generic Cards

#### The status quo already prevents the worst-case scenario for private companies in space. Even though the Outer Space Treaty doesn’t bind private entities, governments still restrict and regulate them to ensure just compliance.

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Two provisions of the Outer Space Treaty (OST), both also customary, are particularly relevant here. OST article II: “Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.” OST article III: “States… shall carry on activities in the exploration and use of outer space, including (…) celestial bodies, in accordance with international law”. SpaceX is a private entity, and is not bound by the Outer Space Treaty – but that does not mean it can opt out. Its actions in space could have consequences for the United States in three ways. First, the US, as SpaceX’s launch state, bears fault-based liability for injury or damage SpaceX’s space objects cause to other states’ persons or property (OST article VII, Liability Convention articles I, III). Second, the US, as SpaceX’s state of registry, is the sole state that retains jurisdiction and control over SpaceX objects (OST article VIII, Registration Convention article II). Both refer to objects in space and are irrelevant. According to article VI OST, States “bear international responsibility for national activities in outer space”, including Mars, including those by “non-governmental entities”. The US, as SpaceX’s state of incorporation, must authorise and continuously supervise SpaceX’s actions in space to ensure compliance with the OST (OST article VI) and international law (OST article III). In practice, this task is done by the US Federal Communications Commission, which licenses and regulates SpaceX. Article VI OST sets a specific rule of attribution, supplementing the customary rules of state responsibility (Stubbe 2017, pp. 85-104). SpaceX acts with US authorisation, and its conduct in space within and beyond that authorisation is attributable to the US (ARSIWA articles 5, 7). In the absence of circumstances precluding wrongfulness, the result is straightforward. If SpaceX breaches a US obligation under international law, the US bears responsibility for an internationally wrongful act.

#### Even if the affirmative is correct in saying that public space efforts are good, the private sector is key to make public space development successful. Urrutia ‘18

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First, people should understand that about **75 percent of the worldwide space enterprise is already commercial**, said Scott Hubbard, an adjunct professor in the Department of Aeronautics and Astronautics at Stanford University. This includes the satellites belonging to DirecTV and Sirius XM radio. “What's new is the extension of that into the human realm," said Hubbard, who also previously directed NASA's Ames Research Center in Silicon Valley. He served as the agency's "Mars czar," restructuring NASA's robotic Red Planet-exploration program after it suffered several failures in the 1990s. And if private companies can get the price of a suborbital flight down to about $50,000, "you get a lot of interest," Hubbard told Space.com. The highest-profile program currently in the works between NASA and the private sector is the agency's Commercial Crew Program, said Eric Stallmer, president of the nonprofit Commercial Spaceflight Federation. Commercial Crew is encouraging the development of U.S. spacecraft that will carry astronauts to and from the International Space Station (ISS). Toward this end, NASA has awarded multibillion-dollar contracts to both SpaceX and Boeing, which are building capsules called Crew Dragon and CST-100 Starliner, respectively. These craft are currently scheduled to start flying astronauts sometime next year. There's also the maturing commercial cargo program, which has given contracts to SpaceX and Northrop Grumman Corp. to fly robotic cargo missions to the ISS. Both of these companies have already completed numerous such flights. Both Hubbard and Stallmer said that **NASA wins by relying on private industry to provide such services in low Earth orbit.** Hubbard argued that this strategy allows the space agency to continue "exploring the fringe where there really is no business case." NASA has a budget about five times larger than the next biggest national space agency out there, but the U.S. agency's ambitious goals are still costly, said Stallmer. **To get the most bang** for the buck, "you'd have to **leverage the innovation and technology that is in the private sector and let NASA do the exquisite" projects.** The "exquisite" projects, Stallmer explained, are the "push-the-envelope-type things on deeper space exploration." "I see it not only as a cooperation or a collaboration, but maybe even interdependence," Hubbard said. "Without a thriving spaceflight entrepreneurship sector, I don't think that deep-space exploration with [regular] people is sustainable," he added. "And I think using the way in which the private sector has demonstrated they can reduce costs, through more nearly assembly-line production techniques, is really critical to sustainable space exploration in the future." Phil McAlister, director of commercial spaceflight at NASA, also advocated these public-private partnerships. Private companies offer the advantages of "being quick, being nimble, being fast, making a decision maybe without perfect knowledge — then moving forward and adjusting as required," McAlister told Space.com. NASA officials, he said, "have a lot of meetings … a lot of discussions, and things tend to take longer" than in private industry. **"The private sector wanting to move fast and wanting to be cost-effective** and NASA having our 50 years of human spaceflight experience … you bring those two things together**, and they actually complement each other very effectively," McAlister said.**

#### We win under either framework. The ethical and moral implications of private space exploration are justified by the benefits.

Sharma 9-7-21

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In recent years, private companies have taken on a larger role in the space exploration system. With lower costs and faster production times, they have displaced some functions of government space agencies. Though many have levied criticism against privatized space exploration, it also allows room for more altruistic actions by government space agencies and the benefits from increased space exploration as a whole. Thus, we should encourage this development, as the process is net ethical in the end. Especially if performed in conjunction with adequate government action on the topic, private space exploration can overcome possible shortcomings in its risky and capitalistic nature and ensure a positive contribution to the general public on Earth. The implications of commercial space exploration have been thrust into the limelight with the successes and failures of billionaire Elon Musk’s company SpaceX. While private companies are not new to space exploration, their prominence in American space exploration efforts has increased rapidly in recent years, fueled by technological innovations, reductions in cost, and readily available funding from government and private sources. In May 2020, SpaceX brought American astronauts to space from American soil for the first time in almost 10 years. Recognizing the greatly reduced costs of space exploration in private companies, NASA’s budget has shifted to significantly relying on private companies. However, private space companies are unique from government space agencies in the way they experience unique sets of market pressures that influence their decision-making process. Hence, the expansion of private control in the space sector turns into a multifaceted contestation of its ethicality. The most obvious ethical concern is the loss of human life. Critics contend that companies must answer to their shareholders and justify their profits. This contributes to a larger overall psyche that prioritizes cost and speed above all else, resulting in significantly increased risks. **However, the possible increase in mishaps is largely overstated.** **Companies recognize the need for safety aboard their expeditions themselves.** After all, the potential backlash from a mishap could destroy the company’s reputation and significantly harm their prospects. According to Dr. Nayef Al-Rodhan, Head of the Geneva Centre for Security Policy’s Geopolitics and Global Futures Programme, “because there were no alternatives to government space programs, accidents were seen to some degree as par for the course… By comparison, private companies actually have a far more difficult set of issues to face in the case of a mishap. In a worst case scenario, a private company could make an easy scapegoat.” Another large ethical concern is the prominence capitalism may have in the future of private space exploration and the impacts thereof. The growth of private space companies in recent years has been closely intertwined with capitalism. Companies have largely focused on the most profitable projects, such as space travel and the business of space. Many companies are funded by individual billionaires, such as dearMoon, SpaceX’s upcoming mission to the Moon. Congress has also passed multiple acts for the purpose of reducing regulations on private space companies and securing private access to space. From this, many immediately jump to the conclusion that capitalism in space will recreate the same conditions in outer space that plague Earth today, especially with the increasing push to create a “space-for-space” economy, such as space tourism and new technologies to mine the Moon and asteroids. Critics, such as Jordan Pearson of VICE, believe that promises of “virtually unlimited resources” are only for the rich, and will perpetuate the growing wealth inequality that plagues the world today. However, others contend that **just because private space exploration has some capitalist elements, it is by no means an embodiment of unrestricted capitalism.** A healthy balance of restricted capitalism—for example, private space companies working through contracts with government agencies or independently under monitoring and regulation by national and international agreements—will avoid the pitfalls that capitalist colonialism faced down here on Earth. Even those who are generally against excessive government regulation should see the benefits of them in space. Lacking any consensus on definitions and rights in space will create undue competition between corporations as well as governments that will harm everyone rather than helping anyone. To create a conducive environment for new space-for-space exploration, one without confrontation but with protection for corporate astronauts, infrastructure, and other interests, governments must create key policies such as a framework for property rights on asteroids, the Moon, and Mars. Another key matter to note is restricted capitalism in space “could also be our salvation.” Private space exploration could reap increased access to resources and other benefits that can be used to solve the very problems on Earth that critics of capitalism identify. Since governments offset some of their projects to private companies, government agencies can focus on altruistic projects that otherwise would not fit in the budget before and do not have the immediate commercial use that private companies look for. Scott Hubbard, an adjunct professor of aeronautics and astronautics at Stanford University, discusses how “this strategy allows the space agency to continue ‘exploring the fringe where there really is no business case’” but still has important impacts on people down on Earth. Indeed, this idea is a particularly powerful one when considering the ideal future of private companies in space exploration. Though there is no one set way governments will interact with companies, the consensus is that they must radically reimagine their main purpose as the role of private space exploration continues to grow. As governments utilize services from private space companies, “[i]nstead of being bogged down by the routine application of old research, NASA can prioritize their limited budget to work more on research of other unknowns and development of new long-term space travel technologies.” According to the Council on Foreign Relations, such technologies have far-reaching benefits on Earth as well. Past developments obviously include communications satellites, by themselves a massive benefit to society, but also “refinements in artificial hearts; improved mammograms; and laser eye surgery… thermoelectric coolers for microchips; high-temperature lubricants; and a means for mass-producing carbon nanotubes, a material with significant engineering potential; [and h]ousehold products.”[2] Agencies like NASA are the only actors able to pursue the next game-changing missions, “where the profit motive is not as evident and where the barriers to entry are still too high for the private sector to really make a compelling business case.”[8] These technologies have revolutionized millions, if not billions, of lives, demonstrating the remarkable benefits of space exploration. It follows then that it is net ethical to prioritize these benefits. This report concludes that the private sector, indeed, has a prominent role to play in the future of space exploration. Further, though private space exploration does bring the potential of increased danger and the colonization of space, these concerns can be effectively mitigated. Namely, strong government frameworks—particularly international ones—will minimize possible sources of ethical violations and ensure an optimal private sector role in space. This also allows government agencies to complete significantly more difficult, innovative projects which have transformative benefits for life on Earth.