### 1NC – Mining DA

#### Space-for-space economy is beginning to develop now because of private enterprise in space

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.

## Space Tourism CP

#### CP Text: States ought to ban Space Tourism by private entities - solves aff impact of space induced climate destruction.

#### Space tourism via private companies will massively increase Co2 emissions, which is the biggest internal link to space travel-induced climate change.

**Parkinson PhD ‘21**

(Stuart Parkinson, July 20, 2021, Parkinson has a PhD in mathematical modelling of global climate change from Lancaster University and is a reviewer for the Intergovernmental Panel on Climate Change, “Space tourism: environmental vandalism for the super-rich” [https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich //](https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich%20//) HM)

The past few weeks have seen some frightening impacts of climate change – from record-breaking temperatures and major wildfires in western Canada and the USA to unprecedented floods in Germany and Belgium. The hottest temperature reliably recorded on the Earth’s surface – 54.4C – was logged in Death Valley in California on 9 July. [[1]](https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich" \l "_edn1" \o ") Scientists said the heatwave in Canada and the USA at the end of June was “virtually impossible” without **human-induced climate change.** [[2]](https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich" \l "_edn2" \o ") One thing that is especially striking is that these events are now happening in some of the wealthiest and weather-resilient nations of the world – but even that didn’t stop major death tolls. The **huge threat of global climate disruption** is leading to ever more urgent calls for society to rapidly reduce its carbon emissions. It is also clear that **technological change** alone will not be enough to tackle the problem. A recent report by the Climate Change Committee – the UK government’s main advisory body on the issue – found that 62% of the necessary measures involve **societal and behaviour change**. [[3]](https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich" \l "_edn3" \o ") Avoiding air travel is one of the most effective changes individuals can make to cut this pollution. For example, the carbon footprint of a return flight from London to Hong Kong – seated in economy-class – is about 3.5 tonnes of carbon dioxide equivalent (tCO2e) [[4]](https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich" \l "_edn4" \o ") – similar to a UK citizen’s average car use for over 10 months. [[5]](https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich" \l "_edn5" \o ") Research by the Institute for Global Environmental Strategies indicates that a globally-sustainable lifestyle carbon footprint in 2020 was 3.9 tCO2e [[6]](https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich" \l "_edn6" \o ") – which gives a clear indication of just how much our society needs to reduce its impacts now (and this figure falls rapidly to 2.5t CO2e by 2030 and then much lower still for 2040 and 2050). Against this backdrop, we have **billionaires travelling in the inaugural flights of their space tourism corporations**. On 11 July, Richard Branson flew in Virgin Galactic’s SpaceShipTwo craft, while on 20 July, Jeff Bezos travelled in Blue Origin’s New Shepard. These activities take the **climate impacts of flying to considerably more damaging level.** Let’s look at the New Shepard space-craft. Prof Mike Berners-Lee of Lancaster University – a leading expert in carbon footprint analysis – has estimated that a single flight results in emissions of at least 330 tCO2e. [[7]](https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich" \l "_edn7" \o ") With four passengers, this means each one is responsible for over 82 tCO2e – over **20 times the sustainable level for a whole year**! And note, this is **a conservative estimate**. It does not include the additional heating effects of emissions at high altitude, the carbon footprint of developing and manufacturing the space-craft, or the emissions of running the Blue Origin corporation. Furthermore, the fuel combination used by the latest generation of New Shepard craft now includes liquid hydrogen [[8]](https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich" \l "_edn8" \o ") – a higher carbon fuel than those used in Prof Berners-Lee’s calculations. What about SpaceShipTwo? Although this craft emits markedly less direct carbon emissions per flight than New Shepard, as SGR discussed back in 2016, [[9]](https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich" \l "_edn9" \o ") it uses a fuel combination which emits **significant levels of black carbon** into the upper atmosphere. Research by the University of Colorado indicates that this can **damage the stratospheric ozone layer** – not only leading to higher levels of damaging ultra-violet radiation reaching the Earth’s surface, but also causing a global heating effect likely to be considerably greater than that from the carbon emissions alone. And the aim of these journeys? A few minutes of ‘zero-gravity’ experience and a nice view. It is hard to see this as anything more than **environmental vandalism for the super-rich**. Virgin Galactic claims to want to launch a “new age of clean and sustainable access to space” [[10]](https://www.sgr.org.uk/resources/space-tourism-environmental-vandalism-super-rich" \l "_edn10" \o ")– but they and the others in the space tourism industry clearly fail to understand the level of their own climate impacts, the **rapidly increasing severity of the climate emergenc**y, or the scale of action needed to cut carbon emissions to a sustainable level. If governments are serious about trying to **prevent ‘dangerous’ climate change**, then there is an important step to take immediately: **ban space tourism**.

Solves their munoz patchen link in advantage one

### Global Commons

#### NU – space is already a global commons

#### Plan fails –

#### Global commons still allow for private appropriation

#### China inevitably undermines solvency

#### Too many private actors ensure conflict

#### Turn – limitations on commons access such as private entity restrictions lead to backlash

Stang 13

Gerald Stang (associate fellow at the EUISS) , 2013, "Global Commons: between cooperation and competition" European Institute for security studies, https://www.iss.europa.eu/sites/default/files/EUISSFiles/Brief\_17.pdf, // HW AW

Rapid economic development and increasing international trade are leading to a more crowded international stage and raising new challenges in the ‘global commons’ – those domains that are not under the control or jurisdiction of any state but are **open for use by countries, companies and individuals from around the world**. Their management involves increasingly complex processes to accommodate and integrate the interests and responsibilities of states, international organisations and a host of non-state actors. Shared rules regarding the usage of - and access to - the global commons encourage their peaceful and cooperative use. Over the last seven decades, the US has led in the creation of a liberal international order which has attempted to define these rules in such a way as to make it easier and more beneficial to join the order and follow the rules than it does to operate outside of (or undermine) it. With the rise of nonWestern, less liberal powers - particularly **China - questions must be asked regarding the durability of the existing processes for managing the global commons,** along with the potential for developing effective new processes that can address new threats and challenges. The EU is uniquely positioned to play an important role in giving value to existing multilateral frameworks and in developing new ones for international cooperation in these domains. But with a multitude of competing interests among stakeholders, much work remains to be done. What exactly are the global commons? Security analysts generally identify **four domains as global commons: high seas, airspace, outer space** and, now, cyberspace. From a security perspective, the primary concern is safeguarding ‘access’ to these domains for commercial and military reasons. It is important to highlight that this language differs from the discourse on commons developed by environmental analysts: their arguments focus on damage to the ‘condition’ of the commons from overuse by actors who do not have to pay direct costs. They worry about the depletion of shared resources such as ocean fish stocks, or the damage to shared domains such as Antarctica or the atmosphere. A third strand of analysis looks not at the need for ‘access’ to or preservation of the ‘condition’ of the commons, but at the capacity of the commons to provide ‘global public goods’. As there is no accepted definition of a global public good (a functioning trading system, peace, clean water, electricity, the internet, and many other things are often included), it may be wiser to focus on the four global commons relevant to security analysts mentioned above. While there are major differences between the ‘access’ views of security analysts and the ‘condition’ views of environmentalists, both are concerned about how the Global commons: Between cooperation and competition by Gerald Stang Photo by NASA / Rex Features (1568628a) European Union Institute for Security Studies April 2013 2 rules for use of the commons are set and enforced. In today’s interconnected world, **any limitations on access to the commons would be highly disruptive**. Militaries rely on access to the commons to pursue security goals in domains outside their sovereign control. Economic actors rely on the commons to trade and conduct business. **Changes to the condition of the commons can therefore disrupt commerce and security, not to mention the status of the global environment.** Each of the four commons discussed below possesses unique attributes and poses unique challenges for international cooperation and governance. Sea As the primary avenue for international commerce since ancient times, norms for access to and passage on the seas have developed and evolved over many years. Only in recent decades, however, have there been agreed regulatory frameworks and institutions to manage them. The UN Convention on the Law of the Sea (UNCLOS), first initiated in 1956 though not legally in force until 1994, is the primary international treaty regarding the sea, laying out rules for territorial boundaries (22km from shore), resource management and the rights of states within their exclusive economic zones (370km from shore). The International Tribunal for the Law of the Sea (ITLOS), created by UNCLOS, has the power to resolve disputes by States Parties. Except for the US, most countries and all global powers - including the EU-27 - have signed and ratified UNCLOS. The UN International Migratory Organization (IMO), created in 1948, regulates international shipping and rulings on safety, environmental and technical cooperation issues (the EU has observer status). As the world’s only global sea power, the United States has historically seen itself as the protector of free movement on the seas. With 11 carrier groups (Russia has one, rarely used) and hundreds of naval bases and allied ports throughout the globe, the US has a naval footprint that dwarfs all its allies and competitors. While countries such as Iran and China may be uncomfortable with US capacity to deny others access to the sea, US support for the creation and respect of transparent international regulations for use of the sea (which they adhere to themselves despite not having ratified UNCLOS), has allowed for the stable management of access to the seas. Except for the disruptive (but still rare) threat of piracy, access to the seas is generally a smooth and well-regulated process. The massive and relatively effective, if ad hoc, global response to the localised piracy problem off the coast of Somalia (for which the EU launched Atalanta, its own anti-piracy mission under the CSDP) highlighted the world’s impressive capacity to handle disruptions of this type. Territorial disputes exist in places like the South China Sea, but relate to historical boundary disagreements rather than conflict over rules of sea access. Normally, no state has an interest in disrupting sea trade. Even in times of crisis, while individual states may wish to deny their opponents access to certain regions, they are unlikely to harm their own interests by disrupting traffic on the world’s oceans. Environmental ‘condition’ issues in the sea commons are disconnected from ‘access’ issues. No single international treaty or body addresses pollution, overfishing or the various challenges in the melting Arctic. A confusing patchwork of sea basin cooperation groupings, regional fisheries management organisations and pollution monitoring agreements is in place. The integrated marine policy of the EU recognizes the need to improve governance of the seas while avoiding treaty congestion. While no unifying treaty or body to manage maritime issues is likely to appear, years of patient discussion in a variety of venues (of the type that the EU excels at) may lead to greater coherence and cooperation in managing environmental threats. Air International air travel requires the use of national airspace for continuous transit and involves detailed agreements that define transit rights. The UN International Civil Aviation Organisation, established in 1947, is the leading institution for regulating air travel. All EU countries are members, while the EU has observer status. As with piracy at sea, any potential disruption of access to the air commons is likely to come from non-state actors. While terrorist events can disrupt air traffic, however, intergovernmental cooperation between national police and security agencies is well established. Any systemic threat to the air commons appears so unlikely that some security analysts do not even include air as a one of the commons. Also like the sea commons, issues of management of environmental ‘condition’ are disconnected from ‘access’ issues. The accumulation of greenhouse gases is a form of pollution of the atmosphere, but the alarm stems from their effects on the biosphere rather than from the risk that the atmosphere may become unbreathable or inaccessible. The EU is a global leader on climate change, with the world’s most comprehensive emissions trading scheme and intense efforts to regulate and limit emissions. The Union has set the tone at the international level but has been unable to win agreement for an internal carbon tax or stronger emissions targets from external partners. European Union Institute for Security Studies April 2013 3 Space More than a thousand orbiting satellites facilitate communications in both the military and the civilian spheres, regulated by a mix of UN guidelines, bilater- al Cold War agreements and industry standards. The UN International Telecommunications Union (ITU) allocates radio spectrum and satellite orbits and develops international technical standards. Established in 1869, the ITU has almost universal membership among existing states, including all EU countries - though not the EU itself. The 1967 Outer Space Treaty, signed by all spacefaring nations, provides the minimal framework for activities in space, banning weapons of mass destruction and preventing states from claims to celestial bodies. The Treaty does not establish infrastructure for coordination, and consultation among party states is ad hoc. Following China’s destruction of one of its own satellites in 2007, there has been increasing concern about protection of satellites from attack. During the later stages of the Cold War, the US and the USSR tacitly agreed to a moratorium on testing anti-satellite weapons (ASAT) - but there are no binding rules in place. The satellite’s destruction also created a debris cloud which could have damaged other satellites or spacecraft. Unlike the sea and air domains, the problem of debris management in space indicates an overlap between ‘access’ and ‘condition’ issues. While access to space has previously been limited to a small number of states, **the increasing role of new actors (including from the private sector) suggests that the creation of comprehensive and binding regulations for the space commons may become more difficult.** The EU has pushed to become a key actor in space matters, working with the European Space Agency (ESA) - an intergovernmental body - on Galileo, Europe’s civilian satellite navigation system. In an effort to get ahead of the curve and manage uncertainty, the European Council approved a voluntary Code of Conduct for Outer Space Activities in late 2008 (revised in 2010) to address both space operations and space debris. It has only limited operational requirements but develops important cooperation, consultation, and notification mechanisms. To make it more palatable to the US and other states, it is not binding and has no enforcement mechanism. As with many efforts in multilateral regulation of the global commons, the US has been hesitant to agree to the Code for fear of diminishing its own freedom of manoeuvre. It may be an important step, however, in setting the groundwork for future space cooperation if the EU can follow up on the Code’s development with diplomatic action by bringing other space-faring countries on board. Cyberspace Cyberspace differs from the other commons because it is not a physical domain and because of the preponderant role of the private sector in both the infrastructure and the management of the domain. All of the physical nodes of the internet also exist within states and are subject to national law, rather than existing physically outside of national control as for the other commons. The American and security-related roots of the internet are reflected in how technical internet standards are managed. The Internet Corporation for Assigned Names and Numbers (ICANN), a private non-profit entity under contract with the US government, has ensured the coordination of internet addresses and registries since 1998. While ICANN operations have been stable - and their inclusive governance style has won imitators for handling technical issues - many countries prefer a formal international body to manage technical internet issues. The ITU has been suggested as a neutral management body, but this idea has been resisted by most Western states. Interestingly, non-Western states are pushing for international management of the internet within a framework that provides individual countries with rights and roles, rather than leaving it to the nonprofit sector to decide how the internet works. All EU-27 countries are members of the ITU and, following a European Parliament deliberation, voted as a bloc against the measures granting more power to the ITU, concerned over states wishing to regulate, control, and limit internet use. The UN Internet Governance Forum (IGF) has become the leading multi-stakeholder platform for states and other actors to debate internet governance. Regardless of the ICANN/ITU issue, states can filter and censor within their territories, and for the time being, efforts to protect against cyber attacks remain within the national sphere. Cyberspace allows for the spread of information, creating pressures for transparency in both democratic and non-democratic states. Discussions on the management of cyberspace, therefore, have become connected with those on the power of states to control information. Finally, although there is no environmental constitu- ency for cyberspace, there are constituencies of users and providers - private and public - who play a similar role in pushing for the protection of certain conditions in cyberspace. Unlike for sea and air domains, therefore, there is overlap between ‘access’ and ‘condition’ discussants. With worries about Cold War-style espionage and cyber conflict between states, cyber security problems European Union Institute for Security Studies April 2013 4 QN-AK-13-017-2A-N | ISSN 2315-1110 are expected to grow worse and are unlikely to be addressed through multilateral fora. Problems with hackers of various types make problems of attribution, response and coordination of policing very difficult. Cyber conflict involving states will ebb and flow along with the quality of the relationship between those states and competing states will continue to test each other’s cyber defences.

#### The term global commons leads to a false sense of security when in actuality makes whatever is supposedly being protected exploited

**Clancy 98** (The Tragedy of the Global Commons, Spring 1998, <https://www.repository.law.indiana.edu/cgi/viewcontent.cgi?article=1136&context=ijgls> pecial Assistant to the Deputy Secretary of State, US Department of State, Indiana Journal of global legal studies)//HWLND

The inherent problem in this communal property is the idea put forth byGarrett Hardin in his 1968 article entitled The Tragedy of the Commons." Hardin theorized that in communal property systems, each individual enjoys the benefit of exploiting the resource to its maximum, while the cost of this increased utilization is spread out over all users. Consequently, there is incentive for individual over exploitation. Applying this theory to global expanses shows that "the disadvantage inherent in this doctrine is that nations are free to make maximum use of resources because no outside mechanism exists to force their acceptance of external costs, either the cost of resource degradation or the cost of resource depletion."'" Much like the herding commons depicted in Hardin's essay, global commons are susceptible to overuse. 19 This problem is indeed a serious one. Global commons become, in effect, a target for over exploitation. Moreover, critics have addressed the problems of free riders and the Prisoner's Dilemma in dealing with commons.2 " The end result is the same, however. These global commons fall victim to the predatory interest of individual exploiting nations.

### AT: Corporate Space Col

#### Space colonization is an insurance policy which guarantees human survival and avoids nearly every single extinction threat

Worrall 18 [Simon Worrall has written for publications all over the world, including The Smithsonian, The London Sunday Times, The Guardian, Paris Review, Conde Nast Traveler and The New Yorker. Since 1997, he has been a regular contributor to National Geographic Magazine, with assignments to London, Wales, Patagonia and China, and now curates a weekly column on the NG website called Book Talk. Michio Kaku is an American theoretical physicist, futurist, and popularizer of science. He is a professor of theoretical physics in the City College of New York and CUNY Graduate Center. “There’s Only One Way For Humanity to Survive. Go To Mars.” National Geographic. March 2, 2018. <https://www.nationalgeographic.com/science/article/there-s-only-one-way-for-humanity-to-survive--go-to-mars->] HW AL

Right at the beginning of the book, you make the shocking prediction: “**Either we must leave the Earth or we will perish.**” Are humanity’s prospects really that dire? And doesn’t this play into the nihilistic feeling that there is nothing we can do to save this planet? If you take a look at evolution on Earth, 99.9 percent of all life forms have gone extinct. When things change, either you adapt or die. That’s the law of Mother Nature. We face various hazards. First of all, we have self-inflicted problems like global warming, nuclear proliferation and bio-engineered germ warfare. Plus, Mother Nature has hurled at the Earth a number of extinction cycles. The dinosaurs, for example, didn’t have a space program. And **that’s why the dinosaurs are not here today.** On the other hand, we shouldn’t use this as an excuse to pollute the Earth, or let global warming run amok. We should cure these problems without having to leave for Mars or another planet, because it’s impossible to remove the entire population of Earth to Mars. **We’re talking about an insurance policy—a backup plan in case something does happen to the Earth.** I once talked to Carl Sagan about this, who said, “We live in the middle of a shooting gallery with thousands of asteroids in our path that we haven’t even discovered yet. So, let’s be at least a two-planet species, as a backup plan.” One of the beautiful images you conjure is of ballet dancing on Mars. Explain why this may one day be less fanciful than it seems. We have the Olympics, where we have athletes that understand the laws of gravity on Earth, but once we’re on the moon and Mars, we have a totally different set of physical constraints. Here, ice skaters can’t do anything more than a quad; four rotations in the air and that’s it! No one has ever done a quint. However, on Mars the gravity is only 30 percent of Earth, so one day we may have an Olympics on Mars where people could do four, five, six, seven rotations in the air, and ballet, or acrobatics, and gymnastics. A whole new set of athletes could be formed because they are adapted to a new environment where the gravity and air pressure is lower. The astronaut Alan Shepard was the first one to golf—golf—on the moon! He snuck on a pair of golf irons. NASA was horrified, yet in the Smithsonian Museum now, you can see a replica of the golf clubs he used, to prove that interstellar sports could become a real possibility. You use the phrase “the fourth wave of science.” Explain what this means and how it could one day make it possible to terraform Mars. We’ve had three waves of scientific innovation. The first wave, the Industrial Revolution, gave us the steam engine, the locomotive, and factories. The second wave was electricity and magnetism, whereby we had TV, internal combustion cars, a beginning of the space program. The third revolution is high tech: computers, lasers, the Internet. Now we have the fourth wave of innovation: artificial intelligence, biotech, and nanotech. That’s going to change the way we view Mars. Many people say Mars is cold and desolate, and there’s nothing to grow there. We can genetically modify plants and algae to thrive in the Martian atmosphere. But who’s going to do the heavy lifting? We all would like to see futuristic cities on Mars, but robots are going to become much more adapted to working in these harsh environments by the end of this century, so we expect to see robotic construction workers building the fantastic domed cities you see in science fiction novels.

#### Public and private companies must work together to overcome blockages that each industry face, only together can the process be expedited

Houser 17 (Kristin Houser is a writer for Futurism , where she covers science and tech. Her written work has appeared in Business Insider, NBC News, and the World Economic Forum’s Agenda, among other publications https://futurism.com/private-companies-not-governments-are-shaping-the-future-of-space-exploration) //HWLND

Private companies may be in the lead, but the finish line for this Space Race isn’t exactly clear. The first iteration was arguably “won” when Neil Armstrong took his first steps on the Moon, so does this sequel end when we establish the first Moon base? When a human walks on Mars? When we leave the solar system? Truthfully, the likelihood of humanity ever calling it a day on space exploration is slim to none. The universe is huge, with galaxy estimates in the trillions, so the goalpost will continue moving back (to bring another sport into the analogy). Rather than focusing on competing in what is ultimately an unwinnable race, private and government-backed space agencies can actually benefit from collaboration thanks to their inherent differences. “The way that SpaceX, Planetary Resources, or Virgin Galactic approaches space exploration is going to be very different from NASA or the Air Force,” explains Lewicki. Private companies aren’t beholden to the same slow processes that often stall government projects, and they can secure or reallocate funding much more swiftly if need be. However, unlike agencies like NASA, they do have shareholders to keep happy and a need to constantly pursue profitability. The two sectors, therefore, have a tremendous opportunity to help one another. Private companies can generate revenue through government contracts —for example, NASA has contracted Boeing to transport astronauts to the International Space Station (ISS), and SpaceX just closed a deal with the U.S. Air Force to launch its secretive space drone. This leaves the government agencies free to pursue the kind of forward-thinking, longer-term research that might not immediately generate revenue, but that can be later streamlined and improved upon in the private sector.

#### Private entities are uniquely crucial to space exploration especially since governments are no longer interested after the space race

Deb 18 [Sandipan Deb is an Indian journalist and writer. He has been the Managing Editor of Outlook, the Editor of The Financial Express and was the founder-editor of Outlook Money, Open, and Swarajya magazines. He is the author of several books. “Space, the next frontier for capitalism.” Mint. March 13, 2018. <https://www.livemint.com/Opinion/NPClPMlOIIAbnwToBO0QiO/Space-the-next-frontier-for-capitalism.html>] HW AL

Jeff Bezos, the richest man on earth, has said that he has been funding his space technology firm Blue Origin at the rate of $1 billion a year and will continue to pump in his “Amazon lottery winnings into a much lower price of admission so we can go explore the solar system." He can afford it — with a net worth of $131 billion, he is richer than two-thirds of the countries of the world. And, along with Elon Musk, the founder of SpaceX, he is the face of the next giant leap of capitalism — into space. Science fiction predicted most of humanity’s technological advancements — from submarines to television, from rockets to robots. But even the most clairvoyant of sci-fi authors failed to foresee that **planet earth would lose interest in manned space exploration after putting a man on the moon.** The space race of the 1950s and 1960s had a grandiose political purpose. **When that battle had been settled, placing communication satellites in orbit became by far the major activity.** Yes, space shuttles were launched, an International Space Station (ISS) is up there, but this was hardly space exploration. The US National Aeronautics and Space Administration’s (NASA) budget, in constant 2014 dollar terms, peaked at $43.6 billion in 1966; it was $18.9 billion in 2017. There were huge potential pay-offs — the obvious one being mining minerals on asteroids and other planets, **but to governments, the returns on investments were too far-off to commit the massive upfront cash outlays.** And thus it stayed for 40 years, till a new breed of capitalists emerged — whose dreams sought frontiers beyond earth. “Our planet is finite," Bezos has said. The turning point was the retirement of the space shuttle in 2011. As a result, NASA awarded billions of dollars of contracts to private companies to carry astronauts and cargo to the ISS. **The industry suddenly bloomed; there are more than a thousand space companies in the US today.** Investment bank Goldman Sachs estimates that space start-ups have, globally, attracted $13.3 billion of investment since 2010. In 2015, President Barack Obama signed the US Commercial Space Launch Competitive Act into law, guaranteeing private companies rights to own, sell and profit from resources extracted from asteroids and other “celestial bodies". In August 2017, Luxembourg became the first European country that officially allows space resources to be “appropriated" by commercial groups based in the country. Many companies have since then set up shop in Luxembourg. Bezos’ Blue Origin has successfully launched and landed several sub-orbital flights. In February this year, SpaceX launched Falcon Heavy into orbit around the sun. The company is aiming to have manned flights by the end of the year, and says that Big Falcon Rocket (BFR), its spaceship for interplanetary travel that may carry up to 100 passengers, will be ready in 2019. Meanwhile, Bigelow Aerospace, owned by Robert Bigelow, who made his billions from his budget hotel chain, plans to set up hotels that will orbit earth. Among start-ups that are focused on space mining, Planetary Resources points out that just one little near-earth asteroid called 3554 Anum has $8 trillion worth of platinum reserves, while our current annual output is $12 billion, of which 88% comes from three mines in South Africa.

### 1NC – AT: Debris Advantage

#### Probability – 0.1% chance of a collision.

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

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

#### Time frame – Kessler effect 200 years away.

Peter Stubbe, PhD in law @ Johann Wolfgang Goethe University Frankfurt, ’17, State Accountability for Space Debris: A Legal Study of Responsibility for Polluting the Space Environment and Liability for Damage Caused by Space Debris, Koninklijke Brill Publishing, ISBN 978-90-04-31407-8, p. 27-31

The prediction of possible scenarios of the future evolution of the debris p o p ulation involves many uncertainties. Long-term forecasting means the prediction of the evolution of the future debris environment in time periods of decades or even centuries. Predictions are based on models84 that work with certain assumptions, and altering these parameters significantly influences the outcomes of the predictions. Assumptions on the future space traffic and on the initial object environment are particularly critical to the results of modeling efforts.85 A well-known pattern for the evolution of the debris population is the so-called Kessler effect’, which assumes that there is a certain collision probability among space objects because many satellites operate in similar orbital regions. These collisions create fragments, and thus additional objects in the respective orbits, which in turn enhances the risk of further collisions. Consequently, the num ber of objects and collisions increases exponentially and eventually results in the formation of a self-sustaining debris belt aroundthe Earth. While it has long been assumed that such a process of collisional cascading is likely to occur only in a very long-term perspective (meaning a time 1 n of several hundred years),87 a consensus has evolved in recent years that an uncontrolled growth of the debris population in certain altitudes could become reality much sooner.88 In fact, a recent cooperative study undertaken by various space agencies in the scope of i a d c shows that the current l e o debris population is unstable, even if current mitigation measures are applied. The study concludes:

Even with a 90% implementation of the commonly-adopted mitigation measures [...] the l e o debris population is expected to increase by an average of 30% in the next 200 years. The population growth is primarily driven by catastrophic collisions between

#### Even a worst-case Kessler syndrome would have little effect—the math checks out.

Fange 17

Daniel Von Fange, senior enginneer @ Origin Protocol, 5-21-2017, "Kessler Syndrome is Over Hyped," Braino.org, <http://braino.org/essays/kessler_syndrome_is_over_hyped/> //MLT

Let’s imagine a worst case scenario. An evil alien intelligence chops up everything in High LEO, turning it into 1cm cubes of death orbiting at 1000km, spread as evenly across the surface of this sphere as orbital mechanics would allow. Is humanity cut off from space? I’m guessing the world has launched about 10,000 tons of satellites total. For guessing purposes, I’ll assume 2,500 tons of satellites and junk currently in High LEO. If satellites are made of aluminum, with a density of 2.70 g/cm3, then that’s 839,985,870 1cm cubes. A sphere for an orbit of 1,000km has a surface area of 682,752,000 square KM. So there would be one cube of junk per .81 square KM. If a rocket traveled through that, its odds of hitting that cube are tiny - less than 1 in 10,000. So even in the worst case, we don’t lose access to space. Now though you can travel through the debris, you couldn’t keep a satellite alive for long in this orbit of death. Kessler Syndrome at its worst just prevents us from putting satellites in certain orbits. In real life, there’s a lot of factors that make Kessler syndrome even less of a problem than our worst case though experiment. Debris would be spread over a volume of space, not a single orbital surface, making collisions orders of magnitudes less likely. Most impact debris will have a slower orbital velocity than either of its original pieces - this makes it deorbit much sooner. Any collision will create large and small objects. Small objects are much more affected by atmospheric drag and deorbit faster, even in a few months from high LEO. Larger objects can be tracked by earth based radar and avoided. The planned big new constellations are not in High LEO, but in Low LEO for faster communications with the earth. They aren’t an issue for Kessler. Most importantly, all new satellite launches since the 1990’s are required to include a plan to get rid of the satellite at the end of its useful life (usually by deorbiting) So the realistic worst case is that insurance premiums on satellites go up a bit. Given the current trend toward much smaller, cheaper micro satellites, this wouldn’t even have a huge effect. I’m removing Kessler Syndrome fro, my list of things to worry about.

#### USFCC solves – Kessler is known and they stop potentially triggering launches

Dvorsky 18

George Dvorsky (senior staff reporter specializing in astromony and advanced tech), 3-9-2018, "California Startup Accused of Launching Unauthorized Satellites Into Orbit: Report [Updated]," https://gizmodo.com/california-startup-accused-of-launching-unauthorized-sa-1823657316, // HW AW

The US Federal Communications Commission says [Swarm Technologies](http://www.swarm-technologies.com/)—a [communications startup](https://www.sbir.gov/node/1155335) run by Silicon Valley expats—launched four tiny internet satellites into space back in January. That’s a problem because the FCC never greenlighted the project, saying the experimental satellites are dangerous. If confirmed, it would mark the first known time in history that unauthorized satellites have been placed in space. The launch happened on what was otherwise a historic day. On January 12, 2018, [the state-owned Indian Space Agency (ISRO) launched its 100th satellite](https://www.thehindubusinessline.com/news/science/isro-to-launch-its-100th-satellite-on-january-12/article10022149.ece), along with 30 others. But as Mark Harris [reports](https://spectrum.ieee.org/tech-talk/aerospace/satellites/fcc-accuses-stealthy-startup-of-launching-rogue-satellites) at IEEE Spectrum, four of these 31 satellites probably shouldn’t have been packed to the cargo hold of the Polar Satellite Launch Vehicle (PSLV). Prior to the launch, ISRO described the quartet as American owned “two way satellite communications and data relay” devices, but with no operator identified. Spectrum has since learned that the four so-called SpaceBees are the property of Swarm Technologies, a company founded two years ago by Canadian aerospace engineer Sara Spangelo, a former Google employee, and Benjamin Longmier, a developer who sold his previous company to Apple. This five-employee startup (currently in stealth mode) is currently working on a system that will enable a space-based Internet of Things communication network, with the potential to hookup ships, trucks, cars, agricultural equipment and anything else equipped with an IP address. **The four SpaceBees currently in orbit represent the first of what the company hopes will be a larger constellation of tiny satellites, which together will be capable of delivering low cost internet to virtually any part of the globe. “The only problem is, the Federal Communications Commission (FCC) had dismissed Swarm’s application for its experimental satellites a month earlier, on safety grounds,**” writes Harris at Spectrum. “It feared that **the four SpaceBees now orbiting the Earth would pose an unacceptable collision risk** for other spacecraft. If confirmed, this would be the first ever unauthorized launch of commercial satellites.” The FCC regulates commercial satellites in the US, and under some interpretations of existing laws, it has purview over American-owed satellites launched from other countries.What Swarm has done is actually quite upsetting. That unscrupulous startups are tossing unsanctioned—and potentially dangerous—objects into space is so not cool. And it appears the FCC agrees. Earlier this week, the communications commission withdrew its approval for a follow-up mission that was supposed to go up in April with an additional four satellites. Another application involving two undisclosed Fortune 100 companies is now also in doubt. Furthermore, the FCC is now investigating the incident, and Swarm could very well lose its launch privileges. As Harris put it, “If Swarm cannot convince the FCC [on its qualifications to be a Commission licensee], the startup could lose permission to build its revolutionary network before the wider world even knows the company exists.” The satellites are considered unsafe because of their diminutive size. Each SpaceBee measures a mere 10 cm x 10 cm x 2.8 cm, which is about the size of a hardcover book, or one-quarter the size of a standard CubeSat

#### Kessler syndrome is media hype – no risk

Von Fange 17

Daniel von Fange (systems engineer. Fond of charts), 5-21-2017, "Kessler Syndrome is Over Hyped," braino, http://braino.org/essays/kessler\_syndrome\_is\_over\_hyped/, // HW AW

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